

OXYGEN CONTENT ANALYSERS

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5 This invention relates to oxygen content analysers including oxygen sensors, in particular oxygen sensors which may be suitable for use in harsh environments.

US Patent No. US-A-5 037 761 (and corresponding EP-A-0 309 104) discloses the use of an automotive type oxygen sensor, such as a so-called lambda sensor, for sensing oxygen in an industrial process analyser.

10 The use of oxygen sensors for measuring oxygen concentrations in natural gas fired processes is known. When such sensors are used for processes fired with coal or other dirty fuels, errors in accuracy can occur due to SO_2 , NO_x and other combustion by-products. The SO_2 , NO_x and other combustion by-products contaminate the sensing element of the
15 oxygen sensor giving rise to calibration shifts, reduced span (by as much as 35%) and other problems.

In order to minimise the problems described above, it is desirable to increase the operating temperature of the sensor. One approach to increasing the sensor operating temperature was to increase
20 the voltage to the heater inside the sensor. This increase in voltage was effective in minimising the above problems, but resulted in severe reductions in heater life.

The use of previously-proposed oxygen sensors in an industrial process analyser may give rise to an undesirable flashback when the
25 process is ignitable. Therefore, it is desirable that any modification to the oxygen sensor which increases the temperature of the sensor without decreasing its heater life should also act as a flash arrestor thereby to prevent flashback.

According to a first aspect of the present invention there is
30 provided an oxygen content analyser for gas in an industrial process, the analyser comprising an automotive type oxygen sensor in an analyser manifold, the automotive type oxygen sensor having a sensor element assembly including a sensor element and electric heating means, characterised by:

35 a thin-walled perforated shield forming an outer wall of the oxygen sensor assembly, the sensor element being spaced inwardly of the shield and connected to the automotive type oxygen sensor, whereby



calibration shifts due to contamination by SO_2 , NO_x and other combustion by-products in the industrial process are avoided.

If required, insulation material may be provided in the shield and around the sensor element.

5 Thus, according to a preferred embodiment of the invention, an automotive type oxygen sensor is modified by removing its relatively thick protective shield and replacing it with an extremely thin protective shield having a selected number of small holes to control the diffusion rate of gas into the sensor. The inside of the thin shield is filled with a ceramic insulation material of controlled weight and density so as to increase the temperature on the outside surface of the sensor. The thin shield helps to maintain the heat provided by the sensor heater at the sensor thereby to assist in the increase of the operating temperature on the outside surface of the sensor.

10 The foregoing modifications were found to be effective against calibration shifts (offsets) while maintaining a broad measurement span and long useful life of the sensor. The modifications stabilised the sensor output and reduced the errors caused by SO_2 , NO_x and other combustion by-products. It is believed that the modifications also act as a flash arrestor for preventing flashback into an ignitable process.

15 According to a second aspect of the present invention there is provided an oxygen content analyser for gas in an industrial process, the analyser comprising an automotive type oxygen sensor in an analyser manifold, the automotive type oxygen sensor having a sensor element assembly including a sensor element and electric heating means, characterised by:

20 a shield forming an outer wall of the sensor element assembly and having limited permeability therethrough, the sensor element being spaced inwardly of the shield.

25 The permeable or porous material may be a ceramic, and insulation material may be provided in the shield and around the sensor element if required.

30 The invention will now be described by way of example with reference to the accompanying drawings, throughout which like parts are referred to by like references, and in which:

Figure 1 is a schematic diagram showing the use of an automotive type oxygen sensor in conjunction with an associated power supply for analysing the oxygen content of a gas in an industrial process;

5 Figure 2 is a side elevational view of the automotive type oxygen sensor of Figure 1 with portions in section;

Figure 3 is a top plan view with a portion cut away of a shield of the sensor assembly modified according to an embodiment of the present invention;

10 Figure 4 is a side elevational view of the sensor assembly shield of Figure 3, with a portion cut away;

Figure 5 is a side elevational view of a ceramic sensor assembly shield according to another embodiment of the invention; and

Figure 6 is a top plan view of the ceramic shield of Figure 5.

15 Figure 1 is a schematic diagram of a system 10 for analysing the oxygen content of an industrial process by using an automotive type oxygen sensor 20 such as a lambda sensor, and is broadly similar to Figure 1 of the above-mentioned EP-A-0 309 104. In the system 10, a gas sample is drawn from the monitored industrial process through a sample probe 12. The extraction of the sample is typically
20 accomplished through the use of an air powered aspirator (not shown) within the system 10. The gas sample is directed through a passageway 14 in an analyser manifold 16 across a sensor element assembly of the automotive type oxygen sensor 20 and is exhausted back into the gas flow of the industrial process. The analyser manifold 16 is controlled
25 at a substantially constant temperature above the gas stream dew point, typically 300° to 400°F (150° to 205°C). The controlled manifold temperature provides a substantially constant ambient temperature for the automotive type oxygen sensor 20.

The analyser manifold 16 is heated by heaters 22. A temperature
30 sensing element 24 is connected to a temperature control circuit 26. The circuit 26 provides the voltage to the heaters 22. An integral heater (not shown) within the automotive type oxygen sensor 20 is connected to a power supply 30 which is manually adjusted to provide the desired operating temperature at the sensor element assembly 18 of
35 the automotive type oxygen sensor 20. For the environment in which the sensor of EP-A-0 309 104 is typically used, the operating temperature

of the sensor element 18 is in the range of about 1300° to 1400°F (705° to 760°C). Additional details concerning the operation of the analyser can be found in EP-A-0 309 104.

As was described above, when the analyser disclosed in EP-A-0 309 104 is used for processes fired with coal or other dirty fuels, errors in accuracy occur due to SO₂, NO_x and other combustion by-products contaminating the sensor element 40 shown in Figure 2 and forming part of the sensor assembly 18. As was also described above, one approach to minimise the occurrence of accuracy errors is to increase the voltage to the heater inside the sensor thereby to increase the sensor operating temperature to a range of about 1450° to 1550°F (788° to 843°C). This increase in voltage and consequent increase in temperature minimised the occurrence of accuracy errors, but resulted in increased heater failure.

The modification proposed by the preferred embodiment of the present invention makes the sensor more efficient, minimises the occurrence of accuracy errors and allows the operating voltage to the heaters 22 to be reduced thereby increasing the life of the sensor. In the preferred embodiment of the sensor system 10 described herein, the voltage to the heaters 22 is reduced from 18 volts as used with the sensor disclosed in EP-A-0 309 104 to 17 volts. It is the modification described herein which allows the reduction in voltage without causing the operating temperature of the sensor element 18 to fall below the lower limit of the 1450° to 1550°F (788° to 843°C) operating range. The end result is that the errors caused by SO₂ and NO_x and other combustion by-products can now be less than two percent (2%).

In accordance with one embodiment of the present invention, the usual shield provided around the sensor element is replaced with a thin-walled perforated shield 42, as shown in Figures 2 to 4. The shield 42 is cylindrical in shape and has an outer diameter of about 0.499 to 0.512 in. (12.67 to 13.00 mm) and a height of about 0.685 to 0.695 in. (17.4 to 17.65 mm).

The shield 42 has a pattern of perforations best shown in Figures 3 and 4, which provide free flow of gas into and out of the shield. The interior of the shield 42 is packed with fibres or other permeable insulation material 44, for example KAOWOOL material available from The

Babcock and Wilcox Company. The wall thickness of the top of the shield is preferably about 0.015 to 0.020 in. (0.38 to 0.51 mm). The inside diameter of the shield is preferably about 0.467 to 0.470 in. (11.86 to 11.94 mm).

5 In the embodiment shown in Figures 2 to 4, the shield 42 has a total of 21 holes. Each hole has a diameter of about 0.045 in. (1.14 mm). There are four columns 41 of four holes each arranged essentially symmetrically about the outside surface 43 of the shield 42. Three of these columns can be seen in Figure 4. Vertical spacing
10 between the holes in each column 41 is advantageously about 0.1 in. (2.54 mm).

On the top 45 of the shield 42 as shown in Figure 3, four holes are provided in a circle around a central hole. The circle has a diameter of about 0.280 in. (7.11 mm).

15 Advantageously, the shield 42 may be fabricated from number 303 stainless steel. The automotive oxygen sensor 20, prior to modification, may be a stock item provided by the Bosch Company, such as that available under stock number 9F-472, and is primarily used in vehicles manufactured by the Ford Motor Company.

20 Referring to Figure 2, the pre-existing neck 46 in the sensor element assembly is cut off to a height of about 0.140 to 0.150 in. (0.36 to 0.38 mm) and provides the seat for the shield 42. The shield 42 does not have any perforations up to about 0.25 in. (0.64 mm) above the lower end of the shield 42 where the first set of perforations are
25 located.

Alternative embodiments may provide a different number of diffusion holes through a different shield made of the same material as the shield described above, or of another material such as ceramic or other non-metals. The shield may have a different shape than the
30 cylindrical shape or a different hole pattern than the shield shown in Figures 2 to 4. The shield may also be fabricated from any suitable porous material, such as ceramic, with or without any insulation therein.

One example of an alternative embodiment involves a ceramic
35 shield 50 having KAOWOOL material 44 therein as shown in Figures 5 and 6.

The following table shows in the first row the sensor temperature

and heater temperature (in °F) obtained from the sensor described in EP-A-0 309 104 ("Standard" Sensor) with the voltage of the heaters 22 set at 18 VDC and 19 VDC. The table shows in the second row the sensor temperature and heater temperature (in °F) obtained from a sensor
5 according to the embodiment of the present invention shown in Figures 2 to 4 having a shield insulated with 0.34 to 0.36 gm of KAOWOOL material with the heater voltage respectively set at 17 VDC, 18 VDC and 19 VDC. The table shows in the third row the sensor temperature and heater temperature (in °F) obtained from a sensor as shown in Figures
10 2 to 4, but without any insulation, for a heater voltage of 18 VDC.

TABLE

SENSOR TEMPERATURE/HEATER TEMPERATURE			
SENSOR HEATER VOLTAGE	17 VDC	18 VDC	19 VDC
SENSOR CONFIGURATION			
STANDARD	---	1417/1947	1473/2044
PERFORATED METAL SHIELD AND INSULATION	1501/1936	1554/2032	1633/2134
METAL SHIELD ONLY	---	1507/1940	---
Initial Testing: 18 VDC and standard sensor. Heater life OK, but sensor temperature too low for good performance in a harsh environment. 2nd Round: 19 VDC and standard sensor. Sensor performance good but heater life too short. 3rd Round: 18 VDC and modified sensor. Sensor performance good but heater life too short (even though only 18 VDC). Final Round: 17 VDC and modified sensor. Sensor temperature still high enough for good performance and heater temperature low enough for good life.			

CLAIMS

1. An oxygen content analyser for gas in an industrial process, the analyser comprising an automotive type oxygen sensor (20) in an
5 analyser manifold (16), the automotive type oxygen sensor (20) having a sensor element assembly including a sensor element (40) and electric heating means (22), characterised by:

a thin-walled perforated shield (42) forming an outer wall of the oxygen sensor assembly, the sensor element (40) being spaced inwardly
10 of the shield (42) and connected to the automotive type oxygen sensor (20) and insulation material (44) being provided in the shield (42) and around the sensor element (40), whereby calibration shifts due to contamination by SO_2 , NO_x and other combustion by-products in the industrial process are avoided.

15

2. An analyser according to claim 1, wherein the shield (42) is cylindrical and has a plurality of holes therethrough.

3. An analyser according to claim 2, wherein the holes are provided
20 in a plurality of vertical rows (41) on the side of the shield (42) and a pattern of holes on the top (45) of the shield (42).

4. An oxygen content analyser for gas in an industrial process, the analyser comprising an automotive type oxygen sensor (20) in an
25 analyser manifold (16), the automotive type oxygen sensor (20) having a sensor element assembly including a sensor element (40) and electric heating means (22), characterised by:

a thin-walled perforated shield (42) forming an outer wall of the oxygen sensor assembly, the sensor element (40) being spaced inwardly
30 of the shield (42) and connected to the automotive type oxygen sensor (20), whereby calibration shifts due to contamination by SO_2 , NO_x and other combustion by-products in the industrial process are avoided.

5. An analyser according to claim 4, including insulation material
35 (44) in the shield (42) and around the sensor element (40).





6. An oxygen content analyser for gas in an industrial process, the analyser comprising an automotive type oxygen sensor (20) in an analyser manifold (16), the automotive type oxygen sensor (20) having a sensor element assembly including a sensor element (40) and electric heating means (22), characterised by:
- 5

a shield (50) forming an outer wall of the sensor element assembly and having limited permeability therethrough, the sensor element (40) being spaced inwardly of the shield.

- 10 7. An analyser according to claim 6, including insulation material (44) in the shield (50) and around the sensor element (40).

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ABSTRACTOXYGEN CONTENT ANALYSERS

5 In an oxygen analyser for an industrial process, an automotive
type oxygen sensor (20) has a sensor element assembly with an outer
thin-walled shield (42) containing insulation (44) and surrounding the
sensor element (40) of the sensor (20). The shield (42) is either
10 perforated with holes, or is made of a porous material such as a
ceramic.

Figure 2

FIG. 1

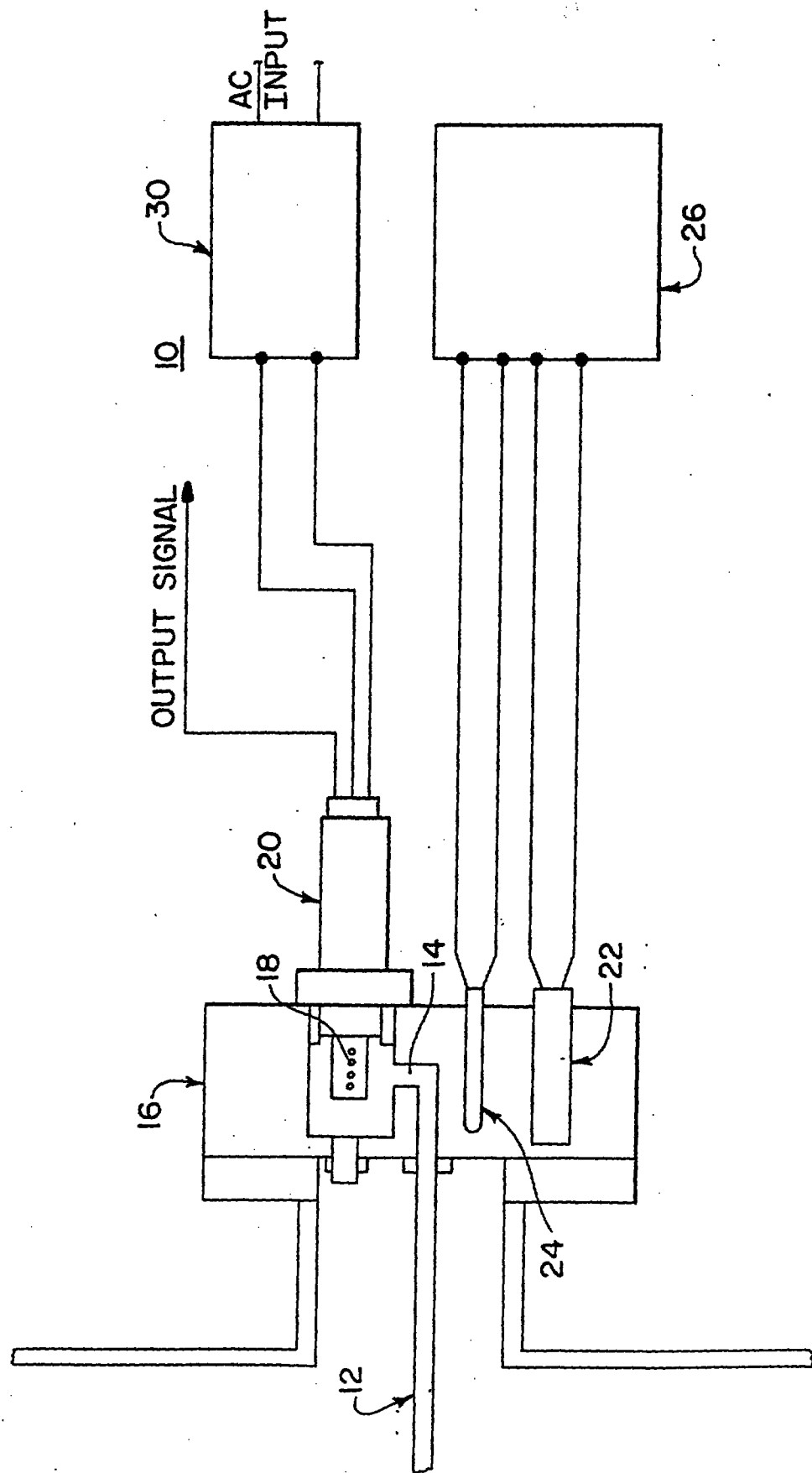


FIG. 2

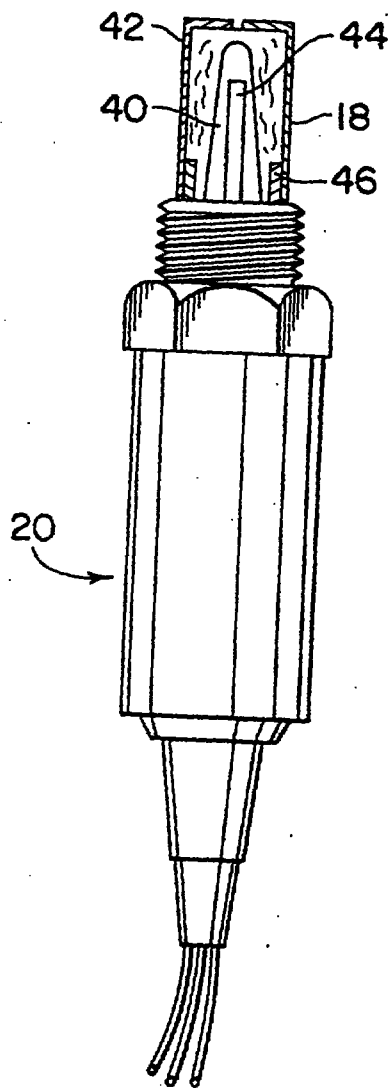


FIG. 3

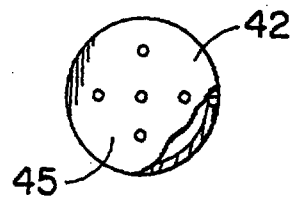


FIG. 4

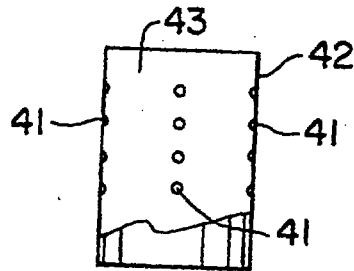


FIG. 5

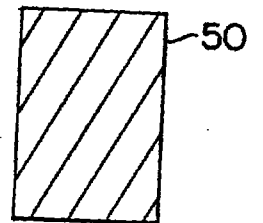
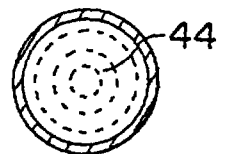


FIG. 6



OXYGEN CONTENT ANALYSERS

This invention relates to oxygen content analysers including oxygen sensors, in particular oxygen sensors which may be suitable for use in harsh environments.

US Patent No. US-A-5 037 761 (and corresponding EP-A-0 309 104) discloses the use of an automotive type oxygen sensor, such as a so-called lambda sensor, for sensing oxygen in an industrial process analyser.

The use of oxygen sensors for measuring oxygen concentrations in natural gas fired processes is known. When such sensors are used for processes fired with coal or other dirty fuels, errors in accuracy can occur due to SO_2 , NO_x and other combustion by-products. The SO_2 , NO_x and other combustion by-products contaminate the sensing element of the oxygen sensor giving rise to calibration shifts, reduced span (by as much as 35%) and other problems.

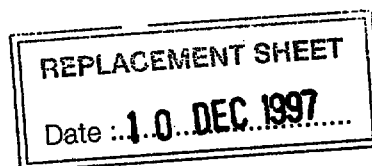
In order to minimise the problems described above, it is desirable to increase the operating temperature of the sensor. One approach to increasing the sensor operating temperature was to increase the voltage to the heater inside the sensor. This increase in voltage was effective in minimising the above problems, but resulted in severe reductions in heater life.

The use of previously-proposed oxygen sensors in an industrial process analyser may give rise to an undesirable flashback when the process is ignitable. Therefore, it is desirable that any modification to the oxygen sensor which increases the temperature of the sensor without decreasing its heater life should also act as a flash arrestor thereby to prevent flashback.

SUMMARY OF THE INVENTION

It is an object of the present invention to ameliorate one or more disadvantages of the prior art.

According to one aspect of the present invention there is provided a method of modifying a shielded automotive sensor assembly having an integral heater to heat the sensor to a range of 705°C to 760°C (1300°F to 1400°F) in response to a predetermined elevated voltage applied to the heater to have the automotive sensor act as an industrial process oxygen sensor comprising the steps of: replacing the automotive oxygen sensor shielding with a thin wall shield; packing a space between said thin wall shield and the sensor with an insulating material; lowering the voltage to the automotive sensor heater below the predetermined elevated voltage to approximately 17 VDC; and providing predetermined perforations in the thin wall shield to allow a predetermined free flow of gas through said packing and to the sensor which will raise and maintain the sensor temperature above 788°C (1450°C) while lowering the operating temperature of said heater below its usual operating temperature without said predetermined perforations at



said lower voltage thus minimising combustion by-product errors and calibration shifts while increasing the life of the sensor.

According to another aspect of the present invention there is provided in a method of modifying a shielded automotive sensor assembly having an integral sensor shield and heater operating at approximately 1064°C (1947°F) to heat the sensor to approximately 769°C (1417°F) in response to a predetermined elevated voltage of approximately 18 VDC applied to the heater to thus have the automotive sensor act as an industrial process oxygen sensor for harsh environments comprising coal combustion processes which require the oxygen sensor to operate above 816°C (1500°F) for extended period of time, the improvement comprising the steps of: replacing the normally found automotive oxygen sensor shielding with a thin wall shield having packing between the sensor and said thin wall shield; lowering the voltage to the automotive sensor heater to approximately 17 VDC; and providing predetermined perforations in the thin wall shield to allow a predetermined free flow of gas through said thin wall shield and packing to the sensor which will raise and maintain the sensor temperature above 816°C (1500°F) while lowering the operating temperature of said heater below its operating temperature at 18 VDC with the normally found shield to thus minimising combustion by-product errors and calibration shifts while increasing the life of the sensor.

DESCRIPTION OF THE PREFERRED EMBODIMENT(S)

The invention will now be described by way of example with reference to the accompanying drawings, throughout which like parts are referred to by like references, and in which:



CLAIMS

1. A method of modifying a shielded automotive sensor assembly having an integral heater to heat the sensor to a range of 705°C to 760°C (1300°F to 1400°F) in response to a predetermined elevated voltage applied to the heater to have the automotive sensor act as an industrial process oxygen sensor comprising the steps of:

replacing the automotive oxygen sensor shielding with a thin wall shield;

packing a space between said thin wall shield and the sensor with an insulating material;

lowering the voltage to the automotive sensor heater below the predetermined elevated voltage to approximately 17 VDC; and

providing predetermined perforations in the thin wall shield to allow a predetermined free flow of gas through said packing and to the sensor which will raise and maintain the sensor temperature above 788°C (1450°C) while lowering the operating temperature of said heater below its usual operating temperature without said predetermined perforations at said lower voltage thus minimising combustion by-product errors and calibration shifts while increasing the life of the sensor.

2. A method as set forth in claim 1 where said insulating material is a ceramic fiber.

3. A method as set forth in claim 1 wherein said thin wall shield is made from a porous ceramic material.

4. A method as set forth in claim 1 wherein said thin wall shield comprises number 303 stainless steel having four columns of four holes each arranged symmetrically about the outside surface of the shield and four holes circularly arranged along the top of the shield.

5. In a method of modifying a shielded automotive sensor assembly having an integral sensor shield and heater operating at approximately 1064°C (1947°F) to heat the sensor to approximately 769°C (1417°F) in response to a predetermined elevated voltage of approximately 18 VDC applied to the heater to thus have the automotive sensor act as an industrial process oxygen sensor for harsh environments comprising coal combustion



processes which require the oxygen sensor to operate above 816°C (1500°F) for extended period of time, the improvement comprising the steps of:

replacing the normally found automotive oxygen sensor shielding with a thin wall shield having packing between the sensor and said thin wall shield;

lowering the voltage to the automotive sensor heater to approximately 17 VDC;
and

providing predetermined perforations in the thin wall shield to allow a predetermined free flow of gas through said thin wall shield and packing to the sensor which will raise and maintain the sensor temperature above 816°C (1500°F) while lowering the operating temperature of said heater below its operating temperature at 18 VDC with the normally found shield to thus minimising combustion by-product errors and calibration shifts while increasing the life of the sensor.