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METHOD FOR WORKING OIL SHALES.
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To all whom it may concern:

Be it known that we, Wilson W. Hoover and Thomas E. Brown, citizens of the United States, and residents of the borough of Manhattan, in the city, county, and State of New York, have invented a certain new and useful Method for Working Oil Shales, of which the following is a specification.

Our invention relates more particularly to that class in which a sub-surface zone, permeable to a heating medium, is produced in a normally impermeable oil shale formation, access to which is gained by drilled wells and the bituminous material treated in situ, with a heating medium and products recovered through such wells.

In the present state of the art, the oil shale is quarried, mined, or isolated columns are exposed and enclosed for treatment, the material excavated in the process being subjected to surface distillation.

Oil shale is recognized by accepted authorities as “containing a great mass of partly bituminized vegetable matter which can be converted into oil by heat.” The oil thus derived is commercially recognized as petroleum and its products as petroleum products, their chemical composition being substantially the same.

Among other objects of our invention is to gain access to a sub-surface deposit of oil shale by drilling a series or group of contiguous wells of limited diameter in such proximity to each other as to enable the production in such deposit of a zone of fracture of a determinate area, through the medium of explosives introduced in such deposit through such wells, which zone shall thus be rendered permeable to a heating medium, also introduced therein through one or more of such wells and by the circulation of a heating medium therein to produce suitable temperatures for the treatment of the bituminous content of such zone, to effect the distillation, either collectively or selectively of the more volatile constituents of such content, the liquefaction of the heavier constituents and the recovery of the products through other wells of the group.

We will first describe our method:

Oil shale is normally of such a compact structure as to be impermeable to the circulation of a heating medium for the treatment of the material in situ, it is therefore necessary, in order to permit of such treatment of a sub-surface deposit, to first fracture the formation within the proposed zone of operation, sufficiently to permit of the free circulation, throughout such zone, of the vapor or gas employed as a heating medium.

In order to gain access to such sub-surface deposits we drill a series or group of contiguous wells, of limited diameter, similar to wells drilled for petroleum. The members of a series or group of wells are located in such proximity to each other, that the fractures produced, by explosive charges introduced into the deposit through one well and exploded therein, shall intercommunicate with those produced in like manner, in the adjacent wells, so that a system of such intercommunicating fractures shall be co-extensive with the area of the zone of fracture thus produced and such fractures by their number and extent shall be adapted to permit of the free circulation throughout the zone of the heating medium and of its exhaustion through any other member of the group.

The zone of fracture thus produced is limited and defined, on all sides, solely by the lines of fracture segregating it from the unfractured formation. The distance intervening between the respective members of a group of wells, will necessarily vary with the special characteristics of the formation involved, with the nature and amount of the explosive charges exploded within the zone of fracture and with other local conditions and where the latter are novel, must be determined by experiment. The individual wells of a group are drilled to an increasing depth from the inlet well to the outlet well for liquid products, to effect the drainage from the latter. Where the formation permits, the wells which are not required for treating material and recovering products need not be cased. The area of the zone of fracture thus to be produced, may be varied in area and thickness, or vertical section with the richness and thickness of the workable deposit, and may be produced at any depth below the surface sufficient to resist the pressures maintained in working the deposit. Two or more such zones may be produced within the same area, at different depths. When the necessary number of wells have been drilled, explosive charges are introduced into the zone through the respective wells of the group and are exploded therein as required, to produce a system of intercommunicating fractures.
throughout the zone, such as hereinbefore described. After the ground has been sufficiently fractured, all wells not required for treatment of material and recovery of products are then securely sealed in any suitable manner, as with cement, so that they will successfully resist the pressures which may be maintained in the treatment of the material in the zone. Each well is preferably provided with exhaust pipes, under valvular control; these pipes have connections, where steam is employed as a heating medium, to receive pressure gauges, and where a gas is employed, they are provided with temperature indicating devices, so that local pressure and temperature at each well may be observed.

In the drawing we show the source for generating the heating medium as a steam boiler and we preferably use steam as the heating medium, but we do not confine ourselves to any specific gas or vapor, but include within the purview of our invention any suitable gas or vapor, including furnace gases, which local conditions may render it profitable or expedient to employ as a heating medium. In the event a gas is used instead of a vapor, then in addition to pressure gauges, with which the boilers are equipped, it becomes necessary to also employ temperature indicating devices as well, in order to govern and control the pressure and temperature of the heating medium supply and of the zone of treatment. Such supply is always under valvular control both at the source and at the inlet well. The outlets for both vaporized and liquid products are also under valvular control in the field as well as at the condenser and tanks.

By the means thus employed the local pressure and temperature in the zone may not only be observed, but can be absolutely governed and controlled and may be varied or maintained at any given point, as desired, in order to carry on any of the respective operations, or to vary the same, herein described, to produce any of the results specified or claimed herein.

These operations include, but are not limited, to the conversion of the bituminous material into shale oil, or petroleum, the selective distillation of any of the more volatile constituents of such material, the progressive distillation of all, or a group of such constituents, in the order of their volatilization, the liquefaction of the heavier constituents and any other operation involved in the treatment of the material in situ, as may be profitable and practicable, which may be desired or developed by progress in this branch of the art.

The distillates produced by the treatment of the material are delivered, through a valve controlled pipe system connected with the exhaust well, to a suitable condensing apparatus, where the distillates may be separated from any foreign vapors or gases, recovered and stored for market or further treatment as the case may be.

The liquid products are pumped or blown from the pool at the outlet well and conveyed through a valve controlled pipe system connecting such well with suitable tanks and there recovered and stored.

We will now describe our apparatus which we preferably employ in the practice of our invention and which is shown in the drawing and adapted therefor, but we do not limit the practice of our method to the use of said apparatus, or the arrangement here shown, as any form of apparatus adapted therefor may be used in the practice thereof.

In the drawing similar reference characters indicate identical parts.

Referring to the drawing:

Fig. 1 is a perspective and sectional view showing the sub-surface material under treatment, and the surface plant and wells.

Fig. 2 is a section of the top of a well showing the installation of the exhaust pipe and pressure gauge, and method of sealing.

Referring to Fig. 1 F, is the fractured sub-surface zone of oil shale under treatment, B, the overlying unfractured rock and C, the surface material, A, A, A₁, A₂, A₃ are wells suitably spaced and forming a group covering the area of the zone under treatment. Only the tops of the wells not in section are indicated.

Any well such as A₁ may be used for the supply of a heating medium and any well such as A₂, for the exhaustion of the gases and distillates and any well such as A₃, for the extraction of the liquids produced by the heating medium.

After the zone of treatment has been properly fractured and rendered permeable as herein described, the tops of the wells A, are provided with exhaust pipes 24, and valves 25, arranged for the reception of pressure gauges 22, and are sealed with cement 23, or other material suited to withstand internal pressure as shown on a larger scale in Fig. 2.

The surface plant consists preferably of a battery of boilers 1, a liquid receiving tank 2, a condensate receiving tank 3, a condensing apparatus 4, and a gas receiver 5, all of which may be duplicated or multiplied in number as desired.

Boilers 1, are connected to well A₁, by pipe 6, with controlling valves 7, 8 and 9 and 12 pressure gauges 10 and 11, and tank 2 is connected to well A₂, by pipe 12, said pipe being extended down to or near the bottom of said well. Pipe 12 is provided with valves 13 and 14 near the top of well A₃ and near tank 2 respectively.

Condenser 4, is connected with the top of well A₃, by pipe 15, provided with valves 16 and 17. Condenser 4, which may be of any usual form, preferably a reservoir provided
with interior coils through which a cooling liquid is circulated, is provided with pipe and valve 18, by which the condensates may be drawn off into tank 3, and with pipe and valve 19, by which the non-condensible or fixed gases may be carried to gas receivers 5, whence said gases may be carried by pipe 20, to the furnace of boilers 1, and used as fuel. Tanks 2 and 3 are preferably provided with draw off valves at different levels and apparatus for the further handling and treatment of the products are omitted from the drawing as not being essential elements of our apparatus.

15 The operation is as follows:

The area to be worked having been selected, the wells are drilled at suitable distances apart and forming a group covering the area to be treated. The wells are preferably of gradually varying depth to provide for drainage of liquids toward the liquid extraction well A, which preferably should be somewhat deeper than the others to form a sump 21.

20 After the wells are drilled explosives are lowered into them and exploded in any usual manner. Preferably each well is exploded separately and successive charges are preferably exploded at various levels in each well, but the number and amount of the charges and the manner of their explosion may be varied to suit local conditions, such as the depth and nature of the particular rock to be treated and the nature and properties of the overlying materials, in order to produce intercommunicating cracks and fissures and render the zone permeable to the heating medium and avoid cracking and fissuring of and causing leakage to the surface through the superincumbent strata.

After the wells have been exploded and the zone rendered permeable, the surface plant having been installed, the pipe connections hereinafter described are made and the tops of all the wells are sealed.

Steam from the boilers 1, under governed control by means of valves 7, 8 and 9 and gauges 10 and 11, is admitted to well A', passes down said well and permeates the fractured zone through the intercommunicating fissures produced by explosion as before described, and gradually raises the fractured shale rock to the desired temperature.

55 During the heating up period the water from the condensation of steam may be removed from well A', through pipe 12, by pumping until a sufficient pressure is reached to force said water to the surface.

60 When the desired temperature and corresponding pressure is reached the lighter constituents of the shale rock which volatilize are exhausted through well A', pass by pipe 15, controlled by valves 16 and 17, to condenser 4, from which the condensates are delivered to tank 3, and the fixed gases which will not condense are delivered to receiver 5.

The liquid products which are melted out of the shale rock accumulate in sump 21, and are forced up through pipe 12, by the internal pressure, and may be discharged into tank 2, at will and the flow controlled by means of valves 13 and 14.

The liquid accumulated in tanks 2 and 3, may be separated therein by gravity. Any water of condensation may be drawn off from the bottom of said tanks and the accumulated oils may be conveyed away in any suitable manner and subjected to any other refining desired.

The exhaust pipes 24, and valves 25, are very useful in determining the conditions in various portions of the zone. The pressure may be determined by the gauges 22, and samples of the gases may be taken out and analyzed and thus the conditions of pressure and temperature and the degree of permeability in various parts of the zone may be determined.

By means of the steam and outlet valves and gauges shown the temperature and pressure in the zone under treatment are under governed control and may be maintained at any point desired or may be gradually varied to produce fractional distillation in situ, as before described.

Having thus specified, shown and described the same, we claim as novel and our invention:

The hereinbefore described method of working oil shales which consists in gaining access to a determinate zone of any desired area, in a sub-surface deposit of oil shale, by drilling a group of contiguous wells, suitable in number, proximity and depth for the purposes hereinafter set forth, in the introduction, through the wells, into such zone, of charges of explosives, in exploding the same, in thereby so fracturing the formation in such zone as to produce a series of intercommunicating fractures throughout the zone which shall render the same permeable to a heating medium, in introducing a heating medium into the zone of fracture through a member of the group of wells, all wells not required for the treatment of material and recovery of products being first securely sealed, in circulating the heating medium through said zone, in treating the bituminous material therewith, in thereby converting such material into oil and in recovering the products through other members of the group.

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