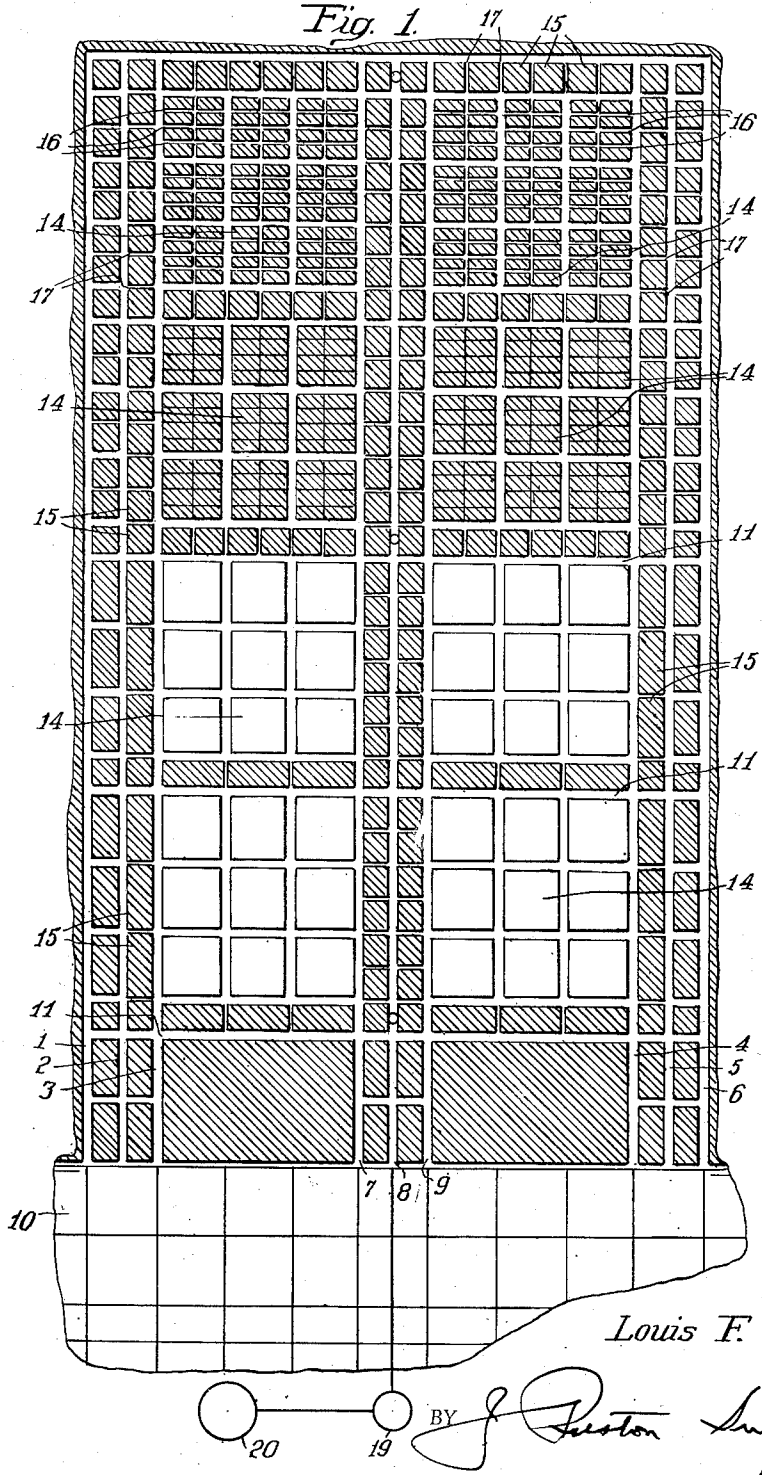
Sept. 4, 1956 L. F. GERDETZ 2,761,663

PROCESS OF UNDERGROUND GASIFICATION OF COAL

Filed Sept. 5, 1952 2 Sheets-Sheet 1

Fig. 1.



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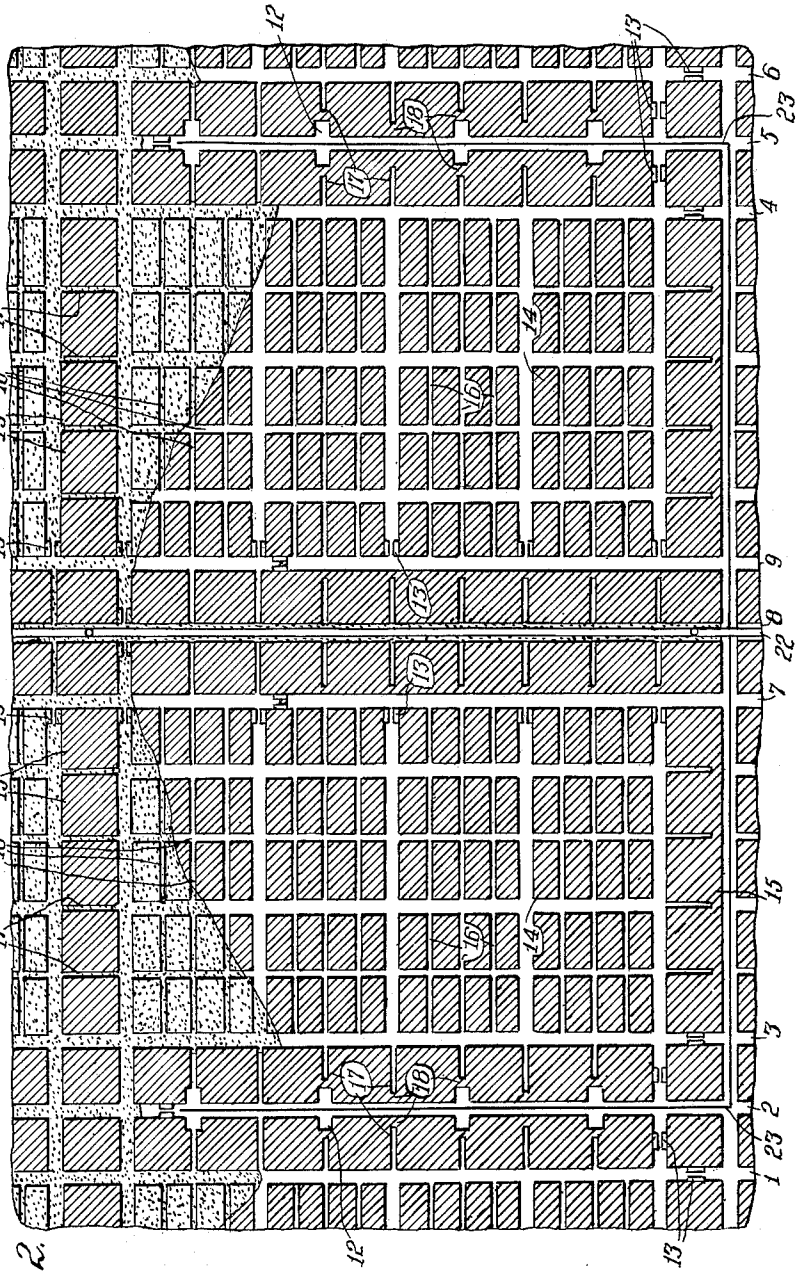

Fig. 2.

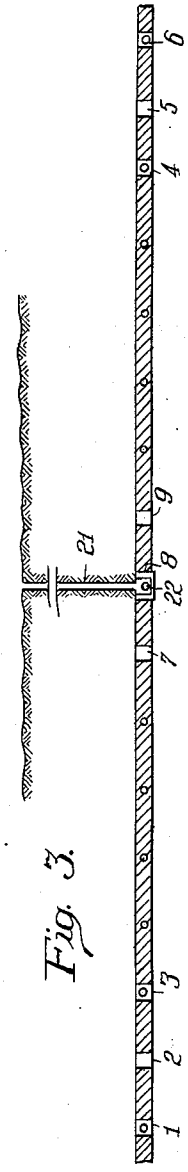

Fig. 3.

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United States Patent Office

2,761,663

Patented Sept. 4, 1956

2,761,663

PROCESS OF UNDERGROUND GASIFICATION OF COAL

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Application September 5, 1952, Serial No. 308,129

5 Claims. (Cl. 262—3)

This invention relates to improvements in a process of gasification of coal and other carbonaceous materials in place, underground.

It has been proposed heretofore to carry out the gasification of coal in situ in such a way that the area of the seam is gasified with the production of useful gases. Nevertheless, such a method, on test, proved to be impractical and was abandoned.

The method proposed heretofore and involved in the aforesaid test, required the drilling of a large number of boreholes from the surface of the ground down to the ignition starting gallery and to the seam of coal to be gasified, both to conduct air into the seam to support combustion and to remove the resultant gas therefrom. The entire area was to be consumed in progress, from the gallery through the seam on a continuous face. No provision was made therein for control of the rate of combustion from within the seam of coal, nor at any other point except on the surface of the ground, and it was impossible for workmen to be stationed adjacent the burning area.

Such a process was unsatisfactory for many reasons. The drilling of many boreholes involved great expense, which would preclude its practical operation by a commercial enterprise in attempting to produce gas at a profit. While a gallery can be formed in the seam of coal and the overhead strata adequately supported, any appreciable burning away of the coal adjacent the gallery would result in caving and falling of the strata, shutting off communication both with the source of air and with the discharge of gas, which is highly objectionable and results in destruction of the rate of combustion. Consequently, the gas was produced at such a low rate and of mediocre quality as to render the process impractical for commercial operation, with the result that it was abandoned.

It has been the practice heretofore to gasify coal aboveground in producer gas plants, but this requires the removal of the coal from the ground, and in many instances, hauling it great distances to such plants, which is expensive.

One object of this invention is to overcome these objections to the process of gasification of coal and to provide for the gasification of coal in situ, underground, yielding a gas product substantially equal in B. t. u. content to that commonly produced above ground in producer gas plants and in large volume.

A further object of the invention is to simplify and improve the process of gasification of coal in place, underground, which will produce a large valume of gas at a high rate that is comparable in B. t. u. content to gas made in producer plants aboveground, usually a low B. t. u. content, while reducing appreciably the cost of producing the gas both in the facilities employed and as a result of causing the gasification of the coal to take place in situ, underground.

Still another object of the invention is to provide for the control of the rate of gasification of the coal to enable the operation to be carried out with assurance of continuous combustion and a high rate of gasification under control of attendants stationed in close proximity to the burning area so as to maintain control thereof and with full assurance that the rate of combustion will be continued without interruption and in sufficient quantity to produce a large amount as gas.

A still further object of the invention is to provide for the generation of steam directly in proximity to the gasification of the coal, not only to circulate into the burning area as an aid to the control of combustion but also as an additional source of power, and which may be directed to the surface of the ground is desired, and serve miscellaneous purposes.

These objects may be accomplished according to the process herein set forth. Where the seam of coal to be gasified lies in a solid or virgin state, it will be opened up by a series of entries, crosscuts, and other openings according to standard or conventional mining practices involving use of the block system, to develop a block mining layout with a multiplicity of panels between the entries.

It is a well known fact that coal in place burns at a slow rate, especially when only one continuous face is exposed to combustion. Therefore, to obtain a more rapid and uniform combustion, coal in situ must be cut-up in relatively reduced blocks offering the gasification elements a multitude of faces instead of only one to perform.

The panels usually consist of one or more relatively large blocks of coal originally blocked-out by entries and crosscuts. These blocks in turn are reduced to any desirable size by auger holes of suitable dimensions to allow thorough and complete combustion of the coal at a high rate and positive process.

At points of intersection these entries, crosscuts and auger holes are suitably protected from immediate collapse or caving by heat resisting supports in order to permit the gasification process to gain efficiency and continue in an orderly manner to its completion under control.

Each pair of joined panels is surrounded by protecting barrier pillars for primary control purposes. The entries around panels serve as inlet and exhaust passages for the air and gas. The latter may be extracted or withdrawn by power from the surface of the ground. Usually no forced feed of air is required inasmuch as the entries will provide sufficient space for the natural flow of air, although, if the seam does not extend to an outcropping, one or more borings or channels may be needed for access thereto and forced feed of air may be used, if desired.

The seam will be worked through to an extended point and the extraction of gas from the coal will be started at that remote point, beginning at the inby boundary of the coal and moving outby to the portal or main entry, thus progressing on the retreat and from panel to panel. The blocks in the panel are opened up successively, being initially sealed off except at the point where combustion takes place. Thus the operators will open the panel initially at the inby boundary and start combustion at that point, and thereafter, while that is being consumed and the gas liberated therefrom, the attendants can move to the next adjacent panel and prepare that for gasification. When the first panel has been substantially completely consumed, the air bores in the next adjacent panel can be opened by the attendants for combustion of that panel.

An example of this process is illustrated, generally, in the accompanying drawings, in which:

Fig. 1 is a horizontal section of a ground plan, illustrative of the steps of the process of preparing the seam of coal for gasification;

Fig. 2 is a similar view showing the steps of combustion and removal of the gas and steam; and

Fig. 3 is a vertical cross-section through the seam of

coal, showing the entries and conduits associated therewith.

The seam of coal or other carbonaceous material is adapted to be developed initially by the block mining process, an example of which is illustrated in Fig. 1, although it will be understood that the layout may be modified materially according to the conditions encountered and the desires of the user of this process. The coal seam to be gasified will be opened up with a series of narrow entries generally indicated at 1, 2 and 3, at one side of the working area, and at 4, 5 and 6, at the opposite side thereof, and by intermediate entries 7, 8 and 9, approximately midway between the entries 1—3 and 4—6. These entries are formed by usual coal mining methods, from the outcropping or other point of entry to the seam backward therethrough, preferably to the inby boundary of the coal area. It will be understood, however, that the number and spacing of the entries may be varied as desired and according to the formation in which the operation takes place. In the example indicated, the entries extend from a main entry 10 backward through the formation and are provided with crosscuts at intervals, as indicated at 11. It will be understood, also, that rooms and other openings may be provided, an example of which is indicated at 12, so as to develop a block mining layout. Suitable closures may be provided at intervals in the entries, as indicated at 13, to close these off against communication therethrough.

Intermediate the several series of entries, the block mining system utilized according to this invention, has a series of pillars 14, surrounded by the entries and the crosscuts, and which are formed in the usual method of mining. One series of panels of coal is formed between the entries 3 and 7, and another series of panels is formed between the entries 9 and 4, in the illustrated embodiment according to Figs. 1 and 2. Each of the series of panels 14 is divided by the crosscuts 11 into separate panels. Moreover, each panel is formed by a plurality of blocks separated from each other in the usual method of block mining, as is well understood in mining operations. The series of panels are also separated from each other by surrounding blocks, as indicated at 15, between the entries through the seam of coal.

The formation of this block mining layout by conventional mining operations will extract from the seam a small proportion of the coal or other carbonaceous material, usually from about 15 to 25 percent thereof. The balance of the seam will be extracted by firing and gasification according to this invention.

This process of underground gasification of coal is mainly a combination of the so-called first mining practices (extraction up to 25%) and the gasification of the remainder of coal under conditions created thereby. It is considered that first mining practices in this instance will considerably contribute to the lowering of the eventual cost of the underground gasification of coal and in fact make this process possible of profitable performance.

The main entry 10 may be located either at the outcropping of the seam or at other point in the earth at, or adjacent, an edge of the seam where an entry may be made thereto downward from the earth, in the usual mining practice. One section of the seam will be prepared in the manner described and started into operation, after which the mining machinery may be shifted to another adjacent portion of the seam and there prepare that for gasification.

The process of extracting the gas from the coal or other carbonaceous material preferably begins at the inby boundary of the coal area and progresses on the retreat outby to the portals of the main entries.

The panel 14, at the point where combustion is to start, preferably at the inby boundary, as stated, has the blocks forming each panel penetrated through and through by a multiplicity of boreholes generally indicated at 16, extending in cross relation through the blocks and at suitable intervals along the length and breadth thereof. These boreholes may be formed by the usual mining auger, and as many as needed, but preferably are spaced apart both vertically and horizontally at intervals of about 20 feet.

If a seam of coal, to be developed and gasified, lies more or less flat, then all boreholes are driven in an horizontal plane regardless of direction. They are spaced at about 20 foot intervals and possibly less (in panel blocks). They are from 18" to 24" in diameter.

In blocks of coal surrounding a panel (barrier pillars) control boreholes may be spaced further apart and be of lesser diameter.

The blocks 15 also are bored through from the entries 2, 5 and 8, for communication therefrom to and around the panels 14, as indicated at 17 in Fig. 2. However, these boreholes 17 preferably are sealed off, as indicated at 18, adjacent the entries 2 and 5, except in the region where combustion is to take place. The entries 2 and 5 form the main air passageways in the double block system illustrated, while the entry 8 forms the exhaust conduit. Usually it is not required that a forced feed means be provided from the main air supply to the entries 2 and 5, at least when these are in open communication with the atmosphere, although fans may be connected therewith if desired or needed. Suction means may be connected with the exhaust entry 8, as indicated at 19, to withdraw the gas therefrom and to direct the latter to a suitable tank or other receptacle 20, usually on the surface of the ground.

After thus preparing the block mining layout, as described, ignition may be started in the usual manner, beginning preferably at the inby boundary of the coal seam at the lateral margins of the adjacent panels 14. Air will be drawn through the entries 2 and 5 and the later openings 17 into and through the panels 14 toward the intervening exhaust entry 8, which forms a gas conduit. The suction which pulls the fresh or intake air through the controlled feed-orifices in the barrier pillars around the panels is induced by differences in temperature and pressure inside the barrier pillars and especially within the fire zone. The induced suction or draft is made continuously positive and susceptible to precise control by the operation of the exhaust fan means, generally indicated at 19, for withdrawing the gas liberated from the coal at the rate desired. Moreover, the rate of combustion is controlled by the number of openings 17 that are uncovered by the sealing means 18 thereover, under control of the attendants, to maintain a uniform desired rate of combustion within the seam so as to supply the needed quantity of gas.

By reason of the above described method of extracting the coal from the mine, the workings can be kept open for entry by the attendants at all times, not only while firing the initial installation, but also as gasification is in progress. The workmen prepare additional panels as those toward the back of the workings are burned out, whereby the combustion area moves gradually outby to the portals of the main entries. The presence of the attendants in the region of combustion enables such attendants to control the rate of combustion, the admission of air, and other combustion means that may be used during gasification, including the use of steam, which is often found beneficial. Moreover, the attendants can observe any caving or other accidental changes in the formation, which otherwise might interfere with the rate of combustion and thus ensure of positive and continuous operation.

In this process of underground gasification of coal it is my intention to complete the first mining development of a layout entirely and to withdraw and transfer miners and the principal mining equipment therefrom to the next layout before initiating the gasification process proper. Only attendants controlling the gasification process and a few men attending to preparation work of panels and other matters incidental to the maintenance of the layout outside

the gasification area are present in the mine (layout) at this stage.

The retreat method here used permits all entries or openings lying outside the fired panels to be swept by fresh or intake air, without returning through any of the live or open workings. All of the fresh or intake air, regardless of its path, is drawn into the fire zone through air feed orifices in the surrounding barrier pillars **15**. However, this does not preclude a natural return air-course through, say entries **1** and **6** (of typical layout) to be kept in readiness at all times as the gasification of the layout is proceeding. In fact during the period of first mining development and before surface gas connection with the entry **8** was established, entries **1** and **6** served as return air-courses for the layout (connected with the main return air-course **10** of the mine).

While I have illustrated the use of the entry **8** as an exhaust or gas conduit, it will be understood that a separate conduit may be provided therein, or the entry, or a portion thereof, may be lined with a suitable material to form a gas conduit. A borehole may be formed into the exhaust entry **8**, or its conduit, for discharge of the gas therethrough to the surface of the ground, or more than one such boreholes may be formed therein, as indicated generally at **21** in Fig. 3, especially if the seam does not extend to an outcropping.

Furthermore the exhaust conduit or entry **8** may be provided with an additional conduit therein, generally indicated at **22**, to which a source of water may be supplied at one end in any suitable manner, as through a borehole downward through the earth. The conduit **22** will be in heat exchange relation with the gas admitted to the entry **8**, whereby such hot gas from the fire zone will cause the formation of steam in the conduit **22**. The latter may be connected through borehole **21**, or other opening, to the surface of the ground, for discharge of the steam, where it may be used for power or other purpose, and/or it may be connected through a multiplicity of conduits, generally indicated at **23**, into the region of the combustion surfaces of the pillars **14**. The use of steam as an aid to combustion as well as to control the rate of combustion is well understood, and this may be provided automatically underground without the expense of piping it down to the region of combustion. At the same time, the heat exchange thereby provided aids in cooling the gas before it reaches the tank **20**.

In this method, it is possible to control the feeding of air, steam, etc., through the controlled orifices formed by the boreholes **17** into and through the panels **14** where combustion is to take place, by attendants located directly in proximity thereto, whereby more effective combustion can be provided and greater speed generation obtained, in a sufficient quantity for practical operation. In this way, producer gas can be made directly underground, without the expense of removing the coal, and yet in sufficient quantity and of comparable B. t. u. content with the producer gas normally made above ground. Thus, the operation is not only practical, but it is possible to produce gas from coal and other carbonaceous material at a sufficiently low cost to compete with natural gas. This has not been possible before, according to the known method, which has required the use of a large number of boreholes through the earth formation to the surface, which not only added to the expense of the installation but also rendered it unsatisfactory in service because of the low rate of combustion obtained thereby.

According to this process complete combustion is obtained at a high rate, and at the same time, the working area adjacent the panels being consumed is sufficiently cool so that the attendants may work comfortably therein in preparing additional panels, with protecting barrier pillars between those being consumed and the others under preparation, to enable the attendants not only to control the air to the burning panels but also to observe and ensure proper conditions for combustion at a sufficient high rate to maintain an adequate supply of low B. t. u. gas comparable to the producer gas heretofore made on the surface.

The use of this underground gasification system is not confined to virgin coal. It may be applied to old mines for the recovery of large blocks and pillars of coal. In that case the recovareable coal may be tapped for gasification by a rock tunnel or tunnels driven under the coal seam and supplemented by raise openings to the coal, and possibly, by vertical boreholes to the surface, driven at intervals dictated by the conditions encountered.

A rock tunnel supplemented by raise openings to the coal, etc., can at any time be substituted for entry **8** as an exhaust, or gas conduit, and also contain steam generating means therein. In practice there may be many instances where a rock tunnel acting as an exhaust for gas may prove itself more advantageous than a gas conduit in coal. A rock tunnel would not change in the least any other advantages of the gasification process herein outlined. The same as gas conduit **8**, a rock tunnel will act as the main return for the system.

While entry **8** acting as the main gas exhaust conduit to the surface is ample to absorb all of the fresh air (intake air) from the layout, and under normal conditions no other air return to the layout is necessary, entries **1** and **6** could act as ventilating media for the layout in case of necessity. In case of a failure of exhaust gas conduit **8**, or a tunnel acting in a similar capacity, entries **1** and **6** could immediately take over the ventilation of the layout outside the barrier pillar-enclosed gasification area, which in such case would remain, for a period of time, dormant.

While the invention has been illustrated and described in one embodiment, it is recognized that variations and changes may be made therein, without departing from the invention as set forth in the claims.

I claim:

1. A process of producing gas from carbonaceous material in situ, comprising the steps of forming a panel of said material with substantially horizontal inlet and outlet passages on opposite sides of the panel, with a row of pillars of said material spaced apart with openings therebetween and substantially surrounding the panel and spaced therefrom, drilling holes through said panel from the faces thereof, igniting said panel of material, circulating air through the inlet passage and through openings between the pillars to said panel to support combustion thereof, regulating combustion by controlling the openings between the pillars, and exhausting the gas therefrom through the exhaust passage.

2. A process of producing gas from a seam of carbonaceous material in situ, comprising the steps of forming a series of panels in said material with each panel formed of spaced blocks and having an opening extending around the panel and substantially throughout the height thereof, forming pillars along a side of the series of panels spaced therefrom, forming an air inlet entry through the seam of material substantially parallel therewith on the side of the pillars opposite from the panels, boring holes through the pillars from the faces thereof at intervals along the length of the inlet entry and connecting with said inlet entry, igniting the material at one of the panels at the inby boundary of the area, blocking off the holes remote from the point of ignition while circulating air through said holes adjacent the point of ignition to support combustion, gradually withdrawing the blocking as ignition progresses, and exhausting the gas therefrom in a direction away from the inlet entry.

3. A process of producing gas from a seam of carbonaceous material in situ, comprising the steps of forming a series of panels in said material with each panel formed of spaced blocks and having an opening extending around the panel and substantially throughout the height thereof, forming pillars along a side of the series of panels spaced therefrom, forming an air inlet entry through the seam of material substantially parallel therewith on the side of the pillars opposite from the panels,

boring holes through the blocks of the panels, boring holes through the pillars from the faces thereof at intervals along the side of the inlet entry and connecting with said inlet entry, igniting the material at one of the panels at the inby boundary of the area, blocking off the last-mentioned holes remote from the point of ignition while circulating air through said holes adjacent the point of ignition to support combustion, gradually withdrawing the blocking as ignition progresses, forming an exhaust entry between a pair of adjacent panels, and exhausting the gas from said adjacent panels through the common exhaust entry therebetween.

4. A process of producing gas from a seam of carbonaceous material in situ, comprising the steps of forming a series of panels in said material with each panel formed of spaced blocks and having an opening extending around the panel and substantially throughout the height thereof, forming pillars along a side of the series of panels spaced therefrom, forming an air inlet entry through the seam of material substantially parallel therewith on the side of the pillars opposite from the panels, boring holes through the blocks of the panels, boring holes through the pillars from the faces thereof at intervals along the side of the inlet entry and connecting with said inlet entry, igniting the material at one of the panels at the inby boundary of the area, blocking off the last-mentioned holes remote from the point of ignition while circulating air through said holes adjacent the point of ignition to support combustion, gradually withdrawing the blocking as ignition progresses, forming an exhaust entry between a pair of adjacent panels, exhausting the gas from said adjacent panels through the common exhaust entry therebetween, circulating water through said exhaust entry out of communication with the gas and in

heat exchange relation therewith to generate steam thereby, and directing said steam to the point of circulation.

5. A process of producing gas from a seam of carbonaceous material in situ, comprising the steps of forming a panel in said material with an air inlet entry extending along one side of the panel and an exhaust entry extending along another side thereof, forming pillars between said inlet entry and the panel spaced from the panel and with controlled openings between the pillars, igniting the material adjacent the inby boundary of the panel, supplying air to support combustion through the air inlet entry and through the controlled openings between the pillars adjacent the point of combustion, and controlling the progress of combustion along the panel by initially closing the openings between the pillars remote from the point of combustion and thereafter opening the last-mentioned openings and supplying air from the entry therethrough as combustion progresses along the panel.

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