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McIntyre et al.

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[54] **GAS MEASURING PROBE FOR INDUSTRIAL APPLICATIONS**

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Related U.S. Application Data

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[52] **U.S. Cl.** ..... **204/195 S;** 204/1 T

[51] **Int. Cl.²** **G01N 27/46**

[58] **Field of Search** ..... 204/1 T, 195 S

[56] **References Cited**

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3,481,855	12/1969	Kolodney et al.	204/195 S
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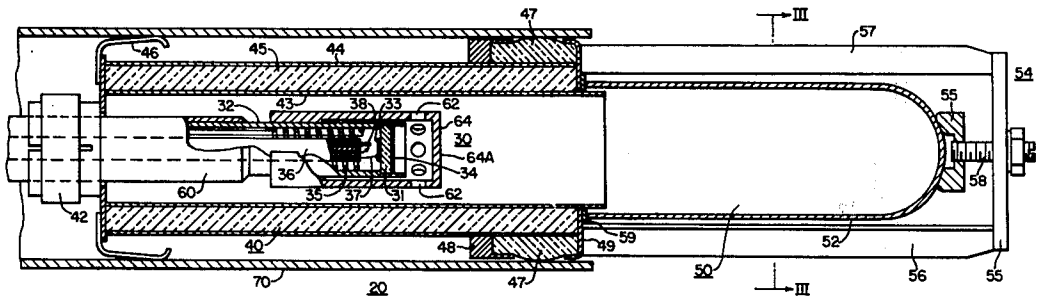
Primary Examiner—T. Tung

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[57] **ABSTRACT**

The invention pertains to improved gas analyzers including solid electrolyte oxygen analyzing devices whereby through the use of a protective fitter-shield exhibiting suitable porosity for the diffusion of gases and sufficient strength to withstand particulate impingement a solid electrolyte analyzer may be inserted directly into a gas stream of environment such as a flue, stack or boiler in the presence of particulate matter such as fly ash, cinder, etc. to provide instantaneous, in situ, measurement of oxygen while preventing damaging contact of the particulate matter with the oxygen analyzer. Further included is a gas deflecting device associated with the porous protective shield to establish a gas flow pattern about the protective shield to prevent direct contact by large particulate matter in the gas flow while directing the gas flow in such a manner across the surface of the protective shield to provide a cleaning action.

3 Claims, 5 Drawing Figures



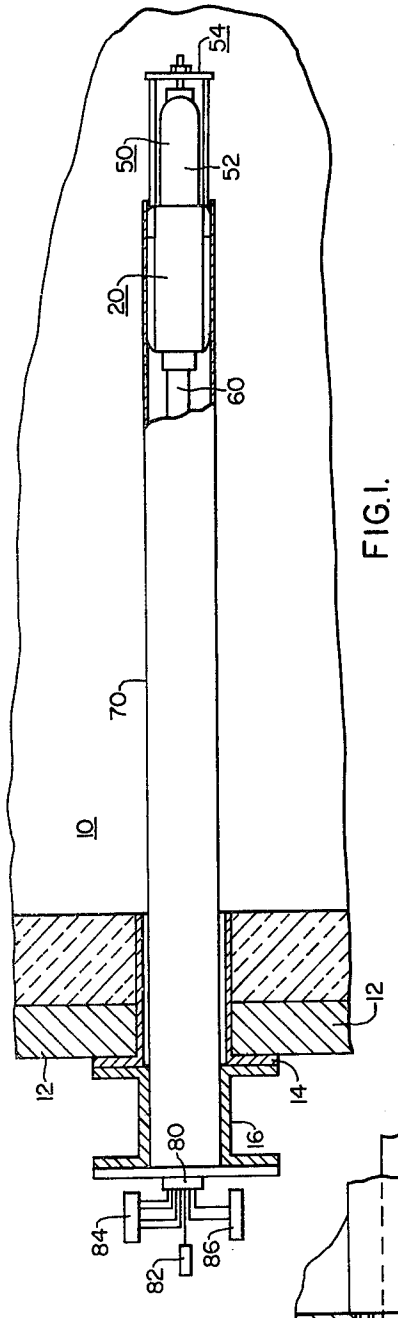


FIG. 1.

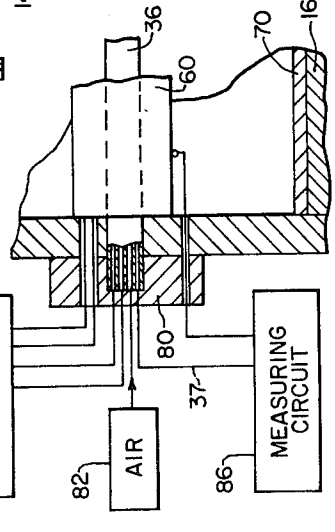


FIG. 1A.

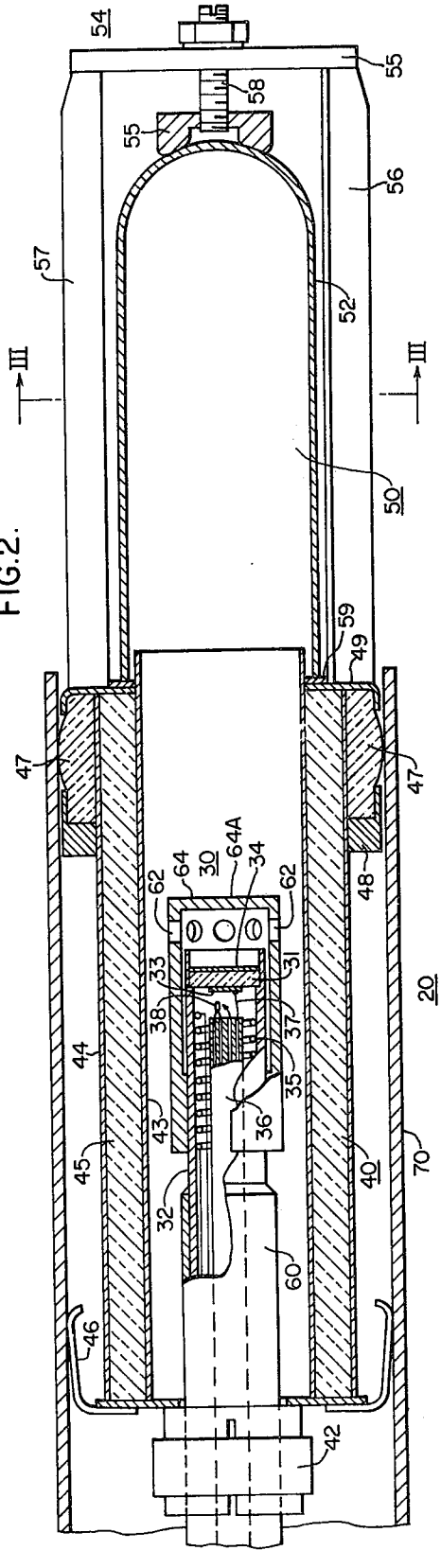
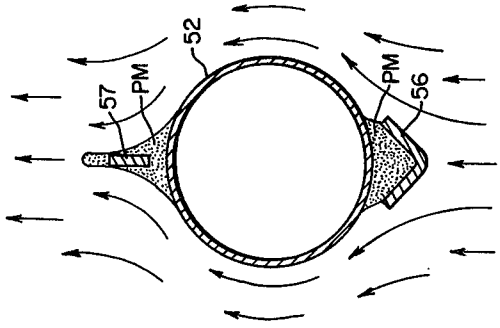


FIG. 2.

FIG. 3.



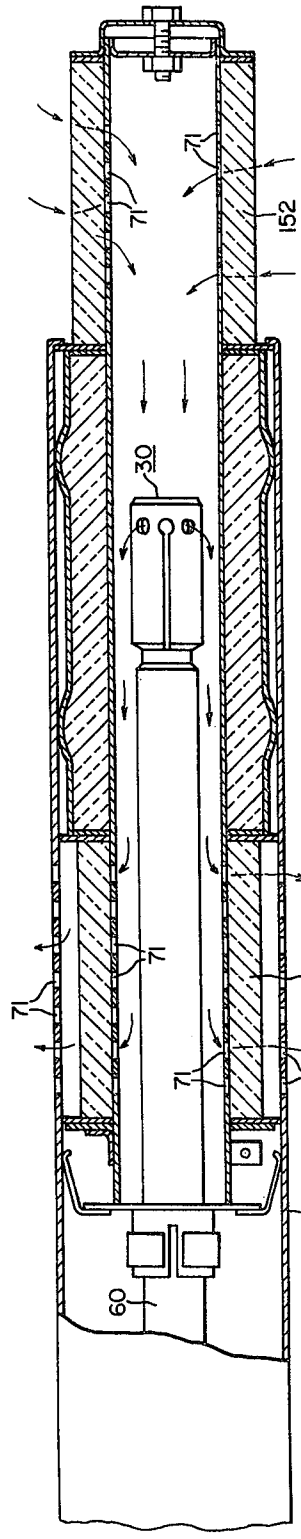


FIG. 4.

GAS MEASURING PROBE FOR INDUSTRIAL APPLICATIONS

This is a division of application Ser. No. 247,368 filed Apr. 25, 1972.

BACKGROUND OF THE INVENTION

Oxygen analyzers presently being marketed for industrial applications generally require a relatively clean gas sample in order to avoid oxygen analyzer failure due to damage caused by foreign matter or unacceptable operation caused by build-up of foreign matter about the oxygen sensor. The limitations of the presently available oxygen analyzers precludes the use of the oxygen analyzer for direct measurements within coal-fired furnaces and boilers wherein large amounts of particulate matter are present. The adaptation of conventional solid electrolyte oxygen analyzers for measurement of oxygen in environments containing foreign matter generally requires the use of a gas sampling system intermediate the source of gas and the oxygen analyzer to perform the function of cleaning and preconditioning the gas sample which is extracted from the working environment and subsequently supplied to the gas analyzer. Although this technique has been widely used, it requires continuous maintenance due to the operational failure of the sampling system. In addition, the time required for the gas sample to travel from the sampling point through the sampling system to the analyzer is too long to permit effective use of the measurement of the oxygen content for use in a closed loop or feedback control application.

SUMMARY OF THE INVENTION

The invention described herein in conjunction with the exemplary embodiment of the drawings relates to a solid electrolyte oxygen analyzer probe assembly inserted within a porous refractory shield comprised of ceramic or metal in the form of a cylinder or a thimble wherein the shield provides rapid diffusion of the oxygen to the solid electrolyte oxygen sensor for rapid in situ measurement of the oxygen present within an industrial environment, such as a furnace, boiler, stack, etc. The protective shield prevents the passage of dust and particulate matter, such as fly ash, from contacting the oxygen sensing element while allowing the rapid diffusion of the hot gases to reach the sensing element. In industrial environments containing significant percentages of particulate matter and matter of significant size, a gas deflector element is positioned relative to the gas flow to deflect the large particles from direct contact with the protective shield while at the same time directing the flow of gas across the surface of the protective shield to provide a wiping or cleaning action, thus avoiding build-up of foreign matter on the protective shield, which could result in restriction of the diffusion of the oxygen gas through the protective shield to the oxygen sensing element.

While the embodiment chosen to illustrate the porous protective shield is that of an oxygen analyzer, it is apparent that the protective shield is equally applicable to gas analyzers in general when subjected to environments containing particulate matter.

The invention will become more readily apparent from the following exemplary description in connection with the accompanying drawings.

DESCRIPTION OF THE DRAWINGS

FIG. 1 is a schematic illustration of a typical application of the solid electrolyte oxygen probe assembly;

FIG. 1A is an enlarged detail schematic illustration of the interconnect section of the assembly at FIG. 1;

FIG. 2 is a detailed sectioned schematic illustration of the oxygen probe assembly of FIG. 1;

FIG. 3 is a section view 3—3 of the probe assembly of FIG. 2 illustrating the gas flow pattern established by the gas deflector element; and

FIG. 4 is a sectioned schematic illustration of an alternate embodiment of the invention utilizing a first and second porous filter element.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring to FIG. 1, there is illustrated a typical embodiment of a solid electrolyte oxygen probe assembly **10** inserted within the wall **12** of a furnace F to monitor the oxygen content of the furnace environment. The furnace F is provided with an insertion flange **14** providing entry from outside the wall **12** into the furnace environment. The probe assembly **10** is secured to the furnace flange **14** by means of flange **16.** The probe assembly **10** is comprised of solid electrolyte oxygen sensor assembly **20,** porous protective shield **50** and tubular extension member **60** for positioning the combination of the oxygen sensor assembly **20** and protective shield **50** within the stationary tubular support member **70.** Supporting apparatus for the operation of the solid electrolyte oxygen cell assembly **20** is typically illustrated in U.S. Pat. No. 3,546,086, entitled Device For Oxygen Measurement, issued Dec. 8, 1970 and assigned to the assignee of the present invention. This includes an interconnect assembly **80** for supplying oxygen reference gas from reference source **82** to the cell assembly **20** as well as providing signal leads for a temperature sensing element in the cell assembly **20** for monitoring cell temperature by temperature controller **84.** The electrical signal developed by the solid electrolyte electrochemical cell assembly **20** in response to the oxygen content of the furnace environment is transmitted to the EMF measuring or recording apparatus **86** through the interconnect assembly **80.** While the signal developed by the cell assembly **20** is indicated as being utilized for record or measurement purposes, it is equally applicable for use as a feedback signal to control a combustion apparatus as illustrated in U.S. Pat. No. 3,404,836, entitled Heat Generating Apparatus, and issued Oct. 8, 1968. The scheme of interconnections of the probe assembly **10** with units **82,84** and **86** is illustrated in FIG. **1A.**

There is illustrated in FIG. **2** a sectioned schematic representation of the combination of the solid electrolyte oxygen sensor assembly **20** and the protective shield assembly **50.** The oxygen sensor assembly **20** is comprised of solid electrolyte cell assembly **30** which is secured to the tubular extension member **60** and which in turn is fixedly secured within a tubular insulating member **40** by the clamp **42.** The tubular thermal insulating member **40** is in the form of a tubular can typically constructed of inner and outer walls **43** and **44** within which is packed a thermal insulating material **45** which functions to effectively insulate the temperature sensitive oxygen solid electrolyte cell assembly **30** from heat transfer from the temperature environment existing within the furnace environment. Attached to the

tubular member **40** are spring members **46** which in conjunction with the cylindrical sealing collar **47** function to stably align and position the combination of the oxygen sensor assembly **20** and the protective shield assembly **50** within the stationary tubular member **70.** The sealing collar **47** which is in the form of a collar positioned about the tubular thermal insulating member **40** is illustrated as comprised of the same thermal insulating material utilized within the walls of the tubular thermal insulating member **40** and provides an effective diameter sufficient to provide essentially a force-fit of the combination of assemblies **20** and **50** within the tubular member **70.** The sealing collar **47,** in addition to providing alignment of the assembly combination, also serves to provide a barrier whereby particles in the furnace environment are prevented from traveling within the tubular member **70,** thus avoiding a build-up of foreign matter which could adversely affect the insertion and removal of the probe assembly **10.** The thermal insulating material utilized within the tubular thermal protection device **40** and used as the sealing collar **47** can be one of many thermal insulating materials available including Fiberfrax insulation, which is a product of the Carborundum Company. The effective diameter of the sealing collar **47** can be varied by the positioning of the adjustable clamp **48.**

The solid electrolyte cell assembly **30** is comprised of a solid electrolyte member **31** illustrated in the form of a disc sealed to form the closed end of tubular support member **32** which has the opposite end secured to the tubular extension member **60.** Disposed on opposite surfaces of the solid electrolyte member **31** are electrode members **33** and **34.** The material composition of the solid electrolyte can be satisfied by any of many compositions of materials well known in the art which support oxygen ion conductivity. Such material compositions are described in U.S. Pat. No. 3,400,054 issued Sept. 3, 1968. A requirement for the electrode members **33** and **34** is that they provide sufficient electronic conductivity and operable at elevated temperatures. The prior art typically represents the electrodes as being porous platinum coatings. In selecting the material for the tubular support member **32** for an oxygen probe assembly for use in industrial applications, the prime considerations are the material's resistance to the corrosion and a need to match as closely as possible the thermal coefficient of expansion of the tubular material with that of the solid electrolyte. Materials satisfying these requirements include 446 Stainless, Ebrite 26–1, Hastelloy B, Inconel X, etc. Investigations have shown that the Ebrite 26–1 provides characteristics compatible with conventional solid electrolyte material composition to satisfy the requirements of corrosion resistance and matching coefficients of thermal expansion to insure an integral seal between the solid electrolyte member **31** and the tubular support member **32.**

A heater assembly **35** positioned within the tubular support member **32** provides uniform operating temperature for the solid electrolyte cell assembly. Electrical leads **35A** from the heater assembly **35** extend within tubular member **60,** through interconnect member **80** to temperature controller **84.**

Entry tube **36** extending from the interconnect member **80** of FIG. **1** includes at least four longitudinal passages therein whereby an electrical lead member **37** is brought in contact with electrode **32** and leads for temperature measuring element **38** are carried to the temperature controller **84** to provide input information for controlling the operation of the heater assembly **35.** The fourth longitudinal passage in the entry tube **36** permits the passage of a reference oxygen supply, such as air, exhibiting a known oxygen content from the reference gas supply **82** to the surface of the solid electrolyte member **31** occupied by the electrode **33** and exhausted back through interconnect member **80.**

A suitable composition for the solid electrolyte **31** includes a composition of zirconia and oxides of calcium or related material which provides sufficient oxygen ion conduction to render the solid electrolyte useful for oxygen gas measurement.

The use of electrically conductive material for the tubular support member **32** permits the extension of the electrode member **34** to electrical contact with the tubular member **32** thus permitting the use of the tubular member **32** as an electrical conductor to conduct the signal developed by the solid electrolyte member in response to oxygen differential pressure. The use of a metal material for the tubular extension member provides additional conduction of the signal to the interconnect member **80** at which electrical contact is made by a lead extending to the signal measuring circuit **86.**

As described in the referenced U.S. patents, the operation of the conventional solid electrolyte oxygen cell is such that the electrolyte member **31** will respond to a difference in oxygen pressure between that of the oxygen reference present at electrode **33** and that of the environment present at electrode **34** by generating an EMF signal which is monitored by the remote measuring apparatus **86** and interpreted as a measurement of the oxygen content of the unknown environment present at electrode **34.** In the instant application, the environment present at the electrode **34** corresponds to the furnace environment which is conducted through the porous protective shield member **52** of the protective shield assembly **50** by diffusion and is introduced into a gas cavity defined by an end portion of a heat-conductive cap **64** and the surface of the solid electrolyte member **31** upon which electrode **34** is disposed through apertures **62** in the heat-conductive cap **64.** The construction and the operation of the solid electrolyte member **31** in conjunction with electrodes **33** and **34** in response to varying oxygen environments is clearly described in the referenced patents and will therefore not be described in detail in this application.

The heat conductive cap **64** serves primarily to conduct heat produced by the heater assembly **35** to the end cap portion **64A** of the heat conductive cap **64.** The end cap **64A** serves as a stable temperature barrier whereby the gas in the gas cavity is maintained at a relatively stable temperature corresponding to that required for the desired operation of the oxygen cell assembly. An annular air space is included to serve as an insulating barrier which essentially eliminates "short circuit" of the thermal conduction from the heat conductive cap to the solid electrolyte **31** through the tubular support member **32** and assures conduction of the heat to the closed end portion **64A.** Of secondary importance, is the mechanical protection provided the relatively fragile solid electrolyte **31** by the closed end heat conductive cap during handling of the oxygen sensor assembly prior to insertion within the furnace environment. The heat conductive cap can be fabricated from any suitable material exhibiting the thermal conduction characteristics required, such as, **304** Stainless Steel, 446 Stainless Steel, Ebrite 26–1, etc.

The protective shield assembly **50** includes a mechanical support structure **54** which is fixedly secured to end piece **49** of the open ended tubular insulating member **40.** The mechanical structure **54** includes end plate **55** and leg members **56** and **57** extending between the end plate **55** and the end piece **49.** An adjustable clamping assembly **58** associated with the end plate **55** serves to apply controlled force against the closed end of the tubular porous member **52** to effectively seal the open end of the tubular porous member **52** against sealing member **59.** The sealed positioning of the open end of the tubular porous member **52** against the sealing member **59** effectively isolates the oxygen sensor assembly **30** from contact by foreign matter present in the furnace environment. The use of a material which will readily support oxygen diffusion at elevated temperatures for the porous member **52** assures the sensitivity of the oxygen sensor assembly to the oxygen content of the furnace environment. The requirements for selecting a material exhibiting desirable mechanical characteristics suitable to enable the porous member to withstand impingement by foreign matter while at the same time providing rapid gas diffusion can be satisfied by selecting a porous refractory material such as a ceramic material or a metal having a porosity sufficient to prevent passage of dust and particulate matter while permitting the desired level of gas diffusion. A commercially available porous refractory material in the form of an extraction thimble produced and marketed by Fisher Scientific satisfies the requirement of the porous member **52.**

Referring to FIG. **3,** there is illustrated a section of the embodiment of FIG. **2** illustrating the position and configuration of the leg members **56** and **57** of the mechanical support structure **54** and the orientation of the leg members relative to the gas flow within the furnace environment. The configuration of the leg member **56** is such as to form a deflecting member resulting in a gas flow pattern as illustrated. The deflector configuration of the leg member **56** serves two purposes:

a. prevents direct impingement of large particulate matter on the surface of the porous member **52;**
b. establishes a sweeping air flow across the outside surfaces **S1** and **S2** of the porous member **52** to effectively provide a wiping or cleaning action, thus eliminating a build-up of particulate matter on the surfaces **S1** and **S2** of the porous member **52** which could ultimately seal the pores of the member **52** thus preventing rapid diffusion of oxygen gas therethrough.

Field tests of the configuration illustrated in FIG. **3** resulted in a build-up of particulate matter PM as illustrated. While the deflector configuration of the leg member **56** is simply illustrated as a right angle member, it is apparent that numerous configurations are available to provide the desired gas flow pattern.

In FIG. **4,** there is illustrated an alternate implementation of the porous member **52.** The single porous member **52** of the illustration of FIG. **2** is replaced by two porous members **152** and **154.** Instead of relying solely on diffusion of the gas from the furnace environment for contacting the oxygen sensor assembly **30,** a gas flow path is established as illustrated by the arrows such that gas which is diffused through porous member **152** and subsequently monitored by the oxygen sensor assembly is ultimately diffused through porous member **154** and exhausted to the furnace environment through the apertures **71** of the stationary tubular members **70** and **73.** It is obvious that the direction of the gas flow can be reversed.

We claim:

1. In a solid electrolyte electrochemical cell assembly adapted for monitoring gas constituents at elevated temperatures wherein the solid electrolyte electrochemical cell is a solid electrolyte member having a first electrode disposed in contact with a first surface of the solid electrolyte member and a second electrode disposed in contact with the opposite surface of the solid electrolyte member, said solid electrolyte electrochemical cell forming the closed end of a tubular member, the improvement for heating said solid electrolyte electrochemical cell, wherein said improvement comprises:

heating means inserted within said tubular member and disposed adjacent to the surface of the solid electrolyte member contacted by the first electrode and remote from the solid electrolyte surface contacted by said second electrode for directly heating said tubular member and the electrolyte surface contacted by said first electrode, and

heat conductive means in thermal contact with the external surface of said tubular member and having an end portion extending adjacent and parallel to and spaced apart from the electrolyte surface contacted by said second electrode to define there-between a gas cavity and to heat said electrolyte surface contacted by said second electrode, said heat conductive means including apertures therethrough to permit the flow of gas containing constituents to be monitored to enter said cavity and contact said electrolyte surface contacted by said second electrode.

2. In a solid electrolyte electrochemical cell assembly as claimed in claim **1** wherein said heat conductive means being a cap of heat conductive material having side walls heat conductively coupled to the walls of said tubular member.

3. In a solid electrolyte electrochemical cell assembly as claimed in claim **2** further including a thermal shield surrounding the heat conductive cap.

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