July 25, 1933. S. N. KARRICK 1,919,636

SYSTEM OF MINING OIL SHALES

Filed March 5, 1930 5 Sheets-Sheet 1

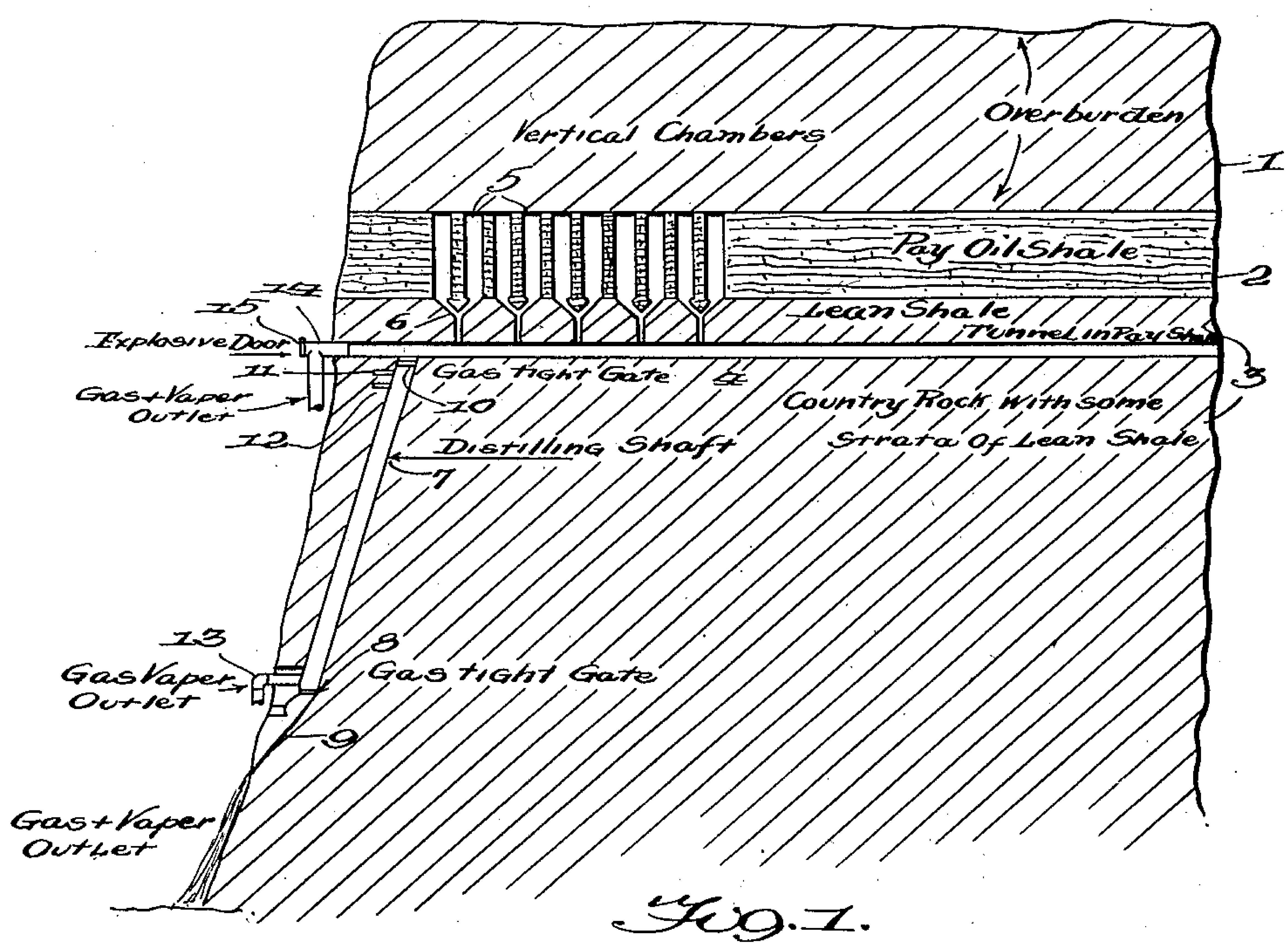

Fig. 1.

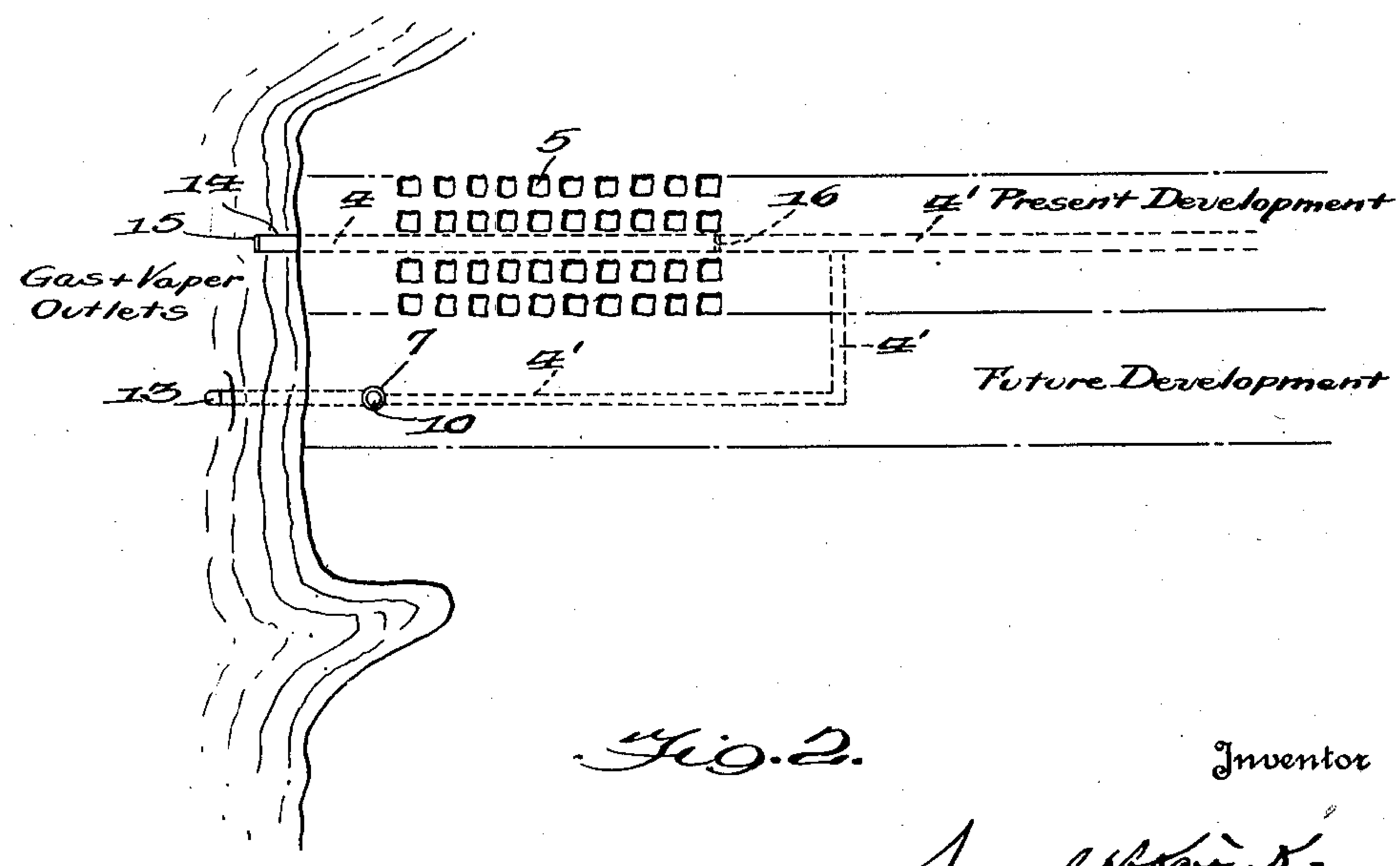

Fig. 2.

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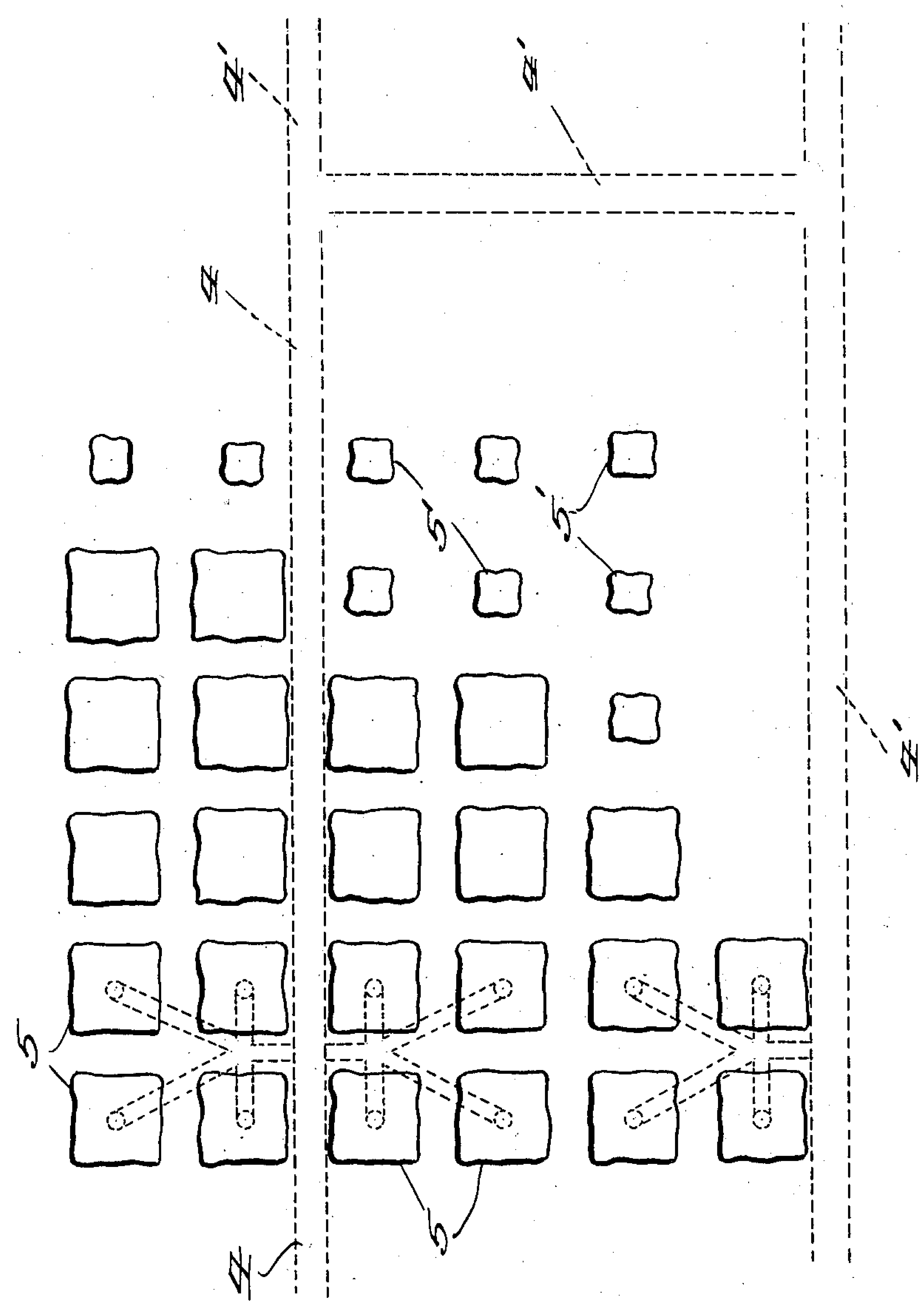
Fig. 3.



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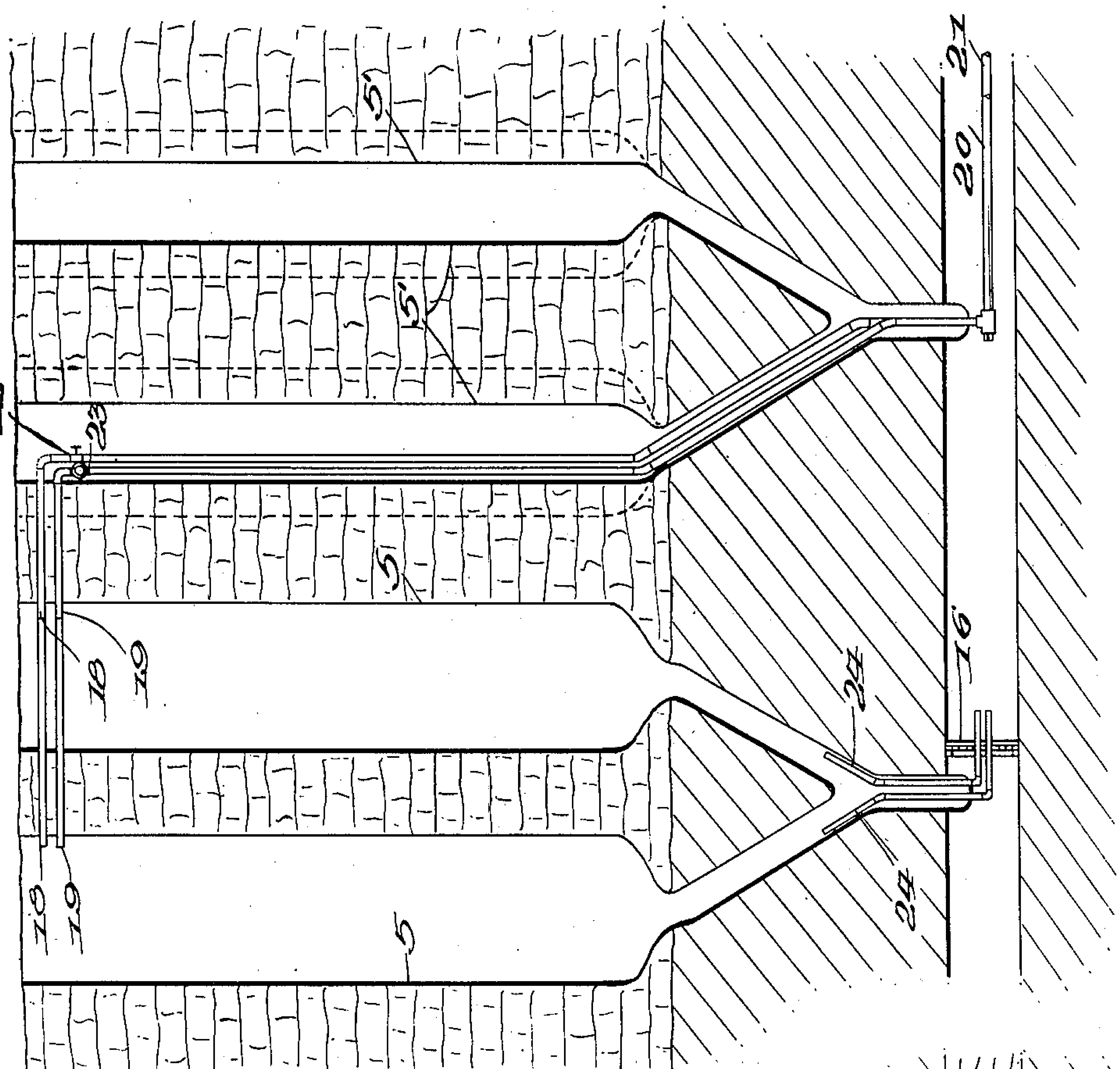

Fig. 5.

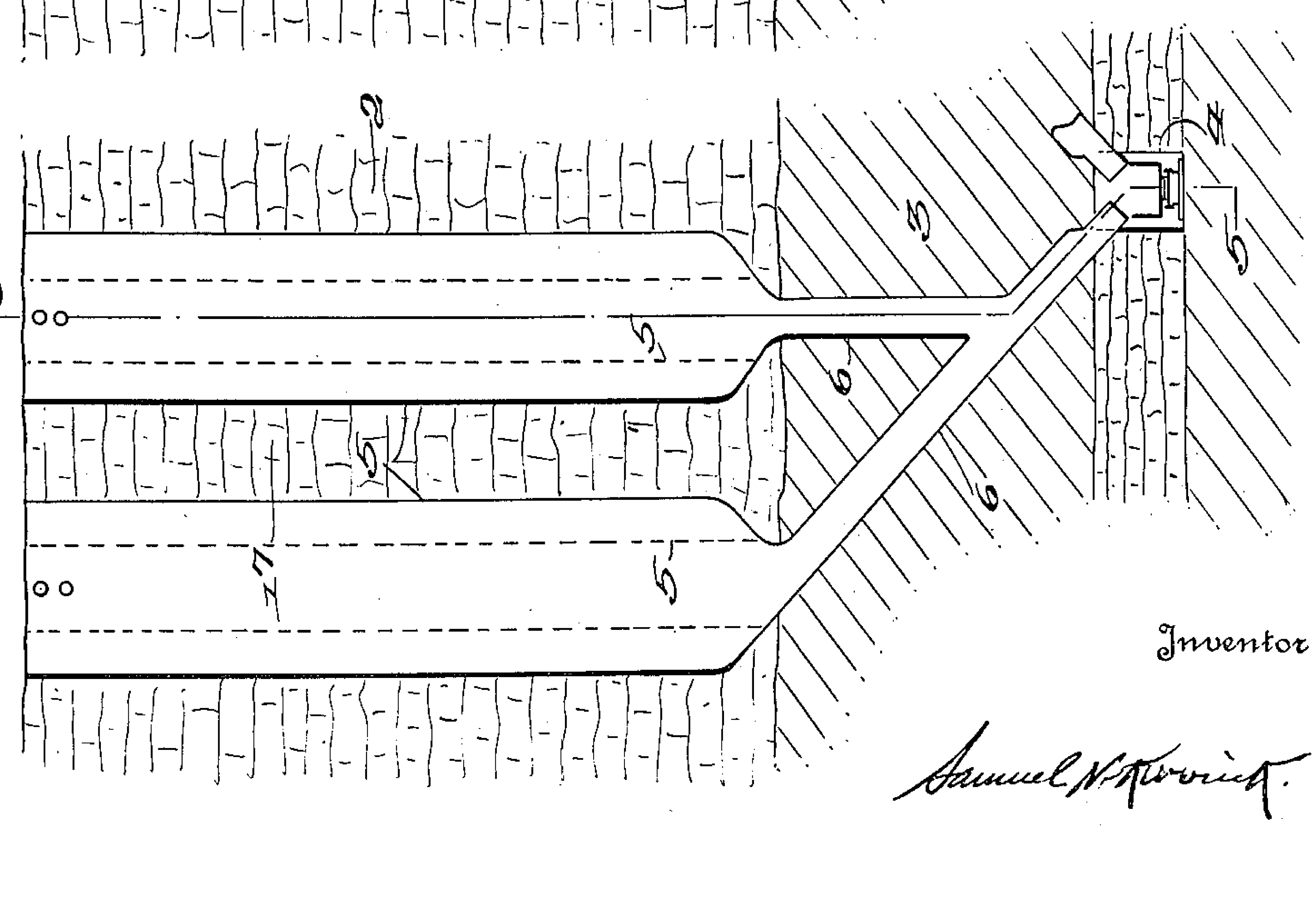

Fig. 4.

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Fig. 6.

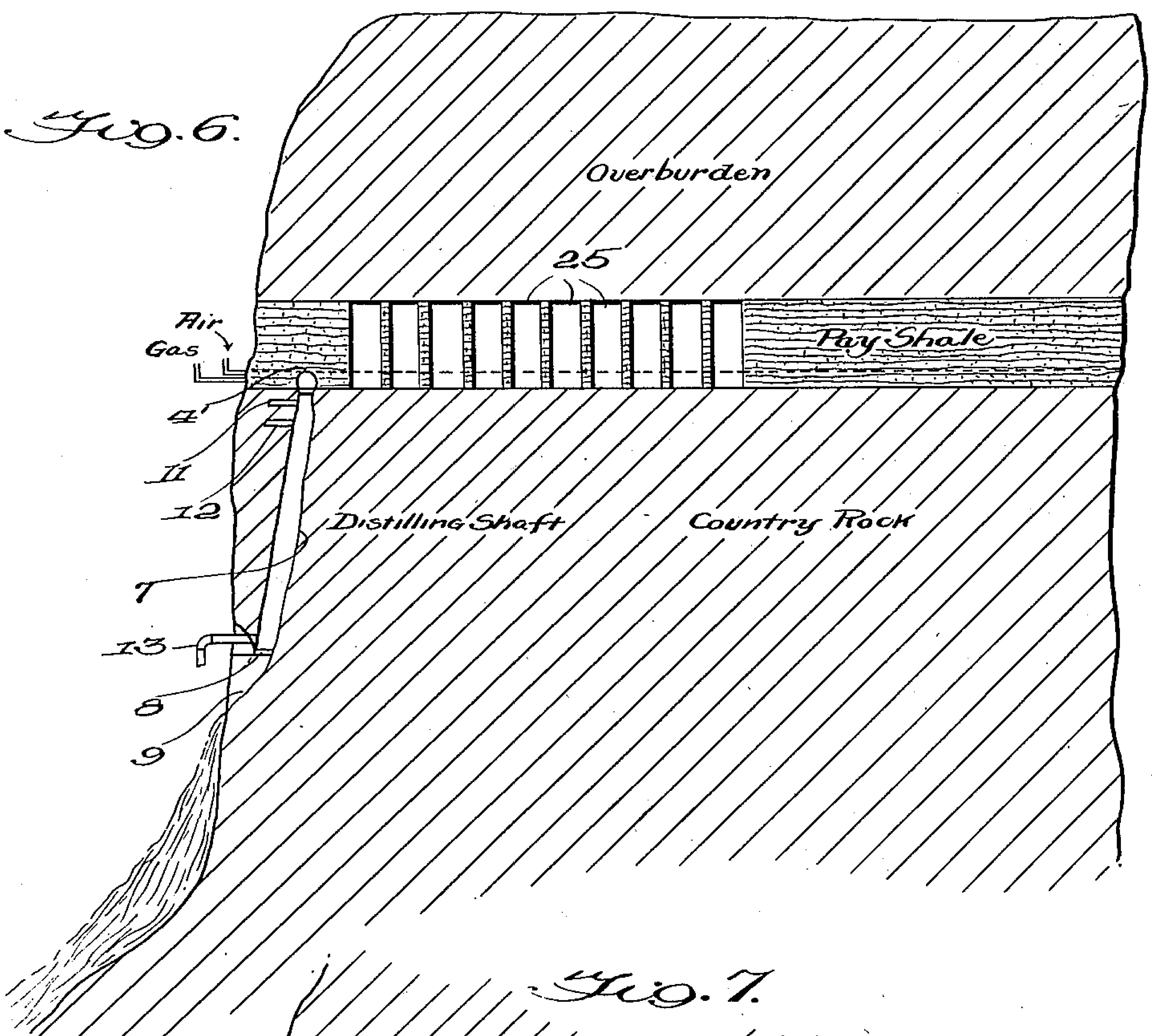
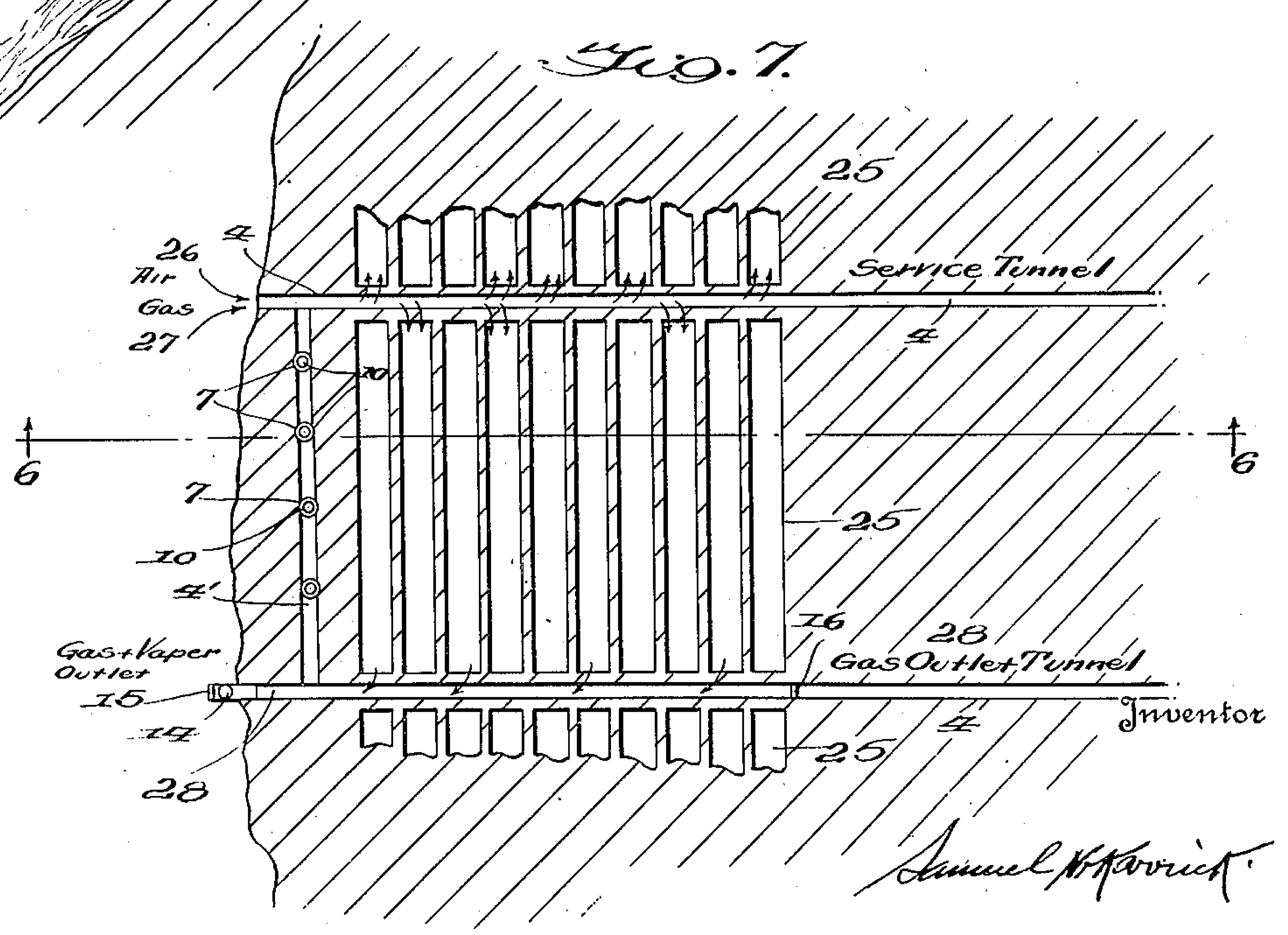


Fig. 7.



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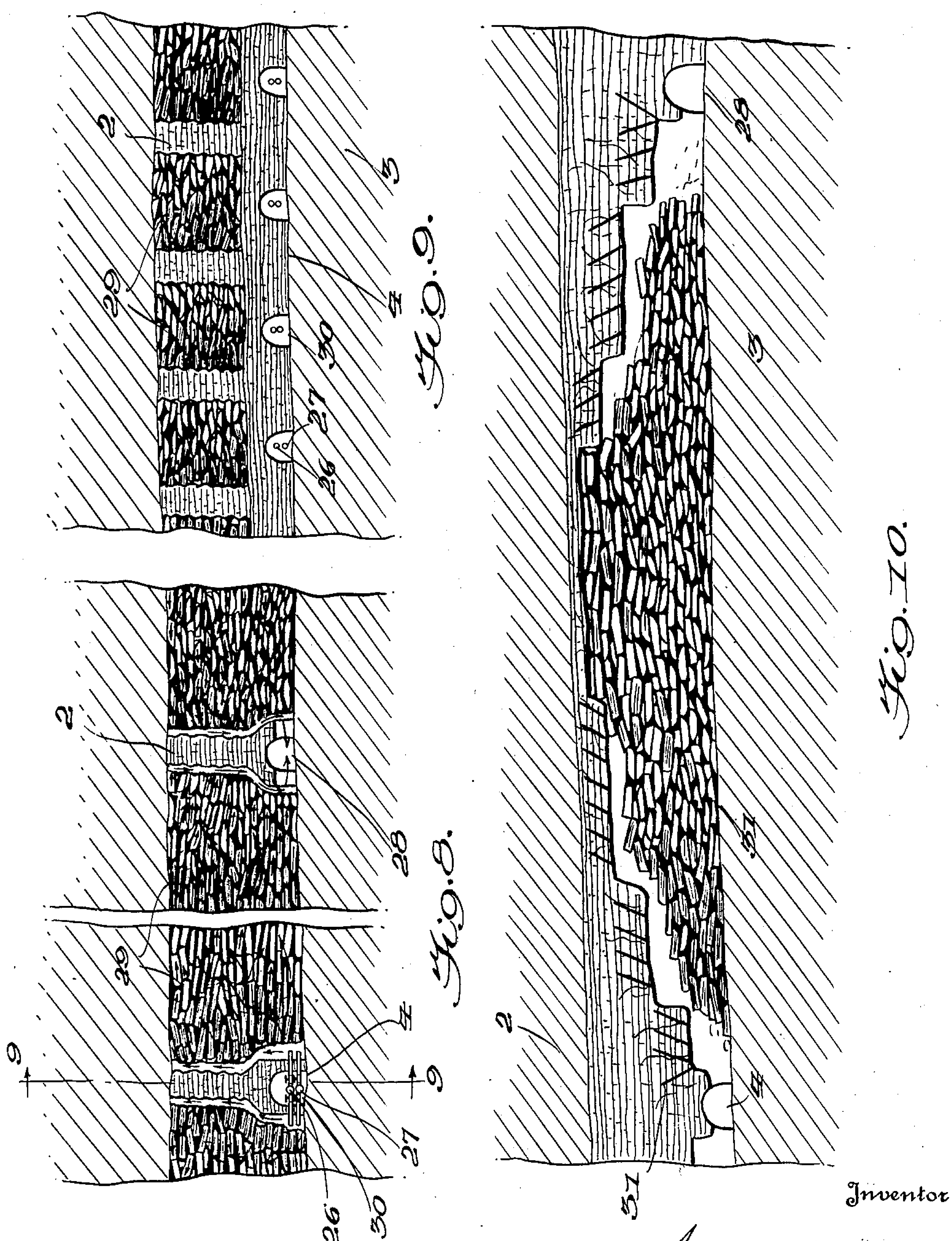

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Patented July 25, 1933

1,919,636

UNITED STATES PATENT OFFICE

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SYSTEM OF MINING OIL SHALES

Application filed March 5, 1930. Serial No. 433,385.

This invention relates to the production of oil from shales or coals and particularly concerns new methods of developing the oil shale deposits and treating the oil-forming materials underground. By my methods of operation shale oils and fuel gases may be produced at a fraction of the costs which must be met by other methods.

The large deposits of oil shales of the United States occurring in Colorado, Utah and Wyoming, also in Indiana and Kentucky, contain contiguous strata of oil shales ranging from twenty-five to one hundred feet in thickness which may be distilled successfully by my method. Also in Utah there are large deposits of suitable coals for this treatment.

I have worked out improved mining methods for preparing the deposits for treatment which take advantage of certain natural features of the deposits, namely, structure, thickness, type of material and height above the valley floors, etc., to obtain great economies in the commercial treating of the shales and handling of the products formed. For example, in the oil shale areas of Colorado the richest oil shales are obtained within a series of strata some fifty feet thick lying approximately 1500 feet above the valley floors and toward the top of a precipitous face some 500 feet in height (see Fig. 1). The methods I prefer to use are hereinafter described in relation to these beds of shales, but are not limited thereto, nor in the precise form as shown and described.

In order to supply the necessary heat for carrying on the distillation, I introduce into contact with the shale the products of combustion from burning variable mixtures of the combustible gas formed in distilling shales. The temperature produced is governed by regulating the amount and proportions of the gas and air used and will be such that the volatiles are removed from the shales and the carbon residue remaining in the spent shale is heated sufficiently high to form producer gas by interaction with the products of combustion. In this way I am able to prevent excessive dilution of the shale gases with nitrogen and carbon dioxide which would render the gases of no value for fuel purposes. Additional fuel gas is also formed by introducing air alone into contact with the hot spent shale after the oils are removed by which the residual carbon is slowly burned and transformed into producer gas. The two sources of gas provide a supply of gaseous fuel which will be a surplus over that required for the distillation of the shale and will leave ample for generating power by gas engines or steam plant to run fans, air compressors, pumps, dynamos, etc., for the entire shale works, refinery and camp uses.

In applying my method of mining and distillation to the oil shales of Colorado in the bodies referred to above, I produce large bodies of lump oil shale either in the form of vertical chambers or tunnels which are substantially full of the broken shale. Only enough of the shale is removed to allow for the normal voidage of the broken shale left in the chambers. The hot gases are then passed either downward or upward through the chambers, or horizontally through the tunnels. The chambers occupy nearly the full height, or thickness, of the series of strata selected as most advantageous to treat and are separated by partition walls of oil shale of the minimum thickness that will preserve a gas-tight separation of the chambers and yet of such minimum thickness that the oil shale forming the walls will be distilled simultaneously with the broken shale occupying the chambers.

In the above case I prefer to develop the shale deposit by using closely spaced vertical or sloping chambers or raises about 50 feet in height. This stratigraphic height has been shown in the Bureau of Mines investigations to contain a series of contiguous strata which are the richest in the oil shale measures and that they vary in oil field from 20 to 65 gallons per ton of shale and the 50 feet will average 35 gallons per ton. In one form of preferred development the chambers will be installed four in a unit on each side of and above a common service tunnel to which they all are connected by a simple series of small sloping branch raises. After the raises within the oil shale are completed the walls are drilled and blasted from bottom to top, thereby filling the chamber with broken material to near the top. The raises within the shale must be of such cross section and so spaced that when the shale rock of the walls is blasted down to fill the chamber, the remaining oil shale of the walls separating the adjacent chambers will not be broken through and will be of proper thickness to permit complete distillation of their contained oils.

The branch raises leading down from the bottom of the shale raises must be amply steep to permit the broken rock or oil shale to run out freely as the blasting proceeds during the development work. Since the branch raises lead down into the service tunnel, I provide for placing mine cars under the raises to receive the rock shot down and, thereby, I avoid any hand loading of the development rock. The rock and oil shale that is removed in the development work will be from 25 to 40 percent of the total shale broken and by my gravity method of transferring the material into cars I reduce the cost of development to a minimum.

The oil shale removed from the raises is trammed to another part of the mine and dumped through a hopper and gates in the tunnel floor leading into a distilling shaft of several hundred feet in depth. This material is separately distilled and gasified by the same method as used in the vertical chambers referred to above.

It will be recognized from this general description that all the shale is treated underground in substantially vertical shafts or chambers without requiring any excavating or loading either by hand or by power operated machinery. Also, both quantities of shale, namely, that treated in place and that removed and dumped into the distilling shafts, are subjected to the downward flow of hot gases which effects the distillation of the large and small lump material and subsequently converts much of the residual carbon of the shale into producer gas.

When the distillation and gasification treatment of the shale in the vertical chambers is completed, the supplies of gas and air are cut off, but no effort is made to remove the spent shale or make further use of the chambers. However, when the treatments of the shale in the shafts are completed, the spent material is removed by bottom discharge gates and a fresh charge is substituted and the treatments repeated. The shafts thereby serve for continuous use and their construction cost, which is very low, is nevertheless charged off in treating many charges of oil shale. By reference to Fig. 1, it will be observed that the discharge gates of the distilling shafts are so located that ample dump room is provided for the spent shale.

The various mining methods I apply are well known and the various treating galleries are modifications of forms of hard rock workings with which I have had experience in Utah and Nevada, but are herein adapted and improved upon to make possible the economical treating of the large deposits of oil shales, all of which methods and forms comprise my invention.

In order to make more clear the details of my invention and the forms in which it may be applied, reference is now made to the drawings forming part of this application.

Figure 1 is a vertical section through a high mesa containing strata of oil shale suitable for mining and treating by my process. Fig. 2 is a plan view of the workings shown in Fig. 1. Fig. 3 is a larger plan view of the workings of Fig. 2 with added details. Fig. 4 is a large scale vertical section of the workings appearing in Fig. 1. Fig. 5 is also a vertical section of the workings of Fig. 1 but at right angles to Fig. 4. Fig. 6 shows a modified form of underground workings from those in Fig. 1, also in vertical section. Fig. 7 is a plan view of the workings shown in Fig. 6. Figs. 8 and 9 are enlarged vertical sections at right angles to each other through the treating tunnels of Figs. 6 and 7. Fig. 10 is a vertical, longitudinal section, like in Fig. 8, but in addition shows some detail of the caving method. 1 is the rock overburden lying on top of the strata of oil shale to be worked. 2 is a series of strata of oil shale which are to be worked as a body. 3 is the country rock lying below the main body of rich oil shale.

4 is a service tunnel approximately 30 feet below the bottom of the oil shale. This tunnel is driven in a stratum of fairly rich oil shale which occurs at this position. 5 are vertical chambers filled with broken oil shale and, as shown, are nested together within the strata of "pay oil shale". 6 are series of sloping branch raises which connect with the bottom of the vertical chambers and with the service tunnel 4.

7 is a vertical or inclined shaft extending downwardly several hundred feet from service tunnel 4. At the bottom of shaft 7 is located a gas-tight gate 8. Below this gate is a chute 9 by which the material discharged from the shaft is deposited on the dump below the escarpment of the mesa. Near the top of the shaft 7 is a gas-tight gate 10 through which the oil shale mined from the chambers 5 is deposited into the shaft. Below the gate 10 are connected a gas pipe 11 and air pipe 12 through which the combustible gaseous mixture is introduced for distilling the contents of the shaft. Near the base of the shaft is also a pipe connection 13 through which the oil vapors and gases from

the shale are removed and conducted to the condensers (not shown). 14 is also a vapor and gas outlet by which the volatile products from the chambers 5 are conducted from the mine to the condensers. On the outer end of connection 14 is shown an explosion door which is provided as a safety measure to obviate damage to the condensing plant in the event of mild explosions occurring within the gas tunnel.

Fig. 2 is a plan view of the workings shown in Fig. 1 and in addition shows the present and future development areas, also a reserve shale area. The gases and vapors coming from chambers 5 pass out of tunnel 4 by way of connection 14. A gas barrier 16 in tunnel 4 is shown at the extreme right of the zone occupied by chambers 5 and serves to prevent the explosive gases and vapors from entering the tunnels 4′. The tunnels 4′ are used for transportation, communication, etc., and haulage of the shale for distillation in shaft 7. The barrier 16 is advanced to the right as new chambers are made ready for use. By this arrangement one system of tunnels serves both as a haulage way, and later as a gas and vapor conduit.

Fig. 3 is a plan view illustrating on large scale the arrangement of the vertical treating chambers and their connections to the service tunnel 4. It will be noted that the chambers are grouped in sets of four on each side of the service tunnel in order to minimize the amount of tunnel and connections required. The chambers are developed in units of eight and are then placed in operation. At the extreme right and at the lower part of Fig. 3 are shown the preliminary small raises which are driven up through the body of oil shale. The shale removed from this operation is deposited in the distilling shafts 7. In dotted lines is shown a plan view of the system of branch raises by which the chambers 5 are connected with the tunnel 4.

Fig. 4 is a section in large scale of the vertical chambers and their connections with the tunnel 4. 2 is the body of oil shale and 3 is the country rock lying immediately below. An end view is also shown of the service tunnel which passes through a stratum of medium rich oil shale.

In preparing to develop the chambers 5, I first install the connecting raises 6 leading from the tunnel 4 up to the base of the rich oil shale strata. The direction of the connecting raises is so governed that the vertical chambers 5 will be properly spaced from each other. Next the small raises 5′ are installed and are made to connect with the tops of the branch raises 6 and extend to approximately the top of the rich oil shale strata. The raises are now ready for filling with the broken shale which is derived by drilling and blasting the surrounding walls of the raises 5′. It is essential that care be exercised in this step of the process in order to produce the required amount of broken shale to fill the chambers with the minimum expenditure of powder while at the same time preventing breaking through the walls into the adjoining chambers. In order that the chambers 5 will be filled with broken shale by the blasting procedure, it is necessary that the volume of the raises 5′ shall be approximately 25 to 35 percent of the volume of the chambers 5. With this in mind the spacing of the chambers is so laid out that the walls 17 between the various chambers will be of substantially uniform thickness and approximately twice the diameter of the large lumps of broken shale in the chambers. By this arrangement and method of development I am able to effect the distillation of the shale rock of the walls simultaneously with the broken shale within the chambers. I thereby make possible the extraction of the oils from much more of the shale rock than is actually mined.

Fig. 5 is a vertical section taken at right angles to Fig. 4 along the line 5—5. The chambers 5 are full of broken shale and are ready to commence the distillation of their contained oil. The heat for carrying on the distillation is herein shown as being supplied by a burning mixture of gas and air introduced by pipes 18 and 19 leading into each of the chambers at the tops. The air and gas are deliverel through the tunnel 4 by pressure mains 20 and 21. Connections are made with the mains by pipes leading up through the raises 5′ of the new galleries undergoing development, as shown at the extreme right. Regulating valves 22 and 23 are used to adjust the flow of air and gas into the various chambers. I may also use gas burners set into the chamber walls and connected to the gas and air pipes 18 and 19.

In order to determine when the distillation is completed in the respective chambers I provide gas sampling pipes 24 which extend from tunnel 4 well up into each of the branch raises. The lower end of the sampling pipes 24 extend through the gas-tight bulkhead 16 and are provided at their outer end with suitable valves. To determine the progress of distillation of any chamber, a sample of the volatile products produced therein is drawn through the gas sampling pipe and analyzed for the percentage of oil vapors, carbon dioxide, oxygen, etc., contained. The amount of one or more of the above ingredients will indicate to an experienced operator the progress of the distillation or gasification and the adjustments, if any, that should be made. The gas-tight bulkhead 16 is satisfactorily made of angle iron posts covered with metal lath and plastered over with cement mortar. When a new set of eight chambers are ready for operating a new bulkhead is erected to correspond as to location with the one herein illustrated, following which the present one is removed. This can be done by use of a cable connection operated from the other side of the new bulkhead.

Figs. 6 and 7 are similar to the vertical section and plan illustrated in Figs. 1 and 2. However, instead of using vertical chambers and branch raises, I show a modified method of development in which large parallel tunnels 25 filled with large lumps of broken shale are used. As described above, in relation to the vertical chamber method, it is necessary to remove approximately 25 to 35 per cent of the shale from the distilling tunnels in order to provide the voidage in the mass of broken shale that fills the tunnels. The removed shale will, as above described, be treated in the underground shafts 7 shown in Fig. 7. A method is provided for supplying the heat to the distilling shale by burning air and gas which are supplied through pipes 26 and 27 passing along the service tunnel 4. The gases and vapors evolved in the chambers are removed by gas outlet tunnel 28. This tunnel will likewise serve both as a transportation and later as a gas outlet tunnel. The tunnel 4 will permanently serve as a service and haulage tunnel. Tunnel 4′ branches off from tunnel 4 and leads to the vertical distilling shafts 7 in which the mined shale is distilled.

Figs. 8 and 9 are vertical sections lengthwise and across the shale distilling tunnels shown in Figs. 6 and 7. Like numbers refer to like parts. These tunnels as used to economically treat the thick oil shale beds in Utah and Colorado may be approximately 20 to 40 feet wide by 50 feet high and one hundred or more feet long. The oil shale is prepared for distilling by first driving a long development tunnel the full length of the distilling tunnel and having a cross section of proper size to provide the voidage between the blocks of oil shale that will fill the distilling tunnel when the treatment is under way; this should be approximately 25 to 35 percent of the cross section of the distilling tunnel.

The driving of the development tunnel is best shown in Fig. 10 and will be by the usual up-to-date tunnelling methods wherein power loading machines will be used to remove the broken shale and care will be exercised to save powder and produce the minimum of fines. The broken shale is trammed away and dumped through the gas-tight doors into the distilling shafts 7 where it is treated by passing hot combustion gases from burning gas down through the charge.

Next holes 31 are drilled into the roof of the development tunnel and of such depth and spacing that when the powder charges are fired the roof shale will be broken down in large blocks 29 with the minimum production of fine material. Following this another round of holes are drilled and fired, each round bringing the pile of broken shale nearer to the roof due to the increase in volume of the broken shale. The space between the broken material and the roof, just before the last round is fired, should be small enough so that the broken shale after the last round is fired will remain touching the roof. This procedure prevents the formation of a channel over the charge by which route the hot distilling gases could pass instead of through the charge. With blocks of shale averaging 2 to 3 feet in minimum diameter, the time required to distill the lumps will be possibly one hundred or more hours. The time required to complete the distillation from end to end of the tunnel will depend on its length, but for tunnels of 100 feet in length the time should be approximately one week.

This method of development has the disadvantage over the vertical chamber method described above in that the shale removed must be loaded by hand labor or power shovels into cars for haulage to the distilling shafts. However, the chambers are much larger and the shale can be broken down into larger blocks by caving at very low cost, also the amount of auxiliary development work is somewhat less.

In Figs. 8, 9 and 10, numeral 4 is the service and haulage drift. 26 and 27 are respectively the air and fuel gas supply mains with branches and valves leading through portals 30 into the distillation tunnels. 28 is the gas and vapor outlet tunnel and 29 the blocks of shale forming the pervious charge. 31 are carefully spaced drill holes in the shale roof.

After the blasting operations are completed and the tunnel is full of blocks of shale, the gas and air pipes are run a short distance into the tunnels and the portals 30 sealed with masonry or concrete to form a gas-tight closure. The closure should be reinforced slightly by cross rails or posts so as to provide the necessary strength to resist explosions within the distilling tunnels.

By my method of underground treatment of oil shales or coals I may make further use of the chambers shown in Figs. 1 to 5 inclusive, to treat further quantities of lump carbonaceous materials. The material may be derived from other strata at higher elevations and charged into the chambers by chutes after removal of the spent charge. Also I do not limit myself to the method shown in Fig. 5 for delivering fuel gas and air into the top of the chambers 5, but may prefer to drive service tunnels above the chambers and introduce the gas and air by pipes leading through the tunnel.

I claim:

1. The method of obtaining oils and gases from carbonaceous material comprising driving passageways in the material in its natural position, depositing the carbonaceous material removed from the passageways within other passageways, made in the deposit wherein the shale is not sufficiently rich for independent working thereof, subjecting the material removed in the formation of the passageways to the action of heat at a carbonizable temperature to drive out the volatiles therefrom, subjecting the walls of the passageways to the action of heat at a carbonizable temperature to drive out the volatiles, and effecting a collection of gases and liquid products from the volatiles derived from the walls and from the removed material.

2. The method of obtaining oils and gases from carbonaceous material comprising driving passageways in the material in its natural position and removing the material dislodged, enlarging the passageways by dislodging carbonaceous material from the walls thereof and thereby effecting the formation of loose bodies of material filling the passageways, subjecting the walls of the passageways and the material therein to the action of heat at a carbonizable temperature to drive out the volatiles, placing the removed material, other deposits containing shale insufficiently rich for independent work thereof and subjecting it to the action of heat at a carbonizable temperature, and effecting a collection of gases and liquid products from the volatiles.

3. The method of obtaining oils and gases from carbonaceous material comprising driving passageways in the material in its natural position, driving a shaft in the earth below the passageways, depositing the removed material from the passageways in the shaft, enlarging the passageways by dislodging carbonaceous material from the walls thereof and thereby effecting the formation of loose bodies of material in the passageways, subjecting the walls of the passageways and the material therein to the action of heat at a carbonizable temperature to drive out the volatiles, subjecting the material in the shaft to the action of heat at a carbonizable temperature to drive out the volatiles, and effecting a collection of gases and liquid products from the volatiles.

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