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(57) Abstract

A vehicle, preferably a public transport vehicle, transports an apparatus providing for intake of polluted air, which is purified of carbon, nitrogen and sulphur oxides, unburned matter and particulate, the impurities being collected and disposed of after a working cycle of around 10 hours. The energy consumption is negligible when compared with the volume of air treated.
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MOBILE APPARATUS FOR THE PURIFICATION OF POLLUTED AIR

DESCRIPTION

Technical Field

The present invention relates to an apparatus and a process that allow purification, with a minimum expenditure of energy, of an appreciable amount of air in a metropolitan environment polluted with carbon, nitrogen and sulphur oxides, as well as with particles of dust and smog.

The apparatus is designed and built in a size suitable for transportation on a vehicle travelling the streets of a town or city. A particularly suitable type of vehicle for this purpose is a public transport vehicle for transport by road or rail, capable of purifying an appreciable amount of air during its day-to-day working cycle while consuming a low amount of energy and using low cost chemical reagents.

Background Art

The problem of atmospheric pollution in towns and cities due to the circulation of vehicles powered by internal combustion engines is universally known, as are the difficulties in solving this problem, even partially.

The International Patent Application No. WO 9755 describes an apparatus for treatment of air transported by a vehicle, and containing a filter system made up of a series of electrostatic filters to retain the ionised particles contained in the air. This system, however, is incapable of acting on the gaseous chemical pollutants, and involves excessively frequent removal and/or maintenance of the filters.

Catalytic systems are also known, and are used for catalytic post-combustion of the products of combustion, to purify them of unburned solids. However, these systems are applied to gaseous fluids with a high concentration of combustion products, and are only active at a temperature much higher than that of the surrounding
environment, which means that a notable consumption of energy is required specifically for the purpose.

The problem of a treatment to purify air characterised by the pollution typical of towns and cities requires performance of the following functions: reduction of dust, reduction of particulate and unburned hydrocarbons, reduction of the concentrations of sulphur, nitrogen and carbon dioxides and if necessary reduction of the concentration of carbon monoxide.

In order to reduce the level of dust, particulate and unburned substances the state of the art provides systems such as dry filters or viscous filters of various degrees of fineness and thus with various levels of filtering power, electrostatic filters, dynamic filters (scrubbers), damp filters and purification tunnels.

None of the above mentioned systems can be used to obtain the object of the present invention.

In fact, dry filters, viscous filters and electrostatic filters loose their effect as the material retained accumulates and thus, in the application in question, given the available surface area, which is limited by problems of bulk, these systems would require the frequent removal or cleaning of the filters, in terms of 1 per hour.

The dynamic filters normally used for separation of medium to large sized particles are of low efficiency when dealing with the size of particle present in the polluted air of a town or city environment, and in any case, to give a sufficient flow of air to be treated, require the presence of centrifugal dust separators of a size unsuitable to be carried on a vehicle.

Washing filters and tunnels, in comparison with the working flow rate of air to be treated and the concentration of fine dust, require the use of excessive amounts of space when compared with that available in case of application on a vehicle, and the same thing can be said for the amount of washing liquid used for
purification, which, according to the current dimensions of these devices, would involve the need to load the vehicle with large amounts of liquid.

**Disclosure of the Invention**

The present invention provides a mobile apparatus on a transport vehicle and a related purification process that performs a cleaning operation which does not require large amounts of liquid or employ large amounts of space, and which is such that it offers the advantages typical of dynamic filters in combination with those typical of washing tunnels, without involving the problems indicated above.

An object of the present invention is therefore a mobile apparatus for the purification of polluted air in a town environment installed on a transport vehicle, characterised in that it comprises: an inlet section for the air to be purified; an oxidisation section following said inlet section, to oxidise CO into CO₂ and nitrogen oxides NOₓ into NO₂ by means of the action of nascent oxygen and a catalyst active at least at room temperature based on an oxide of a metal selected from the class consisting of the first series of the transition group of the Periodic System or on cupric chromite; a washing section following said oxidation section to purify the air from said higher carbon and nitrogen oxides and from SO₂ by reaction with hydroxyl ions deriving from lime or sodium bicarbonate or a mixture thereof in solution in an aqueous washing solution to obtain insoluble salts and to reduce nascent oxygen or residual ozone by means of a catalytic filter, as well as particles, dust and unburned substances; an apparatus for separation of said insoluble salts from the washing liquid and for renewing and returning said liquid to the washing section; a section for discharging the purified air into the external environment, following said washing section; and a system for suction of the outside air to introduce said air into the inlet section.
A further object of the present invention is the process used in the apparatus as described above.

**Brief description of the drawings**

The invention will be described in greater detail with reference to the drawings, in which:

- figure 1 is a general view of the apparatus installed on an urban transport vehicle;
- figure 2 is a plan view of the apparatus according to the present invention; and
- figure 3 is a partly cut-away view of an embodiment of the apparatus of figure 2.

**Modes for carrying out the invention**

A typical application for the present invention is illustrated in figure 1. A vehicle 1 carries on its roof a purification apparatus 2 according to the invention. The vehicle 1 is typically an urban transport vehicle that travels the town roads during its working day, which can be calculated to last around 10 hours. As the apparatus 2 is a module capable of treating an air flow rate of around 2000 m³/hour it can be calculated that each urban transport vehicle can purify 20000 m³ of air per working day in each module installed.

Furthermore, as working tests have shown that the apparatus according to the invention has an energy consumption of approximately 3 kWh, it can easily be seen that a vehicle 1 equipped as indicated above produces an amount of purified air during the day that is greatly in excess of the pollution produced by the vehicle itself, and with minimum energy costs compared with the energy produced by the vehicle to move itself.

The plan of the apparatus is illustrated in figure 2.

It comprises an inlet section 3 for the air, served by a suction feeder 16 provided with traps for leaves and other foreign bodies, in which a fan 4 feeds the flow of air to be treated, at a relatively low speed, into an oxidation section 5. The air then accelerates inside a
washing section 6, passing through a series of labyrinths within which the air is made to pass through several barriers of chemically activated water. From here, the flow of air slows down in an accumulation section 7 or stilling pool, where any water that may have been carried in is separated from the air before the latter is finally returned to the surrounding environment.

It can be noted that the fan 4 can also be situated, for example, downstream of the oxidation section 5, without altering the process. The oxidation section has the aim of transforming the carbon monoxide CO into CO₂, and the nitrogen oxides NOₓ into NO₂, so that these oxides, and in particular NO₂, are able to react in the washing section 6 with chemical reagents capable of transforming them into insoluble products that can be precipitated and separated off.

The oxidation of the polluting oxides mentioned above is obtained by the action of nascent oxygen. The nascent oxygen is generated by the decomposition of ozone produced in the oxidation section. The ozone is produced during the passage of air over a group of lamps capable of producing ultraviolet light with a wavelength of below 250 millimicron.

Normally speaking, the concentration of NO is three times lower than that of CO, so that it is advisable to size the process according to the amounts of CO to be treated. Bearing in mind that the emission of ozone into the atmosphere is to be avoided and considering the positive effect of the subsequent washing, it is preferred to use a limited number of UV lamps.

The ozone or the nascent oxygen could also be produced by means of other physical or chemical processes, for example the formation of high voltage electric discharges.

In order to avoid emission of ozone into the atmosphere it should be noted that the washing chamber and the accumulation chamber immediately beyond the
oxidation section are sized in such a way as to provide for reduction of any ozone remaining after the oxidation process into oxygen. This is also the case in the event of accidental stoppage of the washing system, as the residual ozone is consumed by oxidising the catalytic surfaces, and also because a flow meter is installed in the washing system and, in the absence of flow, this prevents the ultraviolet lamps 8 from turning on.

As regards the problem of reducing the concentration of harmful oxides, the state of the art essentially proposes catalytic oxidation based on catalysts preferably made up of precious metals such as platinum, cobalt and the like, which are activated at high temperatures. In the present invention, the oxidation is preferably promoted by a catalytic bed 9 which is active at room temperature, said bed comprising one or more catalysts selected from the oxides of a metal of the class belonging to the first series of the periodic table transition group. Particularly preferred because of their low cost and high yield are ZNO, MnO₂, CuO, as well as the copper chromite CuCr₂O₄.

In order to improve still further the effect of the catalyst, it is possible to pass inside the section the exhaust pipe from the motor powering the vehicle: in this way the temperature of the catalyst is increased without further thermal pollution of the environment and without additional energy expenditure.

The same catalysts promote decomposition of the residual ozone and, in order to prevent the latter from reaching the external atmosphere, the same catalysts can also be present in the successive washing and accumulation sections.

Reduction of SO₂, NO₂ and CO₂ downstream of the oxidation section 5 takes place mainly in the washing section 6, by intimate contact and reaction with a chemically activated washing liquid made up of an aqueous solution containing hydroxyl ions from substances such as
lime, sodium bicarbonate or the like, which by reacting with the polluting oxides produce insoluble salts that are separated by means of filtration or precipitation.

As reaction products, calcium nitrate is obtained from nitrogen oxides, calcium carbonate from carbon monoxide, and calcium sulphite from sulphur monoxide, or the corresponding carbonates obtained from the decomposition of bicarbonate to carbonic acid.

In a preferred embodiment, the washing section is made up of a labyrinth within which the air follows a route with a series of brusque 180° inversions of direction accompanied by an equal number or double the number of washing barriers. Section 6 is in fact subdivided by a series of walls 10 that form a serpentine-shaped route, while a battery of nozzles 11 spray the washing liquid onto the metal walls, generating an atomisation that promotes contact between the liquid phase and the gaseous phase and also produce a series of liquid barriers to passage of the air. The washing liquid collects on the bottom of the section 6 and is sent to a recycling circuit comprising a filter apparatus 12 and following this a settling chamber 13 from which the liquid is picked up by a pump 14 and recycled to the nozzles 11. The settling chamber 13 is served by a supply device 17 which restores the hydroxyl ions to the desired concentration, measured by means of a pH-meter.

It should be noted that in the present invention the washing operation does not merely perform the process of chemical reduction of the concentration of sulphur, nitrogen and carbon oxides, but also acts as a highly effective filter to reduce particulate and unburned hydrocarbons, due to the mechanical drag produced by the washing barriers and the rapid changes in direction of the route.

On leaving the washing section, the purified flow of air, which is still rich in atomised water particles, passes into the accumulation section 7 or stilling pool,
where the increase in the flow section slows down the mass flow rate of air, allowing precipitation of the drops, which collect on the bottom of the bath. After passing through a final filter 15, preferably catalytic, which helps to retain the liquid phase in the apparatus and reduce any residual ozone until the concentration is brought down to zero, as well as protecting against the entry of foreign substances from the outside, the purified air is returned to the atmosphere.

In figure 3 it is possible to see in a more realistic form a modular unit of the apparatus according to the present invention, which merely as an example, in order to treat an air flow of around 2000 m$^3$/hour is made up of a washing section formed by a parallelepiped of 500 by 1000 mm within which an air passage approximately 4 m long is formed, with between five and eight 180° inversions of direction and between 10 and 16 washing barriers. An apparatus sized in this manner requires less than 70 litres of water to provide an operating range of 10 hours of continuous operation. The energy consumption for the whole process is around 2.8 kWh. When considering the pollution produced by an internal combustion engine continuously supplying the same amount of power, it is found that the amount of pollutants produced by said motor would be 50 times less than the amount of pollutants that the apparatus would eliminate from the atmosphere, which means a considerable gain when comparing the purification achieved and the pollution produced to achieve it.

It should also be noted that the characteristics of the process and the form of construction are such that they do not involve high costs, as the chemical reagents are commonly available and low cost products, and even the catalysts can be obtained using particularly low cost materials.
In figure 3 the elements similar to those illustrated in figure 2 are indicated with the same reference numbers.

A description will now be given of certain embodiments, with the process data found during operation of the apparatus.

Example 1

An apparatus is built with a suction funnel 16 with a size of 520 x 890 x 500 mm and a centrifugal fan having the following characteristics:
capacity: 1960 m³/hour
hydraulic head: 195 mm of water
power consumption: 1.5 kW
motor: three-phase asynchronous
belt transmission
vertical axis to limit bulk.
The fan discharges into a diffuser sized in such a way as to reduce the speed of the air at the entry into the subsequent oxidation section and to reduce the load loss.

The oxidation section is sized in such a way as to optimise load loss, bearing in mind the presence of the obstacle formed by the ozonization lamps.

The washing section was built with passage through five separate water barriers, each one obtained by means of five spray nozzles of the type Hl/4 VV11001 which allow a 110° aperture of the jet at 3 bar giving a total flow rate of all 25 nozzles equal to approximately 10 litres/minute.

The total load loss through the circuit was approximately 5.25 kg/cm². The re-cycling pump 14 had a prevalence of approximately 10 kg/cm² to provide a flow rate of approximately 10 litres/minute, with a power consumption of approximately 0.4 kW.

The UV lamps numbered 8, each of which was capable of producing approximately 1 g/hour of ozone.

The apparatus, when tested in the most severe conditions foreseen for operation, corresponding to an
environmental temperature of 35°C and a relative humidity of 30%, showed a consumption of washing water of 7 litres/hour, a corresponding consumption per hour of aqueous lime equal to 50 g/hour and a consumption of bicarbonate of 500 g/hour.

The washing circuit thus results sized in such a way as to guarantee self-sufficiency for 10 hours of continuous operation with a total capacity of 100 litres, thus requiring regeneration only once every 10 hours of continuous operation.

Example 2

The apparatus described in the preceding example 1 was made to undergo testing as follows.

Upstream of the apparatus a chamber was installed with a volume of approximately 1.5 m³, made of anodised metal plate, within which varying ratios of clean air from the environment were mixed with the exhaust fumes from a 4000 cm³ diesel engine running at a constant speed.

From this chamber the polluted and mixed air was sucked by the fan, on the outlet of which a probe was installed to pick up samples of polluted air (upstream of the treatment). A second probe was installed downstream of the oxidation section in order to pick up samples of oxidised air before it undergoes washing.

A third probe was installed downstream of the device in the stream of treated air leaving it.

Over 500 measurements were taken, using the colourimetric system in a variety of conditions to measure the pollution level, environmental conditions (temperature, relative humidity, pressure), the oxidation level, and the type of reagent. The results obtained can be summarised as follows:

with reference to the pollution level corresponding with the so-called "warning level" for urban pollution, it was seen that even wide variations in environmental conditions have no noticeable effect on the efficiency of
the invention, with the exception of the consumption of washing water, which in any case remains lower than 7 litres/hour;

in the conditions indicated above and with an ozone production equivalent to 2 mg/m³, the results obtained with Ca (OH₂) are equivalent to those obtained with NaHCO₃.

In the conditions indicated above the following levels were measured:

- CO : average level 14 ppm, reduction 28% (4 ppm)
- NOx (NO+NO₂): average level 5 ppm, reduction 60% (3 ppm)
- SO₂ : average level 0.5 ppm; reduction approximately 100%
- CO₂ : average level 2800 ppm; reduction 10% (300 ppm)
- Residual ozone at outlet : traces, << 0.1 mg/m³
- Flow rate of treated air : 1890 mm³/hour
- Energy consumption : < 2.8 kWh
- Water consumption : < 7 litres/hour
- Duration of bath : over 24 hours of continuous running.

Example 3

A test on a prototype apparatus according to the invention as described in Example 1 was conducted by technical staff of ENEA (Italian Authority for New Technologies, Energy and Environment) with a pair of laboratory test apparatuses of their own and with data processed by a pair of Microwax computers. The test apparatuses were of the current mobile type used for tests on environmental pollution and the tests were carried out in a two-day scheduled program.

Upstream of the purification apparatus of the invention a metal chamber with a volume of 4 cubic meters was installed, in which polluted air was produced artificially by dilution into the environmental air of
the exhaust from a diesel motor and an operation controlled motor.

The dilution was controlled in such a way as to obtain a concentration of pollutants comparative with the characteristics of town smog.

A sensor mounted at the inlet of the purification apparatus took up polluted air continuously before treatment in the purification apparatus. This gas was directed to one test apparatus.

Another sensor identical to the first one mentioned above took up air at the outlet of the purification apparatus, and this was directed to the second test apparatus.

The two test apparatuses were identical and with exactly the same calibration.

For definite control during the first two hours of each day of test the same air was introduced into both the test apparatuses (first hour at air inlet, second hour at air outlet) and it was checked that the values measured in the different conditions were the same.

Two series of test were carried out for a six hour period each. After this time the measured values were automatically taken and processed by the two computers installed on board the test apparatuses.

The results of the second test session fully confirmed those of the first session.

The results obtained are reported below.

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Although the invention has been described in considerable detail, it will be evident to experts in the field that modifications and variations thereto may be carried out without departing from the scope of the invention itself.

For example it is possible to provide an additional washing section placed upstream of the oxidation section to perform preliminary reduction of SO$_2$, dust and particulate, which would result in a better yield in the catalytic system in the oxidation section.

Furthermore, the apparatus illustrated in the examples has been designed as a free standing modular unit for application on a vehicle not specifically designed for the purpose, but it is understood that the apparatus may also be constructed during the manufacturing cycle of the vehicle itself as an integral part thereof.
CLAIMS

1. A mobile apparatus for the purification of polluted air in a town environment installed on a transport vehicle, characterised in that it comprises:
   an inlet section (3) for the air to be purified;
   an oxidation section (5) following said inlet section, to oxidise CO into CO₂ and nitrogen oxides NOₓ into NO₂ by means of the action of nascent oxygen and a catalyst (9) active at least at room temperature based on an oxide of a metal selected from a class consisting of the first series of the transition group of the Periodic System or on cupric chromite;
   a washing section (6) following said oxidation section to purify the air from said higher carbon and nitrogen oxides and from SO₂ by reaction with hydroxyl ions deriving from lime or sodium bicarbonate or a mixture thereof in solution in an aqueous washing solution to obtain insoluble salts and to reduce nascent oxygen or residual ozone by means of a catalytic filter, as well as particles, dust and unburned substances;
   an apparatus (12, 13) for separation of said insoluble salts from the washing liquid and for renewing and returning said liquid to the washing section;
   a section for discharging the purified air into the external environment, following said washing section; and
   a system (16, 4) for suction of the outside air to introduce said air into the inlet section.

2. An apparatus according to claim 1, in which said sections are contained within a casing mounted on said vehicle as a modular unit.

3. An apparatus according to claim 1 or 2, in which said discharging section is an accumulation chamber (7) with collection bath having an increased flow section in order to slow down the mass flow rate of air and separate the drops of washing liquid from the air transporting said drops, and a catalytic filter for final reduction of residual ozone.
4. An apparatus according to any one of the preceding claims, in which said catalysts are based on ZnO, MnO₂, CuO or CuCr₂O₄.

5. An apparatus according to any one of the preceding claims, in which the exhaust fumes from the motor of the vehicle are made to pass in thermal transmission contact with the catalysts in the oxidation station in order to be heated.

6. An apparatus according to any one of the preceding claims, in which said oxidation station comprises a group of ultraviolet light lamps (8) with a wavelength lower than 250 millimicron for production of ozone in the air and formation of nascent oxygen.

7. An apparatus according to any one of the preceding claims, in which said washing section (6) comprises a series of partition walls (10) which create a labyrinth route to be followed by the air to be treated, and a series of nozzles (11) to direct said washing liquid under pressure against the surface of said walls and create a barrier of atomised liquid against the passing current of air.

8. An apparatus according to claim 6, in which said partition walls number between 4 and 8.

9. An apparatus according to any one of the preceding claims, comprising an additional washing section upstream of said oxidation section.

10. An apparatus according to any one of the preceding claims, further comprising a re-cycling circuit to purify and re-cycle said washing liquid, said circuit comprising a pump (14), a filter (12) and a settling apparatus (13) for separation of impurities in a solid state and of the precipitate, and a supply device (17) providing fresh reagent to restore the pH concentration to normal.

11. An apparatus according to any one of the preceding claims, in which in the washing or accumulation sections, or in both, the walls are coated with one or
more of the catalysts recited in claim 1, for elimination of residual ozone.

12. An apparatus according to any one of the preceding claims, in which a flow meter is installed in the washing section, to enable switching on of the lamps in the oxidation section only when the mass flow rate of air exceeds a minimum threshold level.

13. Process for the purification of polluted air in an urban environment by means of a mobile apparatus transported by a vehicle, comprising the operations of:

producing nascent oxygen within the polluted air to be purified;

oxidising the pollutants CO, NOₓ to their oxides CO₂ and NO₂ by reaction with nascent oxygen and by passing the polluted air substantially at room temperature through a bed of catalyst based on an oxide of a metal selected from the class consisting of the first series of the transition group of the Periodic System or cupric chromite;

subjecting the flow of air to washing by means of jets of a washing liquid made up of an aqueous solution containing CaO or NH₄CO₃ or both along a serpentine-like route to form insoluble carbonates or sulphates of said higher carbon or nitrogen oxides, as well as of SO₂, and to reduce particulate and unburned materials;

filtering the washing liquid and settling and collecting the insoluble matter and impurities, recovering of the washing liquid, reconditioning and recycling said liquid to the washing operation; and

discharging the purified air into the outer environment.

14. Process according to claim 13, in which said nascent oxygen is produced by means of decomposition of ozone.

15. Process according to claim 13 or 14, in which said catalyst bed is heated by heat exchange from the exhaust fumes of the motor of said vehicle.
16. Process according to claim 11, in which before being discharged into the environments the mass flow rate of air is slowed down in an accumulation chamber to separate the gaseous phase from the atomised liquid phase.
AMENDED CLAIMS

1. A mobile apparatus for the purification of polluted air in a town environment installed on a transport vehicle, characterised in that it comprises:
   an inlet section (3) for the air to be purified;
   an oxidation section (5) following said inlet section, to oxidise CO into CO₂ and nitrogen oxides NOₓ into NO₂ by means of the action of nascent oxygen and a catalyst (9) active at least at room temperature based on an oxide of a metal selected from a class consisting of the first series of the transition group of the Periodic System or on cupric chromite or based on a per se known catalyst comprising Pt or an equivalent noble metal;
   a washing section (6) following said oxidation section to purify the air from said higher carbon and nitrogen oxides and from SO₂ by reaction with hydroxyl ions deriving from lime or sodium bicarbonate or a mixture thereof in solution in an aqueous washing solution to obtain insoluble salts and to reduce nascent oxygen or residual ozone by means of a catalytic filter, as well as particles, dust and unburned substances;
   an apparatus (12, 13) for separation of said insoluble salts from the washing liquid and for renewing and returning said liquid to the washing section;
   a section for discharging the purified air into the external environment, following said washing section; and
   a system (16, 4) for suction of the outside air to introduce said air into the inlet section.

2. An apparatus according to claim 1, in which said sections are contained within a casing mounted on said vehicle as a modular unit.

3. An apparatus according to claim 1 or 2, in which said discharging section is an accumulation chamber (7) with collection bath having an increased flow section in order to slow down the mass flow rate of air and separate the drops of washing liquid from the air transporting said drops, and a catalytic filter for final reduction of
residual ozone.
4. An apparatus according to any one of the preceding claims, in which said catalysts are based on ZnO, MnO₂, CuO or CuCr₂O₄.

5. An apparatus according to any one of the preceding claims, in which the exhaust fumes from the motor of the vehicle or another form of dissipated heat, such as the one available in the cooling circuit of the motor are made to pass in thermal transmission contact with the catalysts in the oxidation station in order to be heated.

6. An apparatus according to any one of the preceding claims, in which said oxidation station comprises a group of ultraviolet light lamps (8) with a wavelength lower than 250 millimicron for production of ozone in the air and formation of nascent oxygen.

7. An apparatus according to any one of the preceding claims, in which said washing section (6) comprises a series of partition walls (10) which create a labyrinth route to be followed by the air to be treated, and a series of nozzles (11) to direct said washing liquid under pressure against the surface of said walls and create a barrier of atomised liquid against the passing current of air.

8. An apparatus according to claim 6, in which said partition walls number between 4 and 8.

9. An apparatus according to any one of the preceding claims, comprising an additional washing section upstream of said oxidation section.

10. An apparatus according to any one of the preceding claims, further comprising a re-cycling circuit to purify and re-cycle said washing liquid, said circuit comprising a pump (14), a filter (12) and a settling apparatus (13) for separation of impurities in a solid state and of the precipitate, and a supply device (17)
providing fresh reagent to restore the pH concentration to normal.

11. An apparatus according to any one of the preceding claims, in which in the washing or accumulation sections, or in both, the walls are coated with one or
more of the catalysts recited in claim 1, for elimination of residual ozone.

12. An apparatus according to any one of the preceding claims, in which a flow meter is installed in the washing section, to enable switching on of the lamps in the oxidation section only when the mass flow rate of air exceeds a minimum threshold level.

13. Process for the purification of polluted air in an urban environment by means of a mobile apparatus transported by a vehicle, comprising the operations of:
 producing nascent oxygen within the polluted air to be purified;
 oxidising the pollutants CO, NO\textsubscript{x} to their oxides CO\textsubscript{2} and NO\textsubscript{2} by reaction with nascent oxygen and by passing the polluted air substantially at room temperature through a bed of catalyst based on an oxide of a metal selected from the class consisting of the first series of the transition group of the Periodic System or cupric chromite or based on a per se known catalyst comprising Pt or an equivalent noble metal;
 subjecting the flow of air to washing by means of jets of a washing liquid made up of an aqueous solution containing CaO or NH\textsubscript{2}CO\textsubscript{3} or both along a serpentine-like route to form insoluble carbonates or sulphates of said higher carbon or nitrogen oxides, as well as of SO\textsubscript{2}, and to reduce particulate and unburned materials;
 filtering the washing liquid and settling and collecting the insoluble matter and impurities, recovering of the washing liquid, reconditioning and recycling said liquid to the washing operation; and
 discharging the purified air into the outer environment.
14. Process according to claim 13, in which said nascent oxygen is produced by means of decomposition of ozone.

15. Process according to claim 13 or 14, in which said catalyst bed is heated by heat exchange from the exhaust fumes of the motor of said vehicle.
STATEMENT UNDER ARTICLE 19

Amendments on page 3 and claims 1 and 13 are of similar content.

Amendments on page 6, line 24 and claim 5 are of similar content.

The above corrections do not add any new matters in the description and claims.

In fact, the per se known catalyst recited on page 3 and 6 and in claims 1 and 13 is mentioned as known in the art on page 6 lines 9 to 14. The recitation of another form of dissipated heat is an obvious equivalent, per se known in the art, of the heat from the exhaust pipe from the motor.

Only in order to expedite the procedure, substitute amended sheets 3, 3a, 6, 6a, 14, 14a, 15, 15a, 16 and 16a are enclosed herewith.
INTERNATIONAL SEARCH REPORT

A. CLASSIFICATION OF SUBJECT MATTER

IPC 6 B01D53/75 B01D53/74 B01D53/88

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 6 B01D B60P B60H

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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<td>DE,C,43 18 738 (LANG VON LANGEN ET AL.) 14 July 1994</td>
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Further documents are listed in the continuation of box C.

| Patent family members are listed in annex. |

* Special categories of cited documents:
  *"A" document defining the general state of the art which is not considered to be of particular relevance
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  *"O" document referring to an oral disclosure, use, exhibition or other means
  *"P" document published prior to the international filing date but later than the priority date claimed

Date of the actual completion of the international search

2 June 1995

Name and mailing address of the ISA

European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+ 31-70) 340-2040, Tx. 31 651 eep nl, Facs (+ 31-70) 340-3016

Authorized officer

Eijkenboom, A

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