Feb. 2, 1960 R. RUMMEL 2,923,260

GASIFICATION OF FUELS

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FIG.1

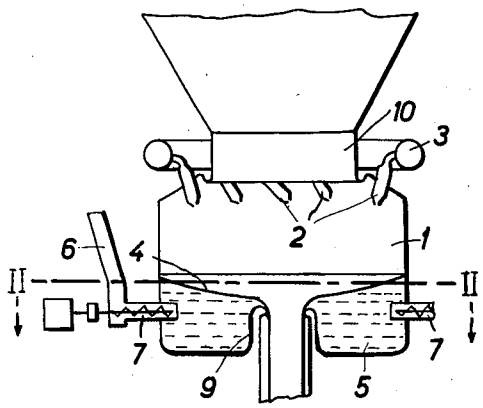
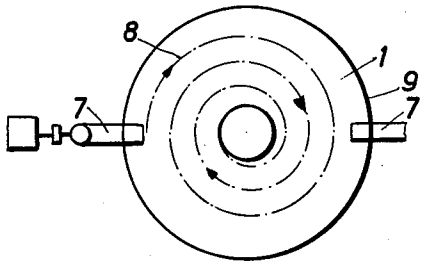


FIG.2



INVENTOR.
ROMAN RUMMEL

BY Connolly and Hutz

his ATTORNEYS

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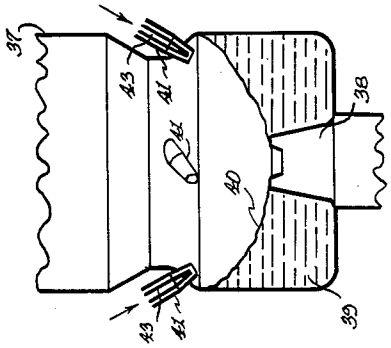


FIG. 9

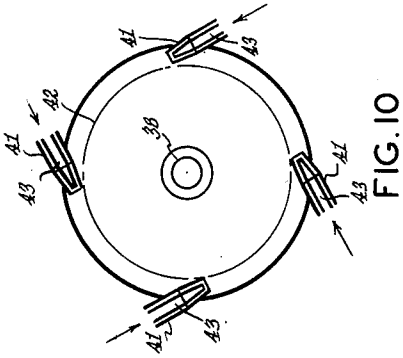


FIG. 10

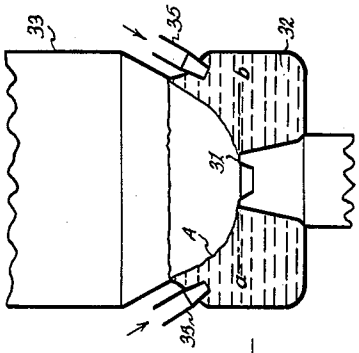


FIG. 7

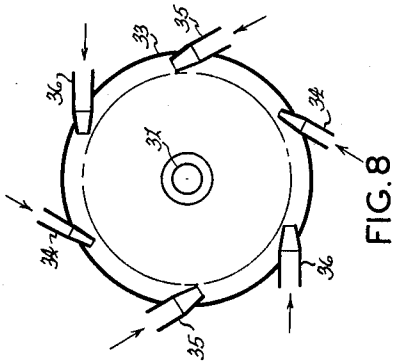


FIG. 8

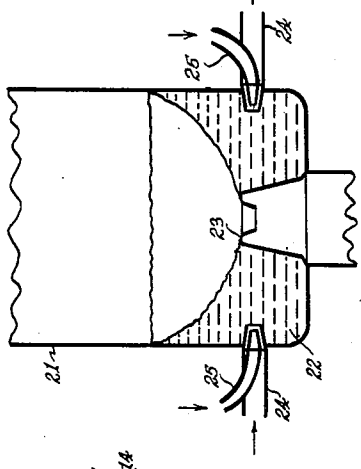


FIG. 5

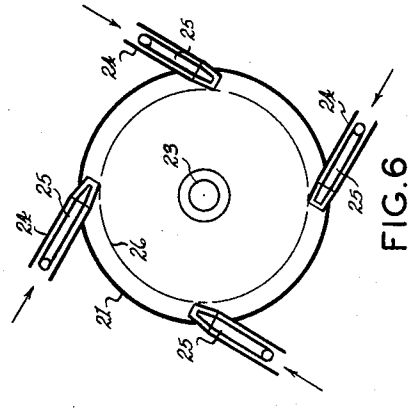


FIG. 6

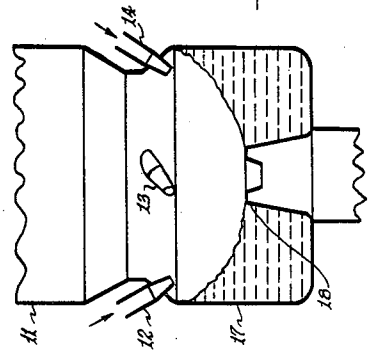


FIG. 3

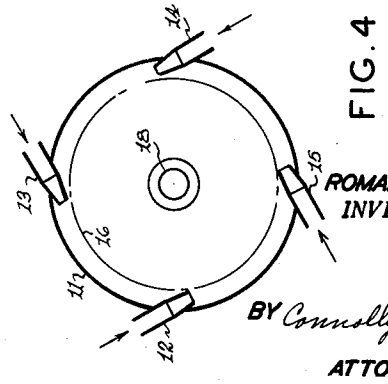


FIG. 4

ROMAN RUMMEL
INVENTOR.

BY Connolly and Hutz
ATTORNEYS

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GASIFICATION OF FUELS

Roman Rummel, Bruhl, Bez. Koln, Germany, assignor to Union Rheinische Braunkohlen Kraftstoff Aktiengesellschaft, Wesseling, Bez. Koln, Germany, a corporation of Germany

Application July 17, 1953, Serial No. 368,711

Claims priority, application Germany August 21, 1952

5 Claims. (Cl. 110—28)

This invention relates to improvements and apparatus for the combustion and gasification of fuels.

It is known to burn or to gasify fuels in a cyclone-type chamber into which air and the fuel are introduced in a substantially tangential direction. The fuel is blown onto the wall of the chamber by centrifugal force where it is burnt or gasified and its residue runs down the wall in the form of a liquid slag. The liquid or molten slag is withdrawn through an outlet provided at the deepest part of the chamber. The essential feature of this prior art combustion process consists in that the fuel adheres to a thin film of slag and the air for combustion passes against the fuel at high velocity. Like the centrifugal dust separators, which operate on the same principle, the aforesaid devices, known as turbulence chamber or cyclone burner, have the disadvantage that in particular the finest dust particles do not all reach the wall but instead part of them are carried off from the chamber together with the gas stream.

The binding force of the liquid slag, which holds the fuel until its combustion or gasification is complete and takes up the residue of combustion, i.e. the newly formed slag, is not effectively utilized but only insofar as the fuel reaches the slag film running down the wall. The remaining portion of the fuel is burnt or gasified whilst in suspension and the ash carried off from the turbulence chamber together with the gaseous stream. The ash issues from the turbulence chamber in liquid or sticky condition and causes the well-known trouble in the apparatuses connected at the outlet side of the chamber, for instance on heating surfaces, by baking unless it is removed from the gaseous stream by special means.

It is also known to destructively distil and to gasify fuels in a liquid slag bath maintained in constant motion by the flow energy of the gasifying agents. In this process the fuel is taken up by the slag and possibly reacts with it so that constituents of the slag are reduced and re-oxidized by the oxygen of the gasifying reactants until the fuel has been converted without residue into the gaseous condition. The fuel residue, i.e. the ash, remains in the slag bath.

It is the object of the present invention to overcome the disadvantages associated with the above prior art methods for the combustion and gasification of fuels and to provide an improved process and an improved apparatus, allowing to effectively utilize the capacity of the slag to bind the fuel until the latter is completely burnt or gasified and to take up its ash to that the gases obtained are free or substantially free from ash particles.

Further objects will become apparent as the following description proceeds.

In accordance with the invention the fuel is supplied to a liquid slag bath designed as a slag turbulence sink and the rotary movement of the slag bath is maintained by the flow energy of air or the gasifying agents introduced into the liquid slag while, at the same time, the fuel distributed in the slag bath is burnt or gasified. The term "slag turbulence sink" as used throughout the

specification and claims is contemplated to comprise a slag reservoir reaction zone, preferably of cylindrical dimensions, wherein the slag bath rotates in a turbulent motion. The quantity of said slag bath is adjusted by an overflow at the level of the surface of the slag bath, preferably positioned in the centre of for instance a cylindrical chamber. The combustion of the fuel retained by the slag takes place on a spiral path of travel from the outer wall to this opening. The newly formed slag runs off through the opening of the slag turbulence sink and can be granulated in known manner in a subjacent water bath.

The fuel may be introduced into the slag bath above or below the level of the slag, in a vertical or inclined direction. The air for combustion or the gasifying agent or agents may also be admitted above or below the level of the slag in a direction equal or substantially equal to that of the rotating slag bath. The fuel can be introduced into the rotating slag bath locally separately from or together with the combustion supporting gases. The fuel when introduced together with the combustion supporting gases will assist in maintaining the circulatory and turbulent motion of the slag bath.

The economy of the process according to the invention is considerably increased by preheating the air or the gasifying agent or agents, particularly in the gasification of fuels of lower calorific value.

The overflow pipe is protected from getting frozen by passing through it a partial stream of the gases produced in the combustion or gasification chamber. This partial gas stream can be merged again with the main stream of the gases in an apparatus connected at the outlet side of the combustion or gasification chamber.

In the gasification according to the invention the fuels are subjected to treatment with predominantly exothermic gasifying agents, i.e. gases, such as air, oxygen enriched air or oxygen, which react exothermically with the fuel to convert it into gas.

The introduction of the combustion supporting gases and, if desired, also the fuel into the slag bath with high velocity imparts a circulatory and turbulent motion to the molten slag. Depending on the required reaction temperature, which must exceed the melting point of the slag, the exothermic gasifying agents may be admixed with varying quantities of endothermic gasifying agents, i.e. gases, such as steam or carbon dioxide, which react endothermically with the fuel to convert it into gas. The proportion of the endothermically reacting agents can be increased by preheating the gasifying agents.

Preferably the walls of the combustion or gasification chamber as well as the nozzles and other devices in this chamber, which come in contact with the slag, are protected from attacks by the liquid slag by cooling with liquid or gaseous media. A slag crust forms then on the walls of the chamber, the valves and said other devices, protecting them from the liquid slag and limiting the transfer of heat. The heat conducted through the walls can be made use of to predry the air for combustion or the gasifying agent or agents and to produce and if necessary to superheat steam. According to a preferred embodiment of the invention the walls of the gasifying chamber are formed wholly or in part as cooling walls, for example by a system of tubes through which a cooling medium, for instance water for steam generation, is led.

One embodiment of the invention is illustrated by way of example in the accompanying diagrammatic drawing in which

Fig. 1 is a sectional view of a combustion or gasification chamber.

Fig. 2 is a horizontal view thereof on the line II—II of Fig. 1.

Fig. 3 is a fragmentary sectional view of a second em-

bodiment of the invention wherein the fuel and combustion supporting gas are separately introduced above the slag level.

Fig. 4 is a top plan view of the apparatus shown in Fig. 3.

Fig. 5 is a sectional view of a third embodiment of the present invention wherein the fuel and combustion supporting gas are introduced together below the surface of the slag.

Fig. 6 is a top plan view of the apparatus of Fig. 5.

Fig. 7 is a sectional view of a fourth embodiment of the present invention wherein the fuel and combustion supporting gas are introduced separately below the surface of the slag.

Fig. 8 is a top plan view of the apparatus of Fig. 7.

Fig. 9 is a fifth embodiment of the present invention wherein the fuel and combustion supporting gas are both introduced together above the level of the liquid slag.

Fig. 10 is a top plan view of the apparatus of Fig. 9.

According to the specific embodiment exemplified in Figs. 1 and 2, the air used for combustion or the gasifying agent is blown onto the rotating slag bath from above whereas the fuel is supplied into the slag bath below the level of the slag by means of feed worms.

Wind nozzles **2**, which are connected to a manifold **3**, open into the gasification chamber **1**. The manifold is connected to a blower. The wind nozzles are directed to the surface **4** of the rotating slag bath **5** in a downwardly inclined position and in such a manner that part of the flow energy of the air injected for combustion is used to maintain the circuit of the slag. The fuel is supplied through the duct **6** to the feed worms **7** transporting it into the slag bath **5** where it reacts with the slag and the air injected for combustion, and is converted without residue into the gaseous condition on the spiral path **8** indicated in Fig. 2 by a dash-dotted line. The slag forming from the ash of the fuel flows through the pipe **9** into a vessel filled with water (not shown in the drawing), from which it is continuously or periodically removed in granular form by conventional means. The combustion gases issue from the chamber **1** through the outlet **10**.

Of course, the invention allows for gasifying fuels which are admixed with air and/or other gasifying agents in proper relation to the fuel.

The fuel may also be blown into the slag pneumatically with air, a gasifying agent or some other suitable carrier gas.

The gases produced according to the invention are free or at least substantially free from ash particles and are directly usable for most industrial purposes without the necessity of special scrubbing or purifying treatments.

As will be apparent from the foregoing the novel apparatus in accordance with the invention for the improved gasification of fuels of all kinds with gaseous exothermic and, if desired, also endothermic reactants to recover thereby industrially valuable gases within the broad concept thereof, essentially comprises means designed as a slag turbulence sink of preferably cylindrical dimensions, said slag turbulence sink being adapted to be partially filled with liquid slag, overflow arrangements for controlling the content of liquid slag in said turbulence sink by continuously withdrawing slag at the rate as it is newly formed in the combustion of the fuel, said overflow arrangements being positioned in the center or approximately in the center of said turbulence sink at the surface of the level of the slag, means for introducing fuels into said slag turbulence sink above or below the surface of the level of the liquid slag, said means for introducing the fuels being arranged and positioned to introduce the fuels vertically to the surface of the liquid slag or in an inclined position to the moving direction of the liquid slag, nozzle means for introducing into said slag turbulence sink high velocity combustion supporting gases to be contacted with the fuels at the required reaction temperature to convert same into the gaseous condition, the inlets of said nozzle means being arranged and positioned to impart to the liquid slag in said slag turbulence sink a rotary and turbulent motion by the impelling force of the high velocity combustion supporting gases, said inlets of said nozzle means being positioned above or below the surface of the level of the liquid slag, and outlet means for recovering the reaction products from said slag turbulence sink. In the apparatus the means for introducing fuels and the nozzle means for introducing high velocity supporting gases may have common or substantially common inlet means into the slag turbulence sink so that the fuels will assist in maintaining the liquid slag in circulatory motion. Alternatively, the means for introducing fuels may simultaneously be used to introduce gasifying reactants. In the apparatus, means may be provided to recover the gases produced from the fuels separately for instance so that a partial gas stream is led through the overflow arrangements to prevent these from freezing; means may be provided outside the apparatus to merge this partial gas stream with the main gas stream. Furthermore, means may be provided to cool the walls of the slag turbulence sink and the other means contacted with the liquid slag. In a preferred apparatus according to the invention the walls of the slag turbulence sink are formed wholly or in part as cooling walls.

Figs. 3 and 4 illustrate an embodiment of the invention wherein the chamber **11** is provided with four annularly spaced nozzles **12**, **13**, **14** and **15** which are arranged tangentially of the chamber so that the material ejected therefrom is whirled in an annular path such as indicated at **16**. These nozzles are all positioned above the level of the slag bath **17** in the chamber and the slag is rotated by means of the tangential whirling action of the materials ejected from the nozzles.

Centrally positioned at the bottom of the chamber **11** is provided an overflow pipe **18** through which the slag flows into a vessel, not shown, from which it is either continuously or periodically removed in granular form by conventional means.

The nozzles **12** and **14** are used to inject the fuel while the combustion supporting gas is injected through nozzles **13** and **15**.

The embodiment of the invention shown in Figs. 5 and 6 comprises a chamber **21**, at the bottom of which is provided the slag bath **22**. Centrally located, at the bottom of the chamber **21**, is an overflow pipe **23**, similar to that shown at **18** in Figs. 3 and 4.

Below the level of the slag bath there are provided four nozzles **24** which are arranged in annularly spaced relationship to each other and tangential to the chamber so that the materials issuing therefrom are whirled in an annular direction indicated at **26**.

Within the nozzles **24** there are coaxially provided additional nozzles **25**. The combustion supporting gas is injected through the nozzles **24** around the internal nozzles **25**, and the fuel is inserted through the internal nozzles **25**. The external nozzles **24** project beyond the internal nozzles **25** and a mixture takes place between the fuel and the combustion gas at the mouth of each combined nozzle before they enter the chamber.

In the embodiment of the invention shown in Figs. 7 and 8 there is provided a chamber **33** having an overflow pipe **31** centrally located at the bottom thereof.

A slag bath **32** is provided at the bottom of the chamber. Extending downwardly into the slag bath, and arranged tangentially of the chamber, in annularly spaced relationship to each other, are a plurality of nozzles indicated at **34**, **35** and **36**. Fuel is injected through the nozzles **34**; oxygen, oxygen-containing gas or air is injected through the nozzles **35**; and water vapor, carbonic acid or a mixture of the two is injected through the nozzles **36**.

During the operation of the apparatus of Figs. 7 and 8, the surface of the slag is arched, as shown at A, so that the nozzles extend therein. However, when rotation

of the bath is halted, the surface of the slag automatically assumes the position indicated at *a—b*. In this manner, it is not possible for the slag to stop up the nozzles during the time that the device is not in operation. This is an advantage over such apparatus as shown in Figs. 5 and 6, since in the apparatus of Figs. 5 and 6, before the operation ceases, the slag must be blown off so that it does not flow into the nozzles and subsequently harden therein.

In the embodiment of Figs. 7 and 8, as long as the slag is not cooled under the ignition point of the fuel, operation can immediately recommence at any time.

In the embodiment of Figs. 9 and 10, an apparatus is shown which is similar to that of Figs. 3 and 4. In this embodiment, the chamber **37** is provided with a centrally positioned overflow pipe **38** at the bottom thereof, with a slag bath **39** surrounding the overflow pipe. Above the level **40** of the slag bath are positioned four annularly spaced nozzles **41**, arranged tangentially to the chamber **37**, to provide an annular flow path indicated at **42**. This construction, up to this point, is identical to that shown at Figs. 3 and 4. However, it differs from that previously described construction in that, within each nozzle **41**, there is provided an internally positioned coaxial nozzle **43**. The combustion-supporting gas is injected through nozzles **41** around the nozzles **43** and the fuel is introduced through the nozzles **43**. Both materials combine at the mouth of the nozzles **41**, in similar manner to the apparatus shown in Figs. **5** and **6**.

The above-described forms of the invention may be used in accordance with the type of slag formed. For example, where the slag is relatively thin and fluid, it is advantageous to inject the fuel beneath the surface of the slag bath. On the other hand, where the slag is thick and highly viscous, it has been found advantageous to inject the fuel from above the surface of the slag bath.

I claim:

1. Process for the combustion and gasification of fuels which comprises introducing the fuel into a relatively deep liquid slag bath below the surface of the level of said liquid slag bath, contacting said fuel in said liquid slag bath with at least one combustion supporting gas, introducing predetermined quantities of an endothermic gasification reactant for said fuel, said combustion supporting gas being introduced into said liquid slag bath so as to maintain a rotary and turbulent movement of said liquid slag bath, continuously withdrawing the newly formed slag in said liquid slag bath, and recovering the gases produced from said fuel.

2. A process for the combustion and gasification of fuels which comprises forming a relatively deep liquid slag bath, introducing fuel into said bath in a direction to maintain a rotary and turbulent movement of the liquid slag in the bath, contacting said fuel in said bath with at least one combustion supporting gas, said combustion gas being introduced below the slag bath surface level, introducing an endothermic gasification reactant for said fuel into the bath to produce product gases and new slag, continuously withdrawing the slag from said bath in proportion to the amount of new slag produced, and recovering the product gases produced from said fuel.

3. Apparatus for the combustion and gasification of fuels, comprising a bath-forming chamber for holding a liquid slag bath, nozzle means for introducing high velocity combustion supporting gases into the bath in said chamber, means for introducing fuels into the bath in said chamber, overflow means spaced a substantial distance above the bottom of said chamber for continuously withdrawing the slag formed in the combustion of the fuels, said nozzle means and said fuel introducing means leading into said chamber below the surface level of said bath, said surface being defined by the level of said overflow means, said overflow means being centrally positioned in said chamber to provide a central overflow area in the bath, and means for recovering the gases produced from the fuels in the said bath.

4. Apparatus according to claim 3, in which the said nozzle means for introducing combustion supporting gases and the said means for introducing fuels have common inlet means into said chamber.

5. Apparatus for the combustion and gasification of fuels, comprising a bath-forming chamber for holding a liquid slag bath, nozzle means for introducing high velocity combustion supporting gases into the bath in said chamber, means for introducing fuels into the bath in said chamber, said fuel introducing means being located below the bath surface, overflow means spaced a substantial distance above the bottom of said chamber for continuously withdrawing the slag formed in the combustion of the fuels, said overflow means being centrally positioned in said chamber to provide a central overflow area in the bath, and means for recovering the gases produced from the fuels in the said bath.

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