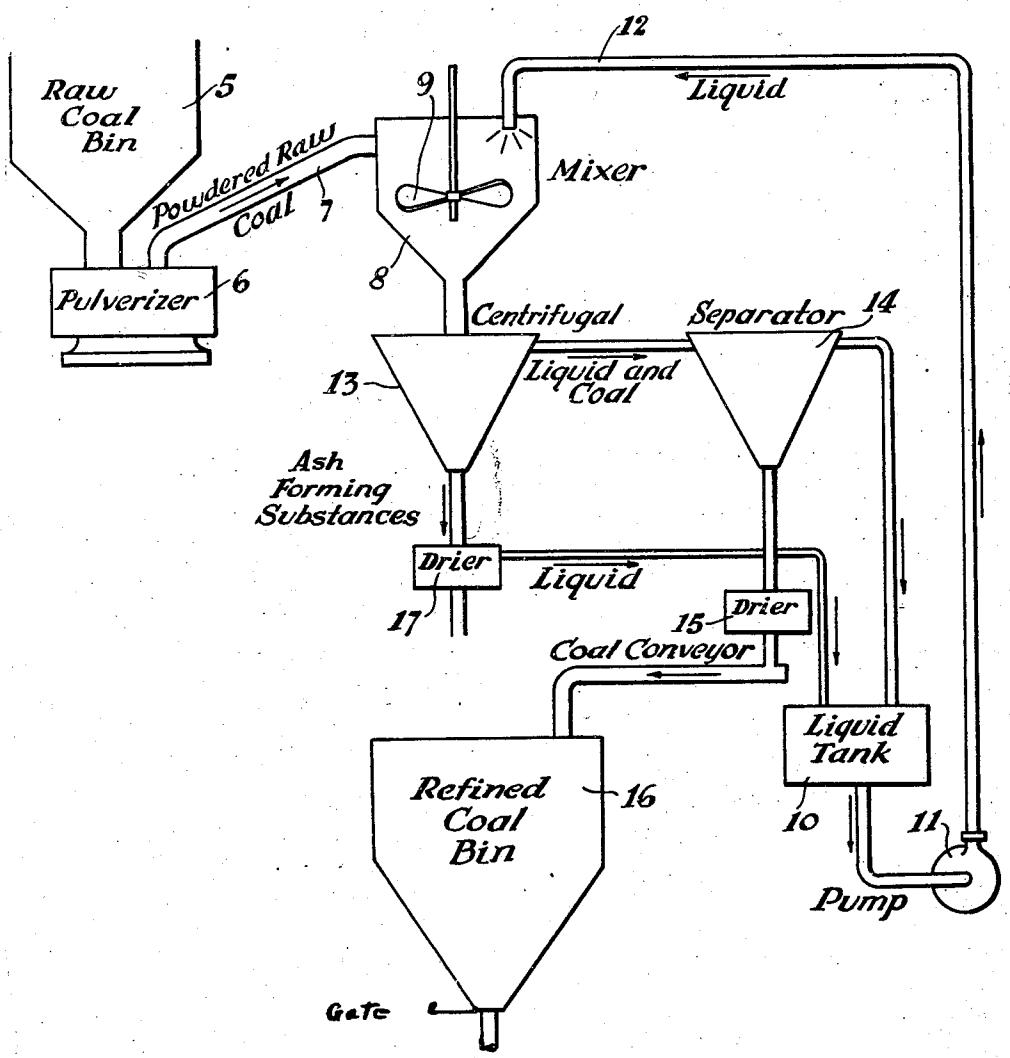
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CENTRIFUGAL ASH SEPARATION

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Fig.1



INVENTOR
Walter M. Keenan
BY Austin & Dix
ATTORNEYS

Feb. 22, 1938. W. M. KEENAN 2,109,234

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Fig.2

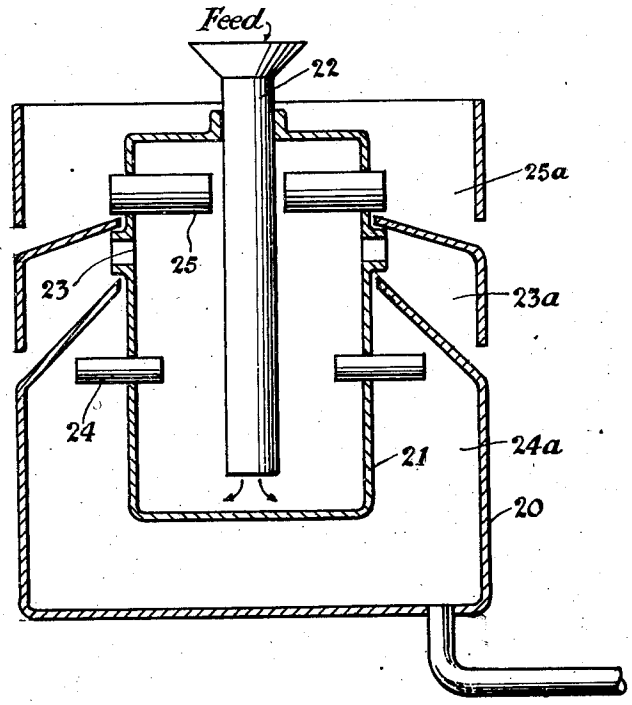
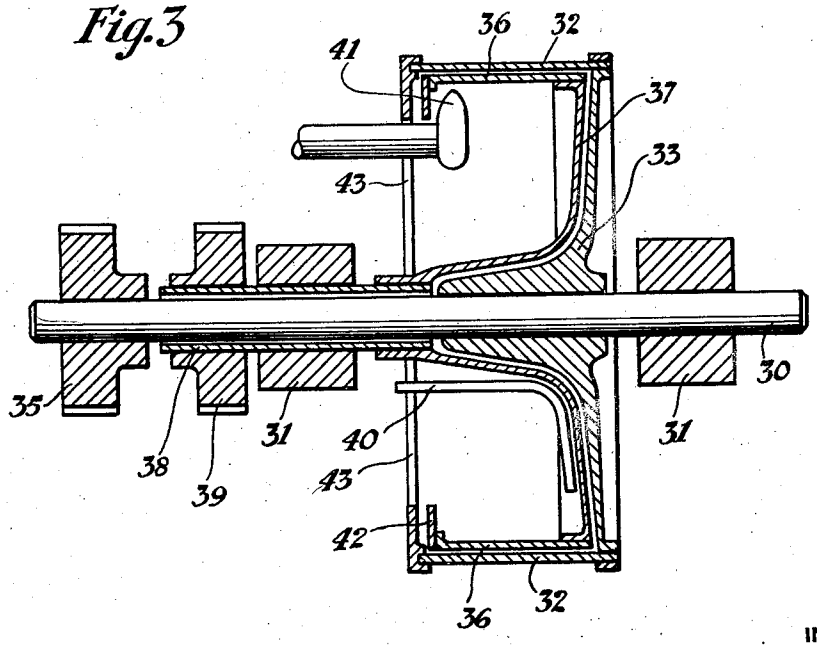


Fig.3



INVENTOR
Walter M. Keenan
BY
Austin & Dix
ATTORNEYS

Patented Feb. 22, 1938 2,109,234

UNITED STATES PATENT OFFICE

2,109,234

CENTRIFUGAL ASH SEPARATION

Walter M. Keenan, Fieldston, N. Y.

Application July 15, 1935, Serial No. 31,538

8 Claims. (Cl. 233—1)

This invention relates to improvements in the treatment of coal to remove certain undesirable constituents therefrom, particularly ash forming constituents, the presence of which in the coal is objectionable for a number of reasons.

Even the highest grades of coal contain impurities which appear as ash or slag when the coal is burned. The ash or slag is the cause of many undesirable effects to the uses of coal. In boiler plants ash particles may be carried along by the combustion gases and deposited on the heating surfaces thus reducing their efficiency or may be carried up the stack to create a nuisance. Considerable labor and expense is incurred in cleaning the ash and slag deposit from the heating surfaces and furnace walls. The cost of cinder catchers and similar devices for removing the ash particles from the flue gases before they leave the stack is high and the cleaning effect is not entirely satisfactory.

Accordingly, a feature of the present invention resides in the provision of an improved process for removing certain objectionable substances from coal prior to combustion.

Another feature of the present invention lies in the provision of such a process through which certain ash forming and slag forming substances are removed from coal prior to the burning, all without excessive, if any, loss of good coal. The character of the substances which may be removed according to the present process is somewhat indeterminate, but for simplicity's sake, they will be referred to herein as ash forming substances or constituents.

A further feature of the invention lies in the provision of a process of this character which is simple and efficient in operation, and which leaves the coal in a satisfactory and even improved condition for burning.

A more specific feature resides in the provision of improved apparatus for this purpose.

Other features, objects and advantages of the invention will become apparent in connection with the following detailed description of forms of apparatus and process illustrating the invention, reference being had to the accompanying drawings, wherein:

Fig. 1 is a diagrammatic flow sheet illustrating one form of process in accordance with the invention; and

Figs. 2 and 3 are diagrammatic sectional views of suggested forms of centrifuges which may be used in connection with the present process.

In general, the present process involves centrifuging a mixture of coal, preferably in finely divided form, and a liquid which is capable of separating the good coal from the ash forming constituents. The coal is preferably afterwards separated from the liquid and restored to a substantially dry condition.

The liquid which is employed in accordance with the present process is preferably lighter than the ash and of such density that it tends to mingle with the good coal, thus promoting a clean separation between coal and ash. I have found that where the specific gravity of the liquid is nearer to that of the good coal than to that of the ash, and between the two, a particularly effective separation takes place, since this feature appears to result in a relatively slow separation of coal from ash, with consequent better washing of the ash and less loss of good coal along with the ash-forming substances. However, viewed in its broadest aspects, the invention may be feasible by employing a liquid which is lighter than the coal, although of about the same specific gravity or density. For instance, the suspension of coal in the liquid may produce a mixture having a good specific gravity for aiding separation from the ash.

A preferred feature of the process according to the present development is the employment of an organic liquid which not only aids in the separation of ash-forming substances from good coal, but which also can be readily removed from the coal by vaporizing it at low temperatures, so that the coal can be dried ready for use, and so that the liquid can be inexpensively recovered for reuse. Preferably, though not necessarily, the liquid is non-aqueous and has a boiling point substantially below 212° F. so that exhaust steam can be employed for heating the coal to dry it. It is desirable to take into account the surface tension or the "wetting" power of the liquid, as well as its viscosity, a liquid which readily wets the coal and which has a fairly low viscosity being in general preferred when other considerations are equal. Moreover, in accordance with the present process the liquid is not explosive or too highly combustible, so that danger of an explosion is avoided should small amounts of the liquid remain in the coal when it is burned. That is to say, instead of entirely removing the liquid from the coal, it may be more practicable to allow some of it to remain with the coal, provided it does not too greatly reduce the B. t. u. value of the latter, or unduly increase solvent losses.

Referring now to the drawings, raw coal may be stored in a suitable bin or hopper 5 and fed from there as required into a grinder or other

suitable pulverizer 6, where the coal may be reduced to the desired fineness. While the invention is not limited to the treatment of coal of any particular grade or fineness, it is particularly useful in connection with the treatment of coal particles of less than ¼ inch size, such as present commercial grade slack or powdered coal. The particles, however, are not necessarily all of any particular fineness. It will be appreciated that if the coal particles are too large, the liquid may not be able to get at the undesired constituents to remove them to best effect.

The powdered raw coal from the pulverizer 6 may then be sent through any suitable tube or conveyor 7 to a mixer 8, which may be provided with a stirrer 9, the coal there meeting a stream of liquid fed from storage tank 10 by pump 11 through pipe 12. Various types of liquid may be employed but I have found that particularly good results are secured with organic liquids which are not explosive, which have a boiling point substantially below 212° F. and which have a specific gravity or density which is considerably less than the specific gravity or density of the ash forming substances to be removed, and preferably close to the specific gravity or density of the rest of the coal. Where the specific gravity of the liquid employed is substantially greater than that of the good coal to be recovered, this factor may prove of advantage in effecting a separation of the coal from the liquid after the ash forming substances have been separated. On the other hand, it appears that a superior removal of ash forming constituents may in general be effected by employing a liquid having a specific gravity close to and slightly greater than that of the good coal. Preferably, the liquid is non-aqueous, or substantially free from water, so that should the coal not be entirely dried after treatment, its effectiveness as a fuel will not be impaired. A satisfactory liquid may be chosen from among those having such properties, but I have found that particularly good results may be secured by the use of chlorinated organic compounds such as carbon tetrachloride, chloroform, trichlorethylene and ethylene dichloride, or mixtures of these. Ethylene dichloride is somewhat lighter than certain types of good coal, and may not be quite satisfactory when used alone, since it is usually advantageous to have the liquid substantially heavier than the good coal to be separated. I have found that excellent results are achieved when the coal is treated with mixtures of ethylene dichloride and trichlorethylene in a ratio of two parts by weight of the former to one part by weight of the latter, although other proportions, such as one part of the former to two parts of the latter, also give good results. In commercial practice, it would seem to be particularly advisable to employ a liquid whose specific gravity is between that of the ash forming constituents and the good coal, for the double purpose of effecting a clean separation of ash forming constituents and a subsequent ready separation of the liquid and good coal.

In the mixer 8 any suitable volume of liquid may be mixed with a given quantity of raw coal. The proportion of liquid mixed with the coal should be such that the mixture is in a free flowing condition. For instance, the amount of liquid may be sufficiently large so that the coal particles may be carried along more or less in suspension in the liquid. Ordinarily, about ten parts by weight of liquid to one part by weight of raw coal constitutes a mixture containing more than ample liquid, and indeed it may be possible to reduce the liquid to a small fraction of that amount in proportion to the coal. In general, the considerations affecting the amount of liquid used are the cost of the liquid, the effectiveness of the separation of the ash forming constituents, and the expense of recovering the liquid at a later stage.

An important feature of the present invention resides in the centrifugal treatment of a mixture of coal and liquid in order effectively and rapidly to separate a large percentage of the ash forming constituents from the coal, and for this purpose the mixture of liquid and raw coal may be sent to a suitable centrifuge 13, which serves to separate, as will be hereafter described in more detail, the mixture into either two parts or three parts, to wit, ash forming constituents and the mixture of liquid and good coal, or ash forming constituents, liquid, and coal mixed with a little residual liquid. That is to say, the centrifuge may perform a two-way or three-way separation. In Fig. 1 the main centrifuge is illustrated as a two-way separator, the discharged mixture of liquid and good coal being sent to a second separator 14, which may be also a centrifuge, to separate the good coal from most of the liquid. This liquid may be returned to storage tank 10, while the coal may then be more or less thoroughly dried in a drier 15 and sent to a suitable storage bin 16. If desired, the ash forming constituents from the centrifuge 13 may be sent to a drier 17, the evaporated liquid from driers 15 and 17 being condensed and recovered.

With particular reference to Fig. 2, there is disclosed diagrammatically a suggested type of centrifuge construction including a housing 20, a rotatable bowl 21, a feed pipe 22, and outlets 23, 24 and 25 carried with the bowl for discharging the centrifuged material in three separate portions, into chambers 23*a*, 24*a* and 25*a*, formed in the housing 20. The bowl may be mounted on any suitable bearings and driven through any convenient type of mechanism. When a mixture of raw coal and liquid is fed into the central tube 22 it may enter the bowl 21 near the bottom thereof and gradually rise to a predetermined level, while the heavy particles or ash forming substances gravitate to the outside of the bowl and are discharged through the openings 23, and while the very light particles of good coal leave the bowl through the passages 25. When a liquid of intermediate specific gravity is employed, it may be desirable to remove a large or substantial portion of this liquid through tubes 24 which extend into the bowl to a distance between the outside wall thereof and the central zone at which the good coal is removed. This may be desirable where the ratio of liquid to coal is high. It will be understood that the tubes 24 may be arranged above the tubes 25, if desired, that the relative points of discharge may otherwise vary, and that suitable pipes may be provided for carrying off the discharged fractions to points where the liquid is recovered from these fractions, for instance, as heretofore described.

With particular reference to Fig. 3, there is illustrated diagrammatically another type of centrifuge for present purposes, in which a horizontal shaft 30 is supported in bearings 31, while a bowl 32 may be secured to the shaft through a central collar 33. A gear 35 may serve to drive the shaft 30 from any suitable source of power. In order to assist the separation of good coal and liquid from the ash forming substances, a series

of scraper blades **36** may be provided, carried on arms **37** of sleeve **38**, for keeping materials near the wall of the bowl in motion. The sleeve **38** and the blades carried by it may be driven at a differential speed, as compared with the bowl, through a gear **39**, so that there is a continuous stirring of the particles. The speeds of the bowl and stirrer may both be varied at will, independently or together. The liquid may be fed into the bowl through any suitable pipe or other device **40**, and flow out through opening **43** formed in a wall of the bowl, or otherwise, for instance, through convenient ports, either continuously or in batches, as will be apparent to those familiar with centrifuges.

A cutter **41** or a series of cutters may be suitably mounted on any convenient supports so that they can be moved back and forth when it is desired to remove any collected solids, intermittently or continuously. A suitable inclined chute may extend into the bowl through opening **43** to convey such material out of the bowl. The blades **36** may be provided with a shroud ring **42** of circular shape for strengthening the construction. The wall of the centrifuge being open as at **43**, the liquid and good coal can be thrown out over the edge of the shroud ring. The bowl may be periodically cleaned, if necessary.

Merely by way of example, when a sample of powdered coal had been treated in accordance with the foregoing process, (using a liquid containing two parts of trichlorethylene and one part of ethylene dichloride and having a specific gravity of about 1.38, which compares with an approximate specific gravity of 1.26 for the good coal free of ash, and then freed of liquid, an analysis of the good coal showed the presence of only 2.4% ash, whereas an equivalent sample of the same coal, but untreated, showed the presence of 7.4% ash. It will be appreciated that the non-combustible matter in the coal may thus be reduced by substantially two-thirds, or more. A further analysis of the iron oxide in the ash in each case, indicated a corresponding reduction in iron. Moreover, the sulfur content of the coal was found to be markedly lower, while the fusion point of the residual ash in the good coal was substantially higher than the fusion point of samples of the untreated coal.

Another sample of the same coal, similarly treated, but with a liquid containing one part of trichlorethylene and two parts of ethylene dichloride, yielded a good coal having on analysis an ash content of only 1.41%.

Without in any wise restricting the invention to the particular substances or specific gravities indicated, there is given by way of example, a table indicating results obtained by treating equal samples of the same coal with various liquids in accordance with the present disclosure, the proportion of ash forming constituents having been reduced from 7.4% to the percentage indicated in the table.

Liquid	Specific gravity	Residual ash
		Percent
Carbon tetrachloride	1.595	3.95
Trichlorethylene	1.476	3.49
2 parts trichlorethylene 1 part ethylene dichloride	1.378	2.42
1 part trichlorethylene 2 parts ethylene dichloride	1.286	1.40

It may be deduced from this table that the closer the specific gravity of the liquid lies to that of the good coal, the better the separation, although, as indicated, other factors may also influence the result.

On the other hand, the present treatment does not decrease the heating value of the combustible material in the coal. In other words, a large proportion of the non-combustible material has been removed from the coal without substantial loss in heat value of combustible material.

This results in elimination of much of the solid particles which would otherwise be discharged from the stack, as well as a saving in the cost of equipment for handling ash and cinders. Moreover, there is less coal to be handled for a given amount of heat and if the treatment of the coal is carried out at the mine, the shipping costs can also be reduced. When the treated coal is employed in furnaces used in connection with steam boilers, not only is the efficiency of the furnace increased, but the necessity of cleaning the boiler tubes may be greatly reduced. The process may also be used to advantage for treating coal before converting it to coke.

Moreover, the method is simple and inexpensive to carry out, and the liquid may be substantially entirely recovered for reuse in the process.

The terms and expressions which have been employed are used for purposes of description and not of limitation, and there is no intention, in the use of such terms and expressions, of excluding any equivalents of the features shown and described, or portions thereof, but it is recognized that various modifications are possible within the scope of the invention claimed.

What I claim is:

1. Process of treating coal to remove ash forming constituents therefrom which comprises mixing finely divided coal with an organic liquid of the class of a chlorinated carbon compound, and centrifuging the mixture.

2. Process of treating coal to remove ash forming constituents therefrom which comprises mixing the coal with an organic liquid having a boiling point of less than 212° F. and a specific gravity substantially less than that of the ash forming constituents and substantially greater than 1, and centrifuging the mixture.

3. Process as claimed in claim 2 wherein the liquid comprises a chlorinated carbon compound.

4. Process as claimed in claim 2 wherein the liquid is a mixture of trichlorethylene and ethylene dichloride.

5. In the art of treating coal to remove ash forming substances therefrom, the steps comprising mixing coal particles of the character described with a relatively large volume of organic liquid of the class of a chlorinated carbon compound, centrifuging the mixture and recovering the liquid.

6. Process of treating coal to separate therefrom ash forming constituents, which comprises mixing powdered coal with a relatively large volume of a non-explosive organic liquid of the class of a chlorinated carbon compound and having a specific gravity markedly less than the specific gravity of the ash forming constituents, and in the order of but somewhat greater than the specific gravity of the good coal, centrifuging the mixture to separate the ash from good coal and liquid, and separating the liquid from the good coal.

7. Process of treating coal to separate therefrom ash forming constituents, which comprises mixing powdered coal with a relatively large volume of a non-explosive organic liquid of the class

of a chlorinated carbon compound and having a specific gravity markedly less than the specific gravity of the ash forming constituents, and in the order of but somewhat greater than the specific gravity of the good coal, centrifuging the mixture to separate the ash from good coal and liquid, separating the liquid from the good coal, and drying the coal to substantially free it from liquid.

8. Process of treating coal which comprises mixing coal fines with a liquid of the group consisting of a mixture of trichlorethylene and ethylene dichloride, causing the separation of coal and liquid from relatively heavy particles, separating coal from the liquid, and recovering the liquid.

WALTER M. KEENAN.