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LIQUID FUEL AND METHOD OF MANUFACTURING IT.

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No Drawing.

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To all whom it may concern:

Be it known that I, LINDON W. BATES, a citizen of the United States, and resident of Mount Lebanon, in the county of Columbia and State of New York, have invented certain new and useful Improvements in a Liquid Fuel and Method of Manufacturing It, of which the following is a specification.

This invention pertains to a liquid fuel and to the method of producing it. The fuel is a composite of pulverized solid carbonaceous substance and liquid hydrocarbon. Anthracite and bituminous coals, lignites, peats, cokes and pitches may be employed. The fuel may contain one variety or a mixture of several of these solids. The liquid hydrocarbon may be an oil, tar or liquefied substance similar thereto. Oil and coal will be taken hereafter as typical ingredients. Pulverization of the coal so that most of it passes a 200 mesh screen is desirable. As the final fuel product is for special reasons to be heavier than water and yet retain its liquid character, the ratio of fuel ingredients should lie between about coal 10%, oil 90%, and coal 40%, oil 60%. The amounts and kinds of ingredients are to be selected with the gravity, stability and calorific value of the fuel in view.

For the purposes of producing a liquid fuel of coal and oil of the character desired and of improved qualities, it is advantageous to pulverize the coal in oil. Dry grinding is hazardous and involves dehydration before pulverizing, while water grinding involves dehydration of the coal before incorporation with oil to form a liquid fuel. Oil grinding promotes the intimacy of the coal-oil mixture better than mere blending subsequent to coal pulverization. So also, when coal is ground in oil it is possible to utilize the occasion to stabilize the particles and to employ the means used to promote grinding efficiency to give also the stabilization treatment. As a result of extensive tests on various aspects of oil grinding or pulverizing certain important conclusions have been reached. Thus, grinding coal in oil promotes ultimate fuel stability by increasing the dispersion of the particles and their association with oil. The treatment to stabilize the particles by artificial means may take place simultaneously with the reduction of the coal. The grinding efficiency in oil increases as the viscosity of the oil is lower; the viscosity of oil in the mill being a vari-

able approaching that of water as a limit. Hot oil pulverizing is superior to cold oil pulverizing, inasmuch as heat reduces the viscosity of the oil and increases the intimacy of the mixture. The temperature of hot oil grinding should not exceed the open cup flash point of the coal-oil mixture, unless protective measures are taken. The lower the viscosity of the oil, the less oil need be used in the mill; the per cent. of maximum efficiency being located according to viscosity between about oil 35% and oil 65% by weight of the mill mixture. It is useful to use less oil of low viscosity than more oil of higher viscosity. When two or more different varieties of carbonaceous material are simultaneously pulverized in a mill with oil or with several liquids the reduction is improved for the fuel purpose. Control of fuel gravity and of character is readily exercised.

In view of these conclusions, the ingredients of the fuel should be carefully selected and incorporated together. The oil used in the mill should not be a semi-liquid, such as molasses or crude petroleum of the viscous varieties, unless its character is changed by heat to reduce viscosity in the mill. The liquid in the mill should have a low viscosity, natural or induced. If a cold semi-liquid is used in the mill the grinding efficiency will be materially reduced compared to pulverization in a liquid of low viscosity, the intimacy of the coal-oil mixture will be less, the mill paste will tend to be non-mobile, and also a larger amount of such heavy liquid will be required and the duration of grinding will be longer to produce a fuel containing particles of the requisite size. In the present process, therefore, low viscosity in the pulverizing mill is essential.

The duration of the grinding step will vary, of course, according to the type of mill used and to the ingredients selected. Such coal pulverizing mills as the Fuller, Hardinge, Smidth, Raymond or the like are recommended. Some mills will require mechanical adjustments to adapt them to pulverize wet or with oil. Others, such as the Smidth mill, may be used as manufactured. For example, in a Smidth "cylpeb" mill, using cylindrical metal pulverizing elements, with a ratio of components and elements of cylpebs 200 lbs., anthracite coal 20 lbs. (35%), water gas tar 37.2 lbs. (65%), at an initial temperature of 200° F., the mill

- revolving at a speed of 40—42 R. P. M., the coal was reduced from 15.8% to 88.6% through 200-mesh in fifteen minutes. The viscosity of the water gas tar was about 37.6° Engler at 70° F. and at 200° F. was under 2° Engler. This result may be contrasted with 89.3% of the same coal passing 200-mesh after twenty minutes pulverization using a like amount of Mexican 18° Baumé oil at a like temperature, and with 89% in seventy minutes using such Mexican oil at normal temperature. The coefficient of grinding efficiency in a Smidth mill, which represents the pounds of like coal ground 85% through 200-mesh per hour per pound of grinding elements, is about as follows: Cold Mexican oil (65%) .09; hot oil (65%) .325; hot oil (50%), water gas tar (15%) .37; hot water gas tar (65%) .417. Using a Pennsylvania oil of viscosity about that of kerosene the coefficient for bituminous coal with only 35% oil reached .8. These examples are correct only for the particular mill, but are representative of the general rule.
- If all the oil to be used in the fuel has been united with coal in the pulverizing mill, the mixture will not ordinarily require the addition of further liquid, save for special purposes. If all the oil to be used has not, however, been added in the mill, the balance should be added to the mill paste in a separate mixing vessel after grinding is completed. It is not essential that the oil used at this stage should be a thinning fluid, such as alcohol or a light hydrocarbon. It is conceivable that liquid of lower viscosity than that used in the mill during the pulverization might be employed, but such a contingency would be rare in practice. The oil used in this step should be of the same viscosity as the oil placed in the mill before the viscosity of the latter has been modified, but the viscosity may be greater than the natural viscosity of the oil first used, or indeed it may be equal to the viscosity of the oil first used as modified by heat in the mill. The oil added after pulverizing the coal will have a viscosity, therefore, preferably equal to or greater than the viscosity of the oil in the mill during pulverization. The purpose of adding oil at this stage is to change the mill paste into a liquid fuel without, however, reducing its density below that of water. The paste should not be reduced in density to that of ordinary fuel oil, as such oil is lighter than water. The reason greater density than water is insisted upon is so that the fuel may be stored for fire-proofing purposes under a water seal which forms a layer of water upon the top surface only of the oil and so that the calorific value of the fuel per unit volume may be as high as possible.
- It is found useful to employ heat for several purposes, as heretofore mentioned. The heat may be used in the mill or when the mill paste is blended with the remaining liquid, or indeed on both occasions, or between these steps or after them. If a viscous oil is to be used as a part of the fuel dispersion medium and is added to the coal in the mill, then heat should be used to reduce viscosity for purposes of efficiency and fuel improvement. The heat may be applied to the mixture by heating the mill, or by heating the pulverizing elements, or by heating the ingredients or some of them prior to insertion in the mill. The longer heat is applied, within reasonable limits, the better the composite will be in regard to natural permanence. Adequate stability for fuel purposes is not claimed for a mixture of coal and oil without special stabilizing treatment. Under rare circumstances, involving immediate use after production, a fuel insufficiently stable for storage may be serviceable. Heat, however, by improving the intimacy of the mixture, serves to delay somewhat the sedimentation. If stabilization treatment is not given the viscosity of the dispersion medium at normal temperature should be reasonably high, whatever may be its viscosity under heat in the mill. An unstabilized fuel of low viscosity will have a very limited field of usefulness. The heat used in this process should not be so high as to crack the oil, or to drive off too many of the volatiles, unless these are recovered. A temperature of about 150° F. to 220° F. will be found suitable both for viscosity reduction and for peptization under most circumstances.
- As remarked earlier, the particles of coal tend naturally to separate slowly from the oil of the mixture. The rate of separation is somewhat according to Stokes' law, but is varied by a number of factors. The rate is affected by the viscosity of the dispersion medium, the specific gravities or densities of the components and by several other characteristics. The rate of separation may be delayed by increasing the viscosity of the oil, adding buoyant substances to the mixture, and also by artificially stabilizing the particles. It is, of course, true that separation may be delayed by stirring or agitating the mixture. So also precipitation may be prevented while the fuel is stirred or agitated, but such a fuel is not considered to enjoy stability since precipitation would continue as soon as agitation terminated. By "stable" is meant non-separation of the components to a reasonable extent and for a reasonable time sufficient to enable the use of the fuel by atomizing it as oil fuel is now used. Such stability, which does not require stirring or agitation during the period of "life," may be obtained by special stabilizing treatment. After the period of life has expired then stirring or agitation may

be useful to restore temporarily a measure of stability. If, in the body of liquid hydrocarbon constituting the dispersion medium, substance is employed having peptizing qualities upon the coal particles it is possible to obtain a considerable measure of artificial stability. Should the entire body of the liquid hydrocarbon be a peptizer, then a less usable fuel will be produced, if heat is employed in the treatment, unless measures are taken to arrest the excessive progress of peptization. The peptizers are preferably liquids. One may mention as examples, coal derivatives or distillates, such as creosote, water gas tar and naphthalene. An amount varying from 5% to 20% or thereabout by weight of total fuel will be found suitable. The duration of the stability obtained may be days, weeks or months, according to the treatment given and controlled within reasonable limits. The stabilizing substance may be added to the other components of the fuel in the mill or at a later stage of the process. Most peptizers are inactive, or are less active at normal temperatures than at higher temperatures, in the natural state, and therefore require heat to bring out their latent qualities. Some, however, will peptize under ordinary conditions. Hot grinding in the presence of a peptizer alone or with other oil or liquid advances peptization and hence promotes stability at the same time that it accelerates pulverization.

It is also possible to stabilize the particles by other artificial means, as by the use of smaller amounts of suitable protective colloids or soaps, such as lime-rosin soap or its equivalent. It is, of course, clear that several varieties of stabilizing substances may be used together in a given fuel, in which case lesser amounts of each are necessary to give corresponding stability. If soap is employed in amount which adds from $\frac{1}{2}\%$ to $1\frac{1}{2}\%$ or thereabout by weight of rosin to the fuel, sedimentation will be materially postponed. The amount of lime or other alkali used with rosin to make soap is usually about one-half the rosin, but adequate saponification is desired and may be obtained with other ratios and kinds of ingredients. The soap is usually carried in oil, forming a grease. The soap may be added to the other components of the fuel in the mill or later, but it must be blended therewith to form a homogeneous mixture.

Aside from the use of these stabilizing substances there are other measures which may be taken to augment the utility of the fuel. Thus, a froth or other flotation step to remove ash from the solid carbonaceous substance may be combined with the steps in the fuel manufacturing process. To do so the mill paste should be agitated in a vessel filled with water with the aid of air

until a froth forms on the top surface of the water carrying coal from which ash separates. If there is an excess of oil in the pulverizing mill, it may be useful to remove some of this oil prior to flotation. Thus, less than 1% of flotation oil by weight of coal yields a good froth, but larger amounts may be employed. Oil may be removed by centrifuging or otherwise, separating out coal and associated oil. The froth may be removed from the surface of the water and the coal and oil found therein, after dehydration, may be thereupon united with the balance of the oil used in the fuel to form the improved liquid fuel product. Grinding coal in flotation oil promotes flotation, at the same time that it prepares the ingredients for the subsequent steps of the fuel process.

While the steps of pulverizing in oil and the subsequent division of further oil are the basic steps in the production of the fuel, the possible stabilization, ash removal and other steps assist in the production of an improved liquid composite. Each of these further steps is intimately related to the preceding and all unite to produce the improved atomizable liquid fuel. The removal of ash, for example, renders the fuel naturally more stable and useful by eliminating a heavy non-combustible impurity. The flotation step logically and appropriately succeeds the mill step and after both are terminated the fuel advances to the final blending step which with greater facility yields the desired fuel. The steps are correlated, synchronized and adapted to each other, and each acts upon the material while the other is doing its work also or in immediate sequence thereafter.

The fuel produced by the present process enjoys a number of special characteristics. Particles of solid carbonaceous substance are found in the fuel in three states of dispersion; molecular, colloidal and suspension. The carbonaceous material is not reduced in the mill to colloidal limits, but in coal mostly passing a 200-mesh screen particles of colloidal and molecular sizes are encountered in the main body of suspension-sized particles. The process reduces to some extent the particle-size after pulverization where peptization occurs, but in the final product many and usually a majority of the particles are well above the colloid in size and above the colloid borderland. Where peptization occurs, pitting, cavitating as well as dissolving and stabilizing are noted. The particles are in such association that the fuel is retained by a filter paper, and even cheese-cloth holds back a large part of the solids. The fuel, however, passes through the screens used in liquid fuel burner installations on shipboard. The fuel is heavier than water and sinks in both fresh and

salt water. Such ratios of components, within the limits indicated, are selected as will produce a fuel of specific gravity greater than unity, but possessing fluidity.

5 A typical fuel produced in the manner described consists by weight of 15% anthracite coal, 15% bituminous coal, 15% water gas tar and 55% fuel oil. The ingredients are combined by pulverizing the coals for 10 about twenty minutes with the tar and 25% oil in a Smidth mill so that about 85% of the coal particles would pass through a 200-mesh screen. The temperature of the paste in the mill is elevated to about 200° F. by 15 means of heat applied to the mill by a steam jacket, or by heated cylpebs. The paste so produced is then conveyed to a mixing vessel fitted with rotating blades where the remaining 30% oil is added and the mixture 20 is agitated and heated by a steam coil in the vessel for about forty minutes. The product is a liquid fuel of gravity heavier than water, and which will enjoy stability for over a month. Another fuel is composed 25 of 35% dehydrated lignite, 55% mineral oil, and 10% fuel oil carrier containing 1% rosin, .5% lime and a small amount of water by weight of total fuel in the form of a seaponified grease. The coal is pulverized 30 to the requisite size, 85% through 200-mesh, in 45% mineral oil. The remainder, 10% oil, and the 10% carrier containing the fixateur, so called, are added to the mill paste in a suitable blending vessel and the com- 35 ponents are mixed for a few minutes. The liquid fuel so produced has a specific gravity above that of water and will be relatively stable for about three months.

It is manifest that the procedure outlined 40 above may be broadly varied without departing from the essential features of the process. Among the novel features are deemed to be: The reduction of the coal in a body of liquid of low viscosity; the sub- 45 sequent addition of liquid of equal or higher viscosity than that of the oil in the mill during the pulverization; and the pulverization together of a plurality of different coals in a plurality of different liquids to govern 50 fuel density and character. The possibility of intimately combining therewith the stabilization treatment to improve the fuel, the ash removal measures and other steps, is considered also a contribution to the fuel 55 art. The control of fuel flash point by the use of bituminous coals among the solids is likewise deserving of attention.

No claim is made herein to the method 60 above set forth of adapting finely divided coal for suspension in oil as a liquid fuel, which consists in pulverizing the coal in the oil of low viscosity and thereafter removing ash by flotation, or that method, as just set forth, wherein the solid particles are sta-

bilized in the liquid with the aid of a sub- 65 stance having stabilizing qualities, as such matter forms the basis of my application Serial No. 471,936, filed May 23, 1921, the same being a division of this application.

Having thus described the nature of my 70 invention, what I claim is:

1. That method of producing a liquid fuel, which consists in pulverizing solid carbonaceous substance in liquid hydrocarbon of low viscosity and subsequently blend- 75 ing therewith further liquid hydrocarbon of higher viscosity, employing such amounts that a liquid fuel of density greater than that of water is produced.

2. That method of producing a liquid 80 fuel, composed essentially of approximately coal 30% oil 70%, which consists in pulverizing the coal in about 50% of the oil, and subsequently blending with the mixture the remaining oil, whereby a liquid fuel 85 heavier than water is produced.

3. That method of producing a stable liquid fuel, which consists in pulverizing solid carbonaceous substance in liquid hydrocarbon of low viscosity, including coal 90 distillate having peptizing qualities, applying heat to the mixture while so pulverizing, and subsequently blending therewith further liquid hydrocarbon with heat, employ- 95 ing such amounts that a stable liquid fuel of density greater than that of water is produced.

4. That method of producing a stable liquid fuel, composed essentially of approxi- 100 mately 30% coal, 15% coal distillate and 55% mineral oil, which consists in pulverizing the coal in the coal distillate and a part of the oil, heating the mixture to about 200° F., and subsequently blending there- 105 with the remaining oil and heating the mixture, whereby a stable liquid fuel heavier than water is produced.

5. That method of producing a stable liquid fuel, which consists in pulverizing solid carbonaceous substance in liquid hydrocarbon, including liquid hydrocarbon 110 having peptizing qualities, to a size such that about 85% would pass a 200-mesh screen, heating the components in the mill to a temperature of about 200° F., and sub- 115 sequently blending therewith further liquid hydrocarbon, whereby a stable liquid fuel heavier than water is produced.

6. That step in the method of producing a liquid fuel of mixed solids and liquids, 120 which consists in pulverizing solid carbonaceous substance in an amount of liquid hydrocarbon, of low viscosity, between 35% and 65% of the weight of the fuel.

7. That step in the method of producing 125 a liquid fuel of mixed solids and liquids, which consists in pulverizing solid carbonaceous substance in an amount of liquid

hydrocarbon, of viscosity reduced by heat, between 35% and 65% of the weight of the fuel. ing coefficient by using liquid of low viscosity in an amount between 35% and 65% of the combined weight of solid and liquid. 10

8. That improvement in the method of grinding solid carbonaceous substance in liquid hydrocarbon for the production of fuel, which consists in increasing the grinding coefficient by using liquid of low viscosity in an amount between 35% and 65% of the combined weight of solid and liquid. 10

Signed at New York City, in the county of New York, and State of New York, this 10th day of April A. D. 1920.

LINDON W. BATES.