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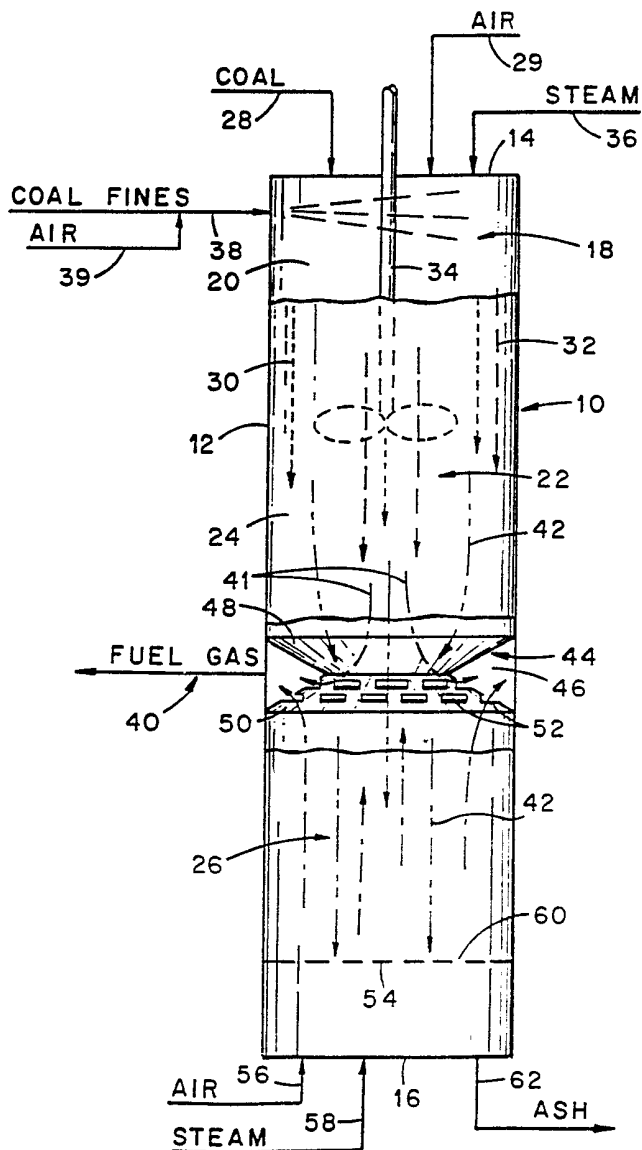
(52) UK CL (Edition L)
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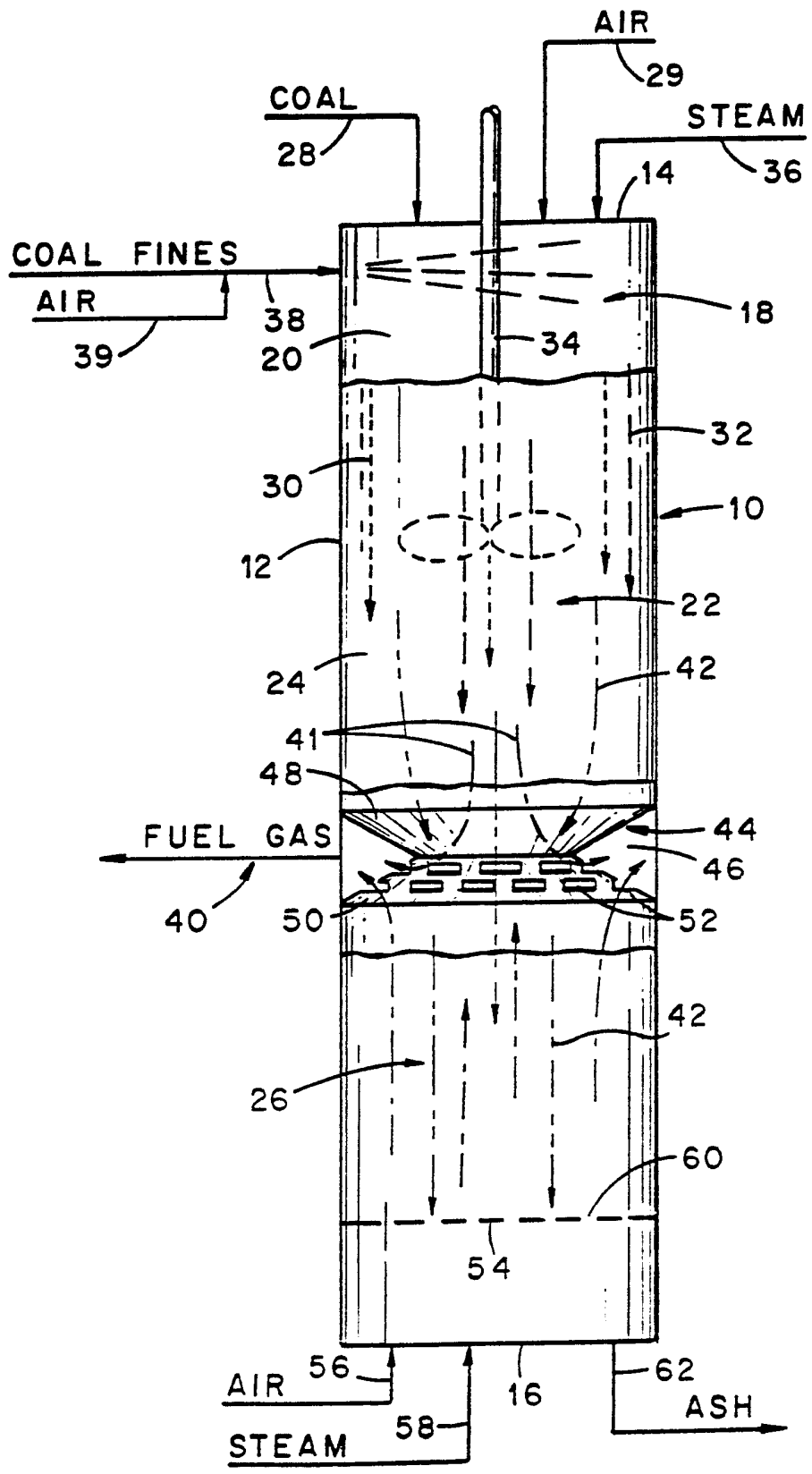
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(54) **Moving bed coal gasifier**

(57) A moving bed coal gasifier 10 for the production of tar-free, low ammonia fuel gas, employs a combustion zone 20 in a free-board area above the moving bed 24 to burn coal fines to provided hot combustion gases for pyrolyzing and gasifying coal particulates in the moving bed to form fuel gas as the hot gases move co-currently with the downwardly moving coal particulates. The fuel gas contains entrained tars and ammonia compounds which contact hot char and ash in the moving bed and are cracked so that the fuel gas removed from the gasifier at a mid-point off-take 40 is essentially tar-free and of low ammonia content. Concurrently with this gasification reaction, steam and an oxidant are introduced into a region below the moving bed to flow countercurrently to the downwardly moving bed to contact and react with carbon remaining in the char to create additional fuel gas which is also extracted from the gasifier at the mid-point off-take 40.



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SPLIT FLOW GASIFIER

BACKGROUND OF THE INVENTION

The present invention relates generally to a moving bed gasifier for the production of fuel gas, and more particularly to a moving bed gasifier having a gas take-off intermediate upper and lower ends of the gasifier and which provides essentially tar-free and low-ammonia fuel gas. The United States Government has rights in this invention pursuant to the employer-employee relationship of the U. S. Department of Energy and the inventor.

Coal gasification techniques used for the production of fuel gas have been practiced in various gasifier configurations and systems including those utilizing fixed, moving and fluidized bed concepts. Of these various gasification systems, the gasifiers employing moving beds have received wide acclaim and usage. In a typical operation of a moving bed gasifier, particulate coal is introduced into the reaction vessel of the gasifier through the upper end thereof while an oxidant and high temperature steam are introduced into the reactor vessel through the lower end thereof for passage upwardly or countercurrently to the downwardly moving bed of coal. As the oxidant and steam contact the moving particulates in a lower portion of the moving bed of coal, the coal particulates are sufficiently heated to provide a reaction capable of producing gaseous products including fuel gas. These gaseous products passing countercurrently to the moving bed of coal, heat the coal sufficiently to volatilize the coal to effect the release of hydrocarbons and tars from the coal in the upper portion of the moving bed. These volatilization products including tars are discharged along with the fuel gas through the top end of the gasifier.

The removal of the volatization products and tars from the fuel gas have presented considerable difficulties and problems. For example, various water scrubbers, condensers, and the like are often used to separate the tars and other condensibles from the fuel gas. Such removal techniques, in turn, present other clean-up problems such as the cleaning of the waste water from the scrubbers. Also, sulfur species contained in volatization products are responsible for environmental pollution problems but the removal of such sulfur species from gas streams containing tars have been found to present some problems. For example, the presence of tars in the gases being treated effectively limits the use of particulate sulfur sorbents such as zinc ferrite since sulfur in the tars is not removed by such sorbents. Also, the tars can destructively coat and plug the sorbent. Thus, in order to use such particulate sorbents the tars must first be removed from the gas stream by employing condensation or other procedures. The tar-removing treatments of the gas stream significantly reduce the temperature of the gas stream and presents a clean-up problem for the condensed tars. The required cooling of the gas stream for the removal of tars prevents the extraction of heat values in the gases in a heat engine such as a turbine or the like.

A still further problem encountered with the use of presently known moving bed gasifiers is that coal fines, i.e., coal particulates of a size less than about 0.25 inch, in the coal feed introduced in the gasifier through the top end thereof are essentially instantly entrained by the upwardly flowing gases and are carried out of the gasifier along with these gases so as to introduce a further clean-up problem while decreasing the overall efficiency of the gasification system with respect to the coal utilization. To overcome this problem, the size distribution of the coal particulates fed to the gasifier is maintained in a relatively narrow range so as to minimize the introduction of coal fines into the gasifier.

SUMMARY OF THE INVENTION

Accordingly, it is a principle aim or objective of the present invention to obviate or substantially minimize the above

and other problems and shortcomings encountered during the use of moving bed gasifiers for the production of fuel gas. The present invention is directed to a moving bed gasifier arrangement which is capable of producing a discharge stream of high temperature fuel gas which is essentially tar-free and contains relatively low concentrations of ammonia species. In accordance with the present invention, the moving bed gasifier is constructed in such a manner that the tars and hydrocarbons devolatilized from the coal are passed downwardly through a bed of hot coal char before exiting the gas off-take positioned on the gasifier at a location substantially midway or intermediate the upper and lower ends thereof. This contacting of the tars and hydrocarbons with the hot char causes the tars and ammonia to crack and thereby effectively remove the tars and ammonia from the fuel gas stream.

Generally, the gasifier of the present invention is a split-flow gasifier comprising an elongated vertically oriented reactor means having upper, lower, and intermediate regions. Means are provided for introducing coal particulates including coal fines into the upper region of the gasifier to form a bed of coal particulates moving downwardly through the intermediate region of the gasifier. Means are also provided for introducing a stream of combustion supporting medium or oxidant into the upper region for effecting therein the combustion of the coal fines to provide a stream of hot combustion gases. This hot gas stream is contactable with downwardly moving coal particulates within an upper portion of the moving bed for reacting with these coal particulates to provide a stream of gaseous products including fuel gas while producing char and ash. Means are employed for introducing a gaseous oxidant and steam into the lower region of the gasifier for contacting and reacting with carbon values in the char entering into a lower portion of moving bed to provide a further stream of gaseous products including fuel gas. Discharge means or gas off-take means are in registry with the intermediate region and the moving bed at a location thereon substantially between the aforementioned upper and lower portions thereof for removing the gaseous products from the gasifier.

The moving-bed coal gasifier of the present invention as generally described above, can utilize a coal-water slurry or the injection of steam at the upper end thereof with a dry coal feed so as to enhance the fuel gas producing reactions by enabling a steam-carbon reaction to occur with the coal during the pyrolysis and gasification thereof. The gasifier is provided with baffle means near the mid-point gas off-take means to permit the withdrawal of the essentially particulate-free fuel gases through the gas off-take means. The baffle means also provides for the continuous flow of coal char, ash and any remaining coal passed the gas off-take means for the gasification of carbon values remaining in any coal and the coal char in the lower portion of the moving bed.

By employing the gasifier of the present invention, the sizing of coal as heretofore required for forming the moving bed is no longer required since in the present gasifier the coal fines are combusted in the upper region of the gasifier to provide the hot gases necessary for the endothermic pyrolysis and gasification reactions occurring in the moving bed.

The fuel gas discharged from the gasifier is at a relatively high temperature and can be directly used in applications where the heat energy in the high temperature gas can be effectively utilized such as in a turbine-driven electrical power generation system. With the present invention, the tars as well as the ammonia species are significantly removed or reduced from the fuel gas while within the confines of the gasifier, thus minimizing any reduction of gas temperature required for gas clean-up procedures such as the removal of sulfur species from the fuel gas in a sorbent bed downstream of the gasifier.

Other and further objects of the present invention will become obvious upon an understanding of the illustrative embodiment about to be described or will be indicated in the appended claims, and various advantages not referred to herein will occur to one skilled in the art upon employment of the invention in practice.

DESCRIPTION OF THE DRAWING

The figure is a sectional schematic view illustrating the moving bed gasifier arrangement of the present invention in which oxidants are introduced at opposite ends of the gasifier vessel while the product gas is withdrawn from the mid-point of the gasifier.

DETAILED DESCRIPTION OF THE INVENTION

As generally described above, the present invention is directed to a moving bed coal gasification apparatus which represents a considerable departure from the construction and the operational features of previously known moving bed gasifiers and which provides an essentially tar-free and low ammonia stream of fuel gas. The tar-free and low ammonia characteristics of the fuel gas extracted from the moving bed of the gasifier of the present invention effectively eliminate the extensive and costly cleanup procedures as heretofore required for fuel gas generated in moving bed gasifiers before the gas could be utilized in an envisioned application.

With reference to the figure, a moving bed coal gasifier embodying features of the present invention is generally shown at 10 and comprises a reaction vessel 12 of an elongated, vertically oriented and cylindrical configuration closed at both the top end 14 and the bottom end 16. The interior of the reaction vessel 12 is divided essentially into three vertically spaced regions as generally provided by an upper region 18 which contains a combustion zone 20 for providing a stream of hot gaseous products produced by the burning of coal particulates, especially coal fines. An intermediate region 22 in registry with the upper region 18 contains a moving bed 24 of coal particulates which are to be pyrolyzed and gasified by the hot gases discharged from the combustion zone 20 as the coal particulates move downwardly through the moving bed 24. The reaction vessel 12 is also provided with a lower region 26 which is in registry or merges with the lower portion of the moving bed 24 for completing the gasification of essentially any carbon remaining in the char

resulting from the pyrolyzation and gasification of the coal in an upper portion of the moving bed 24 as the char moves downwardly into the lower portion of the moving bed 24 so as to significantly increase the overall efficiency of the coal gasification operation.

As shown in the figure, coal particulates which include coal fines of a particle size less than about 0.25 inch from a suitable supply (not shown) are introduced through conduit 28 into the top end 14 of the gasifier into a free-board area in the upper region 18 overlying the moving bed 24 that defines the combustion zone 20. Concurrently, with the feeding of the coal particulates into the combustion zone 20, a stream of combustion supporting medium or oxidant (air or oxygen) is introduced into the combustion zone 20 through the top end 14 of the gasifier via conduit 29 to support combustion of coal fines within the combustion zone 20. This combustion of the coal provides a stream of hot combustion products which as generally indicated by the arrows 30 are directed downwardly into the moving bed 24 for co-current flow with the coal particulates therein as generally shown by the arrows 32.

The coal particulates introduced into the gasifier through the conduit 28 are preferably evenly spread over the moving bed by employing a suitable bed stirring and leveling device such as generally shown at 34. Alternatively, multiple inlet ports for the coal feed could be utilized to provide a relatively level upper surface on the moving bed for achieving the desired definition of the combustion zone 20. The coal feed can contain coal fines in a concentration of about 5 to 50 percent of the coal feed. The non-fine coal particulates are of a size in the range of about 0.25 inch to 2 inches. This coal in the feed may be mixed with water to form a coal-water slurry prior to the introduction thereof into the gasifier 10. Alternatively, the coal can be introduced into the gasifier as a dry feed. In such an instance, steam is preferably injected into the gasifier through conduit 36. The addition of the water, in the slurry or as steam, enables a steam-carbon reaction to occur in the moving

bed 24 to significantly increase the heating value and the quantity of the fuel gas generated by the reaction of the hot combustion gases with the coal particulates. If desired, a stream of coal fines can be injected directly into the combustion zone 20 through line 38. A stream of air through line 39 may be used to disperse the coal fines within the combustion zone 20.

In order to assure that the gasification reaction occurring in the moving bed is an endothermic reaction, the oxidation conditions within the combustion zone 20 are preferably maintained at near stoichiometric or sub-stoichiometric levels. It is only necessary that combustion of the coal fines in the combustion zone 20 provide a sufficient quantity of hot combustion products to effect the endothermic gasification reaction of the coal particulates and the steam-carbon reaction in the moving bed as these combustion gases pass downwardly through a portion of the moving bed.

Coal particulates in the moving bed 24 and the gaseous products of combustion from the combustion zone 20 move concurrently downwardly through the upper portion of the intermediate region 22 towards a off-take or discharge port 40 which is located generally between the upper and lower regions 18 and 26. The hot, essentially reducing, gases produced in the combustion zone 20 contact the coal particulates in the moving bed to sequentially dry, pyrolyze, and gasify the coal to form a gaseous product, as generally shown by the arrows 41, and which is primarily formed of fuel gas containing tars, sulfur species, ammonia compounds, and other hydrocarbons. As this endothermic gasification reaction occurs, the gas and solid temperatures are continually reduced until the gases 41 reach the level of the off-take line 40. During these reactions, the tars and volatile hydrocarbons released from the coal in the uppermost part or portion of the intermediate region 22 are entrained by the combustion gases and by the fuel gas being generated in the moving bed so as to force them downwardly through the moving bed where these tars and hydrocarbons contact hot char and ash being generated by the reactions as generally shown by the arrows 42 so as to cause the

tars and hydrocarbons to crack before the gases reach the off-take line 40. This cracking essentially removes the tars and ammonia compounds from the fuel gas being discharged from the gasifier 12.

5 In order to assure that the gases produced within the gasifier can be withdrawn from the gasifier through the off-take 40 essentially free from particulate material, the interior of the gasifier vessel 12 at the point of gas off-take is preferably provided with baffle means 44 for creating an essentially particle-free annular volume 46 near the inner walls of the
10 gasifier. These baffle means permit partially gasified char and the ash particulates to proceed downwardly through the gas off-take portion of the moving bed while the tar-free, low ammonia fuel gas is separated from the particulate materials and withdrawn from the gasifier through the conduit 40. These baffle means 44
15 may be suitably provided by employing an annular, downwardly and inwardly inclined upper wall 48 which extends into the vessel interior a sufficient distance to permit passage of the char and ash particulates thereby and which will create the annular particle free volume 46 under the wall 48. An upwardly angled or
20 inclined lower wall 50 provided with suitable perforations 52 is preferably joined to the upper wall 48 to support the latter and further define therewith the annular volume or void 46.

The partially gasified char, which still contains some carbon, and the ash as indicated by arrow 42 proceed downwardly
25 through the moving bed 24 to locations in the lower portion of the moving bed disposed below the off-take 40 and towards a suitable perforated grate 54 supporting the moving bed 24. In this lower portion of the moving bed 24, the char is contacted with an oxidant (air or oxygen) and steam which are respectfully
30 introduced into the lower region 26 through conduits 56 and 58. This mixture of steam and oxidant passes upwardly through the perforations 60 in the grate 54 in a direction countercurrently to that of the char and ash in the downwardly moving bed. As a result of this countercurrent flow, the steam and oxidant contact
35 the hot char and react with the residual carbon in the char to burn out carbon remaining in the char. The steam provides an

additional source of heat for this reaction and also causes a steam-carbon reaction to occur which depletes the residual carbon in the char. This steam-carbon reaction effectively reduces the quantity of oxygen which would otherwise be needed to completely
5 burn out the residual carbon in the char and increases the heating value of the fuel gas. The fuel gas formed in the lower portion of the moving bed are combined with the fuel gas produced in the upper portion of the moving bed by the downwardly flowing combustion gases and are withdrawn through the gas off-take line 40.
10 The ash resulting from these gasification procedures is discharged through the perforations 60 in the grate 54 and removed from the gasifier through a discharge port 62.

The gasification apparatus of the present invention provides a stream of hot fuel gas which is characterized by being
15 essentially tar free and with a relatively low content of ammonia values. This essentially tar-free hot gas stream can be advantageously utilized in a gas turbine to extract the heat energy in the fuel gas since the gases discharged from the gasifier can be subject to particulate and sulfur removal
20 procedures without excessively reducing the temperature of the gas stream. In order to further facilitate the reduction of sulfur species in the hot fuel gas, a sulfur sorbing material such as calcium carbonate may be injected into the gasifier along with the
25 alkali catalysts to the coal feed to the gasifier.

What is claimed is:

Claim 1. A split-flow coal gasifier comprising an elongated vertically oriented reactor means having upper, lower and intermediate regions, means for introducing coal particulates including coal fines into said upper region to form a downwardly moving bed of coal particulates in said intermediate region, means for introducing a stream of combustion supporting medium into said upper region for effecting therein the combustion of said coal fines to provide a downwardly flowing stream of hot combustion gases contactable with downwardly moving coal particulates within an upper portion of said bed for reacting with the coal particulates therein to provide a stream of gaseous products including fuel gas while producing hot coal char and ash, means for introducing a gaseous oxidant and steam into said lower region for contacting and reacting with residual carbon in said char in said lower portion of the bed to provide a further stream of gaseous products including fuel gas, and discharge means in registry with said intermediate region and said bed at a location intermediate said upper portion and said lower portion for removing said streams of gaseous products from the reactor means.

Claim 2. A split-flow coal gasifier as claimed in Claim 1, wherein the reaction of the combustion gases with the coal particulates in said upper portion of the bed releases tar and hydrocarbon values from the coal particulates, and wherein the tars and hydrocarbon values released from the coal are supported and conveyed by the first mentioned stream of gaseous products for contact with the hot coal char for sufficient heating thereof to substantially crack said tars and hydrocarbon values prior to the first mentioned stream of gaseous products reaching said discharge means.

Claim 3. A split-flow coal gasifier as claimed in claim 1, wherein said discharge means includes gas off-take means and baffle means for directing solid particulate material away from said gas off-take means.

Claim 4. A split-flow coal gasifier as claimed in claim 3, wherein said baffle means comprises annular inwardly inclined wall

means for defining a gas-receiving annular volume, and wherein said gas off-take means is in registry with said annular volume
5 for receiving gas therefrom.

Claim 5. A split-flow coal gasifier as claimed in Claim 1, wherein said means for introducing coal particulates including coal fines comprises at least one conduit means in registry with said upper region.

Claim 6. A split-flow coal gasifier as claimed in Claim 5, wherein the coal particulates are mixed with water and introduced into the upper region through said conduit means as a coal water slurry.

Claim 7. A split-flow coal gasifier as claimed in Claim 5, wherein the coal fines comprise coal particulates of a size less than about 0.25 inch.

Claim 8. A split-flow coal gasifier as claimed in Claim 7, wherein the coal fines comprise about 5 to 50 percent of the coal particulates.

Claim 9. A split-flow coal gasifier as claimed in Claim 5, wherein said at least one conduit means comprise a plurality of conduit means, and wherein a stream substantially comprising coal fines is introduced into the upper region through at least one of
5 said plurality of conduit means.

Claim 10. A split-flow coal gasifier as claimed in Claim 9, wherein means are coupled to said at least one of said plurality of conduit means for introducing thereinto a stream of air for injecting the coal fines in said at least one of said plurality of
5 conduit means into said upper region.

Claim 11. A split-flow coal gasifier as claimed in Claim 5, wherein a further conduit means is in registry with said upper region for introducing thereinto a stream of steam.

Claim 12. A split-flow coal gasifier as claimed in Claim 5, wherein said combustion supporting medium comprises air or oxygen, and wherein the concentration of air or oxygen is sufficient to provide near stoichiometric or sub-stoichiometric reaction
5 conditions in said upper region.

Patents Act 1977
Examiner's report to the Comptroller under
Section 17 (The Search Report)

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Relevant Technical fields

(i) UK CI (Edition K) C5E (EAF), (EAG), (EAM)

(ii) Int CI (Edition 5) C10J

Search Examiner

R J WALKER

Databases (see over)

(i) UK Patent Office

(ii)

Date of Search

12 NOVEMBER 1992

Documents considered relevant following a search in respect of claims 1-12

Category (see over)	Identity of document and relevant passages	Relevant to claim(s)
X	GB 2116201 A (SKF STEEL ENGINEERING) see whole document particularly figure 1	at least Claim 1
X	EP 0240483 A (DISTRIGAZ) see whole document, particularly figure 2	at least Claim 1
X	EP 0051482 A (DOUGLAS COCHRANE SONS & CO) see whole document, particularly the drawing	at least Claim 1



Category	Identity of document and relevant passages	Relevant to claim(s)

Categories of documents

X: Document indicating lack of novelty or of inventive step.

Y: Document indicating lack of inventive step if combined with one or more other documents of the same category.

A: Document indicating technological background and/or state of the art.

P: Document published on or after the declared priority date but before the filing date of the present application.

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