This invention relates to a sensor that can be used in an exhaust system for sensing the relative presence of oxygen in the exhaust stream. The sensor includes a hollow zirconia element that is conical in shape, and is closed at one end with the zirconia element having platinum electrodes on the inside and outside surfaces. A mounting device that is constructed of easily assembled parts supports the zirconia element. The sensor is constructed and adapted to be mounted in the automobile exhaust stream so as to expose the outside of the zirconia element to the exhaust stream and the inside to atmosphere. A shield that protects the outside of the zirconia element is attached to the mounting device to prevent erosion of the electrode coating. Because of the diverse thermal expansion rates of the components that make up the sensor, a mica insulator is included as an essential element in the assembly to maintain a tight seal between the different component parts and assure electrical continuity.

6 Claims, 4 Drawing Figures
AIR FUEL RATIO SENSOR

A high temperature zirconia element of the electrolyte type has been used as a sensor of unburned constituents in furnace stack gases, and is described in Hickman U.S. Pat. No. 3,347,767 Device for Monitoring Oxygen content of Gases, dated Oct. 17, 1967. A similar element has also been used as an automobile exhaust gas sensor, such a sensor being shown and described in Eddy U.S. Pat. No. 3,616,274 Method and Apparatus for Monitoring Exhaust Gas, dated Oct. 26, 1971.

In the general operation of such sensors, air passes or flows into the center of the zirconia element and when the zirconia element is activated by the heat of the exhaust gases passing around it, oxygen ions conduct through the element from atmosphere to the outer electrode, the overall effect being to create a simple electrochemical cell which develops a potential difference between the two electrodes. The cell output voltage indicates the partial pressure of oxygen at the surface exposed to the exhaust gas. In use in an automobile, as the air-fuel ratio becomes leaner the oxygen concentration in the exhaust gas increases, and the ratio of partial pressures between the outside and inside of the cell approaches unity whereupon the output voltage drops to near zero. When the air-fuel ratio becomes richer, oxidizable gases such as carbon monoxide and hydrogen exist. With such conditions, it is convenient to think of the sensor as a miniature electrochemical fuel cell in which these gases become a fuel source for the cell. At the exhaust side of the sensor the platinum electrode catalytically enhances chemical oxidation reaction which in turn depletes the concentration of oxygen at that surface. A low surface concentration of oxygen results and the sensor voltage rises to generate an EMF signal logarithmically proportional to the relative concentrations of combustible gases in the exhaust. This signal is used in combination with other components to adjust and maintain desired engine air fuel mixtures.

Prior art devices, constructed similar to that of the present invention and used in automobile exhaust systems generally include a mounting means to hold the zirconia element wherein the zirconia element extends the full length of and beyond the ends of the mounting means, with the end of the zirconia element exposed to the exhaust stream extending substantially beyond the lower end of the mounting means. With such an arrangement, the zirconia element requires a substantial amount of zirconia and platinum to make up the element and electrodes, and in addition the prior art devices use a rather expensive and complex mounting system of sleeves and insulators to retain the zirconia element within the mounting means.

The present invention uses a zirconia element as an air-fuel ratio sensor in an automobile exhaust system to detect rich and lean air-fuel conditions that does not extend the full length of the mounting means and therefore requires less material than prior art devices and therefore provides a cost savings in the zirconia base element as well as a savings in the platinum used to make the electrodes. Also the mounting means is made up of parts that are relatively inexpensive to manufacture and are more easily assembled than those of the prior art and includes a material such as mica not found in the prior art devices to compensate for the expansion and contraction of the several diverse materials used, to thereby assure a tight seal between the zirconia element and mounting means. A tight seal is necessary to assure that there are no exhaust gases introduced into the center of the sensor to contaminate the air that passes onto the inner electrode in the center.

It is therefore an object of this invention to provide an exhaust gas sensor that includes a zirconia element that is shorter in length than prior art devices and therefore less expensive to manufacture.

A further object is to provide an exhaust gas sensor in which the zirconia element is easily adaptable to mounting in a compact, easily manufactured and assembled mounting system.

A further object is to provide an exhaust gas sensor in which the zirconia element is easily adaptable to an interchangeable mounting means.

Another object is to provide a mica gasket in the sensor that will compensate for the expansion and contraction of the several different parts having different coefficients of thermal expansion that make up the sensor to thereby provide and maintain a gas-tight seal and electrical contact between the parts.

Further objects and advantages of the present invention will be apparent from the following description, reference being had to the accompanying drawings in which:

FIG. 1 is a side view of the preferred embodiment of the invention showing the sensor in partial cross section mounted in an exhaust pipe;

FIG. 2 is a view in the direction of line 2—2 of FIG. 1, showing the configuration of the openings in the shield;

FIG. 3 is a side view of a second embodiment showing the sensor in partial cross section; and

FIG. 4 is a sectional view taken along line 4—4 of FIG. 3, showing the configuration of the openings in a second embodiment of the shield.

Referring to FIG. 1, the sensor 10 includes a hollow outer metal shell member 12, with the upper section of the interior being larger in diameter than the lower section, thereby forming a shoulder 14 within the shell. The shoulder thus is generally located intermediate the ends. Threads 16 are used to mount the sensor to the exhaust pipe 18.

A zirconia element 20 is positioned on and supported by shoulder 14. Element 20 is hollow and has a thin wall construction 24 that tapers from the thinnest section of the element that begins at a closed small diameter end 22 generally bulbous in shape, and terminates in a thicker section at the opposite end, which end has an enlarged diameter section 26 that forms upper and lower shoulders 27,29 respectively thereon with the zirconia element thereby having a generally conical shape. The lower shoulder 27 is positioned on a metal gasket 28 that is located on shoulder 14. Element 20 has a platinum coating 30 on the inside surface and a platinum coating 32 on the outside surface, with the coatings extending respectively only up to the ends of the upper and lower shoulders. The area 34 between shoulders 27,29 is not platinum coated and thus separates the two platinum coated areas to form an inner electrode 33 and an outer electrode 35 on the zirconia element out of direct electrical contact with each other. The outer electrode 35, metal gasket 28, and grounded outer shell 12 provide for one electrical contact means or circuit portion.
A body member 37 is held within the outer shell by the crimped or rolled over top 36 of the shell and ceramic insulator 40, these members being considered as clamping means. A washer or gasket 38 may be positioned between crimp 36 and insulator 40. Body 37 is positioned on a metal gasket 42, located on the upper shoulder 29 and inner electrode 33 of zirconia element 20 to provide a second electrical contact means or circuit portion through terminal connector 44. The contact means are insulated from each other by the ceramic insulator 40 and the circumferential space 46 between the body 37 and the shell. Centerbore 45 is provided in the body member 37 extending therethrough to provide a passage for introducing air into the hollow zirconia element.

An essential feature of this invention is to include a mica insulating gasket 47 between the bottom of the ceramic insulator 40 and shoulder 49 formed on the body member 37. The mica solves a problem that has been experienced in the past in maintaining a satisfactory mechanical gas-tight seal between the parts. It is essential to preclude any exhaust gases from entering the interior of the zirconia element to avoid contamination of the air within the zirconia element and give a false signal, and further to assure good electrical contact between the electrodes on the zirconia element and the other parts of the sensor. Mica has a thermal expansion coefficient on the order of 5 to 10 times that of the zirconia element, and thereby compensates for the lower expansion of the zirconia element relative to the other metal members.

A shield 48 as best seen in FIG. 1 is attached by any convenient means to the outer shell and has a plurality of struck out vane shaped openings 50 that are positioned in the exhaust stream to cause the exhaust gases to reach the zirconia element in an indirect manner, so as not to erode the outer platinum coating. The areas 52 adjacent and leading into the struck out openings are concave to direct the exhaust gases into the openings in a tangential or circular flow path.

A second embodiment 60, similar in most respects to that shown in FIG. 1, is shown in FIG. 3 and includes a hollow outer shell 62, that also includes threads 64 to mount the sensor to the exhaust pipe 66. Outer shell 62 includes a shoulder 68 within the shell to position the zirconia element 20. As in the embodiment of FIG. 1, a metal gasket 70 is inserted within the grounded outer shell between the shoulder 68 and shoulder 27 of zirconia element 20 to form a first electrical contact means.

A body member 72 having an air entrance opening 77 is inserted within outer shell 62 and rests on a second metal gasket 74 and the upper shoulder 29 of zirconia element 20 to form a second contact means with terminal 73. Body member 72 and zirconia element 20 are clamped within the outer shell member by a nut 75 or similar means that allows easy interchangeability of the zirconia element. A mica insulating gasket 76 that performs the same function as mica insulating gasket 47 is located on a shoulder on body member 72.

As an alternative to that shown in FIG. 1, a shield 78 is attached to the outer shell member 62 and is placed in the exhaust stream in the same manner as the shield described and shown in FIG. 1 and generally has the same configured openings 50 and concave portions 52 leading into openings 50. Shield 78 may be constructed in two sections, a bottom section 80 that is inserted into and attached to the circular body section 82 by welding or edge crimping.

Air sensors of the types described above are useful for the operation of equipment that will adjust air-fuel ratios very quickly readily as they become richer or leaner during operation of an automobile. Since such a sensor may be used on most automobiles, it is essential that the item be made as economically and simply as possible. The sensor as described in the claims is easy to manufacture, is economical and is a simple device that accomplishes the desired objects.

While the embodiments of the invention as herein disclosed constitute a preferred form, it is to be understood that other forms could be adopted within the scope of the claims which follow.

We claim:

1. An exhaust gas sensor for measuring the relative presence of oxygen in an exhaust system comprising: a hollow metal shell having a shoulder therein, a first metal gasket on said shoulder, a conically shaped hollow zirconia element positioned within said hollow metal shell on said gasket having one end closed and thin walls tapering from the thinnest section that begins at the closed end and terminates in a thicker section at the opposite end, which end has an enlarged diameter that forms a top shoulder and a bottom shoulder, said zirconia element having a platinum coating on the inside and outside surfaces including the top and bottom shoulders to form inner and outer electrodes on said zirconia element with the enlarged diameter portion between the top and bottom shoulders being uncoated, said bottom shoulder of said zirconia element being in contact with said first metal gasket to form a first electrical contact means between said outer shell and said outer electrode, a second metal gasket on the top shoulder of said zirconia element that provides electrical contact with the inner electrode on said zirconia element and a metal body member placed thereon forming a second contact means with a terminal on said body member, said outer shell member including clamping means to retain said zirconia element, body, gaskets and said body member in a gas tight relationship, and mica means between said body member and clamping means to compensate for the different expansion and contraction rates of the different components assembled in gas tight relationship to maintain such relationship through the operating life of the sensor.

2. An exhaust gas sensor for measuring the relative presence of oxygen in an exhaust system comprising: a hollow metal shell having a shoulder formed on the inner surface thereof intermediate its ends and being adapted to be mounted in an exhaust gas conduit, a first metal gasket on said shoulder, a conically shaped hollow zirconia element positioned within said hollow metal shell and having its small diameter end closed and adapted to be exposed to the exhaust gas, the large diameter end open of said zirconia element being joined with an enlarged diameter portion on the outer surface thereof to form a top shoulder and a bottom shoulder, a platinum coating provided on the inside and outside surfaces of said zirconia element including the top and bottom shoulders to form inner and outer electrodes thereon, the surfaces of said enlarged diameter portion between said shoulders being uncoated, the bottom shoulder of said zirconia element being positioned in contact with said first metal gasket to complete an electrical path between said metal shell and
said outer electrode, a second metal gasket on the top shoulder of said zirconia element to complete an electrical path between the inner electrode and a metal body member positioned thereon, said body member having an electrical terminal provided thereon, the open end of said zirconia element being positioned within the end of said metal shell, clamping means provided on the end of said shell to retain said zirconia element in gas tight relationship with said shell, mica means between said metal body member and said clamping means to compensate for the different expansion and contraction rates of the different components assembled in gas tight relationship within said shell and thus seal exhaust gas from the inner electrode, and a shield provided on the end of said shell and about the small diameter end of said zirconia element to protect the outer electrode from the direct impact of the exhaust gas.

3. An exhaust gas sensor for measuring the relative presence of oxygen in an exhaust system comprising: a hollow metal shell having a shoulder formed on the inner surface thereof intermediate its ends and being adapted to be mounted in an exhaust gas conduit, a first metal gasket on said shoulder, a conically shaped hollow zirconia element positioned within said hollow metal shell and having its small diameter end closed and adapted to be exposed to the exhaust gas, the large diameter open end of said zirconia element being joined with an enlarged diameter portion on the outer surface to form a top shoulder and a bottom shoulder, a platinum coating provided on the inside and outside surfaces of said zirconia element including the top and bottom shoulders to form inner and outer electrodes thereon, the surface of said enlarged diameter portion between said shoulders being uncoated, the bottom shoulder of said zirconia element being in contact with said first metal gasket to complete an electrical path between said metal shell and said outer electrode, a second metal gasket on the top shoulder of said zirconia element to complete an electrical path between the inner electrode and a metal body member positioned thereon, said body member having an electrical terminal provided thereon, the open end of said zirconia element being positioned on the shoulder formed on the inner surface of said metal shell to thereby position the top shoulder within the end of said metal shell below the end thereof, mica means positioned on a shoulder on said metal body member to compensate for the different expansion and contraction rates of the different components assembled within said shell, a nut threadably attached to said metal shell that is in contact with the mica means to retain said zirconia element in gas tight relationship with said shell and thus prevent exhaust gas from reaching the inner electrode, and a shield provided on the end of said shell that encircles the small diameter end of said zirconia element to protect the outer electrode from the direct impact of the exhaust gas.

4. An exhaust gas sensor for measuring the relative presence of oxygen in an exhaust system comprising: a hollow metal shell having a shoulder formed on the inner surface thereof intermediate its ends and being adapted to be mounted in an exhaust gas conduit, a first metal gasket on said shoulder, a conically shaped hollow zirconia element positioned within said hollow metal shell and having its small diameter end closed and adapted to be exposed to the exhaust gas, the large diameter open end of said zirconia element being joined with an enlarged diameter portion on the outer surface to form a top shoulder and a bottom shoulder, a platinum coating provided on the inside and outside surfaces of said zirconia element including the top and bottom shoulders to form inner and outer electrodes thereon, the surface of said enlarged diameter portion between said shoulders being uncoated, the bottom shoulder of said zirconia element being in contact with said first metal gasket to complete an electrical path between said metal shell and said outer electrode, a second metal gasket on the top shoulder of said zirconia element to complete an electrical path between the inner electrode and a metal body member positioned thereon, said body member having an electrical terminal provided thereon, the open end of said zirconia element being positioned within the end of said metal shell, mica means positioned on a shoulder on said metal body member to compensate for the different expansion and contraction rates of the different components assembled within said shell, a spacer means in contact with the mica means and held in such position by said metal shell to retain said zirconia element in gas tight relationship with said shell and thus prevent exhaust gas from reaching the inner electrode, and a shield provided on the end of said shell that encircles the small diameter end of said zirconia element to protect the outer electrode from the direct impact of the exhaust gas.

5. An exhaust gas sensor as set forth in claim 4, wherein said spacer means is an insulator.

6. An exhaust gas sensor as set forth in claim 4, wherein said spacer means is a metal nut that is spaced from said body member and is attached to said outer shell.

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