April 21, 1942. G. H. CLOUD 2,280,217

SUPER DIESEL FUEL

Filed Nov. 30, 1938 3 Sheets-Sheet 1

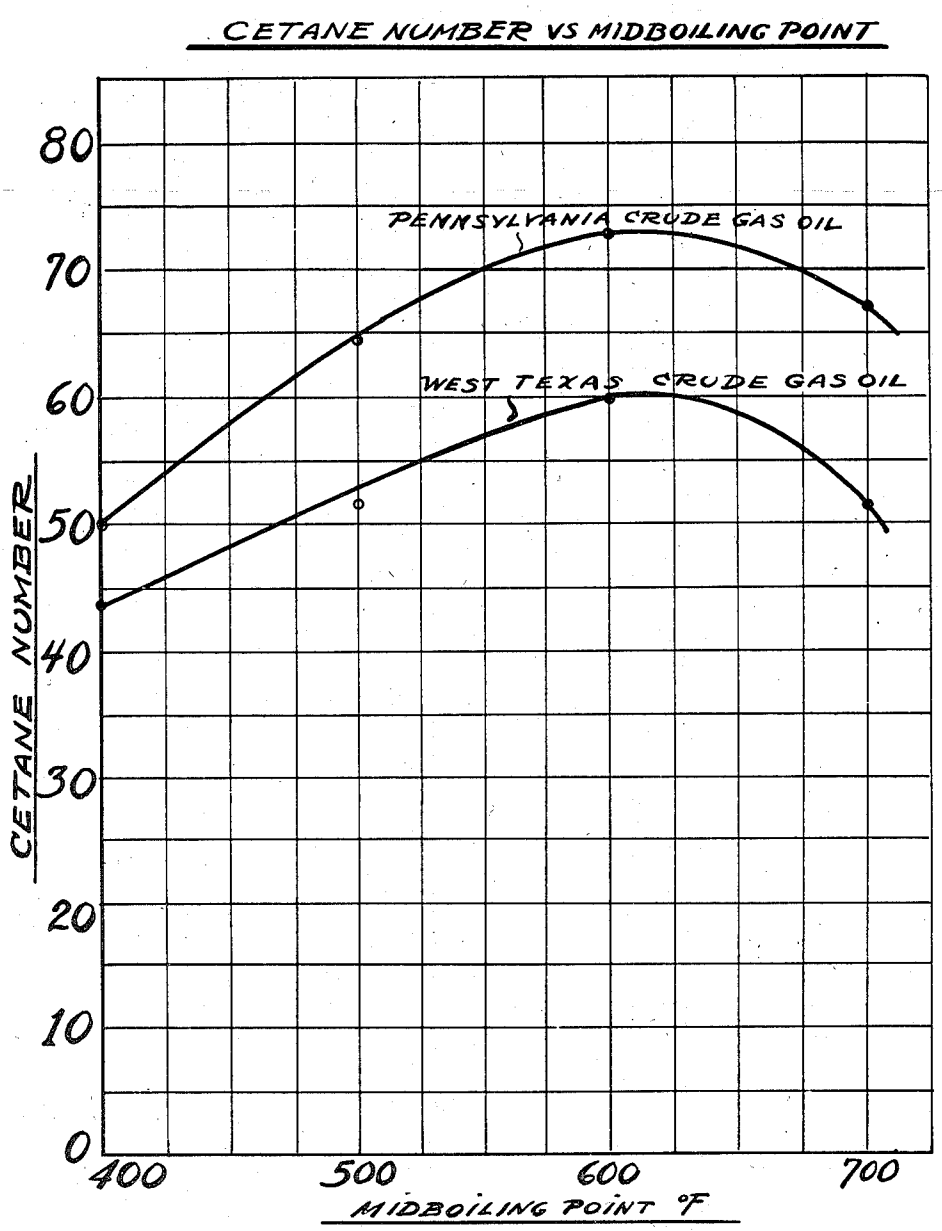


Fig.—1

Gould H. Cloud Inventor

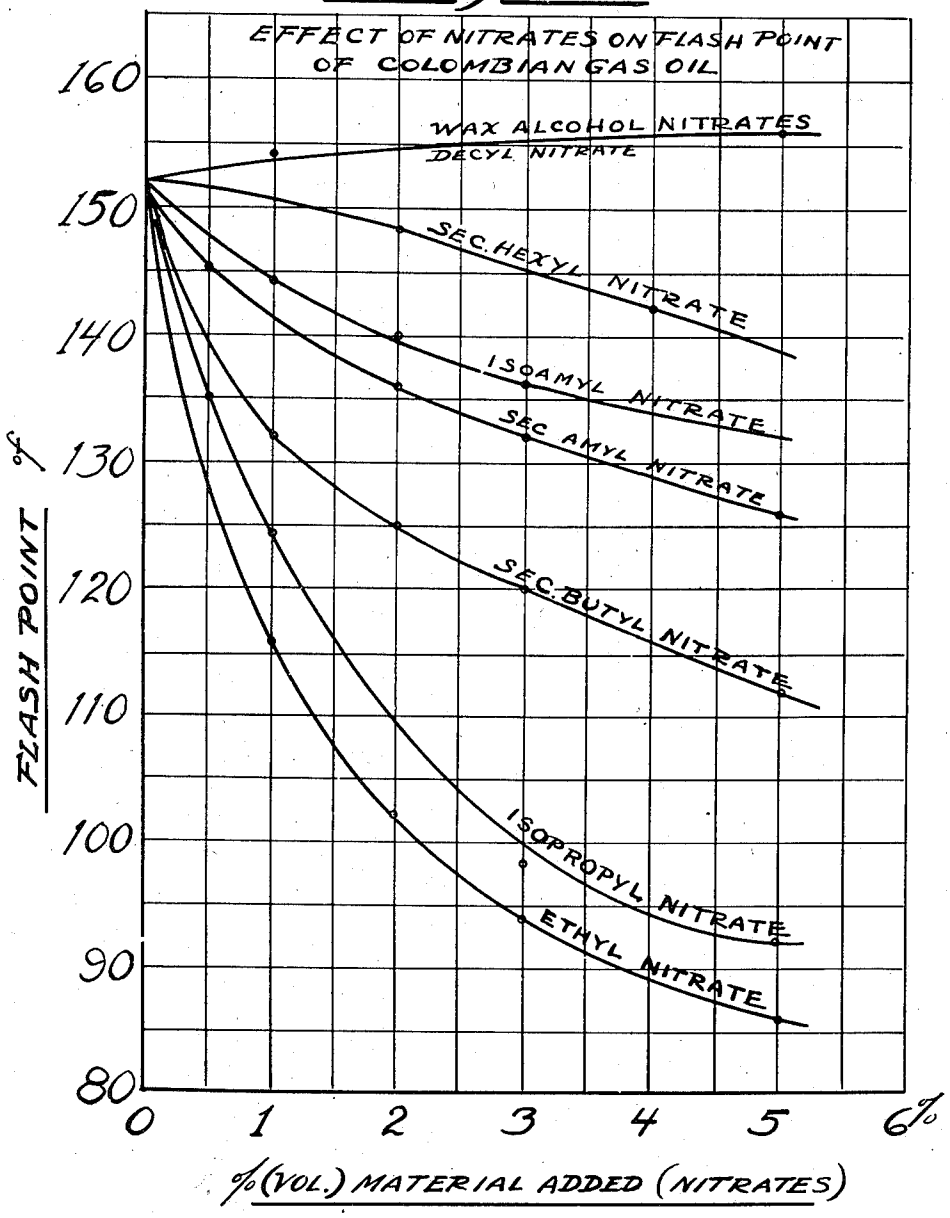
By P. K. Young Attorney

April 21, 1942. G. H. CLOUD 2,280,217

SUPER DIESEL FUEL

Filed Nov. 30, 1938 3 Sheets-Sheet 2

Fig. 2



Gould H. Cloud Inventor

By P. L. Young Attorney

April 21, 1942. G. H. CLOUD 2,280,217

SUPER DIESEL FUEL

Filed Nov. 30, 1938 3 Sheets-Sheet 3

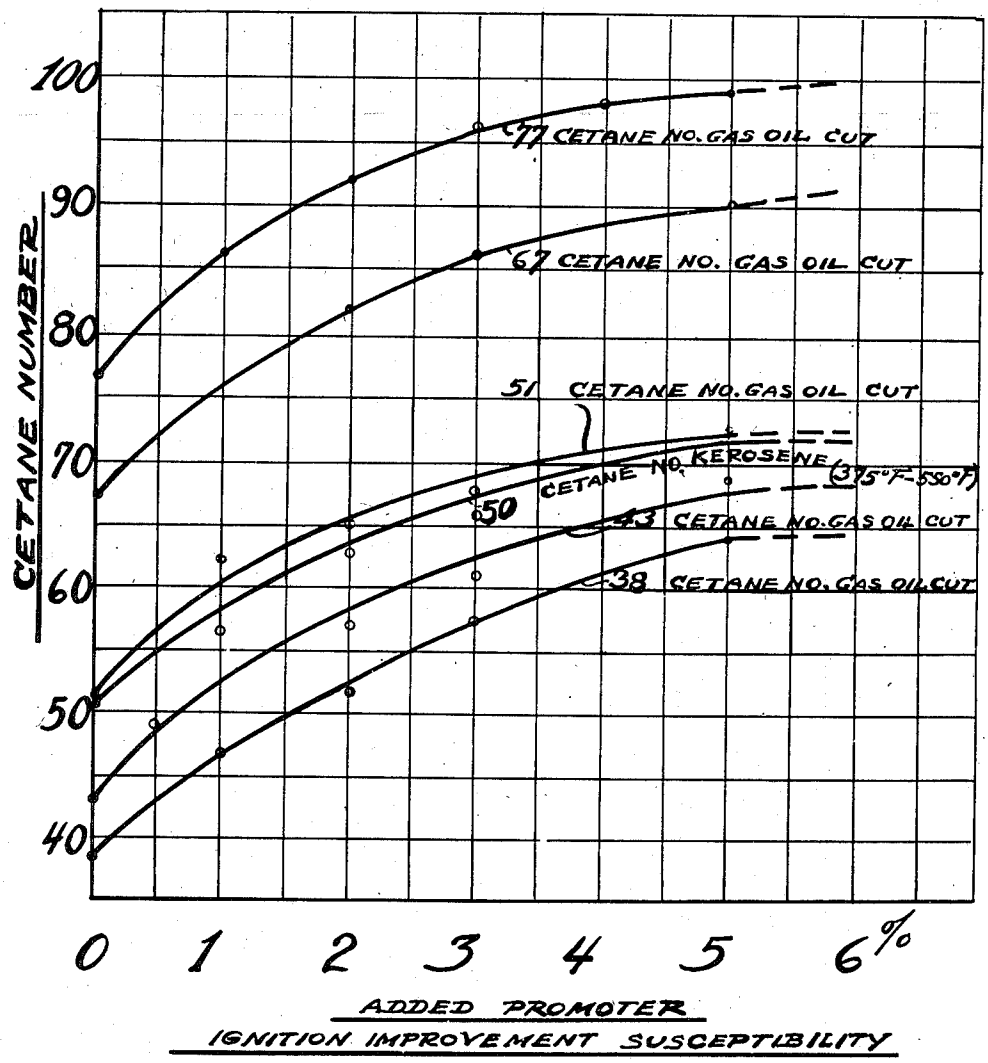


Fig. — 3

Gould H. Cloud Inventor

By P. K. Young Attorney

Patented Apr. 21, 1942 2,280,217

UNITED STATES PATENT OFFICE

2,280,217

SUPER-DIESEL FUEL

Gould H. Cloud, Elizabeth, N. J., assignor to Standard Oil Development Company, a corporation of Delaware

Application November 30, 1938, Serial No. 243,109

11 Claims. (Cl. 44—9)

This invention relates to improvements in high speed compression-ignition engine fuels and particularly to superior safety fuels of high ignition quality, obtainable by use of specific mineral oil fractions and improved addition agents.

Although the present demand for commercial Diesel engine fuels can be met by conventional fuels, instances where superior Diesel type engine fuels would be desirable and even essential are becoming increasingly numerous. For example, increased utilization of high speed Diesel engines in aircraft is largely dependent on the development of fuels having proper characteristics for safety and efficiency, on which requirements aircraft automotive power is more exacting than other uses of automotive power. Owing to the very low fire hazard and very high mileage for a given quantity of fuel in operation of Diesel type engines, great efforts have been made to utilize them in aircraft, but these efforts have been retarded by costly and heavy construction requirements of these engines, and their common performance defects at various stages of their operation, such as, relatively high vibration and audible "knocking" or detonation.

For maintaining desirable features of economy, safety, and efficiency, these engines have been operated with high compression ratios at high speed and on relatively non-volatile fuels having high heating values. Yet, with advancements in the design of compression-ignition engines, it has been found that unless the fuel is improved so as to secure adequate ignition speed, these engines must be excessively heavily built to obtain high compression pressures, and even so, difficulties in starting and from vibrations in idling are not eliminated.

A fuel does not have adequate burning qualities for use in high speed compression-ignition engines unless it ignites at the proper time during injections and burns at a sufficiently slow rate to prevent excessive accumulation of pressure which results in explosive combustion.

To assist in reducing the compression pressure and engine weight requirements, and to eliminate vibrational effects, proposals have been made to add a substance to heavy hydrocarbon fuels for accelerating their ignition in a Diesel engine. For example, the addition of low boiling alkyl nitrates such as ethyl nitrate, amyl nitrate, isobutyl nitrate, and isohexyl nitrate in concentrations of several percent has been recommended. These substances, frequently spoken of as "dopes" have been found costly for effecting an appreciable improvement in the hydrocarbon fuels. Also, they have been found difficult to use because of their instability and corrosiveness. When added in appreciable amounts to a fuel, they effect a substantial reduction in the flash point of the fuel, thereby increasing the fire hazard in handling and using fuel compositions containing them. Other addition agents of the nitro type have been suggested, for example, nitrotoluene and other nitrated hydrocarbons. These have not been found to be as effective nor as practical as desired.

An object of this invention is to meet particularly exacting fuel demands of high speed compression-ignition engines in services where the fuels and engines must furnish the highest degree of engine performance under extremely trying conditions with due consideration to cost of production.

A more specific object of this invention is to provide superior fuel for specified Diesel type engines which have high specifications not only in ignition quality but also in flash point, viscosity, heating value, carbon residue, ash, asphaltum, corrosion, pour point, and stability to moisture. Of these, the ignition quality is generally considered most important, and for aircraft Diesels extraordinarily high ignition quality must, of necessity, be obtained, just as for aircraft gasoline engines, a fuel of maximum octane number has become highly essential.

Formerly, Diesel engines were regarded as capable of burning any heavy fuel. In general, distillate oils, such as a gas oil fraction with an initial boiling point of about 400° F. and an end boiling point of about 700° F. were regarded as suitable fuels. In most Diesel fuel specifications, the boiling range was totally ignored.

In accordance with the present invention the proper selection of a specific hydrocarbon fraction as the fuel base is very important in the preparation of superior Diesel fuels. Now it is found that a specific fraction derived by close fractionation of suitable crude petroleum hydrocarbons gives unexpected and extraordinarily better results in high speed Diesel engines than are given by fuels which have been hitherto used. The method of selecting these specific fractions is based upon the relation between the volatility or boiling range of a fuel and the actual engine performance of the fuel; also, on the relation between volatility and other characteristics of the fuel. These relationships may best be illustrated by reference to data shown in the following tables and figures.

For measuring the ignition and burning quali-

ties which determine the actual engine performance of each fuel, the method herein employed is the one recommended by the S. A. E. Group for Compression-Ignition Fuel Research and described in the S. A. E. Journal of 1936, page 225. This method consists in comparing the performance of a fuel in a test engine with the performance of a blend consisting of normal cetane and alpha-methyl naphthalene. The ignition quality of a fuel is considered to be mainly a function of the fuel's ignition lag, which is a measure of time elapsed between the beginning of the fuel injection into the combustion chamber of a test engine and the point at which the ignition of the fuel sets in. The ignition lag of a fuel may be expressed in terms of time units or degree of crank angle, but is more conveniently expressed by the number representing the volume percentage of cetane contained with alpha-methyl naphthalene in a reference fuel blend giving the same ignition lag or engine performance as the fuel being tested. The ignition lag of the adapted reference fuel is nearly inversely proportional to the concentration by volume of the cetane which may be regarded as having close to an ideal ignition lag, just as iso-octane is regarded as representing a gasoline fuel of ideal anti-knock properties. Alpha-methyl naphthalene, which is the other constituent of the compression-ignition reference fuel, has a long ignition lag.

In the drawings, Figure 1 illustrates graphically the relation between volatility and cetane number of various fuels, including a representative paraffinic base and a representative partly naphthenic or mixed base gas oil distillate.

Figure 2 shows the effect of various aliphatic nitrates on the flash point of a fuel.

Figure 3 illustrates the relationship between ignition qualities of petroleum distillate fuels and their susceptibility to improvement by preferred types of addition agents.

In the following table is tabulated pertinent data on representative hydrocarbon fuels and their component fractions:

TABLE 1

	Range of cuts	B. t. u. per gal.	Cetane No.	Flash point	Conradson carbon	Aniline point	° A. P. I. gravity	Saybolt sec. viscosity at 100° F.
	° F.			°F.	Percent	° F.		
Paraffinic base distillate	350–450	132,800	50.0	144	.03	152	47.6	30.0
	450–550	134,600	64.5	206	.02	171	44.2	35.0
	*550–650	138,200	72.5	290	.01	187	37.6	46.0
	650–750	141,200	67.9	325	.07	207	32.0	122.0
Total range	359–760	137,000	66.5	184	.03	181	39.7	39.0
Mixed base distillate	350–450	135,700	43.7	150	.01	133	42.1	30.0
	450–550	138,700	51.5	216	.01	148	36.6	34.0
	*550–650	141,200	60.1	295	.04	165	32.0	47.0
	650–750	144,600	50.7	375	.11	184	26.8	111.0
Total range	362–750	139,800	54.0	132	.05	159	34.7	40.0

These data point the way to the present method of preparing highest grade fuels for satisfactory performance in Diesel type engines having advanced refinements and operating at speeds above 1000 R. P. M. In the large number of instances in which a variety of commonly used crude oils were studied, the intermediate cut boiling between the approximate limits of 550° F. and 650° F. has been found superior in physical and chemical characteristics to gas oil or prevalent Diesel fuel distillate fractions of the same crude oils for use in high speed compression-ignition engines. While the best specific cuts tend to be nearer the end point of 650° F. for higher cetane numbers, it has been found desirable to make the initial point of the cut selected as a high grade fuel between 450° F. and 550° F. A slight lowering of the initial point below 550° F. permits some improvement in the pour point.

The crude oil cut or fraction which from all considerations can be used in the highest grade fuel should meet the following specifications:

Initial boiling point	About 550° F. and above 450° F.
10% distillation point	Between 475° F. and 580° F.
90% distillation point	Between 600° F. and 650° F.
Final boiling point	About 650° F. and not above 675° F.
A. P. I. gravity	About 30° to 40°.
Aniline miscibility point	Above 140° F.
Cetane No	Above 55 and generally above 60.
Flash point	Above 150° F. and close to 290° F.
Saybolt Universal viscosity at 100° F.	About 40 to 65 seconds.

These specifications substantially characterize the selected 550° F. to 650° F. straight run cuts from the various types of crude oils and correspond to the cuts indicated by asterisks in Table 1. These cuts have just about every major virtue in contrast to the other cuts and the total gas oil fraction. Obviously, they have the remarkably higher cetane numbers, and this is more plainly illustrated in Figure 1, which shows the optimum boiling range of a fuel for maximum ignition quality. In being well above 150° F., their flash points are quite satisfactory and even better than those of many crude gas oil distillates. In many instances, these cuts have even lower pour points than other gas oil fractions. Generally, the Conradson carbon test of this preferred cut is lower than that of the other cuts. This is a big factor in clean burning to eliminate smoke in exhaust and carbon deposits in the engine. Their negligible content of undesired ash, bottoms settling, etc., make them superior also. A very important characteristic of these preferred cuts is their very suitable viscosities. Considering the effects of fuel on leakage past the injection valves and lubrication of the pump mechanism, it has been determined that to assure satisfactory working in these parts, the fuel should have a minimum viscosity of about 40 Saybolt seconds at 100° F. and a maximum of about 65° F. It will be noted that the preferred cuts are precisely qualified in this property, and little or no viscosity increasing agent need be added thereto for securing proper operation.

One can observe that primarily in the preparation of the superior hydrocarbon fraction, the crude or refined petroleum oil to be processed by distillation should contain a gas oil fraction which permits the desired hydrocarbon fuel to

be segregated. This can be determined by the aniline miscibility point and the gravity of the initial oil. The aniline miscibility point or aniline point is the temperature at which a mixture of a hydrocarbon oil and aniline in equal volumetric proportions changes from a heterogeneous mixture to a homogeneous solution.

Crude petroleum gas oils to be adaptable for the improvement to high grade fuel should have an aniline miscibility point above 125° F., preferably above 150° F., and an A. P. I. gravity between about 30° and 45°. Natural paraffinic base, mixed base, and naphthenic base crudes or their straight run fractions may thus be used without any preliminary refining treatment or selective solvent extraction treatment; asphaltic crude fractions may be employed if they are first refined as by hydrogenation or selective solvent extraction to increase their aniline points and their A. P. I. gravities to within the above-mentioned limits.

In line with the object of providing the superior fuel for high speed Diesel engines, it has been found desirable to use ignition promoters which can be added to selected hydrocarbon fuels to prepare fuels having cetane numbers tending to above 100 without impairment of other qualities or characteristics.

Contrary to earlier beliefs, the higher aliphatic nitrates, more particularly open chain aliphatic nitrates having 10 or more carbon atoms per molecule, have been found to be substantially as effective for accelerating ignition of hydrocarbon fuels as the already proposed low boiling alkyl nitrates. The relative effectiveness of aliphatic nitrates in raising the cetane number of hydrocarbon fuel is illustrated in the following table:

TABLE 2

Nitrate tested in blend with a hydrocarbon fuel	Cetane No. increase for the following volume percent added			
	1	2	3	4
Ethyl nitrate	10	17	21	27
Isopropyl nitrate	10	18	21	26
Butyl nitrate	10	17	22	28
Sec. amyl nitrate	9	14	20	25
Sec. heptyl nitrate	8	14	16	23
Sec. octyl nitrate	7	10	13	20
Decyl nitrate	11	18	21	32
Dodecyl nitrate	10	13	18	25
Cetyl nitrate	7	16	18	25
Octadecyl nitrate	7	13	16	20
Cracked wax alcohol nitrates	9	15	18	25
Wax alcohol nitrates	7	12	14	16

From the foregoing table can be observed that the cetane number improvement by lower akyl nitrates declines as the alkyl group becomes larger, going from ethyl nitrate to octyl nitrate. However, in an unexpected manner, the higher aliphatic nitrates, beginning with decyl nitrate ($C^{10}H^{21}NO^3$), make a markedly higher cetane number increase; a slow decline following in the subsequent homologues. These facts aid in the selection of the most effective aliphatic nitrates for blending with hydrocarbon fuels to prepare superior high speed Diesel engine fuels. Evidently, while wax alcohol nitrates having an average molecular weight of $C^{18}H^{37}NO^3$ are effective ignition promoters, the nitrates of aliphatics containing from about 10 to 18 carbon atoms are still more effective. Since the nitric acid treatment is the most expensive part of the nitrate or nitric acid ester formation, it is desirable to secure maximum improvement with a minimum addition of a nitrate blending agent; therefore, nitrates comprising principally those containing about 10 to 18 carbon atoms are preferentially useful.

The wax alcohol nitrates may include in addition to the preferred aliphatic nitrates, such as decyl, dodecyl, cetyl to octadecyl nitrates, and others of higher molecular weight, since the wax alcohols from which the nitric esters are formed are preferably prepared by oxidation of waxy paraffins obtained from petroleum oils by dewaxing. These paraffins comprise some low melting waxes such as cetane and, in general, include paraffins having from about 16 to about 36 carbon atoms per molecule; hence, in the oxidation process, which is carried out at elevated temperatures, a substantial amount of splitting occurs to produce alcohols having about half the number of carbon atoms contained in the wax molecules. The nitrates of these alcohols are formed by esterification of the wax alcohols with nitric acid at low temperatures. To obtain principally the more highly effective nitrates without producing the less desirable ones, the wax alcohols may be fractionated prior to the esterification of nitric acid so that a fraction comprising mainly the C_{10} to C_{16} or to C_{18} alcohols may be segregated for the esterification treatment.

Other methods may be used for preparing the preferred types of nitrates to the exclusion of less desired nitrates; for example, waxy hydrocarbons may be subjected to a mild cracking or splitting to produce aliphatics having on the average half the number of carbon atoms per molecule present in the original wax molecule. In a pyrolytic treatment which might be described as mild cracking or splitting, long chain aliphatic compounds tend to primarily undergo a scission at the center of their carbon chains.

Having obtained by these methods a product generally known as cracked wax distillate largely composed of aliphatic hydrocarbons containing about 10 to 18 carbon atoms per molecule, the product may be further selectively fractionated to narrow down its constituents to only one or a few specific aliphatics, for example, to a fraction predominately composed of decyl, 10 carbon atom molecules, or of 10 to 18 carbon atom molecules. Hydrocarbons in the cracked wax distillate or selected fractions may be converted into nitrates by steps best suited for the type of hydrocarbon, whether the treatment be a reaction of olefinic hydrocarbons with oxidizing agents to form the alcohols which in turn can be esterified with the nitric acid or be more directly converted.

Eminently, the manufacture of the improved high boiling nitrate addition agents is economical since suitable starting materials such as solid waxes and petrolatum are separated from heavier fractions of crude petroleum oils, being frequently a by-product in the production of low pour point lubricating oils. Higher aliphatic hydrocarbons which may be employed are also by-products in the synthesis of hydrocarbons from hydrogen and carbon monoxide.

The source of aliphatic alcohols having about 10 or more carbon atoms per molecule with a straight chain structure is not restricted to compounds procured from mineral sources, for animal and vegetable oils, fats and waxes can also supply useful alcohols. Some of the natural esters need be only subjected to saponification or split-

ting to obtain desired alcohols, for example, spermaceti, which may be obtained from sperm oils, on saponification yields dodecyl alcohol, tetradecyl alcohol, cetyl alcohol, and octadecyl alcohol. Partial hydrogenation of acid derivatives in oils such as cocoanut oil also yields the desired alcohols.

Not only do the higher aliphatic nitrates, beginning with decyl nitrate, give exceptionally high cetane number increases, but also a favorable effect on the flash point of the fuel. This favorable effect on the flash point is contrasted with the deleterious effect by the lower nitrates in the following table and its accompanying graphical illustration in Figure 2:

TABLE 3

Nitrate Blended	Flash point in °F. for blends containing the following percent of nitrate				
	0	1	2	3	5
Ethyl nitrate	152	116	102	94	86
Isopropyl nitrate	152	124	110	98	92
Sec. butyl nitrate	152	132	125	120	112
Sec. amyl nitrate	152	142	136	132	126
Isoamyl nitrate	152	144	140	136	132
Sec. hexyl nitrate	152	150	148	145	139
Decyl nitrate	152	154	156	156	156
Wax alcohol nitrates	152	154	156	156	156

The effect of decyl nitrate and higher alkyl nitrates in raising the flash point rather than lowering it, as done by the lower alkyl nitrates, is just about as pronounced in even a higher flash point hydrocarbon fuel, as for example a fuel having a flash point of 164° F., viz.;

TABLE 4

Flash points for blends containing the following per cent of decyl nitrate

0	1	2
164	166	166

So far, it has been shown that in the preparation of superior high speed Diesel fuels, two main factors are taken into account: the proper selection of the hydrocarbon fuel fraction and of the blending agent to obtain a high flash point and cetane number in the fuel blend. Moreover, the cetane number improvement thus obtained is even far greater than would be calculated on the basis that the improving action of the addition agent and the cetane number of the selected fuel are merely additive. In other words, a fuel of higher cetane number is more susceptible to improvement by the addition agent than a fuel of lower cetane number. This fact is brought out by reference to Figure 3, in which the curves of cetane Number V percentage of agent added are much steeper when the hydrocarbon fuel has inherently a cetane number above about 55. This means that while many low quality Diesel fuels are substantially improved by the effective addition agents from a cetane number of about 40 to about 60, the present invention establishes a large source of fuels which can be improved to cetane numbers tending to above 100.

As a further example, a Rodessa crude gas oil fraction having an A. P. I. gravity of 40.6 and an aniline point of 181° F. was distilled and fractionated to yield three fractions:

TABLE 5

Properties	Rodessa crude oil		
	Fraction I	Fraction II	Fraction III
10% distillation point ° F	378	478	570
90% distillation point ° F	438	548	640
Cetane number	54.6	56.2	71.8
Cetane No. with 5% by weight of aliphatic nitrate added	70 to 75	72 to 80	95 to 105
Saybolt Universal viscosity at 100° F seconds	30.0	35	43.0

On comparing the qualities of these reactions, it was found that the third fraction (III) met the rigid specification requirements of high speed Diesel engines and could be improved to an extremely high cetane number fuel in the range of 95 to 105 upon addition in economical amounts of a higher aliphatic nitrate, while the other two fractions were far behind in meeting these requirements, and even with the addition of the same agent in the same concentration, their cetane numbers were not much better than the third fraction (III) without any addition agent with respect to ignition qualities.

To look at the matter from another viewpoint, this invention makes possible the preparation of high quality fuels having cetane numbers in a range of about 60 to 100 from available domestic crude fuels. Therewith it becomes economically feasible to use slightly additional amounts of the blending agent for preparing superior fuels, since the cost of the agent becomes smaller in proportion to the total improvement of the fuel.

Although selected specific hydrocarbon fractions from petroleum oils, in general, have been observed to have lower pour points and better viscosity characteristics than the gas oil or usual Diesel fuel fraction, it may be desirable in some instances to add a pour point depressant for further lowering of their pour points in accordance with the objects of the present invention to prepare superior fuels having cetane numbers above 55 and tending to above 100. Materials which have been found to make the desired improvement in viscosity and cold tests are non-aromatic high molecular weight compounds. Specific examples of preferred agents are non-drying fatty oil polymers, such as thickened or polymerized rapeseed oil, and polymerized or condensed long straight chain hydrocarbon aliphatics. These polymers may be produced by thickening processes in which heat, air blowing, catalysts, such as boron fluoride or the Friedel Crafts' type, or silent electric discharges are employed. By these methods of interlinking long aliphatic hydrocarbon groups, preferably those with straight chain structures containing 10 or more carbon atoms in a chain and with an absence of cyclic structures, compounds having molecular weights above 500 and more suitably in the range of 1,000 to 10,000 are obtained. Voltolized esters, waxes, unsaturated hydrocarbons, and alcohols produced by silent electric discharge action are among the polymerized substances having the desired functions of lowering the pour point and increasing the viscosity of a hydrocarbon fuel along with an enhancement of the ignition quality of the fuel. Some of these aliphatic polymers are even susceptible to conversion into compounds having more effective ignition accelerating properties;

for example, alcohol polymers, including polyhydric polymers, may be converted into effective aliphatic nitrates by esterification with nitric acid. The chemical condensation for preparing preferred types of non-aromatic polymers is well illustrated in the U. S. Patent 2,062,354 granted December 1, 1936 to G. H. B. Davis. In general, this method involves the condensation of chloroparaffins with one another. Fatty oil polymers may be prepared from various plant and animal oils such as cottonseed, maize, rapeseed, seal, or sperm oil. These fatty oils may be thickened by blowing with air for a period of about 15 to 30 hours at a temperature of about 170° F. until the desired molecular weight, specific gravity, or viscosity is imparted to the oil. For obtaining a substantial pour point lowering and enhancement of the viscosity characteristics, only about .2% to about 6% by weight of these polymerized aliphatic compounds need be added and dissolved in the fuel to be improved in either or both of these respects. The favorable effect of these compounds on the ignition qualities of Diesel fuels is shown in the following table:

TABLE 6

Agent blended	Added	Cetane No. increase
	Percent	
Rapeseed oil polymer	2	+3

Advantageously, the higher aliphatic nitrates are less soluble in and more stable to water than the lower alkyl nitrates and therefore undergo less hydrolysis to form corrosive products. But as a further precaution to minimize corrosion when an aliphatic nitate is used in a Diesel fuel a small proportion of the following class of organic nitrogen compounds may be added: tertiary alkyl amines, preferably those having a total of at least 10 carbon atoms per molecule. Triamyl amine is a specific example of this class of compounds. These compounds have a desirable effect on the flash point of the fuel and tend to increase the cetane number of the fuel.

TABLE 7

Agent blended	Added	Cetane No. increase
	Percent	
Triamyl amine	3	+5

Even though the higher aliphatic nitrates having 10 or more carbon atoms per molecule, and preferably from 10 to 18 carbon atoms per molecule, are particularly useful in preparing the superior fuels with selected crude petroleum fractions, they are also useful for adapting various low quality hydrocarbon fuels for efficient service in low and medium speed Diesels. By including about .025% to about 10% by volume of these nitrates in hydrocarbon oils having flash points above 150° F., fuels having satisfactory ignition qualities and proper flash points are obtained. In this way, not only are gas oil fractions boiling in the range of about 400° F. to 700° F. or 750° F. improved for service in Diesel engines, but also reduced crude oils, residual oils, and highly aromatic oils procured from recycle stocks of cracking operations, non-paraffinic extracts, and oils from destructive distillations or liquefaction of pyro-bituminous and asphaltic materials are made adaptable for service in compression-ignition engines.

From the foregoing will be seen that this invention contemplates the preparation of improved compression-ignition fuels by blending with petroleum oil distillates of recognized boiling range for Diesel engine fuels higher aliphatic nitrates which do not lower the flash point of the fuel and which make an excellent increase in the cetane number of the fuel. In particular, it relates to the use of aliphatic nitrates which can be economically obtained from cracked and oxidized waxy hydrocarbons, the aliphatic nitrates derived in this manner having been found to comprise compounds which are more effective than other alkyl nitrates for improving the ignition quality of the fuels. Additionally, this invention contemplates the preparation of superior high speed compression-ignition fuels by a selection of specific hydrocarbon fractions having more restricted boiling ranges than commonly used Diesel fuels. It also involves the blending of these specific hydrocarbon fractions with improved addition agents which increase the ignition quality of these fuels to a higher degree and which further enhance their physical characteristics without adversely affecting other characteristics of the fuels, such as their flash points, storage stability, etc.

Among the beneficial effects derived from the practice of this invention are notably:

(*a*) Reduction in "knocking"
(*b*) Reduction in exhaust smoke
(*c*) Reduction in maximum combustion chamber pressures
(*d*) Prevention of excessive bearing wear
(*e*) Reduction of oil dilution in sludging
(*f*) Reduction of ring sticking
(*g*) Better fuel economy
(*h*) Easier starting
(*i*) Increase in power
(*j*) Avoidance of vapor lock
(*k*) High stability in handling and storage
(*l*) Prevention of fire hazards

While this invention has been described in connection with specific examples and embodiments thereof, it is to be understood that these are merely by way of illustration. It is desired to define this invention only by the claims which are intended to contain all novelty inherent in this invention which the prior art permits.

I claim:

1. An improved fuel for compression-ignition engines of the Diesel type which comprises a hydrocarbon fuel having a flash point above 150° F. and a small amount of an alkyl nitrate having at least 10 carbon atoms per molecule.

2. A fuel composition as described in Claim 1, in which decyl nitrate is used as said alkyl nitrate.

3. A fuel composition as described in Claim 1, in which dodecyl nitrate is used as said alkyl nitrate.

4. A fuel composition as described in Claim 1, in which cetyl nitrate is used as said alkyl nitrate.

5. An improved fuel for compression-ignition engines of the Diesel type which comprises a hydrocarbon fuel having a flash point of 150° F. and a small amount of an oxidized wax alcohol nitrate to improve the ignition qualities of the fuel, said nitrate having at least 10 carbon atoms per molecule.

6. A fuel particularly adapted for efficiently operating engines of the high speed Diesel type, said fuel having a flash point above 150° F. and comprising a petroleum distillate having a boiling range within the approximate limits of 450° F. and 650° F. and a small amount of a nitrate of a saturated monohydric aliphatic alcohol having at least 10 carbon atoms per molecule to increase the ignition quality of the fuel.

7. A composition as described in Claim 6, in which said nitrate has between about 10 and 18 carbon atoms per molecule.

8. An improved fuel for compression-ignition engines of the high speed Diesel type which comprises a hydrocarbon fuel having a flash point above 150° F., a small quantity of an alkyl nitrate having 10 to about 18 carbon atoms per molecule, and a small quantity of a tertiary alkyl amine having more than about 10 carbon atoms per molecule.

9. A method for preparing a high speed Diesel engine fuel having high ignition qualities and increased susceptibility to improvement by an ignition accelerating agent which comprises distilling a petroleum gas oil having an aniline miscibility point above 125° F. and an A. P. I. gravity between about 30° and 45°, and selectively fractionating from said gas oil undergoing distillation a cut boiling substantially within the range of 550° F. and 650° F., having a 10% distillation point between 475° F. and 580° F., a 90% distillation point between 600° F. and 675° F., and an A. P. I. gravity of 30° to about 40°, and adding to said cut about 1% to 6% by volume of an alkyl nitrate having at least 10 carbon atoms per molecule.

10. A method of improving a high speed Diesel engine fuel having a flash point above 150° F. and containing an alkyl nitrate having at least 10 carbon atoms per molecule which comprises adding a small quantity of a tertiary alkyl amine having at least 10 carbon atoms per molecule in an amount sufficient to minimize corrosiveness of the alkyl nitrate and to further increase the cetane number of the fuel.

11. A method of improving a high speed Diesel engine fuel containing a major proportion of a hydrocarbon distillate having a 10% distillation point between about 475° F. and 580° F., a mid-boiling point of about 600° F., a 90% distillation point between 600° F. and 650° F., an A. P. I. gravity between 30° and about 40°, an aniline miscibility point above 140° F., a flash point above 150° F., and having a cetane number in the range of 60 to about 100 promoted by a minor proportion of an alkyl nitrate having 10 to 18 carbon atoms per molecule which comprises dissolving in said fuel a small quantity of a high molecular weight aliphatic polymer in an amount sufficient to improve pour point and viscosity characteristics of the fuel and a small quantity of a tertiary alkyl amine having more than about 10 carbon atoms per molecule in an amount sufficient to minimize corrosiveness of the alkyl nitrate, both the aliphatic polymer and tertiary alkyl amine further increasing the susceptibility of the fuel to ignition quality improvement by the alkyl nitrate.

GOULD H. CLOUD.