

UNITED STATES PATENT OFFICE

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MOTOR FUEL

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6 Claims. (Cl. 44—63)

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The present invention relates to a motor fuel composition adapted to provide distinctly improved motor operation under cool moist operating conditions. The motor fuel composition of the present invention comprises a hydrocarbon mixture boiling in the gasoline boiling range which contains as an ingredient a very small percentage of a furfuryl alcohol. In addition the fuel compositions of the present invention may contain solvent oil and other additives such as lead alkyl anti-detonants, dyes, gum inhibitors, oxidation inhibitors, and the like.

The novel fuel compositions of this invention are primarily intended to overcome certain operational difficulties in connection with automotive, marine, stationary, and airplane engines. The difficulties referred to result in frequent stalling of the engine under idling conditions. This stalling may be encountered whenever the weather conditions in which the engine is used are such as to provide a relatively high humidity, and a temperature below about 60° F.

While this problem has actually been existent for many years, attention has recently been focused on it due to numerous complaints of car owners particularly in the northern portion of the United States. These owners report that during cool, wet weather their cars give poor idling performance characterized by a high number of engine stalls. The difficulty is encountered in all types of cars employing all types of carburetors and utilizing all commercial brands of gasoline.

In order to indicate the magnitude of this difficulty, reference may be made to a survey conducted in the New Jersey area based on the experiences of 300 car owners driving twenty different car models, during the fall and winter period. These cars employed the winter grade of regular and premium commercial gasolines. Table I gives a summary of the results obtained, showing the substantial number of stalls encountered in the operation of the cars under the indicated conditions.

Table I

|                                  | Number of Complaints of Two Stalls or More (Per 100 Cars) |           |            |            |      |
|----------------------------------|-----------------------------------------------------------|-----------|------------|------------|------|
|                                  | 32                                                        | 35        | 37         | 52         | 56   |
| Temperature, °F.....             | 52                                                        | 70        | 96         | 100        | 96   |
| Relative Humidity, per cent..... | Clear                                                     | Over-cast | Light Rain | Heavy Rain | Rain |
| Weather.....                     | 5                                                         | 15        | 20         | 21         | 7    |
| Winter Regular Users.....        | 6                                                         | 38        | 40         | 42         | 2    |
| Winter Premium Users.....        |                                                           |           |            |            |      |

The bare statistics of Table I coupled with the common experience of all automotive users serves

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to indicate the magnitude of the problem of engine stalling encountered under cool, humid temperature conditions. However, it is significant to note that this problem has of late become of increased importance due to certain specific factors. First, most post-war cars are now provided without a manual throttle so that car owners are no longer able to increase the idle speed during the warm-up period to prevent stalling. Second, the idle speed of cars with automatic transmissions is rather critical during a warm-up and the fastest idle which may be used must not be too fast, increasing the criticality of stalling conditions. Third, stalling of a car with automatic transmission frequently does not occur until the driver is ready to accelerate, so that just at this most inconvenient time it is necessary to shift the car to neutral, restart the engine, and shift back into gear; magnifying the inconvenience of frequent stalls. A fourth factor affecting the magnitude of stalling difficulties relates to the volatility of the fuels now provided for automotive use. The volatility of commercial fuels over a period of years has been increased sufficiently to increase stalling difficulties as will be brought out herein.

On investigating this problem, it has been determined that the cause of repeated engine stalling in cool, humid weather is the formation of ice in the carburetor of the engine. On a cool, moist day, gasoline evaporating in the carburetor exerts sufficient refrigerating effect to condense and freeze moisture present in the air entering the carburetor. Normal fuel vaporization within the carburetor can cause a temperature reduction of the metal parts of the carburetor up to 50° F. below that of the entering air. Consequently, prior to the time of complete engine and radiator warm-up, this drop in temperature may cause formation of ice in the carburetor. Ice formation probably occurs most readily under conditions of light load operation. The result is that after a period of light load operation, when the throttle is closed to the idle position, ice already formed on the throttle plate and adjacent walls, plus ice which then forms, restricts the narrow air openings to cause engine stalling.

To more clearly define the problem of engine stalling due to carburetor icing, data were tabulated based on customer reaction surveys, carefully controlled road tests, and laboratory cold room engine performance tests. These tests show that carburetor icing depends primarily upon atmospheric temperature and humidity conditions. The tests show that stalling difficulties due to ice formation in the carburetor are not encountered below about 30° F., nor above

about 60° F. when employing fuels having conventional volatility characteristics. Similarly, these tests demonstrate that stalling is only encountered when the humidity is in excess of about 65%.

Another factor having a bearing on the formation of ice in the carburetor, is the volatility of the fuel employed. To determine this effect laboratory cold room tests were conducted to evaluate the stalling characteristics during warm-up of a number of fuels varying in volatility. In these tests a 1947 Chrysler car was installed in a room equipped with temperature and humidity controls. While the temperature and humidity were maintained at particular levels, the stalling characteristics of the car were determined during the warm-up period. The procedure employed was to start the car and to then immediately raise the engine speed to 1500 R. P. M. This speed was maintained for 30 seconds, after which the engine was allowed to idle for 15 seconds. If the engine stalled before 15 seconds had expired, the car was again started and raised to a speed of 1500 R. P. M. for 30 seconds, while if stalling did not occur, the speed was immediately increased to 1500 R. P. M. after the 15 second idling time. The alternate cycles of 30 seconds at 1500 R. P. M. followed by 15 seconds at idling were repeated until the engine was completely warmed up. The number of stalls encountered during this procedure, and up to the time of complete engine warm-up were then recorded. Tests were conducted at 40° F. and at a relative humidity of 100% employing three fuels of varying volatilities. The most volatile fuel was a premium grade of commercial gasoline having a 10% ASTM distillation point of 110° F., a 50% point of 190° F., and a 90% point of 294° F. It was found that this fuel resulted in about 14 or 15 stalls during warm-up. A medium volatility fuel was also tested, consisting of a regular grade commercial gasoline having ASTM distillation characteristics such that 10% distilled at 121° F., 50% distilled at 220° F., and 90% distilled at 342° F. The number of stalls encountered with this fuel were 11. Finally a low volatility gasoline was subjected to the same test procedure. The gasoline had ASTM distillation 10, 50, and 90% points, at 126° F., 270° F. and 387° F. It was found that 5 stalls were encountered with this fuel.

As indicated by these data, carburetor icing is related to the volatility of the fuel employed. Thus, the least volatile fuel tested above, having a 50% distillation point of 270° F., only resulted in 5 stalls, while the highest volatility fuel, having a 50% distillation point of 190° F., resulted in 15 stalls. Extrapolating these data as to the volatility of the fuel, it appears that a fuel having a volatility such that the ASTM 50% distillation point is 310° F., or higher would not be subject to stalling difficulties during warm-up. It must be appreciated, however, that a fuel having ASTM distillation characteristics of this nature would not be desirable as regards warm-up time, cold engine acceleration, economy and crank case dilution. However, in appreciating the scope of the present invention, it is important to note that this invention is only of application to gasoline fuels having an ASTM 50% distillation point below about 310° F. At the same time, as will be brought out, it is possible to correlate the quantity of additives required to overcome icing problems with the volatility of the fuel to be improved. In other words, smaller proportions of

additives may be employed with fuels of relatively low volatility, while higher proportions of additives may be required with fuels of higher volatility.

It has now been discovered that distinctly improved operating conditions are secured with respect to stalling providing a relatively small critical amount of a furfuryl alcohol be employed. The furfuryl alcohol may be unsaturated and have the formula  $C_4H_3OCH_2OH$ . However, the preferred furfuryl alcohol comprises tetrahydrofurfuryl alcohol ( $C_4H_7OCH_2OH$ ).

The amount of furfuryl alcohol employed should be appreciably less than about 1% by volume based upon the volume of gasoline present. The preferred concentration is in the range from about .05% to .5%, especially in the range from about .1 to 3% by volume.

It is appreciated that it has heretofore been suggested that relatively large quantities of furfuryl alcohol be employed in motor gasolines in order to improve their antidetonant characteristics. In order to secure this result it has been necessary, as stated, to use relatively large quantities, as for example, in the range from about 1% to 10% and higher of the furfuryl alcohol. If quantities less than this be employed, no antidetonant effect is secured. Furthermore, in the prior art if furfuryl alcohol were employed, it was necessary that the base fuel have a relatively low octane number value, otherwise the furfuryl alcohol would actually have an adverse antidetonant effect. Thus, nowhere in the art has it been taught or disclosed to use furfuryl alcohol particularly tetrahydrofurfuryl alcohol in conjunction with fuels having clear octane numbers above about 80.

The present invention may be more fully appreciated by the following examples illustrating the same.

#### EXAMPLE I

Tetra-hydro-furfuryl alcohol was blended in various concentrations in two gasolines; a premium grade automotive gasoline and an aviation gasoline. The anti-knock quality of the blends was compared with the same quality of the original gasolines according to the test methods appropriate for each type of gasoline. The results secured are as follows:

| Samples Tested                                      | Antiknock Quality                            |                                          |
|-----------------------------------------------------|----------------------------------------------|------------------------------------------|
|                                                     | Motor Method Octane No. <sup>1</sup>         | Research Method Octane No. <sup>2</sup>  |
| 1. Premium Motor Gasoline.....                      | 80.5                                         | 91.4                                     |
| 2. No. 1 with 1.0 vol. percent t-h-f. alcohol.....  | 80.5                                         | 91.4                                     |
| 3. No. 1 with 10.0 vol. percent t-h-f. alcohol..... | 79.3                                         | 90.5                                     |
| Samples Tested                                      | Aviation Method Performance No. <sup>3</sup> | Rich Rating Performance No. <sup>4</sup> |
|                                                     |                                              |                                          |
| 4. Aviation Gasoline.....                           | 103.2                                        | 132.2                                    |
| 5. No. 4 with 1.0 vol. percent t-h-f. alcohol.....  | 101.2                                        | 125.7                                    |

<sup>1</sup> ASTM Motor Method D-357-47.

<sup>2</sup> ASTM Research Method D-908-47T.

<sup>3</sup> ASTM Aviation Method D-614-47T.

<sup>4</sup> ASTM Supercharge Method D-909-47T.

From the above it is evident that the tetrahydrofurfuryl alcohol did not improve the anti-

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knock quality and actually decreased the anti-knock quality of these high octane number gasolines.

## EXAMPLE II

Additional operations were conducted wherein a motor fuel having the following inspections:

## Engler distillation

|            |     |     |
|------------|-----|-----|
| Initial    | °F  | 100 |
| 15%        | °F  | 130 |
| 30%        | °F  | 158 |
| 60%        | °F  | 212 |
| 93%        | °F  | 302 |
| Reid V. P. | lbs | 12  |

was run in a gasoline engine as described. Various quantities of blending agents were used with the following results:

## AUTOMOTIVE CARBURETOR ICING TESTS

## Effect of addition agents on icing severity

[1947 Chrysler; 40° F. and 100% relative humidity gyro-matic transmission; Sisson automatic choke]

| Fuel                                     | Number of Engine Stalls |
|------------------------------------------|-------------------------|
| +1.0% (Vol.) Isopropyl Alcohol           | 3                       |
| +1.0% (Vol.) Tetrahydro furfuryl Alcohol | 0                       |
| +0.5% (Vol.) Tetrahydro furfuryl Alcohol | 0                       |
| +0.1% (Vol.) Tetrahydro furfuryl Alcohol | 4                       |
| +1.0% (Vol.) N-Octyl Alcohol             | 16                      |
| +1.0% (Vol.) Methanol                    | 8                       |
| +0.1% (Wt.) Sorbitan Mono-Oleate         | 5                       |
| +0.1% (Wt.) Butyl Cellosolve             | 12                      |
| No additive                              | 14, 15                  |

From the above it is apparent that tetrahydro furfuryl alcohol is particularly effective, especially when employed in a concentration from .2 to .5% by volume.

## EXAMPLE III

Additional operations were conducted using an aviation fuel of the following inspections:

## Engler distillation

|            |     |     |
|------------|-----|-----|
| Initial    | °F  | 100 |
| 50%        | °F  | 200 |
| Final      | °F  | 325 |
| Reid V. P. | lbs | 7   |

The initial engine speed (Fixed Throttle) was 1750 R. P. M. The loss in speed after 3 minutes was determined when using various blends. The results secured are as follows:

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## CARBURETOR ICING IN CONTINENTAL ENGINE ANTI-ICING ADDITIVE EFFECTIVENESS

Initial engine speed (fixed throttle), 1750 R. P. M.; intake air, 50° F., 97 ±3% relative humidity; air surrounding carburetor, 50° F.

[Amount of carburetor ice accumulated is reflected in magnitude of speed loss]

| Additive                   | Concentration in Fuel, Vol. Per Cent | Loss in Speed Due to Icing After 3 Minutes Δ R. P. M. |
|----------------------------|--------------------------------------|-------------------------------------------------------|
| None                       |                                      | 425                                                   |
| Isopropyl Alcohol          | 2.5                                  | 15                                                    |
| Tetrahydrofurfuryl Alcohol | 0.25                                 | 0                                                     |
| 2,5 Hexanediene            | 0.25                                 | 10                                                    |
| Butyl Carbitol             | 0.25                                 | 60                                                    |
| Butyl Cellosolve           | 0.50                                 | 110                                                   |
| Dioxane                    | 0.50                                 | 140                                                   |
| Cocoonut Amine             | 0.10                                 | 95                                                    |

From the above it is apparent that tetrahydro furfuryl alcohol is particularly effective.

Having described the invention, it is claimed:

1. A fuel composition comprising a mixture of hydrocarbons boiling in the gasoline boiling range containing from about .05 to 1% by volume of a tetrahydro furfuryl alcohol.

2. Composition as defined by claim 1 wherein the concentration of the tetrahydro furfuryl alcohol is in the range from .2 to .5%.

3. Composition as defined by claim 2 wherein said composition comprises an aviation motor fuel.

4. Fuel composition comprising a motor fuel having an octane number above about 80 to which has been added from about .05 to 1% of a furfuryl alcohol.

5. Fuel composition comprising a motor fuel having an octane number above about 80 to which has been added from about .05 to 1% of a tetrahydro furfuryl alcohol.

6. Composition as defined by claim 5 wherein the concentration of the tetrahydro furfuryl alcohol is in the range from .2 to .5% by volume.

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## REFERENCES CITED

The following references are of record in the file of this patent:

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