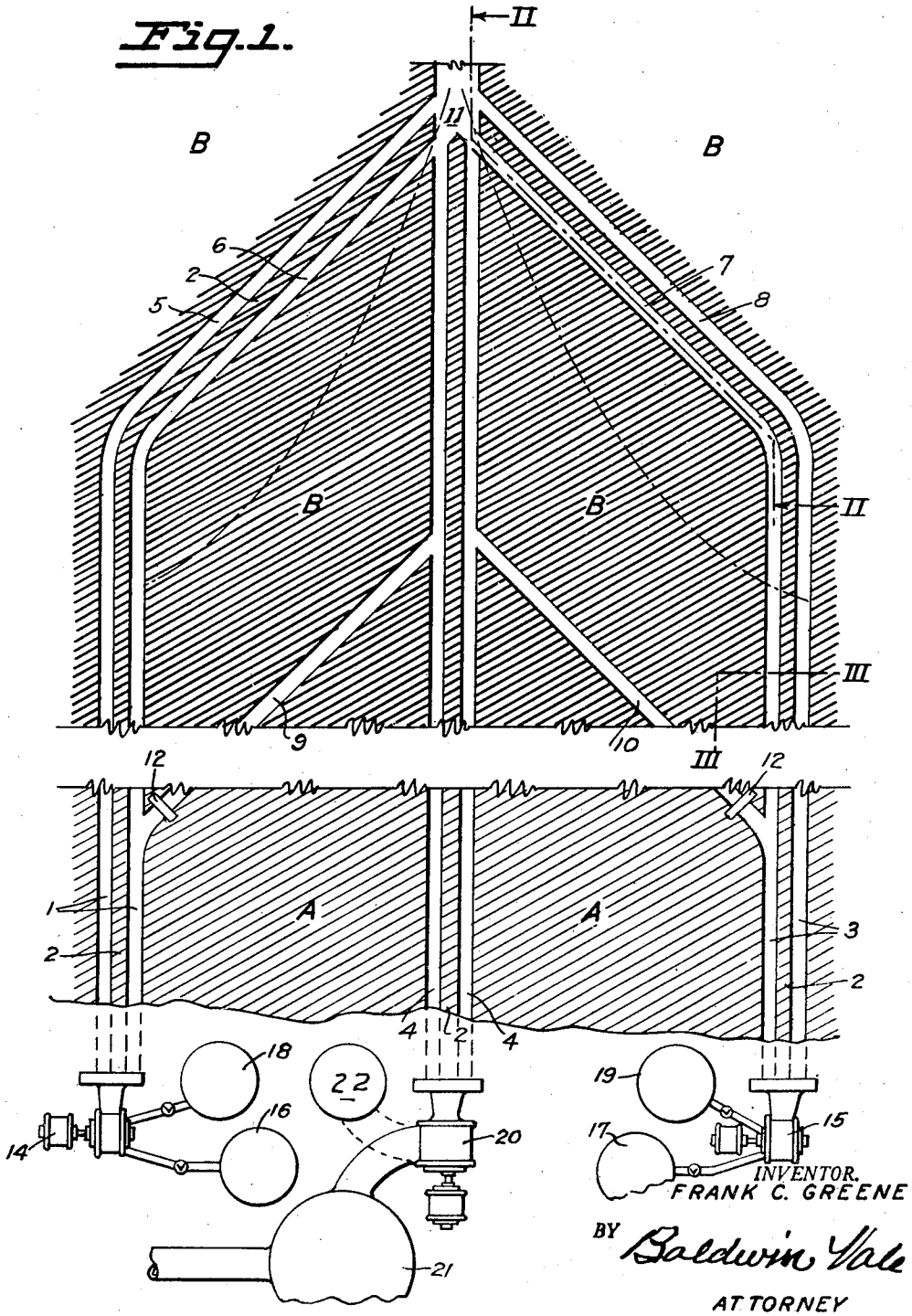
April 12, 1949. F. C. GREENE 2,466,945

GENERATION OF SYNTHESIS GAS

Filed Feb. 21, 1946 2 Sheets-Sheet 1

Fig. 1.



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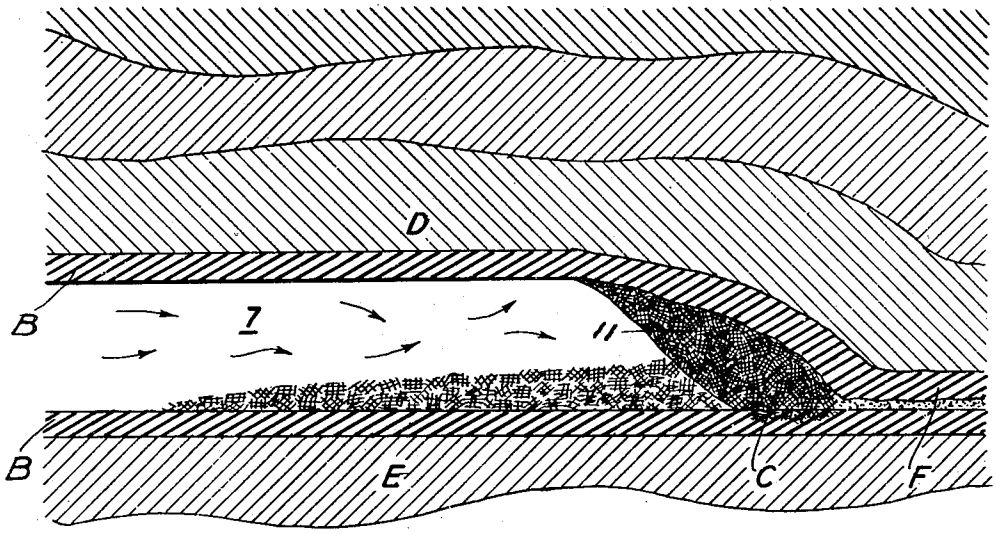

Fig. 2.

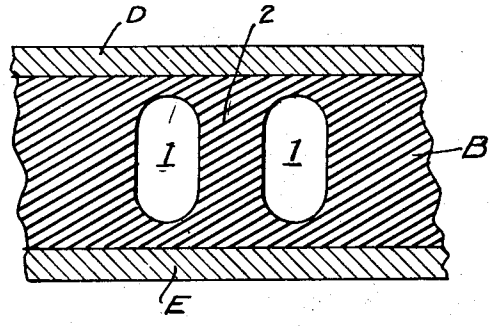

Fig. 3.

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GENERATION OF SYNTHESIS GAS

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Application February 21, 1946, Serial No. 649,295

10 Claims. (Cl. 262—1)

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This invention relates to the generation of synthesis gas, and more particularly to the reduction in situ, of carbonaceous deposits, such as coal, by mechanically controlled combustion underground.

Among the objects of the invention is the simplification of the process and the elimination of costly apparatus in the production of synthesis gases by the combustion of carbonaceous natural deposits in situ.

Another object is the control of the volume of combustion in situ, and the modification of the constitutent values of the resultant gases, by remote control.

A further object is the initial mechanical preparation of such natural deposits for controlled disintegration by their inherent combustibility.

Heretofore it has been the practice to mine the higher grades of coal and similar carbonaceous deposits and remove them for fuel for the generation of thermic power through the generation of steam for prime movers. Such fuel has also been hydrogenated in the form of liquid fuels and gases, by the use of elaborate apparatus and costly methods.

The lower grades of coal, such as the lignites and the like, are not commercially adaptable to such methods, and are not so utilized, and are lost to human economy.

Similarly crude oil deposits are recovered by expensive drilling and pumping methods and rendered commercially valuable by expensive means for reducing them to hydrocarbon liquids and fuel gases.

All of such prior methods, involving the removal to the surface of such carbonaceous values, for processing by indirect methods for the generation or reduction to commercial products are costly, hazardous and unduly complicated, and costly to transport as solids.

Some elementary attempts have been made to recover gaseous values from mine fires underground, but such efforts have lacked the geological pre-preparation and remote controls of the present invention.

This invention provides simple and direct means for the recovery, by conversion, of natural deposits of any form of combustible material in situ.

Other objects and advantages will appear as the description proceeds. In the specification and drawings of this disclosure the invention is shown in its presently preferred form. But it is to be understood that it is not limited to this form; because it may be embodied in modifications for specialized purposes, within the spirit of the invention as defined in the claims following the description.

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In the two sheets of drawings:

Fig. 1 is a horizontal cross section of a ground plan of the inlet and outlet ducts and combustion area, formed in the geological structure of a typical coal deposit.

Fig. 2 is an enlarged detail in vertical section of the combustion area of the same, on the line II—II, Fig. 1.

Fig. 3 is a similar detail on the line III—III, Fig. 1, showing the common characteristics of the inlet and outlet ducts.

In detail the physical structure of this invention includes the geological mass surrounding the desired carbonaceous deposit or bed of coal to be disintegrated by the present method and process. Such deposits are often buried deep below hilly or mountainous locations with indicative surface outcroppings.

Neither the top nor the bottom of the coal beds are mined but are left intact for combustion extraction, which thus occurs nearly within combustible confines.

Ducts within the coal bed are driven through the carbonaceous geological structure at the level of the deposit as determined by surveys in the usual manner. These ducts are best bored by the use of the machine disclosed in my copending patent application entitled "Granular mining machines," Serial Number 628,434, filed November 14, 1945.

The first step is to bore one or more parallel inlet ducts such as 1, 1, through the earth envelope A at bed outcrop, and through the coal deposit or bed B, and evacuate the detritus from these tunnels and salvage the granular coal for future use. The vertical partition rib 2, between these tunnels is a precautionary measure to prevent cave-ins, the danger of which is minimized by the curvilinear tunnel roof and floor, in addition to the usual timbering supports, where earth conditions require additional support.

A pair of similar inlet ducts 3, 3 are provided at a suitable distance from the first ducts 1, 1. The distance between these inlets is determined by the desired magnitude of the undertaking.

A similar outlet duct or ducts 4, 4, is bored in like manner between the two inlets 1—3. Lateral tunnels such as 5, 6, 7, 8, are bored between the inlets 1—3, preferably at an acute angle to the center outlet 4, and forming the apex or cape at 11, which is the point of higher combustion. The lateral tunnels such as 9, 10 are walled off from the inlet as at 12, by concrete stops, until opened

automatically by the advancing destruction resulting from the combustion of the coal faces at 6, 7.

These lateral tunnels 9, 10 are not essential to the mode of operation of the invention, but are legal requirements in certain mining districts, for protective reasons where coal is mined underground by man power.

The external equipment comprises the mechanically driven blowers 14, 15 respectively discharging into the inlet ducts 1—3. The suction intake of these blowers is surcharged with oxygen O, from the sources 16, 17 and with steam from the sources 18, 19 respectively, in addition to the volume of atmosphere admitted to the intakes of these blowers. The components of the discharge from these blowers to the intake ducts is proportioned with respect to the nature of the coal or other deposit being burned and the nature of the gas that it is desired to generate in situ.

Where it is desired to finally hydrogenate the carbonaceous deposit in the form of synthetic crude oil or the like, the natural water content of the deposit, if any, is supplemented by the introduction of water or heavy vapor through these inlet blowers, or by direct introduction of water into the combustion area by pipes or ducts independent of the blower system.

The center outlet duct 4 is provided with the suction exhauster 20 sucking through this tunnel outlet and discharging into the storage holder 21, which may be formed underground, or into appropriate refining or mixing apparatus 22, for the ultimate production of stabilized, synthesis gas or liquefactions.

This invention operates substantially as follows: Fires are built in the advance laterals 5, 8 for igniting the top, bottom and side faces of the exposed combustible walls of these lateral ducts, that are back to the far reaches of the deposit. In the meantime the exhauster 20 is turning slowly to provide ventilation for the workmen starting the initial fires. When combustion is well under way the blowers 14, 15 are started at reduced capacity until combustion has reached a point where it cannot be snuffed out by an excess air blast through the inlets 1, 3. The opposed blasts through both these inlets meet at the outlet region at 11, and cause an active turbulence surrounded by the adjacent combustible walls.

The exhaust blower 20 is then speeded up and the products of combustion are withdrawn through the outlet 4. When combustion has reached stability, the desired supercharge of oxygen, steam, water and or other desired constituents are added to the intake volume pumped through the intakes 1, 3, and combine with the natural gases evolved from the products of combustion.

The acute angle of the mass at the juncture of the inlet and outlet ducts at 11, falls away under combustion and forms loose burning embers C at the inlet of the duct 4, through which the evolved gases must pass and reduce chemically the gases given off by these embers. This porous glowing mass C at 11, acts as a damper to slow down the rate of combustion and assure the release of all gases impounded in the coal, from top to bottom of the combustion area. This obstruction also increases the turbulence of the incoming blast through the inlets 1, 3, meeting in the combustion area surrounding the cape at 11.

Coal is a poor conductor of heat, and when overlaid by the usual stratum of clay D, and a similar stratum E beneath the combustion area, the characteristics of a thermo-insulated blast furnace in situ are present, with the result that all combustibles are reduced without waste, except the residual ash on the bed of the combustion area.

As the face, roof and floor of the deposit at 11, spalls and falls away under combustion and recedes from the "goaf" or burned area F, the overhanging earth strata D, no longer supported by the deposit, disintegrates and caves in behind the combustion area, holding its cubic volume at the most efficient point.

Many geological areas contain ferrous, aluminous, and other metallic and like constituents contributing to the catalysis if needed, of the products of combustion in the conversion to synthesis gas, in situ, the chemical nature of which can be controlled by the introduction of oxygen, hydrogen and other elements lacking in the original carbonaceous or other combustible natural deposit, under ground, by introduction through the inlets 1, 3, as previously described. Where the deposit is not sufficiently self catalizing, powdered or gaseous catalysts may be introduced through the inlets, or the recovered gas may be passed through catalizing towers, as at 22.

Oil holes or oil impregnated deposits can be converted to synthesis gas or the like in situ, by the above described means and mode of operation. Where the geological structure permits, petroleum oil deposits can be recovered in like manner, by boring the inlet ducts 1, 3, horizontally into the point of oil seepage of reservoirs of oil, and either converting the oil to a synthesis gas as described, or recovering it as a vapor or oil as it seeps through the sand barrier. Such practice is within the spirit of this invention. It is cheaper to tunnel with the boring machine cited or by other means, than to sink vertical wells for a mile or more, with the incidental withdrawal of drilling tools and the provision of tubular casings and the loss of tools which often destroy the wells which involves the capital loss in abandoned wells. Any combustible geological deposit can in the present manner be mined by the generation of synthesis gas in situ, or by draining this hydrogenated carbon or other oil deposits laterally through substantially horizontal tunnels. The proper location of such tunnels can often be determined by oil outcropping on the surface, without elaborate geological surveys, after the probable quantity of the deposit has been scientifically determined.

Having thus described this invention and its mode of operation, what I claim and desire to secure by Letters Patent is:

1. In a geological formation having a deposit of natural combustible material therein; a pair of separated inlet ducts extending into said formation and converging together within said deposit; an outlet duct extending into said formation and terminating at said point of convergence of said inlet ducts and forming acute angles with the inlet ducts; air blowers discharging into said inlet ducts; and an exhauster sucking from the outlet of said outlet duct, when said deposit is in a state of combustion.

2. In a geological formation having a deposit of natural combustible material therein; a pair of separated inlet ducts extending into said formation and converging together within said deposit; an outlet duct extending into said formation and terminating at said point of convergence of said inlet ducts, the angles of incidence of said inlet and outlet ducts being such that under combustion said deposit will spall away and block said outlet

duct with burning embers, and means for exhausting the products of combustion through said embers.

3. In a geological formation having a deposit of natural combustible material therein; a pair of separated and substantially parallel inlet ducts extending into said combustible material; an outlet duct between said inlet ducts; lateral tunnels extending from said inlet ducts and converging into said outlet duct at relatively acute angles and forming a sharp cape at the point of combustion at the juncture of said inlet and outlet ducts; an air blower discharging into each of said inlet ducts; and a gas exhauster sucking from said outlet duct when said material is in a state of combustion.

4. In a geological formation having a deposit of natural combustible material therein, a pair of separated and substantially horizontally disposed inlet ducts extending into said formation and converging together within said deposit, a horizontally disposed outlet duct extending into said formation and terminating at said point of convergence of said inlet ducts and forming acute angles with the inlet ducts, air blowers discharging into said inlet ducts, and an exhauster sucking from the outlet of said outlet duct when said deposit is in a state of combustion.

5. In a geological formation having a deposit of natural combustible material therein, a pair of separated horizontally disposed inlet ducts extending into said formation and converging together within said deposit, a horizontally disposed outlet duct extending into said formation and terminating at said point of convergence of said inlet ducts, the angles of incidence of said inlet and outlet ducts being such that under combustion said deposit will spall away and block said outlet duct with burning embers, and means for exhausing the products of combustion through said embers.

6. In a geological formation having a deposit of combustible material therein, a pair of horizontally disposed, separated and substantially parallel inlet ducts extending into said combustible material, a horizontally disposed outlet duct between said inlet ducts, horizontally disposed lateral tunnels extending from said inlet ducts and converging into said outlet duct at relatively acute angles and forming a sharp cape at the point of combustion at the juncture of said inlet and outlet ducts, and a gas exhauster sucking from said outlet duct when said material is in a state of combustion.

7. A method of producing synthesis gas in situ from a geological formation having a deposit of combustible material therein including the steps of forming an outlet duct extending and terminating within the deposit, forming inlet ducts on opposite sides of said outlet duct extending into the deposit and each converging together and terminating in communication with the outlet duct at relatively acute angles thereto and substantially opposite to each other to form sharp capes between the respective inlet ducts and the outlet duct at their point of convergence, igniting the exposed combustible material in the inlet ducts, passing combustion supporting fluid through said inlet ducts to increase combustion to evolve gases and effect a spalling away of said capes to block said outlet duct with burning embers, and withdrawing the gases through the embers into the outlet duct and discharging the same therefrom.

8. A method of producing synthesis gas in situ

from a geological formation having a deposit of combustible material therein including the steps of forming a horizontally disposed outlet duct extending into and terminating within the deposit, forming horizontally disposed inlet ducts on opposite sides of said outlet duct extending into the deposit and each converging together and terminating in communication with the outlet duct at relatively acute angles thereto and substantially opposite to each other to form sharp capes between the respective inlet ducts and the outlet duct at their point of convergence, igniting the exposed combustible material in the inlet ducts, passing combustion supporting fluid through said inlet ducts to increase combustion to evolve gases and effect a spalling away of said capes to block said outlet ducts with burning embers, and withdrawing the gases through the embers into the outlet duct and discharging the same therefrom.

9. A method of producing synthesis gas in situ from a geological formation having a deposit of natural combustible material therein including the steps of forming an outlet duct extending into and terminating within the deposit, forming inlet ducts on opposite sides of the outlet duct, each inlet duct extending into the deposit and merging into and communicating with the outlet duct at relatively acute angles thereto adjacent the terminus thereof to form sharp capes in the deposit between the respective inlet ducts and the outlet duct at their zone of juncture, forming additional inlet ducts extending into the deposit and converging into said outlet duct from opposite sides thereof at relatively acute angles thereto, said additional inlet ducts being formed in parallel spaced relation to said first mentioned inlet ducts to define a zone of combustible material between said ducts and to form additional capes at their point of juncture with the outlet duct, blocking the outer end of said additional inlet ducts, igniting the combustible material within said first mentioned inlet ducts, supplying combustion supporting fluid through said first mentioned inlet ducts to increase combustion and evolve gases from said combustible material, the increased combustion at the point of convergence of the first mentioned inlet ducts effecting a spalling away of the said first mentioned capes to block the outlet duct with burning embers, withdrawing the gases through the outlet duct through the embers, and continuing the supply of combustion supporting fluid to maintain combustion throughout the zone of combustible material defined between the first mentioned inlet ducts and the additional inlet ducts which automatically opens the outer end of said additional inlet ducts, and repeating the process.

10. The method of producing synthesis gas in situ in a geological formation having a deposit of combustible material therein, including forming an outlet duct having a terminus in the combustible material, forming an inlet tunnel in the material with the inner end thereof in communication with the outlet duct at its terminus at a relatively acute angle thereto, which results in the formation of a sharp cape of combustible material adjacent the juncture of the inner end thereof with the outlet duct, igniting the material in the inlet tunnel, supplying combustion supporting fluid through the tunnel to its juncture with the outlet duct to initially increase combustion, withdrawing gases from the outlet duct at a reduced capacity, increasing the supply of combustion supporting fluid to the tunnel to increase the combustion therein to burn the com-

bustible material at a higher degree of temperature at the cape to effect spalling away of the cape to block the adjacent portion of the outlet duct with burning embers, and increasing withdrawal of the formed gases through the embers into and discharging the same from the outlet duct.

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The following references are of record in the file of this patent:

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