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PATENT REQUEST: STANDARD PATENT

I/We, the Applicant(s)/Nominated Person(s) specified below, request I/We be granted a patent for the invention disclosed in the accompanying standard complete specification.

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[54] Invention Title:

Exhaust Gas Purification System For Reducing Hydrocarbon Emissions During The Cold Start of Combustion Engines

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NOTICE OF ENTITLEMENT

I, John Gordon Hinde, of Spruson & Ferguson, St Martins Tower, 31 Market Street, Sydney, New South Wales 2000, Australia, being the patent attorney for the Applicant(s)/Nominated Person(s) in respect of Application No 51988/93 state the following:-

The Applicant(s)/Nominated Person(s) has/have entitlement from the actual inventor(s) as follows:-

> The Applicant(s)/Nominated Person(s), by virtue of a Contract of Employment between the actual inventor(s) as employee(s) and the Applicant(s)/Nominated Person(s) as employer(s), is a person entitled to have the patent assigned to it if a patent were granted on an application made by the actual inventor(s).

The Applicant(s)/Nominated Person(s) is/are the applicant(s) of the basic application(s) listed on the Patent Request. The basic application(s) listed on the Patent Request is/are the first application(s) made in a Convention Country in respect of the invention.

DATED this 11th day of January 19 94

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EXHAUST GAS PURIFICATION SYSTEM FOR REDUCING HYDROCARBON EMISSIONS DURING THE COLD START OF COMBUSTION ENGINES

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(56) Prior Art Documents
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(57) Claim

1. An exhaust gas purification system for reducing hydrocarbon emissions during the cold start of combustion engines, comprising:

a hydrocarbon adsorber; and

a downstream catalyst system comprising a three-way catalyst or a combination of oxidation, reduction and/or three-way catalysts in one or more beds, wherein:

said downstream catalyst system contains an oxidation catalyst with platinum and/or palladium and a three-way catalyst with platinum and/or palladium and/or rhodium, wherein the loading of said oxidation catalyst with platinum and/or palladium is at least 3.5 g of platinum and/or palladium per litre of catalyst volume;

said oxidation catalyst is placed immediately after said adsorber; and wherein

the difference between the light-off temperature of the oxidation catalyst for conversion of hydrocarbons and the desorption temperature of the adsorber is less than 50°C.

3. An exhaust gas purification system for reducing hydrocarbon emissions during the cold start of combustion engines, comprising:

a hydrocarbon adsorber; and

a downstream catalyst system comprising:

a three-way catalyst in one or more beds, wherein said three-way catalyst

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comprises the platinum group metals platinum and/or palladium and/or rhodium in an amount of at least 3.5 g of platinum and/or palladium per litre of catalyst volume;

the difference between the light-off temperature of the oxidation catalyst for conversion of hydrocarbons and the desorption temperature of the adsorber is less than 50°C.

5. An exhaust gas purification system for reducing hydrocarbon emissions during the cold start of combustion engines, comprising:

a hydrocarbon adsorber in immediate contact with an oxidation catalyst and a downstream three-way catalyst in one or more beds, wherein:

said oxidation catalyst and adsorber are present in the form of superimposed coatings on a monolithic honeycomb body, the adsorber coating lying on the catalyst coating and the oxidation catalyst contains platinum and/or palladium in an amount of at least 3.5 g platinum and/or palladium per litre of catalyst volume; and wherein

the difference between the light-off temperature of the oxidation catalyst for conversion of hydrocarbons and the desorption temperature of the adsorber is less than 50°C.

Exhaust gas purification system for reducing hydrocarbon emissions during the cold start of combustion engines

Description

The invention relates to an exhaust gas purification system for reducing hydrocarbon emissions during the cold start of combustion engines. The exhaust gas purification system contains a hydrocarbon adsorber and a downstream catalyst system, which may comprise one individual three-way catalyst or a combination of oxidation, reduction, and/or three-way catalysts in one or more beds.

The future limits for pollutant emissions from motor vehicles are laid down in the regulations TLEV/1994 and LEV/1997 (LEV = Low Emission Vehicle). They represent a substantial tightening of the limits, particularly for hydrocarbons. As present-day exhaust gas catalysts have reached a high level of pollutant conversion in the hot operating state, it is possible to comply with the future limits only by an improvement in pollutant conversion during the cold start phase. This is because a large proportion of the hydrocarbons released as a whole is emitted during the cold start phase of the test cycles laid down by law (e.g., US FTP 75). In said phase, the catalysts have not yet reached the operating temperature of 300 to 400 °C required for conversion.

The hydrocarbons emitted during the cold start phase are chiefly C_1 to C_{10} compounds such as paraffins, isoparaffins, olefins and aromatics.

In order to reduce the pollutant emissions during the cold start phase, an exhaust gas purification system comprising a hydrocarbon adsorber and a downstream catalyst is proposed, for example, in US patent 5,078,979. The hydrocarbon adsorber has the task of adsorbing the hydrocarbons contained in the exhaust gas during the cold start phase at temperatures that are still relatively low. Only when the adsorber becomes hotter are the hydrocarbons desorbed again and arrive with the now hotter exhaust gas at the catalyst which is now almost at operating temperature and are converted here to harmless water and carbon dioxide. An important requirement in respect of the adsorber is the ability to adsorb hydrocarbons preferentially before the water vapour which is also present in abundance in the exhaust gas.

A disadvantage of said described solution is the desorption of hydrocarbons commencing even at relatively low temperatures, with the result that optimum conversion on the downstream catalyst cannot yet take place. Usually, there is a temperature gulf of more than 100 °C between the light-off temperature T_A of the catalyst of 300 to 400 °C and the desorption temperature T_D of the adsorber immediately upstream of about 150 to 200 °C, i.e., $T_A - T_D > 100$ °C. Moreover, there is the risk of thermal destruction of the adsorber since it has to be incorporated near the engine in the exhaust gas purification system and is therefore exposed to temperature loads of up to 1000 °C during continuous operation.

In order to overcome said disadvantages, there is a large number of proposals in the patent literature, for example, in German specification DE 40 08 789, in European patent application EP 0 460 542, and in US patent 5,051,244. Said documents likewise start out from the combination of a hydrocarbon adsorber and a catalyst, but propose complex circuits for the exhaust gas in order to overcome the disadvantages described.

For example, USP 5,051,244 proposes to provide a molecular sieve adsorber upstream of the actual catalyst, which in the cold state adsorbs the pollutants in the exhaust gas, particularly hydrocarbons, and releases them again as the exhaust gas purification system becomes hotter. In order to protect the adsorber from destruction by overheating when the engine is in continuous operation, provision is made for a short circuit line which can be connected from the engine directly to the catalyst.

During the first 200 to 300 seconds after the start, the exhaust gas is passed completely over the adsorber and the catalyst. In said operating phase, the hydrocarbons are adsorbed by the adsorber. Adsorber and catalyst are heated to an increasing extent by the hot exhaust gas. The adsorber is short-circuited if desorption begins to exceed adsorption as a result of the temperature increase. The exhaust gas now flows directly over the catalyst. When the operating temperature is reached, part of the hot exhaust gas is passed over the adsorber until complete desorption of the pollutants, which may now be converted by the catalyst with a good level of efficiency. After desorption has taken place, the adsorber is short-circuited again in order to protect it from destruction by thermal overload.

Adsorbers proposed by USP 5,051,244 and USP 5,078,979 are natural or synthetic zeolites with an Si/Al atomic ratio of at least 2.4. Suitable zeolites mentioned are silicalite, faujasite, clinoptilolite, mordenite, chabizite, ultrastable Y-zeolite, Y-zeolite and ZSM-5 and mixtures thereof. The zeolite adsorber may, moreover, contain finely divided, catalytically active metals such as platinum, palladium, rhodium, ruthenium, and mixtures thereof.

Said solutions known from the state of the art are either technically very complex, expensive and susceptible to breakdown or, as in the case of USP 5,078,979, lack a solution for bridging the temperature gulf between the desorption temperature of the adsorber and the light-off temperature of the downstream catalyst.

Object of the Invention

It is an object of the present invention to overcome or substantially ameliorate the above disadvantages.

Summary of the Invention

There is disclosed herein an exhaust gas purification system for reducing hydrocarbon emissions during the cold start of combustion engines, comprising:

a hydrocarbon adsorber; and

a downstream catalyst system comprising a three-way catalyst or a combination of oxidation, reduction and/or three-way catalysts in one or more beds, wherein:

said downstream catalyst system contains an oxidation catalyst with platinum and/or palladium and a three-way catalyst with platinum and/or palladium and/or rhodium, wherein the loading of said oxidation catalyst with platinum and/or palladium is at least 3.5 g of platinum and/or palladium per litre of catalyst volume;

said oxidation catalyst is placed immediately after said adsorber; and wherein

the difference between the light-off temperature of the oxidation catalyst for conversion of hydrocarbons and the desportion temperature of the adsorber is less than 50°C.

There is further disclosed herein an exhaust gas purification system for reducing hydrocarbon emissions during the cold start of combustion engines, comprising:

a hydrocarbon adsorber; and

a downstream catalyst system comprising:

a three-way catalyst in one or more beds, wherein said three-way catalyst comprises the platinum group metals platinum and/or palladium and/or rhodium in an amount of at least 3.5 g of platinum and/or palladium per litre of catalyst volume; and wherein

the difference between the light-off temperature of the oxidation catalyst for conversion of hydrocarbons and the desportion temperature of the adsorber is less than 50°C.

There is still further disclosed herein an exhaust gas purification system for reducing hydrocarbon emissions during the cold start of combustion engines, comprising:

a hydrocarbon adsorber in immediate contact with an oxidation catalyst and a downstream three-way catalyst in one or more beds, wherein:

said oxidation catalyst and adsorber are present in the form of superimposed coatings on a monolithic honeycomb body, the adsorber coating lying on the catalyst coating and the oxidation catalyst contains platinum and/or palladium in an amount of at least 3.5 g platinum and/or palladium per litre of catalyst volume; and wherein

the difference between the light-off temperature of the oxidation catalyst for conversion of hydrocarbons and the desportion temperature of the adsorber is less than 50°C..

The light-off temperature T_A of the catalyst is the exhaust gas temperature upstream of the catalyst, at which temperature the catalyst converts exactly 50% of the hydrocarbons.

The desorption temperature T_D of the adsorber is a parameter which may be determined from the engine only in dynamic operation. To this end, the crude hydrocarbon emission of the engine without the use of an adsorber is recorded as a function of time initially during the first 200 to 300 seconds after the cold start. Said crude emission typically shows a high and broad maximum during the first 60 to 100 seconds. As the engine becomes hotter, the hydrocarbon emission falls to the normal level when the engine is hot. In a second test run, the hydrocarbon emission after the connected adsorber and the temperature before the adsorber is then measured as a function of time.

As a result of the adsorber, the hydrocarbon emission is initially greatly suppressed by adsorption, but then increases as the exhaust gas becomes hotter as a result of increasing desorption by the adsorber and likewise passes through an emission maximum with a time delay compared with the crude emission, before it eventually falls to the value of the crude emission when the engine is hot. As a result of the time shift in the emission maxima of the crude emission and the emission with adsorber, the two emission curves intersect at a particular time within about 60 to 100 seconds after the cold start.

The exhaust gas temperature present before the adsorber at this point in time is known as the desorption temperature of the adsorber. It depends on the design of the exhaust gas system in each case and on the adsorber material itself, and is typically between 150 and 200°C.

Zeolites are used as preferred adsorber materials. As already disclosed in USP 5,051,244, however, only those zeolites that adsorb hydrocarbons preferentially before water, i.e., which are hydrophobic and, moreover, have a high temperature- and acid stability, are suitable for the adsorption of hydrocarbons from the exhaust gas of combustion engines.

The hydrocarbon adsorber preferably contain at least one hydrophobic, temperature- and acid-stable zeolite with an Si/Al ratio of more than 20. In a particularly favourable embodiment of the invention, two zeolites which have unequally steep temperature curves of their hydrocarbon adsorption capacities are combined with one another in the adsorber. At least two zeolites I and II should be combined, of which zeolite I has a greater adsorption capacity at temperatures below 100°C than zeolite II, and zeolite II has a greater adsorption capacity above 100°C than zeolite I. The zeolite I used is, for example, a dealuminised Y-zeolite with an Si/Al ratio of more than 40 and the zeolite II used is a zeolite ZSM5 with an Si/Al ratio of more than 20. Dealuminised Y-zeolite and zeolite ZSM5 should be present in the adsorber in a weight ratio to one another of 1:10 to 10:1.

Zeolite Y belongs to the wide-pore zeolites with a pore diameter of 0.74 nm, a pore volume of 0.3 ml/g and a specific surface area of more than 700 m^2/g. Zeolite ZSM5 is a medium-pore zeolite with a pore diameter of approx. 0.55 nm. As a result of its large pore aperture, the Y-zeolite has a high initial adsorption capacity for the aromatics contained in the exhaust gas. The adsorption capacity falls very rapidly, however, as the temperature rises. Zeolite ZSM5, on the other hand, has a lower initial adsorption capacity for aromatics, but exhibits a smaller fall in said capacity as the temperature rises. Moreover, said zeolite has a good adsorption capacity for other hydrocarbons still contained in the exhaust gas. The combination of the two zeolites according to the invention leads to an optimum adsorption behaviour in the temperature range concerned. The invention is not, however, confined to a mixture only of said two zeolites. Other zeolite mixtures may also be used if their components fulfil the requirements regarding temperature dependence of the adsorption capacity and pore diameters.

The high Si/Al ratio of the zeolites preferably used provides, on the one hand, high selectivity of the adsorption of hydrocarbons compared with water and, on the other hand, good temperature stability to 1000°C and above, and good acid stability. The temperature stability is necessary for the exhaust gas purification system according to the invention since the adsorber is placed near the engine and is thus exposed to high temperatures in operation.

The catalyst system downstream of the hydrocarbon adsorber may comprise a three-way catalyst or a combination of oxidation, reduction and/or three-way catalysts in one or more beds.

Such catalysts and the preparation thereof are known to the expert. They usually comprise a support in the form of an open-cell honeycomb body made of ceramic or metal. In order to accept catalytically active noble metals, said honeycomb bodies are provided with an activity-increasing, high surface area oxide dispersion coating made of, for example, γ-aluminium oxide in a quantity of 100 to 400 g, usually 160 g per litre of honeycomb body volume. The catalytically active noble metals may be deposited on said oxide coating by impregnation. In the case of oxidation catalysts, platinum and/or palladium are used in preference. Three-way catalysts contain platinum and/or palladium and/or rhodium as catalytically active noble metals.

In an exhaust gas purification system comprising an adsorber, oxidation catalyst and three-way catalyst, the loading of the oxidation catalyst with platinum and/or palladium compared with the loading of conventional oxidation catalysts of 0.01 to 1.8 g per litre of catalyst volume is at least doubled to at least 3.5 g of platinum and/or palladium per litre of catalyst volume. In preference, the loading should be 7 g per litre or more. Loadings with more than 10, or more than 20 g of noble metal per litre of catalyst volume are particularly effective. The oxidation catalyst is placed immediately after the adsorber. Said high loading with the catalytically active elements leads to a reduction in the light-off temperature by about 50 to 100°C compared with normally loaded catalysts.

If the catalyst system downstream of the adsorber is composed only of a three-way catalyst with the platinum group metals platinum and/or palladium and/or rhodium, the loading with platinum and/or palladium compared with the loading of conventional catalysts of 0.01 to 1.8 g per litre of catalyst volume can also be at least doubled with said catalyst to at least 3.5 g of platinum and/or palladium per litre of catalyst volume in order to reduce the light-off temperature for the conversion of hydrocarbons.

The adsorber may be used as bulk material in the form of pellets, extruded pieces or agglomerates. The use of the adsorber in the form of a dispersion coating on a monolithic honeycomb body in a quantity of 100 to 400 g per litre of honeycomb body is, however, preferred. The actual quantity of coating to be used depends on the hydrocarbon emissions of the combustion engine to be detoxified. The optimum quantity may be determined by any expert with few tests.

The dispersion coating is deposited on the honeycomb body, for example, by immersing the honeycomb body in an aqueous dispersion of the adsorber mixture followed by blowing out excess dispersion, drying and, if necessary, calcining to fix the coating. In order to apply the desired quantity of adsorber, said coating may be repeated many times, if necessary.

A further possibility consists in an exhaust gas purification system for reducing hydrocarbon emissions during the cold start of combustion engines, which contains a hydrocarbon adsorber in immediate contact with an oxidation catalyst, and a downstream three-way catalyst in one or more beds. This exhaust gas purification system is characterised in that the difference between the light-off temperature T_A of the oxidation catalyst for the conversion of the hydrocarbons and the desorption temperature T_D of the adsorber in immediate contact with the oxidation catalyst is less than 50°C, ie, $T_A - T_D < 50°C$.

The immediate contact of the adsorber with the oxidation catalyst may be realised in the form of superimposed coatings on a monolithic honeycomb body, the adsorber coating lying on the catalyst coating.

The statement already made above applies to the choice and design of adsorber mixture and catalyst. Apart from reduced hydrocarbon emission, said exhaust gas purification systems also exhibit a substantially reduced carbon monoxide emission during the cold start phase.

Description of the Drawings

The present invention will now be described, by way of example only, with reference to the accompanying drawings, wherein:

Figure 1:	Hydrocarbon emission of a combustion engine with exhaust gas purification system according to comparative example 3a during the cold start phase of the US FTP-75 test.
Figure 1a:	Diagrammatic representation of the structure of the exhaust gas purification system.
Figure 2:	Hydrocarbon emission of a combustion engine with exhaust gas purification system according to comparative example 3b during the cold start phase of the US FTP-75 test.
Figure 2a:	Diagrammatic representation of the structure of the exhaust gas purification system.
Figure 3:	Hydrocarbon emission of a combustion engine with exhaust gas purification system according

to example 3 during the cold start phase of the US FTP-75 test.

Figure 3a: Diagrammatic representation of the structure of the exhaust gas purification system.

Example 1 Adsorption properties of zeolite Y and ZSM5

The adsorption capacity of a DAY zeolite (dealuminised Y-zeolite) with an Si/Al ratio of >100, and of two zeolites ZSM5 with the Si/Al ratios of >500 and 58 was determined for toluene at 20 and 80 °C. The results are shown in Table 1.

Table 1 Adsorption capacity of a DAY zeolite and of ZSM5

T[°C]	Zeolite	Si/Al	^{M}Toluene [g/100 g]
20	DAY	>100	15.1
20	ZSM5	>500	6.2
20	ZSM5	58	7.1
80	DAY	>100	0.8
80	ZSM5	>500	1.4
80	ZSM5	58	2.2

The data in Table 1 are applicable to a toluene concentration of 1 g/m^3 air. ^{M}Toluene is the amount of adsorbed toluene which is in equilibrium with the surrounding atmosphere at the temperature given in each case, in grammes of toluene per 100 g of zeolite. Table 1 shows very clearly the different adsorption behaviour of the DAY zeolite and of zeolite ZSM5. Whilst the DAY zeolite exhibits an excellent adsorption capacity for toluene at low temperature, which falls very quickly, however, as the temperature rises, the corresponding curve for the ZSM5 zeolite is much flatter. Even at 80 °C, zeolite ZSM5 is superior to the DAY zeolite. A mixture of both zeolites gives a more uniform adsorption behaviour over a fairly large temperature range.

Example 2

The light-off temperatures T_A for the conversion of hydrocarbons by palladium-oxidation catalysts with differing palladium loading and of a standard platinum/rhodium three-way catalyst in the fresh and aged state at space velocities of 75,000 h^{-1} and 60,000 h^{-1} and with an air ratio lambda of 1.15 were measured.

The catalysts were composed of the relevant oxide dispersion coating of 160 g γ aluminium oxide per litre on ceramic honeycomb bodies made of cordierite and the catalytically active noble metals precipitated thereon. The honeycomb bodies had a cell density of 62 cells per cm^2. The light-off temperatures are listed in Table 2.

Table 2 Light-off temperatures of various catalysts; lambda = 1.15

Loading	T_A [°C]		Space velocity
[g Pd/l]	Fresh	Aged	[h^{-1}]
3.53	226	237	75,000
5.30	227	232	75,000
7.06	220	235	75,000
10.59	219	220	75,000
20	191	209	60,000
40	189	204	60,000
5 Pt/1 Rh standard three-way catalyst			
1.41 g/l	251	286	60,000

In order to measure the light-off temperatures of the aged catalysts, they were operated for a period of 100 hours on the engine at exhaust gas temperatures before the catalyst of 850 °C. In view of the heat of reaction, this leads to temperatures in the catalyst bed of 1000 °C.

The palladium-oxidation catalysts of Table 2 have a much lower light-off temperature for the conversion of hydrocarbons than the standard three-way catalyst. The high ageing stability of their light-off temperature, which can be attributed to the high palladium loading, is also worth noting. Table 2 also shows that the light-off temperature of the palladium-oxidation catalyst falls considerably with increasing palladium loading.

The light-off temperatures of said highly loaded palladium oxidation catalysts, with values of below 237 °C, lie just above the typical desorption temperatures of the adsorbers and exhibit light-off temperatures at about 200 °C with very high loadings. They are capable of converting directly the hydrocarbons desorbing from the adsorber at about 200 °C without the complex exhaust gas circuits known from the state of the art. The standard three-way catalyst is not able to do so because of its high light-off temperature, particularly in the aged state.

The hydrocarbon emissions of a motor vehicle with an Otto motor (Mercedes 300 E; capacity: 3 l, power: 162 kW) were measured below during the cold start phase for different exhaust gas purification systems in accordance with examples 3 and the comparative examples 3a and 3b. The results of the residual emission measurements according to the US FTP-75 test are summarised in table 3.

The exhaust gas purification systems comprised in each case 3 successive honeycomb bodies made of cordierite with 62 cells per cm^2. The honeycomb body on the engine side had a length of 154 mm and a volume of 1.8 l. The two rear honeycomb bodies each had a length of 102 mm and a volume of 1.2 l.

Said honeycomb bodies were coated as follows for comparison of an exhaust gas purification system according to the invention with conventional systems:

<u>Comparative example 3a</u> (Fig. 1, 1a)

1.-3 Honeycomb body: Coating with a standard three-way catalyst according to example 2; aged

<u>Comparative example 3b</u> (Fig. 2, 2a)

1. Honeycomb body: Coating with 100 g/l of DAY zeolite (Si/Al > 100)

2.-3 Honeycomb body: Coating with a standard three-way catalyst according to example 2; aged

<u>Example 3</u> (Fig. 3, 3a)

1. Honeycomb body: The first honeycomb body was replaced by two partial bodies. The partial body 52 mm long on the engine side received a coating of 100 g/l of DAY zeolite (Si/Al > 100). The second partial body was coated with an oxidation catalyst with 7 g of Pd per litre of honeycomb body volume. These coatings, too, were aged before the exhaust gas tests were carried out.

2.-3 Honeycomb body:	Coating with a standard three-way catalyst according to example 2; aged.

Figures 1 to 3 show the emission curves for hydrocarbons during the first 250 s after the start when various exhaust gas purification systems are used (Figures 1a - 3a). The given hydrocarbon concentrations relate to an exhaust gas diluted to one tenth by air in accordance with the US FTP-75 test specification.

Figure 1 shows that the aged three-way catalysts (according to Figure 1a) begin after about 50 seconds to convert the pollutants in the exhaust gas. At this point in time, the temperature in the exhaust gas before the catalysts is 300 °C. Figure 2 shows the same relationships as Figure 1, but with an adsorber with a DAY zeolite upstream of the three-way catalyst in the exhaust gas purification system (Fig. 2a). The desorption of hydrocarbons by the adsorber begins after only about 30 seconds at a temperature of about 200 °C in front of the adsorber. The three-way catalysts are not yet, however, capable of converting the majority of the desorbing hydrocarbons. Figure 3, in contrast, shows a marked decrease in the residual emission as a result of combining the adsorber with an oxidation catalyst highly loaded with palladium in conjunction with the two standard three-way catalysts (Fig. 3a). The hatched area in Figure 3 represents the reduction in hydrocarbon emission of the exhaust gas purification system according to the invention according to example 3 in comparison with the conventional exhaust gas purification system according to comparative example 3b.

The residual emission measurements of the exhaust gas purification systems according to comparative example 3b and according to example 3 are shown in Table 3. As these measurements show, the use of a highly loaded palladium oxidation catalyst in combination with hydrocarbon adsorber and standard three-way catalysts has a positive effect on the residual emissions of the exhaust gas system. During the cold start phase, not only are the hydrocarbon emissions reduced by 30%, but also the emission of carbon monoxide. Said positive effect also remains throughout the entire test.

Table 3 Residual emission measurement according to US FTP-75

Exhaust gas system	Content of the first bag in g/miles (Cold start phase)		
	CO	HC	NO_x
according to comparative example 3b*)	3.00	0.51	0.83
according to example 3	2.05	0.37	0.89

Exhaust gas system	Total emission in g/miles		
	CO	HC	NO_x
according to comparative example 3b	1.29	0.22	0.46
according to example 3	0.48	0.10	0.38

*) = Comparative example

The claims defining the invention are as follows:

1. An exhaust gas purification system for reducing hydrocarbon emissions during the cold start of combustion engines, comprising:

a hydrocarbon adsorber; and

a downstream catalyst system comprising a three-way catalyst or a combination of oxidation, reduction and/or three-way catalysts in one or more beds, wherein:

said downstream catalyst system contains an oxidation catalyst with platinum and/or palladium and a three-way catalyst with platinum and/or palladium and/or rhodium, wherein the loading of said oxidation catalyst with platinum and/or palladium is at least 3.5 g of platinum and/or palladium per litre of catalyst volume;

said oxidation catalyst is placed immediately after said adsorber; and wherein

the difference between the light-off temperature of the oxidation catalyst for conversion of hydrocarbons and the desorption temperature of the adsorber is less than 50°C.

2. The exhaust gas purification system according to claim 1, wherein said hydrocarbon adsorber comprises a mixture of a dealuminised Y zeolite with a Si/Al ratio of more than 40 and a zeolite ZSM5 with a Si/Al ratio of more than 20, and wherein dealuminised Y zeolite and zeolite ZSM5 are present in the adsorber in a weight ratio to one another of 1:10 to 10:1 and wherein said hydrocarbon adsorber is present in the form of a coating on a monolithic honeycomb body in a quantity of 100 to 400 g per litre of honeycomb body volume.

3. An exhaust gas purification system for reducing hydrocarbon emissions during the cold start of combustion engines, comprising:

a hydrocarbon adsorber; and

a downstream catalyst system comprising:

a three-way catalyst in one or more beds, wherein said three-way catalyst comprises the platinum group metals platinum and/or palladium and/or rhodium in an amount of at least 3.5 g of platinum and/or palladium per litre of catalyst volume;

the difference between the light-off temperature of the oxidation catalyst for conversion of hydrocarbons and the desorption temperature of the adsorber is less than 50°C.

4. The exhaust gas purification system according to claim 3, wherein said hydrocarbon adsorber comprises a mixture of a dealuminised Y zeolite with a Si/Al ratio of more than 40 and a zeolite ZSM5 with a Si/Al ratio of more than 20, and wherein dealuminised Y zeolite and zeolite ZSM5 are present in said adsorber in a weight ratio to one another of 1:10 to 10:1, and wherein said hydrocarbon adsorber is present in the form of a coating on a monolithic honeycomb body in a quantity of 100 to 400 g per litre of honeycomb body volume.

5. An exhaust gas purification system for reducing hydrocarbon emissions during the cold start of combustion engines, comprising:

a hydrocarbon adsorber in immediate contact with an oxidation catalyst and a downstream three-way catalyst in one or more beds, wherein:

said oxidation catalyst and adsorber are present in the form of superimposed coatings on a monolithic honeycomb body, the adsorber coating lying on the catalyst coating and the oxidation catalyst contains platinum and/or palladium in an amount of at least 3.5 g platinum and/or palladium per litre of catalyst volume; and wherein

the difference between the light-off temperature of the oxidation catalyst for conversion of hydrocarbons and the desorption temperature of the adsorber is less than 50°C.

6. The exhaust gas purification system according to claim 5, wherein said hydrocarbon adsorber contains a mixture of a dealuminised Y zeolite with a Si/Al ratio of more than 40 and a zeolite ZSM5 with a Si/Al ration of more than 20, and dealuminised Y zeolite and zeolite ZSM5 are present in the adsorber in a weight ratio to one another of 1:10 to 10:1.

7. An exhaust gas purification system for reducing hydrocarbon emissions during the cold start of combustion engines substantially as hereinbefore described with reference to Figures 3 and 3a.

8. An exhaust gas purification system for reducing hydrocarbon emissions during the cold start of combustion engines substantially as hereinbefore described with reference to the Examples, excluding the comparative examples.

DATED this Twentieth Day of November 1995
Degussa Aktiengesellschaft
Patent Attorneys for the Applicant
SPRUSON & FERGUSON

ABSTRACT

Exhaust Gas Purification System for Reducing Hydrocarbon Emissions During the Cold Start of Combustion Engines

An exhaust gas purification system for reducing hydrocarbon emissions during the cold start of combustion engines is disclosed. The system comprises a hydrocarbon adsorber and a downstream catalyst system composed of a three-way catalyst or a combination of oxidation, reduction and/or three-way catalysts in one or more beds. The catalyst system downstream of the hydrocarbon adsorber contains an oxidation catalyst with platinum and/or palladium and a three-way catalyst with platinum and/or palladium and/or rhodium, wherein the loading of the oxidation catalyst with platinum and/or palladium is at least 3.5 g of platinum and/or palladium per litre of catalyst volume, and the oxidation catalyst is placed immediately after the adsorber.

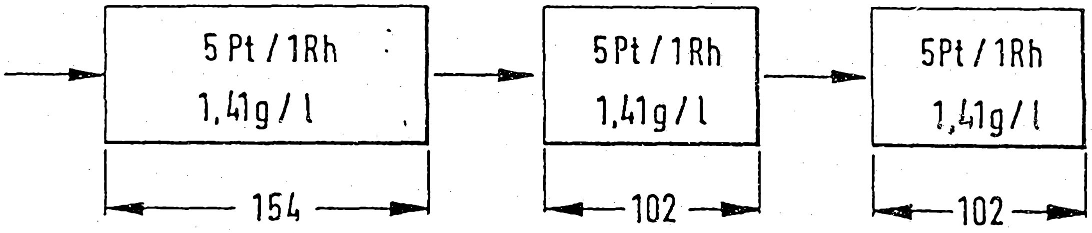
5 Pt / 1Rh
1,41g / l
154
5 Pt / 1Rh
1,41g / l
102
5Pt / 1Rh
1,41g / l
102

Fig. 1a

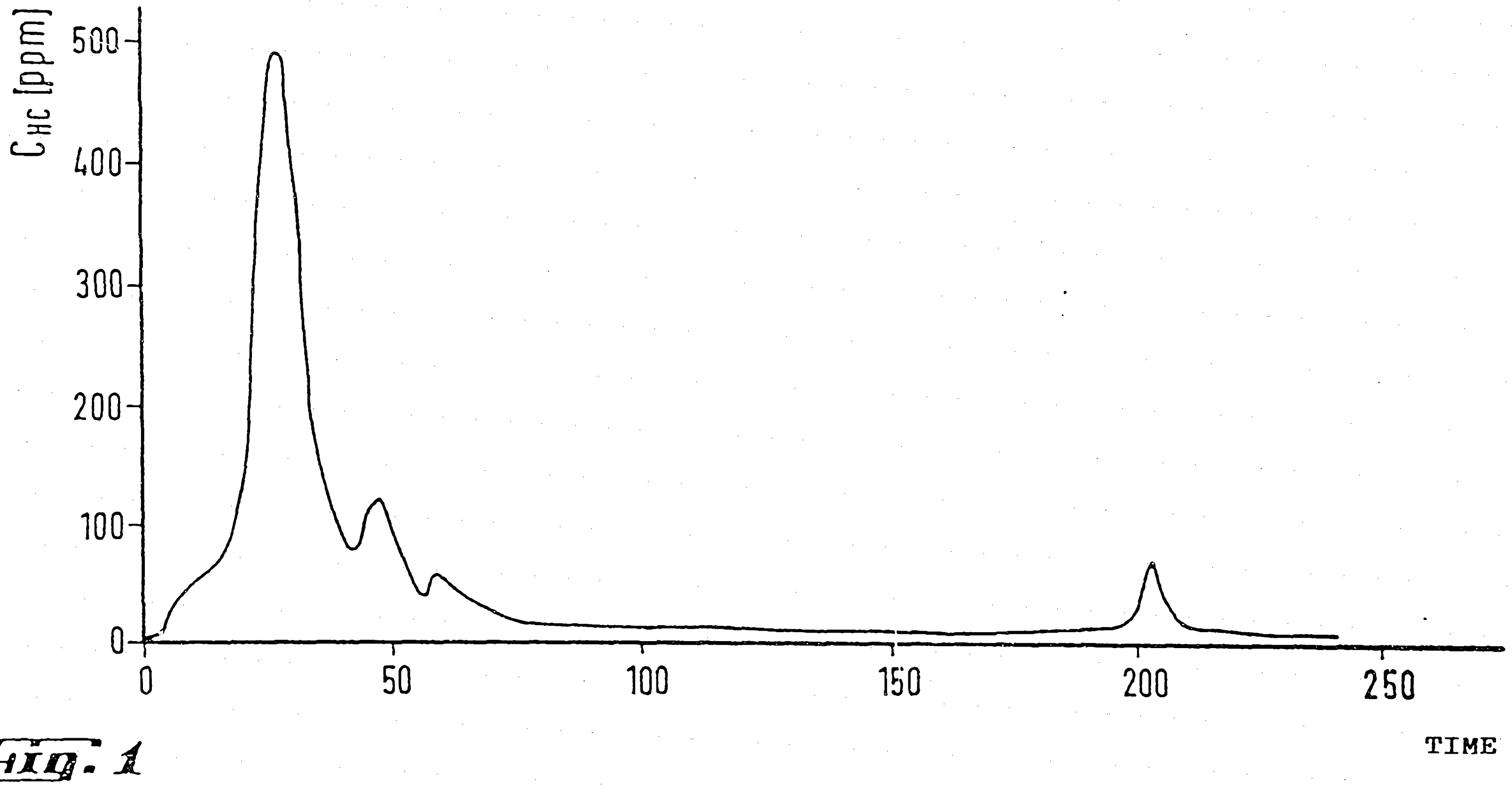
C_HC [ppm]
500
400
300
200
100
0
0
50
100
150
200
250
TIME [S]

Fig. 1

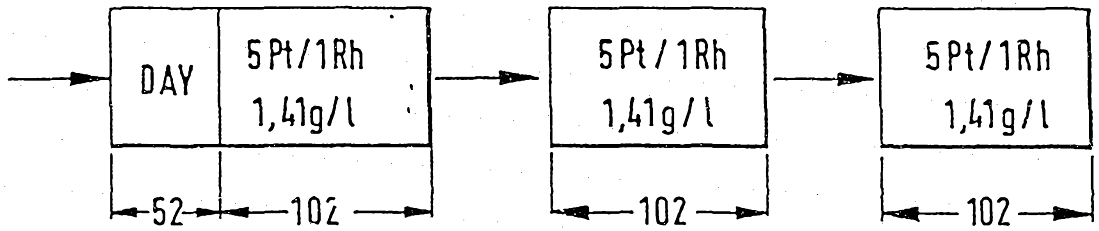
DAY
5Pt/1Rh
1,41g/l
5Pt/1Rh
1,41g/l
5Pt/1Rh
1,41g/l
52
102
102
102

Fig. 2a

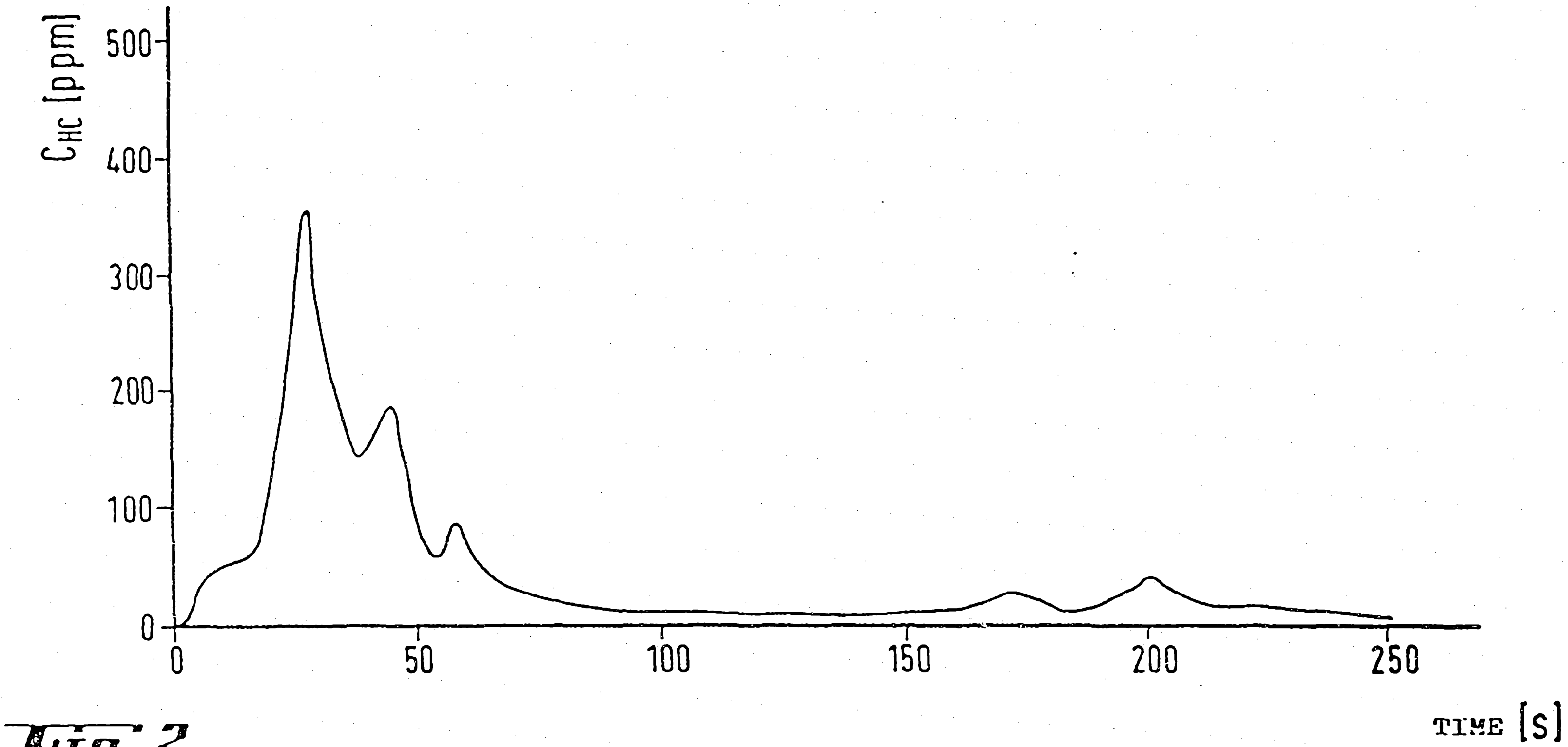
C_{HC} [ppm]
500
400
300
200
100
0
0
50
100
150
200
250
TIME [s]

Fig. 2

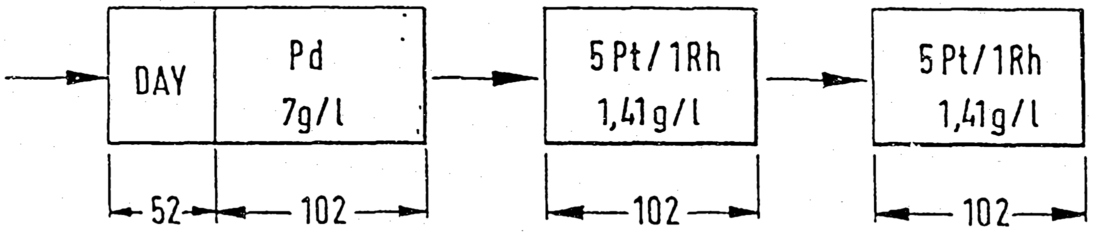
DAY
Pd
7g/l
5Pt/1Rh
1,41g/l
5Pt/1Rh
1,41g/l
52
102
102
102

Fig. 3a

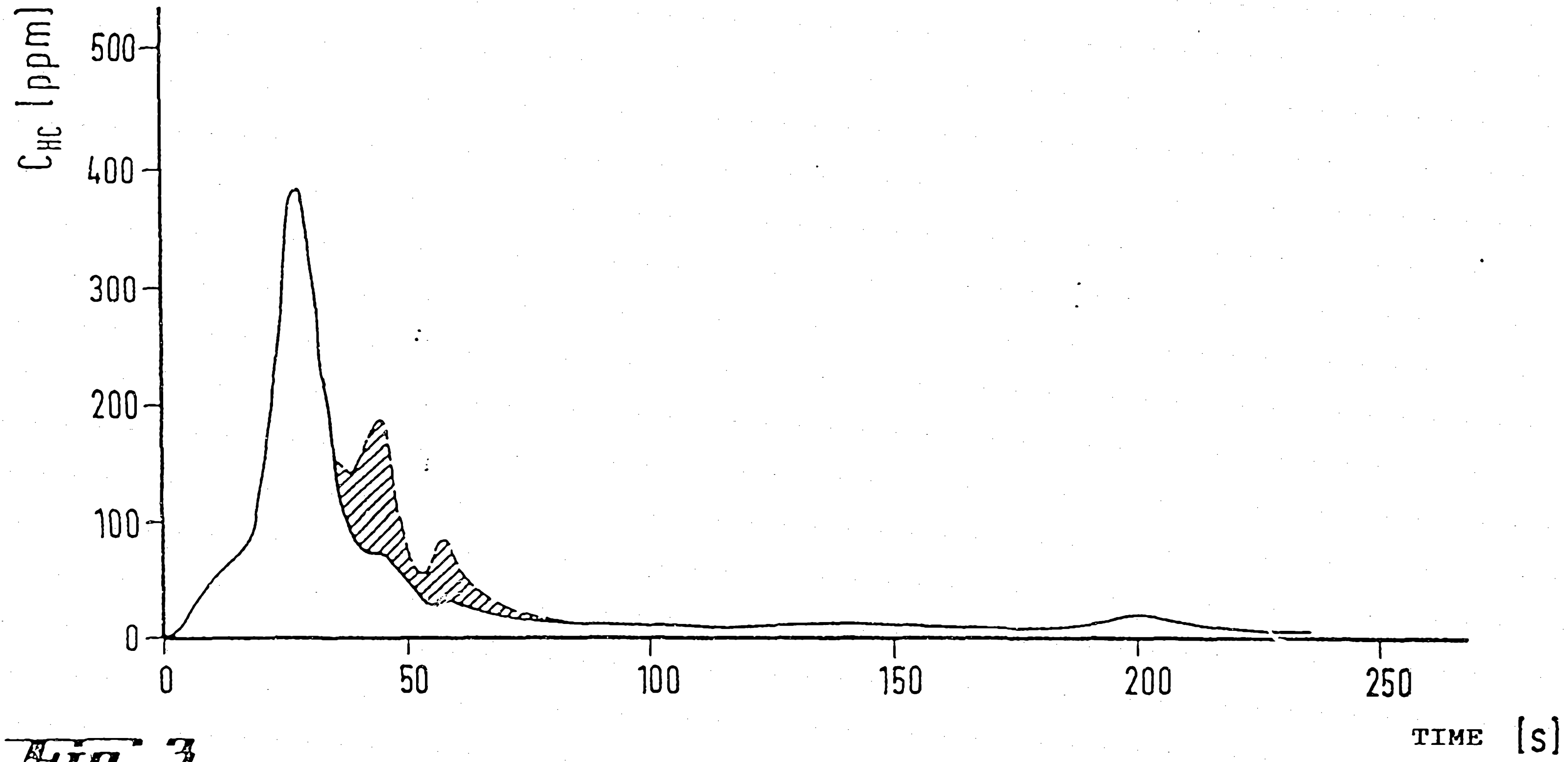
C_{HC} [ppm]
500
400
300
200
100
0
0
50
100
150
200
250
TIME [s]

Fig. 3