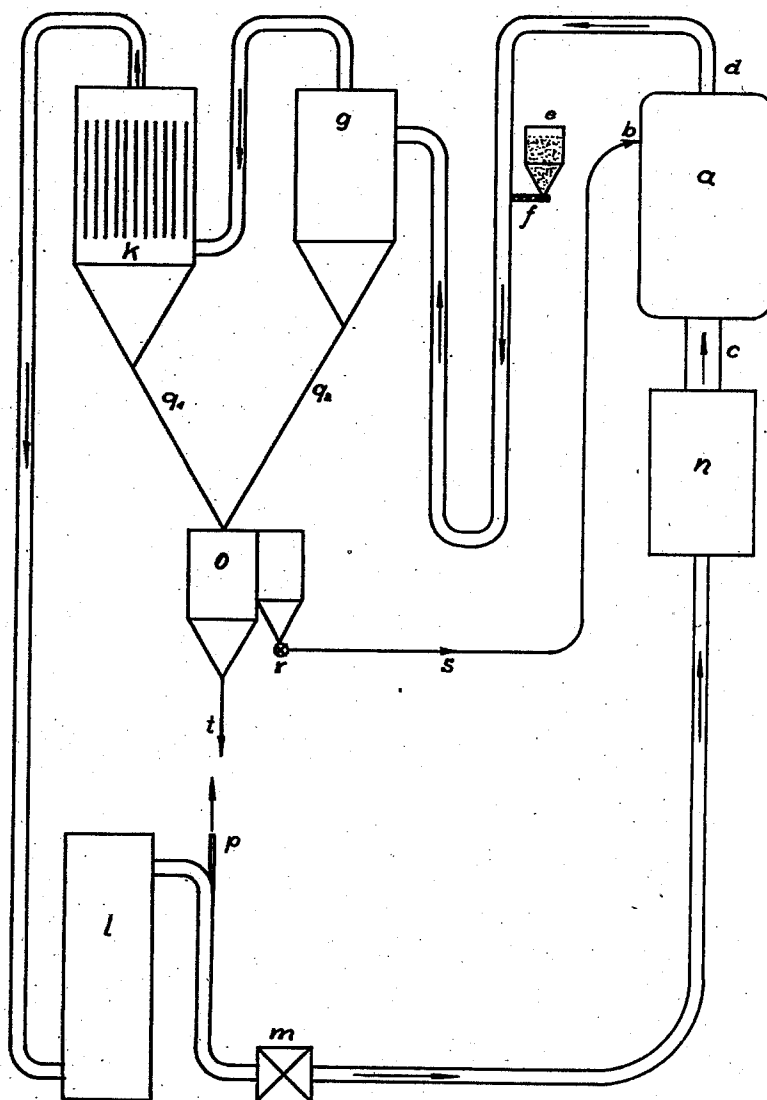


April 12, 1938.

3. **H. SCHMALFELDT**
PROCESS FOR THE GASIFICATION OF DUST OR FINE
GRAINED FUELS WITH CIRCULATING GAS
Filed Nov. 7, 1935 2 Sheets

2,113,774

2 Sheets-Sheet 1



Hans Schmalfeldt
INVENTOR

Fig. 1.

By DeWitt
his ATT'Y.

April 12, 1938.

H. SCHMALFELDT
PROCESS FOR THE GASIFICATION OF DUST OR FINE
GRAINED FUELS WITH CIRCULATING GAS
Filed Nov. 7, 1935

2,113,774

2 Sheets-Sheet 2

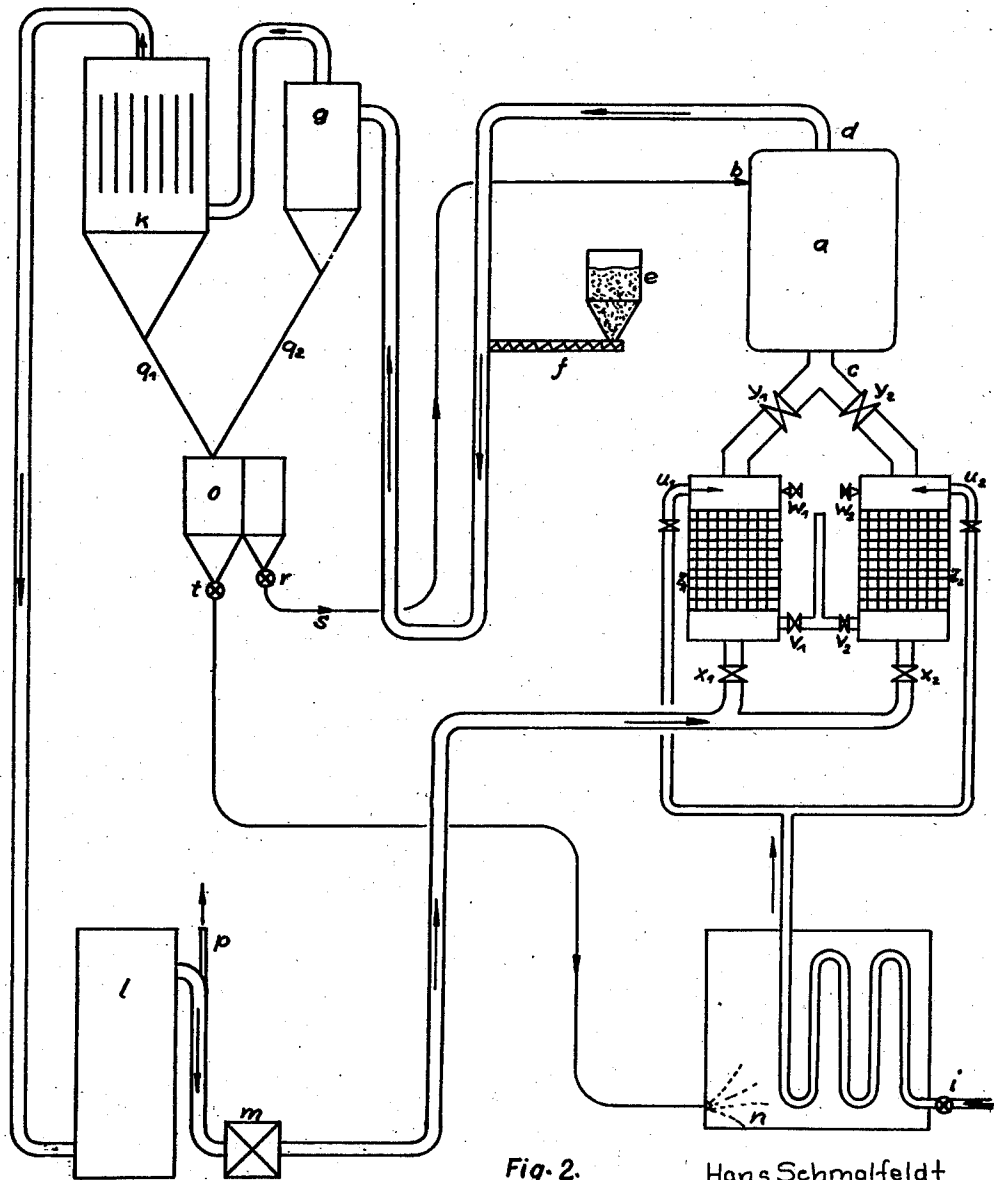


Fig. 2.

Hans Schmalfeldt
INVENTOR
By *[Signature]*
His ATTY.

UNITED STATES PATENT OFFICE

2,113,774

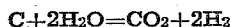
PROCESS FOR THE GASIFICATION OF DUST
OR FINE-GRAINED FUELS WITH CIRCULATING GAS

Hans Schmalfeldt, Kassel, Germany

Application November 7, 1935, Serial No. 48,730
In Germany November 26, 1934

4 Claims. (Cl. 48—202)

In gasifying fuels for the purpose of producing a gas free from nitrogen or poor in nitrogen, for example water gas, even today large coke is chiefly employed. The use of coke presents the advantage that, during the hot blowing, a quantity of heat can be accumulated in the glowing coke bed sufficient to supply the quantity of heat necessary for the gasification with water vapour corresponding to the two equations



Under certain conditions, and particularly in the treatment of lignite and similar fuels which on account of their less firm structure are not suitable for the accumulation of the reaction heat, it may be preferable to carry out the gasification with the coal in a fine-grained or dust state. The coal is preferably employed in a pulverous state, somewhat like lignite dust, in order to obtain the largest possible surface. It has been found that in the use of dust coal a very rapid gasification can be obtained with simultaneous treatment of a large quantity of coal dust.

The quantity of heat required for the gasification may be introduced, by internal heating either with a gas which has a high oxygen content or with heated circulating gas. As the first method possesses the disadvantage of the high expense of oxygen and the large content of carbon monoxide and carbon dioxide in the gas produced, only the production of the reaction heat with highly heated circulating gas, consisting of water vapour or of a mixture of water vapour and gas produced in the process, comes into question when the gas produced is to have the smallest possible percentage of carbon dioxide and carbon monoxide and a large amount of hydrogen.

For gasifying fine-grained and pulverous fuels by means of circulating gas a number of measures are necessary. First, the coal must be dried and ground to dust fineness. The dust coal must then be charged into the gasifier proper and gasified in the same, the highly heated circulating gases supplying the reaction heat. On leaving the gasifier the residue coal, which has not been gasified, must be separated, together with the ash, from the circulating gas cooled to a certain temperature. Then the circulating gas is again heated to a high temperature after the freshly generated gas quantities have been separated and again comes in contact with fresh dust coal for further reaction. The whole process takes place continuously.

During the gasification of dust fuels the following fundamental difficulties arise:—

The separation of non-gasified and gasified coal cannot be carried out in the gasifier owing to the fact, that the gas-fuel dust mixture comprises very slightly gasified dust particles together with almost completely gasified fuel dust particles all of which are discharged from the gasifier together with the circulating gas current. For this reason it is very difficult to attain a complete gasification of the coal dust. The gasification requires with increasing degree of gasification very materially longer periods of treatment and consequently large gasifying chambers.

Another difficulty, which, however, can be more easily overcome by employing corresponding expense in apparatus is that the circulating gas must be again freed from ash and fuel dust before it is re-heated, on the one hand in order to remove the dust separated by reaction, but chiefly to prevent that part of the gasifying plant which effects the heating of the circulating gas from becoming dusty. For re-heating the circulating gases either recuperators or regenerators may be employed. The recuperators which are less often used will soon lose in efficiency by becoming dusty and sluggy, if the circulating gases are not suitably cleansed before entering the recuperator. It is similar in the case of regenerators which, if used with non-purified circulating gas, not only become dusty and slagged, but are also soon destroyed by slag flux.

Besides the apparatus necessary for the gasification there is also the auxiliary apparatus for the drying and grinding of the coal to be gasified. It has been found, that for drying and grinding, as a fine-grained or pulverous coal has to be gasified, circulating driers can advantageously be fitted with combined material disintegration. These driers work with a current of hot flue gases produced by a separate furnace, these gases flowing through a riser or downcomer conduit. The previously broken coal is introduced into this rapidly flowing flue gas current. A very rapid drying of the coal takes place owing to the direct contact with the rapidly flowing highly heated flue gases and also by the continual disintegration of the coal particles due to the friction and impact on the one hand and to surface drying and heat tension which is the difference in temperature between the surface of the fuel particles and their interior. The particles come from the bunker in a cool state and are readily heated by the hot gases on their surfaces, while the interior is still cool. The sufficiently fine, that is

preferably dust-fine dry coal particles are separated by wind separation, whereas the coarser and not yet sufficiently dry particles pass along the drying path in being again passed through a coarser or finer disintegrating apparatus, until fineness and degree of dryness are sufficient. The dust coal or fine coal is separated from the exit gases generally by several dust removing devices arranged one behind the other and the flue gases freed from dust and cooled are discharged into the atmosphere. The dust separation evidently also requires particular care during the circulating drying. Usually an electric dust purification is arranged in series with one or several centrifugal separators, so that there are often three or more dust removing plants connected in series.

In the production of water gas from a layer of finely divided fuel by means of air and steam it has already been proposed to use the gases escaping from the production of gas for drying the fuel, the process working in direct current.

According to the invention a considerable improvement and also simplification can be obtained in the gasification of dust coals with circulating gas by simultaneously employing the latter as a circulating dryer for the production of the dry dust coal in the procedure hereinafter set forth:—

The finely divided carbonaceous fuel (mineral coal, charcoal, lignite, peat, etc.) is gasified in a gasifying zone by means of circulating gas of about 700°–1600° C. The circulating gas always contains steam, together with e. g. water gas of different composition or hydrogen and carbonic acid or producer gas. The gases, escaping from this zone and charged with the more or less gasified fuel dust, are used to dry the necessary amount of fuel, e. g. by means of drying apparatus (drying by means of a drum). Advantageously the raw fuel is introduced into the flowing gas stream; by the quick drying obtained thereby, the fuel is simultaneously disintegrated. This may be supplemented by mechanical means for disintegrating. Thereupon the mixture of gas and fuel is separated by suitable means and at this point a part of the produced ash and fuel dust (about 10–50% of the total amount produced by drying and disintegrating) is removed from the circulation. The other part is led back to the gasifying zone. The gas is led—if necessary after washing and freeing it from the last ash and fuel dust particles—to the gasifying zone. In this way a part of the produced gas is removed as final product; the amount of this final product naturally corresponds to the amount of gas produced during the circulation. Before the other part of the gas discharges into the gasifying zone, it is reheated. The fuel removed from the circulation may be used for this purpose. It may also be used to heat an air-heater which preheats the combustion air for the regenerators.

Advantageously the ash and fuel dust to be removed from the circulation is taken from the dust separator which shows the highest content of ash.

From the foregoing it is clear that according to the present invention it is possible to combine the gasifying known per se with a special method of drying by introducing the raw fuel into the gas stream escaping from the gasifying zone, whereby also disintegrating of the lumps of raw fuel takes place. This method is followed by removing a part of the so produced dust of fuel, advantageously after separation from the gas and before introduction into the gasifying zone. In-

stead of the first described method of simultaneously drying and disintegrating also an ordinary drying of the raw fuel by means of the gases escaping from the gasifying zone may take place combined with mechanical means for disintegrating the raw fuel.

Two forms of embodiment of an apparatus suitable for carrying out the process as above described are illustrated in diagrammatic form in the accompanying drawings in which Fig. 1 illustrates one form of apparatus and Fig. 2 another form.

Referring now to Fig. 1 the fuel dust to be gasified is introduced into the gasifier *a* and *b*. Instead of one gasifier also several gasifiers may be used, being connected in series. The dust to be gasified is in suspension in the gasifier. The amount of the fuel in the gasifier is such that the suspension may be obtained and that the temperature necessary for the gasification may be maintained. The hot circulating gas enters at *c*, whereas the more or less gasified fuel dust is discharged at *d*, together with the cooled circulating gas. The circulating gases are not cooled by a special measure, but this is effected thereby, that a part of their heat content is given off to the dust particles in the gasifier. These quantities of circulating gas charged with the more or less gasified dust particles are then used for drying and disintegrating the fresh coal according to the circulating process. For this purpose the coal, which may have been previously disintegrated, is supplied from the bunker *e* through a device (in the figure a worm) *f* into the current of the hot circulating gas and disintegrated to the necessary fineness in the following manner:—A highly heated gas stream of a temperature of 500°–900° C. is led through a pipe in which the raw fuel, such as lumps of lignite, is discharged. By the sudden heating of the raw lignite in the quickly moving gas stream the exterior layer of the fuel is dried and bursts into small layers due to the great difference of the specific volumes of dry and wet fuel. The dried fuel thus obtained is relatively fine. The temperature in the pipe is reduced quickly. At the end of the pipe the fine, dry particles are separated by means known per se, the larger particles, not yet perfectly dry are led back into the pipe, thereby coming again into the gas stream. This disintegrating (taking place simultaneously with the drying) may be supplemented by mechanical means, e. g. a beater-drum by means of short, strong blows disintegrates the particles, which are too large, and which run back to the pipe. The dry and preferably dust fine coal is now separated by several dust removing devices in series connected, namely first by a cyclone device *g* and then by an electric dust separator *k*. The gases discharged from *k* enter a washer *l* in order to be simultaneously cooled and freed from the last traces of dust; the liquids used in the washer may be e. g. water or a suspension of coal dust in water. The circulating gases are drawn out of *l* and compressed by a fan or a blower *m*. One part of the cleansed gas is blown off at *p*. The rest is again forced into the device *n* where the re-heating of the circulating gas takes place. The highly heated circulating gases flow from *n* into the gasifier whereby the circulation path is closed.

The ash and fuel dust produced passes from the dust separators through the conduits *q*₁ and *q*₂ into a dust silo with overflow *o*. The largest quantity of the ash and fuel dust is now drawn 75

off by a dust pump, for example by a Fuller pump *r* and forced through the dust conduit *s* into the gasifier at *b*. A certain portion of the whole of the dust produced is, however, drawn off at *t* through a separate conduit and passes to some separate point of consumption of coal dust.

The advantages of the present invention are the following:—

(1) The present apparatus is considerably more simple than an apparatus using normal circulating drying and normal dust gasification with circulating gas. Whereas, in the normal construction the circulating drying and the dust gasification must each have a carefully constructed dust remover, only one single dust separator is now necessary, namely posterior of the circulating drying, instead of the two dust-separators.

(2) The present gasifying apparatus may be kept considerably smaller than in known devices, because complete gasification of the coal dust is no longer essential. If, for example, the degree of gasification of the coal during a single pass is below normal, the quantity of dust again supplied to the gasifier increases automatically because the ungasified dust is returned to the gasifier in the continuous circuit, so that, the circulation of a somewhat greater quantity of dust takes the place of a more intensive gasification. In order, however, to prevent the ash content in the circulation from becoming too great, a certain portion of the dust coal is always drawn off and thus removed from the circulation together with the ash. This portion of the dust coal may be used for some other purpose. The quantities of ash and fuel dust removed from the circulation, however, need not be particularly great in order to keep the average ash content low, as the following example shows:—

30 tons of dry coal dust containing 8% ash are to be passed hourly through the dust gasifier. However, enough coal must be dried hourly to obtain about 10 tons of coal dust of normal composition, that is with 8% ash, which composition corresponds to about 9.2 tons of ash-free dust coal. Consequently 40 tons of coal dust with 8% ash must be introduced per hour. The total amount of ash therefore amounts to 3.2 tons per hour. Therefore 3.2 tons of ash must be removed with 9.2 tons of ash-free coal dust the latter being removed for some other purposes. Consequently, it is necessary to remove 12.4 tons of coal dust with an average ash content of 26%. With this ash content it is possible to directly employ the coal dust which is drawn out of the circulation, provided it is for burning purposes. On the other hand the average ash content in the coal arriving at the gasifier is just as high. However, the gasification can still be satisfactorily carried out with such an ash content of the coal. It is therefore evident that by the manner of operation indicated, that is by the continual returning of the dust coming from the gasification, combined with a simultaneous withdrawing of a dust mixture from freshly dried dust and from dust returned from the gasification, it is possible to maintain at a satisfactory percentage the ash content of the fuel dust entering the gasifier. This results in a considerable increase in the efficiency of the dust gasifier, as the latter is no longer dependent upon a high degree of gasification because, with a lower degree of gasification, the quantity of dust returning to the gasifier increases.

A special condition presents itself by the mode

of operation in which the heating of the circulating gas is effected by means of regenerators (Figure 2). In this instance the dust gasifier (or gasifiers connected in series) is again denoted by *a*, whereas the dust to be gasified enters at *b* and the highly heated circulating gas at *c*. Gasified fuel dust and cooled circulating gas flows out at *d*, whereas the coal to be dried is introduced from the silo *e* through the device *f* into the circulating drier. The dust separators *g* and *k* again effect the purification of the circulating gases. In the washer *l* the gas is finally cooled and washed, before the blower or the fan *m* brings the moving gas into circulation. A part of the produced gas is again withdrawn at *p*. The cold circulating gas enters the two regenerators *z*₁ and *z*₂ at *x*₁ and *x*₂. Instead of two regenerators several regenerators may be used. The highly heated gases flow out of the regenerators alternately at *y*₁ and *y*₂ and again enter the gasifier at *c*. For the re-heating of the regenerators highly heated air is introduced at *u*₁ and *u*₂ and hot gas at *w*₁ and *w*₂, the flue gases escaping at *v*₁ and *v*₂ during the heating period. The heating of the combustion air to a high temperature is effected in an air heater *n*. A fan *i* sucks in the air and forces it through the air heater into the regenerator which is actually to be heated. The air heater *n* is heated with a coal dust flame. The coal dust necessary for this heating is taken from the collecting silo in the following manner. The coal dust passes from the dust separator through the conduits *q*₁ and *q*₂ into a dust bunker *o*. The greater portion of the ash and fuel dust is pumped, by a dust pump or a similar device, for example by a Fuller pump, through a conduit *s* into the dust gasifier at *b*. The dust pump *t* draws a certain portion of the dust out of the circulation and supplies it to the furnace for heating the air heater.

If it should be found that the ash content of the dust from the several dust separators is different, the quantity of dust, which is removed from circulation can preferably be drawn from the dust separator showing the highest ash content. In this manner the ash content in the dust in circulation and in the dust introduced to the gasifier is further reduced.

The most important feature of the present invention is in the combination of a special method for gasifying (i. e. gasifying of dusty fuels in suspension by means of highly heated circulating gas) with a special ("circulating") method of drying relatively wet, solid fuel. The circulating gases escaping from the gasifying zone and showing a temperature of about 500°-900° C., are still charged with the ungasified part of the fuel dust. The lumps of raw material to be dried are introduced into this mixture of circulating gas and of more or less gasified fuel. The fuel coming from the gasifying zone and already partially gasified is separated together with the dusty fuel newly produced by the drying. A part of this dusty fuel is re-introduced into the gasifying zone, the other part being removed from circulation. If there were no removal of a certain quantity of fuel from the circulation, the ash-content would be always increased. No removal of ash from the gasifying zone—as usual in other processes—takes place, but a relatively small part of the fuel is removed, which is not gasified or only partially gasified.

Having thus described the invention, I claim:

1. The herein described process of gasifying carbon fuel, comprising the steps of heating the

- finely divided fuel in a gasifying zone by means of a gas stream of 700° to 1600° C. containing water vapor thereby bringing said water vapor in reaction with said fuel, withdrawing from said gasifying zone a gas stream containing the finely divided fuel ash as well as any finely divided unreacted fuel particles, introducing into said latter undivided gas stream, before it has passed a separator, raw fuel to dry and disintegrate the same, separating at least part of the gas from said fuel dust and disintegrated fuel and finally returning at least part of said fuel dust and disintegrated fuel to said gasifying zone.
2. The herein described process of gasifying carbon fuel, comprising the steps of heating the finely divided fuel in a gasifying zone by means of a gas stream of 700° to 1600° C. containing water vapor thereby bringing said water vapor in reaction with said fuel, withdrawing from said gasifying zone a gas stream containing the finely divided fuel ash as well as any finely divided unreacted fuel particles, introducing into said latter undivided gas stream, before it has passed a separator, raw fuel to dry and disintegrate the same, separating at least part of the gas from said fuel dust and disintegrated fuel, returning at least part of said fuel dust and disintegrated fuel to said gasifying zone, charging part of said gas with a fresh quantity of the water vapor, reheating said part of the gas and returning it to the gasifying zone.
3. The herein described process of gasifying carbon fuel, comprising the steps of heating the finely divided fuel in a gasifying zone by means of a gas stream of 700° to 1600° C. containing

water vapor thereby bringing said water vapor in reaction with said fuel, withdrawing from said gasifying zone a gas stream containing the finely divided fuel ash as well as any finely divided unreacted fuel particles, introducing into said latter undivided gas stream, before it has passed a separator, raw fuel to dry and disintegrate the same, separating at least part of the gas from said fuel dust and disintegrated fuel, returning at least part of said fuel dust and disintegrated fuel to said gasifying zone, washing the separated gas, whereby it becomes saturated with water, reheating part of said water-saturated gas, and returning said reheated gas to said gasifying zone.

4. The herein described process of gasifying carbon fuel, comprising the steps of heating the finely divided fuel in a gasifying zone by means of a gas stream of 700° to 1600° C. containing water vapor thereby bringing said water vapor in reaction with said fuel, withdrawing from said gasifying zone a gas stream containing the finely divided fuel ash as well as any finely divided unreacted fuel particles, introducing into said latter undivided gas stream before it has passed a separator, raw fuel to dry and disintegrate the same, separating at least part of the gas from said fuel dust and disintegrated fuel, returning part of said fuel dust and disintegrated fuel to said gasifying zone, washing the separated gas whereby it becomes saturated with water, using the remaining part of said fuel dust and disintegrated fuel to reheat part of said water saturated gas, and returning said reheated gas to said gasifying zone.

HANS SCHMALFELDT.