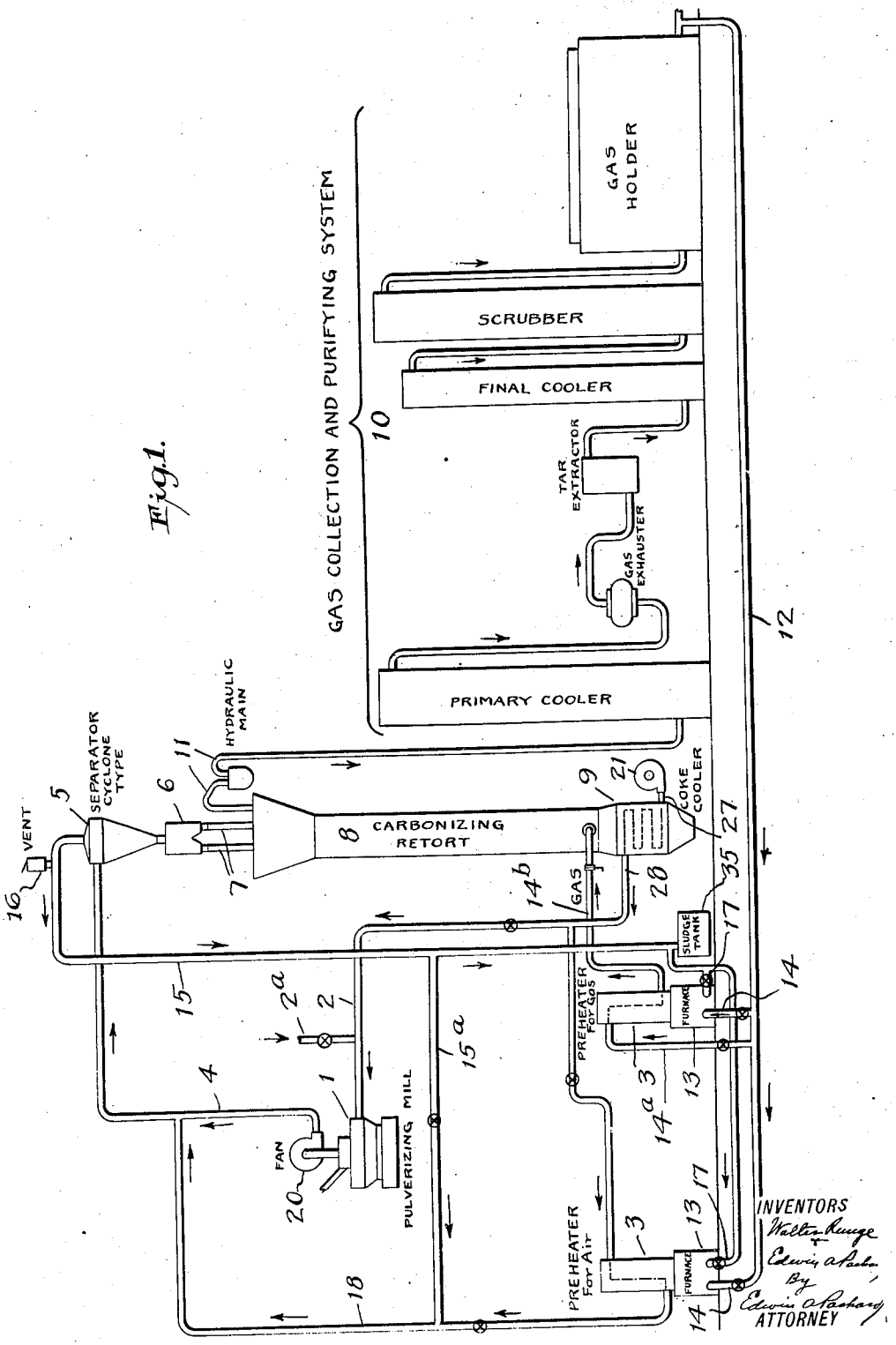
May 12, 1931. W. RUNGE ET AL 1,805,109

PROCESSING OF COAL

Filed March 12, 1925 7 Sheets-Sheet 1

Fig. 1.



May 12, 1931. W. RUNGE ET AL 1,805,109

PROCESSING OF COAL

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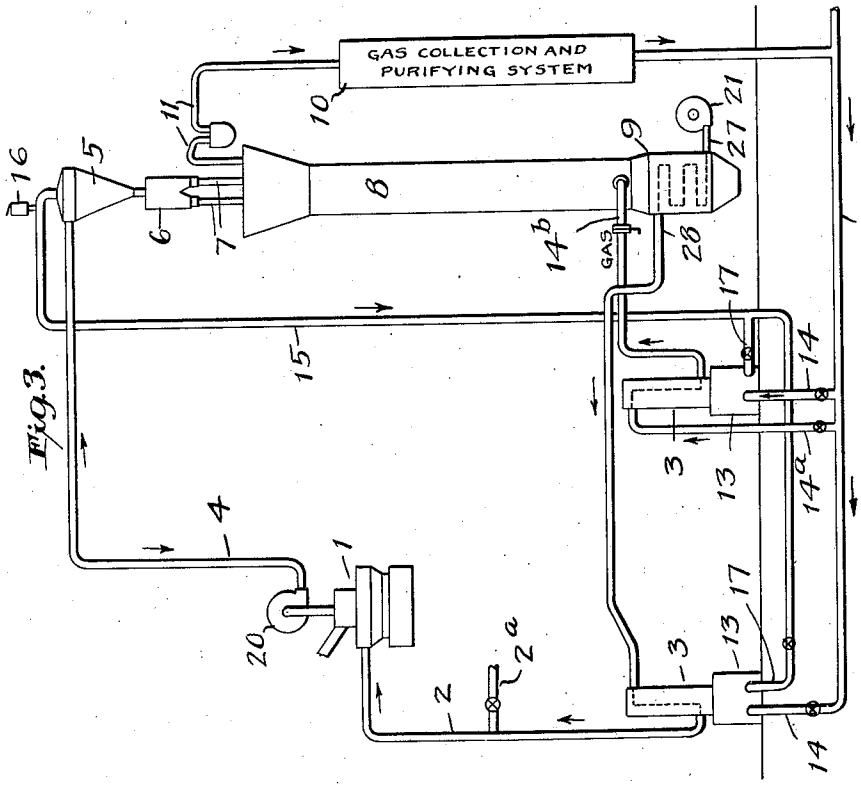


Fig. 3.

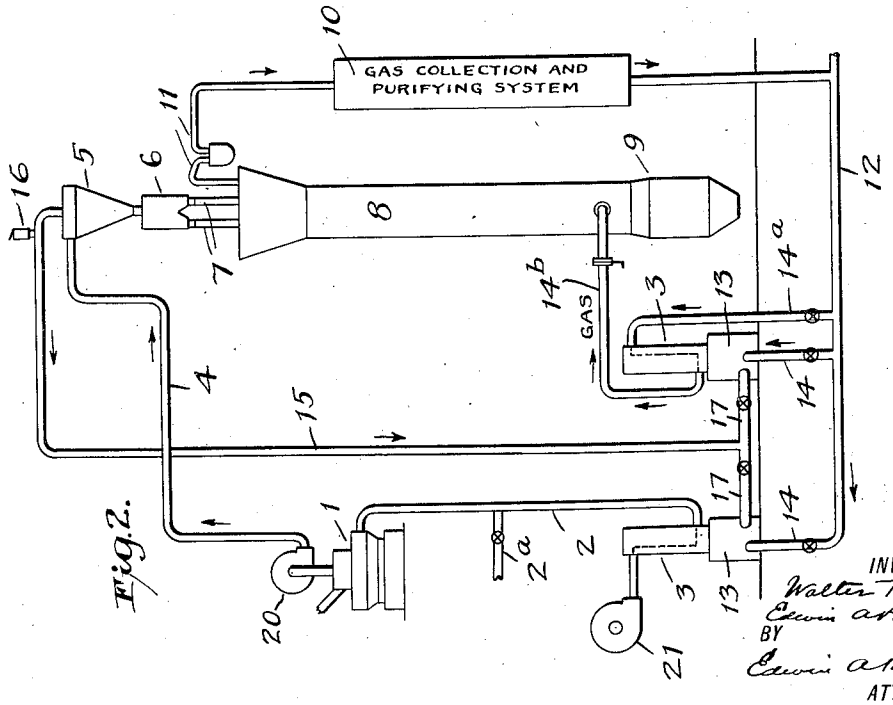


Fig. 2.

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PROCESSING OF COAL

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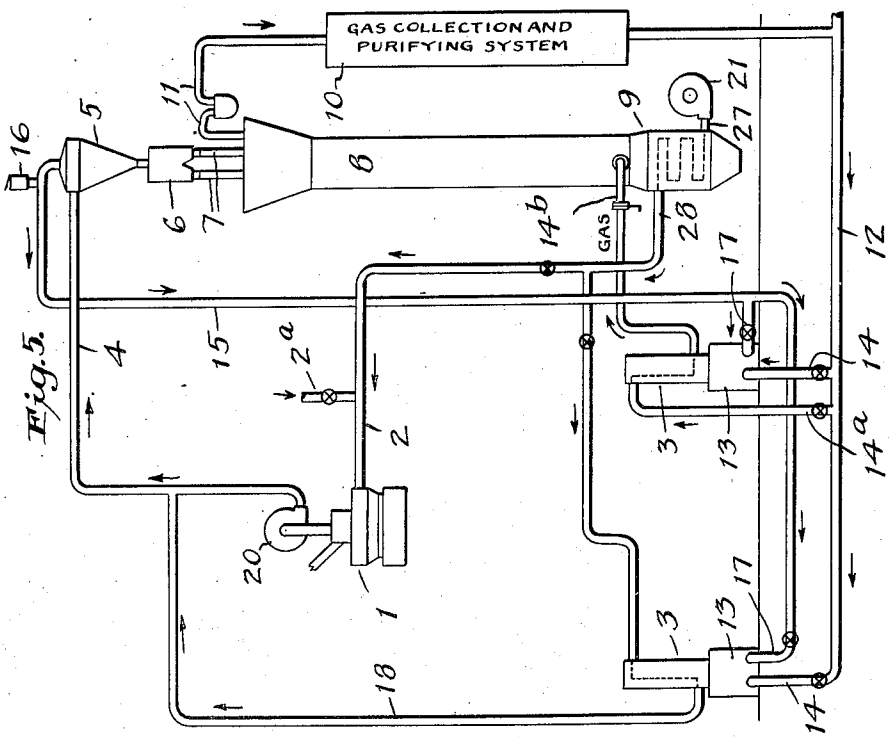


Fig. 5.

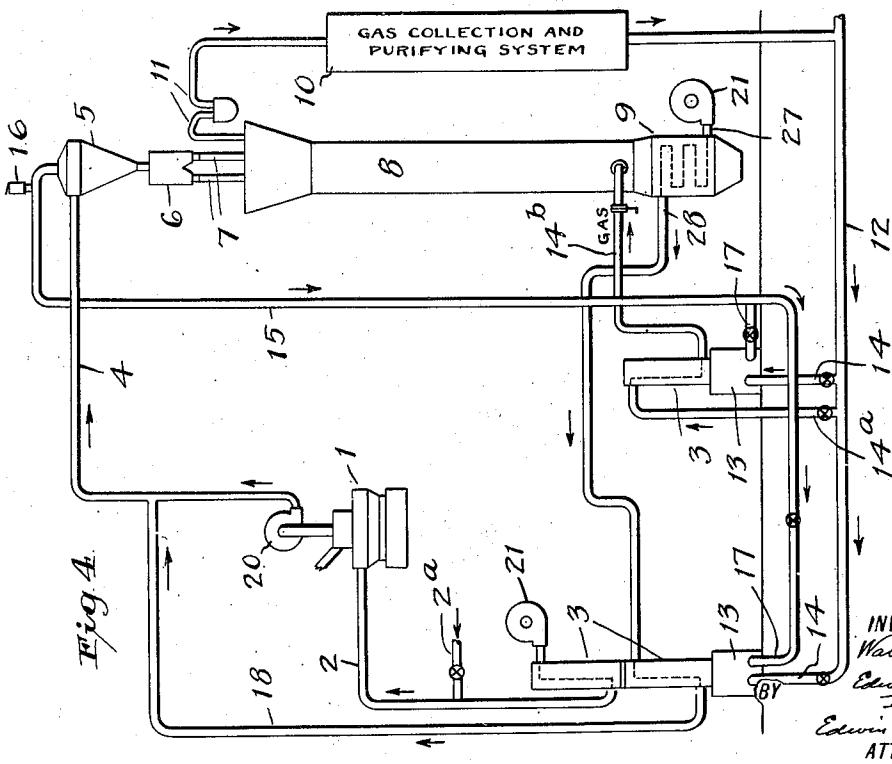


Fig. 4.

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PROCESSING OF COAL

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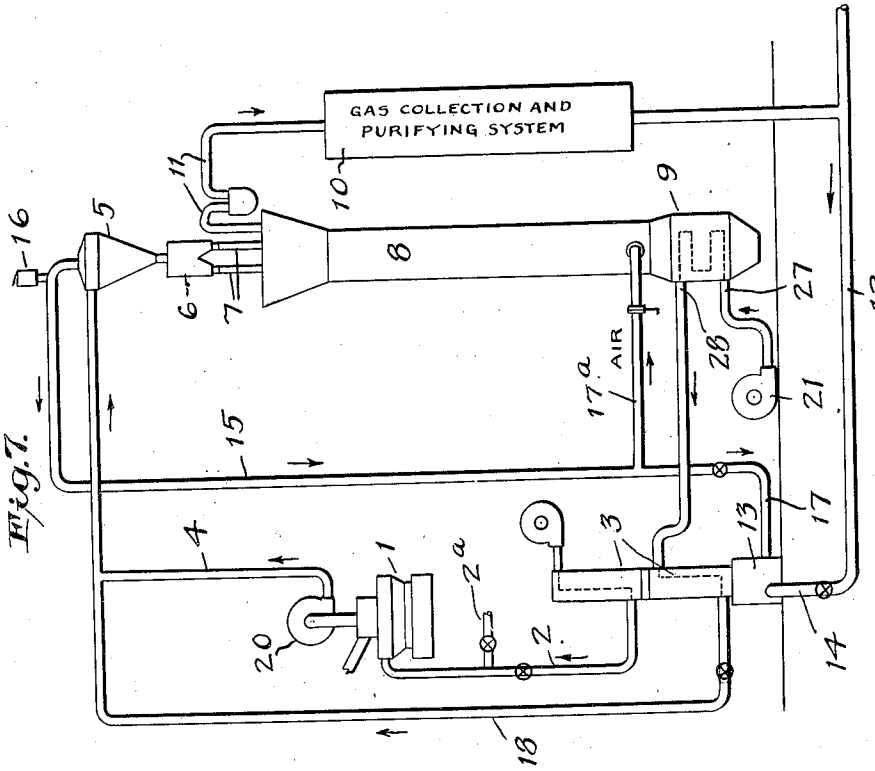


Fig. 7.

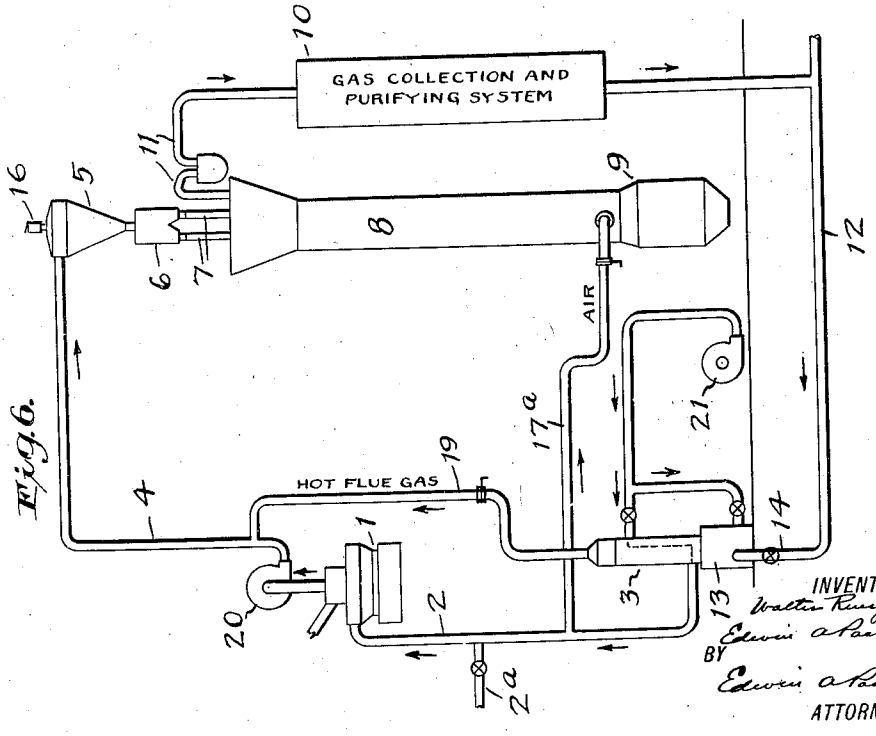


Fig. 6.

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May 12, 1931. W. RUNGE ET AL 1,805,109

PROCESSING OF COAL

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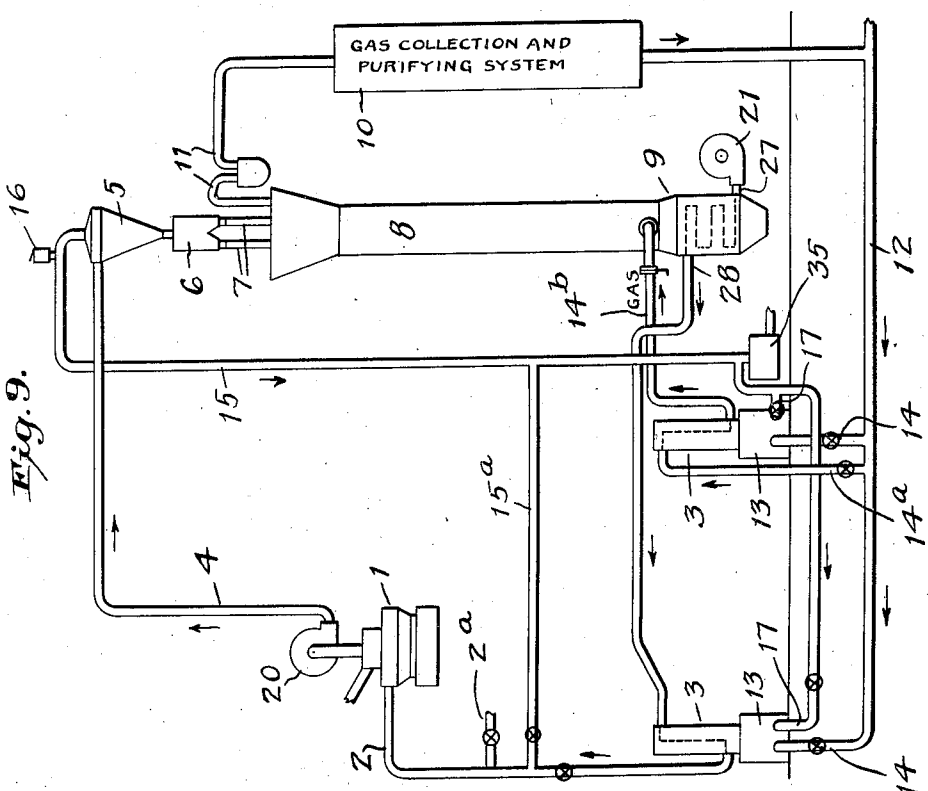


Fig. 9.

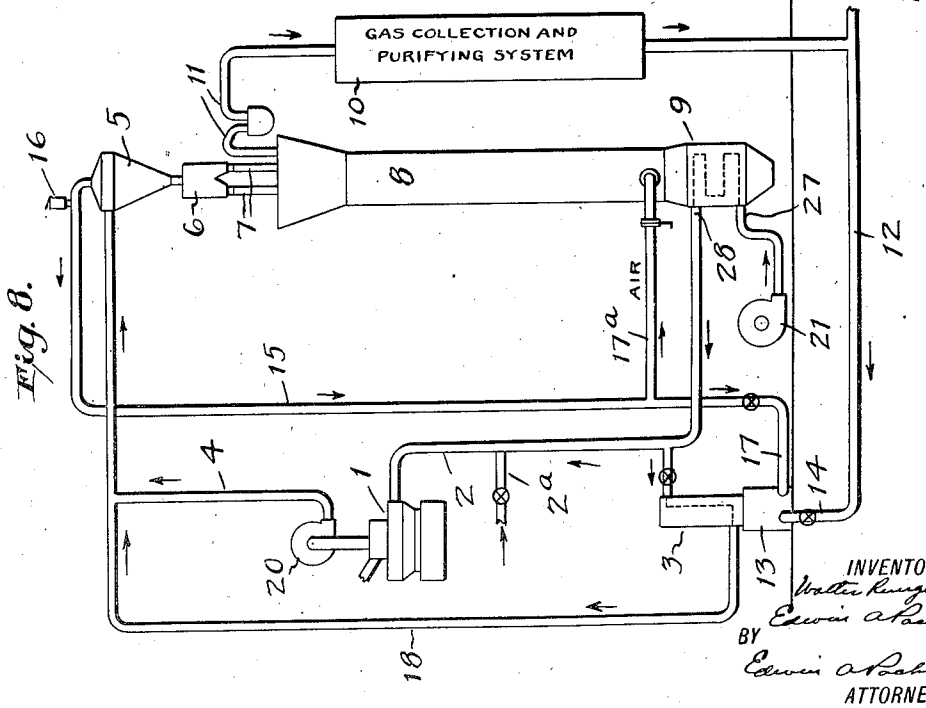


Fig. 8.

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May 12, 1931. W. RUNGE ET AL 1,805,109

PROCESSING OF COAL

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Fig. 10.

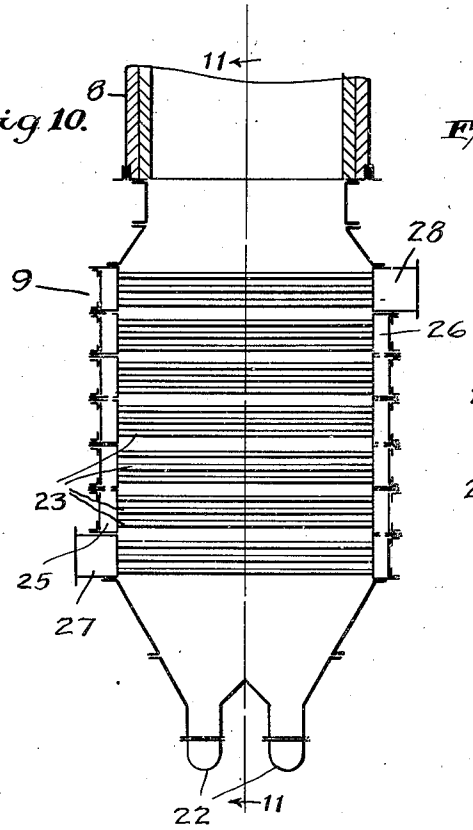


Fig. 11.

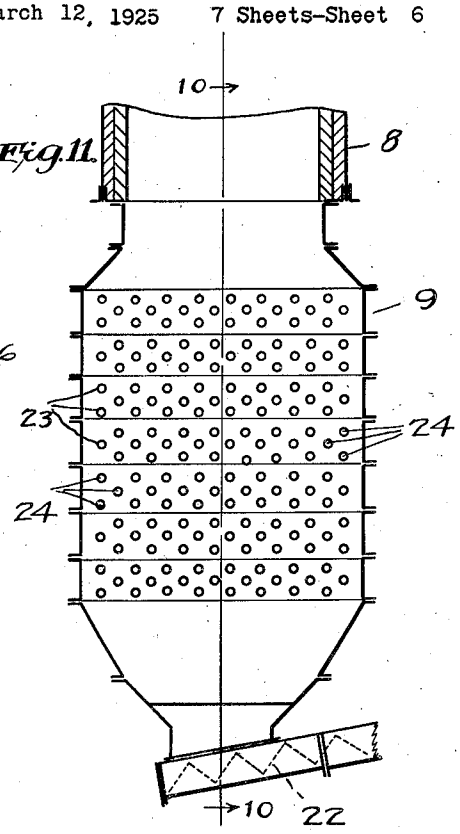


Fig. 12.

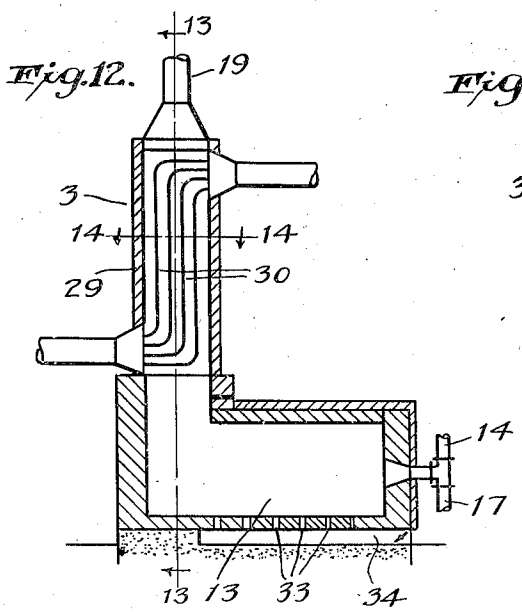


Fig. 13.

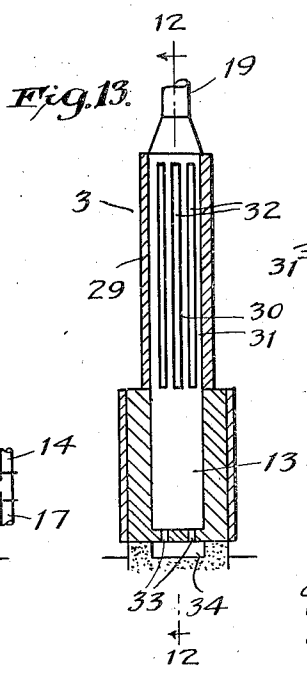
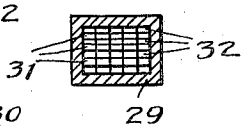


Fig. 14.



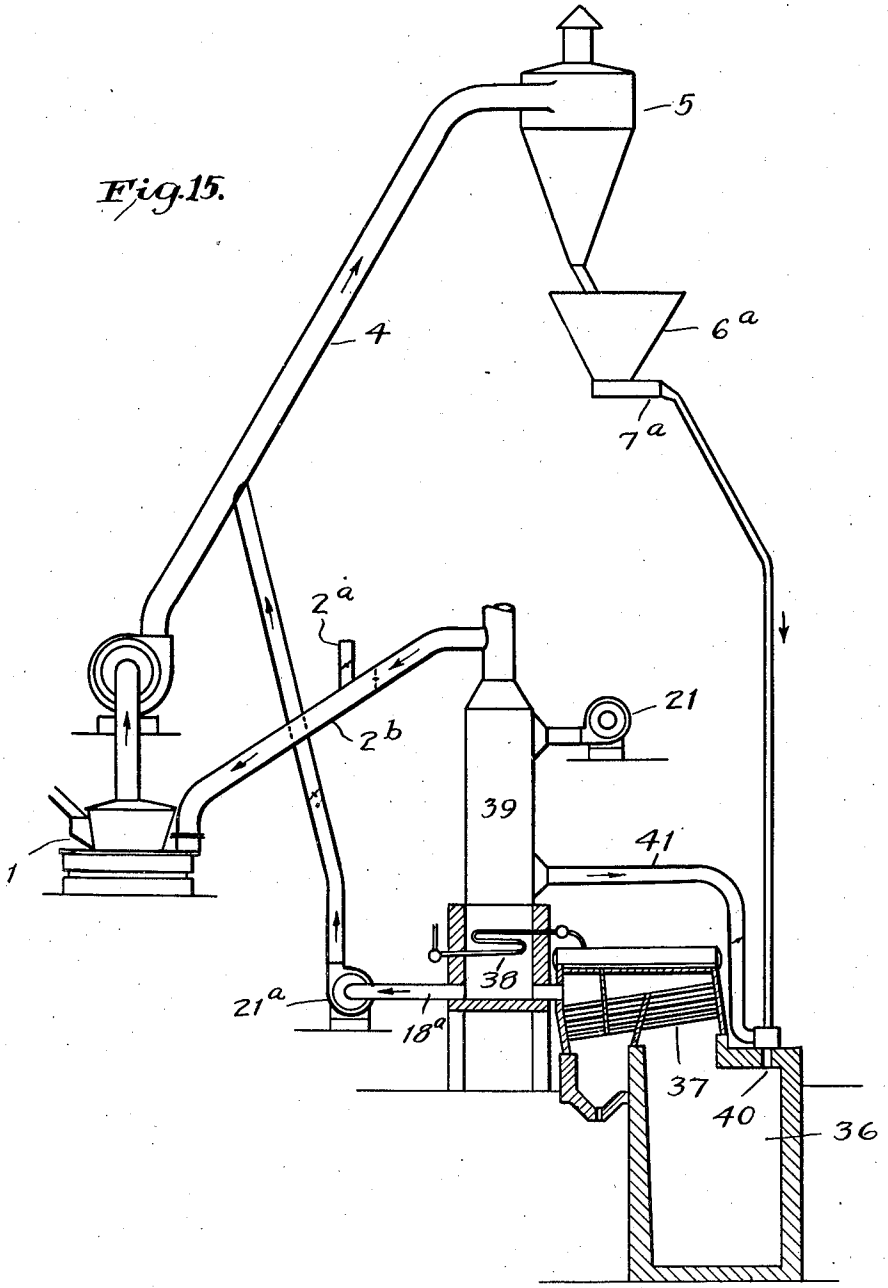
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PROCESSING OF COAL

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Fig.15.



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Patented May 12, 1931 1,805,109

UNITED STATES PATENT OFFICE

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PROCESSING OF COAL

Application filed March 12, 1925. Serial No. 14,998.

The invention relates to the treating or processing of coal.

It primarily relates to processes and apparatuses wherein the coal is pulverized or crushed into finely divided form in a pulverizing mill or pulverizer in the presence of a current of gaseous medium and heat, as hot or preheated air or some other hot or preheated gaseous medium as flue gas, and from which pulverizing mill or place of pulverization, the resulting mixture of hot gaseous medium and pulverized coal is conveyed through a suitable conduit or piping to a separator, as of the cyclone type, and within which the pulverized coal and hot gaseous medium are separated from each other.

The invention, according to a more specific aspect thereof, contemplates the introduction into the mixture while in transit from the pulverizer to the separator of a hot gaseous medium, to wit, preheated air or other hot or preheated gaseous medium, that is hotter than the mixture, and such introduction may be for completing the drying of the coal while the latter is in transit, for the further elevating of the temperature of the pulverized coal while in transit; or even for treating the coal as for the purpose of destroying certain properties of or for the purpose of obtaining certain oxidizing effects upon the coal particles.

According to certain aspects of the invention the heating of the pulverized coal in what may be referred to as the pulverizing system, to wit, in the system which includes the pulverizer and conduit leading to the separator, is to bring the pulverized coal to a desired heat, state or condition prior to processing or prior to further processing.

According to a more specific aspect of the invention the coal is dried, heated or preheated and treated or pretreated so as not only to dry the coal but also so as to destroy to a certain extent the agglutinating or further swelling properties and the hot coal thus preheated or pretreated is fed with a substantial part of the heat still therein to a retort, sometimes referred to herein as a carbonizing retort, where the coal may be either partially distilled or completely gasified, as desired. According to other aspects of the invention the air which is separated from the mixture as by means of the separator is passed to a place where it further functions in the process and from what follows it will be manifest that various products of the process and various parts of the plant employed in performing the several aspects of the invention are brought into association or are arranged in cooperative relationship in a manner not heretofore known or realized.

The invention relates not only to the feature or aspects above pointed out but also to others as will be apparent to one skilled in the art and particularly in view of the description embodied in or the disclosure of this application.

For a more specific embodiment and arrangement of the various aspects of the invention reference is made to the accompanying drawings forming a part of this specification in which drawings

Figures 1 to 9 inclusive each diagrammatically shows a plant for realizing the invention or at least certain aspects thereof. It will also be clear from what hereinafter appears that in each of the plants in Figures 1 to 9 there is shown what is designated as a carbonizing retort having at the lower end thereof a coke cooling chamber constructed so as to constitute a heat interchanging device. In each of said plants there are also indicated certain preheaters for preheating air or gas as the case may be.

Figures 10 and 11 are vertical sections showing the construction of the coke cooling chamber, Figure 10 being a vertical section taken as on the plane indicated by the line 10—10 looking in the direction of the arrows while Figure 11 is a vertical section taken as on the plane indicated by the line 11—11 looking in the direction of the arrows.

Figures 12 to 14 are sections illustrating typical preheaters which can be utilized in said plants, Figure 12 being a vertical section taken as on the plane indicated by the line 12—12 looking in the direction of the arrows, Figure 13 a vertical section taken as on the plane indicated by the line 13—13 looking in the direction of the arrows, and

Figure 14 is a horizontal section taken as on the plane indicated by the line 14—14 looking in the direction of the arrows.

Figure 15 shows an arrangement wherein coal is pulverized and pretreated or partially carbonized to the extent desired preparatory to burning in a pulverized fuel burning furnace.

Reference will now be made to the drawings wherein it will be noted that like or equivalent parts are designated by the same reference characters throughout the several figures.

General as to plants shown in Figures 1 to 9

It will be noted that each of these plants comprises a pulverizing mill 1, sometimes hereinafter referred to as a pulverizer, pulverizing apparatus or place of pulverization—to which a hot gaseous medium, as hot or preheated air, is continuously fed by pipe 2 serving as means for conducting the hot air, as from passageways, through the coke cooling chamber 9 (see Figure 1), or from a preheater 3 (see Figure 2). A conduit or pipe 4 conducts the mixture of air and pulverized coal from the pulverizing mill 1 to a separator 5 which may be of the cyclone type and which designates what may be referred to as the place for separating the coal and air or other gaseous medium. The coal which is separated falls to the lower portion of the separator 5 into a receiving means or bin 6 and by suitable feeding means, as 7, is fed (preferably sprayed) into the upper portion of what is referred to herein as the carbonizing retort 8 having at the bottom thereof the coke cooling chamber 9. This retort while referred to as being a carbonizing retort is to be broadly construed, since within the broader aspects of the invention it is possible not only to carbonize material within the retort—that is to distil it to the extent desired—but it is also possible to carry out a complete gasification in this retort should one desire to perform such operation. Retorts and processes for carrying out either partial distillation or complete gasification, are shown and described in pending U. S. applications filed by one of the applicants herein, to wit, the Runge applications Serial Nos. 748,037; 748,038 and 748,039, each filed November 6, 1924.

It will also be observed that each of the plants of Figures 1 to 9 comprehends a gas collecting and purifying system or apparatus collectively designated by the reference character 10 and which is illustrated diagrammatically in Figure 1. In each of these figures the gas of or produced by the carbonizing or gasifying operation is withdrawn or conducted from the carbonizing retort 8 to the gas collecting and purifying system 10 by an off-take means or piping 11. There is also provided a gas pipe 12 for conducting combustible gas from the gas collecting and purifying apparatus 10 to a place where the same may be utilized in the process, to wit, to the furnaces 13 of the preheaters 3 by means of branches or branch pipes 14 where it can be utilized for burning and thus supply heat for the preheaters; or in certain instances (see Figure 1) by branch pipes 14*a*, a preheater 3 and pipe 14*b* back to the carbonizing retort 8 where it is utilized as a heat conveying medium or a heat producing medium. The air from the cyclone separator 5 passes into an air pipe 15, having a damper-controlled vent 16, which pipe 15 in most of the plants shown extends downwardly and has branches 17 leading to the furnaces 13 of the preheaters 3 whereby the contaminated air from the separator is used, some in the preheater furnace or furnaces to support combustion with the purified gas of the process that is supplied thereto. The air pipe 15 in certain instances has a branch pipe 17*a* for supplying some of this contaminated air to the carbonizing retort 8 for functioning in the performing of the carbonizing operation in the retort.

It will also be noted that in respect to certain of the figures, particularly Figures 1, 4, 5, 7 and 8 preheated air is, as by means of piping 18, conducted from a preheater and delivered into the mixture in transit from the pulverizing mill 1 to the separator 5 so as to add further heat to the mixture while in transit. The temperature of this hot air, which is a hot gaseous medium, is sufficient to complete the desired effects upon the coal in transit, be it to complete the drying of the coal, to raise the temperature of the coal, or even to oxidize the coal particles to a desired extent, for example a slight oxidization, prior to the introduction of the hot coal thus treated into the carbonizing retort 8.

In Figure 6 it will be noted that a pipe 19 is arranged to convey hot products of combustion which have passed through the flue gas passageways (described later) of the preheater 3 and introduce said hot products of combustion or flue gas into the mixture of pulverized coal and hot air which is in transit on way to the separator 5.

In each of the figures shown there is embodied in conduit 4 a suitable exhauster or fan 20 for conveying and maintaining a flow of the mixed gaseous medium and pulverized fuel from the pulverizer 1 to the separator 5. There are also provided such instrumentalities as blowers 21 for causing enforced circulation of the gaseous products, air or the like, into or through the system. If desired for tempering the air entering the mill there can be employed a pipe 2*a* having a damper through which the tempering air or flue gas can enter. The tempering gaseous medium for the purpose, be it air or flue gas, may be either colder or even hotter

than that flowing through the pipe 2, this being dependent upon the heat conditions desired within the mill.

Reference will be made to each of the plants of Figures 1 to 9 but before doing this reference will first be made to the coke cooling chamber or heat interchanging device 9 of Figures 10 and 11 and the typifying preheater 3 of Figures 12 to 14.

As to the coke cooling chamber 9, such is arranged at the bottom of the carbonizing retort 8 so as to receive and hold the precipitated carbonized residues resulting from the process and which are removed by means of screws 22. It will be observed that each of these coke cooling chambers or heat interchanging devices 9 comprises spaced pipes 23 between which the precipitating or precipitated coke passes and these pipes provide passageways 24 in communication with sinuous passageways 25 and 26, into, through and from which passageways 25, 24 and 26 air used in the process is passed and preheated while at the same time serving to indirectly cool the coke in the coke cooling chamber 9.

Pipes conducting air to this system of passageways are designated by 27 and the pipe for conducting air from said system of passageways is designated by 28.

As to the preheaters of Figures 12 to 14, it will be noted that a casing 29 supports therein preheating elements 30 arranged so as to provide a series of air or gas passageways 31 and a series of flue gas passageways 32, all arranged so that the air or gas flowing through passageways 31 can be indirectly heated from the flue gas flowing through passageways 32. Each preheater 3 is provided with a furnace 13 constructed so as to receive through branch pipes 14 and 17 gas and air for supporting combustion in the furnaces, which combustion is relied upon to heat the air passing through the preheaters 3 by the indirect action from the flue gases, as above described. The furnaces may also be constructed so as to have an auxiliary air supply 33 through damper-controlled passageways 34. As previously indicated, the air usually employed in the furnace and which is supplied through the air branch pipe 17 is some of the air from the separator and the gas supplied through gas branch pipe 14 is the purified gas of the process.

Reference will now be made to the plants of each of the Figures 1 to 9.

Plant of Figure 1

In this figure it will be noted the hot air entering the pulverizing mill 1 is heated by passing through the coke cooling chamber 9, being tempered if desired by air from the outside, and the temperature within the pulverizing mill should be approximately 212° F. Said temperature may either be lowered or even raised dependent upon the type of pulverizing apparatus used. It will also be noted that some of the air which is preheated by flowing through passageways of the coke cooling chamber 9 passes through a preheater 3 where it is further heated to the extent desired; i. e. to a temperature such that when the air is introduced into the mixture flowing from the mill 1 through conduit 4 to the separator 5 it will elevate the temperature of the mixture to 500° F. and upwards. The travel of the coal in the mixture at this temperature imparts to the coal heat and also effects certain oxidization thereof which may be used to advantage in the carbonizing operation subsequently carried out within the carbonizing retort 8. It will also be noted from this figure that the contaminated air from the separator 5, or at least some of it, is utilized to support combustion in the furnaces 13 for the preheaters 3 and it will also be noted in this figure that one of said preheaters is employed for preheating combustible gas supplied to the carbonizing retort for the carrying out of the carbonizing operation therein. The path of this combustible gas is through gas branch pipe 14*a*, preheater 3 and pipe 14*b* to the carbonizing retort 8. The contaminated air leaving the separator 5 contains considerable moisture—it should contain all of the moisture of the coal—and in its travel through the air pipe 15 some of this moisture becomes condensed. In order to remove this condensed moisture which carries with it some of the coal particles there is provided a sludge tank 35. It will also be manifest from an inspection of this figure that a valve-controlled branch pipe 15*a* extends from the air pipe 15 to the pipe 18, which in turn leads from the preheater 3 to the conduit 4, whereby the preheated air flowing through pipe 18 can be tempered by some of the returned contaminated air, or whereby some of the contaminated air can be recirculated through the system. Further comments in respect to the plant of this figure are believed to be unnecessary in view of the remarks preceding.

Plant of Figure 2

In this figure it will be noted that the preheated air supplied to the pulverizing mill 1 passes first through a blower 21, then preheater 3, thence to the pulverizing mill 1. The contaminated air passing through pipe 15 is employed for supporting combustion in the preheater furnace 13 and in the instance of this plant the purified combustible gas of the process is preheated by passing through one of the preheaters 3 and is conducted to the carbonizing retort 8 for carrying out the carbonizing operation therein. The only heat supplied to the coal being pulverized or in transit is that supplied to the pulverizing mill 1 and consequently there is a certain limitation in the temperature at which the

coal can be heated. With the arrangement shown the coal should not be heated much above 212° F. for at temperatures slightly below this the coal is practically dry and combustion might take place in the pulverizing system if the air were supplied to the pulverizing mill at too high a temperature.

Plant of Figure 3

In the instance of this plant, air for the pulverizing mill 1 is first passed through the coke cooling chamber 9 thence through a preheater 3, and finally to the pulverizing mill. In this plant combustible gas to wit, gas of the process which is chemically inert with respect to the coal which is heated by passing through a preheater 3 is employed for carrying out the carbonizing operation.

Plant of Figure 4

Here, as in Figure 1, the sensible heat of the coke is utilized for effecting a preheating of the air by passing some of the air used in the process through the passageways in the coke cooling chamber 9. According to the arrangement of this figure one of the preheaters 3 is made in two sections, one of which may be referred to as the lower or hotter preheater section and the other as the upper or cooler preheater section. The gaseous medium, to wit, air, passing to the pulverizing mill 1 is preheated in this upper or cooler section while the air or other gaseous medium which is introduced into the mixture flowing through the conduit 4 first receives heat by its passage through the passageways of the coke cooling chamber 9 and further heat in its transit through the lower or hotter section. This arrangement can be utilized to preheat and pretreat the coal to any desired extent within the limitations imposed by the particular heating medium employed. With air, as previously indicated, the temperature in the pulverizing mill 1 should be approximately 212° F. and the temperature of the mixture within the conduit 4 may be raised to approximately 500° F. and upwards. According to the arrangement of this plant combustible gas is used for carrying out the carbonizing operation, which combustible gas is chemically inert with respect to the coal and has been preheated by passing through a preheater 3.

Plant of Figure 5

Here, air of the process is first preheated by passing through passageways of the coke cooling chamber 9 and part of the air thus preheated is conducted directly to the pulverizing mill while another portion thereof is passed through a preheater 3 and further preheated, thereafter being introduced into the mixture flowing through conduit 4. In this plant combustible gas is used for carrying out the carbonizing operation which gas (gas chemically inert with respect to the coal) has been preheated by passing it through a preheater 3.

Plant of Figure 6

According to this arrangement air is preheated in a preheater 3 and is conducted directly to the pulverizing mill 1. It will also be noted that a stack of the preheater 3 is connected into the pulverizing system so that the flue gases resulting from combustion within the furnace 13—or at least some of these flue gases—are conducted by stack pipe 19 and delivered into the mixture while in transit through the conduit 4. The temperature of these flue gases can be relied upon to materially raise the temperature of the mixture, even above that where preheated air alone is employed, and in this way added heating or treating effects upon the coal within the conduit 4 can be realized while the coal is in transit. In the instance of this installation the contaminated air from the separator 5 is allowed to escape to the atmosphere. In this arrangement the air for supporting combustion within the furnace 13 is that supplied by the blower 21 and some of the preheated air is also used for functioning in carrying out the carbonizing operation within the carbonizing retort.

Plant of Figure 7

This arrangement is similar in many respects to the arrangement of the plant of Figure 4 with the exception that some of the contaminated air from the process is supplied for assisting in carrying out the carbonization operation within the retort 8. As in the plant of Figure 4, the air or gaseous medium supplied to the pulverizing mill 1 is preheated in an upper or cooler section of the preheater 3 while other air which is first preheated by passing through the passageways of the coke cooling chamber 9 and thence through the lower or hotter section of the preheater 3 is conducted through pipe 18 and delivered into the mixture flowing through conduit 4, while the mixture containing pulverized coal is in transit from the pulverizing mill 1 to the separator 5.

Plant of Figure 8

In the plant of this arrangement some of the contaminated air is employed for functioning in supporting the carbonizing operation carried out within the retort 8 while the air which is preheated and utilized in the pulverizing system is first heated by passing through passageways to the coke cooling chamber 9. Some of the air thus preheated is conducted directly to the pulverizing mill 1 and some passed through the preheater 3, thence through pipe 18 by which pipe 18 it is introduced into the mixture in transit from

the pulverizing mill 1 through conduit 4 to the separator 5.

Plant of Figure 9

This arrangement has a sludge tank 35 functioning substantially according to the arrangement of Figure 1 and in many respects the plant of Figure 9 is similar to that of Figure 1 with the exception that in the plant of Figure 9 the air which is passed through the preheater 3 is conveyed directly to the pulverizing mill 1 instead of to the mixture flowing from the pulverizing mill to the separator 5 as in the plant of Figure 1.

The plants of Figures 1 to 9 show an arrangement that includes a retort within which the coal is carbonized, after it has been preheated or pretreated within the pulverizing system. This pulverizing system in general, however, has a broad field of application. It may be employed for either pretreating or partial carbonization of coal used in other fields. For example, the coal can be treated in a manner to prepare it for burning in pulverized or finely divided form and such an arrangement is shown in the plant of Figure 15.

Plant of Figure 15

In this figure it will be noted that a pulverized fuel burning furnace 36 is employed for heating a boiler 37. There is associated with this furnace and boiler certain heat absorbing elements, as steam superheaters 38 and air preheaters 39, and it will be noted that the arrangement of these parts is such that the products of combustion passing from the furnace first traverse the boiler tubes, thence pass the superheaters 38, and finally pass through the air preheaters 39, all of which serve to cool to a substantial extent the products of combustion or flue gases. It will be manifest that the flue gases in the space behind the air preheaters 39 have less temperature or are cooler than the flue gases passing through the space which is ahead of the superheaters 38, and advantage is taken of this difference in temperature, as will presently appear.

The plant of this figure has a pulverizing mill 1 a separator 5, and a conduit 4 extending a substantial distance from the pulverizing mill to the separator, and it will be noted that some of the flue gases are tapped from the space behind the air preheaters and are conducted by means of pipe 2*b* to the pulverizing mill 1. This pipe 2*b* also has a damper-controlled portion 2*a* by which tempering air may be allowed to enter the pulverizing mill, together with the flue gases, if the temperature of said flue gases is too high for practical operation of the mill. The space ahead of the superheater elements 38 is also tapped and a pipe 18*a* with a blower 21*a* therein is employed for conducting these hot products of combustion or hot flue gases—which are hotter than those conducted through the pipe 2*b*—to the conduit 4 for elevating the temperature of the mixture within the conduit to any desired extent. As previously indicated the pipe 2*b* has a damper-controlled pipe 2*a* whereby the gaseous medium entering the pulverizing mill can be brought down to proper working temperature within the pulverizing mill, to wit, to a temperature between approximately 200° F. and 500° F. and even upwardly, provided the pulverizing mill is of such construction as will withstand high temperatures. The temperature within the conduit 4 can be carried high enough and can be maintained long enough to effect a desired degree of heating of this coal and a desired carbonizing of the coal while in transit. The coal residues resulting from this partial carbonizing can in the separator 5 be separated from the treating gaseous medium. The collected residue is then conveyed to and through a suitable hopper 6*a* and feeding means 7*a* to the burners 40 of the furnace 36 where it can be burned as in the manner common to pulverized fuel burning apparatus, and it is preferred to inject the partially carbonized residue thus obtained into the furnace 36 with a substantial portion of the heat retained still therein, together with the preheated air which is conducted to the furnace by piping 41.

It will therefore be seen that in the instance of this arrangement the pulverizing apparatus is not only a preheating apparatus but the pretreatment therein goes to the extent of carrying out a partial carbonizing operation, by which substantial portions of the volatile matter of the coal are distilled. In order to recover the volatile matters thus distilled from the coal the gas leaving the separator 5 should be collected and treated as is customary in gas collecting and purifying systems. Such collecting and purifying of gas is well known, in fact a system therefor is indicated in Figure 1.

In order that heat may be retained in the pulverizing system it will be obvious that the pulverizing mill 1, the conduit 4 and the associated parts—particularly the exhauster of fan 20 and the cyclone separator 5—should be heat insulated. In fact all parts from which heat is radiated can well be insulated as is customary in a class of work where heat losses are to be avoided.

It will be noted that the generic aspects of this invention have broad fields of application and that the invention hereof may be embodied in various forms and modifications without departing from the spirit and scope thereof.

What is claimed is:

1. In the process of carbonizing powdered coal, the steps of pulverizing and drying coal

prior to carbonization comprising feeding coal to a mill wherein all of the coal fed thereto is pulverized, continuously introducing a hot gaseous medium into the mill and carrying out the pulverizing operation, continuously conducting the pulverized coal in suspension in said gaseous medium from the mill and introducing a gaseous medium hotter than the coal and gas leaving the mill, but not sufficiently hot to cause ignition of the coal into the mixture while in transit on the way to a place where the coal is separated from the gaseous medium, and separating the coal thus treated from the gaseous medium.

2. In the process of carbonizing powdered coal, the steps of pulverizing and drying coal prior to carbonization comprising feeding coal to a mill wherein all of the coal fed thereto is pulverized, continuously introducing hot air into the mill and carrying out the pulverizing operation in the presence thereof but below the ignition temperature of the coal, continuously conducting the pulverized coal in suspension in said air from the mill and further heating by introducing a hot gaseous medium into the mixture while in transit on the way to a place where the coal is separated, the temperature of the air admitted to the mill and of the gaseous medium introduced in the conduit being insufficient to cause ignition of the coal and separating the coal thus treated.

3. In the process of carbonizing powdered coal, the steps of pulverizing and drying coal prior to carbonization comprising feeding coal to a mill wherein all of the coal fed thereto is pulverized, continuously introducing hot air into the mill and carrying out the pulverizing operation in the presence thereof, continuously conducting the pulverized coal in suspension in said air from the mill and further heating by introducing hot air into the mixture while in transit on the way to a place where the coal is separated, and separating the coal thus treated, the hot air introduced as provided for being below a temperature which is sufficient to cause ignition of the coal.

4. In the process of carbonizing powdered coal, the steps of pulverizing and drying coal prior to carbonization comprising feeding coal to a mill wherein all of the coal fed thereto is pulverized, continuously introducing a hot gaseous medium into the mill and carrying out the pulverizing operation, continuously conducting the pulverized coal in suspension in said gaseous medium from the mill and further heating by introducing a hot air into the mixture while in transit on the way to a place where the coal is separated, and separating the coal thus treated, the temperature of the gaseous medium admitted at the mill and of the air introduced into the conduit being insufficient to cause ignition of the coal.

5. In the process of carbonizing powdered coal, the steps of pulverizing and drying coal prior to carbonization, comprising feeding coal to a pulverizing mill wherein the coal is pulverized, introducing hot air into the mill so as to create and maintain within the mill temperatures approximating 212 degrees F., conducting the pulverized coal in suspension in said air from the mill to a separator, raising the temperature of the mixture by the addition thereto of a gaseous medium hotter than 212 degrees F. while in transit to further heat the coal and separating the pulverized coal out of the hot gaseous medium, the temperature of the mixture being kept below the ignition temperature of the coal.

6. In the process of carbonizing powdered coal, the steps of pulverizing and drying coal prior to carbonization, comprising pulverizing coal in the presence of air and heat, conducting the pulverized coal in suspension in said air under conditions to further heat the coal by the addition of hotter air and in a manner to complete drying and to cause a slight degree of oxidization of the coal, the temperature of the air employed being insufficient to cause ignition of the coal and separating the oxidized coal from the air.

7. The method of drying and carbonizing pulverized coal comprising pulverizing the same in the presence of hot air but below the ignition temperature of the coal, conducting the pulverized coal in suspension in said air to a separator, further heating the coal while in transit to the separator by adding hotter air also below the ignition temperature of the coal, separating the coal and air, carbonizing the coal while in finely divided form, cooling and washing the gases resulting from the carbonizing, burning a portion of said gases in the presence of air which has been separated from the coal, to heat another portion of said gases and to heat the said added air and using the heat so imparted to said other portion of the gases in the carbonization of the coal.

8. The method of drying and carbonizing pulverized coal comprising pulverizing coal in the presence of heated air but below the ignition temperature of the coal, conducting the pulverized coal in suspension in said hot air to a separator wherein the coal and air are separated, carbonizing the coal, burning a portion of the gases resulting from the carbonization in the presence of air which has been separated from the coal, to heat another portion of said gases, using the heat so imparted to said other portion of the gases in the carbonization of the coal, and cooling the solid residues resulting from the carbonization of the coal by imparting the heat thereof to the air in the presence of which the coal is to be pulverized.

9. The method of drying and carbonizing

pulverized coal comprising pulverizing coal in the presence of heated air but below the ignition temperature of the coal, conducting the pulverized coal in suspension in said air to a separator, further heating the coal while in transit to the separator by adding hotter air also below the ignition temperature of the coal, separating the coal and air, carbonizing the coal while in finely divided form, cooling and washing gases resulting from the carbonizing, burning a portion of said cooled washed gases to furnish heat for the carbonizing, absorbing heat from the solid residues of the carbonizing process by air, using a portion of such air as the air in which the coal is pulverized, and further heating another portion and using it as the air added to the coal while in transit to the separator.

In testimony whereof we have hereunto signed our names.

WALTER RUNGE.
EDWIN A. PACKARD.