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FUEL CHARGE FOR INTERNAL-COMBUSTION ENGINES

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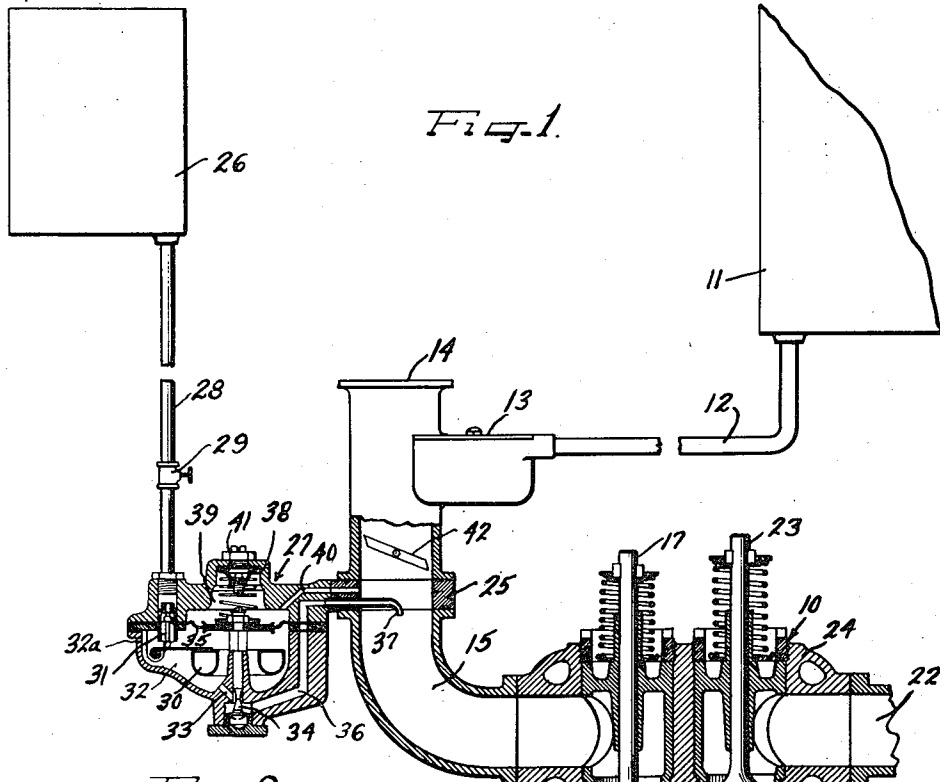
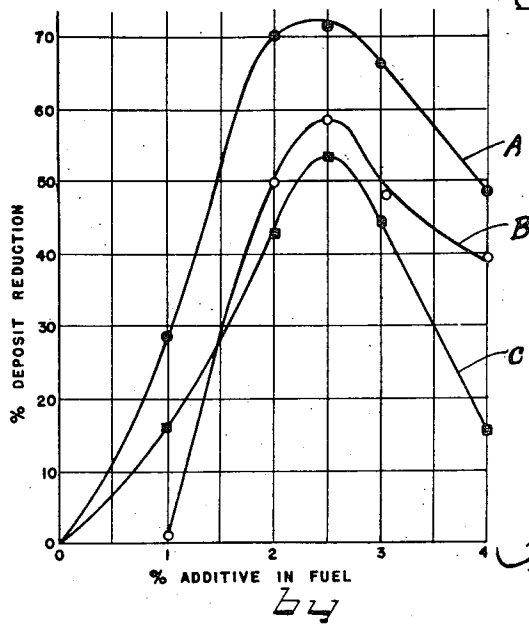


Fig. 2.



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FUEL CHARGE FOR INTERNAL-COMBUSTION ENGINES

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4 Claims. (Cl. 44-56)

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The present invention relates to internal combustion engine fuel charges which eliminate and prevent formation of deposits on the engine parts. The invention includes methods of introducing the fuel charge into the engine.

More specifically, this invention provides a fuel charge comprising gasoline or other fuels in combination with an additive which prevents formation of and which eliminates deleterious deposits created by the heating or burning of the fuel as well as lubricating oil in the combustion chambers and fuel intakes of spark-type engines. The invention further relates to methods for forming the fuel charge and introducing the same into the engine, including the use of supplemental anti-detonant fuels such as monohydric alcohols and water containing the additive.

Heretofore, the presence of deleterious deposits of gum, carbon, and other fuel constituents, such as tetraethyl lead in leaded gasoline in the fuel intake and combustion chamber has been accepted as a natural consequence of the use of modern blended, high octane gasolines. Such deposits are formed by the heat polymerization and incomplete combustion of the fuel-air mixture in the engine to form non-volatile gums and carbon black. The gums may become quite hard and flint-like and act as an adhesive to bind the carbon black to the interior surfaces of the combustion chamber as an agglomerate deposit. These deposits are initially present as a thin, varnish-like material upon the combustion chamber walls and the piston head. This varnish-like deposit is initially soluble in organic solvents. However, on continued operation of the engine, the deposits accumulate at an alarming rate and the deposit becomes a thick, black insoluble thermo-insulating layer upon the interior surfaces of the combustion chamber and the piston head.

It has been found that the hardest flint-like deposits are formed when the engine is operating at full throttle conditions, due to the higher operating temperatures and the increased fuel feed to the engine, which is necessary to provide these operating conditions.

The aforementioned deposits have a definite deleterious effect upon engine performance. It has been found that these deposits cause an increase in the octane requirements for border line detonation, power loss due to heat confined in the combustion chamber, and pre-ignition due to the over-heating of the fuel-air mixture in the combustion chamber.

The present invention now provides a fuel charge by means of which such deposits are eliminated with a consequent increase in engine

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performance, a lowering of the octane requirements, and an elimination of pre-ignition due to the presence of the deposits. The fuel charge of this invention comprises a main hydrocarbon fuel and a minor amount of an additive which is a reaction product of alcohols and alkylene oxides. Such reaction products have the following generic structural formula:



where R_1 and R_3 are the same or different hydrogen, alkyl, aryl, alkaryl, or aralkyl radicals, R_2 is one or more alkylene radicals, and n is greater than 4.

The fuel charge of the present invention may be introduced into the combustion chamber continuously during the operation of the engine by combining the additive directly with the fuel. Preferably, however, the fuel charge is introduced into the chamber only during those periods at which the hardest flint-like deposits are most likely to form, thereby effecting economies in the use of the additive. Thus, it is desirable to introduce the fuel charge into the engine when the engine is operating on a fuel-rich fuel-air mixture, or, in other words, when the engine is functioning at full throttle.

A metering device which is automatically controlled by the throttle valve setting of the engine may be employed to introduce the additive into the main fuel-air mixture in metered amounts to form the fuel charge of the present invention during full throttle operation of the engine. Since the engine intake manifold pressure is determined by the throttle valve setting, the metering unit or injector may be actuated by the manifold pressure.

The fuel charge of the present invention may contain supplementary fuels such as those containing alcohols, water, and anti-detonants such as tetraethyl lead, monomethyl aniline, and the like. These supplementary fuels may be introduced into the main fuel stream by means of metering devices such as those above described. The additives of the present invention are compatible with such supplementary fuels and a mixture of additive and supplementary fuel may be added to the fuel stream from a common source through a common metering device to provide an efficient, unitary injection system by means of which the octane rating of the gasoline may be raised and any carbon deposits within the combustion chamber eliminated by employing the supplementary fuel and additive only at full throttle operation of the engine.

It is, therefore, an important object of the present invention to provide a fuel charge compris-

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ing a hydrocarbon fuel and an additive for preventing formation of as well as for eliminating previously formed deleterious deposits normally caused by heating and burning the fuel in internal combustion engines.

It is another important object of the present invention to provide a method of eliminating and preventing the formation of deleterious deposits in internal combustion engines by injecting a fuel charge comprising a mixture of a hydrocarbon fuel and an additive effective to prevent the formation of such deposits, said additive having the structural formula:



in which R_1 and R_3 are the same or different hydrogen, alkyl, aryl, alkaryl or aralkyl radicals, R_2 is one or more alkylene radicals, and n is greater than 4.

A further object is to provide a method of preventing formation of deleterious deposits in an internal combustion engine by incorporating an additive such as specified above into the combustion chamber only when the engine is operating under detonating conditions.

It is a still further important object of the present invention to provide a fuel charge composed of gasoline, a monohydric alcohol, water, an anti-detonant and a minor proportion of an additive having the structural formula:



in which R_1 and R_3 are the same or different hydrogen, alkyl, aryl, alkaryl or aralkyl radicals, R_2 is one or more alkylene radicals, and n is greater than 4.

Other and further objects of the present invention will be apparent to those skilled in the art from the following detailed description of the annexed sheet of drawings which illustrates apparatus for forming the fuel charge of this invention and for carrying out the method of the invention together with a graph showing effects of use of the invention.

On the drawings:

Figure 1 is a diagrammatic, vertical cross-sectional view, with parts in elevation, of an internal combustion engine and fuel supply and intake assembly equipped with a fuel injector or metering device for supplying additives of the present invention to the intake manifold of the engine and to the combustion chamber of the engine.

Figure 2 is a graph diagrammatically illustrating the percent deposit reduction obtained by the use of the fuel charge of the present invention as a function of the amount of additive present in the charge.

As shown on the drawings:

Figure 1, an internal combustion engine 10 is equipped with the customary air and fuel-charging assembly and is supplied with a hydrocarbon fuel, such as gasoline, from tank 11, the fuel passing through main fuel line 12 to carburetor 13. In the carburetor 13, the gasoline is commingled with an amount of air entering the system through air intake port 14. The fuel-air mixture is introduced into the engine 10 through intake manifold 15, the introduction of the fuel-air mixture into the combustion chamber 16 being controlled by intake valve 17. A piston 18 is mounted in the combustion chamber 16 and is connected through connecting rod 19 to a conventional crankshaft (not shown). A spark plug 20 is mounted in one cylinder wall 21 of combustion chamber 16 to ignite a fuel-air mixture contained therein. The gases of combustion

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are discharged through the exhaust manifold 22 under control of the exhaust valve 23. Both the intake valve 17 and the exhaust valve 23 are mounted in a cylinder head 24.

A mounting block 25 is interposed between the carburetor 13 and the intake manifold 15. A relatively small tank 26 is provided for the additive of the present invention and/or supplementary anti-detonant fuel for introduction into the combustion chamber of the engine in combination with the main fuel contained in tank 11. The tank 26 is connected to metering device 27 through a supplementary fuel line 28 equipped with a valve 29. The metering device 27 includes a float 30 controlling inlet valve 31 to control the flow of additive into the device 27. The float 30 is mounted in float chamber 32 which is vented to the atmosphere at 32a and additive under atmospheric pressure in the float chamber flows through a passage 33 to a metering valve 34 which is controlled by a diaphragm 35. Additive flowing past the metering valve passes through the passageway 36 to a nozzle 37 carried by the block 25 and opening downstream in the intake manifold 15.

A spring 38 is mounted in spring chamber 39 which is vented through passageway 40 to the interior of block 25. The spring 38 is adjusted by means of adjusting mechanism 41 to bear against the diaphragm 35 tending to open the metering valve 34. Since it is desired to feed the additive and/or supplementary fuel contained in tank 26 to the engine only during those periods of operation during which the majority of carbon deposition will occur within the combustion chamber, and since such periods of engine operation are accompanied by a decreased vacuum or increased pressure in the inlet 15, the spring 38 is effective to move the metering valve 34 toward open position, because the vacuum in the chamber 39 is insufficient to overcome the spring pressure. Additive and/or supplementary fuel is thereupon discharged through nozzle 37 in amounts determined by the opening of the metering valve. The fuel is discharged through the nozzle 37 to become intimately mixed in fine spray form with the main fuel and air mixture flowing through intake manifold 15. Upon a decrease in the intake manifold pressure and an increase in the vacuum in the spring chamber 39, the diaphragm 35 pulls the metering valve to closed position to interrupt the feed of additive and/or supplementary fuel.

The intake vacuum is a function of the degree of the opening of the throttle 42 which controls the flow of the main fuel and air stream into the engine 10. As the setting of throttle controls both the flow of the main fuel from tank 11 and the intake manifold pressure, and thereby the flow of additive or supplementary fuel through the metering device 27, it may be seen that the additive may be introduced through the metering device 27 during those periods when the harder flint-like deposits are most likely to form both in the intake assembly and in the combustion chamber 16 due to the higher operating temperatures therein.

It is desired that the additives which are herein described be introduced continuously into the engine 10, the valve 29 may be closed to shut off the flow of additive to the metering device 27, and the additive may be added in the desired amount directly to the main fuel supply contained in tank 11.

It has been found that in operation of an en-

gine, such as the engine illustrated in Figure 1, with fuels not containing the additives of this invention, gums are deposited in the intake 15, on the intake valve 17, and on the guide for this valve. In addition, gum and carbon deposits are formed in the combustion chamber 16. Further, lacquers are formed on the skirt of the piston 18 and in the piston ring grooves of the piston 18.

The gums which are deposited in the intake system of the engine are probably formed by heat polymerization of unsaturated constituents of the fuel. The gum and carbon deposits in the combustion chamber of the engine are most likely formed from lubricating oil in the combustion chamber. The lacquers deposited on the piston skirt and ring grooves can be formed from both the oil and the fuel.

As the operating temperature of the engine increases under full load or open throttle operating conditions, the intake assembly is further heated and the gum formation is accelerated both because of the increased temperature and the increased rate of fuel feed. These gums are relatively non-volatile and deposit mainly on the valve stem. At the same time, in the combustion chamber, the higher operating temperatures, the increased oil consumption, and the increased richness of the fuel-air charge necessary to operate the engine under full load, accelerate the carbon and gum deposits in the combustion chamber and the lacquer deposits on the piston skirt and rings.

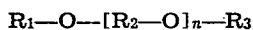
We have found that an additive composition, in order to effectively prevent or eliminate the formation of the above-described deleterious deposits as a component of the fuel charge, must possess certain physical and chemical properties.

To be effective in the combustion chamber, the additive must be fairly non-volatile, have a low vapor pressure and be capable of condensation at the combustion surface temperatures. These temperatures vary from about 400 to 700° F. at the cylinder head to a value of approximately 1600° F. at the piston head. The additive must decompose at elevated temperatures to form completely volatile decomposition products in order that the additive itself will not form a deposit within the combustion chamber. Also, the additive composition must be able to wet the surface of the combustion chamber and of the piston head.

To be effective in the intake assembly of the engine, the additives should have a gum solvent action or a polymerization depressing effect upon the fuel unsaturates. The intake assembly operating temperatures are less than the temperatures in the combustion chamber, varying from atmospheric temperatures up to about 400° F.

It is, of course, important that neither the additive nor its decomposition products have a corrosive effect on the engine parts.

We have found that the reaction products of alcohols and alkylene oxides possess the properties above enumerated as necessary for such materials and are suitable additives for use in fuel charges of the present invention. Such reaction products have the following structural formula:



Those reaction products of alcohols and alkylene oxides having the above given structural formula in which R_1 and R_3 are the same or different hydrogen, alkyl, aryl, alkaryl or aralkyl radicals,

R_2 is one or more alkylene radicals, and n is greater than 4, are particularly suitable for use in the present invention. Such compositions may be prepared as set forth in U. S. Patent No. 2,425,755 to F. H. Roberts et al. and Patent No. 2,425,845 to W. J. Toussaint et al. These compositions are commercially available under the trade-mark "Ucon" and are manufactured by the Carbide and Carbon Chemical Corporation.

We prefer to employ compounds having the above identified structural formula in which n is at least 10, or such compounds in which the average molecular weight is not less than 300.

Such high molecular weight compositions as are herein contemplated are generally mixtures of compounds in which mixtures the values for n and the molecular weight are average values only. For example, a composition formed by the reaction of butyl alcohol and 1,2-propylene oxide having a viscosity index of 144 (ASTMD-567-41) may have an average molecular weight of 1133 and a value of n of 18.4. The molecular weights of individual compounds present in this mixture may vary from about 1000 to about 1300, and the value for n may vary from 15 to 20. The values for n and the molecular weights as given herein are merely average values for the entire composition, and should not be construed as a limitation upon the structure of individual components of the mixture.

Further, the radicals represented by R_1 , and R_3 , in the structural formula may vary in the individual compounds which constitute the mixture. For example, in the composition given above, individual compounds in which both R_1 and R_3 are each butyl radicals, other compounds in which both R_1 and R_3 are H radicals, or in which R_1 and R_3 are hydrogen and butyl radicals respectively may be obtained. Thus although an acetyl value may be obtained indicating that R_1 is a butyl radical and R_3 is a hydrogen radical, it is probable that in at least some of the individual components of the composition R_1 and R_3 are both butyl or hydrogen radicals. However, in the present invention, the specific composition of the individual components of the mixture are unimportant and the average values may be used to designate the compositions, since we have found that compounds in which R_1 and R_3 are the same or different hydrogen, alkyl, aryl, alkaryl or aralkyl groups are suitable for use as additives.

The fuels which may be employed in combination with these additives to form the fuel charge may be straight run gasoline, thermally cracked gasolines, or catalytically cracked gasolines, or blended fuels containing more than one type of gasoline. We have found that fuel charges entering the combustion chamber which contain from 0.1 to 10% additive in combination with such hydrocarbon fuels are effective to reduce the amount of deposit within the combustion chamber. We have found that fuel charges for ignition in the combustion chamber which contain from 0.5 to 5% additive are particularly desirable due to the more efficient utilization of the additive at these concentrations. For example, we have found that the presence of 0.1% by weight of additive in the fuel charge of the present invention is effective to reduce the deposit formed in the combustion chamber by an amount equal to from 15 to 37% of the deposit formed in the absence of the additive. It is evident that the amount of additive employed when the additive is injected into the combustion

chamber intermittently will depend upon the operating conditions of the engine, or more specifically upon the total operating time at full throttle.

We have found that the additives of the present invention are suitable for use with leaded gasolines. However, blended gasolines containing anti-detonants, such as tetraethyl lead, are ordinarily continuously fed into the engine during all conditions of engine operation, although the use of the expensive anti-detonant is seldom required in internal combustion engines under normal engine operating conditions. Accordingly, we prefer to employ the additives as herein described in combination with supplementary fuels for injection into the internal combustion spark engine only when the engine is operating under detonating conditions. These detonating conditions in the engine coincide with those conditions under which the most harmful deposition of deleterious deposits occur in the engine. Consequently, it is feasible to simultaneously inject the additive and supplementary fuel into the main fuel stream and hence into the combustion chamber. Suitable supplementary fuels for use in conjunction with the additives of this invention are those which contain from 30 to 90% by weight monohydric alcohol, 5 to 65% by weight water, or high octane hydrocarbons and preferably small amounts of additional anti-detonant such as 0.1 to 15 cc. per gallon of tetraethyl lead, and/or from 5 to 20% by weight monomethyl aniline, iron or nickel carbonyl, glycols, benzene, phenols, xylidine and its homologues, and the like.

The fuel charge of the present invention has been found to be effective in the removal of as much as 88% of the deposits incurred upon the use of ordinary gasoline. The actual removal is considerably greater than indicated by the following experimental data. The small amount of deposit obtained upon use of the fuel charge is actually an oil and is not particularly objectionable since it does not cause sticking of the valves and piston and does not cause predetonation of the fuel-air mixture in the combustion chamber.

It has been found that the intermittent injection of the additives of the present invention results in the more effective use of that amount of additive which is introduced. For example, we have found that the introduction of 2½% of a typical additive of this invention continuously during operation of the engine results in

a 71.7% reduction in the amount of deposit formed in the combustion chamber. By introducing 2½% additive based on the amount of hydrocarbon fuel employed during only 25% of the operating time of the engine, we have obtained a 50.6% reduction in the amount of deposit formed. In other words a 75% reduction in the amount of additive employed results in only a 21.1% increase in the amount of deposit formed in the combustion chamber.

Thus it may be seen that the introduction of additive upon an intermittent schedule results in the more effective utilization of the deposit-inhibiting characteristics of the additive.

The following examples illustrate further details of the methods of this invention and the results obtained thereby.

EXAMPLE 1

Five single-cylinder internal combustion marine-type spark-engines attached to generators, each generator having a rated output of 1000 watts, were set up to determine the deposit reduction obtained by the use of the fuel charge of the present invention. Throughout the tests of this example the engines were run to obtain a generator output of 780 watts. The gasoline employed was a thermally cracked hydrocarbon stock having an octane rating of 65.5. The additive employed was a reaction product of a lower aliphatic alcohol such as butyl alcohol and 1,2-propylene oxide having a molecular weight of approximately 1200, the compound containing an average of approximately 18 propylene units per molecule. For the continuous introduction of additive, as in test II hereinafter described, the additive was added in the indicated amounts to the fuel and the mixture of fuel and additive was fed directly into the engine carburetor. For the intermittent injection of the additive, as in tests III and IV, a pair of tanks were connected to the carburetor and valve means for controlling the flow of fuel from the tank to the carburetor were provided. One of the tanks was filled with hydrocarbon fuel containing the above-identified additive, while the other contained only the hydrocarbon fuel. These two fuels were fed into the carburetor of the engine in accordance with the schedules indicated in Table I with the indicated results. Table I indicates the testing conditions and the results obtained in tests I through IV. The amount of deposit obtained was deter-

Table I

Test No.	Engine No.	Per Cent Additive	Additive Schedule (Total Time 16 hrs.)	Deposit Obtained, mg.	Per Cent Reduction in Deposit
I	1	none	no additive	839	none
	2	none	do	1,072	none
	3	none	do	1,083	none
	4	none	do	734	none
	5	none	do	1,492	none
II	1	2	constant addition of additive	598	28.7
	2	2½		321	70.0
	3	3		305	71.7
	4	4		256	66.2
	5	1		776	47.9
III	1	2	20 minutes no additive 20 minutes additive in specified amount and then repeat	918	-9.4
	2	2½		564	47.3
	3	3		472	56.4
	4	4		408	44.5
	5	1		921	38.3
IV	1	2	30 minutes no additive 10 minutes additive in specified amount and then repeat	760	7.4
	2	2½		660	38.3
	3	3		535	50.6
	4	4		428	41.4
	5	1		1,404	0.6

mined by disassembly of the engine, scraping the combustion chamber surfaces and the piston head and weighing the deposit thus obtained. It was found upon analysis that the amount of metal scraped from the chamber surfaces and piston head was negligible and had no effect upon the results obtained. The deposit reduction was determined by dividing the difference between the deposit obtained in each test II, III and IV and the corresponding deposit of test I by the weight of the deposit of test I expressing the result as percentage.

The results obtained on tests II, III and IV are illustrated in the table comprising Figure 2 on the attached drawings as lines A, B and C respectively. It is to be noted from the test data that, in each instance, the maximum results were obtained by employing a concentration of 2½% additive based upon the total amount of fuel employed. It should also be noted that by a reduction in the amount of additive added to an amount equal to only 25% of that employed in test II, a deposit increase of only 21.1% was obtained. Thus it may clearly be seen than an improved utilization of the deposit-inhibiting characteristics of the additive is obtained by intermittent injection of the additive into the main fuel stream.

EXAMPLE 2

To determine the extent of combustion chamber deposition under the test conditions of Example 1, while employing leaded gasoline, 2 cc. per gallon of tetraethyl lead were added to the thermally cracked gasoline employed in Example 1. The other test conditions were identical with those of Example 1, the same additive was injected continuously, and the results were determined in the same manner. Table II summarizes the test conditions and the results obtained upon the use of the additive in conjunction with leaded gasoline.

Table II

Test No.	Engine No.	Per Cent Additive	Deposit Obtained, mg.	Per Cent Reduction in deposit
V-----	1	None	4,549	None
	2	None	2,680	None
	3	None	3,179	None
	4	None	2,816	None
	5	None	4,107	None
VI-----	1	2	3,720	18.2
	2	2	2,570	4.1
	3	2½	2,475	22.1
	4	3	2,084	25.9
	5	4	2,210	46.1

EXAMPLE 3

To determine the effect of engine load upon the effectiveness of the fuel charge in the prevention of carbon deposits within the combustion chamber, the engine load was varied from a value of 200 watts to 950 watts by the insertion or removal of resistance in the generators attached to the engines. The other conditions of this example are identical to the conditions of Example 1, the same fuel and additive being employed, the additive being injected continuously into the engine. Table 3 summarizes the engine load conditions and the results obtained:

Table III

Test No.	Engine load	Engine No.	Per Cent Additive	Deposit Obtained, mg.	Per Cent Reduction
VII-----	200	1	None	1,275	-----
		2	None	1,148	-----
		3	None	930	-----
		4	None	843	-----
		5	None	1,187	-----
VIII-----	200	1	1	369	71
		2	2	326	71.5
		3	2½	118	87.4
		4	3	152	82.1
		5	4	176	86.4
IX-----	950	1	None	1,149	-----
		2	None	967	-----
		3	None	926	-----
		4	None	740	-----
		5	None	1,173	-----
X-----	950	1	1	655	43
		2	2	494	48.9
		3	2½	333	64
		4	3	371	60.1
		5	4	493	57.9

EXAMPLE 4

To determine the effect of the additives of the present invention when employed in combination with supplementary fuels containing a monohydric alcohol and water, a number of additives were employed with a supplementary fuel comprising a 50% solution of methanol in water. The additive was added to the supplementary fuel in an amount equivalent to 7% by weight of the total mixture. The mixture of supplementary fuel and additive is then injected continuously into the engine through a metering device 27 as illustrated in Figure 1. The amount of supplementary fuel added to the main hydrocarbon fuel was equivalent to about 15% of the total weight of the fuel. This gave an amount of additive present in the fuel equivalent to about 1% by weight. The fuel charge actually introduced into the engine thus contained approximately 7% water, 7% methanol, 1% additive, and the balance gasoline. The additives employed are the reaction products of a mixture of ethylene and propylene oxides with an aliphatic alcohol. The molecular weights of the additives range from 355 to 3,120. The test conditions and the results obtained are summarized in Table IV:

Table IV

Test No.	Additive Mol. Wt.	Per Cent Additive	Deposit Obtained, mg.	Per Cent Deposit Reduction
XI-----	355	None	1,141	-----
	710	1	824	27.7
	980	1	490	57.9
	1,070	1	258	77.4
	1,300	1	496	57.3
XVI-----	1,960	1	343	70.0
	3,120	1	343	70.0

EXAMPLE 5

To determine the effect of the additives of the present invention upon the amount of combustion chamber deposit obtained when the engine was run under a fluctuating load, the following conditions were employed. Five engines were set up as described in Example 1. The load upon the engines was varied so that each engine ran 30 minutes at a generator load of 200 watts and then 10 minutes under a load of 900 watts. The additive was introduced into the engine during the high load cycle only in the amounts given. The load was varied thus for 40

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hours. The fuels and additives employed were those of Example 1. The test conditions and results are summarized in Table V.

Table V

Test No.	Engine No.	Per Cent Additive	Deposit Obtained, mg.	Per Cent Deposit Reduction
XVIII	1	None	2,034	None
	2	None	2,016	None
	3	None	1,276	None
	4	None	1,156	None
	5	None	2,750	None
XIX	1	1	1,390	34.2
	2	2	1,045	48.3
	3	2½	583	54.3
	4	3	633	45.2
	5	4	2,025	26.4

It will, of course, be understood that various details of construction may be varied through a wide range without departing from the principles of this invention and it is, therefore, not the purpose to limit the patent granted hereon otherwise than necessitated by the scope of the appended claims.

We claim as our invention:

1. A fuel charge for combustion in internal combustion engines comprising a hydrocarbon fuel and a minor amount of a reaction product of an alcohol and an alkylene oxide, the reaction product having the structural formula $R_1-O-[R_2-O]_n-R_3$ where R_1 and R_3 are selected from the group consisting of hydrogen, alkyl, aryl, aralkyl and alkaryl radicals, R_2 is an alkylene radical and n is greater than 4.

2. A fuel charge for combustion in internal combustion engines comprising gasoline and from 0.1 to 10% by weight of a reaction product of an alcohol and an alkylene oxide, the reaction product having the structural formula $R_1-O-[R_2-O]_n-R_3$ where R_1 and R_3 are selected from the group consisting of hydrogen, alkyl, and aralkyl radicals, R_2 is an alkylene radical and n is greater than 4.

3. A fuel charge for injection into the combustion chambers of an internal combustion engine and combustion therein when said engine is

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operating under full throttle conditions comprising gasoline, water, a monohydric alcohol, and a reaction product of an alcohol and an alkylene oxide, the reaction product having the structural formula $R_1-O-[R_2-O]_n-R_3$ where R_1 and R_3 are selected from the group consisting of hydrogen, alkyl, aryl, aralkyl and alkaryl radicals, R_2 is an alkylene radical, and n is greater than 4.

4. A fuel charge for periodic injection into the combustion chamber of an internal combustion engine and combustion therein when said engine is operating under detonation conditions consisting essentially of gasoline, water, a monohydric alcohol, an antidetonant, and a reaction product of an alcohol and alkylene oxide, the reaction product having the structural formula $R_1-O-[R_2-O]_n-R_3$ where R_1 and R_3 are selected from the group consisting of hydrogen, alkyl, aryl, alkaryl, and aralkyl radicals, R_2 is an alkylene radical and n is greater than 4.

5. A fuel charge for periodic injection into the combustion chamber of an internal combustion engine and combustion therein when said engine is operating under detonation conditions consisting essentially of gasoline, water, a monohydric alcohol, an antidetonant, and a reaction product of an alcohol and alkylene oxide, the reaction product having the structural formula $R_1-O-[R_2-O]_n-R_3$ where R_1 and R_3 are selected from the group consisting of hydrogen, alkyl, aryl, alkaryl, and aralkyl radicals, R_2 is an alkylene radical and n is greater than 4.

ARCHIE T. COLWELL.
MILTON S. ROUSH.

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