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(54) **AUTOMOTIVE GASOLINE FUEL FOR INTERNAL COMBUSTION ENGINES**  
BENZINKRAFTSTOFF FÜR INTERNE VERBRENNUNGSMOTOTREN  
CARBURANT ESSENCE AUTOMOBILE POUR MOTEURS A COMBUSTION INTERNE

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(72) Inventor: **TALBERT, William, L.**  
**York, PA 17402 (US)**

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(74) Representative: **Thomson, Craig Richard**  
**Murgitroyd & Company**  
**Scotland House**  
**165-169 Scotland Street**  
**Glasgow G5 8PL (GB)**

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(73) Proprietor: **TALBERT FUEL SYSTEMS, INC.**  
**Allentown, PA 18103 (US)**

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**Description**Field of the Invention:

5 **[0001]** The present invention pertains to gasoline compositions and the use thereof in spark ignited, internal combustion engines as in automobile type engines.

Background Information:

10 **[0002]** Pollutants produced by combustion include oxides of nitrogen which are more commonly referred to as NO<sub>x</sub> (where x is an integer which represents the number of oxygen atoms in the molecule). Such oxides include NO and NO<sub>2</sub>. In the combustion process NO<sub>x</sub> is formed by air (a gas containing nitrogen and oxygen) being subjected to high temperatures for a period of time. Recent studies have been made on lower 90% distillation temperature gasoline which show that faster burning gasoline (lower 90% distillation temperature) comes up to high temperature more rapidly  
 15 increasing the time the nitrogen and oxygen in the air are exposed to high temperature thereby causing an increase in NO<sub>x</sub> (see the figure which shows data developed by the Air Quality Information Research Program).

U.S. Patent No. 3,758,628 discloses a process for manufacturing high octane gasoline from low octane raffinate comprising hydrocracking a first portion of the raffinate, fluid catalytically cracking a second portion of the raffinate, recovering a hydrocracked light naphtha fraction as a gasoline blend stock and charging a hydrocracked C<sub>4</sub> fraction to an alkylation  
 20 zone.

Gasolines now used as fuel in current spark ignited internal combustion engines require octane numbers (R+M)/2 falling almost entirely within the range of 84-94. Some engines require a higher octane gasoline than others depending on their compression ratio or carbon deposit buildup (age) in order to avoid or reduce engine "knock" or to improve fuel combustion efficiency.

25 **[0003]** Lower octane gasolines have been used in the past in low compression engines but were abandoned in common practice because of poor efficiency and power output. It was later discovered that increasing the engine compression and advancing the spark timing substantially improved the fuel combustion efficiency. Achieving this result, however, required that the gasoline have a much higher octane number. In fact, the state of California now requires by law that automotive type gasoline made, imported, sold or used in California must have a minimum octane number (R+M)/2 of  
 30 87. It would be highly desirable if lower octane gasolines could be efficiently used in currently available engines especially if their use resulted in reduction of NO<sub>x</sub> pollution.

**[0004]** As described below, the present invention relates in part to a low octane fuel having an octane number (R+M)/2 of less than 82 and an ASTM D-86 90% distillation temperature less than 154.4°C (310°F (referred to herein as E-gasoline II). The aforementioned E-gasoline II is advantageous because it is a fuel with a low octane rating which can  
 35 nonetheless be used in conventional internal combustion automobile engines by merely retarding the spark advance of the engine. Thus current engines are able to provide improved combustion efficiency with gasoline having octane numbers (R+M)/2 of less than 82 providing the spark advance is retarded and the gasoline has a low distillation temperature ASTM D-86 90% distillation temperature less than 154.4°C (310°F).

40 **[0005]** Using prior art gasoline in engines that have a retarded spark advance causes an increase in pollutants of combustion so that prior art gasoline and the E-gasoline II cannot be used interchangeably in an engine having less spark advance. Accordingly, it would be highly desirable to additionally provide a gasoline which can be efficiently used in current engines without retarding the spark advance as well as in engines in which the spark advance has been retarded to accommodate the E-gasoline II.

45 Summary of the Invention

**[0006]** An objective of this invention is to provide a novel gasoline for use in a spark ignited internal combustion engine that will permit or allow reduction of NO<sub>x</sub> emissions.

50 **[0007]** It is an objective of this invention to provide a low octane automotive gasoline which can nonetheless be used to efficiently operate conventional automotive engines without producing undesirable levels of pollution. More particularly, it is a first objective of this invention to provide a method for achieving NO<sub>x</sub> reduction by engine modification so that the fuel of this invention can be efficiently used. In this regard it has been discovered that the fuels of this invention which have an octane number (R+M)/2 less than 82 and a 90% distillation temperature of 154.4°C (310°F) or less can none-  
 55 theless be used in conventional internal combustion automobile engines by merely reducing the spark advance of the engine. Such gasoline (referred to herein as E-gasoline II) cannot be used in conventional engines in which the spark advance has not been retarded.

**[0008]** It is a further objective of this invention to provide a fuel that is clean burning and which produces low levels of pollutants in the exhaust stream of an internal combustion engine.

[0009] It is a further objective of this invention to provide a gasoline having good driveability and cold start properties.

[0010] It is a still further object of this invention to provide a gasoline that will perform well at air to fuel ratios above stoichiometric in an internal combustion engine.

5 [0011] It is yet another object of this invention to provide a liquid fuel that can be formed into a vapor or gaseous state and yet will tend to remain in this state when mixed with induction air in an internal combustion engine.

[0012] These and other objects are obtained with a gasoline that has a low 90% distillation temperature and a low octane number  $(R+M)/2$ . The low 90% distillation temperature is used so that the gasoline can burn quickly and more thoroughly when mixed with air and ignited in an engine. The low octane number  $(R+M)/2$  is utilized so that the combustion rate with air is rapid. The octane number  $(R+M)/2$  may be lowered by known techniques such as by reducing the amount of high octane components used in the production of the gasoline or by reducing the octane booster additives which are conventionally added to gasoline. The desired distillation temperature can be achieved by conventional gasoline production or refining techniques such as by distilling the heavy ends off of gasoline blending streams in a refinery. More particularly, the first and other objectives (i.e., the objectives associated with the E-gasoline II) are achieved by providing a gasoline having an octane number  $(R+M)/2$  less than 82 and an ASTM D-86 90% distillation temperature of 154.4°C (310°F) or less.

#### Brief Description of the Drawing

20 [0013] The figure is a graph which shows the effects on auto exhaust emissions when the ASTM D-86 90% distillation temperature is reduced from 182.2°C to 137.8°C (360°F to 280°F).

#### Detailed Description of the Invention and Preferred Embodiment

##### 1) E-Gasoline II

25 [0014] Lower endpoint gasoline reduces "cylinder wall wetting", thus permitting less "knocking" in an engine at octane levels less than the minimum established by the state and federal regulators for modern, Phase 2 gasoline - 87 octane minimum. All of the octane numbers indicated herein are determined from the formula  $(R+M)/2$  where R is defined by ASTM D-2699 and M is defined by ASTM D-2700. Through testing and using standard federal test procedures, it has been discovered that such lower endpoint gasoline can be used to operate a standard automobile engine without knocking even though the gasoline has an octane number  $(R+M)/2$  less than 82 (e.g., as low as 81.8). An example of such a fuel with a 90% distillation temperature of less than 154.4°C (310°F) is the "special" gasoline of Example 1. Example 1 shows a comparison between conventional gasoline and a gasoline of the present invention (designated herein as "SPECIAL") having an ASTM D-86 90% distillation temperature of less than 154.4°C (310°F).

35 [0015] Previously low octane gasolines were used for low compression engines. However, it was discovered that by lowering the 90% distillation temperature (as determined by ASTM-86 distillation tests) to 154.4°C (310°F) or less, (preferably within a range of 122.2°C-138.9°C (252°-282°F) the octane number of currently available gasoline could also be lowered and used in today's engines which now require gasolines having an octane number  $(R+M)/2$  of 84 or higher. The fuels of this invention have octane numbers  $(R+M)/2$  of less than 82, most preferably less than 80.

40 [0016] In engine dynamometer testing (example 2) it was further discovered that lower 90% distillation temperature gasoline could operate a standard automobile engine at less spark advance than would be required for the same engine burning conventional 87 octane gasoline. Furthermore, it was also discovered that burning low 90% distillation temperature gasoline in the engine with less spark advance achieved reduced emissions, particularly reduced emissions of NO<sub>x</sub>. This is very important in that lower 90% distillation temperature gasolines normally increase NO<sub>x</sub> emissions (see the figure) but by reducing spark advance these same fuels can operate at reduced levels of NO<sub>x</sub> emissions (see example 2). Lowering spark advance also permits a further reduction in octane number  $(R+M)/2$  to less than 81.8, preferably to 80 or less.

[0017] The gasoline of this invention uses standard gasoline components which may include additives and/or oxygenates. Thus, apart from the lower 90% distillation temperature and lower octane, the gasoline of the present invention is otherwise the same as conventional gasoline which is currently available.

[0018] In a preferred embodiment the ASTM D-86 90% distillation temperature falls within the range of 129.4°C to 140°C (265°F to 285°F). In addition, the octane number  $(R+M)/2$  of the gasoline is preferably in the range of 72-82. Such a gasoline can lower the pollutants in the exhaust of a conventional internal combustion engine by retarding the spark advance of the vehicle preferably within a 4° to 12° range.

55 [0019] The present invention is unique in that the novel low octane gasoline described herein is workable in currently available engines and also provides improved combustion efficiency and lower levels of combustion pollutants compared to the use of currently available gasolines in these engines. Also the gasolines of this invention are easy to vaporize or gasify and once in the vapor or gaseous state they have improved stability so that they essentially remain in this state

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when combined with induction air. This characteristic improves the gas-to-air ratio and the ignition properties of higher air-to-fuel ratio combustion charges. The low octane of the gasoline also contributes to higher air-to-fuel ratio combustion since excess air is an excellent octane booster. If octane numbers (R+M)/2 get too high, the fuel will not have time to burn completely in the engine. It is well know that fuel combustion efficiency and lower tailpipe pollutants are achieved with air-to-fuel ratios higher than stoichiometric.

**[0020]** In a preferred embodiment the gasoline has a distillation (ASTM D-86) endpoint temperature les than 173.9°C (345°F) and an octane number (R+M)/2 less than 80. The fuel may additionally contain additives, oxygenates, fuel extenders or other compositions which enhance the properties or combustion characteristics of gasoline. Such additives may be used singularly or in any combination thereof.

**[0021]** In operation the fuels of this invention may be used in an internal combustion engine in the form of a liquid, vapor or gaseous state, or in any combination thereof. The use of the fuel of this invention results in a reduction of harmful emissions of combustion from internal combustion engines.

**[0022]** The gasoline of this invention also allows one to achieve reliable ignition of combustion mixtures containing higher air-to-fuel ratios than are currently used in spark ignited internal combustion engines.

**EXAMPLE 1**

**[0023]** Dynamic testing done at Compliance and Research Services, Inc., Linden, NJ, on an Oldsmobile Cutlass in November, 1989 shows that a fuel designed for improved injector volatilization (i.e., the fuel of this invention having a 90% distillation temp less than 154.4°C (310°F) designated herein as SPECIAL) can perform well without engine knock at low octane. Both HC (hydrocarbon) and CO emissions increase substantially when "knocking" occurs in an engine. In this test the fuel of the invention performed well without elevated emissions of HC and CO, thus establishing that the engine performed well without knocking even though the fuel utilized had an octane rating of only 81.8.

	GASOLINE*	SPECIAL**
Emissions City	HC (avg) - .146 CO (avg) - 1.449	HC (avg) - .136 CO(avg)- 1.431
Emissions Highway	HC (avg) - .076 CO (avg) - .785	HC (avg) - .070 CO (avg) - .593
*Octane R+M/2 = 92.0		
**Octane R+M/2 = 81.8		
Emissions data in grams per mile.		

**EXAMPLE 2**

**[0024]** At Pittsburgh Applied Research Center (PARC) tests were done using a Pontiac 4-cylinder engine (2.5 L) with a Go Power Dynamometer and a TEC Electromotive Control System. The following data were taken from spread sheets operating the engine at about 2,000 rpm with all conditions being about the same except for hydrocarbons, NO<sub>x</sub> and fuel used as per the following chart:

DATE	HC	NO <sub>x</sub>	SPARK ADVANCE (measured in degrees)	GASOLINE
06/14/90	784	1,076	49	Chevron
06/14/90	788	1,232	49	Chevron
06/13/90	800	960	49	Special*
06/13/90	804	968	49	Special*
06/13/90	752	556	43	Special*
06/13/90	744	596	44	Special*
06/13/90	712	368	38	Special*

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(continued)

DATE	HC	NO <sub>x</sub>	SPARK ADVANCE (measured in degrees)	GASOLINE
06/13/90	712	328	38	Special*

\*less than 154.4°C (310 degrees F), 90% distillation temperature.  
Note the change in NO<sub>x</sub> with the variation in spark advance.

[0025] While the present invention has been described in terms of certain preferred embodiments and exemplified with respect thereto, it is intended, that the present invention be limited solely by the scope of the following claims:

### Claims

1. An automotive gasoline composition for use as the fuel in a spark ignited internal combustion engine, said fuel comprising a hydrocarbon mixture of gasoline components with the proviso that said gasoline has an ASTM D-86 90% distillation temperature of 154.4°C (310°F) or less and an octane number (R+M)/2 which is less than 82.
2. The gasoline of claim 1 having an octane number (R+M)/2 which is 80 or less.
3. The gasoline of claim 1 wherein the 90% distillation temperature is in the range of 129.4°C-140.6°C (265°F-285°F) and the octane number (R+M)/2 falls within a 72 to less than 82 range.
4. The gasoline fuel composition of claim 1 wherein said hydrocarbon mixture has an ASTM D-86 endpoint temperature less than 173.9°C (345°F) and an octane number (R+M)/2 less than 80 and where said composition may include additives and fuel extenders common to gasoline.
5. The gasoline of claim 1 wherein the 90% distillation temperature is less than 143.3°C (290°F).
6. A method of operating a spark ignited internal combustion engine having at least one combustion chamber therein and a spark advance setting; said method comprising introducing, as the fuel, the gasoline of any of claims 1-3, and air into said at least one combustion chamber and igniting said mixture with a spark; with the proviso that said spark advance setting of said engine is set at a level whereby knocking is avoided while said engine is running.
7. The method of claim 6 wherein the spark ignited internal combustion engine is operated to reduce NO<sub>x</sub> emissions.
8. The method of claim 6 wherein the spark ignited internal combustion engine is operated to reduce tailpipe emissions of pollutants in automobiles powered by said internal combustion engines, wherein the gasoline used as the fuel has a 90% distillation temperature of less than 143.3°C (290°F).
9. The method of claim 8 wherein said gasoline includes additives, oxygenates or any gasoline volume extender.
10. The method of claim 6 wherein the spark ignited internal combustion engine is operated to reduce combustion pollutants by operating said engine above stoichiometric air-to-fuel ratios with a gasoline having a 90% distillation temperature of less than 143.3°C (290°F).

### Patentansprüche

1. Eine Kraftfahrzeugbenzinzusammensetzung zur Verwendung als Kraftstoff in einem Otto-Verbrennungsmotor, wobei der Kraftstoff eine Kohlenwasserstoffmischung aus Benzinkomponenten beinhaltet, mit der Maßgabe, dass das Benzin eine 90%ige Destillationstemperatur nach ASTM D-86 von 154,4 °C (310 °F) oder weniger und eine Oktanzahl (R + M)/2, die weniger als 82 beträgt, aufweist.
2. Benzin gemäß Anspruch 1, das eine Oktanzahl (R + M)/2 aufweist, die 80 oder weniger beträgt.
3. Benzin gemäß Anspruch 1, wobei die 90%ige Destillationstemperatur im Bereich von 129,4 °C- 140,6 °C (265 °F - 285 °F) liegt und die Oktanzahl (R + M)/2 in einen Bereich von 72 bis weniger als 82 fällt.

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4. Benzinkraftstoffzusammensetzung gemäß Anspruch 1, wobei die Kohlenwasserstoffmischung eine Endpunktemperatur nach ASTM D-86 von weniger als 173,9 °C (345 °F) und eine Oktanzahl (R + M)/2, die weniger als 80 beträgt, aufweist und wobei die Zusammensetzung Zusatzstoffe und Kraftstoffstreckmittel, die bei Benzin üblich sind, umfassen kann.
5. Benzin gemäß Anspruch 1, wobei die 90%ige Destillationstemperatur weniger als 143,3 °C (290 °F) beträgt.
6. Ein Verfahren für den Betrieb eines Otto-Verbrennungsmotors mit mindestens einem Verbrennungsraum darin und einer Frühzündungseinstellung; wobei das Verfahren das Zuführen als Kraftstoff von Benzin gemäß einem der Ansprüche 1-3 und Luft in den mindestens einen Verbrennungsraum und das Entzünden der Mischung mit einem Funken beinhaltet; mit der Maßgabe, dass die Frühzündungseinstellung des Motors bei einem Niveau eingestellt ist, bei dem das Klopfen verhindert wird, während der Motor läuft.
7. Verfahren gemäß Anspruch 6, wobei der Otto-Verbrennungsmotor betrieben wird, um NO<sub>x</sub>-Emissionen zu reduzieren.
8. Verfahren gemäß Anspruch 6, wobei der Otto-Verbrennungsmotor betrieben wird, um die Auspuffemissionen von Schadstoffen bei mit den Verbrennungsmotoren angetriebenen Kraftfahrzeugen zu reduzieren, wobei das als Kraftstoff verwendete Benzin eine 90%ige Destillationstemperatur von weniger als 143,3 °C (290 °F) aufweist.
9. Verfahren gemäß Anspruch 8, wobei das Benzin Zusatzstoffe, Oxygenate oder ein beliebiges Benzinvolumenstreckmittel umfasst.
10. Verfahren gemäß Anspruch 6, wobei der Otto-Verbrennungsmotor betrieben wird, um die Verbrennungsschadstoffe zu reduzieren, indem der Motor über stöchiometrischen Luft-Kraftstoff-Verhältnissen mit einem Benzin, das eine 90%ige Destillationstemperatur von weniger als 143,3 °C (290 °F) aufweist, betrieben wird.

### Revendications

1. Une composition d'essence automobile destinée à être utilisée comme carburant dans un moteur à combustion interne à bougie, ledit carburant comprenant un mélange d'hydrocarbures de composants d'essence à condition que ladite essence ait une température de distillation à 90 % ASTM D-86 de 154,4 °C (310 °F) ou moins et un indice d'octane (R+M)/2 qui soit inférieur à 82.
2. L'essence de la revendication 1 ayant un indice d'octane (R+M)/2 qui est de 80 ou moins.
3. L'essence de la revendication 1 dans laquelle la température de distillation à 90 % se trouve dans la gamme allant de 129,4 °C à 140,6 °C (265 °F à 285 °F) et l'indice d'octane (R+M)/2 tombe dans la gamme allant de 72 à moins de 82.
4. La composition de carburant d'essence de la revendication 1 dans laquelle ledit mélange d'hydrocarbures a une température de point final ASTM D-86 inférieure à 173,9 °C (345 °F) et un indice d'octane (R+M)/2 inférieur à 80 et où ladite composition peut inclure des additifs et des charges de carburant communs à l'essence.
5. L'essence de la revendication 1 dans laquelle la température de distillation à 90 % est inférieure à 143,3 °C (290 °F).
6. Une méthode pour faire fonctionner un moteur à combustion interne à bougie ayant au moins une chambre de combustion dans celui-ci et un réglage d'avance à l'allumage ; ladite méthode comprenant l'introduction, comme carburant, de l'essence de n'importe lesquelles des revendications 1 à 3, et d'air dans ladite au moins une chambre de combustion et l'allumage dudit mélange avec une étincelle ; à condition que ledit réglage d'avance à l'allumage dudit moteur soit réglé à un niveau grâce auquel un cognement est évité lorsque ledit moteur est en fonctionnement.
7. La méthode de la revendication 6 dans laquelle le moteur à combustion interne à bougie est amené à fonctionner pour réduire les émissions de NO<sub>x</sub>.
8. La méthode de la revendication 6 dans laquelle le moteur à combustion interne à bougie est actionné pour réduire les émissions de polluants de tuyau d'échappement arrière dans les automobiles entraînées par lesdits moteurs à combustion interne, dans laquelle l'essence utilisée comme carburant à une température de distillation à 90 %

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inférieure à 143,3 °C (290 °F).

9. La méthode de la revendication 8 dans laquelle ladite essence inclut des additifs, des composés oxygénés ou toute charge de volume d'essence.

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10. La méthode de la revendication 6 dans laquelle le moteur à combustion interne à bougie est actionné pour réduire les polluants de combustion en actionnant ledit moteur au-delà des rapports stoechiométriques air / carburant avec une essence ayant une température de distillation à 90 % inférieure à 143,3 °C (290 °F).

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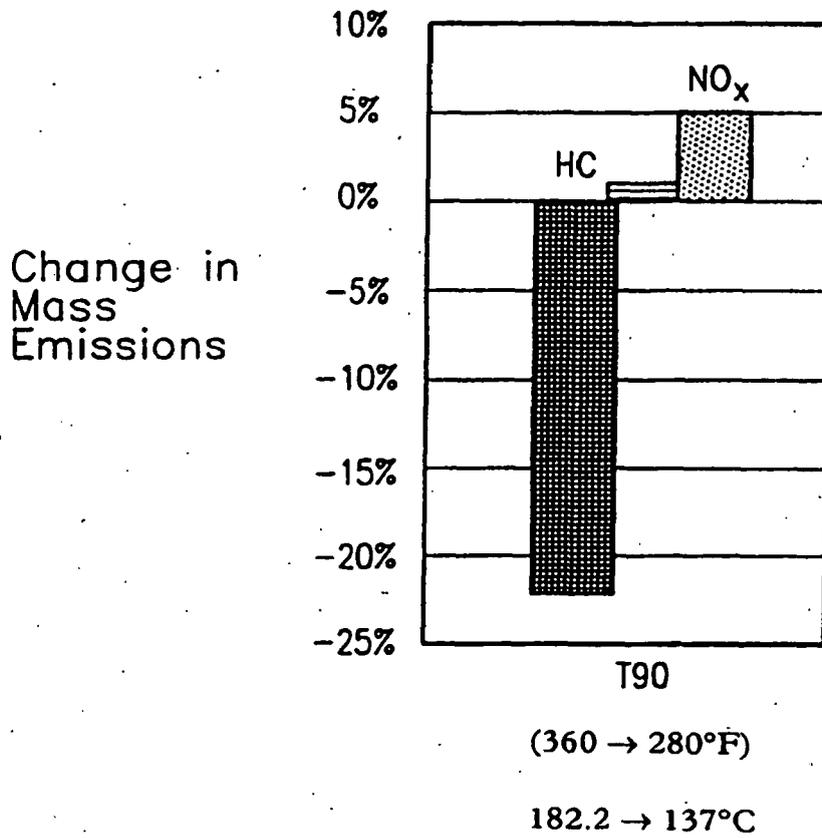
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# Fuel Effects on Auto Exhaust Emissions

Current Vehicles - 1989



**REFERENCES CITED IN THE DESCRIPTION**

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**Patent documents cited in the description**

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