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W. K. KIRBY

PROCESS AND APPARATUS FOR TREATING OIL SHALES

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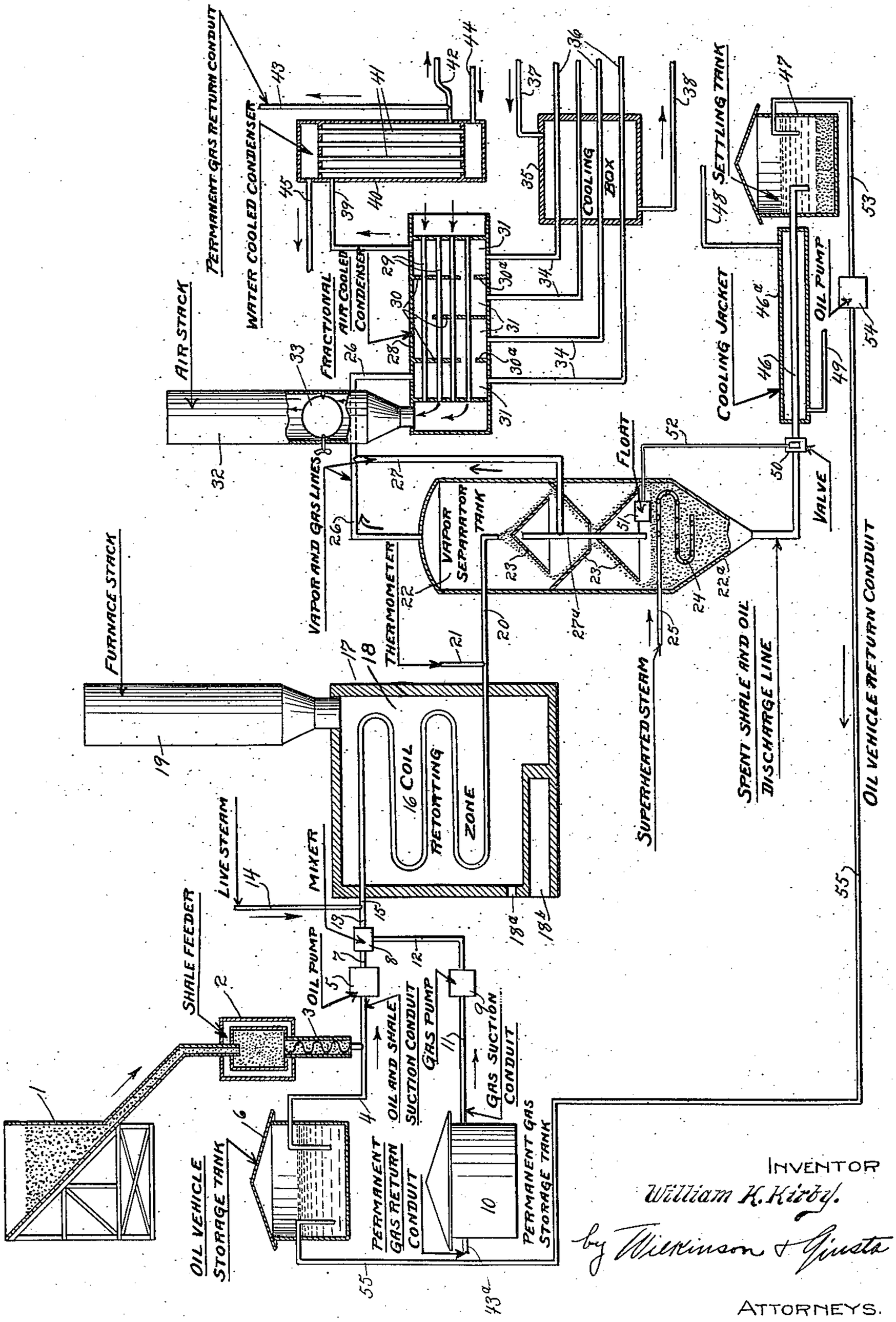

INVENTOR
William K. Kirby.
by Wilkinson & Gioeta
ATTORNEYS.

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WILLIAM K. KIRBY, OF GOLDEN, COLORADO.

PROCESS AND APPARATUS FOR TREATING OIL SHALES.

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To all whom it may concern:

Be it known that I, WILLIAM K. KIRBY, a citizen of the United States, residing at Golden, in the county of Jefferson and State of Colorado, have invented certain new and useful Improvements in Processes and Apparatus for Treating Oil Shales, of which the following is a specification.

This invention relates to improvements in the art of obtaining shale oil, which improvements embody a novel process or method of and apparatus or system for treating oil shales, whereby the valuable constituents thereof are educed and conserved with the aims in view of maximum production, superior quality and comparatively minimum expense.

It is believed to be generally understood that all of the oil shales at least do not necessarily contain any substantial amount of oil per se, that is to say that oil may not be obtained therefrom by pressure or solvents, but when such shales are retorted they then give off, in addition to other values probably, certain gases and oily vapors, which latter may be converted readily by proper methods into a liquefied state, or as valuable shale oil products.

It naturally follows, however, that the same oil shale might yield varying quantities and qualities of said shale oil products, largely dependent upon the manner in which the decomposition or destructive distillation of the oil shale is carried on, because any fixed or non-condensable gases formed are generated at the expense of the desired shale oil products.

Under former processes, in so far as I am aware, there has always been a large yield of fixed or permanent gases, owing to the extremely high retorting temperature requisite for decomposing lump shale, it being understood that the chemical and physical characteristics of oil shales are such as to render them very poor conductors of heat. As before stated, the permanent gases thus generated are formed at the expense of the desired oil, not only on account of the diminished yield of the condensable products but also because of the inferior quality of the resultant oil, which under such conditions contains a high percentage of unsaturated hydrocarbons instead of the desired stable hydrocarbon compounds of the saturated or paraffin series.

Also, there are many other objectionable features, under the methods or processes practised prior to my invention, some of which may be set forth briefly in that the oil yielded has not always been suitable for practical refining into commercial products, or that when even partially suitable the yield has only been in the nature of one condensed crude oil, as distinguished from fractional distillates, thus requiring the redistillation of the said crude shale oil into the different fractions requisite for making commercial products, that local over-heating and the cracking or decomposition of the shale oil itself constantly occurred, especially where any oily vapors happened to become condensed and were afterwards subjected to revaporization before escaping from the retort, and finally that the distillates have been produced in relatively minimum quantities but with maximum labor, time and general expense.

The primary aim of mv present invention has been to devise a process and apparatus for overcoming all of the aforementioned objectionable features, in obtaining shale oil products as aforesaid, by an economical and efficient method. However, as these and other objects and advantages will be so clearly apparent, as incidental to the following disclosure, it would serve no useful purpose to further enlarge on the same initially, but it may not be amiss at this point to berifly state the broader embodiment of the invention as follows:—

In the initial steps, a mixture of finely divided, ground, or pulverized oil shale and high boiling point oil, or other appropriate and analogously functioning liquid, are caused to flow through a pipe coil retort and, while flowing therethrough, this mixture is heated to the required temperature for the proper vaporization of the vaporizable constituents of the oil shale, and this mixture may be thus retorted with or without the addition of, although preferably as associated with, a suitably introduced continuous stream of either steam or permanent gas, or both, or their equivalents if any. Subsequently, the vapors arising during this or any later steps of the process are conducted through suitable liquefying steps. The object of mixing high boiling point oil with the finely comminuted oil shale is that the former serves as a carrying or vehicle

medium for the latter, and the object of employing a pipe coil retort is that the small diameter of the pipe coil not only provides for a continuous flow of the mixture in a stream of comparatively or relatively small cross-sectional area, whereby it is effectively heated in a shortened length of travel, but the small diameter of the pipe coil also allows the mixture to traverse its heating zone at a high velocity, thereby avoiding the aforesaid objectionable features of local overheating and cracking, which also are factors to be taken into serious consideration. The object of introducing permanent gas into the mixture is to provide, or saturate the internal heating zone with, an excess of permanent hydrocarbon gas, thereby lessening the tendency to form fixed gases from the oil shale when heated, and the object of introducing live steam into the mixture is primarily for the purpose of assisting in circulating the mixture through the pipe coil retort. Also, it may be further stated that the oily vapors given off by the oil shale may be condensed by fractional cooling, into oil fractions which are suitable for refining into commercial products, in the one operation or series of steps, as distinguished from subsequent treatment for separation into the desired oil fractions, although the vapors may be liquefied in any other suitable way.

Supplementing these prefacing remarks, the true merits of the process can perhaps be better emphasized in narrative form and concurrently with a description of an efficient system or apparatus for carrying forward the steps thereof. To this end, therefore, reference will now be had to the accompanying drawings, illustrating certain practical embodiments of such a system, although it is to be understood that I do not restrict myself to the employment of all of the details thereof exactly as disclosed.

In these drawings, the single figure is a diagrammatic view illustrating one such system, which view is partly in elevation and partly in vertical section, while some of the obvious elements are simply shown conventionally.

In the initial steps of the process, the pulverized or finely divided oil shale may be fed, by a chuteway or feed conduit, from a storage bin 1 to a hopper or feeder receptacle 2, which latter may provide a tubular discharge spout 3, containing a screw conveyer, in communication with a main conduit section 4 between the ends thereof, for supplying the said conduit section 4 with a regulated forced feed supply of the pulverized shale.

One portion of the conduit section 4 is in communication with a supply of any appropriate liquid, serving as a carrying medium or an entraining fluid vehicle for the pulverized shale, which liquid is preferably a high boiling point hydrocarbon oil, contained in an oil storage tank 6, while the other portion of the conduit 4 is coupled up with a pump 5 which supplies a mixing chamber 8, by way of the pipe connection 7, with a continuous feed of pulverized shale and the high boiling point oil in desired proportions.

A branch conduit 11—12, having a pump 9 in its line, leads from a permanent hydrocarbon gas supply tank 10 to the mixing chamber 8, for supplying the latter, if desired, and hence the other contents thereof with a continuous stream of the permanent gas.

Upon leaving the mixing chamber 8, the pulverized shale and high boiling point oil, as well as the permanent gas if the latter be employed as is preferred, then passes through the main conduit sections 13—15 and to and through the retorting zone. This retorting zone is preferably provided for by a pipe coil element 16 that is of relatively small or comparatively restricted cross-sectional area, say between approximately one to six inches inside diameter, for the reasons hereinbefore set forth.

However, before actually retorting the aforesaid mixture, the latter may also be supplied with a continuous stream of live steam, as is desired, by way of a steam pipe line 14 in communication with the main conduit sections 13—15 between the ends thereof.

For the sake of convenience and brevity in terms, the expression "oil vehicle," wherever herein appearing, is intended to be understood as referring to a high boiling point oil, and likewise the single word "shale" or the expression "oil shale" is intended to refer to the oil shales in a finely divided, ground, or pulverized state, when containing all or some of their locked up oily values, as distinguished from the finally spent shale or ash. Also, the main conduit section 4 may be appropriately referred to as an "oil suction conduit," although in reality it is a suction conduit for both the shale and its entraining oil vehicle, and the conduit 11—12 may analogously be referred to as a "gas suction conduit," while the pumps 5 and 9, respectively, may be appropriately referred to as an "oil pump" and a "gas pump."

17 designates a suitable brick setting or furnace box providing the combustion chamber 18, enveloping the pipe coil retorting element 16, which may be fired either by an oil or other suitable burner associated with a burner opening 18^a, or by a grate fire as would be indicated by the fire box 18^b.

As before stated, either the permanent gas or the live steam or both of them are preferably introduced into entrained or entraining association with the shale and its oil vehicle, but whether they are or not the then existing mixture, which may now be ap-

propriately termed as the "charge," is conducted through the retorting pipe coil 16 and, being heated to the desired temperature, the shale releases its locked up volatilizable values, liberating them in oily vaporous form.

Inasmuch as my process is peculiarly adapted for the treatment of oil shales, in the production of shale oil therefrom, it is to be understood that the operations of the apparatus, such as the regulation of temperature and the travel of the shale charge through the heating zone, are governed in accordance with the nature and condition of the oil shale being treated, in order to obtain the most satisfactory results. To such ends, therefore, observations should be made and the aforesaid regulations adjusted as occasions may require. Also, it may be stated at this point that my process may be conducted under atmospheric pressure or any pressure above atmospheric pressure. The proper pressure is determinable from the capacity of the retorting pipe coil and its length, as the pressure required is that which is necessary to pump the prepared charge through the pipe retorting coil 16.

The gases of combustion finally pass from the chamber 18 of the furnace out through a stack 19, while the aforesaid flowing shale charge with its unlocked oily vapors pass from the coil retorting zone to and along a continuing conduit 20, which is supplied with a suitably attached indicating thermometer as designated at 21, and which conduit has a terminal outlet opening downwardly into a vapor separator or liberating zone.

This vapor separator may consist of a tank 22 providing a domeshaped top and a downwardly converging bottom chamber 22ª, between which are mounted suitable baffling elements 23. The baffling elements 23 may consist of the upper and the lower hollow upstanding cones and an intermediate inverted hollow cone that is truncated. A perforated coil 24 may be mounted in the conical bottom chamber 22ª, and is supplied with superheated steam by way of the pipe line 25.

The aforesaid heated mixture, as it passes from the conduit 20, is discharged directly over and upon the apex of the upper cone baffle 23. The downward baffled course of the now substantially spent shale and the oil vehicle therefor is clearly shown, and during this stage of the operations the oily vapors are completely liberated and separated from the charge.

The greater volume of the oily and other vapors, as well as the permanent gas, arise into the upper portion or collecting chamber of the vapor separator tank 22, and pass therefrom to a fractional air cooled condenser by way of the conduit 26, their separation from the shale and its oil vehicle having been aided and they being further assisted in leaving the tank 22 by the superheated steam introduced through the perforated coil 24, as will be obvious. Any of the vapors or permanent gases which may happen to be trapped within the upper and lower baffle cones 23, however, escape from the vapor separator tank 22, by way of the vertically disposed open-ended tubular arm 27ª of a branch pipe 27, and enter the conduit line 26 leading to any suitable liquefying means, but illustrated as a fractional air cooled condenser.

This fractional air cooled condenser consists of the shell 28, spaced open-ended air tubes or flues 29 mounted by header plates providing end air chambers, alternating downwardly and upwardly disposed overlapping baffle plates 30, and also upwardly disposed shallow partitioning walls 30ª, which latter are employed for the purpose of dividing the lower portion of the shell 28 into a series of base drip receiving compartments 31. In the drawings these base compartments 31 have been illustrated as being four in number, and they function as the drip receiving chambers or channels for certain of the fractionally condensed distillates, it being understood that the heavier or more easily condensable vapors are divisionally condensed as the vapors and gases are tortuously diverted by the baffles 30 in their encompassing passage around the air flues 29 from the left to the right of the condenser, while air is being drawn from the right to the left through the flues 29 and passes out by way of a stack 32, the suction therethrough being controlled by a damper 33.

These condensed shale oil fractions, dripping into the compartments 31 of the fractional air cooled condenser, flow by gravity along pipe line conduits 34, which extend through a water cooled cooling box 35, and finally flow to storage tanks, by way of conduits 36, being in the form of shale oil distillates suitable for refining into commercial products. Cold water enters the cooling box 35 through the pipe line 37 and leaves by the pipe line 38.

The permanent gas, lighter shale oil vapors and steam, which have not been condensed in the fractional air cooled condenser 28, leave the latter by way of the conduit 39 and enter a water cooled condenser 40. In this water cooled condenser, these remaining shale oil vapors, permanent gas and steam circulate around between the water tubes 41 thereof and are condensed, excepting of course the permanent gas, into lighter shale oil and water, both of which latter leave the condenser by the slightly upset conduit 42 leading to storage tanks, and this lighter shale oil is also in the form of a shale oil distillate that is suitable for refining into commercial products.

During this final step, the permanent hydrocarbon gas is conducted off from the condenser 40 by a connecting pipe line 43 and is conveyed back to the storage gas tank 10, by any suitable pipe line not shown, where it enters at 43ª to be used over again in successive operations.

Water enters the water cooled condenser 40 through the pipe line 44 and leaves by the pipe line 45.

The spent shale and its oil vehicle flow by gravity from the conical bottom chamber 22ª, of the vapor separator 22, through a pipe line 46 which discharges into a settling tank 47, and the pipe line 46 may provide a cooling jacket 46ª that may be supplied by cooling water through the pipe line 48, the outlet therefor being indicated by the pipe line 49.

The pipe line 46 may also be provided with a valvular control or cut-off 50, connected by suitable means 52 with a float 51 disposed within the separator tank 22 at a suitable position with reference to its bottom, the object of which is to maintain a level of the spent pulverized shale and the high boiling point oil in the conical bottom of the vapor separator tank 22.

The cooled and discharged spent shale settles to the bottom of the settling tank 47, and may be removed in any suitable way, or even by a sediment cock line not shown, while the high boiling point oil is pumped from the settling tank 47 back to the oil vehicle storage supply tank 6, by way of the pipe line 53—55 and a pump 54 included therein, to be used over again in successive operations.

From the foregoing complete description, it is believed that my improved process, and a satisfactory system for carrying forward the steps thereof, will be clearly understood, and it may finally be observed that there are three stages of operation, as it were, the treating and retorting stage, the vapor separation stage, and the condensing stage.

For the most satisfactory results as a whole, I prefer to carry out my process as a continuous method embodying the particular nature of these stages in a conjointly coacting manner as herein set forth, yet the novel features of the initial treating and retorting stage could be satisfactorily employed in association with final condensing methods other than herein disclosed. Also, it is not altogether unlikely that some other specific form of vapor separating tank could likewise be satisfactorily employed.

It is to be understood, therefore, that I do not wish to unnecessarily limit myself, viewed from various aspects, excepting in respect of the terms of the ensuing claims, equivalent features thereof, and as fairly interpreted in the light of the specification if necessary.

What I do claim as new and patentable is:—

1. The process of producing shale oil, which includes the steps of causing a properly proportioned charge of finely divided oil shale and an entraining high boiling point oil to flow in a stream of restricted cross-sectional area through an analogously restricted retorting zone, supplying heat to said retorting zone of an intensity to liberate the desired values of said shale in the form of oily vapors, and subsequently liquefying said vapors as separated from said shale.

2. The process of producing shale oil, which includes the steps of causing a charge of finely divided oil shale and an entraining high boiling point oil to flow in a stream of restricted cross-sectional area through an analogously restricted retorting zone, supplying a suitable charge of permanent gas to said oil shale charge before entering said retorting zone, supplying heat to said retorting zone of an intensity to liberate the desired values of said shale in the form of oily vapors, and subsequently liquefying said vapors as separated from said shale.

3. The process of producing shale oil, which includes the steps of causing a charge of finely divided oil shale and an entraining high boiling point oil to flow in a stream of restricted cross-sectional area through an analogously restricted retorting zone, supplying suitable charges of both permanent gas and live steam to said oil shale charge before entering said retorting zone, supplying heat to said retorting zone of an intensity to liberate the desired values of said shale in the form of oily vapors, and subsequently liquefying said vapors as separated from said shale.

4. The process of producing shale oil, which includes the steps of causing a properly proportioned charge of finely divided oil shale and an entraining high boiling point oil to flow through a retorting zone of winding disposition and of restricted cross-sectional area, supplying a stream of permanent gas to the aforesaid charge, supplying heat to said retorting zone of an intensity to liberate the desired values of said shale in the form of oily vapors, and subsequently liquefying said vapors as separated from said shale.

5. The process of producing shale oil, which includes the steps of causing a properly proportioned charge of finely divided oil shale and an entraining high boiling point oil to flow through a retorting zone of winding disposition and of restricted cross-sectional area, supplying suitable streams of both permanent gas and live steam to the aforesaid charge, supplying heat to said retorting zone of an intensity to properly liberate the desired values of said shale in the form of oily vapors, and

subsequently liquefying said vapors as separated from said shale.

6. The process of producing shale oil, which includes the steps of causing a charge of finely divided oil shale and an entraining high boiling point oil to flow through a retorting zone of restricted cross-sectional area, supplying heat to said retorting zone of an intensity to properly release the volatile values of said shale in the form of oily vapors, discharging the retorted charge in a continuous stream within a separator zone, introducing superheated steam into said separator zone below said discharging stream, and conveying off from said separator zone the liberated oily vapors in volume separately of said high boiling point oil and the now spent shale charge.

7. The process of producing shale oil, which includes the steps of causing a proportionate mixture of finely divided oil shale and an entraining high boiling point oil to flow through a retorting zone of winding disposition and of restricted cross-sectional area, supplying suitable streams of both permanent gas and live steam to the aforesaid mixture, supplying heat to said retorting zone of an intensity to properly release the volatile values of said shale in the form of oily vapors, discharging the retorted charge in a continuous stream within a separator zone, introducing superheated steam into said separator zone below said discharging stream, conveying off from said separator zone the permanent gas and liberated oily vapors in volume separately of said high boiling point oil and the now spent shale, conjointly conducting off said high boiling point oil and the spent shale for removal and separation purposes, liquefying said oily vapors, and conducting said high boiling point oil, after separation from said spent shale, back to its initial source of supply for cyclical reuse.

8. In apparatus for procuring shale oil from oil shale, the combination of a main conduit including a retorting pipe coil and a suction conduit in advance thereof for flowing the charge to be retorted through said coil, a tank for containing a supply of high boiling point oil in communication with said suction conduit, means for feeding finely divided oil shale to said suction conduit, a tank for containing a supply of permanent gas in suctional communication with said main conduit and a steam supply line for said main conduit in advance of said coil, means for heating said coil to such a degree as to properly release the desired values of said shale in the form of oily vapors, a separator vessel for receiving the discharge from said coil, a vapor conduit for the liberated vapors and said permanent gas and a residue conduit for the spent shale and high boiling point oil leading from said separator vessel, means for liquefying the vapors conducted through said vapor conduit as desired, a conduit for returning said permanent gas to said gas tank, and a conduit for returning said high boiling point oil to said oil tank.

In testimony whereof, I affix my signature.

WILLIAM K. KIRBY.