United States Patent

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[54] **ELECTRICAL HEATERS**
24 Claims, 11 Drawing Figs.

[52] U.S. Cl. **219/541,** 73/359, 174/50.52, 219/544, 219/553, 338/238, 338/274
[51] Int. Cl. **H05b 3/08**
[50] **Field of Search** .... 219/541-4, 553—2; 338/238—42, 237, 261, 273—4; 174/77, 50.52—50.59, 77 R; 123/145, 145 P; 73/341, 359

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ABSTRACT: Electrical heaters having an outer metal sheath within which is a resistance element, conductors being in electrical contact with said element and projecting outwardly of said sheath for connection to a power source; said resistance element being surrounded by electrically insulating, heat-conductive material capable of withstanding relatively elevated temperatures, and hermetic seals provided at the ends of said sheath formed of swageable material capable of retention of inherent physical characteristics at substantially high temperatures.

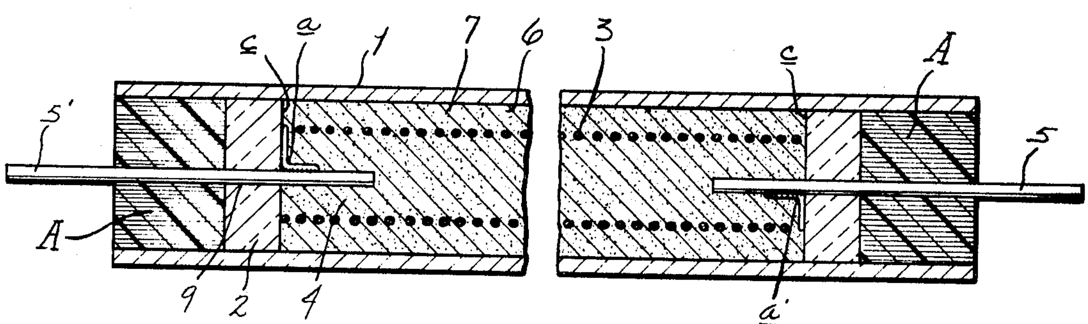

FIG. I

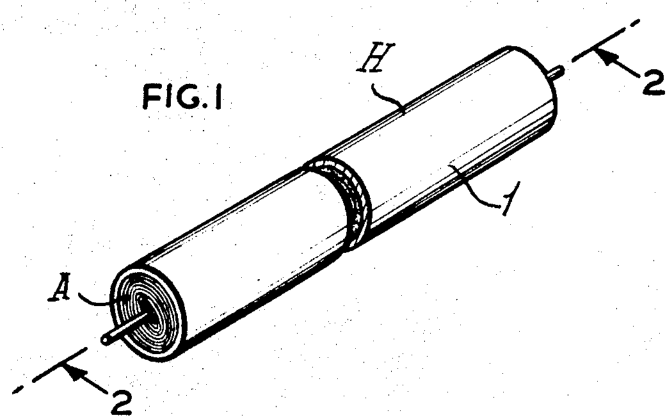

FIG. 3

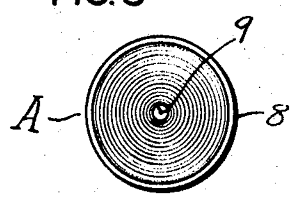

FIG. 2

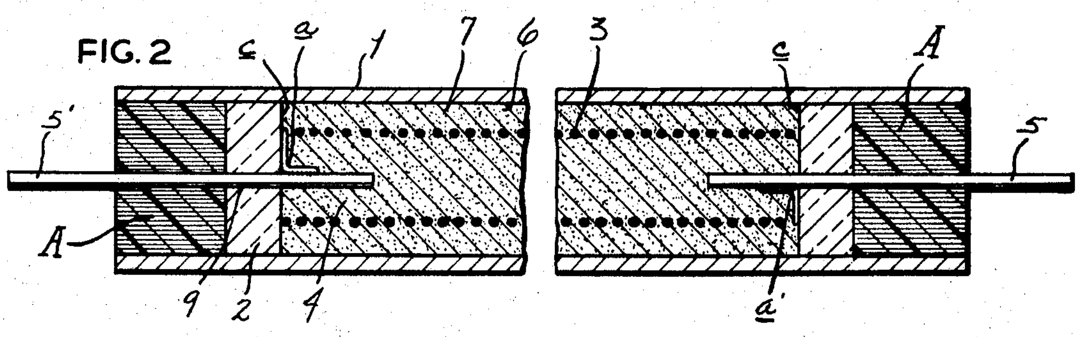

FIG. 4

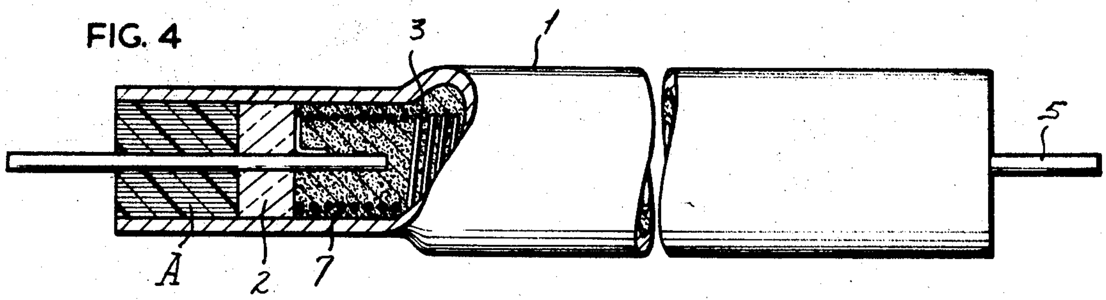

FIG. 5

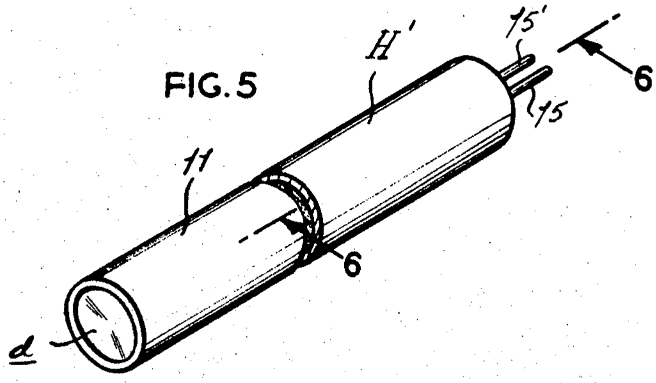

FIG. 7

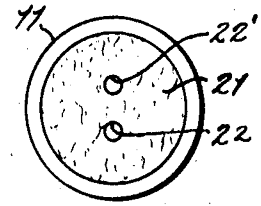

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FIG. 6

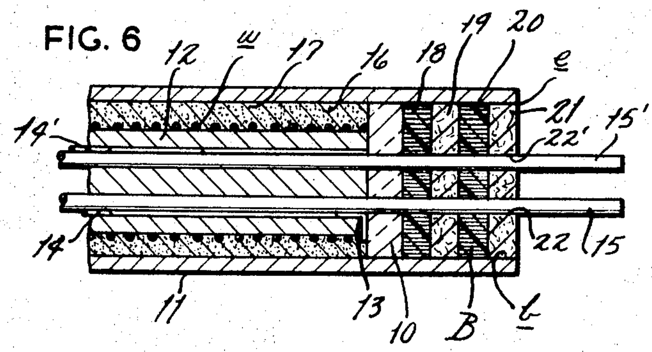


FIG. 8

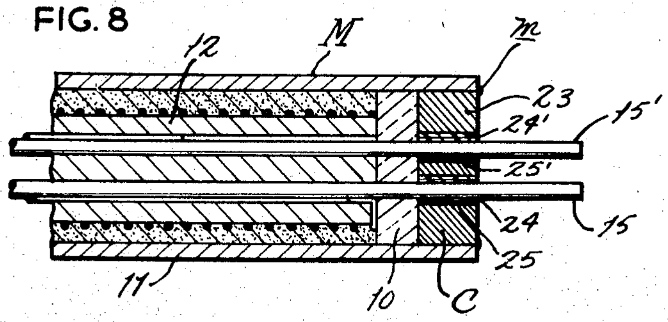


FIG. 9

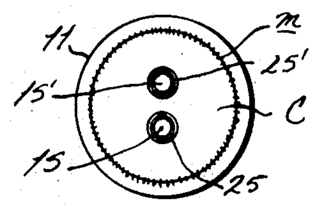


FIG. 10

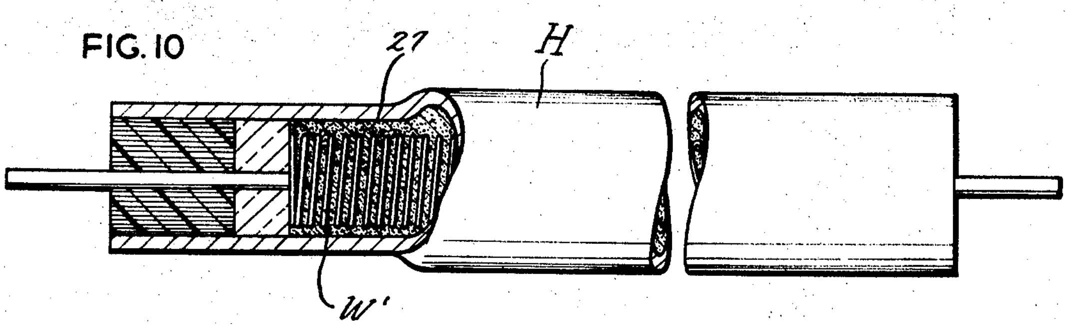
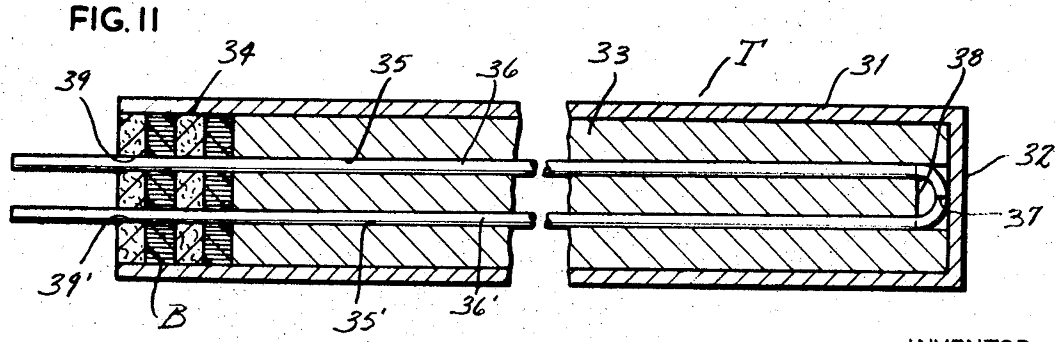


FIG. 11



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ELECTRICAL HEATERS

BACKGROUND OF THE INVENTION

The present invention relates in general to electrical heaters and, more particularly, to means for enhancing the hermetic properties of same.

A major problem in electrical heaters is the tendency of the resistance element to oxidize at high temperatures thereby resulting in a substantial reduction of the operating life of the heater. It is well-known in the art to hermetically seal the ends of the sheath so as to protect the resistance element from oxygen in the atmosphere, as in moisture, or in gaseous form. For this purpose, ceramic seals have been generally used because of their relatively nonpourous, high temperature resistant character, but the same have proved inadequate because of their relative rigidity and brittleness which conduce frequently to fractures with development of open cracks which latter markedly increase the leak rate of the seal. Accordingly, there has been the recognized need for relatively high temperature resistant hermetic seals of a more durable and fracture resistant character which maintain their physical characteristics at a temperature in excess of 1000° F. and reliably prevent the untoward entry of ambient oxygen within the sheath.

Additionally, the aforesaid problem has been compounded by reason of the nature of the customarily utilized insulating material in such heaters which is magnesium oxide. It appears that under conditions of relatively high heat and low vapor pressures the magnesium oxide tends to dissociate releasing oxygen resulting in loss of the insulating properties of the magnesium oxide and in the development of high leakage currents which further conduce to the breakdown of the insulating material. By reason of the foregoing, the selection of the metal or other materials forming the resistance element have been determined by temperature considerations, with limitations below the desideratum. Accordingly, material such as graphite and refractory metals such as molybdenum, niobium, and tungsten, which generate a markedly higher temperature than conventional resistance elements, could not be effectively utilized in view of present heater technology. The extreme sensitivity of said refractory metals to oxygen at high temperatures is well-known. Therefore, the industry has long sought an insulating material which may be utilized in place of magnesium oxide and which would permit of the effective incorporation in said heaters of resistance elements from materials of the type stated whereby sheath temperatures, not deemed hitherto normally obtainable, could be achieved.

SUMMARY OF THE INVENTION

An object of the present invention is to provide a heater of the type stated having a hermetic seal constructed from a relatively gas impervious, swageable material which substantially increases the heater life; which is extremely stable at high temperatures; which permits maintenance of a constant high temperature for a long period of time; which possesses relatively great dielectric properties; and which has substantial mechanical strength.

Another object of the present invention is to provide a heater of the type stated, having a hermetic seal which is flexible and resilient so that same can be subjected to rough handling without fracturing or fragmenting thereby preserving its peculiar leak rate.

A further object of the present invention is to provide a heater of the type stated, having a hermetic seal constructed of small oriented flakes of mica, such as mica paper.

A still further object of the present invention is to provide a heater of the type stated, containing an insulating material with relatively low gas porosity and low reactivity with refractory metals and graphite and relatively high electrical and thermal properties so that oxygen sensitive refractory materials may be used for the resistance elements in such heaters so as to effect the development of relatively high sheath temperatures in both oxidizing and nonoxidizing atmospheres.

It is another object of the present invention to provide a heater of the type stated, containing boron nitride as the insulating material and a resistance element formed from refractory materials having high melting points and low vapor pressures, such as, molybdenum, niobium, tungsten, graphite and the like.

It is a further object of the present invention to provide a heater of the type stated, incorporating hermetic seals capable of reliably denying entry of gases and particularly oxygen-bearing gases from the atmosphere and insulating material having properties conducive to the development of relatively high temperatures in the resistance element without diminution of the operating life of the heater.

Another object of the present invention is to provide a hermetic seal of the type stated for use within thermocouples for relatively increasing the life of the latter by the development of a substantially gas-impervious condition.

It is another object of the present invention to provide a heater of the type stated which is inexpensive to manufacture and which is reliable and durable in usage.

DESCRIPTION OF THE DRAWINGS

FIG. 1 is a perspective view of a tubular-type heater having a hermetic seal constructed in accordance with and embodying the present invention.

FIG. 2 is a vertical longitudinal section taken on the line 2–2 of FIG. 1.

FIG. 3 is an end view of the tubular heater shown in FIG. 1.

FIG. 4 is a side view of a tubular heater, having portions broken away, illustrating same in a partially swaged condition.

FIG. 5 is a perspective view of a cartridge-type heater incorporating another embodiment of a hermetic seal constructed in accordance with and embodying the present invention.

FIG. 6 is a vertical longitudinal section taken on the line 6–6 of FIG. 5.

FIG. 7 is an end view of the cartridge heater as shown in FIG. 5.

FIG. 8 is a vertical longitudinal section taken through a cartridge-type heater incorporating another embodiment of a hermetic seal constructed in accordance with and embodying the present invention.

FIG. 9 is an end view of FIG. 8.

FIG. 10 is a side view of a tubular-type heater, with portions broken away, incorporating another embodiment of the present invention.

FIG. 11 is a vertical longitudinal section taken through a thermocouple incorporating a hermetic seal of the present invention.

DESCRIPTION OF THE PRACTICAL EMBODIMENTS

Referring now by reference characters to the drawings which illustrate practical embodiments of the present invention, H generally designates a heater of the tubular-type having an outer metal sheath 1 within which is coaxially disposed a resistance element 3, shown in FIGS. 2 and 3 as a helical wire although other conventional forms, such as of rod, tubular, mesh and ribbon construction, may be readily substituted therefor; said element being formed of conventional metal alloys such as of copper, nickel, chromium and the like. The opposite ends of element 3, as at *a*, *a'*, project inwardly into opposite ends of a bore 4 of element 3 for suitable connection to conductors 5, 5', respectively, for making electrical contact therewith. The terminals of each conductor 5, 5' extend outwardly from opposite ends of sheath 1 for connection to a suitable power source (not shown). Element 3, which is of less diameter and length than sheathe 1, defines therewith an intervening annular space 6, which is filled, along with bore 4, with a granular electrically insulating, heat-conductive refractory material, indicated 7, such as magnesium oxide, for surrounding said element 3, and a compartment *c* adjacent each end for accommodating a high-temperature, hermetic seal A being resistant to temperatures in excess of 1000° F.; there being a "no heat" spacer **2**, as of ceramic material, interposed between seal A and element **3** so as to insulate the former from direct contact with the latter. Said hermetic seal A is constituted of resilient, gas-impervious, swageable material, such as mica paper, which is wound upon itself into a roll **8**. Both seal A and spacer **2** are provided with aligned axial openings, as at **9**, for extension therethrough of conductor **5**, **5'**.

Mica is a comprehensive term for certain complex hydrous aluminum silicate compounds having a sheet or platy structure and being extremely variable in composition, containing metallic ions, particularly those from the alkali group. Mica paper is flexible, consisting of fine flakes of mica deposited as a continuous and highly uniform mat or sheet which is durable and resistant to fragmentation, fracturing and the like due to the overlapping laminar structure thereof. Mica paper is stable at relatively high temperatures and has recognizedly substantial dielectric strength and electrical resistivity. The physical characteristics of mica paper are unaltered under heat, to a temperature of about 1600° F. whereat the mica paper tends to expand, thereby enhancing its sealing properties.

With rolls **8** of mica paper being positioned within compartment *c*, heater H is swaged throughout its length in a conventional manner, so that the diameter of same is decreased in the range of 10 percent to 25 per cent, as suggested in FIG. **4**, thereby compressing rolls **8**, insulating material **7**, and spacer **2** into a dense, compact unit; augmenting the airtight character of heater H. It has been found that by substituting two relatively shorter mica paper rolls for each of the aforesaid rolls **8**, the hermetic quality of seal A is markedly increased as a result of the labyrinth effect caused by the laminated structure of mica as well as the non alignment of any pores that may be peculiar to one roll. Accordingly, it is within the contemplation of the present invention that seal A may comprise a single roll of would mica paper, as designated **8**, or may consist of a plurality of shorter rolls for establishing the requisite gas-impervious condition.

Testing has revealed that mica paper roll seals have a consistent leak rate within the range of 10^{15} to 10^{17} cm.^{3}/sec. which conduces to the enhancement of the effective life of heaters, such as H, utilizing said seals. A leak rate of 10^{15} cm.^{3}/sec. has been considered within this field a substantially airtight seal.

Referring now to FIGS. **5**, **6**, and **7** of the drawings, H' generally designates a heater of the cartridge-type comprising a cylindrical metal sheath **11** closed at one end, as at *d*, and having coaxially disposed a core **12** therein fabricated of insulating material, there being a helical resistance element *w* coiled therearound. The end **13** of element *w* are bent for extension into the proximate end of parallel longitudinal bores **14**, **14'** formed within core **12**. Extending through each of said bores **14**, **14'** is a conductor **15**, **15'** respectively which engage the opposite ends **13**, of resistance element *w* for establishing electrical contact therewith. It will be understood that the form of element *w* a nd the particular means for effecting electrical connection between same and conductors **15**, **15'** do not constitute part of the present invention as other conventional means may be readily substituted therefor. The terminals of conductors **15**, **15'** project outwardly of the open end *e* of sheath **11** for suitable connection to a power source (not shown). Core **12** is of less diameter and length than sheath **11** and defines therewith an intervening annular space **16** which is filled with a granular, electrically insulating heat-conductive, refractory material **17**, such as magnesium oxide, and an endwise opening compartment *b* at the open end of sheath **11** within which is fitted a high-temperature hermetic seal B being resistant to temperatures in excess of 1000° F.; there being a "no heat" spacer **10**, as of ceramic material, interposed between seal B and core **12** so as to insulate the former from direct engagement with the resistance element *w*. Seal B comprises a plurality of discs **18**, **19**, **20**, **21** arranged in tight, face-to-face abutting relationship, each having a pair of aligned apertures, as at **22**, **22'** through which conductors **15**, **15'** extend. Discs **18** and **20** are constructed of mica paper while discs **19** and **21** are formed from insulating material, such as magnesium oxide, lava or the like, although lava is preferred; and said discs are presented in alternating relationship, with mica disc **18** being innermost, abutting against the proximate end face of spacer **10**. Mica paper discs are stable at relatively high temperatures and possess recognized dielectric strength and electrical resistivity immediately comparable to mica paper rolls **8** described hereinabove. Since mica paper is relatively hygroscopic, it is essential to insulate same against reception of ambient moisture so as to assure maintenance of its electrical resistivity. As is well-known, lava seals are relatively impervious to ambient moisture. Therefore, lava disc **19** is disposed between mica discs **18** and **20**, and lava disc **21** is positioned outwardly of disc **20**, being exposed to the atmosphere, for protecting mica discs **18** and **20** against undeserved collection of ambient moisture. It will be understood that any number of alternating mica and lava may be utilized in seal B but it has been found that four such discs as arranged bring about optimum results.

With discs **18—21** inclusive, being installed within the compartment *b* of sheath **11**, heater H' is swaged throughout its length for reducing its diameter in the range of 10 per cent to 25 per cent causing a compression of said discs as well as the insulating material **17**, spacer **10** and resistance element *w*. This swaging process causes heater H' to be formed into a compact unit which is substantially impervious to gas and resistant to ambient moisture.

Discs **18** and **20** of seal B may be constructed of boron nitride, in lieu of mica paper, which compound being of normally powdered form provides a relatively high degree of airtightness after compacting through swaging. Lava discs, such as at **19**, **21**, are also utilized with boron nitride discs in alternating or sandwiching relationship so as to provide the lateral stability to said boron nitride discs.

Tests have shown conclusively that cartridge heaters, such as H', utilizing seal B, have an effective life in excess of four times that of cartridge heaters not using said seal.

Referring now to FIGS. **8** and **9**, C generally designates a high temperature hermetic seal disposed within the open end of a cartridge heater M which latter is identical in construction to the cartridge heater H' as shown in FIG. **5**, so that like numbers designate like elements. Seal C comprises a metal plug **23** welded, brazed, or the like, as at *m*, to the adjacent annular end wall of sheath **11**. Plug **23** is provided with a pair of bores **24**, **24'** through which conductors **15**, **15'** respectively extend for connection at their outer ends to a suitable power source (not shown). The diameter of each bore **24**, **24'** is greater than the diameter of the respective conductor **15**, **15'** for receiving a mica paper sleeve **25**, **25'** respectively in rolled form and disposed coextensively within said bores of plug **23**. Plug **23** is formed of the same metal as sheath **11** and thus has the same expansion characteristics so that there is obviated the development of any mechanical stresses which would normally be encountered through differentials in thermal expansion if the said components were of different metals.

With seal C positioned within the open end of sheath **11**, heater M is swaged throughout its length for compressing same together with seal C, insulating material **17**, spacer **10** and core **12** to provide a compact unit which enhances the hermetic character of heater M, making same relatively impervious to ambient gas. Although the hermetic seals A,B, and C of the present invention have been described for use within electrical heaters of the tubular and cartridge type as the preferred embodiment, it will be understood that said seals may be modified for incorporation within other type electrical heaters, such as flat, rectangular or the like.

As observed above, heretofore consideration had to be given to temperature limitations of tubular and cartridge heaters by reason of the characteristics of the particular materials used in forming the resistance elements. Most high temperature resistance materials will tend to effect a relatively rapid degeneration if the same are brought into contact with oxygen at a relatively elevated temperature so that it has been necessary to make certain that the temperatures do not reach such damaging levels. Accordingly, materials such as molybdenum, niobium, tungsten, and graphite, which possess relatively high melting points and low vapor pressures are extremely oxygen reactive at high temperatures, have not been to the present time deemed practical for use in heaters of the type in question. Since magnesium oxide has been the insulating material of choice, it is believed that conceivably the dissociation characteristics of such compound at elevated temperatures cause resulting of oxygen for interreaction with the metals with such resulting in high leakage currents and resistance element embrittlement with further deterioration in the physical properties of the insulating material. Accordingly, it has been discovered that by replacing the magnesium oxide with boron nitride as the insulating material, disposed surroundingly of the resistance element within sheaths **1**, **1**1' that elements formed from the aforesaid metals may be used without breakdown and thereby allow of the development of a temperature considerably elevated above that and deemed heretofore maximum. Thus, in FIG. **10**, H indicates the tubular heater shown in FIG. **1** and with like reference numbers designating like elements. **27** indicates insulating material formed of boron nitride while W' indicates a resistance element, helically wound upon itself, and being formed of one of the aforesaid high-temperature materials which can reach temperatures in the range of 2600° to 3000° F. and be productive therefore of a sheath temperature of approximately 2400° F. in an oxidizing atmosphere.

Boron nitride possesses relatively low gas diffusivity and extremely high thermal conductivity and electrical resistivity, and, when compressed by swaging is markedly impervious to gas. By such swaging, the density of boron nitride is in excess of 2.0 grams per cubic centimeter, and the air leak rate thereof is approximately 10⅓^{6} cm.^{3}/sec. Moreover, boron nitride acts as a "getterer" for absorbing the small volume of oxygen that may penetrate the seals.

Tests have conclusively shown that heaters, such as H, utilizing mica paper rolls **8** as seals, boron nitride as insulating material **27** and one of said high temperatures resistance materials, such as tungsten, have an effective life in excess of 10 times that of identical heaters which are not subjected to the swaging operation.

Therefore, it can be seen that by the present invention the utilization of mica paper and boron nitride as a seal in tubular and cartridge heaters substantially increases the hermetic character as well as the life span of the same. By substituting boron nitride for the commonly used magnesium oxide, oxygen sensitive metals such as molybdenum, niobium, tungsten and graphite may be utilized for the resistance element resulting in developing considerably higher sheath temperature than heretofore believed attainable. Accordingly, a single tubular or cartridge heater may thus be created embodying both the unusual hermetic seals A, B and C of the present invention as well as boron nitride **27** as the insulating material for resistance element with the heater thus having properties of considerably greater magnitude than conventional heaters.

The hermetic seals B and C of the present invention may also be incorporated within thermoelectric elements, such as thermocouples. The life of a thermocouple, or the duration of time over which the thermocouple retains acceptable accuracy of calibration, decrease with increasing temperature and is affected by the ambient atmosphere. At temperatures in excess of 1000° F. it is necessary to provide a hermetic seal therefor to offset the injurious effects of high temperatures in an oxidizing atmosphere or in any other atmosphere which tends to change the composition of materials that are exposed to it. Referring now to FIG. **11** of the drawings, T generally designates a thermocouple comprising a cylindrical metal sheath **31** being closed at one end, as at **32**, and having coaxially disposed therein a core **33** fabricated of insulating material, such as magnesium oxide or aluminum oxide. The outside diameter of core **33** is substantially the same as the inner diameter of sheath **31** for providing a snug fitting herein, the length of core **33** being less than that of sheath **31** for defining therewith a compartment **34** adjacent the open end of sheath **31**. Formed within core **33** are a pair of parallel, longitudinal bores **35**, **35'** for extension therethrough of conductors **36**, **36'** respectively. Said conductors **36**, **36'** are fabricated from dissimilar metals, such as chromel and alumel, and are joined at one end as by welding or the like, indicated at **37** known in the art as the "hot junction" which is received within a transverse slot **38** connecting the bores **36**, **36'** for facilitating flush abutment of bore **33** against closed end **32**. The terminals of conductors **36**, **36'** project outwardly of the sheath open end for suitable connection to a measuring device, (not shown) such as millivoltmeter or a potentiometer calibrated in temperature. Thermocouples, such as T, are used to measure temperature by placing the hot junction **37** at the point of measurement while the terminals are connected to the measuring unit to complete the circuit.

Provided for snug accommodation within compartment **34** is a hermetic seal B disposed adjacent core **33** and being of identical construction as the hermetic seal B described hereinabove. Said seal B is provided with aligned apertures, as at **39**, **39'**, through which conductors **36**, **36'** extend. With seal B being installed within compartment **34**, thermocouple T is swaged throughout its length for reducing its diameter in the range of 10—25 per cent causing a compression of seal B and core **33** for accordingly forming thermocouple T into a compact unit which is substantially impervious to gas and resistant to ambient moisture.

It will be understood that seal C, in addition to seal B, may be readily installed within compartment **34** of thermocouple T for hermetically sealing the open end thereof in the same manner as above set forth with H, H'to heaters H,H' and M. By utilizing either of seals B or C within compartment **34** of a thermocouple T, the life of the latter is increased by the development of a relatively, substantially gas-impervious condition.

Having thus described my invention, what I claim and desire to obtain by Letters Patent is:

1. A hermetic electrical device having a metal sheath; an electrical element disposed within said sheath, said electrical element including a pair of terminals projecting outwardly endwise of said sheath; electrically insulating, heat-conductive material surrounding said electrical element; a hermetic high-temperature seal provided within said sheath surroundingly of said terminals, said seal being fabricated from gas-impervious swageable material capable of resisting deformation at temperatures in excess of 1,000° F., said material being selected from the class consisting of mica paper and boron nitride.

2. A hermetic electrical device as defined in claim **1** and further characterized by said seal comprising mica paper being of sheet character and wound upon itself to form a roll, a mica paper roll being positioned in tight, surrounding engagement with each terminal of said electrical element.

3. A hermetic electrical device as defined in claim **2** and further characterized by there being at least a pair of mica paper rolls in end to end relationship disposed closurewise within said sheath in tightly surrounding engagement with each terminal of said electrical element.

4. An electrical device as defined in claim **1** and further characterized by said seal material comprising mica paper formed into a disc.

5. An electrical device as defined in claim **4** and further characterized by a lava disc being presented on opposite sides of said mica paper disc.

6. An electrical device as defined in claim **5** and further characterized by at least one lava disc being presented on the outer face of said mica paper disc in abutting relationship.

7. An electrical device as defined in claim **1** and further characterized by said seal material comprising boron nitride in disc form.

8. An electrical device as defined in claim **7** and further characterized by a lava disc being presented on opposite sides of said boron nitride disc.

9. An electrical device as defined in claim 7 and further characterized by at least one lava disc being presented on the outer face of said boron nitride disc in abutting relationship.

10. A hermetic electrical device as defined in claim 1 and further characterized by said electrical element comprising an electrical resistance element electrical connected to said terminals said electrically insulating material comprising boron nitride.

11. An electrical device as defined in claim 10 and further characterized by said hermetic seal being constructed of mica paper would upon itself into roll form.

12. An electrical device as defined in claim 11 and further characterized by said resistance element being selected from the group consisting of molybdenum, tungsten, niobium, and graphite.

13. An electrical device as defined in claim 10 and further characterized by said hermetic seal consisting of mica paper formed into a disc, a lava disc being presented on the outer face of said mica paper disc in abutting relationship thereto.

14. An electrical device as defined in claim 13 and further characterized by said resistance element being selected from the group consisting of molybdenum, tungsten, niobium, and graphite.

15. An electrical device as defined in claim 10 and further characterized by said hermetic seal comprising a first lava disc disposed within said compartment, a boron nitride disc inserted in abutting relationship to said first lava disc and a second lava disc inserted within said compartment in abutting relationship to said boron nitride disc.

16. An electrical device as defined in claim 15 and further characterized by said resistance element being selected from the group consisting of molybdenum, tungsten, niobium, and graphite.

17. An electrical device as defined in claim 10 and further characterized by said resistance element being selected from the group consisting of molybdenum, tungsten, niobium, and graphite.

18. An electrical device as defined in claim 1 and further characterized by said insulating material comprising a core disposed within said sheath, said core having a pair of parallel longitudinal bores extending therethrough, said electrical element comprising a first conductor extending through one bore of said core and a second conductor extending through the other bore of said core, said conductors having inner and outer ends and being constructed of different metals, said conductors being joined at their inner end, said outer ends comprising said terminals.

19. An electrical device as defined in claim 18 and further characterized by said hermetic seal comprising mica paper formed into a disc, and at least one lava disc being presented on the outer face of said mica paper disc in abutting relationship.

20. An electrical device as defined in claim 18 and further characterized by said hermetic seal comprising boron nitride in disc form and at least one lava disc being presented on the outer face of said boron nitride disc in abutting relationship.

21. A hermetic electrical device having a metal sheath provided with an open end; an electrical element disposed within said sheath and including a pair of terminals projecting outwardly endwise through said sheath open end; electrically insulating, heat-conductive material surrounding said electrical element; a metal plug provided within said sheath open end and having a pair of bores therein, said terminals extending through said bores, the diameter of each of said bores being greater than the diameter of said terminals, a hermetic high-temperature seal provided within each of said bores, said seal being fabricated from gas-impervious swageable material, capable of resisting deformation at temperatures in excess of 1,000° F., said material consisting of mica paper wound upon itself to form a rolled-formed sleeve for disposition within each plug bore surroundingly of the terminal of the resistance element.

22. A hermetic electrical device having a metal sheath provided with at least one open end; an electrical element disposed within said sheath and including a pair of terminals projecting outwardly endwise through said sheath open end; said electrical element consisting of an electrical resistance element being electrically connected to said terminals; an electrically insulating heat-conductive material provided within said sheath surroundingly of said resistance element; a metal plug provided within said sheath open end and having a pair of bores therein, said terminals extending through said bores, the diameter of each of said bores being greater than the diameter of said terminals; a hermetic, high-temperature seal provided within each bore, said seal being fabricated from gas-impervious swageable material, capable of resisting deformation at temperatures in excess of 1,000° F., said material consisting of mica paper wound upon itself to form a rolled form sleeve for disposition within each plug bore surroundingly of the adjacent terminal of the resistance element.

23. An electrical device as defined in claim 22 and further characterized by said resistance element being selected from the group consisting of molybdenum, tungsten, niobium, and graphite.

24. A hermetic electrical device having a metal sheath provided with at least one open end, a core of electrically insulating heat-conductive material disposed within said sheath, said core having a pair of parallel longitudinal bores extending therethrough, an electrical element including a pair of terminals, said electrical element comprising a first conductor extending through one bore of said core, a second conductor extending through the other bore of said core, said first and second conductors having inner and outer end portions and being constructed of different metals, said first and second conductors being joined at their inner end portions, the outer end portions of said first and second conductors projecting through said sheath open end and comprising said terminals, a metal plug provided within said sheath open end and having a pair of bores therein, said terminals extending through said bores, the diameter of each of said bores being greater than the diameter of said terminals, a hermetic, high-temperature seal provided within each bore, said seal being fabricated from gas-impervious swageable material, capable of resisting deformation at temperatures in excess of 1,000° F., said material consisting of mica paper wound upon itself to form a rolled-formed sleeve for disposition within each plug bore surroundingly of the terminal of said resistance element.

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UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,582,616 Dated June 1, 1971

Inventor(s) Ronald M. Wrob

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

In the Specification:

Column 2, line 69, erase "sheathe" and insert ---sheath---.

Column 3, line 36, erase "would" and insert ---wound---;

line 40, erase "10^{15} to 10^{17}" and insert ---10^{-5} to 10^{-7}---;

line 42, erase "10^{15}" and insert ---10^{-5}---.

Column 5, line 36, erase "$10^{1/3^{6}}$" and insert ---10^{-6}---.

Column 6, line 34, after "with" erase "H,H'" (first occurrence) and insert ---respect---.

In the Claims:

Column 6, Claim 6, line 67, erase "5" and insert ---4---.

Column 7, Claim 10, line 6, erase "electrical" (second occurrence) and insert ---electrically---;

line 7, after "minals" insert ---,---.

Signed and sealed this 26th day of October 1971.

(SEAL)
Attest:

EDWARD M.FLETCHER,JR.
Attesting Officer

ROBERT GOTTSCHALK
Acting Commissioner of Patents