Aug. 12, 1969 R. R. POOLE 3,461,275

INFRARED QUARTZ HEATER

Filed Jan. 26, 1968 3 Sheets-Sheet 1

Fig. 1

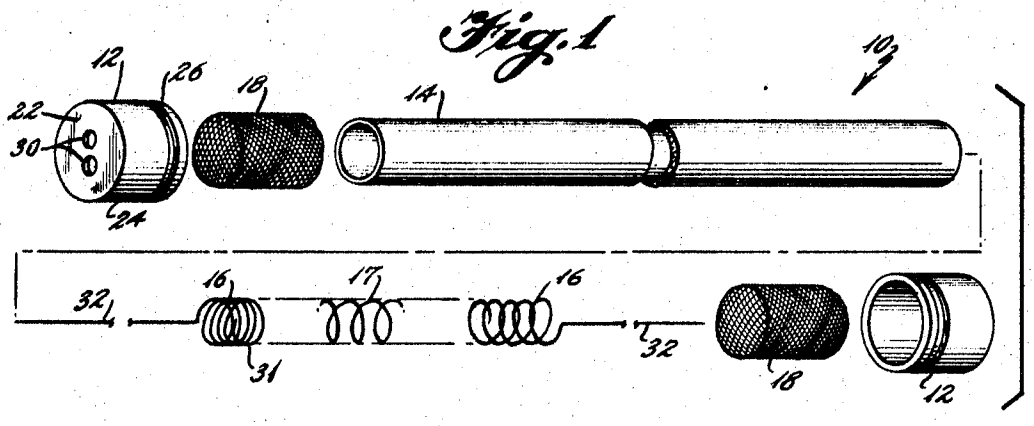


Fig. 2

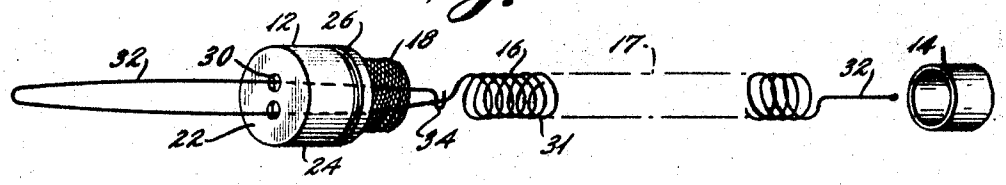


Fig. 3

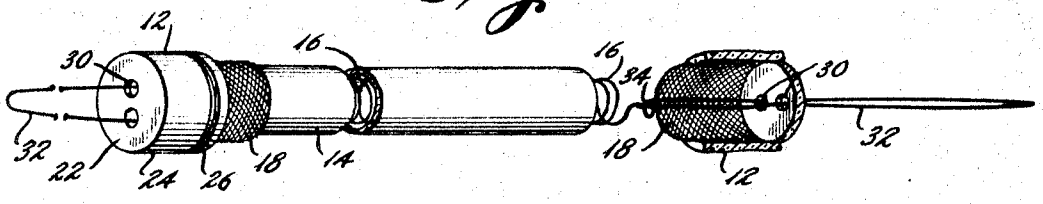


Fig. 4

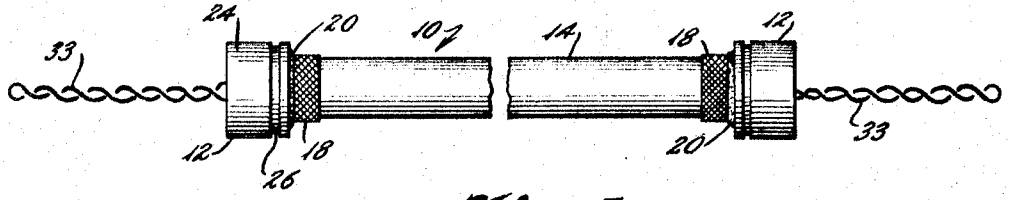
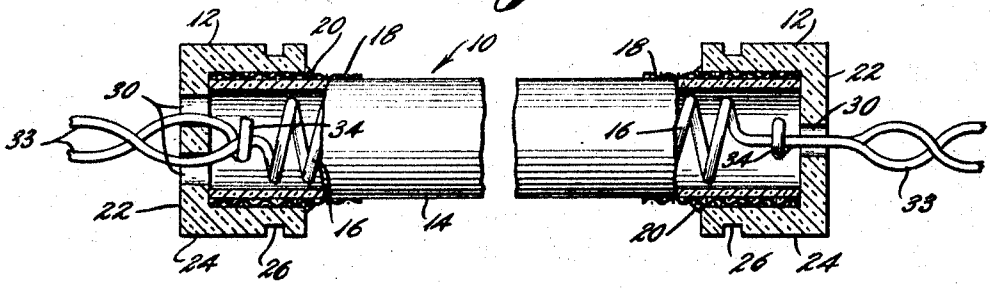


Fig. 5



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INFRARED QUARTZ HEATER

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Fig. 6

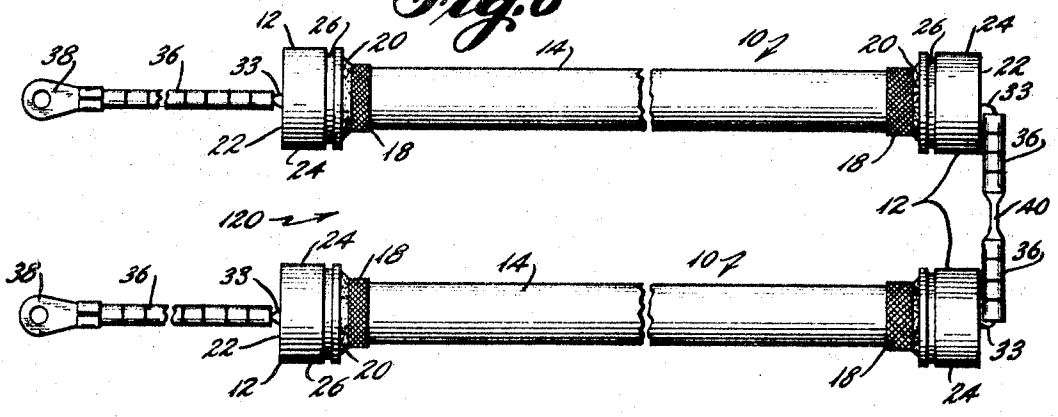
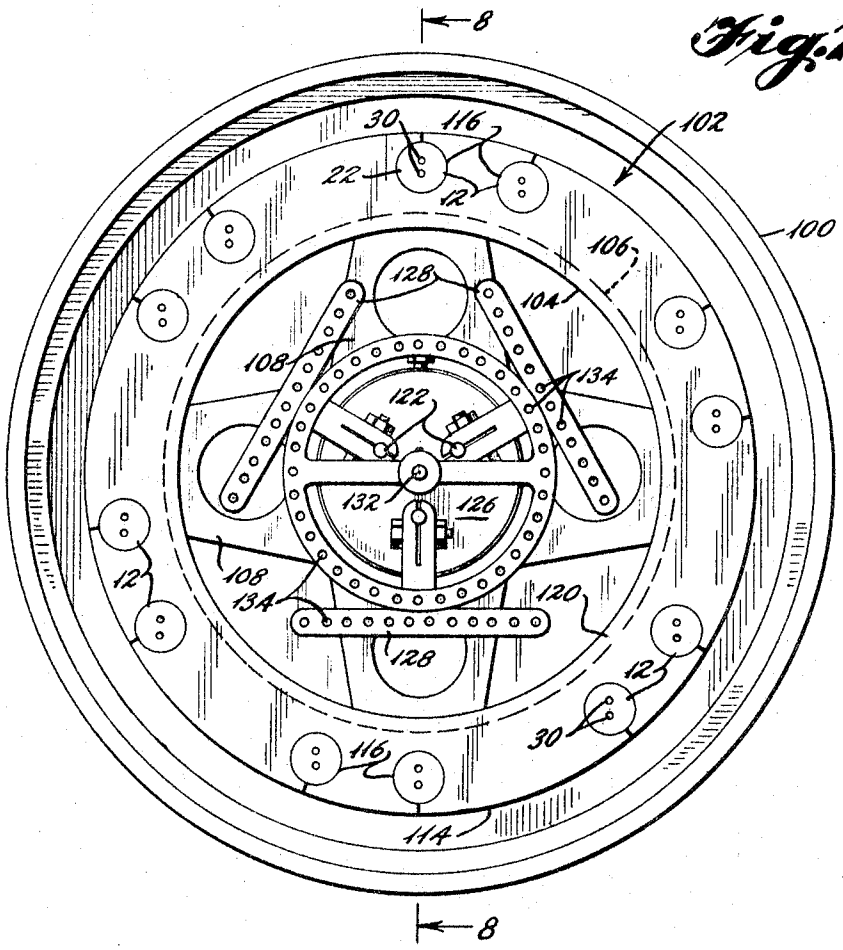


Fig. 7



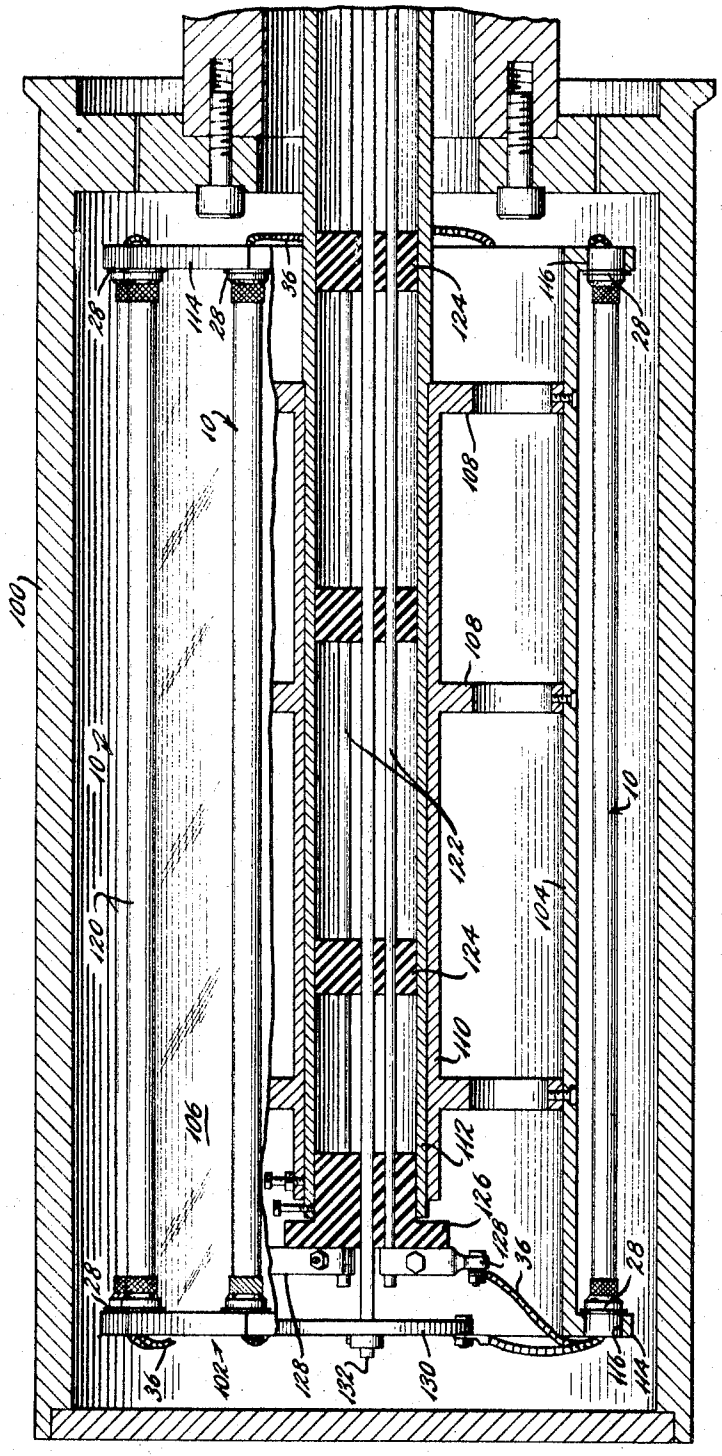

100
10
102
104
106
108
110
112
114
116
120
122
124
126
128
130
132
36
28

Fig. 8

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INFRARED QUARTZ HEATER

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U.S. Cl. 219—553 10 Claims

ABSTRACT OF THE DISCLOSURE

The quartz heater of the present invention comprises a coiled electrical resistance wire inside a quartz tube and capped at each end by an end cap. The coils may have a variable pitch, to generate less radiant heat energy at the center of the heater than adjacent the end caps. The cemented juncture of the end caps and quartz tube has a metallic filler mesh interposed between the tube and the end cap; the filler mesh is believed to lower the failure rate of the quartz heater. The terminus of resistance wire itself extends through the base of each end cap and is formed into the terminal leads for the quartz heater.

The present invention relates to a high intensity heat radiating unit and more particularly to a quartz heater constructed to withstand the severe environmental stresses imposed by rotary process rolls.

The usual quartz infrared heater consists essentially of a resistance wire heating element, appropriate electrical connections to the heating element and a surrounding quartz envelope or tube. Typically the quartz tube is mounted in ceramic end caps through which the electrical connections pass, the caps serving to mount and attach the heater in the desired position on a structural support.

The art has long since recognized the extent to which quartz heaters of this nature are subject to breakage; the quartz tube is fragile. This problem is particularly severe when thermal cycling (i.e., the heater being turned on and off at frequent intervals) is associated with considerable vibration. In point of fact conventional quartz heaters used as the heating element for thin wall rotary process rolls have shown a distressingly short life. The bulk of the failures occur from fracture at the juncture of the quartz envelope with the ceramic end caps and from electric failure due to weakness at the termination structure of the heater wire.

Accordingly, the object of the present invention is to provide an improved high intensity quartz heater of long operating life.

A further object of the present invention is to provide for an improved juncture of the quartz envelope with the end caps in a quartz heater assembly.

Still another object is to provide a quartz heater terminal lead of improved construction.

An additional object is to provide a quartz heater with a simplified yet effective mounting structure.

Further objects and the advantages of the present invention will be apparent from the description thereof which follows.

Reference is now made to the attached drawings wherein:

FIG. 1 is an exploded view of the components of the quartz heater;

FIG. 2 is a side view of the quartz heater during the assembly thereof;

FIG. 3 is a partial section showing the quartz heater in a late stage of assembly.

FIG. 4 is a side view of the quartz heater.

FIG. 5 is a sectional view of the quartz heater shown in FIG. 4.

FIG. 6 is a side view of a dual heater assembly.

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FIG. 7 is an end view of thin wall rotary process roll with portions broken away.

FIG. 8 is a side section of the precess roll taken along the lines 8—8 in FIG. 7.

The quartz heater **10** of the present invention is formed from a pair of end caps **12**, a quartz tube **14** and a heater element **16** in the form of a coiled resistance wire. Also present is a metal filler mesh **18** of temperature resistant metal, e.g., stainless steel or nickel, which also is highly resistant to oxidation at the elevated operating temperatures of quartz heater **10**. A ceramic cement **20** serves as an adhesive to bond the juncture of metallic filler mesh **18**, end caps **12** and quartz tube **14** as shown in FIG. 5.

End cap **12** is formed by a circular base **22** and a cylindrical shoulder **24** upstanding therefrom. A circumferential circular groove **26** is provided on shoulder **24** to accommodate a crescent type metallic (e.g., stainless steel) snap ring **28** (shown on FIG. 8), the snap ring **28** being employed in the installation of quartz heater **10** in an overall heater assembly. The base **22** of end cap **12** is provided with a pair of apertures **30** through which the electrical leads to heater element **16** may be passed.

Advantageously the present quartz heater construction uses the heating element wire itself for the high temperature lead wire. As shown in FIG. 2 the resistance wire forming heater element **16** has a coiled central portion **31** and straight or at least noncoiled end portions **32**. The end portion **32** is passed through one of the double apertures **30** in the base **22** of end cap **12**, then doubled back on itself, the doubled back segment being passed back through end cap **12** by way of the other aperture **30**. The terminus of end portion **32** is now looped or hooked around itself (shown in FIG. 2) with loop **34** closely adjacent the coiled central portion **31** of heater element **16**. Element **16** is then inserted into end cap **12** so that loop **34** and the coil itself set down into cap **12** adjacent the base **22** thereof (as illustrated in FIG. 5). The doubled back terminal portion **32** is now twisted, e.g., five turns per inch, as shown in FIGS. 4, 5 to provide an anchored, integral terminal lead wire **33** for the heating element **16**. The lead wire **33** is suitably insulated as by the ceramic fish spine insulators **36** shown on FIG. 6. A terminal **38** may be welded or otherwise secured to the free end of lead wire **33**. Desirably two or more quartz heater units can be associated in series by welding or otherwise attaching their lead wires together as at **40**, in the double unit structure shown in FIG. 6.

At some stage during formation of lead wires from end portions **32**, the filler mesh **18** and quartz tube should, of course, be placed around heater element **16** and inside end caps **12**. FIGS. 2 and 3 illustrating the relationship of these component parts during assembly of quartz heater **10**. A preferred assembly technique is to form completely a twisted lead wire **33** at one end, cement the tube, mesh and cap together at that end, then repeat the assembly operation at the other end, i.e.,

(1) Place the components in proper juxtaposition.

(2) Form the doubled back, looped resistance wire end (as shown in FIG. 3).

(3) Set quartz tube **14** and filler mesh into end cap **12**, then twist the exposed end portion **32** and cement.

(4) Add insulators **36**, and weld on terminal **38**. Desirably the completed quartz heater **10** has the axis line of apertures **30** of one end cap **12** disposed at a right angle to the axis line of the apertures of the other end cap.

In any event a conventional adhesive ceramic heat resistant cement **20** is placed at the juncture of quartz tube **14**, filler mesh **18**, and cap **12**, then set, e.g., by heating at 175° F. for about six hours to adhesively bond together the end cap, the filler mesh and the quartz tube.

The low failure rate of present quartz heater structure seems attributable to several features. Allusion has already been made to use of the heating element wire itself as the terminal leads. This feature is desirable, aside from any saving in cost by elimination of the several pieces of hardware otherwise used to affix separate lead wires to the heater element. The integral character of the terminal lead permits a more compact heater construction and avoids possibility of burnout at the juncture of the lead wire to the heating element wire. Another feature of construction significant for low failure rate is the metal filler mesh **18**. Presence of metal filler mesh **18** seems to reduce the incidence of fracture of the quartz tube where it enters an end cap. It is theorized that submitting the quartz heater to extensive vibration causes breakdown of the ceramic cement joining the quartz tube and end cap, with loss of cement particles. Thereafter vibration causes the quartz tube to move separately from the end cap, which in turn causes the tube surface to craze; eventually the tube fractures. The mesh of filler **18** acts to trap the adhesive cement in the mesh openings, and seems also to absorb some of the vibrational energy thereby preventing breakup of the cement and subsequent tube fracture.

Filler mesh **18** may be of several forms such as woven wire, knitted wire or expandes metal, the lattermost being preferred. Thus a sheet of expanded (or woven) wire mesh cut to proper size is rolled into a tubular piece of appropriate diameter without overlapped ends. The height of the tubular piece is sufficient for filler mesh piece **18** to extend beyond end cap **12** (e.g., 0.25 inch) as shown in the drawing.

Repeated allusion has been made to use of the present quartz heater structure for the heating elements of thin walled process rolls. Such a structure is illustrated in FIGS. 7 and 8 wherein a rotary thin walled process roll **100** is radiantly heated by multiple quartz heaters **10** mounted in a heater assembly support **102**. Support **102** comprises a hollow cylinder **104** carrying a heat insulator **106**. A plurality of spiders **108** secure cylinder **104** to a cylindrical sleeve **110** surrounding a supporting shaft **112**. Shaft **112** is of course supported at one or both ends independently of rotating process roll **100** and of the roll drive mechanism. There the heating assembly **102** as a whole is disposed in a stationary position inside rotating process roll **100**. Present on the cylinder **104** at or adjacent its terminal ends are rings **114**. The spacing between rings **114** corresponds closely to the overall length of quartz heaters **10** so that the heaters may be mounted therein. The terminals **38** of one polarity from each quartz heater **10** extend to a bolted connection on one electrode connector **130** at apertures **134**. The terminals of opposite polarity connect to electrode connector **128**, as is shown in FIGS. 7, 8. The electrodes **122** themselves are spaced apart inside shaft **112** by bushings **124** and an end bushing **126**. The central electrode **122** is joined at **132** to connector **130** while the outside electrodes are joined to connector **128**.

The heater assembly actually illustrated in FIGS. 7, 8 is for a twelve pack, using six heater pairs **120**, each pair being formed as shown in FIG. 6. Six pairs of apertures **116** are provided in the rings **114** on cylinder **104**. Insertion of the quartz heaters **10** on the heater assembly support is relatively facile, since the end caps **12** fit closely inside the apertures **116**. The heaters are slipped into apertures **116**, then retaining crescent rings **28** are placed in the groove **26** (one at each end cap) to lock the quartz heater **10** in place. These ring retainers **28** are to restrain longitudinal movement of heater **10** in either direction. The fit of quartz heater **10** in apertures **116** is sufficient to prevent disengagement from rings **114**, whether heater **10** is hot or cold, allowing for the differential thermal expansion and contraction characteristics of support **102** and heater assembly **10**. Pairing heaters **10** in a series connection as shown in FIG. 6 permits all of the electrical connections to the heater assembly to be at whichever end may be most convenient to the power supply.

Process rolls such as the roll **100** shown in FIGS. 7 and 8 have relatively rigid heating requirements. The present quartz heater construction and heater assembly are particularly well adapted to heat thin wall rotary process rolls. For example they may be employed as the roll heating elements in the system disclosed by copending application Ser. No. 475,206 of John H. Troll, filed July 26, 1965, now Patent No. 3,369,106, issued Feb. 13, 1968. Alluded to in that application is the desirability of controlling the axial thermal profile of the process roll. Inescapably, a process roll such as roll **100** loses more heat by radiation and convection adjacent the roll ends (end effect) than from the mid regions of the roll. A particular advantage of the present quartz heater construction is the possibility therein for providing a non-uniform heat output from the heater by appropriate construction of heater element **16**.

As illustrated in the drawing, heater element **16** is a coiled resistance wire. Normally the coiled central portion **31** has coils of uniform pitch throughout, with the adjacent convolutions being closely spaced so as to provide maximum (uniform) output per running inch of heater element. For installation of quartz heater **10** in process rolls, however, such a resistance wire is relatively disadvantageous because end effects create an axial temperature differential along the roll; the roll is hotter in the center than adjacent either end. However, if the resistance wire of heater element **16** is constructed with a variable pitch in coiled central portion **31**, the nonuniformity of heat output from the wire coil can be predetermined so as to flatten out the temperature differential along the roll. Thus, in one preferred embodiment heater element **16** is constructed with the coil convolutions in the middle **17** of central portion **31** spaced farther apart than the coils adjacent straight ends **32** of the heater element **16**. Thereby, the temperature profile of process roll **100** is flattened out. Still other pitch variations can provide special heating effects. Thus quartz heater **10** may be built to emit 50% of its radiation from ⅓ of the heater length and 50% from the remaining ⅔.

While particular embodiments of the invention have been illustrated and described, it will be obvious that changes and modifications may be made without departing from the invention and it is intended to cover in the appended claims all such modifications and equivalents as fall within the true spirit and scope of this invention.

What is claimed is:

1. A quartz heater comprising a quartz tube, a ceramic end cap at each end of said tube, and a resistance heating element inside said tube with the terminal leads thereof extending out through said caps and a cylindrical metal filler mesh interposed between the quartz tube and the end cap at the juncture of the tube and cap, the juncture of tube, filter mesh and cap being adhesively bonded by a heat resistant ceramic cement.

2. The heater of claim **1**, wherein the metal filler mesh is a piece of rolled, expanded metal.

3. The heater of claim **1**, wherein the lead wires thereto are formed from the heater element.

4. The apparatus of claim **1**, wherein said coiled resistance wire has a predetermined nonuniform pitch whereby the energy emitted by said heater varies axially thereof.

5. A quartz heater comprising a quartz tube, a ceramic end cap at each end of said tube and secured thereto, and a resistance heating element inside said tube with the terminal leads thereof extending out through said caps, each cap having a pair of apertures in the base thereof, the resistance heating element being a coiled resistance wire with noncoiled terminal end portions thereon, the noncoiled end portion passing out from the cap through one base aperture thereof and doubling back in through the other base aperture thereof with the doubled back wire end portion outside the cap being twisted, said exposed twisted wire end portions being said terminal leads.

6. The apparatus of claim 5, wherein the doubled back end portion of said resistance wire terminates in a loop hooked around said resistance wire inside the cap.

7. The apparatus of claim 5, wherein the said coiled resistance wire has a predetermined nonuniform pitch whereby the energy emitted by said heater varies axially thereof.

8. The apparatus of claim 5, wherein a cylindrical metal filler mesh is interposed between the quartz tube and the end cap at the juncture of the tube and cap, the juncture of tube, filter mesh and cap being adhesively bonded by a heat resistant ceramic cement.

9. The apparatus of claim 1, wherein each end cap has a circular groove on the periphery thereof, said grooves being adapted to placement therein of a retainer ring for ultimate installation.

10. The apparatus of claim 7, wherein the mount for said quartz heater comprises a cylindrical support means having apertured ring members around the periphery

thereof adjacent each end, the apertures on each ring being aligned, said quartz heater end caps fitting into a pair of aligned apertures and retainable therein by placement of a retaining ring in the circular groove of each end cap.

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U.S. Cl. X.R.

219—548; 338—218, 236