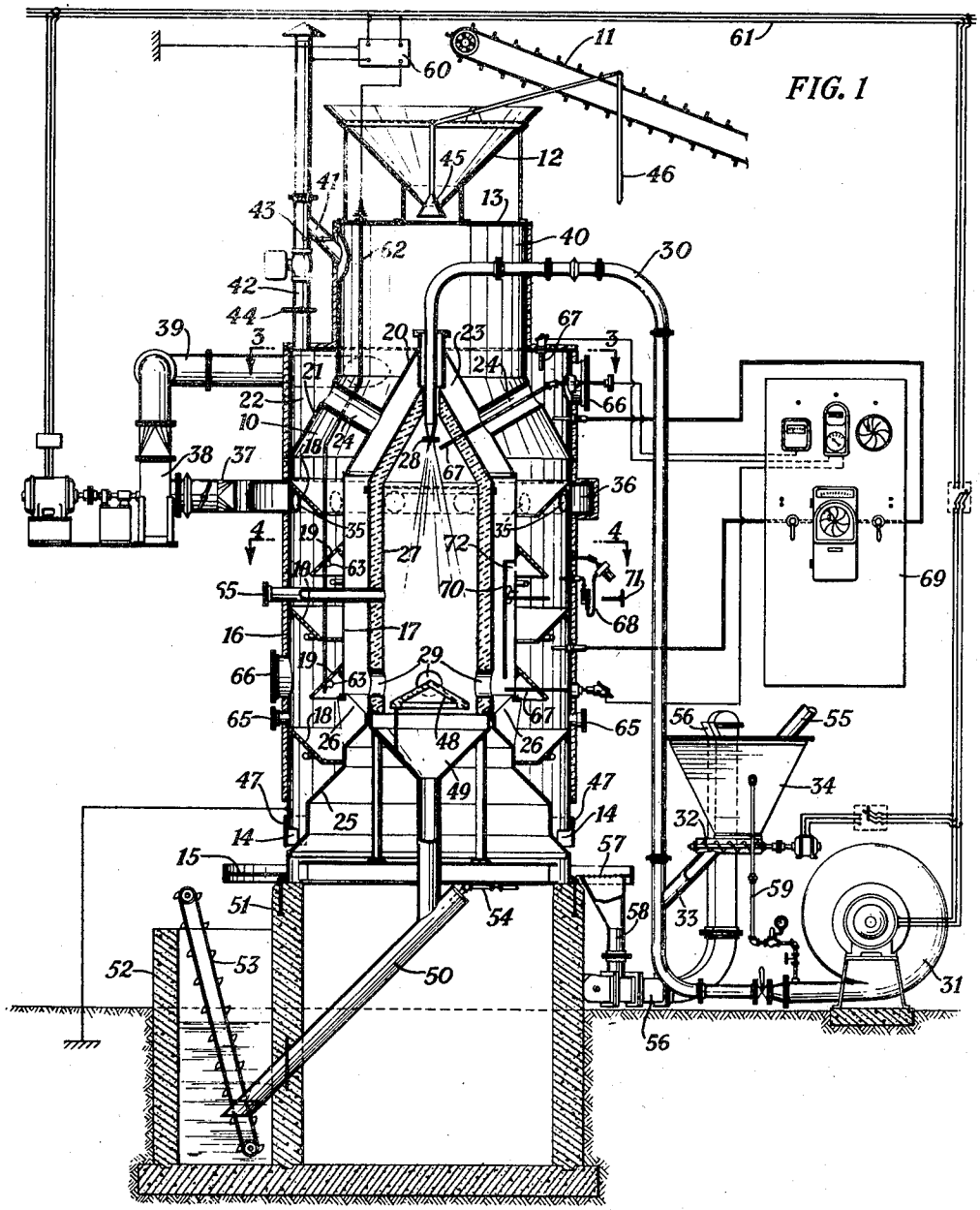
March 23, 1948. H. E. BECKER 2,438,199

METHOD AND APPARATUS FOR THE HEAT TREATMENT OF LOW GRADE COAL

Filed Jan. 12, 1942 4 Sheets-Sheet 1

FIG. 1



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METHOD AND APPARATUS FOR THE HEAT TREATMENT OF LOW GRADE COAL

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FIG. 2

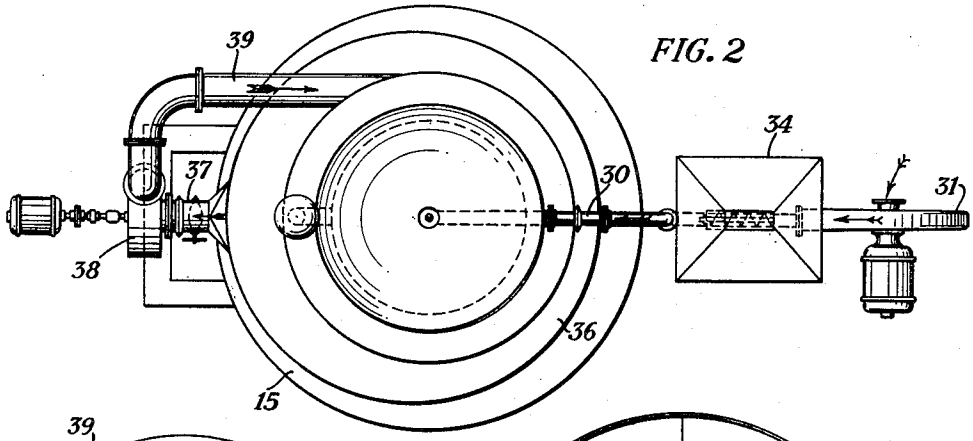


FIG. 3

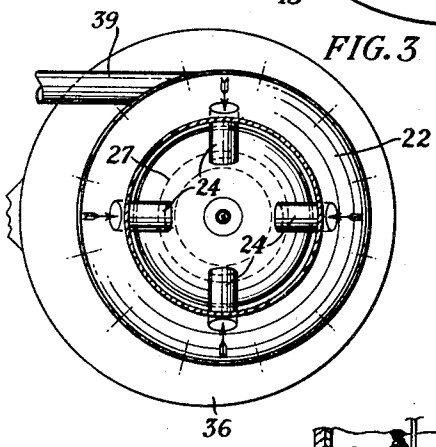


FIG. 4

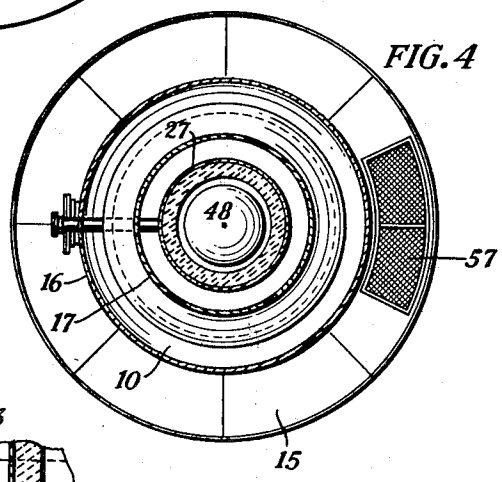


FIG. 6

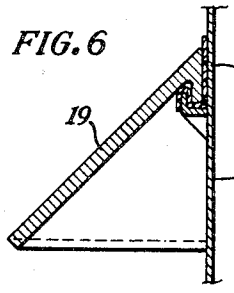
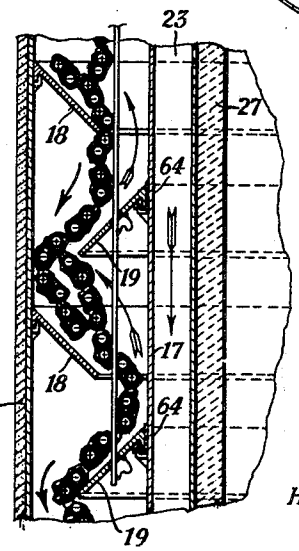


FIG. 7



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METHOD AND APPARATUS FOR THE HEAT TREATMENT OF LOW GRADE COAL

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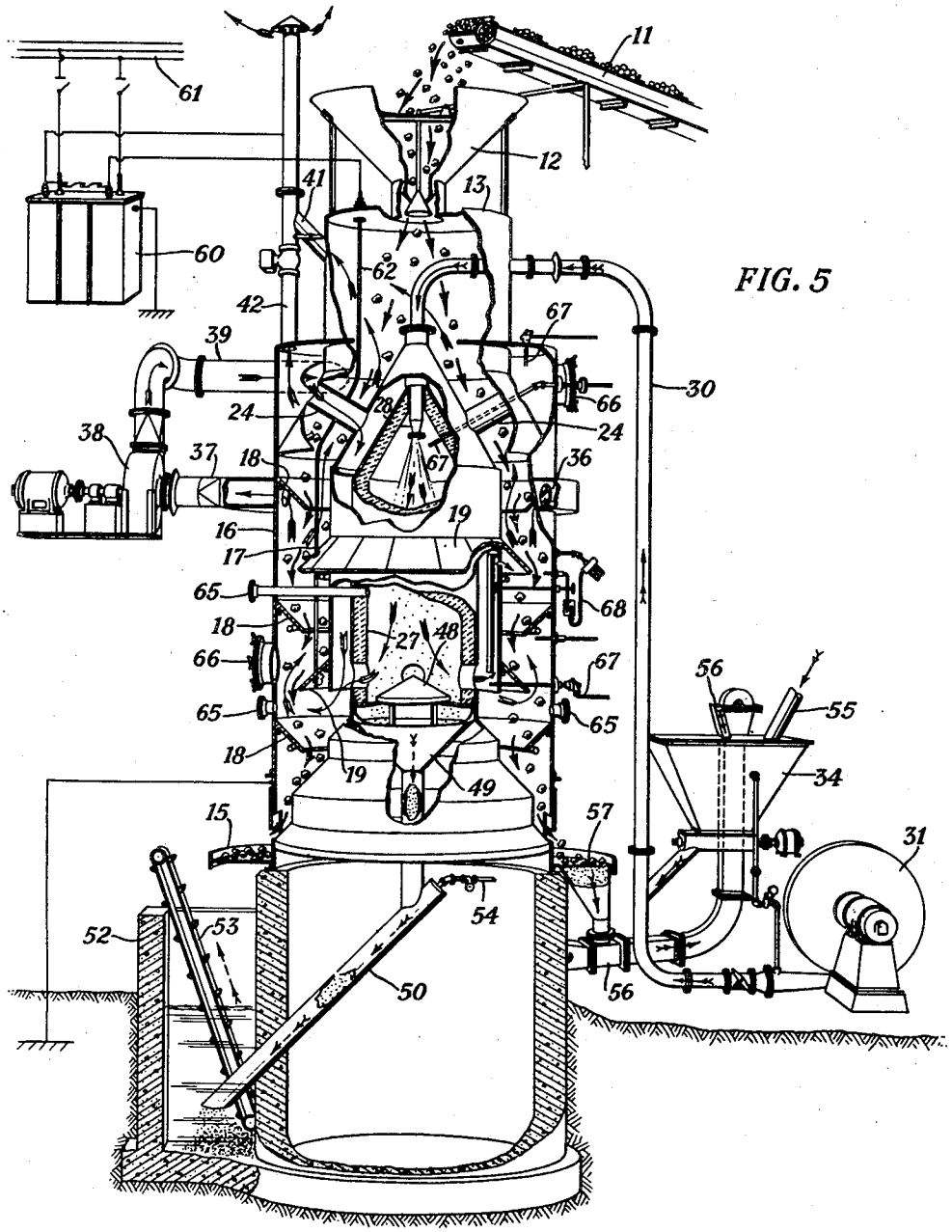


FIG. 5

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BY Howard, Gilbert & Howard

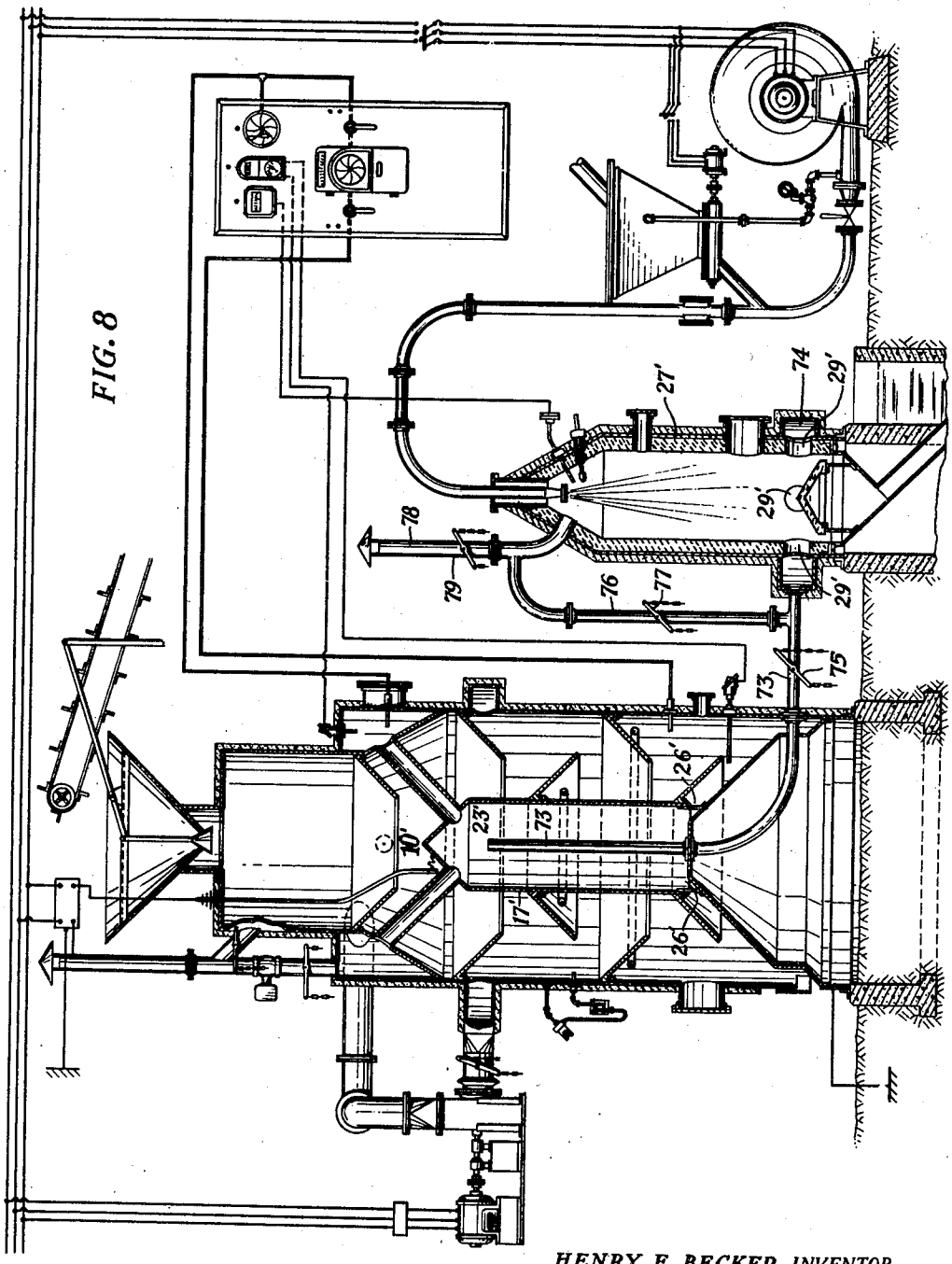
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March 23, 1948. H. E. BECKER 2,438,199

METHOD AND APPARATUS FOR THE HEAT TREATMENT OF LOW GRADE COAL

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FIG. 8



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Patented Mar. 23, 1948

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UNITED STATES PATENT OFFICE

2,438,199

METHOD AND APPARATUS FOR THE HEAT-TREATMENT OF LOW GRADE COAL

Henry E. Becker, Chicago, Ill.

Application January 12, 1942, Serial No. 426,409

3 Claims. (Cl. 202—16)

1

This invention has to do with the treatment of low grade coal.

One of the objects of the invention is to provide a method of treating a low grade coal whereby to increase the thermal value of the same.

Another object of the invention is to provide a special converter with which such method can be practiced rapidly continuously and inexpensively on a large commercial scale.

While the foregoing statements are indicative in a general way of the nature of the invention, other more specific objects and advantages will be apparent to those skilled in the art upon a full understanding of the new method and converter.

Two different embodiments of the invention are presented herein by way of exemplification, but it will of course be appreciated that the invention is susceptible of incorporation in various other structurally modified forms coming equally within the scope of the appended claims.

In the accompanying drawings:

Fig. 1 is a vertical section through a converter constructed in accordance with the invention;

Fig. 2 is a plan view of the converter;

Fig. 3 is a horizontal section, taken on the line 3—3 of Fig. 1;

Fig. 4 is another horizontal section, taken on the line 4—4 of Fig. 1;

Fig. 5 is a perspective view of the converter, with portions broken away to illustrate the path of travel of the coal being treated and the path of travel of the treating gases;

Fig. 6 is a vertical section through one of the electrically charged baffles;

Fig. 7 is a vertical section through one side of the treating stack, showing diagrammatically the action of the electric current on the coal; and

Fig. 8 is a vertical section through another converter constructed in accordance with the invention.

The new method, generally stated, consists in subjecting a low grade coal to an atmosphere of heated carbon monoxide and other reducing gases, under certain hereinafter described conditions, whereby to accomplish in an artificial way a conversion of the coal equivalent to that heretofore accomplished only by processes of nature. By "low grade coal" is meant coal of low B. t. u.'s and containing an abnormally high amount of moisture, volatile matter and ballast. As these undesirable constituents of the coal vary considerably in different kinds of low grade coal the treatment to which the coal is subjected in accordance with the new method will of course depend to a certain extent upon the character of the particular coal undergoing treatment.

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Experiments have shown that a low grade coal, when subjected to the action of reducing gases maintained at a certain temperature (depending on the characteristics of the particular coal under treatment) will be dehydrated and will not only undergo substantial changes with respect to its carbon constituents but will have the "non-combustible" volatile matters separate from the "combustible" volatile during the conversion process. The temperature at which the conversion will take place will ordinarily range between 800° F. and 1000° F. or higher. Most of the ballast matters comprising a part of the raw coal have either evaporating or melting points which are considerably lower than the temperature employed in effecting the conversion. Many inferior coals, besides containing large amounts of moisture, contain sulphur in various forms. When the raw coal is subjected to the above mentioned temperature by the reducing gases most of such sulphur will evaporate and pass off into such gases. Because of the complete lack of oxygen or air in the reducing atmosphere burning of the sulphur fumes is prevented.

When low grade coals containing a high content of moisture and oxygen are heated up in the presence of air, great losses are incurred, due to unpreventable self-oxidation. The present process is carried out with practically no losses of the carbon constituents and without oxidation. Oil and tar products, under certain conditions, may be produced, but this can be minimized through correct timing of the converting or improvement process, which timing is determined in accordance with the particular characteristics of each type of coal treated, the setting of the thermostatic and other controlling devices employed in connection with the converter being experimentally determined for each type of coal.

After a low grade coal has been subjected to the treatment contemplated by the present invention it will be free from so-called volatile ballast matters while still containing a considerable amount of so-called volatile combustible matters, and will therefore have its thermal value greatly enhanced.

To render the new method sufficiently economical to be practiced on a large commercial scale the process of conversion should be carried on continuously, and a converter capable of con-

tinuous operation is therefore an important requisite.

The present invention contemplates the employment of a converter of special form in which the coal under treatment does not come in contact with any open flame but is subjected only to heated reducing gases, which gases are produced by an imperfect combustion of coal dust with compressed air and in which the coal dust used may advantageously have mixed with it the ash-like siftings from coal previously treated in accordance with the process. During the treatment the pressure prevailing within the converter is kept higher than the pressure of the outside atmosphere, and the treatment is carried out in the complete absence of oxygen or air. A catalyst, in the form of metallic contact elements, is preferably employed within the converter, and an electric circuit, or passage of static electricity, employing the reducing gases together with the coal as the conducting means, is also preferably employed.

The method may be practiced in a converter of the construction shown in Figs. 1 to 7 inclusive. As will be observed in those views this converter contains an upright treating chamber 10 which is adapted to be filled with the coal undergoing the treatment. The raw coal is dumped from an endless conveyor 11 into a hopper 12 which opens into the top 13 of the chamber. Upon entering the upper portion of the chamber 10 the coal works slowly downward in the chamber and during its passage through the chamber is subjected to the heated reducing gases, which effect the desired conversion. By the time that the coal has worked down to the bottom of the chamber it will have been fully converted by the reducing gases. When it reaches the bottom it is discharged through side openings 14 onto an exposed gallery 15.

The chamber 10 is of annular cross section throughout the greater part of its vertical extent, and is formed between an insulated metal outer wall 16 and a concentrically arranged metal inner wall 17. The outer wall 16 is provided with several vertically spaced baffle rings 18 which project at an inclination into the chamber 10, and the inner wall 17 is likewise provided with several vertically spaced baffle rings 19 which project at an inclination into the chamber, between the baffle rings 18. The rings 18 and 19 cause the coal in descending to work slowly back and forth between the outer and inner walls of the chamber.

The upper part of the inner wall 17 terminates a substantial distance below the top 13 of the chamber 10 in a conical closure portion 20 which directs the descending coal uniformly about the same into the annular portion of the chamber. The outer wall 16 is provided, opposite the conical portion 20 of the inner wall, with a conical partition 21 which forms a circular gas manifold 22 about the upper portion of the chamber 10. This manifold 22 is connected with the upper part of the space 23 on the inside of the inner wall 17 by radially extending gas ducts 24.

The chamber 10 is provided with a bottom 25 of generally conical form which directs the treated coal to the side openings 14, and the lower edge of the inner wall 17 of the chamber is spaced above the bottom 25, leaving an annular gas passage 26 between the lower part of the space 23 on the inside of the inner wall and the lower part of the chamber 10.

A gas producer 27 is located in the center of

the converter, within the previously mentioned space 23, in inwardly spaced relation to the inner wall 17. The producer 27 consists of a fire dome which is provided at its top with a downwardly directed burner nozzle 28 and at its bottom with a number of radially directed gas ports 29. The nozzle 28 burns a mixture of coal dust and compressed air, which mixture is supplied through a pipe 30. The mixture is so constituted in its proportions as to result in incomplete combustion and thereby give off through the gas ports 29 reducing gases containing primarily carbon monoxide. The air employed in the mixture is forced by a blower 31 into the pipe 30, and the coal dust used, which may also include screenings from the treated coal, is metered by a screw 32 into a branch 33 of the pipe 30 from an air-tight hopper 34.

The reducing gases, upon being discharged from the fire dome 27 through the ports 29, enter the lower portion of the chamber 10 through the annular passage 26 and flow upwardly through the coal in the chamber. When these gases, after having seeped upwardly through the slowly descending coal, reach approximately the level of the uppermost baffle ring 18, the greater portion of the gases will leave the chamber 10 through side openings 35. The openings 35 are located back under the uppermost baffle ring 18, out of the way of the descending coal, and are connected with a circular manifold 36 on the outside of the chamber. This manifold is connected by a pipe 37 with a recirculating pump 38. The reducing gases, upon reaching the pump 38, are directed by the latter through another pipe 39 back to the previously described circular manifold 22.

From the manifold 22 the gases flow through the ducts 24 into the top of the space 23 which surrounds the fire dome 27, and then flow downwardly about the sides of the fire dome to the annular passage 26, commingling at that point with the additional reducing gases continuously being discharged, as above described, from the ports 29.

While the greater portion of the reducing gases leave the chamber 10 through the side openings 35 in the latter, to be recirculated again through the chamber, a portion of the gases will continue upwardly in the chamber past the uppermost baffle 18 into the drum-like upper portion 40 of the chamber, thereby subjecting the entering coal in that portion to a preliminary treatment with such gases. The spent gases are then permitted to escape from the upper portion 40 of the chamber 10 through a pipe 41. In a similar manner a certain proportion of the spent gases are permitted to escape from the circular manifold 22 through a pipe 42. The pipe 41 discharges into the pipe 42, and the latter is open at its upper end to the atmosphere. Adjustable dampers 43 and 44 are mounted respectively in the pipes 41 and 42 for regulating the amount of gases permitted to escape to the atmosphere from these parts of the system.

The pressure in the system built up by the reducing gases is maintained above atmospheric pressure by controlling the rate at which the reducing gases are permitted to escape to the atmosphere. A small amount of the reducing gases will of course escape from the points where the coal enters and leaves the system, but this is maintained at a minimum through the provision of special sealing means at those points. The hopper 12 is provided at the opening in the bottom of the same with a conical sealing plug 45

which is operated by a linkage arrangement 46 to allow coal from the hopper 12 to flow into the upper portion 40 of the chamber 10. When the plug 45 is in its closed position the reducing gases in the system will be prevented from escaping through the hopper 12. At the bottom of the chamber 10 the openings 14 are partially closed by vertically shiftable gates 47. The position of these gates determines the rate at which the coal under treatment will travel through the chamber 10. When the gates are moved upwardly the period during which the coal will be subjected to the treatment will be shortened, and when the gates are moved downwardly the period will be lengthened. Ordinarily, the coal under treatment will be exposed to the reducing gases in the chamber 10 for from two to four hours, with the coal in the upper portion of the chamber heated by the gases to a temperature of about 800° F., and with the coal in the lower portion of the chamber adjacent the annular passage 26 heated to a temperature in the neighborhood of 1100° F. However, a higher temperature in the lower portion of the chamber is contemplated, for example, in the neighborhood of 1260° F. The gates 47, by partially closing the openings 14, tend to prevent any large amount of the reducing gases from escaping through the openings along with the treated coal.

From the foregoing it will be understood that the reducing gases circulate continuously through the chamber 10 in an upward current which is counter to the path of travel of the coal. This reverse flow, effected under the back pressure set up by the continuous formation of additional reducing gases in the fire dome 27, permits any traces of oil and tar carried up by the gases to have an opportunity to precipitate in the upper portion of the chamber 10 where the coal is still moist and at a comparatively low temperature.

The ashes which are formed in the fire dome 27, as a result of the incomplete combustion of the coal dust taking place therein, drop onto a conical plate 48 in the bottom of the fire dome and are discharged from the periphery of the plate into a chute 49. The ashes drop through the chute 49 into an inclined tube 50 in the base 51 of the converter, and are discharged from the tube 50 into a tank 52. The tank 52 is partially filled with water and acts as a water seal for the ash discharge portions of the converter. From the tank 52 the ashes are removed by an endless conveyor 53. An air jet from a pipe 54 may be turned on at intervals to prevent the tube 50 from becoming clogged with the ashes.

The coal dust which is used in the production of the reducing gases is fed to the hopper 34 through a conduit 55. Screenings from the treated coal are fed to the same hopper through a conduit 56, by an endless conveyor of the "Redler" type operating in such conduit. A screen 57 is provided in the bottom of the gallery 15 at one side of the same and the fine ash-like particles from the treated coal are brought around the gallery by any suitable means to this screen and allowed to sift from the same into a chute 58 in communication with the conveyor in the conduit 56. The requisite equalizing pressure in the sealed hopper 34 is maintained by an air line 59 which leads from the pipe 30 into one side of the hopper.

The baffle rings 18 and 19 in the chamber 10, in addition to working the coal back and forth as it travels downwardly, act as catalysts in connection with the conversion process. For this purpose they are preferably made from an alloy containing a high percentage of nickel and a little chromium.

The baffle rings 19, on the inner wall 17 of the chamber 10, may be advantageously charged with current from a static condenser 60, preferably of the alternating current type commonly used for power factor correction. The condenser 60 is connected continuously across an alternating current power line 61 and is charged at all times. The condenser 60 is connected to an insulated rod 62 which extends down through the chamber 10, and the baffle rings 19 are individually connected with the rod 62 by short leads 63. The baffle rings 19 are insulated from the inner wall 17 of the chamber by asbestos gaskets 64 (see Figs. 6 and 7). The baffle rings 18, and the outer wall 16 of the chamber on which they are mounted, are connected to the opposite terminal of the condenser through the metal exhaust stack 42, and both the condenser and the outer wall 16 of the chamber are grounded.

It is a well known fact that sulphur molecules in either solid or gaseous form react easily to the action of alternating discharge current. The action which will take place with the static condenser battery hookup above described is of much the same nature as that in a so-called electrostatic precipitator (Cottrell). In other words, small sulphur particles inside the coal under treatment will be polarized or charged and discharged (as schematically illustrated in Fig. 7) due to the reaction of the electrostatic discharge passing through the coal. This will create great agitation among the sulphur particles and will force mechanical movement of the same even though no heat be applied at the same time. When sufficient heat is applied to produce sulphur fumes—which is the case in connection with the operation of the present converter—the sulphur particles will be more easily forced out of the coal under treatment. Structural changes will also take place in the coal under the influence of the electrostatic discharge passing through the same, even in the absence of heat, provided the intensity of the current is sufficient. The structural changes in the coal thus inaugurated by the electrostatic discharge will be further augmented by the heat to which the coal is subjected. During these changes oxidation is prevented due to the fact that the entire conversion process is caused to take place in a specially created atmosphere of reducing gases, in the absence of air and oxygen.

The sulphur particles carried away in the exhaust fumes will still carry the electric charge to a certain extent, and after the fumes have left the converter through the stack 42 the sulphur particles may be collected from the same by the employment of small capacitors.

It will be understood from the foregoing that the discharge current from the condenser battery is forced to travel through the charge of coal in the chamber 10 while such coal is undergoing treatment. The resistance of carbon or coal is very high in comparison to metal, but in any case the coal will act as a discharge resistor across the terminals of the static condenser battery 60. Consumption of active power or input for the battery 60 will be very low, representing less than one-third of one per cent of the rated capacity of the condenser.

The converter is preferably provided with several observation windows 65, and several clean-out doors 66. The converter is also preferably

provided with a number of electrically registering thermostats 67, in the fire dome 27, in the circular recirculating manifold 22, at various levels in the annular portion of the chamber 10, and at other places. A pressure gauge 68 is also provided. These instruments are all preferably connected up in the usual way with readily observable indicators on a panel 69. In the normal circulation of the reducing gases all of such gases in entering the annular portion of the chamber 10 will flow through the annular passage 26. If it is desired to increase the temperature of the coal at a higher point in the chamber, this may be accomplished by opening a damper 70 in a duct in the space 23 by means of an exterior handle 71, thus by-passing the gases through an opening 72 located just beneath the uppermost baffle ring 19 in the wall 17 of the chamber. The pumps 31 and 38 and other mechanically moving parts of the apparatus are operated by electric motors which are connected up with the power line 61.

The converter shown in Fig. 8 of the drawings operates on the same principle as the one shown in Figs. 1 to 7 inclusive but differs primarily in the respect that the fire dome 27', instead of being located physically within the space 23' on the inside of the inner wall 17' of the treating chamber 10', is located off to one side. The function of the fire dome 27', however, is the same, and the gases which are produced are conducted from the fire dome by a conduit 73 to a discharge point adjacent the upper end of the space 23'. From the space 23' the gases pass through an annular passage 26' into the lower part of the chamber 10'. The conduit 73 communicates with a circular manifold 74, and the gases enter the manifold 74 from the fire dome through radially directed ports 29' in the lower part of the fire dome.

By employing this modified construction the fire dome is rendered more accessible. In addition, a battery of two or more treating chambers can be supplied with the necessary reducing gases from a single relatively large fire dome, if desired. The rate at which the gases are fed to any particular treating chamber can be controlled by a valve 75 in the conduit 73 leading to that chamber, and any excess can be by-passed back to the fire dome through a return pipe 76 under control of a valve 77. Likewise, any aggregate excess of the gases being produced in the fire dome can be released to the atmosphere through a vent pipe 78 controlled by a valve 79. In all other material respects the converting apparatus shown in Fig. 8 is in substance the same as that shown in Figs. 1 to 7 inclusive.

I claim:

1. The method of treating a low grade coal to increase the thermal value of the coal while retaining it in the form of coal, which consists in subjecting the coal to an atmosphere of heated carbon monoxide and other reducing gases in the absence of any appreciable quantity of oxygen, in the presence of a metallic catalyst, and at the same time subjecting the coal to an alternating electrostatic discharge, and heating the coal in such atmosphere at temperatures in the approximate range of 800° F.–1260° F. for a predetermined length of time.

2. The method of treating a low grade coal to increase the thermal value of the coal while retaining it in the form of coal, which consists in subjecting the coal to an atmosphere of heated carbon monoxide and other reducing gases in the absence of any appreciable quantity of oxygen, in the presence of a metallic catalyst, and at the same time subjecting the coal to an alternating electrostatic discharge, while continuously feeding the coal into such atmosphere and continuously removing it from the same, and maintaining the coal in such atmosphere at a temperature of approximately 800° F.–1260° F. for a predetermined length of time.

3. In an apparatus for treating low grade coal to increase the thermal value of the coal while retaining it in the form of coal, a treating chamber, means for causing coal to pass through the chamber, means for causing heated reducing gases to pass through the chamber, means to exclude air from the chamber, a stationary metallic catalyst in the chamber in relatively movable contact with the coal means for subjecting the coal to the influence of an alternating electrostatic discharge during its passage through the chamber in contact with the catalyst, and means for maintaining the coal undergoing treatment at a temperature falling in the approximate range of 800° F.–1260° F.

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