

Oct. 30, 1962

E. L. WIEGAND
ELECTRIC HEATERS

3,061,808

Original Filed Jan. 5, 1955

2 Sheets-Sheet 1

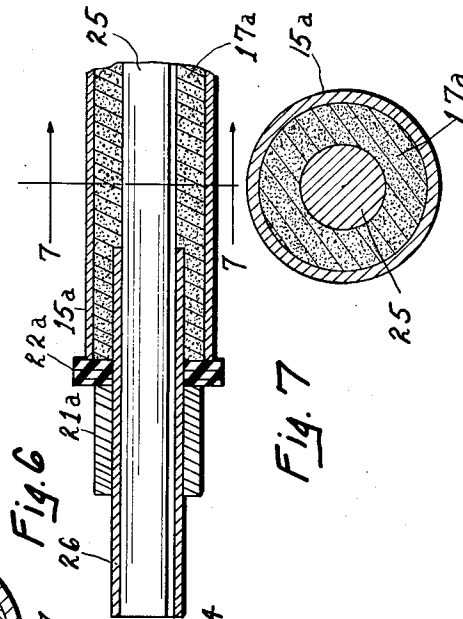
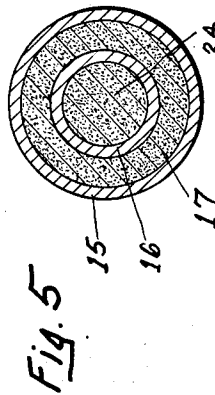
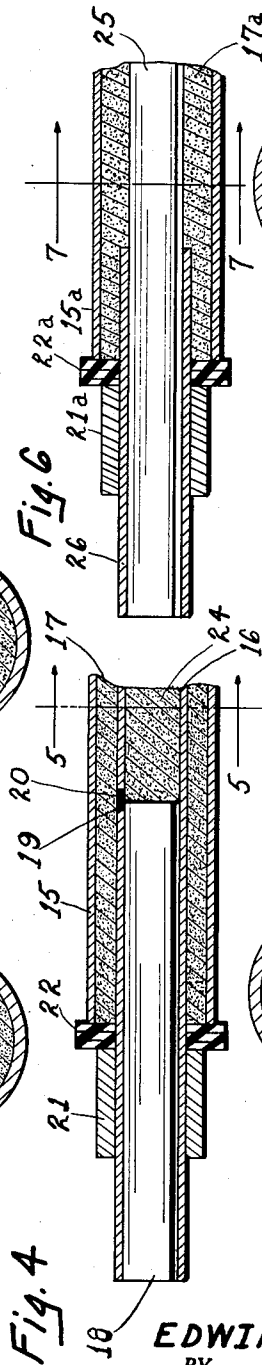
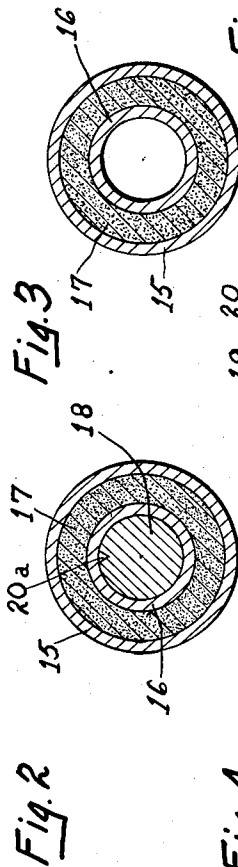
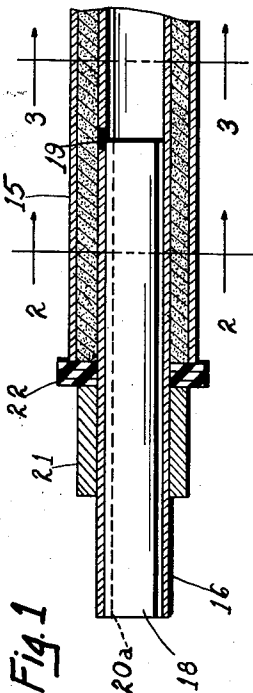
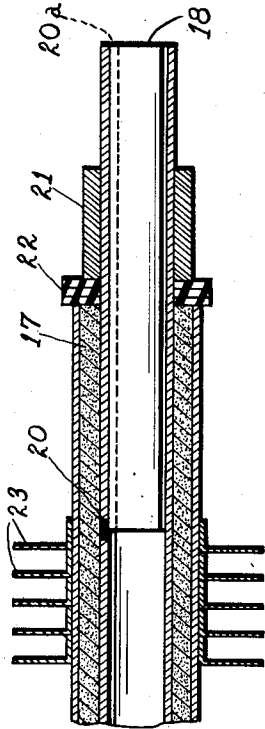


Fig. 7

INVENTOR.
EDWIN L. WIEGAND
BY *Michael Williams*
Attorney

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2 Sheets-Sheet 2

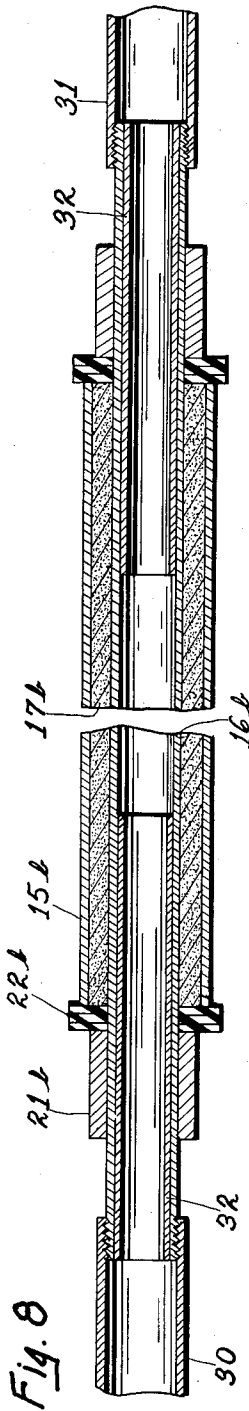


Fig. 8

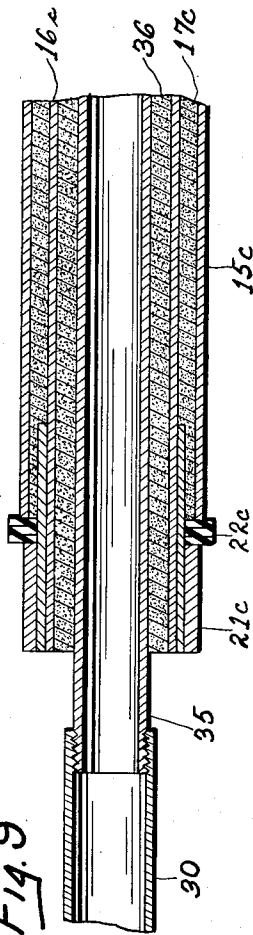


Fig. 9

Fig. 10

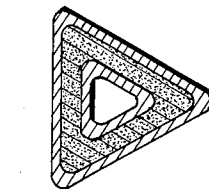


Fig. 11

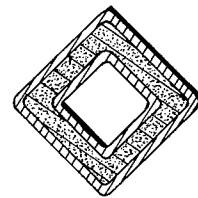


Fig. 12

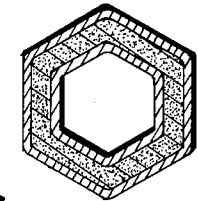


Fig. 13

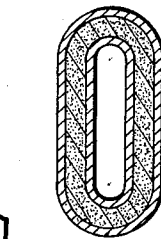
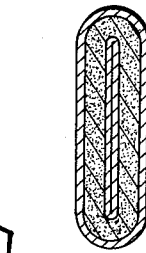


Fig. 14



INVENTOR.
EDWIN L. WIEGAND
BY
Michael Williams
Attorney

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3,061,808

ELECTRIC HEATERS

Edwin Leo Wiegand, Greenwich, Conn., assignor to
Edwin L. Wiegand Company, Pittsburgh, Pa.

Continuation of application Ser. No. 479,886, Jan. 5,
1955. This application July 24, 1959, Ser. No. 831,687
10 Claims. (Cl. 338-242)

My invention relates to electric heating elements, more particularly to durable, heavy-duty elements capable of producing and withstanding high temperatures, and the principal object of my invention is to provide new and improved electric heaters of this characteristic. This application is a continuation of an application previously filed by me on January 5, 1955, Serial No. 479,886 now abandoned.

The present invention is particularly adapted to applications in which high wattage capacities must be met and which applications accordingly require an electric heater which is not subject to damage caused by internal fusion or by insulation breakdown. The present invention is also adaptable to conditions where low voltage is desirable or where generally low electrical resistance per lineal unit is required or desired, or where a very minimum temperature gradient between the resistor surface and the outer sheath surface is desired at maximum wattage density per unit of sheath surface area.

A feature of this invention is that the resistance element of the heater of my invention is of the rigid type as contrasted with the generally flexible straight or coiled wire resistors of the prior art. The functional characteristics, accordingly, of the heaters of my invention are that such heaters will have much higher electrical and thermal capacity in relation to the fusion point of the resistor. The linear resistance of the improved element, however, will be lower than that for wire or coiled resistors of the prior art, thus suiting such element for very high loading per lineal unit.

Heating elements made in accordance with this invention may be used in rectilinear form, or may be readily bent to non-rectilinear form and may be wound to spiral or helical shape to condense a great amount of heat energy within a minimum amount of space. Further, the improved heating elements may be utilized to deliver their heat from the external surface thereof, or from an internal surface, or from both.

The foregoing, and other and further advantages will become apparent from a study of the following description in conjunction with the accompanying drawings.

In the drawings accompanying this specification and forming a part of this application, there are shown, for purposes of illustration, several embodiments which my invention may assume, and in these drawings:

FIGURE 1 is a broken longitudinal section through an electric heating element showing an embodiment of my invention,

FIGURE 2 is an enlarged transverse section corresponding generally to the line 2-2 of FIGURE 1,

FIGURE 3 is an enlarged transverse section corresponding generally to the line 3-3 of FIGURE 1,

FIGURE 4 is a fragmentary longitudinal sectional view through an electric heating element showing another embodiment of my invention,

FIGURE 5 is an enlarged transverse sectional view generally corresponding to the line 5-5 of FIGURE 4,

FIGURE 6 is a fragmentary longitudinal sectional view through an electric heating element showing another embodiment of my invention,

FIGURE 7 is an enlarged transverse sectional view generally corresponding to the line 7-7 of FIGURE 6,

FIGURE 8 is a broken longitudinal section through

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an electric heating element showing a further embodiment of my invention,

FIGURE 9 is a fragmentary longitudinal sectional view through an electric heating element showing still another embodiment of my invention, and

FIGURES 10, 11, 12, 13 and 14 are transverse sectional views through electric heaters showing various cross sections which the foregoing embodiments may assume.

Referring particularly to FIGURES 1 through 3 of the drawings, the heating element therein disclosed comprises an outer sheath 15 formed of a material suitable to meet specified conditions required of the heater. The sheath is preferably formed of a tubular material and, in a majority of the applications, a metal, such as steel or a steel alloy, has been found suitable. In the presently disclosed embodiment, the sheath 15 is of metal and is cylindrical at least during initial assembly operations of the heater.

Within the sheath 15 is positioned a resistor member 16 which is formed of any suitable material which will produce heat by reason of its resistance to the passage of electrical current. The resistor member 16 has form retaining properties which sustain it against the stretching or sagging characteristics of a coiled wire or ribbon resistor of the prior art, and comprises a body transversely bounded by a defining surface of a length generally longitudinally co-extensive with the length of the resistor member. Preferably, the resistor member is formed of a metal which may be the same or similar or compatible with the metal of the sheath 15. Heaters having Inconel or Ni-chrome resistor members 16 have been built and operated satisfactorily.

In the embodiment shown in FIGURES 1 through 3, the resistor member 16 is formed of metal tubing which may be either of the seamless or welded type, and this resistor member is of considerably less diameter than the diameter of the sheath to form a longitudinally extending space 17 therebetween. As best shown in FIGURES 2 and 3, the tubes 15 and 16 are generally concentrically arranged. The diameter and/or wall thickness of the resistor member 16 may be varied in accordance with its metallic current resistance characteristics to produce a known resistance per lineal increment whereby a member of predetermined active length will produce an established heat range upon application of known electrical current or currents at known voltage or voltages. It will be appreciated, accordingly, that the heater of this invention is very flexible in that either one or a combination of diameter, wall thickness and metallic resistance characteristics will afford variation of the heat produced by electrical energy of selected amperage and voltage.

The annular space 17 is filled with a heat-durable, electric-insulating heat-conducting material which maintains the generally concentric relation of the sheath 15 and the resistor member 16. Preferably, such material may take the form of a stable refractory material which solidly fills the space 17 and is compacted at a later stage of manufacture. Zircon (crystalline zirconium silicate) has been found suitable for this purpose and may be used in any desired granular or powdered form, such as, for example, unground of 60 mesh and finer or ground to 140 mesh and finer, and preferably the sheath 15 is end filled and vibrated during filling to compact the zircon within the space 17. Zircon is suitable for relatively high temperature operations but for temperatures such as, for example, in excess of 800° F. it may be preferable to use crystalline magnesium oxide (periclase) as the main electrical insulation between the resistor 16 and the sheath 15, although purified zircon or calcined magnesia may be used for selected temperature ranges.

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It is preferable, although not essential, to provide the heater with end portions which are not heated as highly as the intermediate active portion, and for this purpose current resistance-reducing members may be connected to respective ends of the resistor member 16. As seen in FIGURE 1, metal rods 18—18 are inserted a predetermined amount into the respective open ends of the resistor member 16, preferably with a shrink or press fit to insure electrical contact therebetween. It will be appreciated that the rods 18—18 and the resistor member 16 should be well cleaned prior to their assembly to remove dirt, grease and other foreign matter which may affect good electrical contact therebetween. If desired to further insure electrical and mechanical interengagement between the rods 18—18 and the resistor member 16, the latter may be formed with a transverse opening 19 and a plug weld 20 may be made to structurally integrally unite the parts.

Thus, the active heating portion of the resistor member will be that portion intermediate the inner terminal ends of the rods 18—18. The ends of the resistor member 16 which are coextensive with the rods 18—18, the sheath 15 surrounding the coextensive parts of resistor member 16 and rods 18, and the rods 18, will be relatively cool as compared with the active heating portion of the heater, so that electrical connections may be readily made and maintained.

In certain instances, it has been found that expansion of fluids or gases trapped within the hollow resistor member 16 may present dangerous conditions and it has been found preferable to form the heater construction so that the hollow resistor member may "breathe," that is, vent any fluids or gases which may be trapped or become trapped within the resistor member 16. A construction found suitable for this purpose is to provide the plug with a small air or pressure vent hole and this may be accomplished by forming each rod 18—18 with a longitudinally extending U or V groove 20a which establishes communication between the interior of tube 16 and the atmosphere.

Terminal sleeves 21 are preferably mechanically and electrically connected to the outwardly extending portions of respective ends of the resistor member 16, and such connections may be made in any suitable manner. Preferably, electrical insulation, such as mica washers 22, is interposed between adjoining ends of the heater and sleeves, as seen in FIGURE 1.

Since the heaters of this invention have relatively large internal heat capacity and thus are capable of producing and withstanding considerably higher temperatures than prior art heaters of comparable size, a great advantage of this invention lies in the fact that less heaters will be required to produce a great amount of heat, thus requiring less space and less electrical connections. Because of the materially greater internal capacity of heaters of my invention, a greater extension of external area is possible and, in this connection, it is pointed out that fins 23 may be pressed or wound on the exterior of the sheath 15 to extend the radiating surface thereof for cases where lower watts per square inch of external area are indicated but larger kilowatt capacity is required.

In some cases it is preferred to fill the space within the tubular resistor member 16 and, in such cases, as shown in FIGURES 4 and 5, it is preferable to fill this space solid with an inert and stable mineral 24, such as, for example, zircon (crystalline zirconium silicate) either unground of 60 mesh and finer or ground to 140 mesh and finer. Preferably, the tubular member 16 is end filled and is vibrated during the time it is being filled to compact such material 24 to fill voids. This construction reduces the need for venting the interior of the resistor member 16 although the rods 18 may be formed with longitudinal grooves, as shown at 20a in FIGURES 1 and 2, if desired. The construction of the heater shown in FIGURES 4 and 5 further increases the ruggedness characteristic of the heaters of my invention.

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Particularly in the case where the tubular resistor is formed with a thin wall, the refractory material filling the interior of such resistor provides the additional advantage of opposing any collapse or wrinkling of the wall during the time the entire construction is compacted by swaging, rolling or pressing. Compacting of the construction results in compacting of the resistor-filling refractory material to a highly dense condition and such compacted material maintains the tubular resistor in symmetrical shape throughout any reasonable amount of compacting and regardless of subsequent change of cross-sectional shape.

The embodiment of the invention disclosed in FIGURES 6 and 7 is somewhat similar to the embodiments hereinbefore described and like parts will be given like reference numerals supplemented with the suffix "a." In the embodiment shown in FIGURES 6 and 7, the resistor member is formed as a rod 25 of metal and, as before, refractory material solidly fills the annular space 17a between the rod 25 and the interior wall surface of the sheath 15a. In this embodiment, the heater may be formed with relatively cool ends by mechanically and electrically securing metal sleeves 26 over respective ends of rod 25. The sleeves 26 are shrunk or pressed over the respective ends of rod 25 and the extending ends of the sleeve provide support for the current connecting terminals 21a.

The heaters of my invention are equally adapted for the heating of fluids, either liquids and gases, and the resistor member may be connected to fluid flow conduits to form a continuation thereof. Attention is directed to FIGURE 8 of the drawings wherein a heater suitable for heating of fluids is illustrated, parts similar to those hereinbefore described being designated with a like reference numeral supplemented by the suffix "b."

The sheath 15b, as before, encloses a tubular resistor member 16b which, as herein shown, has ends extending outwardly and beyond the open ends of the sheath. The ends of the resistor member 16b may be connected to fluid conduits 30, 31, in any suitable manner, to form a continuation of such conduits. Because of heat dissipation through the medium of the fluid circulating in the resistor member, even greater watts per lineal increment of the heater may be applied without danger of resistor fusion or insulation breakdown.

The construction shown in FIGURE 8 may be formed with relatively cool ends by pressing metal tubing 32 either within respective resistor ends, as shown, or pressing such tubing to surround the resistor ends. It will be appreciated that desirable orifice or venturi effects may be provided by properly forming the opening in the tubing 32. The heater shown in FIGURE 8 may be used to selectively heat fluids passing through the resistor member 16b or to heat substance through conduction or radiation of heat from the sheath 15b, or both.

The embodiment of the invention shown in FIGURE 9 is also adaptable for heating fluids by circulation through the interior of the heater. In this embodiment, however, the fluid circulating conduit 35 is disposed within the resistor member 16c and is electrically insulated therefrom by means of a stable refractory material such as compacted zircon, as shown at 36. The ends of the resistor member 16c may extend outwardly of and beyond the ends of the sheath 15c and suitable metallic sleeves, such as previously described sleeves 21, may be mechanically and electrically connected to the resistor to provide relatively cool ends as before described. In the disclosed embodiment, the tubes 15c, 16c and 35 are of progressively reduced diameters and fit one within the other in concentric relation, refractory material being compacted in the annular space 17c as before.

Since a good portion of the heat of the resistor member in the embodiments shown in FIGURES 8 and 9 is absorbed by the fluid circulating through the resistor member, a heat-insulating jacket may be disposed about

the sheath of the heater to prevent loss of heat through radiation from the sheath.

All of the heaters heretofore described may be used in rectilinear fashion, or such heaters may be bent or curved along the longitudinal axes thereof to any desired configuration within the limitations of the particular heater structure.

In some case, particularly after a heater is bent, it has been found desirable to further compact the refractory material within the heater by compressing the heater by a laterally applied force and this may be readily accomplished by swaging, rolling or side pressing between dies. Such operation further densifies the refractory material to insure filling of all voids and, in the case where the heater has been bent, lateral compression compacts any looseness of the refractory material which might have been caused by the bending operation. Thus, undesirable localized hot spots which might occur in the heater are eliminated.

In some cases, certain applications of the heater dictate that the heater be other than round in cross section and the cross section of the heater may readily be changed from round to that desired by swaging, rolling or side pressing between dies. Such swaging, rolling or side pressing may be used to change the cross section and to simultaneously further compact the refractory material.

FIGURES 10, 11 and 12 show heaters which have been formed to polygonal cross section and specifically FIGURE 10 shows a heater which has been pressed to triangular or heart-shaped cross section to meet requirements specifying that type of cross section. FIGURE 11 shows a heater having a hexagonal cross section. FIGURES 13 and 14 show heater cross sections providing two wide flat sides, the heater in FIGURE 14 having been side pressed to a degree wherein the resistor member approaches a flat ribbon form. Although the drawings show the heaters of FIGURES 10 through 13 with hollow unfilled resistor members, it will be appreciated that suitable refractory material may have been compacted within the hollow resistor member prior to the operation wherein the cross-sectional shape of the heater is changed.

Although the heat-durable, heat-conducting electric-insulating material between the sheath and the tubular resistor, and within the resistor, has herein been particularly described as granular refractory material, it will be appreciated that such material may be either in the granular or pulverized form, or may be in the form of preformed crushable sticks, tubes, slabs, pellets or beads which, after assembly in the heater construction, are crushed and/or compacted in the subsequent processing of the heater, both before and after bending if the heater is bent to a predetermined pattern.

Further, it will be understood that the heat-durable, heat-conducting electric-insulating material may be of any other suitable material, such as mica for lower temperatures, or as integrated mineral layers, for example, synthetic mica. However, in the higher temperature ranges of 800 degrees Fahrenheit and higher, the pulverized mineral insulators, such as crystalline magnesium oxide, calcined magnesia or treated zirconia are much more heat durable.

The resistor members shown in the drawings and heretofore described preferably comprise bodies of metal which have longitudinally extending imperforate defining walls, such as the tubular and rod-like members specifically mentioned. However, it will be appreciated that the tubular and rod-like members may also be transversely perforated to provide for variation of electrical resistance characteristics.

In view of the foregoing it will be apparent to those skilled in the art that I have accomplished at least the principal object of my invention and it will also be apparent to those skilled in the art that the embodiments herein described may be variously changed and modified, without departing from the spirit of the invention,

and that the invention is capable of uses and has advantages not herein specifically described; hence it will be appreciated that the herein disclosed embodiments are illustrative only, and that my invention is not limited thereto.

I claim:

1. An electric heater adapted for heating fluids, comprising a metallic tubular sheath, a tubular metallic member within said sheath and capable of producing heat by resistance to passage of electrical current therethrough and having end portions at respective opposite open ends of said sheath for connection to a source of electrical energy, and a conduit member within said tubular member and having end portions at respective opposite end portions of said tubular member for connection to fluid passage lines whereby fluid may be circulated through said conduit member and be heated, and heat durable electric-insulating heat conducting material between facing surfaces of said sheath and said tubular member and between facing surfaces of said tubular member and said conduit member.

2. An electric heater capable of producing and withstanding high temperatures, comprising a sheath, a tubular metallic member disposed longitudinally within said sheath and capable of producing heat by resistance to passage of electrical current therethrough, said tubular member having a peripheral size smaller than the interior of said sheath to provide a circumferential space between the outer surface of said member and the inner surface of said sheath, heat durable material within said space to electrically insulate said member from said sheath and to conduct heat therebetween, a metallic rod-like member tightly fitted into each end of said tubular metallic member to decrease electrical resistance at each end and thus provide for lower temperature thereof during heating operations of said heater, at least one of said rod-like members having a small opening providing for venting of the interior of said tubular metallic member.

3. An electric heater, comprising a tubular sheath, a resistance heating element extending longitudinally within said sheath in spaced lateral relation with respect to the internal wall surface thereof, said element being transversely bounded by a defining surface of a length generally longitudinally co-extensive with the length of said element and having a terminal portion extending beyond an adjacent end of said sheath, heat durable material between the exterior surface of said heating element and the interior wall surface of said sheath to hold said heating element positioned relative to and electrically insulated from said sheath and to conduct heat from said heating element to said sheath, a metallic connector sleeve disposed about and mechanically and electrically secured to the terminal portion of said heating element, and insulator washer means about the terminal portion of said heating element and disposed between said connector sleeve and said sheath end.

4. The construction according to claim 3 wherein said resistance heating element is a metallic rod.

5. The construction according to claim 3 wherein said resistance heating element is a metallic tube.

6. The construction according to claim 3 and further including metallic members electrically connected to opposite ends of said resistance heating element to reduce the resistance to current flow at such ends.

7. An electric heater, comprising three metal tubes arranged one concentrically within the other in laterally spaced relation, heat durable material in the space between the inner tube and the intermediate tube, heat durable material in the space between the intermediate tube and the outer tube, said inner tube providing a passage for circulation of a fluid, said intermediate tube being connectable to a source of electrical current to produce heat by resistance to passage of current there-

through, and said outer tube providing a protective sheath peripherally about said intermediate tube.

8. An electric heater capable of producing and withstanding high temperatures, comprising an electrical resistance in the form of an elongated hollow metal tube having at least one open end, insulating material compacted within said tube and stopping short of filling said end, a metallic rod-like member fitting within said end and closing the same, said tube having an aperture located in line with an inner portion of said rod-like member, and a plug weld in said aperture joining said tube and member.

9. An electric heater capable of producing and withstanding high temperatures, comprising an electrical resistance in the form of an elongated hollow metal tube having at least one open end, a metallic rod-like member fitting within said end and closing the same, a longitudinal portion of the interior of said tube and a coextensive portion of the exterior of said rod-like member defining a small vent opening for the interior

of said tube, and a pair of terminals disposed at the opposite ends of said tube.

10. The construction of claim 9 wherein said rod-like member has a small groove extending longitudinally thereof to provide said vent opening.

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