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J. B. JENSON

PROCESS FOR TREATING OIL SHALE

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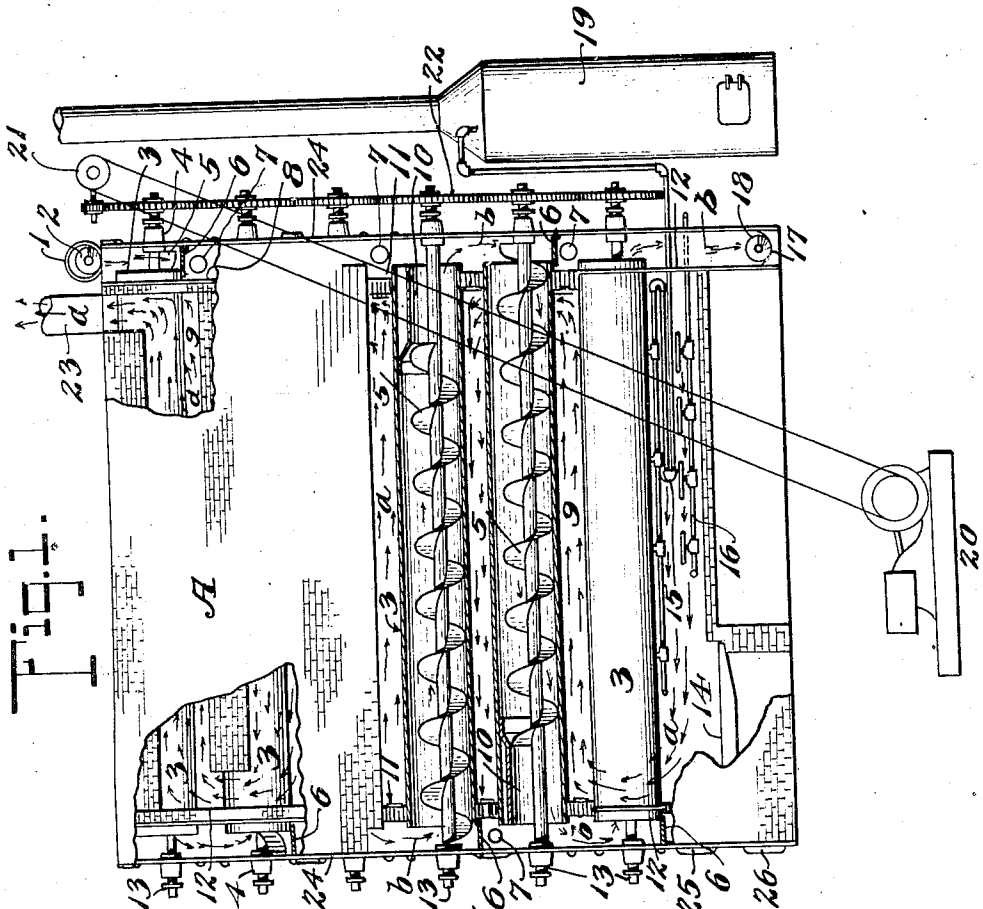

Fig. 1.

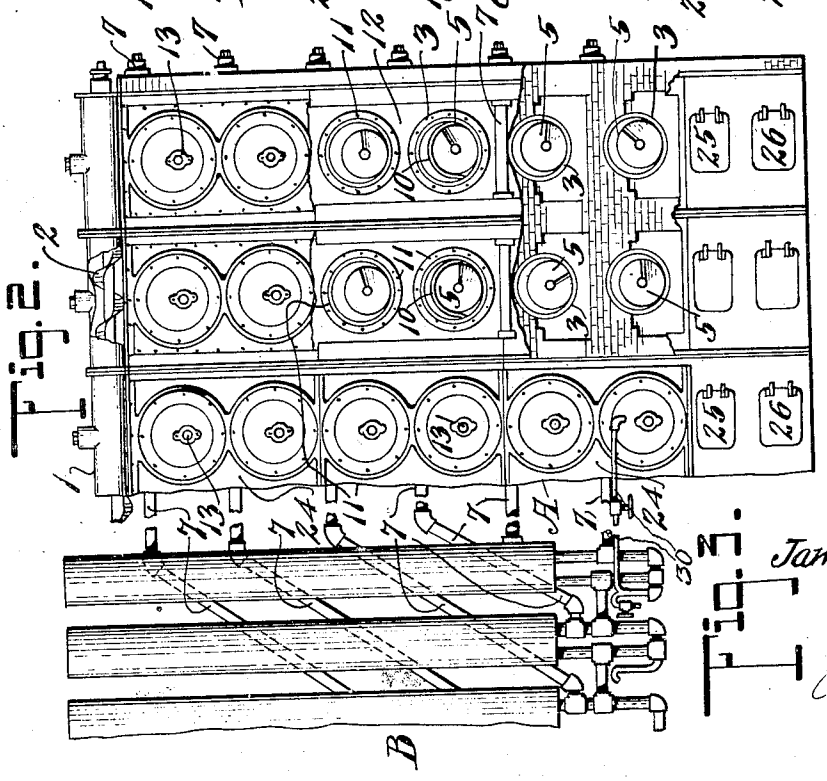

Fig. 2.

Fig. 3.

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UNITED STATES PATENT OFFICE.

JAMES B. JENSON, OF SALT LAKE CITY, UTAH.

PROCESS FOR TREATING OIL SHALE.

Application filed September 18, 1919. Serial No. 324,280.

To all whom it may concern:

Be it known that I, JAMES B. JENSON, a citizen of the United States, residing at Salt Lake City, in the county of Salt Lake and State of Utah, have invented certain new and useful Improvements in Processes for Treating Oil Shale, of which the following is a specification.

In extracting the oil from oil bearing shales under the present methods, three serious difficulties are encountered. The first is the fluxing of the shale within the retort, when high grade massive shale is being treated; the second is the formation of a very large proportion of unsaturated hydrocarbons which form a complex mass and makes refining difficult, as well as also causing high refining loss, and the third is the decomposing of the lighter gases produced at low temperature by bringing them into contact with portions of the retort or other gases of a higher temperature than that at which they were produced. The fluxing of the shale under treatment, is caused by gases from the hotter portions of the retort coming in contact with the colder shales which are being charged into the retort, and said gases condensing; thereby making an oily, viscid mass, which, when it reaches the heat zones and the partially volatilized oils, and is again vaporized leaves a solid mass consisting of the broken pieces of shale cemented together by fixed carbon or coke, often found so hard that it is necessary to use steel bars to dislodge it. This necessarily causes additional expense and the delay of shutting down the plant.

I have found that if a proper temperature is maintained within the retort and condensation prevented that fluxing is avoided. I have discovered and perfected a stage eduction process whereby the bituminous shale is treated in separate chambers, at predetermined temperatures for each chamber, for a sufficient length of time to educt such hydrocarbons (volatilize the oil content) as may be volatilized at that particular temperature and while this step in my process is being carried out, I withdraw the gas produced by this particular chamber and until the eduction has been completed I then carry the material under treatment, by gravity, mechanically or otherwise into a succeeding chamber where it is again treated at a higher temperature, for further eduction or volatilization, and I again draw off the gas produced in the second chamber as it is educed. The same material is again subjected to volatilization in the third, fourth or even more separate chambers and the withdrawal of the particular gases therefrom. The kind, form and number of chambers used, the material from which constructed, degrees of heat of the respective chambers, as well as the variation in the temperature between the coolest and hottest chamber, depend on the grade and number of products desired. I have found that with our western shales not less than three stages are best and I prefer to begin operation with the first chamber at a temperature of 100° F. and for the eduction and volatilization of the heavy hydrocarbons such as paraffin and asphalt the temperature required for the hottest chamber may range from 900° to 1400° F. or more.

Inasmuch as the gases generated at each successive step of the process are withdrawn before the bituminous material passes into the next succeeding chamber of a higher temperature there is no possibility of fluxing taking place, and it is found in actual operation that the shale is at all times perfectly dry and dusty as soon as the water, usually found in such shales when first dug out of the earth, is driven off. I use the term "stage eduction" to particularly differentiate between my process and that of "zone vaporization" as described in some patents heretofore granted, and attempted to be carried out in some plants, as I have found that in the practice of "zone vaporization", it is impossible to prevent the mingling of the gases as produced in the adjacent successive zones of gradually increased temperatures. The zone demarkation is not practical because the gases can not be kept absolutely separate and during eduction or otherwise, when mingled or mixed more or less unsaturated hydrocarbons will be developed or formed; and in refining such eductions, more loss will occur from extra time and operations required and a smaller per cent of oil recovered, on account of the hotter gases of one zone circulating and coming in contact with the shale of colder zones, thereby depositing by condensation or otherwise, the heavy fluids upon the shale particles which, when they reach the hotter zone and these fluids are again volatilized the fixed carbon or coke is left; thereby cementing together the shale particles which is commonly known in shale treatment as

fluxing. This is entirely avoided in my process which I term "stage eduction".

The decomposition of the lighter gases is caused by subjecting them to a temperature above that at which they are formed either thru bringing them into contact with the hotter gases or hotter portions of the retort before being withdrawn.

I have found further, that if the gases as they are produced in the various chambers are immediately withdrawn and carried thru separate pipes to their condensers that by stage eduction I absolutely avoid the destruction or decomposition of gases produced at lower temperatures such as is the case when these lighter gases come in contact with the heavier gases produced at higher temperatures, as commonly practiced. I also find that on account of no decomposition taking place, I am able to produce an entirely fluid oil instead of the heavy greases which form at moderate temperatures by other processes. I also find that by condensing each gas separately, and not permitting it to intermingle with the gases produced at higher or lower temperatures, that I avoid almost entirely the complex unrefinable combinations resulting from the unsaturated hydrocarbons formed at different temperatures by other processes, thereby making it possible to refine perfectly at a loss of approximately 6% compared with approximately 24% refining loss by other processes.

The condensation of the heavier fluids on the particles of the shale and which cause the fluxing in other processes also has the effect of converting the heavier fluids into lighter fluids. To accomplish this in my process and also to be able to perfectly control the amount of condensation I carry this on outside of the retort in a condensing cylinder or chamber, the temperature of which I regulate in order to produce a predetermined gravity oil or fluid. Such fluid as is condensed within this chamber is conveyed back through the pipe 30 into the cylinder of highest temperature where it is again volatilized. By conveying the stream of condensed oil thus into the hot shale over a comparatively small area I am able to effect a perfect "cracking" or decomposition of the heavier fluid and convert it into a lighter fluid without causing any fluxing whatever, owing to the fact that the fluid does not become disseminated throughout the entire mass such as is the case in other processes where condensation takes place directly on the shale. By this arrangement, I can automatically produce fluid or oil of any desired gravity owing to the fact that it will continue to condense and return to the cylinder automatically until it has reached such gravity as will enable it to pass this condenser. By this operation I also remove a large percentage of fixed carbon which attaches to the spent shale and passes out of the eduction chamber, thereby making refining of the fluid much simpler and causing less fixed carbon to be deposited in the coking stills.

Altho the distillation may be performed dry or without the use of steam, I prefer to use superheated steam in the process:

First, to enable me to volatilize at a lower temperature.

Second, to increase the oil yield by releasing hydrogen atoms from the steam which combine with the carbon atoms in the material under treatment.

Third, for the prevention of decomposition of the iron contained in the retort.

Fourth, to facilitate uniform heating within the chamber.

I also find it advantageous especially when treating low grade shales to add a small percentage of the non-condensable gases which I also pass thru super-heating pipes in order that the gases may enter the chamber at a temperature as high as that at which eduction is being carried on within that chamber.

I prefer to operate at or under a slight vacuum but some bituminous material may be treated to advantage under pressure of one or more atmospheres. The steps of my process may be carried out by moving the material under treatment from one chamber to another wherein the oil content is volatilized or it may be equally as well carried out by moving the chamber, with its charge of material under treatment, from one position in the furnace to another where the chamber and contents may be subjected to the desired successive temperatures to volatilize the oil content at the temperatures ranging from 100 to 1400 or more degrees Fahrenheit, and wherein the gas may be withdrawn as educted and without allowing the gas produced at one position and temperature to mix with the gas educted at another temperature. I have shown in the drawings filed as a part of this application, a special form of furnace within which the steps of my process may be economically and efficiently carried out and in which Figure 1 is a side elevation, partly in section of said furnace.

Figure 2 is an end elevation of my furnace, parts cut away, and parts shown in section to show the interior construction. Figure 3 is a fragmentary view in elevation of a condenser system which I use in connection with my furnace and in which portions of my process may be carried out.

In the drawings I show the inlet feed cylinder as 1 with the screw conveyor 2 as smaller in diameter than the cylinder 1 and mounted eccentrically therein. A plurality of parallel horizontally disposed cylinders 3, are provided and secured one above the

other in parallel rows within a brick lined furnace A. A screw conveyor 5 is journalled for rotation eccentrically in each of said cylinders 3 upon bearings 4, which bearings 4 are secured in the ends 24 of said furnace A. The shafts of said screw conveyors 5 are suitably packed by the stuffing boxes 13 in said bearings 4 to prevent the escape of gases from the said furnace. Each of said screw conveyors 5 is smaller in diameter than its enclosing cylinder 3 with the object of forming a gas holding space between the material carried along by the screw 5 and the wall of the cylinder. A bracket shelf, taking the form of a chute 6, is provided at one end of each of said cylinders 3 and at alternate ends thereof in each vertical row to direct the material under treatment as it falls from one cylinder into the end of the next succeeding cylinder. A plurality of pipes 7 are secured transversely in said furnace to carry off the gas from said cylinders, and said pipes are connected with the condensers B which are conveniently mounted and within which the gas is condensed. A slot or a number of perforations are provided on the lower side of that portion of said pipe 7 which passes across or adjacent the open end of each cylinder 3 to receive the gas educed in that cylinder. A partial closure in the form of a sleeve 10 is secured eccentrically in the alternate end portions of cylinders 3 and the said screw conveyors are cut off or removed at that point in order to form a closure of material in the cylinder which closure will be deposited and formed by the screws piling up the material in said sleeve 10. A vertical metal partition 12, which is lined with fire brick, is provided and spaced from each of said ends, 24, of the furnace, and packing rings 11 are provided therein to prevent the escape of gas and allow the expansion and contraction of the cylinders 3. A grate 14 is provided in the lower part and at one end of said furnace upon which fuel is burned to provide heat for generating gas from the shale as it is treated. A steam generating boiler 19 is provided and a pipe 15 conveys supersteam generated therein under the lower ones or row of said cylinders 3. A screw conveyor 18 is mounted in the lower portion of said furnace A to carry away the gangue from the discharge hopper 17. Gear wheels 22 are secured on the shafts of said screws 5 the teeth of which intermesh and they are rotated by the belt 21 which is driven by the motor 20. Clean out doors 26 are provided for removing the fuel ashes, while the fuel is fed thru the doors 25.

The operation of my apparatus by which the steps of my process may be carried out is as follows:

The shale to be treated is crushed and fed into the cylinder 1, and by means of the screw conveyor 2 is carried into all of the upper ones of each vertical row or tier of cylinders 3. As the crushed shale, frequently called herein, (the material under treatment) is carried thru said cylinders 3 by their respective screw conveyors 5 it, (the material) is subjected to the heat of the burning fuel, as applied to and around the underside of the said cylinders 3, which fuel may be supplied on the grate 14 and thru the gas burners 27, the gas being supplied thru the pipes 28 which may lead from the non-condensable gases remaining after condensation in the condensers B. A space 9 is provided under and partially around each of said cylinders 3 thru which the heat may pass from the burning fuel on said grate 14 and burners 27, upwardly in a zigzag path thru the successive spaces 9, as shown by the arrows *a* alternating from end to end of the furnace and out thru the escape flue 23. As the material under treatment is carried thru each of said cylinders 3 by its respective screw conveyor 5 the material is directed by the chute 6 into the next succeeding one below, where the screw of that cylinder catches it, and said material is carried in the opposite direction, as shown by the arrows *b*, the screw of one cylinder being rotated in opposite direction to that of the one above or below it by said intermeshing gear wheels 22.

As the material is passed thru said cylinders 3 the oil content of the shale is volatilized and passes or flows as a gas out of that section of said furnace A thru the pipes 7 to the respective condensers B, as indicated by the arrows *c*. The space within each cylinder 3 between the material carried therein and the overhanging wall of the cylinder, which space is closed at one end by a bank of material deposited within said sleeve 10, forms individual gas receptacles which open into the under side of said pipes 7 thru the slot or perforations provided therein. In this way I keep the gas generated at a certain temperature from mingling with the gas generated at another temperature, also keeping the gas of one temperature from coming in contact with the shale receiving treatment at another temperature. As will be obvious the heat in the upper tier of cylinders 3 will volatilize some of the oil in the shale at the lowest temperature of the furnace and the gas will be carried off to one condenser thru the upper pipe 7. A portion of the oil remaining in this shale will be volatilized as said shale is drawn thru the cylinders in the second tier and the gas generated therein will be drawn or flow off thru the second pipe 7 to another condenser and continuing on down in succeeding horizontal tiers, the heavier oils will be subjected to the heat of the lowest tier of cylinders at a temperature of practically 1400° F. The condensate from any one or all of the con-

densers B may be returned for further volatilization thru the pipe 30 into the lowest and hottest cylinder 3.

In treating some bituminous and volatile material it may be found desirable to fill a receptacle with the material and then move the receptacle or chamber from one portion of the furnace wherein a low temperature is maintained, to another part of the furnace, where a higher temperature is maintained, to educe the volatile content of the material and draw off the gases generated at each temperature before moving to the position of a higher temperature.

Having thus described my process, and shown an apparatus within which the different steps may be carried out, I desire to secure by Letters Patent and claim:—

1. The process for treating oil shale to produce oil therefrom, which consists of subjecting the shale to various degrees of heat while it is passing through coacting individual chambers; condensing the vapors of each chamber in another separate chamber; again volatilizing the condensate of some of said separate chambers by bringing it into contact with the shale under treatment in the chamber of highest temperature to carry off with the spent shale any particles of fixed carbon or other solids resulting from the operation.

2. The process for treating oil shale which consists of subjecting the shale in separate chambers to varying degree of heat; leading off the vapors from each chamber and separately condensing the same to produce light oils; again volatilizing in a chamber of higher temperature the heavy oils by contact with shale to carry off fixed carbon on the shale gangue.

3. The process of treating oil shale which consists of subjecting the shale while in motion to heat in a plurality of chambers each of which has an increased temperature; separately condensing the vapors from each chamber to produce oil; treating the condensate from all of said chambers by contact with partially treated shale in a chamber of higher temperature to produce other oil vapors and to deposit carbon on the shale for removal therewith; and condensing the last mentioned oil vapors.

In testimony whereof I have affixed my signature.

JAMES B. JENSON.