March 24, 1931. W. RUNGE 1,797,796

METHOD OF AND APPARATUS FOR CARBONIZING COAL BY THE LOW TEMPERATURE PROCESS

Filed June 12, 1925 3 Sheets-Sheet 1

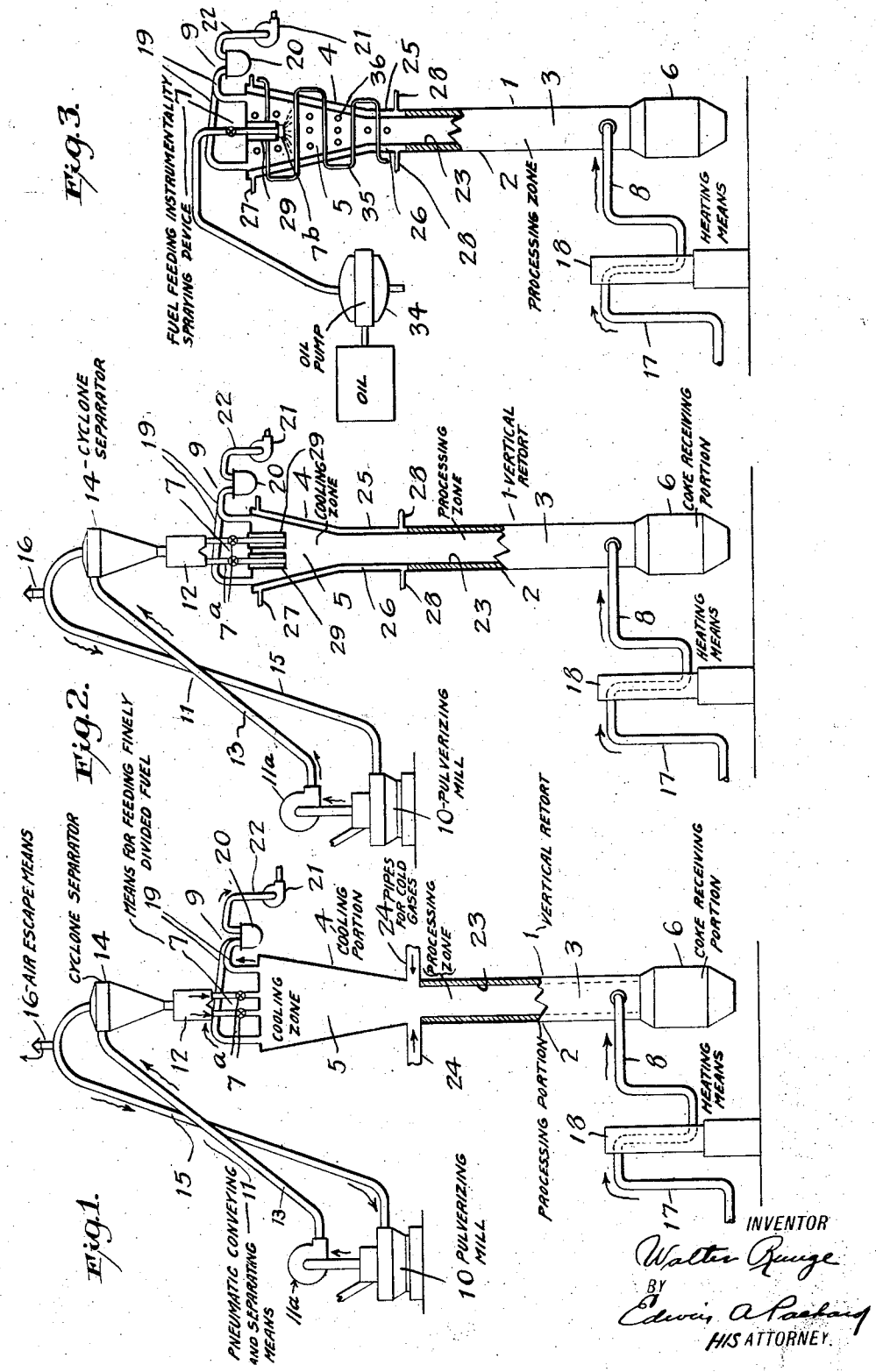

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Fig. 4.

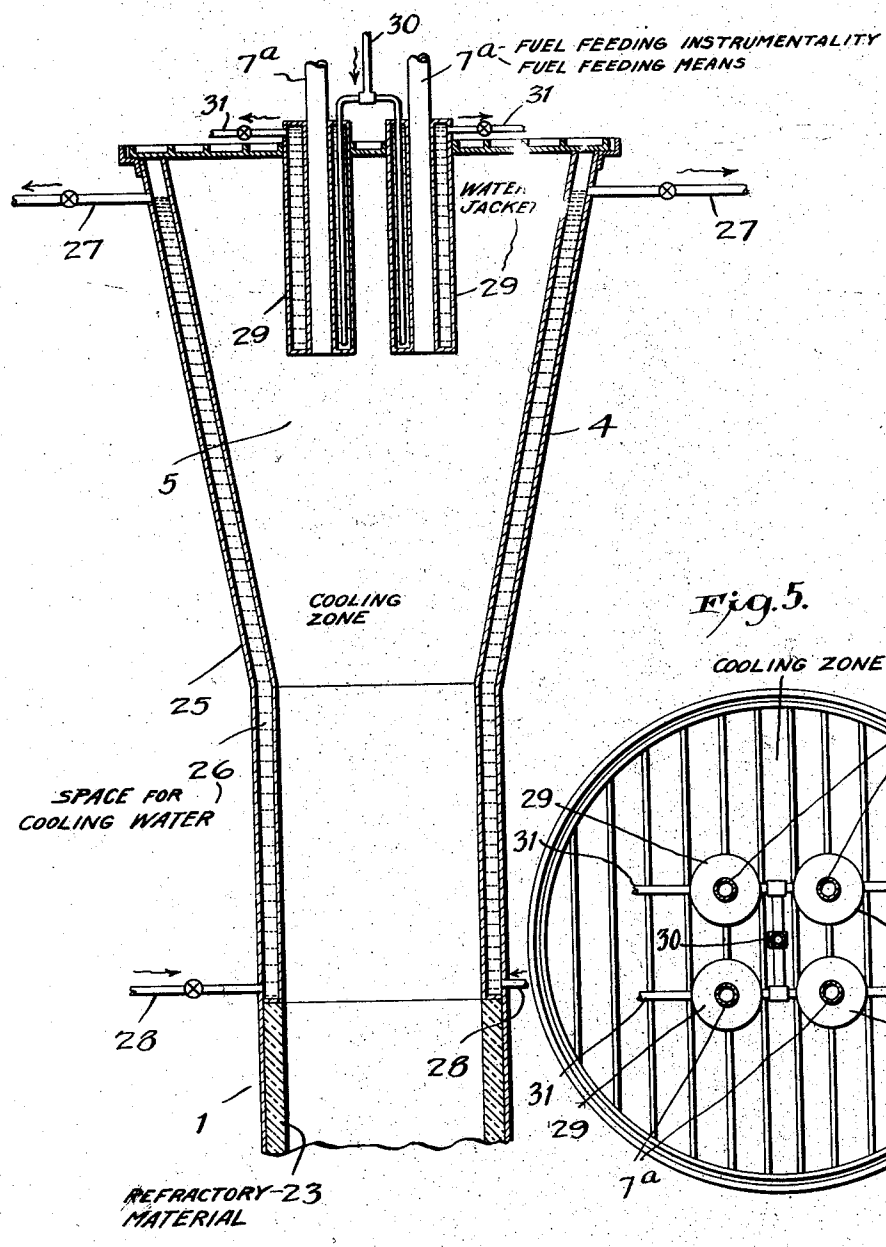

Fig. 5.

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Fig. 7.

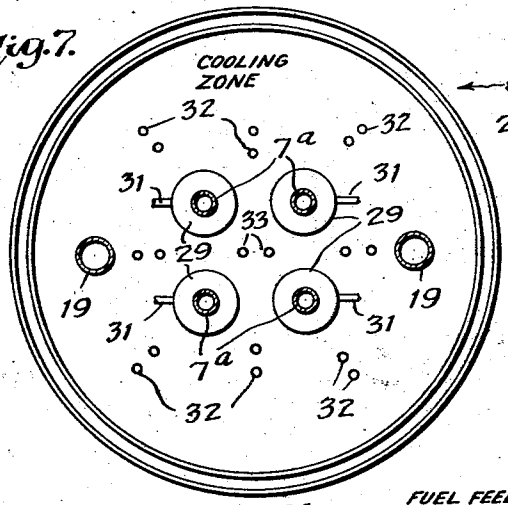
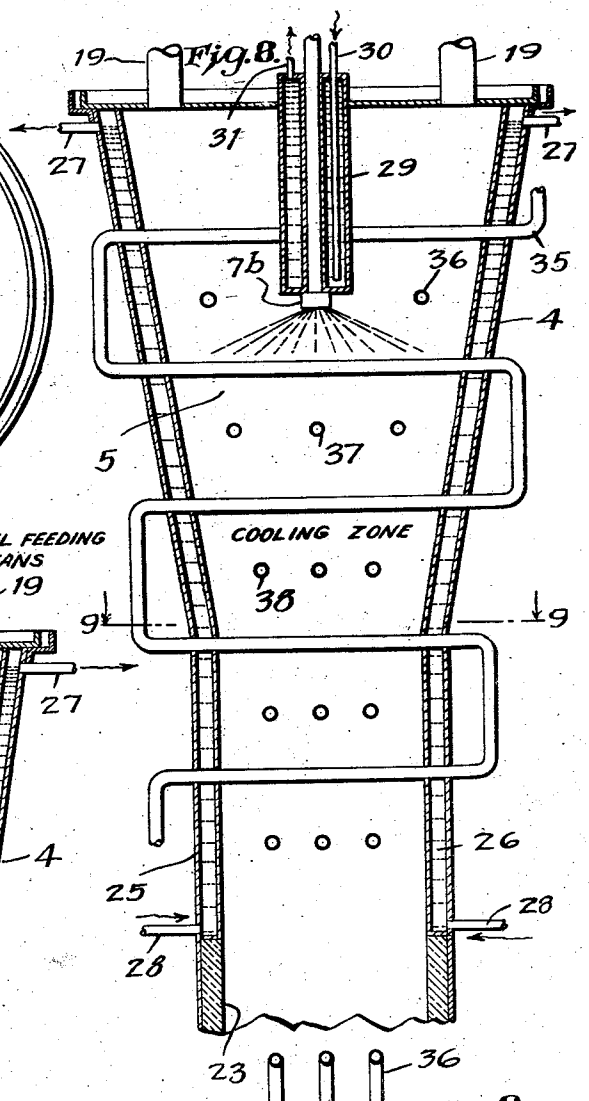


Fig. 8.



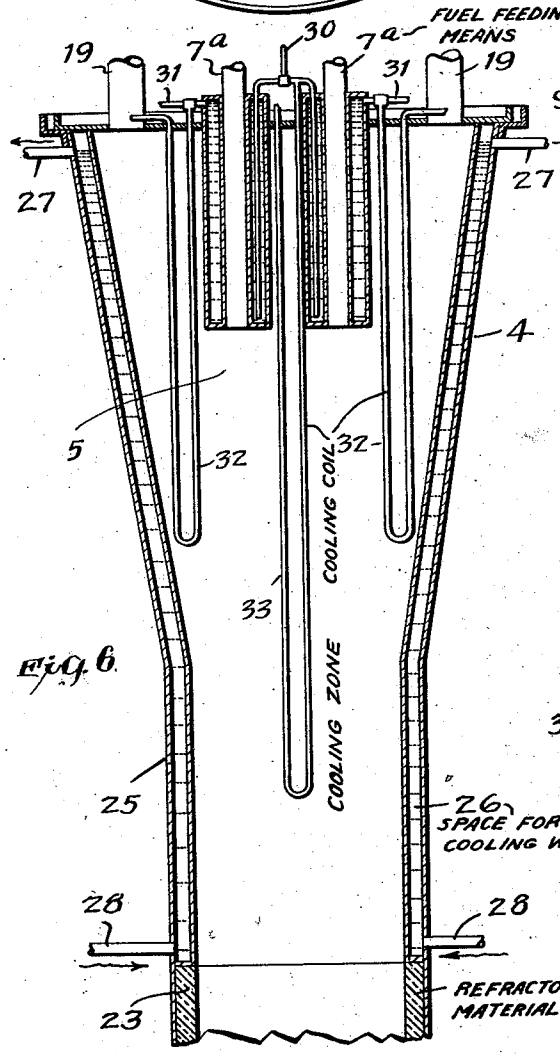
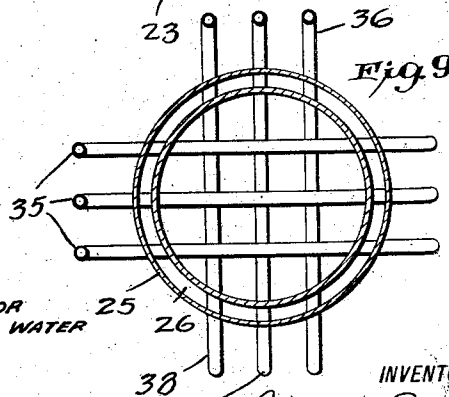


Fig. 6.

Fig. 9.



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UNITED STATES PATENT OFFICE

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METHOD OF AND APPARATUS FOR CARBONIZING COAL BY THE LOW-TEMPERATURE PROCESS

Application filed June 12, 1925. Serial No. 36,599.

The invention relates to the processing of fuel. It particularly relates to the processing of coal, or according to certain broad aspects thereof even liquid fuel, in finely divided form under conditions to effect carbonization, gasification and cracking or carbonization, gasification, or cracking and under conditions to obtain a large yield of gases and of low boiling hydrocarbons.

The invention according to certain broad aspects particularly concerns the employment of cooling, either a direct cooling or an indirect cooling, within the processing retort of gases evolved by the processing carried out within the retort under conditions such that by the cooling certain vapors of the process are condensed and are returned or passed back to the processing zone wherein a large percentage of the condensed vapors are, by the heat of the processing zone, ultimately broken up or rearranged as by cracking into low boiling hydrocarbons, permanent gases and free carbon.

The processing however is preferably such that the cooled gases—minus the condensed tar vapors—pass from the retort to any suitable cleaning and recovering apparatus.

The invention relates to processes according to which the desired ends are realized and also to apparatuses for performing the processes.

Further objects of the invention will be apparent from that which follows.

As illustrative of certain modes in which the invention may be realized, reference is made to the accompanying drawings constituting a part of the specification.

Each form of apparatus for realizing the invention as illustrated in the several figures of the drawings embody as an important part thereof a vertical retort having the following general characteristics to wit a cooling portion or zone at the top, a processing zone in the intermediate portion of the retort or in other words below the cooling zone, and a receiving chamber or space at the bottom of the retort for any solid residual of the process which may settle therein from the processing zone. The vertical retort has means for feeding the finely divided fuel into the cooling zone under conditions such that the fuel can settle into the processing zone counter to the evolved gases rising from the processing zone and flowing into the cooling zone.

Also according to each form of apparatus there is provided means for maintaining the cooling zone at the desired temperatures.

Figure 1 illustrates an apparatus for processing finely divided fuel, pulverized coal, and this apparatus has a vertical retort possessing the general characteristics above described. In the apparatus of Figure 1 the cooling zone is maintained at the desired temperatures by the introduction of cooling fluids such as cold gas practically at the juncture of the bottom of the cooling zone and the top of the processing zone.

Figure 2 illustrates an apparatus for processing finely divided fuel, as pulverized coal and the apparatus has a vertical retort possessing the general characteristics previously recited.

Figure 3 illustrates an apparatus for processing finely divided fuel, as atomized oil, and the apparatus has a vertical retort possessing the general characteristics previously recited.

In the apparatus of Figure 2 and also in the apparatus of Figure 3 the cooling is indirectly effected as by cooling water flowing through the space in the upper walls of the retort shell and also flowing through certain cooling members located so as to extend a substantial distance into the cooling zone.

Figure 4 is a vertical sectional view showing on somewhat larger scale the upper portion of the retort structure employed in Figure 2.

Figure 5 is a plan view of the top of the retort shown in Figure 4.

Figure 6 is a vertical sectional view of the upper portion of a retort adaptable for use in the arrangement of Figure 2.

Figure 7 is a plan view of the retort shown in Figure 6.

Figure 8 is a vertical sectional view of another form of retort particularly adaptable for use in the arrangement of Figure 3; and

Figure 9 is a horizontal sectional view tak-

en on the line 9—9 of Figure 8 looking in the direction of the arrows.

Reference will now be made to the drawings in further detail and in this connection it should be noted that like parts are referred to by the same reference characters. At the outset a general description of the several vertical retorts illustrated is set forth as this leads to an early understanding of the general subject matters involved.

Each of the vertical retorts designated 1 comprises a processing portion 2 which defines a processing zone 3, a cooling or condensing portion 4 which defines a cooling or condensing zone 5, and a coke receiving portion 6. The processing portion 2 or processing zone 3 occupies the intermediate portion of the retort, the cooling portion 4 or cooling zone 5 occupies the top or upper portion of the retort, and the coke receiving portion 6 is located at the bottom or lower portion of the retort. Each vertical retort has means collectively designated as 7 for feeding finely divided fuel, either pulverized coal or finely divided oil as the case may be, into the cooling zone 5 and each retort is also provided with any suitable means collectively designated as 8 for supplying heat into the interior of the retort and more particularly within the processing zone 3 whereby the process will function in the manner hereinafter described.

Each retort also has means collectively designated as 9 for withdrawing from the top or upper portion of the retort such gases as pass through or from the cooling zone 5.

As to the apparatus of Figure 1 there is indicated a suitable pulverizing mill 10, often referred to as a pulverizer, for crushing or pulverizing the coal into finely divided form and there is associated therewith a pneumatic conveying and separating means broadly designated by 11 for conveying the pulverized coal from the mill to a receiving hopper 12 from which it is fed by any specific feeding instrumentality designated as 7^a. The conveying and separating means 11 comprises an exhauster or exhaust fan 11^a the piping 13, a cyclone separator 14, a return pipe 15 and any suitable air escape means as pipe 16. The further functioning and operating of the several parts of the conveying and separating means are not further described at this time since such is well known.

The heating means 8 comprises piping 17 for conducting any suitable heating medium—a gaseous heating medium such as a combustible gas, for example, that obtained by or from the process—in the processing zone 3 and this piping 17 passes through a heater 18 whereby the gaseous medium can be heated to the desired degree before introduction into the processing zone. It will also be observed that this gaseous medium for carrying out the process is introduced into the lower portion of the processing zone and the gases flow upwardly toward the cooling zone in the upper portion of the retort. The gases used in the process together with some of the gases produced by the process constitute and maintain a current of slowly moving upwardly rising hot gases into and counter to which the finely divided fuel, and condensates hereinafter described, enters and gravitates or tends to gravitate during the processing. After leaving the processing zone the gases used in and provided by the process pass through the cooling zone wherein certain tar vapors are condensed and finally the cooled gases minus the condensates are withdrawn by means 9. The means 9 by which the cooled gases are withdrawn comprises the piping 19 leading to the hydraulic main 20, and from the hydraulic main the gases are sucked as by means of the exhauster 21 and piping 22 leading from the hydraulic main to the exhauster.

The same arrangement of piping for heating the interior of the processing zone and of piping for withdrawing the gases of or resulting from the process is employed in each form of apparatus herein shown and further reference thereto will not be made.

The retort of Figure 1 is shown partly in section and it will be observed that the processing portion of the retort has suitable refractory material 23 extending substantially the full height and periphery thereof. The cooling portion 4 may or may not be heat insulated and cooling fluids such as cold gases are introduced by means of the pipes 24 into the bottom of the cooling zone 5 or to express this same thing in another way, these pipes 24 introduce cooling fluid at practically the juncture of the top of the processing zone 3 and the bottom of the cooling zone 5. The cooling fluid or cold gases rise with the gases used in and resulting from the processing and the cold gases are sufficient in quantity to cool the gases of the process to an extent such that the resulting mixture of gases have temperatures below the dew point of the tar vapors in the gases of the process to wit below the dew point of the tar vapors in the gases which are educed in the processing zone. This cooling is sufficient to condense substantially all of the higher boiling hydrocarbons and these condensates or condensed vapors pass downwardly with the incoming fuel into the processing zone 3 wherein they are cracked into the lower boiling hydrocarbons, permanent gases and free carbon. It will therefore be manifest that the gases which are withdrawn from the top of the retort by means of the exhauster 21 are the permanent gases—the gases out of which there has been condensed the higher boiling hydrocarbons—and which retain the lower boiling hydrocarbons.

The apparatus of each of the other figures to wit Figures 2 and 3 functions much in the

same manner as the apparatus of Figure 1.

The apparatus of Figure 2 has a retort the cooling portion of one form of which is shown somewhat in detail in Figures 4 and 5 and the cooling portion of another form of which is shown in Figures 6 and 7. It will be noted that in the retort of Figure 4 and in the retort of Figure 6 there is employed the indirect cooling effect of a cooling medium such as water. In the instance of the retorts of Figures 4 and 6 it will be observed that there is a hollow shell portion 25 at the top of the retort providing a space 26 for cooling water supplied as through the pipes 28 and leaving as through the pipes 27. The fuel feeding instrumentalities as 7^a in Figures 4 and 6 and which are frequently referred to as fuel feeding means, are surrounded by water jackets 29 having water supply pipes as 30 and offtake pipes as 31. The retort of Figure 6 has in addition the depending cooling coils 32 and 33 which extend a substantial distance downward into the cooling portion 4 or cooling zone 5 of the retort. The arrangement of the feeding instrumentalities 7^a, the water jackets therefor and of the cooling coils 32 and 33 are shown in plan views in Figures 5 and 7 which are respectively plan views of the upper portion of the retorts shown in vertical section in Figures 4 and 6.

In Figure 3 there is illustrated as has been previously indicated, an apparatus for processing oil in finely divided form and while the retorts illustrated in any of the figures previously described are adaptable for this general purpose, there has been illustrated in Figures 3, 8 and 9 a still further form of retort with a cooling section or portion at the top of the retort. An inspection of Figures 8 and 9 will make it clear that some of the cooling pipes have different arrangement from that shown in the figures previously described. The feeding instrumentality for the liquid fuel to wit the oil is specifically a spraying device and is designated as 7^b which constitutes a part of the general feeding instrumentality herebefore designated at 7. According to the arrangement indicated the oil is by the pump 34 forced into and through the nozzle at 7^b under considerable pressure and under conditions to thoroughly atomize the oil or in other words convert the oil into minute form or particles. The atomized or finely divided oil gravitates, the same as in the case of pulverized coal which is showered in the form of a cloud into the upper portion of the vertical retort, downwardly through the cooling zone thence into and through the processing zone 3, to wit, into and counter to the slowly rising hot gases in the processing zone.

In the retorts of Figures 3, 8 and 9 there is the hollow shell portion 25 providing the space 26 for the cooling water which is introduced as through the pipes 27 and which leaves as through the pipes 28; there is the water jacketed portion 29 around the fuel supply pipe and there is also a series of sinuous cooling pipes as 35, 36, 37 and 38 arranged so as to thoroughly, effectively and quickly cool the entire space constituting the cooling zone of the retort. It will be manifest that this arrangement of the cooling pipes or the cooling systems shown in Figures 4 and 6 could be utilized in the instances of the retorts of Figures 3 and 8 or reversely the cooling system of the retort of Figures 3 and 8 could be utilized in any of the other retorts herein described.

As to the processing zone of each of the retorts, which zone has been referred to as processing zone 3, it will be noted that this is preferably a low temperature treating zone such as is used in the low temperature carbonization of coal and the temperatures within this zone preferably approximate when coal is being carbonized, an average of about 1000 degrees F. These temperatures can be varied however according to the conditions and process desired to be performed.

By one method of processing—carbonizing—coal, according to the invention pulverized coal is fed—by suitable feeding means, collectively designated as 7—in a dust-like formation into the top of the vertical retort 1. There is introduced into the retort at a point near the bottom thereof, as through piping 17 of heating means 8, a gaseous heating medium such as a combustible gas the temperature of which approximates 1500 degrees F., at the time of entry into the retort so as to produce in the processing zone 3 an average temperature of approximately 1050 degrees F. There may be introduced at a point approximately midway between the top and the bottom of the retort, as through pipes 24, a combustible gas the temperature of which is such that when mixed with the gases arising from the bottom of the retort there results a temperature which is below the dew point of the vapors. The arrangement of the parts of the retort is preferably such that the coal thus introduced into the upper portion or cooling zone 5 thereof passes into and through the processing zone 3 counter to the upwardly rising gases in such a manner as to lose a part of the hydrocarbon volatile content of the coal in the form of gases and vapors which are given off within the hot processing zones.

According to the process also the upper portion of the retort may be sufficiently cold; for example, the temperature in some parts of the upper portion or cooling zone 5 may run as low as 300 degrees F. or even lower and the gases and vapors given off are caused to pass through this cooling zone so that there is a condensation of the condensible vapors whereby the condensed vapors are returned toward the bottom or lower portion of the

retort for a second treatment in the hot processing zone thereof, which second treatment may be referred to as a second heat treatment. The retorts are constructed so that the gases used in, of, or resulting from the process—after such condensible vapors have been subjected to the action of the cooling zone 5—pass out or are withdrawn from the retort 1 from the upper portion thereof, as through piping 19, while the solid residuals of the process, for example coke, are collected within and recoverable from the lower portion of the retort, as from the coke receiving portion 6. In general, it will be stated that the average temperature of the processing zone in the processing portion of the retort is preferably maintained at 1050 degrees F.

The invention hereof is applicable to the processing of coal according to the invention of my application Serial No. 748,037, filed November 6, 1924 and entitled "Improvements in or relating to the treating of coal".

What is claimed is:

1. The method of carbonizing coal by the low temperature process comprising subjecting coal while suspended in cloud-like form to the action of gases in a processing zone having average temperature approximating 1050 degrees F. and thereby educing a large portion of its hydrocarbon volatile content in the form of gases and vapors, cooling or chilling the gases and vapors thus educed within the same structure employed for the carbonizing to such an extent that a large portion of the vapors are condensed in a cooling zone with parts having a temperature as low as 300 degrees F., returning or allowing the condensates thus obtained to return to the processing zone where they are subjected to carbonization, separating from the gases the coke thus obtained and removing and collecting the gases.

2. A method of carbonizing coal by the low temperature process comprising showering pulverized coal into the top of a vertical retort the upper section of which is cooled to a temperature approximately as low as 300 degrees F. so as to provide a cooling zone and the lower section of which is heated to temperatures averaging approximately 1050 degrees F. so as to provide a processing zone allowing the coal to pass through the cooling zone to the processing zone, carbonizing the coal in the processing zone and removing the coke thus produced, chilling in the cooling zone the gases and vapors educed in the heated section and by said chilling condensing some of the gases and vapors, causing the condensed gases and vapors to pass to the heated section, and removing and collecting the permanent gases of or resulting from the process.

3. The method of carbonizing coal by the low temperature process comprising feeding coal into a structure a lower portion of which is heated to temperatures averaging approximately 1050 degrees F. so as to provide a processing zone and an upper portion of which is cooled to temperatures ranging as low as 300 degrees F. so as to provide a cooling zone, carbonizing the coal in the processing zone within the cooling zone, cooling all and condensing some of the gases and vapors produced in the processing zone, returning the condensate to the processing zone for a cracking treatment, collecting with the semi-coke produced by the carbonization of the coal the carbon formed by the cracking of the condensates, removing the permanent gas resulting from the process and collecting and purifying the same.

4. The method of carbonizing coal by the low temperature process comprising pulverizing coal, showering the pulverized coal in the form of a cloud into the upper portion of a vertical retort where it passes through an upwardly moving body of gases the temperature of which becomes greater as the coal precipitates toward the bottom of the retort, carbonizing the coal in the lower portion of the retort, cooling and condensing in the upper portion of the retort the gases that are formed by the carbonization and in the lower portions of the retort, allowing the condensates from the cooled gases to pass to the lower portion of the retort with the coal undergoing carbonization and therein cracking the condensates, removing from the upper portion of the retort permanent gases, collecting these gases, and removing from the bottom of the retort the semi-coke resulting directly from the carbonizing of the coal together with the coke resulting from the cracking of the condensates.

5. The method of carbonizing pulverized coal by the low temperature process comprising feeding pulverized coal into a vertical carbonizing retort, the lower portion of which is maintained at an average temperature of approximately 1050 degrees F. and the upper portion at a temperature of less than 300 degrees F. in such a manner that the coal travels counter to an upwardly rising current of gases and so as to free the coal of a large part of its hydrocarbon volatile content, causing the educed gases and vapors to mingle and travel upwardly with the gases employed for effecting the carbonization, chilling the mixed gases in the upper portion of the retort to cause condensation of condensible vapors, returning the condensed vapors to the lower portion of the retort with the coal being fed, subjecting them to a second heat treatment to cause a breaking down or cracking of them, removing permanent gases of the process and removing from the bottom of the retort the solid residuals resulting from the process.

6. The method of carbonizing coal by the low temperature process comprising feeding

coal in a dust-like formation into the top of a vertical retort, introducing into the retort at a point near the bottom a combustible gas whose temperature is approximately 1500 degrees F., introducing into the retort at a point approximately midway between the top and the bottom of the retort a combustible gas whose temperature is such that when mixed with the gases arising from the bottom of the retort the resulting temperature is below the dew point of the vapors, causing the coal to pass counter to the upwardly rising gases in such a manner that it loses a large part of its hydrocarbon volatile content in the form of gases and vapors, condensing in the upper part of the retort wherein the temperature runs as low as approximately 300 degrees F. the condensible vapors so educed and returning them to the bottom portion of the retort for a second heat treatment, removing the coke produced in the process and removing and collecting the gases produced in the process.

7. In the treating and carbonizing of coal the method comprising showering coal into the top of a vertical retort, the upper portion of which is cooled and the lower portion of which is heated, allowing the coal to pass through the cooled portion to the heated portion, carbonizing the coal in the heated portion and removing the coke thus produced, chilling in the upper portion wherein the temperature runs as low as approximately 300 degrees F. the gases and vapors educed in the heated portion by causing the educed gases and vapors to mix with a coal gaseous medium introduced into the upper portion so that the temperature of the mixed gases is approximately at or below the dew point of substantially all of the tar vapors and thereby effecting a condensation, causing the resulting condensates to pass to the heated section and removing and collecting permanent gases of or resulting from the process.

8. The method of carbonizing coal by the low temperature process comprising subjecting the coal to carbonization while the coal traverses a path and counter to that of the educed gases, chilling the educed gases after they have left the zone in which the coal is carbonized sufficiently to condense a substantial portion of the condensable tar vapors, the gases from the zone being chilled to temperatures approximating 300 degrees F. so as to effect a condensation of certain tar vapors therein, causing the condensed tar vapors to mix or mingle with the coal to be carbonized and thus be returned to the zone of carbonization, and collecting and withdrawing the gases and vapors which have not been condensed.

9. The method of carbonizing coal by the low temperature process comprising feeding pulverized coal into the top of a retort having a carbonizing zone therein so that the coal thus fed settled in the form of a cloud into and through the carbonizing zone, causing the coal as it settles through the carbonizing zone to be sufficiently heated to carry out a low temperature carbonization within the carbonizing zone, but under conditions such that the gases educed by the process travel upwardly counter to the gravitating coal particles constituting a cloud within the carbonizing retort, chilling within a cooling zone having a temperature running as low as approximately 300 degrees F. the gaseous products under conditions such that the chilled vapors drop out of the rising gases in the immediate presence of pulverized coal gravitating towards the carbonizing zone and under conditions such that a substantial portion of the tar vapors are thus precipitated from the gases and mingle with the coal and pass to the zone of carbonization where they undergo heat treatment, removing the solid carbonized residuals from the lower portion of the carbonizing retort, and withdrawing and collecting the gaseous products remaining after the chilling treatment.

10. A retort of the class described comprising in combination a vertical shaft provided with a refractory carbonizing portion providing the walls of a carbonizing zone, a coke receiving portion below the refractory carbonizing portion, means whereby the hottest zone is in the lower regions of the carbonizing zone, a condensing portion providing a condensing zone above the carbonizing portion, which condensing portion has water cooling sections for indirectly cooling the gases passing from the carbonizing zone through the condensing zone, means for feeding pulverized coal that is to undergo carbonization into the upper portion of the condensing zone so that the coal thus fed remains relatively cool until it settles into the carbonizing zone, and means for withdrawing from the upper portion of the condensing zone cooled educed gases given off by the process.

In testimony whereof I have hereunto signed my name.

WALTER RUNGE.

CERTIFICATE OF CORRECTION

Patent No. 1,797,796. Granted March 24, 1931, to

WALTER RUNGE.

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction as follows: Page 4, lines 57 and 60, claim 2, for the words "heated section" read processing zone; and that the said Letters Patent should be read with these corrections therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 21st day of April, A. D. 1931.

M. J. Moore,
Acting Commissioner of Patents.

(Seal)