

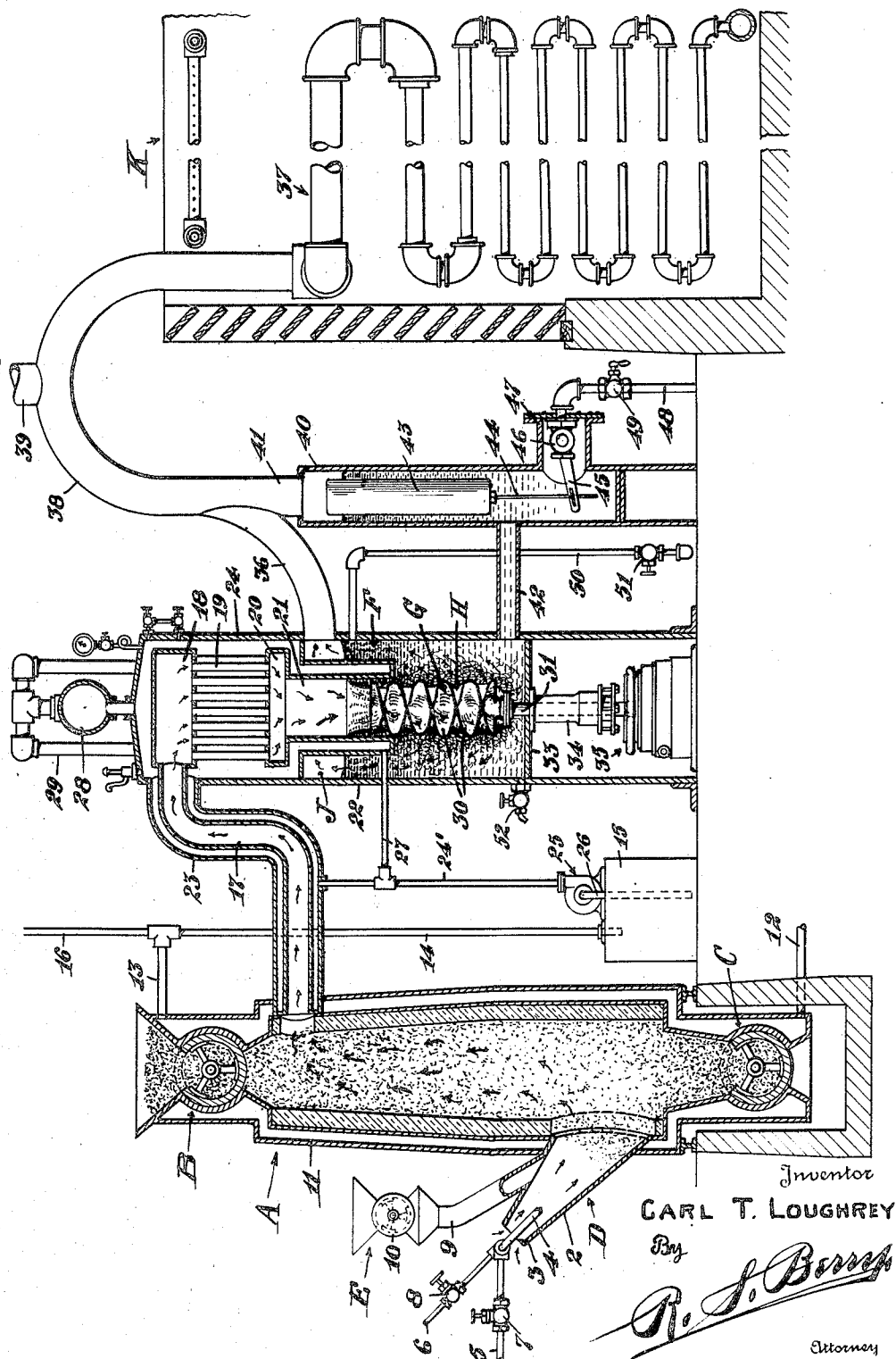
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MEANS AND METHOD FOR REMOVING VOLATILES FROM SOLIDS

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MEANS AND METHOD FOR REMOVING
VOLATILES FROM SOLIDS

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This invention relates to a method and apparatus for removing volatiles from solids containing same and more particularly from solid carbonaceous materials such as oil shale, coal, and in general any mass containing a hydrocarbon.

The primary object of the invention is to provide a means and method whereby volatiles may be removed from solid material containing same by passing gases and/or vapors through a mass of the material and effecting separation of vapors and gases, and condensation of vapors.

Another object is to provide a means and method of the above character in which the generation of the gases may be effected by the combustion of fuel within a mass of the materials or adjacent thereto in such manner that heat developed by the combustion and the action of hot products of combustion on the mass under treatment will act to liberate volatile constituents of the materials and the gases serve as a carrier for the removed vapors.

Another object is to provide a means and method whereby combustion within the mass may be confined to a relatively small predetermined zone and complete combustion effected in such zone so as to produce hot fixed gases and thereby prevent oxygen from mingling with, or entering into combination with volatiles being sublimated and thus avoid combustion of condensable vapors desired to be recovered.

Another object is to provide a means and method for removing hydrocarbon from granular materials in mass by the action of a flow of gases through the mass, in which a uniform distribution of the gases throughout the interstices in the mass is attained so as to rapidly effect complete vaporization of volatiles in the mass and in a fashion such as to permit recovery of the volatiles and also a calcined residuum.

Another object is to provide a means and method for effecting a constant positive flow of gases and vapors through a mass under treatment, that is a flow of gases and vapors through a mass in one general direction without pulsation, which will enable complete removal and recovery of all the volatiles in the mass and insure against solids being removed from the mass with the gases and vapors.

A further object is to provide a means and method for treating granular materials to effect removal of volatiles therefrom in which a fluid comprising either gases or vapors, or a mixture of gas and vapors, may be caused to pass at barometric pressure through the interstices in a mass

of the materials in a fashion to intimately contact under rapid flow of the fluid the superficial areas of the granular particles throughout the mass.

Another object is to provide a means and method of the recited character whereby the treatment of the materials may be effected without destructive distillation when so desired.

With the foregoing objects in view and in contemplation of such other objects and advantages as may subsequently appear I employ an apparatus and certain steps substantially as hereinafter described and claimed and illustrated by way of example in the accompanying drawing, in which the figure is a view in section and elevation of an apparatus for carrying the method into effect.

In the drawing A indicates generally a retort which is equipped at its upper end with a mechanical feeder B for delivering the material to be treated in granular form into the upper end of the retort to charge the latter, and which retort is also equipped at its lower end with a mechanical discharger C for effecting removal of residuum therefrom. The lower end portion of the retort is fitted with a twyer D which embodies a frustroconical shell 2 opening at its enlarged end to the interior of the lower portion of the retort; the shell protruding from the retort at an upward inclination and having an opening 3 in its outer end for the admission of air to the twyer. The twyer D is designed so that it may function in conjunction with the lower portion of the retort as a combustion chamber and to this end is fitted with a burner nozzle 4 with which is connected a fuel feed line 5 and a steam line 6 through control valves 7 and 8 in a manner common in liquid fuel burner construction. The twyer is also equipped with a stoker E for feeding solid fuel thereto as occasion may require, which stoker embodies a feed pipe 9 connecting with the upper portion of the shell 2 and leading from a mechanical feeder 10 which may be of any suitable construction.

The retort A is fitted with a water jacket 11 which encompasses the walls of the retort and also the feeder B and discharger C, to the lower end of which water is supplied through a feed pipe 12. An overflow pipe 13 leads from the upper end portion of the water jacket 11 and connects with a drain pipe 14 leading to a reservoir 15. A vent pipe 16 extends upwardly from the intersection of the overflow pipe 13 with the drain pipe 14.

Leading from the upper end portion of the retort A is a conduit 17 which communicates with

a chamber 18 from the lower end of which leads a series of downwardly extending tubes 19 connecting with a chamber 20 having a downwardly extending open ended cylinder 21 opening at its lower end below the surface of a body of liquid F contained in a reservoir 22. The conduit 17 is fitted with a water jacket 23 which communicates with a water jacket 24 encompassing the chambers 18 and 20, tubes 19, and cylinder 21.

A water feed pipe 24' connects with the water jacket 23 and leads from the discharge end of a pump 25 fitted with an intake pipe 26 which extends into the hot water reservoir 15; the feed pipe 24' having a branch 27 connecting with the lower portion of the water jacket surrounding the cylinder 21.

The water jackets 23 and 24 constitute a heat exchanger to effect a cooling action on gases and vapors flowing from the retort and serve in conjunction with the conduit 17, chambers 18 and 20, tubes 19, and cylinder 21 as a steam generator; a steam dome 28 being provided at the upper end of the water jacket 24 from which discharge conduits 29 lead to suitable points of steam discharge and utilization.

Arranged in the reservoir 22 is a vertically extending screw impeller G embodying a pair of twin helical blades 30 mounted on a shaft 31, one-half of a convolution of the upper portion of which blades extend into the lower end of the cylinder 21 in close juxtaposition with but slightly spaced from the inner periphery of the latter. The pair of blades 30 of the impeller are arranged in parallel relation around an axis 31 in the manner common in double screw or spiral constructions.

The lower end of the shaft 31 extends through the bottom wall 33 of the reservoir 22 and through a gland 34 and connects with the drive shaft of a steam turbine 35 whereby the shaft 31 and the impeller G may be rotated.

The impeller G is designed on rotation to effect positive displacement of the portion of the liquid in which it is submerged and to form a vertically extending vortex tube H leading downwardly beneath the surface of the liquid and to a considerable depth within the body of liquid, and in forming the vortex tube H to set up rotational motion and produce a multiple of vortices and vortex folds within the portion of the liquid surrounding the vortex tube and forming the wall thereof.

Surrounding the water jacket of the cylinder 21 in the upper portion of the reservoir 22 above the level of the liquid F in the latter, is a space J and leading from such space is a vapor conduit 36 leading to the condensing tubes 37 of a cooling tower K through a goose neck 38 which latter is fitted with a vent pipe 39 for exhausting fixed gases.

A fluid level regulator is provided for automatically maintaining liquid in the reservoir 22 at a predetermined level, which regulator is here shown as embodying a tank 40 which opens at its upper end through a pipe 41 to the vapor conduit 38. Leading from the lower end of the reservoir 22 is a pipe 42 connecting with the tank 40 intermediate the upper and lower ends thereof. Arranged in the tank 40 is a float 43 from the lower end of which extends a stem 44 connecting with a lever 45 of a valve 46 arranged in an off-set 47 on the lower end portion of the tank 40, and which valve 46 is carried on the end of a liquid supply pipe 48 leading from any suitable source of liquid supply under pressure;

the valve being designed to operate in the well known manner under the control of the float 43 to feed liquid to the tank 40 on lowering of the float 43. A cut-off valve 49 is provided in pipe 48.

The reservoir 22 is fitted with an overflow pipe 50 fitted with a cut-off valve 51 through which liquid from the reservoir may be withdrawn from time to time for testing purposes; the reservoir also being fitted with a draw-off valve 52 for drainage purposes.

In the operation of the invention the materials to be treated are delivered to the retort A through the feeder B, which materials for the purpose of the invention here set forth comprise solids in a broken, crushed or granular state and containing volatiles desired to be removed. The materials may be of carbonaceous character, such as shale, coal, coke, etc., but also may consist of solids accompanied by a liquid or a semi-liquid carbonaceous substance such as oil-sand. The materials are delivered to the retort in such quantity as to fill the latter and to maintain it substantially full; the materials being free to gravitate downwardly through the retort. To maintain a proper charge in the retort, such quantity of the material is fed thereto as to constantly replace the materials discharged therefrom by the discharger C.

It will be seen that a continuous feed of the material may be effected through the retort at a speed which may be controlled according to requirements by regulating the operations of the feeder B and discharger C.

After thus charging the retort or during the charging thereof, the shaft 31 is set in operation to effect rotation of the impeller G within the liquid body F which acts to displace the liquid and to create a large vortex tube H therein as before stated. At the same time the impeller G imparts a rotational motion, or gyratory or swirling movement to the liquid forming the wall of the vortex tube, and also creates a multiple of vortices and vortex folds in the liquid; a general spiral or rolling movement of the liquid away from the blades and wall of the vortex tube also being effected.

The upper portion of the impeller G surrounded by the cylinder 21 will act to displace the liquid in the cylinder and force at least a portion of the liquid with a positive action downwardly through the open lower end of the cylinder and into the swirling body of the liquid contained in the latter thus forming a communication between the space enclosed by the cylinder 21 and the vortex tube H within the liquid body F.

On formation of the vortex tube H a rush of gases, initially atmosphere, will flow into the vortex tube from the retort A under barometric pressure to compensate for the displaced liquid; a positive displacement thus being effected throughout the spaces extending from the vortex tube through cylinder 21, chamber 20, tubes 19, chamber 18, conduit 17, interstices of the charge in retort A, and twyer D; air entering the twyer D through the inlet 3 with a constant flow and passing through the recited spaces into the vortex tube where it is enfolded in the folds of the vortices in the liquid and carried into the latter outwardly and upwardly away from the impeller and passed through the body of liquid to the space J and to discharge through conduits 36, 38 and 39.

Where the materials under treatment are of such character that volatiles contained therein may be removed therefrom by the flow of gases

through the charge at atmospheric temperature, such for example as in effecting removal of volatiles from hydrocarbon bearing solids by the action of butane gas, a suitable connection is made between the intake opening 3 of the twyer D and a source of butane supply, whereupon the butane gas will flow through the charge in the retort A and through the body of liquid F carrying therewith vapors removed from the charge by the action of the butane thereon.

At least a portion of the vapors thus entrained by the gas and delivered into the body of liquid F will be condensed in the latter, while such vapors as are not so condensed or as may be carried forward with the butane into the conduits 36 and 38 will be directed to the condensing tube 37 of the condenser K, thus separating the vapors from the butane which latter is carried to a suitable point of discharge through the conduit 39.

Where the volatiles of a material under treatment are such that their removal may be effected by subjecting the material to the action of steam, the requisite volume of steam may be delivered to the twyer D from a suitable source of supply through the nozzle 4 by pipe 6 under regulated control by valve 8, which volume of steam may be accompanied by air supplied through the intake 3 or by closing the intake 3 may be delivered to the charge alone. The steam flowing through the charge together with entrained vapors is directed into the vortex tube H and into the liquid F in the fashion before described, condensation of both steam and entrained vapors occurring at least in most part in the body of liquid F while fixed gases, if any will be carried over to discharge through the conduits 36, 38 and 39, with further condensation of separated vapors effected in the condenser K.

Where it is desired to subject the material to the action of hot gases to effect removal of volatiles therefrom such gases may be generated as needed either by combusting a hydrocarbon fuel within the twyer D by directing such fuel from a source of supply through the pipe 5 control valve 7 and nozzle 4 and igniting the fuel in the twyer D; air to support combustion being admitted through the opening 3.

In like manner a solid carbonaceous fuel may be combusted in the twyer D by directing such fuel from the feeder E to the twyer through the conduit 9; the air for supporting the combustion being supplied through the opening 3. In either the combustion of liquid or solid fuel in the twyer D the hot products of combustion developed thereby will flow into the charge in the retort and will pass from the latter with entrained vapors into the vortex tube H and into the liquid F in the fashion before described; a portion of the volatiles being condensed in the liquid while other volatiles may pass forward with the fixed gases for subsequent separation, with the gases flowing to discharge through the conduit 39 and the vapors passing to the condenser K for final condensing.

Where the materials under treatment are carbonaceous and have requisite fuel properties, combustion of a portion of the charge may be effected in the lower part of the retort and at inner end of the twyer D; air for supporting the combustion being supplied through the opening 3. The hot fixed gases formed by such combustion flow upwardly through the interstices of the upper portion of the charge and effect liberation of volatiles therefrom and then pass together

with entrained vapors apart from atmosphere into the vortex tube H and into the liquid F in the fashion before described. The entrained vapors will be separated from the fixed gases by condensation of a portion of the vapors in the liquid and by subsequent separation the vapors from the fixed gases in the conduit 38 and passing of the vapors to the condenser K.

Manifestly combustion of a portion of the charge or mass within the retort may be supplemented by combustion of either a liquid fuel supplied through the nozzle 4, or auxiliary fuel supplied through the feeder E. In either mode of producing hot fixed gases, as herein set forth the zone of combustion will be fixed and predetermined by the volume of air supplied to the support combustion, which is governed by the capacity of the impeller and which may be varied as occasion may require by varying the dimensions of the impeller G to effect the desired result.

A mixture of hot gases and steam may be directed through the mass under treatment by effecting combustion of fuel to form fixed gases as above described, and delivering water into the combustion zone in regulated volume such that the heat of combustion will act to convert the water into steam. In this fashion the use of a boiler to generate the steam may be dispensed with, and the cost of generation of steam reduced to a minimum.

By regulating the water feed to the combustion zone an approximately definite proportion of steam and fixed gases passing through the charge may be obtained, and in some instances the major portion of the B. t. u.'s of the heat of combustion may be converted into a volume of steam. The temperature of the steam may likewise be controlled to be of any predetermined temperature and may readily be lower than temperatures required to effect destructive distillation of the volatiles of the charge, and whereby the steam will act as a carrier for the volatiles in effecting their removal and delivery to the condensing liquid F.

Temperature control of hot gases and vapors passing through the charge is effected by regulating the rapidity of the flow of the solids being passed through the retort, since incoming materials at atmospheric temperature will absorb heat from the ascending gas and thus effect reduction of temperature of the latter, and as a consequence, the more rapid the descending flow of the materials relative to the ascending flow of the gases and/or vapors therethrough the greater the cooling action, and conversely the slower the flow of the materials the lesser the cooling action.

Where hot gases are utilized in effecting the removal of the volatiles reduction of the temperature of the gases preliminary to their flow into the vortex tube is effected by the heating exchanger embodying the tubes 19 and the water jackets 23 and 24; water in the jackets absorbing a portion of the heat conducted from the gases through the walls of the tube 17, chamber 18, tubes 19, chamber 20, and cylinder 21. In this fashion steam may be generated for use in operating the turbine 35, pump 25, and other power driven devices, as well as to supply steam for delivery to the charge where such is desired.

During treatment of the materials in the retort the treated solids will be ejected by the discharger C from time to time, and fresh materials fed to the retort as needed through the feeder B, such as to maintain a substantially continuous flow of the materials through the

retort; the gases for effecting removal of volatiles flowing through the charge counter to the flow of the latter.

Where the materials are subjected to the action of hot products of combustion and especially to combustion in the charge, a calcined residuum will be formed which may in some instances be utilized as a by-product.

An important feature of the invention resides in the fact that the entire performance is effected at barometric pressure with a constant positive flow or advance of gases and/or vapors in uniform continuity through the interstices of the charge in a forward or general direction under the natural flow of the gases, stimulated in some instances by the action of heat, without pulsation or molecular rebound; no back pressure occurring at any point in the passage of the gases from one end of the apparatus to the other.

Another important feature of the invention resides in causing the gases and entrained vapors to flow directly into the folds of vortices formed beneath the surface of the liquid in developing the vortex tube H, whereby the gases and vapors will be temporarily occluded in the liquid F. To this end the impeller is arranged with its upper end spaced below the normal level of the liquid F so that when the impeller is still it will be submerged, and the cylinder 21 is extended below the liquid to encompass at least one-half a convolution of the upper portions of the helical blades so as to afford an adequate seal at the upper end of the impeller and also afford such hydrostatic head above the impeller as to maintain such seal. While the impeller may be formed of various dimensions according to the volume of gases to be caused to flow through the liquid in a given time, I have found in practice that by forming the impeller approximately thirty inches in length and sixteen inches in diameter with adjacent flights of the blades spaced approximately eight inches apart on a pitch slightly exceeding forty-five degrees, and then rotating the impeller approximately one thousand revolutions per minute, a volume of approximately one thousand cubic feet of hot gases generated by combustion of fuel in the twyer D or the lower portion of the retort, will flow into the vortex tube and through the body of liquid F per second.

It will be understood that where hot gases are directed into the vortex tube and into the liquid, vaporization of a portion of the liquid will be effected with resultant vapors being entrained with the gases flowing through the liquid and carried by the latter to the point of separation through the conduit 36. In this fashion diminishing of the liquid F will be effected which however will be compensated for by the supply of fresh liquid delivered to the reservoir. The liquid with the entrapped condensate may be drawn off from the reservoir through the valve 52 as occasion may require.

The liquid may be of any suitable character and may initially comprise either water or oil; its characteristics manifestly being changed as condensates accumulate therein.

By confining the charge in the retort A and causing combustion of a fuel and the flow of the products of combustion through the charge in the fashion set forth, that is without pulsation or molecular rebound, the theoretical ultimate in combustion will be effected, so that the resultant gases will be fixed and accordingly

will flow through the charge without setting up chemical reaction therein, and so solids will be passed to the vapor condensing liquid F as would occur if smoke were formed. Furthermore by effecting complete combustion in a predetermined zone oxygen will not be permitted to mingle with the volatiles being sublimated, thus obviating causing combustion of the condensible volatiles desired to be recovered.

In the recovery of hydrocarbon from solids bearing same by the process herein recited the temperatures generated may be such as not to effect distillation or fractionation of the volatiles, and by effecting complete reaction upon the oxygen entering the combustion zone permits the generation of volumes of steam together with the products of combustion and the consequent flow of gases and steam into the interstices of the mass so as to effect liquifying of hydrocarbons in the mass with the flowing gases and steam acting as a carrier of the hydrocarbon liquid into the liquid F, thus effecting removal of the hydrocarbons without fractionation.

I claim:

1. The method consisting in confining a mass of granular volatile-containing solids and causing a hot fluid to advance in uniform continuity through the interstices of the mass without pulsation to effect removal of volatiles from the solids and also causing the fluid with entrained vapors to enter a body of liquid by creating vortices within the liquid and directing the fluid and vapors into the folds of the vortices whereby the fluid and vapors will become temporarily occluded in the liquid and at least a portion of the vapors condensed in the liquid.

2. The method consisting in generating gases and causing the gases to advance in uniform continuity through the interstices of a mass of granular volatile-containing solids without pulsation to effect removal of volatiles from the mass and also causing the gases with entrained vapors to enter a body of liquid, by creating vortices beneath the surface of the liquid and directing the gases and vapors into the vortex folds whereby the gases and vapors will become temporarily occluded in the liquid and at least a portion of the vapors condensed in the liquid.

3. The method consisting in generating gases and causing the gases to advance in uniform continuity through the interstices of a mass of granular volatile-containing solids without pulsation to effect removal of volatiles from the mass and also causing the gases with entrained vapors to enter a body of liquid, by creating vortices beneath the surface of the liquid and directing the gases and vapors into the vortex folds whereby the gases and vapors will become temporarily occluded in the liquid and at least a portion of the vapors condensed in the liquid, and thereafter separating other condensible vapors from the gases, and condensing such separated vapors.

4. The method consisting in generating hot gases and causing the hot gases to flow through the interstices of a mass of granular volatile-containing solids to remove volatiles from the solids and also causing the hot gases with entrained vapors to enter a body of liquid by creating vortices within the liquid and directing the gases and the vapors carried thereby into the vortex folds to effect occlusion of the gases and vapors in the liquid and effect condensation of at least a portion of the vapors in the liquid.

5. The method consisting in generating hot

fixed gases and causing the hot gases to flow through the interstices of a mass of granular volatile-containing solids to remove volatiles from the solids and also causing the hot gases with entrained vapors to enter a body of liquid by creating vortices within the liquid and directing the gases and the vapors carried thereby into the vortex folds to effect occlusion of the gases and vapors in the liquid and effect condensation of at least a portion of the vapors in the liquid.

6. The method consisting in generating hot fixed gases by combustion of fuel and causing the hot gases to flow through the interstices of a mass of granular volatile-containing solids to remove volatiles from the solids and also causing the hot gases with entrained vapors to enter a body of liquid by creating vortices within the liquid and directing the gases and the vapors carried thereby into the vortex folds to effect occlusion of the gases and vapors in the liquid and effect condensation of at least a portion of the vapors in the liquid.

7. The method of removing volatiles from granular solids consisting in generating fixed gases and causing the gases to flow through a mass of granular volatile-containing solids apart from atmosphere to effect removal of volatiles from the mass and also causing the gases with entrained vapors to enter a body of liquid by creating vortices beneath the surface of the liquid and directing the gases and vapors into the vortex folds whereby the gases and vapors will become occluded in the liquid and at least a portion of the vapors become condensed in the liquid.

8. The method of removing volatiles from granular solids containing same consisting in generating hot gases and causing the gases to flow through a mass of granular volatile-containing solids at a temperature to effect removal of volatiles from the mass without distillation, and also causing the gases with entrained vapors to enter a body of liquid by creating vortices beneath the surface of the liquid and directing the gases and entrained vapors into the vortex folds whereby the gases and vapors will become occluded in the liquid and at least a portion of the vapors condensed in the liquid.

9. The method consisting in generating gases and causing the gases to flow through a mass of granular volatile-containing solids apart from atmosphere to effect removal of volatiles from the solids and also causing the gases with entrained vapors to enter a body of liquid by creating a vortex tube in the liquid, and directing the gases and vapors into the vortex tube apart from atmosphere and free of resistance so as to effect occlusion of the gases and vapors in the vortex folds developed in the walls of the vortex tube and consequent condensation of at least a portion of the vapors in the liquid.

10. The method of removing volatiles from granular solids containing same consisting in confining a mass of the granular material, generating hot fixed gases by combustion of a carbonaceous fuel and causing the hot gases to flow through the mass and together with entrained vapors to enter a body of liquid, by creating a vortex tube within the liquid and directing the gases and vapors from the mass apart from atmosphere into the vortex tube to effect occlusion of the gases and vapors in the liquid and effect condensation of at least a portion of the vapors in the liquid separating the gases and uncondensed vapors apart from the liquid, and condensing condensable vapors.

11. The method of removing volatiles from granular solids containing same consisting in confining a mass of the granular material, generating hot fixed gases by combustion of carbonaceous fuel, causing said gases to flow directly from their point of generation through the mass, effecting positive displacement by gyratory motion of a submerged portion of the body of liquid to form vortices beneath the surface of the liquid, passing the gases in volume together with entrained vapors directly into the vortices apart from atmosphere whereby the gases and vapors will flow into and through the body of liquid and causing a portion of the vapors to condense in the liquid, then separating gases and such condensable vapors as pass through the liquid, and condensing the vapors.

12. The process which consists in confining a body of divided carbonaceous solids, producing hot fixed gases, displacing a portion of a body of liquid to form a vortex tube therein, causing the hot fixed gases to flow to the point of generation through the carbonaceous mass and into the vortex tube together with vapors developed by the flow of the hot fixed gases through the mass to cause the gases and vapors to pass into the body of liquid and effect separation of vapors from the gases.

13. The method consisting in effecting complete combustion of a carbonaceous fuel to form hot fixed gases, displacing a submerged portion of a body of liquid by rotational movement to form a vortex tube therein, passing the hot fixed gases through a body of divided carbonaceous solids and into the vortex tube together with vapors removed from the carbonaceous solids by action of the hot gases thereon to cause the gases and vapors to enter the body of liquid and thereby effect condensation of at least a portion of the vapors in the liquid, then separating the liquid and vapors.

14. The method consisting in effecting complete combustion within a predetermined zone of a body of divided carbonaceous solids to form hot fixed gases, forming a vortex tube within a body of liquid, passing the hot fixed gases together with vapors extracted from the solids through the other portion of the mass of carbonaceous solids into the vortex tube and through the body of liquid to effect separation of gases and vapors and condensing of at least a portion of the vapors in the liquid, and thereafter separating other vapors from the fixed gases apart from the liquid and condensing such separated vapors.

15. The process of removing hydrocarbon from carbonaceous solids containing same consisting in forming a vortex tube within a body of liquid, effecting continued complete combustion of a carbonaceous material to afford a constant supply of hot fixed gases, passing the hot gases through a confined mass of divided carbonaceous solids and directly into the vortex tube with atmosphere excluded, at barometric pressure and without effecting distillation of the hydrocarbons in the mass, maintaining vortices within the body of liquid such as to permit gases with entrained vapors to flow into the body of liquid and thereby effect condensation of a portion of the vapors in the liquid, then separating condensable vapors from the fixed gases apart from the liquid.

16. The process of removing volatiles from carbonaceous solids consisting in forming a vortex tube in a body of liquid, effecting complete com-

- bustion within a portion of a mass of divided carbonaceous solids, effecting a flow of the solids into the zone of combustion and passing the generated gases together with vapors developed in the mass through the mass counter to the direction of movement thereof into the vortex tube in the liquid and into the body of liquid through the wall of the tube to cause condensing of a portion of the vapors in the liquid, thereafter separating gases and condensible vapors apart from the liquid.
17. The method consisting in confining a mass of divided carbonaceous solids, forming a combustion zone in a portion of the mass, directing air and steam into such combustion zone, effecting feeding of the materials of the mass toward the combustion zone, directing hot fixed gases generated in the combustion zone through the mass counter to the flow thereof, displacing liquid to form a vortex tube therein, and passing the gases together with entrained vapors generated in the mass directly into the vortex tube and through the liquid; the recited step being performed under barometric pressure.
18. The method consisting in confining a mass of divided carbonaceous solids delivering gas to the mass of solids and causing the gas to pass through the interstices of the mass into intimate contact with the solids and then to flow into a body of liquid by forming and maintaining a vortex tube within the body of liquid and directing the gas with entrained vapors directly

into the vortex tube to cause temporary occlusion of the gas and vapors in the liquid and condensation of at least a portion of the vapors in the liquid.

19. An apparatus for removing vapors from granular solids comprising a retort, means for feeding granular materials continuously through said retort, a liquid reservoir containing a body of liquid, a rotary helix submerged in said body of liquid for forming a vortex tube within the liquid, means for conveying gases with entrained vapors from the upper portion of said retort into the vortex tube in the liquid, and means for delivering fuel and air into the lower portion of said retort to effect combustion therein and the formation of hot fixed gases in the lower portion of the retort.

20. The method consisting in confining a mass of divided carbonaceous solids, delivering gas to the mass of solids and causing the gas to pass through the interstices of the mass into intimate contact with the solids and then to flow into a body of liquid by forming and maintaining a vortex tube within the body of liquid and directing the gas with entrained vapors directly into the vortex tube to cause temporary occlusion of the gas and vapors in the liquid and condensation of at least a portion of the vapors in the liquid, and cooling the gases and vapors as they flow from said retort to said vortex tube.

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