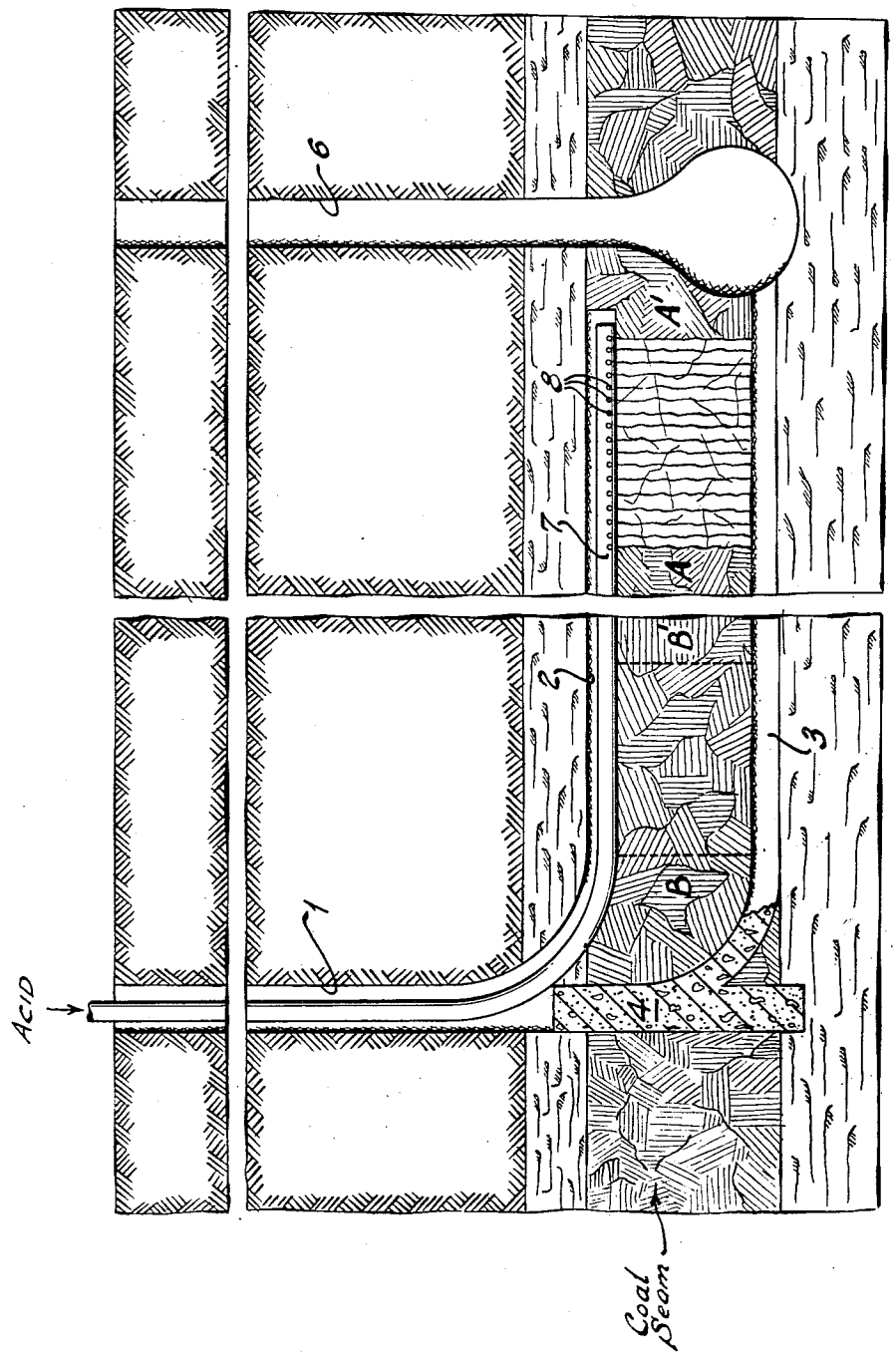
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GENERATION OF CARBON MONOXIDE AND HYDROGEN
BY UNDERGROUND GASIFICATION OF COAL
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GENERATION OF CARBON MONOXIDE AND HYDROGEN BY UNDERGROUND GASIFICATION OF COAL

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This application relates to the partial combustion of coal in underground seams. In one of its more specific aspects, the invention relates to a method for preparing coal beds for underground gasification.

Since 1933, the underground gasification of coal has been seriously investigated and exploited by a special Russian trust, Podzem, and extensive Russian literature has grown out of this work. A review in English by Chekin was published in Collary Garden 162, 1193–6 (1936) and Fuel Economist 11, 331–5 (1936). Since the end of World War II, this problem has been seriously examined in England, France, Belgium and the United States. A review by M. L. Kastems appeared in Chemical and Engineering News, March 24, 1952.

Underground gasification of coal has been carried out in a number of cases with encouraging results. In preparing the coal seam for gasification, it is generally necessary to drive two parallel main drifts through the coal seam, one as an inlet and the other as an outlet, and to connect these shafts with one or more lateral drifts at right angles to the main drifts. A combustion-supporting gas, e. g. air, oxygen or other gas containing free oxygen is introduced through one of the main drifts and products of combustion are withdrawn through the other. Steam or carbon dioxide may be used in conjunction with air, oxygen, or a mixture of air and oxygen as the gasifying medium or combustion-supporting gas. Combustion is initiated by igniting the coal along the path of flow, usually at the lateral cross drifts. The main drifts may be used alternately as inlets and outlets. After the coal seam is fired, air or oxygen is blown through the corridor to bring the surface of the coal to the desired temperature, and then steam is blown in either alone or with air or oxygen. If steam alone is used, the flow of steam must be periodically interrupted and the coal seam fired with combustion-supporting gas to maintain the required temperature. A mixture of steam with oxygen or air may be used for continuous gasification. The gas produced generally has a low B. t. u. value, a result which is not unexpected due to poor contact of the coal with the steam and oxygen.

It has been proposed previously to prepare a portion of a coal seam for gasification by breaking the coal loose from the bed by mining methods and then passing the reacting gases through the lumps of coal. Although this procedure results in effective contact between the coal and the gases it obviously is a costly one. By the process of this invention the coal seam is prepared for underground gasification in such a way that intimate contact between the coal and the gaseous reactants is obtained without the necessity of mining the coal from the seam.

In accordance with this invention a mineral acid having solvent power for one or more of the constituents of the coal is brought into contact with the coal seam effecting solution of coal substance. Preferably, the acid is permitted to drip onto the coal at a pluarlity of points. The acid forms a multitude of passages through the coal which are irregular in shape and which are very permeable to gaseous reactants used for the gasification of coal.

In a specific embodiment of the present invention a main channel or passageway is drilled through an upper portion of the coal seam, preferably as near as possible to the top of the seam, while a second main passageway is drilled through a lower portion of the coal seam substantially parallel to the upper passageway. In general, the passageways are parallel to the bedding plane of the coal seam. The process of the invention remains the same for an inclined seam as for a horizontal seam. The acid is introduced through the upper main passageway or drift. The acid percolates downward through the coal seam and eventually reaches the lower main passageway. Intermediate passageways parallel to the main passageways may be provided and are particularly advantageous in thick beds.

In a preferred embodiment of the present invention strong sulfuric acid containing 90 percent sulfuric acid by weight is introduced slowly into contact with the coal in the upper part of the seam. Strong sulfuric acid may be introduced through the passageway into contact with the coal seam through a steel tube. The tube may be perforated to distribute the acid along the desired section of the passageway. With other acids other types of acid resistant tubing are required, e. g. plastic or synthetic rubber tubes.

Strong mineral acids, e. g. hydrochloric, hydrofluoric, nitric, and sulfuric acids, are useful in the process of this invention. The acid concentration should exceed 30 weight percent. Higher concentrations of sulfuric and nitric acids are desirable. Sulfuric acid in excess of 90 weight percent is preferred.

Selective gasification of the coal seam may be accomplished by treating sections of the seam with acid and leaving pillars or untreated sections of the coal seam between treated sections. One or more of the treated sections may be ignited while others are blocked off.

Preferably the reaction is initiated in an upper passageway, the gasification proceeding downwardly through the coal bed to a lower passageway. As indicated above, exit passageways may be provided at varying depths and are particularly useful in thick seams of coal.

Firing of the coal may be initiated in any of a number of ways, for example by pumping a colloidal or semi-colloidal dispersion of phosphorus in water, or phosphorus in carbon disulfide into the upper part of the pretreated section of the coal. As the carrier liquid trickles downwardly through the treated section, phosphorus is deposited on the coal. After the bed has been pretreated with the phosphorus solution, an oxygen-containing gas is introduced which, upon contact with the phosphorus, ignites simultaneously and thereby ignites the coal. Once the reaction commences it is self sustaining so long as an adequate supply of oxygen-containing gas is provided.

The figure is a diagrammatic sectional view through a section of the earth illustrating the application of the process of this invention to underground gasification of coal.

With reference to the figure, a well **1** is drilled into or through the coal seam. A main passageway **2** is then drilled along the upper part of the coal seam. Means for horizontal drilling and directional drilling are known in the art. Generally, a deflecting device known as a whipstock is positioned in the well at the desired depth and a rotating drill bit on a flexible conduit is operated from the whipstock to effect horizontal or near-horizontal drilling. After a horizontal bore **2** of the desired length has been drilled, the bit is removed, the whipstock is lowered and a second bore **3** is drilled through the coal seam parallel to and below bore **2**. Bore **3** forms the second main passageway. Obviously a number of such passageways may be drilled through the coat seam. The portion of well **1** below bore **2** is then filled with cement **4**. A second well **6** is drilled into the coal seam to intersect passageway **3**. Well **6** may be enlarged at its lower end by means of explosive charges.

A conduit **7**, closed at its end and provided with a series of perforations **8**, is then introduced into the upper main passageway **2**. Strong mineral acid, e. g. sulfuric acid, is

pumped through conduit 7 from which it escapes through perforations 8 into section A—A' of the coal seam. The rate of injection of sulfuric acid may be controlled so that the acid is introduced at approximately the rate that it is consumed in the formation. The sulfuric acid dissolves a portion of the coal, eating its way downwardly through the coal seam to the lower main passageway 3. A series of channels are formed in the coal seam connecting the upper main passageway 2 with the lower main passageway 3. Similarly, other sections of the coal seam, e. g. section B—B' may be acid treated. Following acid treatment, an ignition agent may be introduced through pipe 7. Following preparation pipe 7 is withdrawn from the well bore. A combustion supporting gas is then introduced through one of the wells, preferably through well 1 into the upper horizontal pasageway 2. The coal seam is ignited at the top of the treated section. The oxygen-containing gas stream passes down through channels formed by the acid in the treated section. As the coal is consumed, combustible gas comprising carbon monoxide and hydrogen is generated. The combustible gas, together with volatile constituents distilled from the coal, is collected in the lower pasageway 3 and produced through well 6 to the surface.

The coal seam may be ignited initially in any suitable manner, as by electrical means or by a squib or incendiary shell, placed in contact with the coal in the horizontal passageway 2.

Air or relatively pure oxygen may be employed as the source of oxygen-containing gas. Relatively pure oxygen is preferred from the standpoint of producing gas which contains a minimum amount of nitrogen and other inert constituents. Once combustion is well established, steam may be introduced either continuously, in admixture with oxygen or oxygen-containing gas, or intermittently as in gas making apparatus with alternate blast and blow gas make cycles. Steam helps to control the temperature in the formation and produces hydrogen.

It will be understood that although passageway 2 is preferred as the input passageway for the combustion-supporting gas, either main passageway 2 or 3 may be used as the input pasageway while the other is used as the outlet passageway. It will also be understood that either of the main passageways may be drilled through well 6.

In an alternative procedure, channels between passageways 2 and 3 are first made by hydraulic fracturing of the coal seam between the passageways. In this case, hydraulic fluid under pressure, suitably water or oil with or without thickeners or viscosity increasing additives, is introduced through well 6 into passageway 3 under sufficient pressure to fracture the coal seam and form cracks extending upwardly toward or even as far as passageway 2. Similarly, hydraulic fluid under pressure may be introduced through well 1 into the upper passageway 2, fracturing the coal seam between bores 2 and 3. The cracks produced by hydraulic pressure in passageway 2 extend downwardly until they cross the path of cracks produced by hydraulic fracturing from passageway 3. This establishes fissures or auxiliary passageways between main passageways 2 and 3 through which the gasifying medium may be subsequently passed. A hydraulic fracturing liquid containing solid particles, such as sand or gravel, may be used. The solid particles are deposited in the fissures or cracks formed in the coal seam by the pressure of hydraulic liquid. When the hydarulic liquid is withdrawn, the grains of sand or gravel serve to help prevent the cracks from closing. Following hydraulic fracturing, acid is introduced through passageway 2 onto the top of the coal seam. The acid percolates down through the fissures, forming auxiliary passageways interconnecting the main passageways. The gasifying medium may be readily passed through the auxiliary passageways.

Spent acid may be withdrawn from the coal seam through passageway 3 and well 6. Ordinarily it is not necessary to separately withdraw the spent acid. Acid recovery is effected by processing the product gas. Fresh acid thus may be made up for additional treatment operations. Sulfuric acid is a preferred acid because of the natural occurrence of sulfur in coal.

Obviously, many modifications and variations of the invention, as hereinbefore set forth, may be made without departing from the spirit and scope thereof and therefore only such limitations should be made as are indicated in the appended claims.

We claim:

1. In a process for the underground gasification of coal in which an exothermically-reacting gas is introduced into contact with the coal in situ, the coal is reacted with said gas, and gaseous products of reaction are withdrawn from the coal bed, the improvement which comprises forming a first main passageway through an upper portion of the coal bed along the seam, forming a second main passageway through a lower portion of the coal bed along the seam substantially parallel to and below said first passageway, forming auxiliary passageways interconnecting said main passageways by introduction of strong mineral acid through said first passageway into contact with said coal effecting solution of coal substance in said acid, and thereafter supplying reactant gas to one of said main passageways, and withdrawing gaseous products from the other of said main passageways.

2. A process as defined in claim 1 wherein said acid is sulfuric acid.

3. A process as defined in claim 1 wherein said acid is nitric acid.

4. A process as defined in claim 1 wherein said acid is hydrochloric acid.

5. In a process for the underground gasification of coal wherein a combustion-supporting gas is introduced into contact with the coal in situ, the coal is ignited, and gaseous products of reaction are withdrawn from the coal bed, the improvement which comprises forming a first main passageway through an upper portion of the coal bed along the seam, forming a second main passageway through a lower portion of the coal bed along the seam substantially parallel to and below said first passageway, and introducing strong mineral acid through said first main passageway into contact with the bed of coal at a plurality of selected points along said first main passageway thereby effecting solution of coal substance and forming auxiliary pasageways interconnecting said main passageways.

6. In a process for the underground gasification of coal wherein a combustion-supporting gas is introduced into contact with the coal in situ, the coal is ignited, and gaseous products of reaction are withdrawn from the coal bed, the improvement which comprises forming a first main passageway through an upper portion of the coal bed along the seam, forming a second main passageway through a lower portion of the coal bed along the seam substantially parallel to and below said first passageway, introducing liquid under pressure through at least one of said main passageways effecting fracturing of said coal seam and forming fluid permeable channels interconnecting said main passageways, withdrawing said fracturing liquid and introducing a strong mineral acid into said first main passageway and through said channels into said second main passageway effecting solution of coal substance in said strong mineral acid, withdrawing reaction products of said acid from said coal bed, introducing combustion-supporting fluid through one of said main passageways, and withdrawing gaseous products of reaction from the other of said main passageways.

References Cited in the file of this patent

UNITED STATES PATENTS

2,630,306 Evans ..... Mar. 3, 1953