(12) UK Patent Application (19) GB (11) 2 318 310 (13) A

(43) Date of A Publication 22.04.1998

(21) Application No 9621639.5

(22) Date of Filing 17.10.1996

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(51) INT CL[6]
F02D 41/14, B01D 53/04, F01N 3/18 9/00

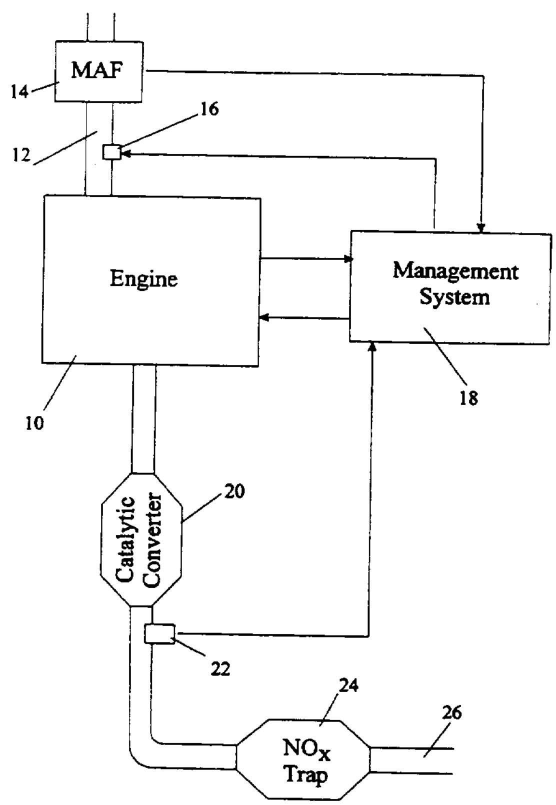
(52) UK CL (Edition P)
B1W WD W10C W10Y
G3R RA24 RA33 RA37 RA43 RBE72 RB27

(56) Documents Cited
EP 0580389 A1

(58) Field of Search
UK CL (Edition O) **B1W WD, G3R**
INT CL[6] **B01D 53/04 53/14 53/94, F01N 3/08 3/18 9/00, F02D 41/14**
Online databases: WPI and CLAIMS

(54) Reducing NOx emission from an engine

(57) An internal combustion engine 10 has an exhaust system 26 that includes an NO_x trap 24 and an exhaust gas oxygen sensor 22, and a management system 18 for selectively operating the engine in a lean burn mode, during which NO_x gases produced by the engine are stored in the NO_x trap 24 and a closed loop mode in which the mixture strength is oscillated about stoichiometry in dependence upon the output signal of an exhaust gas oxygen sensor located in the engine exhaust system. The response of the management system to the output signal of the exhaust gas oxygen sensor 22 when operating in closed loop mode is biased to create a slightly lean condition in the exhaust system to prevent the release of the NO_x gases stored in the trap 24.



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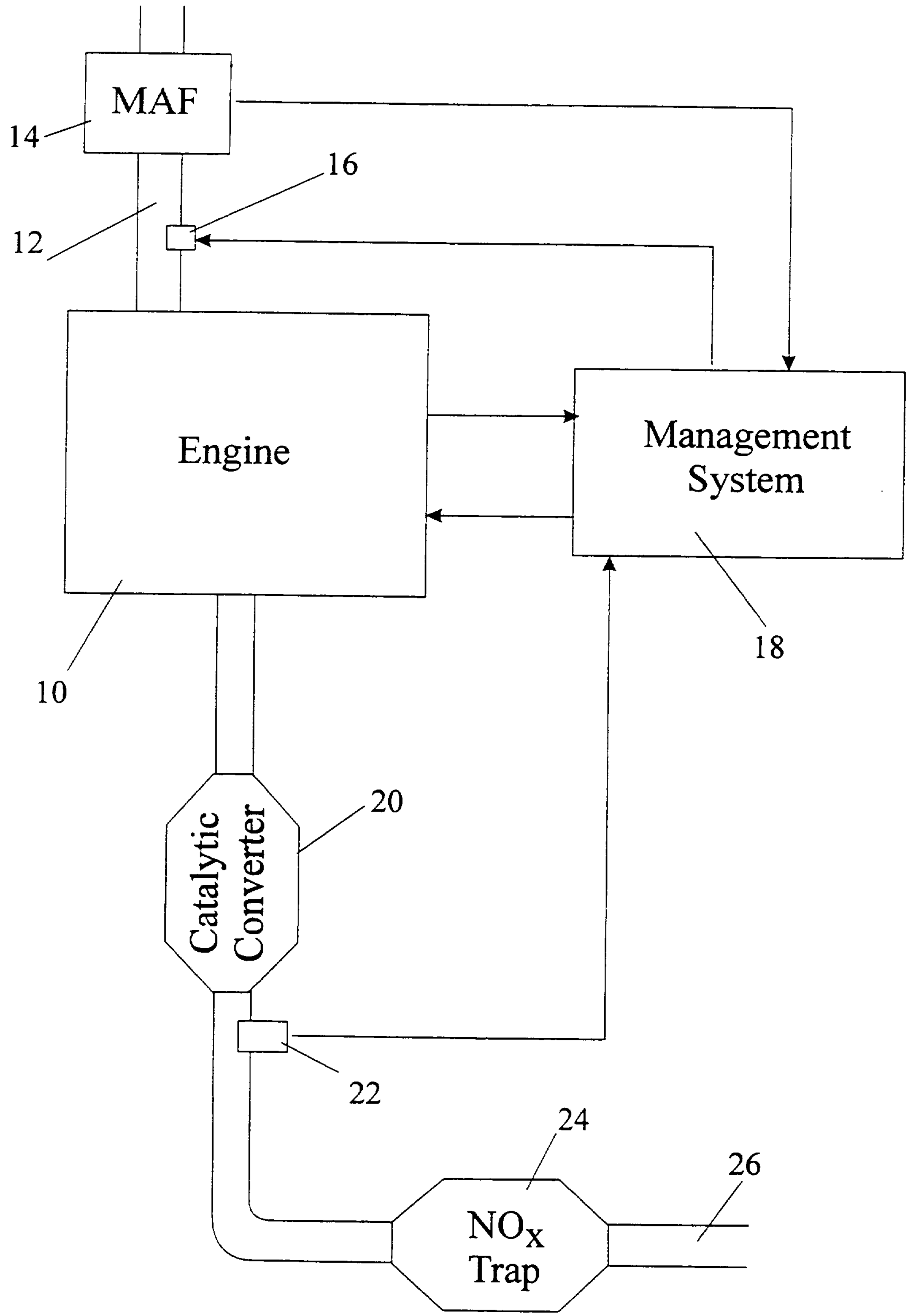
MAF
14
16
12
Engine
Management System
10
18
Catalytic Converter
20
22
24
26
NOx Trap

Reducing NO_x Emission from an Engine

Field of the invention

The present invention relates to reducing the NO_x emissions from a lean burn internal combustion engine fitted with an NO_x trap.

Description of the prior art

Internal combustion engines designed mostly to burn a mixture lean of stoichiometry tend to produce NO_x gases in the exhaust feed gas and in order to comply with emission regulations it is necessary to intercept and neutralise these gases in the exhaust system before they are discharged into the ambient atmosphere.

It is known to use an NO_x trap to store the gases and to purge the trap by creating a rich (i.e. reducing) atmosphere in the exhaust system. More specifically, a reversible chemical reaction takes place in the NO_x trap. In the presence of an oxidising atmosphere in the exhaust system, NO_x gases react with the material in the trap and are stored in the trap in the form of a nitrate. At a later stage, when the trap is estimate to be approaching its maximum storage capacity, a purge cycle is initiated in which excess fuel is supplied to the engine for a brief interval. The stored NO_x gases are released and react with excess fuel in the exhaust gases to be reduced to nitrogen before being discharged into the ambient atmosphere.

It is not practicable for a various reasons to operate in lean burn mode at all times. In particular, when the engine is idling and during low speed and low load operation, combustion cannot be easily controlled in lean burn mode resulting in engine instability. Also at higher engine speeds and loads it is preferred to operate the engine at stoichiometry. This is because the efficiency of the NO_x trap reduces with temperature and at higher speeds and loads if fills too rapidly and requires purging too frequently.

It is common therefore for the engine management system of a lean burn engine to be able to switch between modes, supplying a stoichiometric mixture under some operating conditions and a lean mixture at other times.

Whereas the lean burn mode relies on an open loop calibration, in order to maintain stoichiometry the management system normally operates in a closed loop mode relying on the feedback error signal from a heated exhaust gas oxygen (HEGO) sensor, the output signal of which switches between two states depending on the oxygen concentration in the exhaust gases. The closed loop control system acts in the presence of surplus oxygen to enrich the mixture strength and in the sensed based of oxygen to reduce the mixture strength, with the result that the fuel to air ratio is dithered about stoichiometry.

A problem that has been encountered with an engine that can operate in lean burn and stoichiometric mode is that on reverting to the stoichiometric mode after a period of lean burn, NOx gases tend to leak out of the trap. Because there are not sufficient reluctance (hydrocarbons and carbon monoxide) present in the exhaust gases to react with the released NO_x gases, these gases leak out and are discharged into the ambient atmosphere.

Object of the invention

The present invention therefore seeks to avoid leakage of NO_x gases from the exhaust system when the engine reverts to closed loop stoichiometric operation after a period of lean burn operation.

Summary of the invention

According to the present invention, there is provided an internal combustion engine having an exhaust system that includes an NO_x trap and an exhaust gas oxygen sensor, and a management system for alternately operating the engine in a lean burn mode, during which NO_x gases produced by the engine are stored in the trap and a closed loop mode in which the mixture strength is oscillated about stoichiometry in dependence upon the output signal of an exhaust gas oxygen sensor located in the engine exhaust system, wherein the response of the management system to the output signal of the exhaust gas oxygen sensor when operating in closed loop mode is biased to create a slightly lean condition in the exhaust system to prevent the release of the NOx gases stored in the trap.

The invention will now be described further, by way of example, with reference to the accompanying drawing, which is block diagram of an engine.

In the drawing, an internal combustion engine 10 has an intake manifold 12 incorporating an intake mass air flow meter 14 and fuel injectors 16, and an exhaust pipe 26 incorporating a catalytic converter 20 and a NO_x trap 24. The engine fuel mixture strength and spark timing are set by means of a computerised engine management system 18 that receives input signals from the engine representing engine operating parameters such as crankshaft position and engine temperature. The management system also receives a signal from at least one HEGO sensor 22 which may be located downstream byt more preferably upstream of the catalytic converter 22 as well as the output signal from the mass air flow meter 14 located in the intake manifold.

The management system 18 can operate in one of three modes. In the first mode, open loop calibration is used to set a lean mixture. In other words, based on the sensed engine speed and load, the optimum fuel injection quantity for the prevailing operating conditions is computed, or read from a look-up table, and the quantity of fuel injected by the fuel injectors during each engine cycle is controlled by setting the width of the pulses applied to the injectors 16.

The second mode is a purge mode which again relies on open loop calibration to supply a rich mixture to the engine for a brief period to purge the NO_x trap. The engine management system 18 estimates at all times, by the use of a mathematical model, the quantity of NO_x gases stored in the trap and initiates a purge mode cycle when necessary to avoid the exceeding the storage capacity of the NO_x trap.

In the third mode, the management system 18 operates in a closed loop configuration to maintain stoichiometry using a feedback signal from the HEGO sensor 22. The output signal of the HEGO sensor adopts one state when oxygen is present in the exhaust gases and another when the presence of oxygen is not detected. If a surplus of oxygen is detected, the mixture is made richer until in due course no oxygen is sensed by the HEGO sensor 22. At this point, the management system again reduces the mixture strength. In this way, the average mixture strength is maintained at stoichiometry, with the gases in the exhaust system dithering between oxidising gases and reducing gases.

The management system 18 selects between lean burn open loop mode and stoichiometric closed loop mode in dependence upon the prevailing operating conditions in or to optimise combustion stability, fuel economy and emissions.

When the engine changes from a lean burn mode to a stoichiometric mode, there is a tendency for the NO_x trap to leak as there are times when a reducing atmosphere is present in the exhaust system. If such stored gases are released prematurely, there will not be enough reductants present in the exhaust gases to neutralise them and the will be discharged untreated from the exhaust system.

To avoid this problem, the management system 18 and the HEGO sensor 22 are biased to hold longer on the lean side of stoichiometry and thereby create a slightly lean condition in the exhaust system to prevent the release of the NO_x gases stored in the trap.

More particularly, the rate at which the amount of fuel supplied to the engine is changed by the management system depends on whether the mixture is sensed by the HEGO sensor 22 to be rich or lean of stoichiometry. When the mixture is sensed to be rich, the fuel quantity is reduced relatively rapidly to return the mixture to a lean value. On the other hand, when the mixture is sensed to be lean, the fuel quantity is increased relatively slowly so that the mixture remains lean for a longer time before returning to a rich value. Consequently, overall the lean excursions of the mixture have a longer duration that the rich excursions and on average the mixture in the exhaust system remains lean and thereby inhibits the undesired release of NO_x from the filter trap.

It should be mention that biasing the HEGO sensor and management system in this manner is known per se and is used for controlling a three way catalyst in order to maintain all three types of exhaust emission (HC, CO and NO_x) under tight control. The invention proposed using this known technique to present premature release of NO_x from an NO_x trap.

CLAIMS

1. An internal combustion engine having an exhaust system that includes an NO_x trap and an exhaust gas oxygen sensor, and a management system for selectively operating the engine in a lean burn mode, during which NO_x gases produced by the engine are stored in the NO_x trap and a closed loop mode in which the mixture strength is oscillated about stoichiometry in dependence upon the output signal of an exhaust gas oxygen sensor located in the engine exhaust system, wherein the response of the management system to the output signal of the exhaust gas oxygen sensor when operating in closed loop mode is biased to create a slightly lean condition in the exhaust system to prevent the release of the NO_x gases stored in the trap.

2. An internal combustion engine constructed, arranged and adapted to operate substantially as herein described with reference to and as illustrated in the accompanying drawings.

The Patent Office

Application No:	GB 9621639.5	**Examiner:**	John Warren
Claims searched:	1-2	**Date of search:**	9 January 1997

Patents Act 1977
Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.O): B1W (WD); G3R

Int Cl (Ed.6): B01D 53/04, 53/14, 53/94; F01N 3/08, 3/18, 9/00; F02D 41/14

Other: Online databases: WPI and CLAIMS

Documents considered to be relevant:

Category	Identity of document and relevant passage	Relevant to claims
A	EP 0,580,389 A1 TOYOTA	

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.