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METHOD OF TREATING DIESEL FUELS

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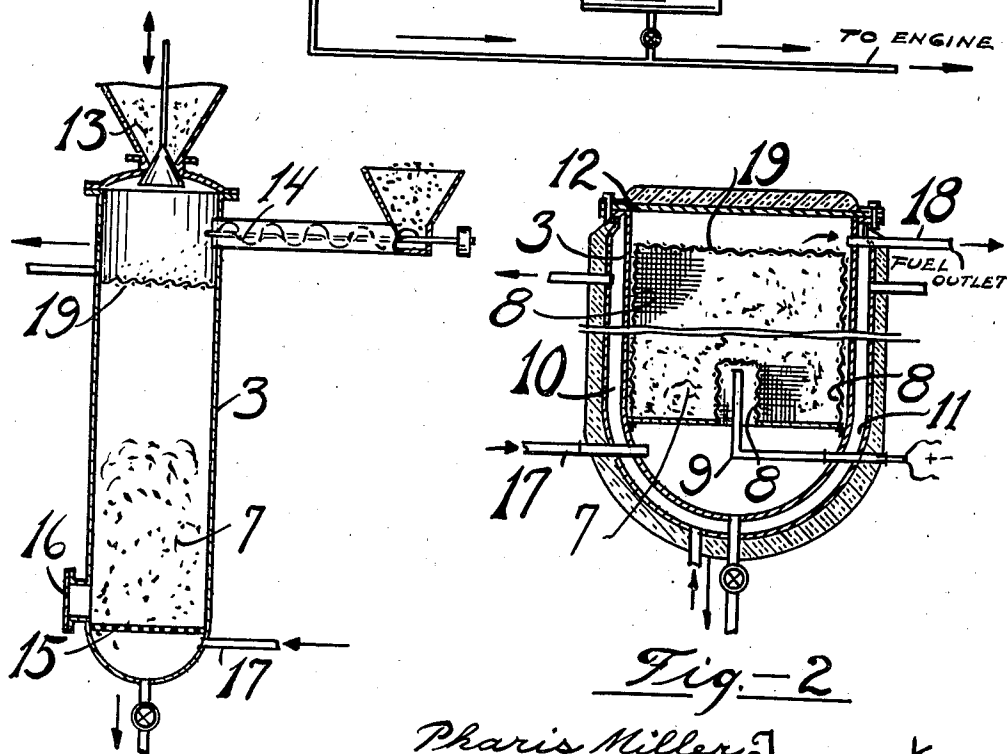
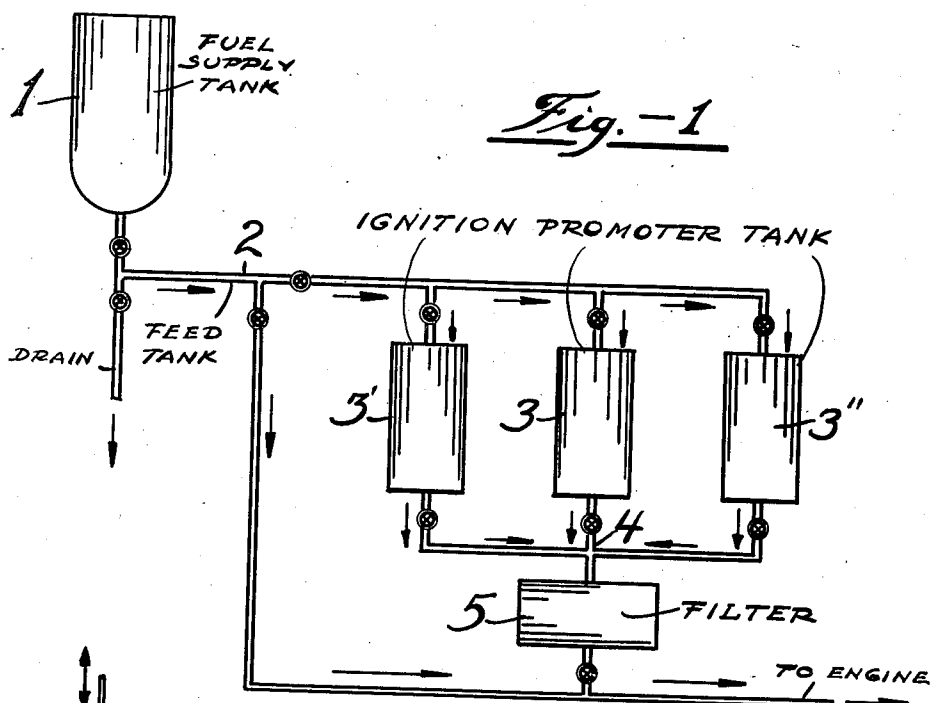


Fig. -3

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METHOD OF TREATING DIESEL FUELS

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5 Claims. (Cl. 44—57)

This invention relates to an improved method of fueling engines having solid injection fuel systems, particularly compression-ignition engines, and to apparatus especially adapted therefor.

For compression-ignition engines of which the well known Diesel engine is representative, it is desirable to have a fuel which has a high cetane number in order to prevent knocking of the engine, as well as smoking and other harmful results usually attendant upon the use of low cetane number fuels. The S. A. E. Journal of June, 1936, page 225, describes the usual cetane number tests which, briefly, consists in matching the performance of a test sample with blends of cetane and alpha methyl naphthalene, the percent by volume of cetane in the blend with the alpha methyl naphthalene giving the same ignition quality test performance as the fuel in the test sample, being taken as the cetane number rating of that fuel. It is a well known fact that many petroleum oil fractions have a suitable boiling range and other characteristics which, in general, would make them suitable as Diesel fuels, are unfortunately not sufficiently high in cetane number to give satisfactory performance; this is particularly true in regard to Diesel engines operating at very high speed such as over 1,000 R. P. M. It has therefore been proposed in the past to incorporate in the petroleum oil fraction to be used as Diesel fuel, a small amount of addition agent usually called an ignition promoter or Diesel dope, which is adapted to cause a substantial increase in the cetane number of the fuel base stock. A number of such ignition promoters have been proposed heretofore but many of them possess inherent disadvantages which more than offset the value in raising the cetane number. For instance, ethyl nitrate is very effective for improving the cetane number but it is such a volatile liquid that when added in substantial quantities to a Diesel fuel base stock, it causes an undesirable lowering of the flash point of the fuel. On the other hand, some other types of ignition promoters are known which are very effective in raising the cetane number of the fuel but have the very harmful characteristics that they cause corrosion of the fuel tank; sulfur and certain compounds of sulfur belong in this latter class.

Broadly, this invention comprises contacting at least a portion of the liquid fuel after it leaves the supply tank, with a separate supply of solid and at least partially soluble ignition promoters, controlling the amount of the promoter added to the fuel either by controlling the amount of

promoter which dissolves in the fuel or by controlled blending of some plain fuel by-passed from the supply tank in with the fuel containing dissolved promoter.

5 It has now been discovered, and is a primary object of the present invention, that normally corrosive ignition promoters which are solid, can be blended with the fuel after it has been withdrawn from the usual fuel tank or fuel reservoir and just before it is injected into the engine, this makes possible the use of relatively cheap, solid ignition promoters such as sulfur in crushed or otherwise comminuted form, without at the same time requiring the use of very expensive corrosion-resistant lining in the fuel storage tanks, and other equipment required in the usual handling of fuels for such engines.

Another object of this invention is to permit the use of normally solid promoters which do not lower the flash point of the fuel base stock. A still further object of the invention is to provide apparatus for controlling the amount of a partially soluble solid ignition promoter dissolving in the fuel as it passes on its way from the fuel reservoir tanks to the engine, in such a way that the amount of the ignition promoter used can be raised or lowered at will during the use of the engine in accordance with the demand or necessity for a fuel of high cetane number.

30 The type of promoter to be used should preferably be one which is relatively insoluble in the Diesel fuel base stock but which is sufficiently soluble that when a relatively small amount of the fuel is contacted with a relatively large bulk of the solid promoter, with or without the application of head to accelerate solution, the amount of promoter which dissolves will give the desired raise in cetane number. Sulfur is one material which may be used, either in the form of crushed roll sulfur or powdered sulfur. The sulfur is preferably in the rhombic form. Nitrogen sulfide, S_4N_4 , is another material which may be used. Still others include alkoxy phospho polysulfides, heterocyclic compounds such as mercapto benzo thiazole, acyl amines, acyl oximes, sulfurized aliphatic amines, alkyl hydrazones or corresponding alkyl-aryl derivatives, nitro urea, thio carbazones, thio carbamates and sulfurized derivatives.

50 By the expression "solid injection fuel system" is meant a system of fueling an internal combustion engine by which a solid stream of liquid is injected under pressure into the engine. It may comprise a single jet, or a multiple jet in which two or more jets are used, usually at some suitable

angle in order to give wider dispersion or spreading of the fuel into the combustion chamber, or the injection may be by the so-called conical envelope in which the included angle between the opposite sides of the conical spray is somewhere in the range of about 8 to 30°. In Diesel engines, which use solid injection fuel systems, the fuel is usually injected under a pressure of about 1,000 to 3,000 lbs. per sq. in., and more usually between the limits of 1,200 and 2,500 lbs. per sq. in.

The invention will be better understood from the following drawing in which Fig. 1 is a schematic elevation showing how one or more ignition-promoter tanks may be connected in the fuel feed line between the fuel supply tank and the engines, whereas Fig. 2 is a detailed sectional elevation of one promoter tank unit, and Fig. 3 gives an alternative design of a promoter tank in the shape of a tower.

Referring to Fig. 1, fuel is drawn off from the fuel supply tank 1, through feed line 2, into promoter tank 3 with the optional use of additional promoter tank 3' and 3'' and the resulting fuel containing dissolved ignition promoter is passed through line 4 into filter 5 and then on to the engine not shown. If desired, some fuel not containing any ignition promoter may be by-passed from the fuel tanks through line 6 and blended in the desired proportion with some of the treated fuel. Suitable valves are provided in order to permit flexibility of operation by the use of any one or more of the promoter tanks and for regulation of the amount of flow in the various lines. Suitable drains are also provided for cleaning out all of the units of the system.

Referring to Fig. 2, which is an enlarged vertical section of a single ignition promoter tank 3, ignition promoter 7 is charged into a suitable basket 8, the side walls of which consist of fine screen and the bottom of a solid plate having a hole in the center thereof to permit oil to flow into the basket and to provide a suitable pocket space for electric thermometer 9 for measuring the temperature of the oil being contacted with the ignition promoter. Heating means 10 is provided in order to heat the oil to the desired temperature for obtaining a sufficient solution of ignition promoter in the fuel. This heating unit may be an electrical heating element or may be a hollow jacket through which exhaust gases from the engine may pass or through which hot water from the engine radiator may pass or it may be any other suitable heating element or any combination thereof. The promoter tank is preferably provided with an insulating layer or jacket 11. For charging a supply of ignition promoter into the promoter tank, the lid 12 may be removed and the ignition promoter either dumped into the screen basket 8 or, if desired, the basket may be removed from the tank 3, the promoter packed into the basket in any desired manner and then the basket replaced in the tank.

Referring to Fig. 3, ignition promoter tank 3 is shown in the form of a tower in which ignition promoter 7 is charged in at the top through a bell hopper feeding device 13 or an alternative screw conveyor feed 14 and is packed on the screen 15 near the bottom of the tank. Clean-out hold 16 is provided for use in emergency or for cleaning out any insoluble residue which may be left from the ignition promoter.

As shown in both Figs. 2 and 3, the fuel inlet 17 is preferably located at the bottom of the ignition-promoter tank and the outlet 18 at the top so that the upward flow of liquid fuel through

the unit will tend to prevent undesirable tight packing of small particles of the solid ignition promoter which might otherwise form an impervious layer and prevent passage of the fuel through the unit.

A fine screen 19 should preferably be provided in the upper part of the ignition promoter tank just below the fuel outlet 18 to insure that no solid particles of ignition promoter pass out of promoter tank into the engine.

Also the usual fuel line filter may be provided which filters the fuel just before passing into the injection pump on the engine. The filter may be insulated or heated to maintain a temperature high enough to keep any promoter from precipitating, if necessary.

When the partially insoluble ignition promoters to be used are corrosive, as in sulfur, it is best to either make or line the ignition promoter tank 3 with corrosion-resistant metal and similarly to use such metal for all other metal parts in contact with the solution of ignition promoter in the fuel. If desired, either hand-operated or automatic means may be provided for draining off the fuel from contact with the ignition promoter when the engine is not in use.

As an example of the operation of the invention, two tests were made on a C. F. R. Diesel engine, using a promoter tank substantially similar to that described in Fig. 2 and using powdered sulfur as the ignition promoter, the one test being run at a temperature of 70° F. and the other at about 200° F. as the temperature in the ignition promoter tank. The engine conditions used were as follows:

R. P. M.	900
Lube oil temperature	120 °F.
Water temperature	212 °F.
Inlet air temperature	150 °F.

The Diesel fuel base stock was a Colombia gas oil having the following inspection:

A. P. I. gravity	33
Vis. Say. Univ. at 100° F.	secs. 37
Distillation:	
Initial b. pt.	390 °F.
50% point	525 °F.
End point	667 °F.
Sulfur	0.51 per cent.

When the ignition promoter tank was maintained at a temperature of 70° F. (room temperature), the engine operating entirely on fuel passing through the ignition promoter tanks (without any by-pass), the cetane number of the fuel was found to be 39, the same as the fuel without any ignition promoter.

When using precisely the same equipment and same fuel but regulating the temperature of the ignition promoter tank to 200° F., the cetane number was found to be 46.5 which is an increase of 7.5 over the base stock. The base stock gave a cetane number of 39 when passed through the equipment without any sulfur being present at 200° F.

In the above experiments, 100 grams of powdered sulfur were used and the ignition promoter tank which had an inside diameter of about 5 inches and an inside length of about 9 inches, was heated electrically by a coiled heating element around the outside of the tank.

In the above series of tests, a sample was taken of the fuel after coming through the ignition promoter tanks and the sulfur content was found to be increased to 0.89%; as the original oil con-

tained 0.51% sulfur the increase in sulfur content was 0.38%, which increase was due to the fuel passing through the promoter tank containing sulfur, and maintained at 200° F.

It is thus apparent that by raising or lowering the temperature of the ignition promoter tank, the amount of promoters dissolving in the fuel can be readily controlled. This can also be done by increasing or decreasing the surface area of the promoter.

With materials and equipment designed and adapted to dissolve about 0.3% of ignition promoter in the fuel, when passing through the ignition promoter tank, it is found that about 5 lbs. of the crushed solid ignition promoter will suffice for the treatment of about 200 gallons of fuel, and therefore, for instance, with a truck or bus obtaining a mileage of about 5 miles per gallon of fuel, 5 lbs. of ignition promoter would last for about 1,000 miles of running.

The ignition promoter tank can, of course, be built in various sizes or capacities and can be adapted to be charged either by hand or automatically by engine drive operated through feed reducing gears.

The proportion of ignition promoter to be added to the fuel may range from very small concentrations, such as .02% to as much as 2% or even 3% and in the case of extremely low cetane number base stocks, the ignition promoter may be even used as high as 5%. The use of such extremely high amounts of ignition promoters which may be very corrosive is made possible by means of the present invention, although such amounts would not be practical heretofore.

The fuel base stock to be used is preferably a gas oil boiling from about 400° F. to 700° F. or 750° F., or, in general, it should be a fuel having a suitable boiling range and viscosity for use as a fuel in Diesel type engines. Under some circumstances, a more narrowly cut fraction such as one distilling from 400 to 600° F. or from 500 to 700° F. may be used.

Although oil of the paraffinic type or hydrogenated oils are preferred for fueling compression ignition engines, such fuels are generally more expensive and are not always available or practical, and therefore, the present invention is of particular advantage in making commercially feasible, the preparation of Diesel fuels giving satisfactory engine performance, from crude oils, gas oils, and residual fuels having low pour point, low A. P. I. gravity and high heat value, such as are procured from naphthenic base, asphaltic base, or mixed base stock. Heavier and lower grades of petroleum oil, such as residual oils, are even made more suitable for a slow-speed engine. On the other hand, for high-speed engines, such as those operating at speeds above 1,000 R. P. M. it is probably best to use a fuel base stock rich in paraffinic hydrocarbons or hydrogenated oil and still further improve the cetane number thereof according to the provisions of the present invention.

It is, of course, understood that other known addition agents may be used, such as oiliness agents, sludge dispersers, colloidal suspension dispersers, stabilizers, dyes, anti-oxidants, viscosity improvers, pour point depressors, solubilizers, gum solvents, and corrosion inhibitors. Substances, such as olefins, amines and peroxides may be mentioned as being effective for reducing any corrosive tendencies of the ignition promoter, such as sulfur or various sulfur compounds containing active sulfur. Also other

known ignition promoters, of the soluble liquid type, may be admixed into the fuel prior to passing through the ignition promoter tank of the present invention, for instance, various alkyl nitrates may be used, such as amyl nitrate, etc.

The alkoxy phospho polysulfide mentioned previously as an alternative ignition promoter, may have the formula $S=P(OR)_2S_x(RO)_2P=S$, where R is alkyl aryl or aralkyl group, and x is an integer from 2 to 6. The solubility of such a compound in a Diesel fuel base stock, may be regulated at will by selecting an alkyl aryl or aralkyl group of proper size and shape; for increased oil solubility, long alkyl groups should be used, whereas to reduce the oil solubility and thereby obtain a partially insoluble ignition promoter which is thus adapted for the present invention, a shorter alkyl group should be used.

It is not intended that this invention be limited to the specific examples which are given merely for the sake of illustration, but it is desired to claim all novelty inherent in this invention in the appended claims as broadly as the prior art permits.

We claim:

1. The method of treating a Diesel hydrocarbon fuel prior to ignition of the fuel in a compression-ignition engine of the Diesel type, which comprises contacting a substantial portion of said fuel with solid free sulfur under suitable conditions and for a sufficient time to homogeneously admix with the fuel a substantial ignition quality improving amount of free sulfur, the admixed free sulfur being added in a proportion of at least a concentration of 0.02% by weight of the fuel just prior to the injection of the fuel into the combustion zone.

2. The method of improving the ignition quality of a fuel for a solid injection compression-ignition engine which comprises contacting a substantial portion of a hydrocarbon Diesel fuel as it is being fed to the combustion zone with a mass of a normally solid free sulfur-containing ignition promoter to incorporate into said fuel a substantial ignition quality improving amount of the promoter, and controlling the amount of said promoter incorporated into the fuel feed by the conditions during and extent of the contact between the fuel and the promoter.

3. The method of improving the ignition quality of a fuel for a solid injection compression-ignition engine which comprises contacting a substantial portion of a hydrocarbon Diesel fuel as it is being fed to the combustion zone with a mass of a normally solid sulphur containing corrosive ignition promoter to incorporate into said fuel a substantial ignition quality improving amount of the promoter, and controlling the amount of said promoter incorporated into the fuel feed by the conditions during and extent of the contact between the fuel and the promoter.

4. The method of improving the ignition quality of a fuel for a solid injection compression-ignition engine which comprises contacting a substantial portion of a hydrocarbon Diesel fuel as it is being fed to the combustion zone with a mass of nitrogen sulfide compound having the formula S_4N_4 to incorporate into said fuel a substantial ignition quality improving amount of the nitrogen sulfide compound, and controlling the amount of said compound incorporated into the fuel feed by the conditions during and extent of the contact between the fuel and the compound.

5. The method of improving the ignition qual-

ity of a fuel for a solid injection compression-ignition engine which comprises contacting a substantial portion of a hydrocarbon Diesel fuel as it is being fed to the combustion zone with a mass of a normally solid only partially soluble alkoxy phospho polysulfide ignition promoter to incorporate into said fuel a substantial ignition qual-

ity improving amount of said promoter, and controlling the amount of said compound incorporated into the fuel feed by the conditions during and extent of the contact between the fuel and the compound.

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