Aug. 9, 1932. L. RANNEY ET AL 1,870,869

METHOD AND MEANS FOR DEVELOPING IMPERMEABLE BARRIERS IN POROUS MEDIA

Filed Aug. 23, 1929 3 Sheets-Sheet 1

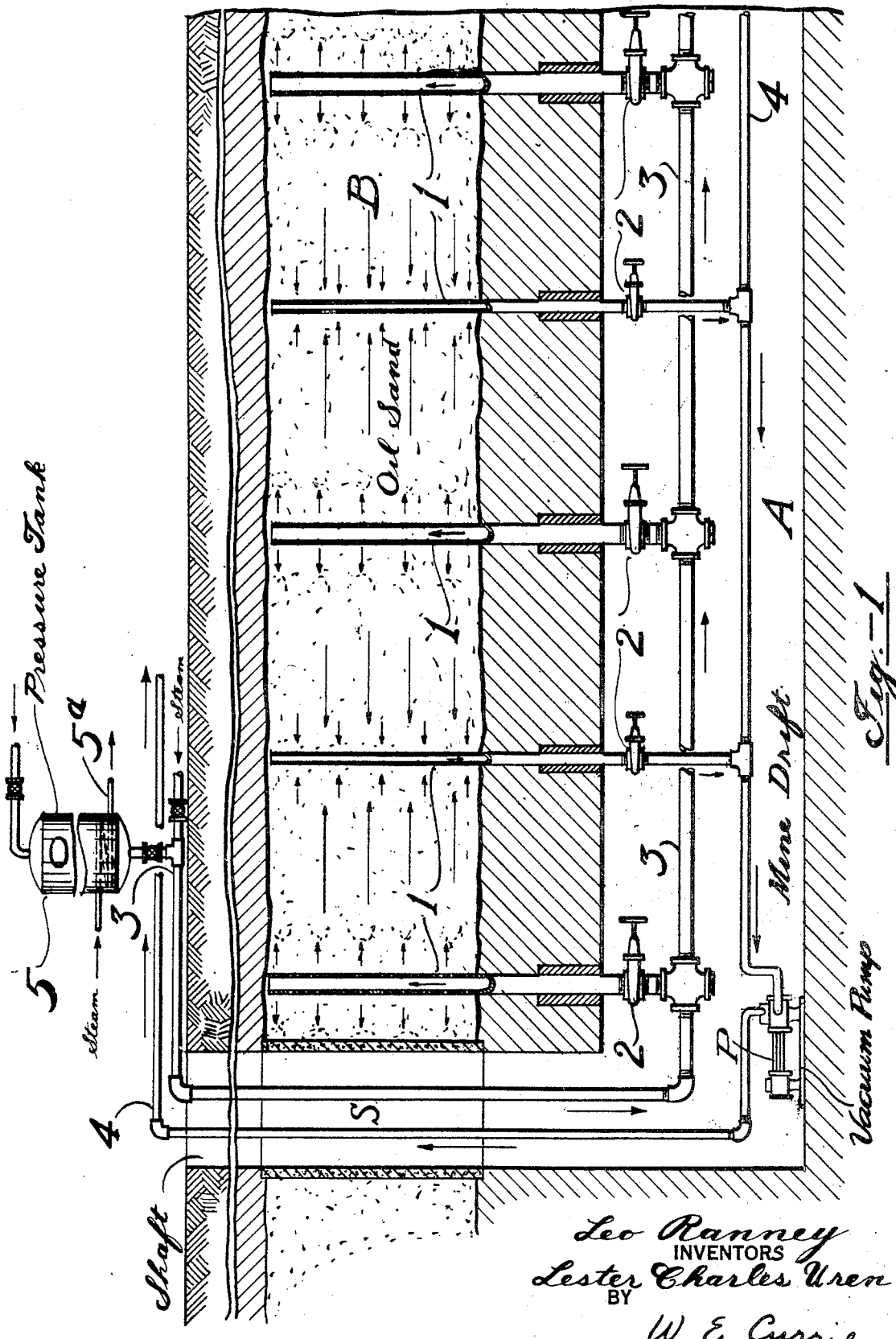


Fig. 1

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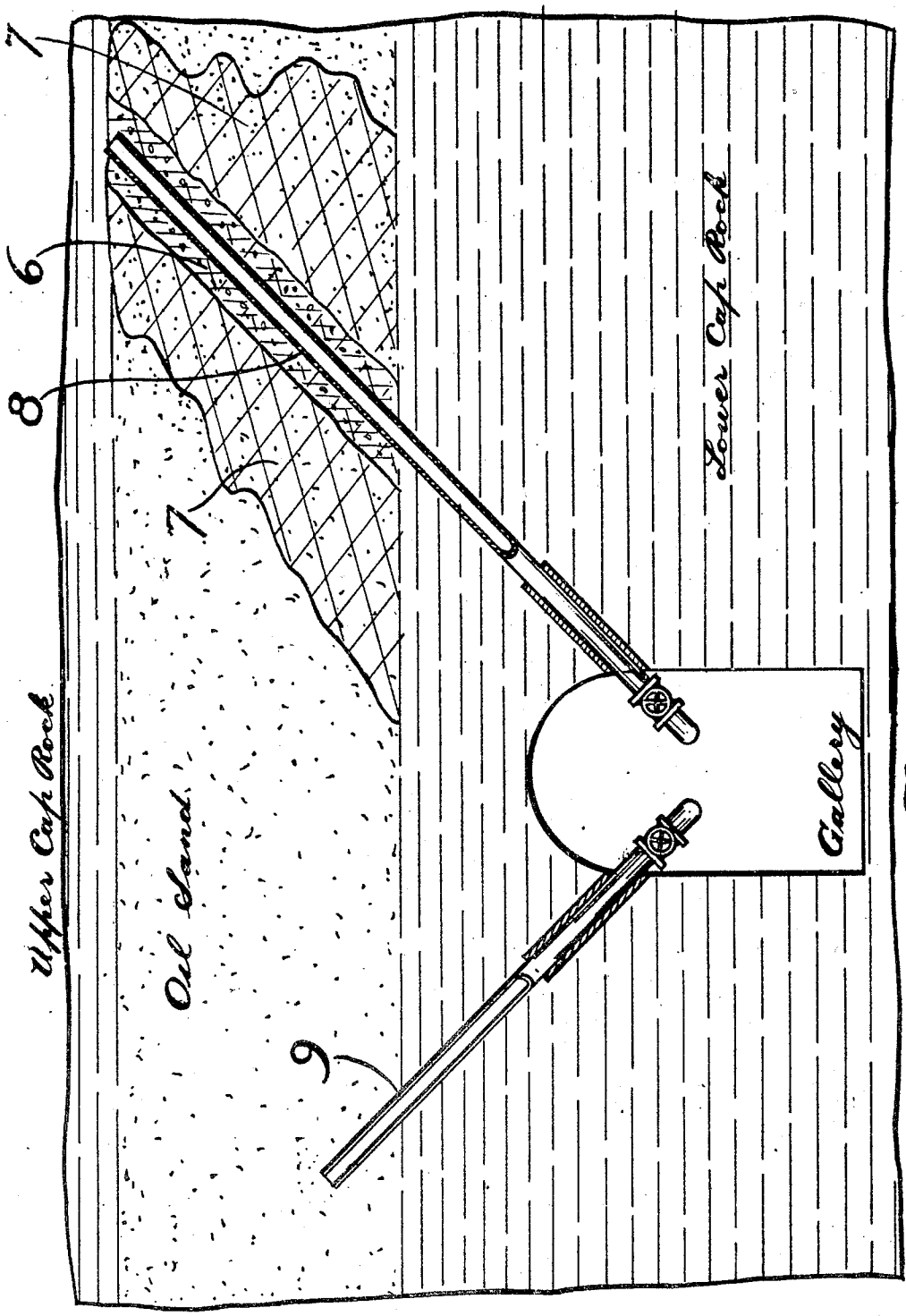


Fig. 2

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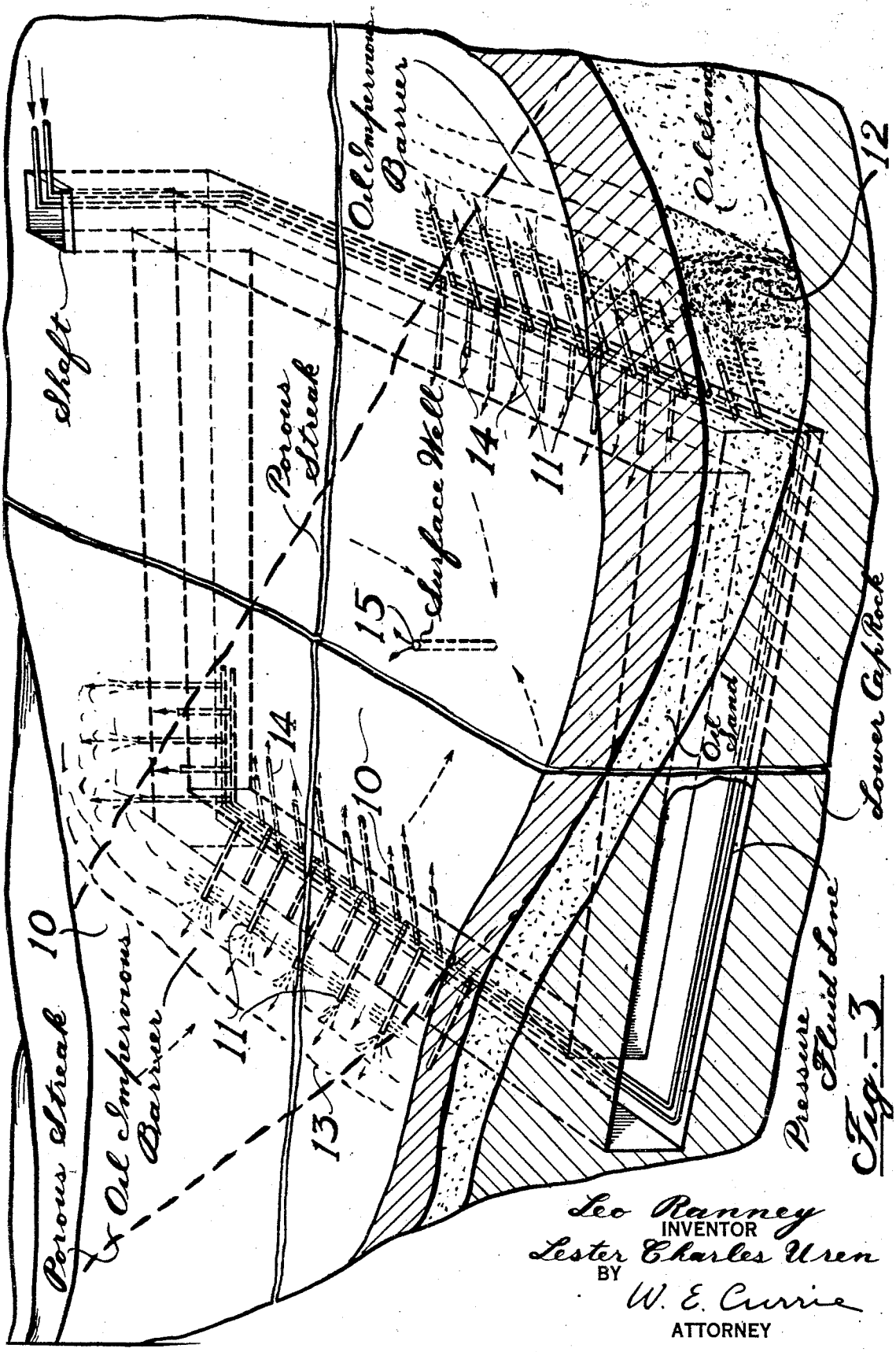


Fig. 3

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UNITED STATES PATENT OFFICE

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METHOD AND MEANS FOR DEVELOPING IMPERMEABLE BARRIERS IN POROUS MEDIA

Application filed August 23, 1929. Serial No. 387,841.

This invention relates to the formation of zones of cementation in oil and gas-producing sands, designed to confine oil, gas and water saturating the pore space of said sand within specified boundaries, or to prevent flow of fluids through the sand from one property or one part of a property to another. While the method may be successfully applied through a series of wells drilled from the surface, it is especially useful and may be applied with particular facility through bore holes drilled from mine openings.

In applying the method through mine bore holes, a mine gallery or drift installation is utilized, for example, of the general type described and claimed in United States Patents Nos. 1,634,235 and 1,634,236, granted to Leo Ranney on June 28, 1927. As described in these patents, a mine shaft is sunk to the level of the oil sand and galleries are driven adjacent to the sand, in the upper or lower cap rock. Holes are then drilled from the galleries into the sand, in which pipes carrying valves are sealed, forming "mine wells" for the collection of oil, or for the introduction of oil-expelling media.

The invention will be fully understood from the folowing description read in connection with the accompanying drawings, in which:

Fig. 1 is a diagrammatic vertical longitudinal section showing a series of mine wells penetrating a stratum of oil sand above a mine drift;

Fig. 2 is a transverse vertical section of two bore holes drilled from opposite sides of the drift, and illustrating the form of an impermeable barrier across the oil sand, resulting from application of the present process; and

Fig. 3 is a perspective view showing the application of the invention to a fluid drive.

Referring to Fig. 1, a series of mine wells drilled from a mine drift A to penetrate an oil-bearing sand B, are shown. Access to the drift is obtained through a shaft S of usual construction. The mine wells are lined with metal tubes, 1, sealed in the rock intervening between the mine drift and the oil sand, and perforated where they are in contact with the sand. Within the drift, each of these tubes is connected through a valve, 2, to either of two pipe-lines, one of which, 3, carries a fluid under pressure, of the nature of molten paraffin, molten asphalt or molten sulphur, a solution of some chemical reagent or a precipitating gas or liquid, or other substance appropriate for closing the pores of an oil sand in the manner described below; while the other, 4, is a vacuum line communicating with a suction pump, P. Prior to their use for these purposes, either or both lines may be used to deliver steam under pressure into the oil sands, through the mine wells. Preferably the tubes 1 extend through the oil bearing sand for a distance such that the sand will be subjected to the heat of the steam substantially from the lower to the upper cap rock and the pore closing material will penetrate from the lower to the upper cap rock.

As indicated in the foregoing paragraph, a variety of different substances may be used in forming the barrier within the sand pores, and the method to be followed in introducing the material, and in controlling the mine wells during its introduction, will vary somewhat with the nature of the substance used. In the use of certain of the media suggested for filling the sand pores, it is first necessary to heat the oil sand to an appropriate elevated temperature. This is accomplished by circulating steam through the sand, connecting alternate mine wells with the steam supply, and encouraging flow to the intermediate wells connected with the vacuum line, as shown in Fig. 1. Circulation of steam must proceed for a considerable time, during which the sand pores will be gradually freed of oil and condensed water, so that live steam may enter. During the early stages of steam application, water will tend to condense to some extent in the mine wells and in the sands immediately about them, but if the steam lines are given a slight inclination in the direction of flow, this condensed fluid will drain off to a suitable trap, not shown in the drawings, placed at the end of the steam line. During later stages, steam will condense in the sand pores between the inlet and outlet wells, but

this condensed fluid will be forced by the steam pressure toward the outlet wells. If desired, after steam has flowed for a time in one direction through the sand, the connections with the steam supply and vacuum pump may be reversed, so that flow through the sand may be in the opposite direction. This practice permits of developing a somewhat higher average temperature in the sand.

When the temperature of the sand in the immediate vicinity of the outlet wells has reached a point somewhat above the minimum desired for proper application of the medium to be used in filling the sand pores, pipe 3 is disconnected from the steam supply and connection made with pressure tank, 5, containing a supply of the medium to be employed. Steam coils, 5*a*, are also provided within the pressure tank, as a means of heating the medium. To prevent undue loss of heat in transmission of the medium, pipe 3, may be covered with heat insulating material.

The medium employed for sealing the pores of the sand may conveniently be a crude paraffin having a melting point, generally, of less than 130° F. The sand between the mine wells is in this case heated to a temperature well in excess of 130°. A sufficient supply of paraffin is placed in pressure tank, 5, is converted into a molten condition by application of heat, and is then forced under steam pressure through pipe 3 and into the oil sand through the alternate mine wells connected therewith, flowing toward and eventually into the intermediate wells which are maintained under vacuum. Flow of molten paraffin through the oil sand under pressure, is continued for a time so that the entire cross-section of the sand along the line of mine wells, is saturated with it. Flow is then shut off by closing all valves, 2, and pipes 3 and 4 are drained. As the sands cool, the congealing point of the paraffin is reached and the sand pores will be completely filled with a solid wax.

Molten asphalt or sulphur may be used in a similar way, but materially higher temperature must be maintained in the case of sulphur. An alternative plan to that described above, consists in saturating the hot sand with an oil high in asphaltic content, and then forcing steam or hot compressed air through the oil until it is oxidized to an asphalt that will be solid at lower temperatures. In some cases a viscous oil forced into the sand will serve satisfactorily as a flow-obstructing agent.

When chemical reagents are employed, elevated temperatures may usually be dispensed with. The general procedure to be followed in this case, is that of first filling the sand pores with a water solution of a reagent which separates out solids tending to fill the sand pores on contact with a second precipitating reagent which is forced into the sands after the solution is in place. The precipitating reagent may be either in the form of a liquid or a gas. A variety of reagents are possible, but two are particularly preferred. These are, a solution of calcium hydroxide (hydrate of lime) which precipitates calcium carbonate on contact with carbon dioxide, and sodium silicate, which forms amorphous silica on contact with carbon dioxide.

When reagents of this character are employed, a supply of the particular solution to be used is placed in the pressure tank, 5, and forced with the aid of compressed air, or by pump pressure, through pipe 3, and into alternate mine wells, causing flow through the oil sand toward the intermediate mine wells, which may be conveniently maintained under vacuum, though this is not essential to the success of the method. Circulation of the solution continues until the sand in the vicinity of the line of mine wells is saturated with it. The solution spreads out laterally in the sand to some extent, as shown in Fig. 2, saturating a zone several feet in width and completely filling the sand cross-section. When this condition is attained, gaseous carbon dioxide is forced under pressure through pipe 3, into alternate mine wells. Gas flows with comparative freedom through water-saturated sands, and will quickly saturate a narrow zone, 6, extending from the inlet to the outlet wells. This zone of carbon dioxide-gas-saturated sand develops contact on each side, with the body of solution, 7, previously introduced, and by solution and diffusion, slowly permeates the mass of solution precipitating calcium carbonate or silica in accordance with the primary solution used. These substances are insoluble in water, and under favorable circumstances completely cement the pore spaces of the sand so that an impermeable barrier is formed.

This barrier may serve as the starting point for a water flood or gas-drive, with the purpose of displacing oil from the sand into other mine drifts equipped with drainage wells. As shown in Fig. 2, the impermeable barrier may be formed somewhat to one side of the mine drift, by inclining the mine wells 8 from the vertical, as shown. A second series of inclined mine wells, 9, drilled from the opposite side of the drift, affords a means of introducing flood-water or compressed air or gas for driving purposes.

In Fig. 3 we have illustrated an application of our invention to a fluid drive conducted upon a lease which has a diagonal porous streak 10 extending through it and beyond. This would serve as a vent for the pressure medium unless obstructed. Mine wells 11 are extended down into the oil sand at the diagonally opposite points indicated. A sealing agent of the type previously described is supplied through these wells, forming oil-impervious barriers 12 and 13

across the porous streak. When this barrier is formed, a fluid under pressure is forced into the sand from mine wells 14. This fluid drives the oil before it along lines converging to a surface well 15 or other central point of withdrawal. There is no objectionable escape of pressure fluid through the sealed porous streak.

It is evident that the same procedure is applicable to drives conducted from one border of the oil sand to the other as described in the United States Patent No. 1,722,679 granted to Leo Ranney on July 30, 1929, and in the pending application of Lester C. Uren, Serial No. 220,126 filed Sept. 17, 1927.

The extent of barrier which can be economically formed will depend on various factors, including of course, the price obtainable for the grade of oil to be recovered. In most cases a complete walling in of the lease would not be justifiable commercially, but the sealing of porous areas of limited extent is eminently practical.

It is apparent that the method of forming impermeable barriers in porous media may find a variety of other applications than the particular one described above, as for example, in sealing off fissures in mine openings or in reservoirs or embankments to prevent leakage or to prevent high-pressure gases or liquids from flowing through them. Various changes and alternative arrangements may be made within the scope of the appended claims, in which it is our intention to claim all novelty inherent in the invention, as broadly as the prior art permits.

We claim:

1. In a method of forming impermeable barriers in a sand stratum from a mine gallery, the improvement which comprises heating a section of the sand by causing flow of a heated fluid medium through the pores in the sand of the section from an inlet to an outlet opening communicating with the gallery, and then injecting a molten substance, caused to flow in like manner from the inlet to the outlet opening, and which on subsequent cooling, will solidify and seal the pores of the sand stratum.

2. Method according to claim 1, in which paraffin is the substance used.

3. The method of rendering a section of porous earth stratum impervious to fluid, which comprises forcing a liquid into horizontally spaced portions of the section under greater than atmospheric pressure, applying sufficient suction to the section between the portions to draw the liquid through the section to form a continuous body of the liquid throughout the section, and introducing a fluid into the section adapted to cooperate with the liquid to form an impervious barrier in the interstices of the material of the section.

4. The method of forming an impermeable barrier from the upper to the lower cap rock in a given section of porous earth stratum, which comprises introducing under pressure a hot liquid material capable of solidifying when cooled to the natural temperature of the stratum into the material of the stratum at a plurality of levels in the vertical plane of the section and at spaced intervals horizontally of the section, and applying suction at spaced intervals in the section to draw the material through the stratum in quantities sufficient to form a continuous body of the material in the section from the upper to the lower cap rock.

5. The method of rendering a section of porous earth stratum impervious to fluid, which comprises forcing heating fluid into horizontally spaced portions of the section under greater than atmospheric pressure, applying sufficient suction to the section between the portions to draw the heating fluid through the section until the section is heated to a predetermined temperature, forcing melted material having a melting point below the temperature of the heated section into the section, and drawing the melted material through the section by suction to replace the heating fluid.

6. The method of rendering a section of porous earth stratum impervious to fluid, which comprises forcing heating fluid into horizontally spaced portions of the section under greater than atmospheric pressure, applying sufficient suction to the section between the portions to draw the heating fluid through the section, reversing the flow of heating fluid through the section until the section is heated to a predetermined temperature, forcing melted material having a melting point below the temperature of the heated section into the section, and drawing the melted material through the section by suction to replace the heating fluid.

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