Feb. 5, 1957 G. T. STROKES 2,780,715

IMMERSION HEATER

Filed Aug. 2, 1955 3 Sheets-Sheet 1

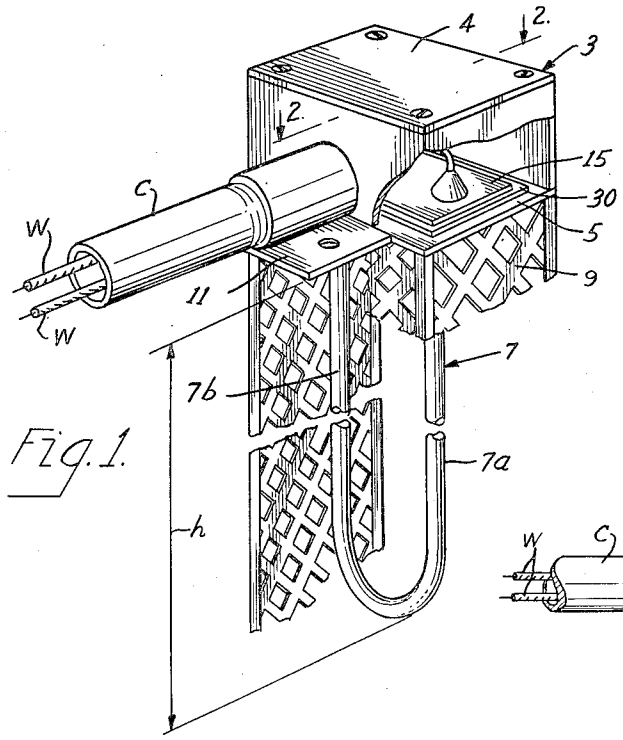
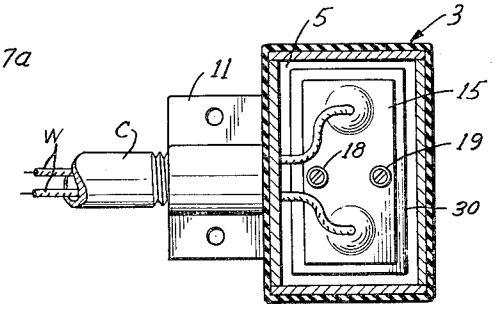


Fig. 1.

Fig. 2.



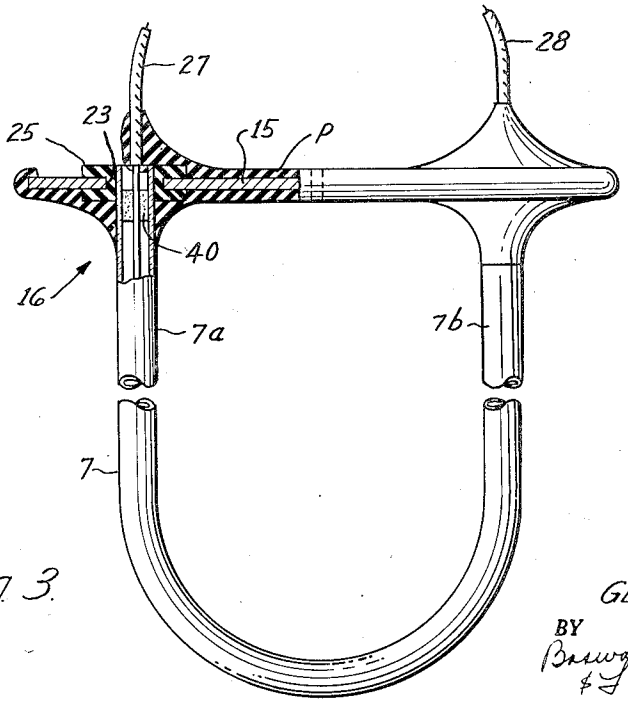


Fig. 3.

INVENTOR.
GEORGE T. STROKES
BY
Burgworth Sessions Herrstrom & Lawler
ATTORNEYS.

Feb. 5, 1957 G. T. STROKES 2,780,715

IMMERSION HEATER

Filed Aug. 2, 1955 3 Sheets-Sheet 2

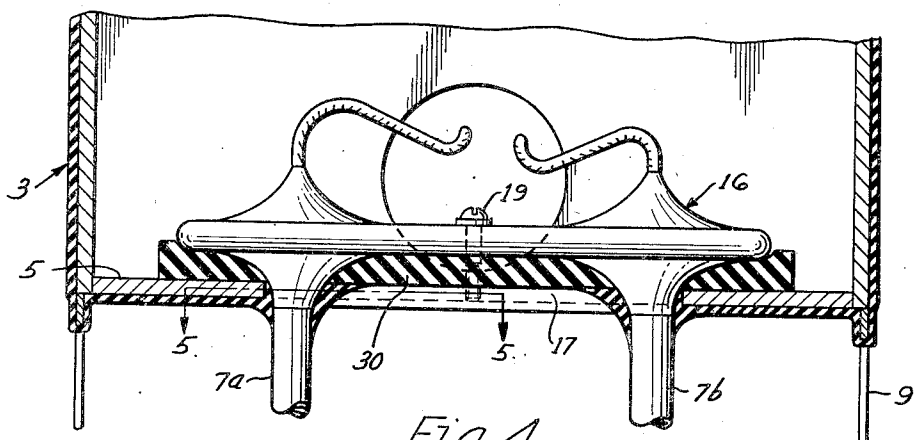


Fig. 4.

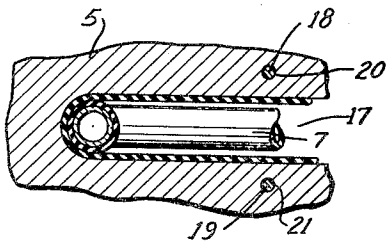


Fig. 5.

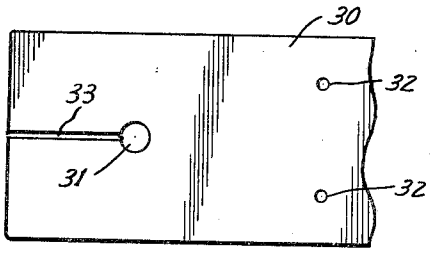


Fig. 6.

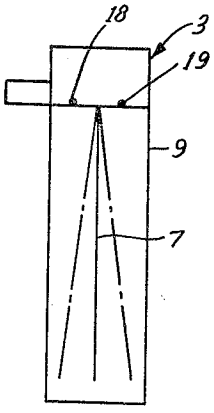


Fig. 7.

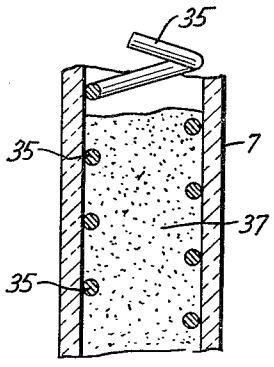


Fig. 8.

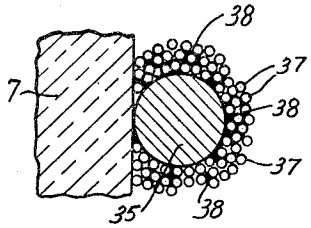


Fig. 8A.

INVENTOR.
GEORGE T. STROKES
BY
Barnwarth, Jennings, Herrstrom & Fowler
ATTORNEYS

Feb. 5, 1957 G. T. STROKES 2,780,715

IMMERSION HEATER

Filed Aug. 2, 1955 3 Sheets-Sheet 3

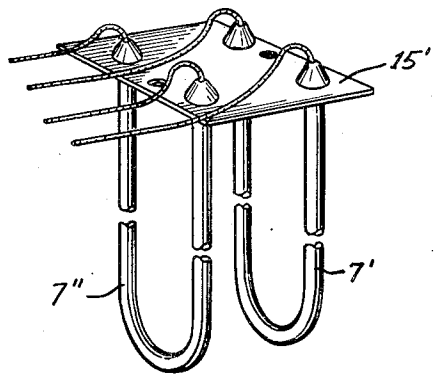


Fig. 9.

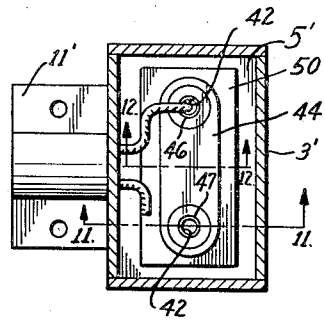


Fig. 10.

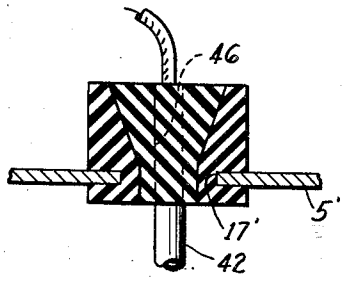


Fig. 12.

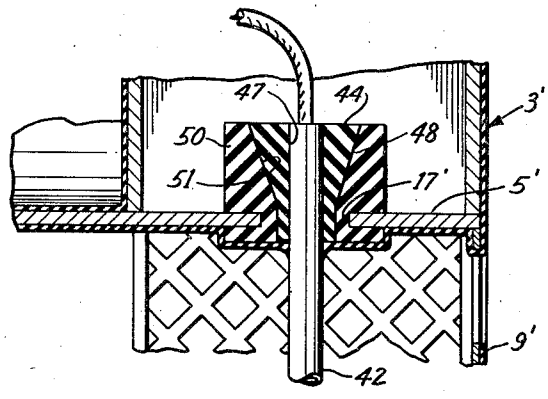


Fig. 11.

INVENTOR.
GEORGE T. STROKES
BY
Bosworth Sessions Herrstrom & Fowler
ATTORNEYS.

United States Patent Office 2,780,715 Patented Feb. 5, 1957

2,780,715

IMMERSION HEATER

George T. Strokes, Willoughby, Ohio, assignor to Glo-Quartz Electric Heater Co., Inc., Willoughby, Ohio

Application August 2, 1955, Serial No. 525,943

10 Claims. (Cl. 219—41)

This invention relates to electric immersion heaters, and in particular to an improved quartz sheathed immersion heater.

Quartz sheathed immersion heaters heretofore have been constructed with a coil of resistance wire wound on a ceramic core and disposed in a straight cylindrical tube of fused quartz, the lower end of which is closed. Laise et al. Patent No. 1,459,307 is an example of such heater construction. The tube length per watt of heating capacity of the straight tube quartz heater is relatively large because (1) the core wound coils are radially spaced from the interior of the tube and this dead space tends to impede transfer of heat from the coil to the outside of the tube, and (2) the return lead of the coil which extends from the lower closed end of the tube through the center of the core to the top of the tube is ineffective for heating purposes. Accordingly, some of the effective length of the heating element is used to overcome these losses. Attempts have been made by heater manufacturers to reduce the ratio of tube length to heating capacity by decreasing the spacing between the coils of the heating element. However, closely spaced coils readily tend to arc over and short out the element, especially when foreign matter or moisture is present in the tube. Filling the tube with an inert gas tends to alleviate this electrical shorting of the coils, but the expense of such a system and the difficulty of sealing the gas in the tube make such practice undesirable.

The sensitivity of quartz heater tubes to damage from mechanical shocks and impacts is directly proportional to the depending tube length, which, in heaters of higher wattage ratings, becomes considerable. For example, a 10 kilowatt heater requires a straight tube approximately 5 feet long. Such heaters are easily damaged and must be handled with extreme care. Moreover, the tube of the core-type heater must be sufficiently large in diameter and in wall thickness to provide space for and to support the weight of the core with a resultant sacrifice of heater efficiency and of economy in tube manufacture.

A general object of my invention is the provision of a coreless quartz tube immersion heater which overcomes the difficulties mentioned above. Another object is the provision of a quartz sheathed immersion heater which is thoroughly protected from damage due to mechanical shocks and impacts incident to handling and shipping. A more specific object is the provision of an efficient quartz immersion heater having maximum heating capacity per unit length of heater and which therefore has a heating tube with a minimum unsupported length. A further object is the provision of a compact quartz immersion heater having a heater tube with a minimum diameter and wall thickness.

Other objects are the provision of a quartz tube immersion heater with means for properly aligning the tube with respect to the other parts of the heater; the provision of an improved method of assembling a coreless heating element within a U-shaped heater tube; the provision of a heater in which arcing between the coils of

the heating element is effectively prevented; the provision of a vapor-tight, air-tight seal between the quartz tube and the heater junction box; and the provision of a durable, efficient, light-weight immersion heater assembly which is economical to manufacture and which is fully sealed against corrosive vapors and fumes emanating from acid solutions it heats.

These and other objects of my invention will become apparent from the following description of preferred embodiments thereof, reference being had to the accompanying drawings.

Figure 1 is a perspective view of an immersion heater assembly embodying my invention, the protective guard and junction box being partially cut away.

Figure 2 is a horizontal section of the junction box showing a top interior view of the heater assembly, the section being taken on the line 2—2 of Figure 1.

Figure 3 is an enlarged elevation partly in section of the quartz heater tube and end plate which comprise the sub-assembly heating unit of the heater assembly.

Figure 4 is a vertical section of the junction box and heating unit assembly showing the shock-proof, vapor-tight connection of the heating unit to the junction box.

Figure 5 is a detail sectional view of the junction box bottom wall taken on the line 5—5 of Figure 4.

Figure 6 is a fragmentary plan view of a resilient gasket forming part of the heater assembly.

Figure 7 is a schematic drawing of the complete immersion heater illustrating the adjustable positioning of the heater tube relative to the protective guard.

Figure 8 is an enlarged longitudinal section of the quartz heater tube showing the location of the resistance wire against the wall of the tube.

Figure 8–A is a greatly enlarged detail of Figure 8 showing the mixture of granular insulating material and powdered carbon which surrounds the coils of the resistance wire in the tube.

Figure 9 is a perspective view showing a multiple tube heating unit.

Figure 10 is a horizontal section of the junction box, similar to Figure 2, showing a heater with a modified form of a shock-proof vapor-tight mounting for the heater tube.

Figures 11 and 12 are vertical sections of the junction box taken on the lines 11—11 and 12—12, respectively, of Figure 10.

According to the present invention, a fused quartz tube in which the resistance heating element is disposed is formed in the shape of a U, and the open upper ends of the legs of the tube extend through and are resiliently supported on a mounting member by means of which the heater is suspended from the side of a tank to heat a solution in the tank. The connection of the quartz tube to the mounting member is vapor-tight and shockproof, the tube being supported on the member by a resilient element to cushion it against mechanical shock. The tube depends from the mounting member and is enclosed by a protective guard, and means are provided for centering the lower part of the tube within the guard to prevent contact of tube and guard. The heating element consists of a resistance wire formed into a helical coil which is expanded against the interior of tube, so that the coil for its full length is in contact with the quartz tube. The coils of the heating element are spaced apart sufficiently to prevent arcing between adjacent parts of the element, and the portion of the tube which encloses the element is filled with a loose granular mixture of dielectric material and carbon powder which facilitates and directs outward transfer of heat through the tube.

Referring now to the drawings, a preferred embodiment of my invention is illustrated in Figures 1–8, inclusive, and comprises a junction box 3 having a removable cover

plate 4 and a bottom wall 5 from which a U-shaped quartz heater tube 7, preferably cylindrical in cross-section, depends for immersion in an acid bath to be heated. A lattice-like guard 9 connected to the bottom of the junction box protectively surrounds the full depending height *h*, see Figure 1, of the tube 7. The bottom wall 5 of the junction box extends outwardly from one side as indicated at 11 for mounting the entire heater assembly on the side of a tank or vat, not shown. Wires W, connected to a source of power, extend through a conduit C connected to the junction box and are electrically connected within the junction box to the leads of the heating element. In the embodiment shown in Figure 1, the side of the guard adjacent the side of the vat on which the heater is mounted is omitted.

The parallel side legs 7*a* and 7*b* of the tube are connected at their upper ends to a generally rectangular end plate 15, see Figure 3, which traverses the tube legs and which supports the tube on the junction box. Tube 7 and plate 15 preferably comprise a sub-assembly heating unit, generally designated by reference character 16 and shown in Figure 3, which is removably mounted on the junction box. The bottom wall 5 of the junction box has an elongated opening 17 therein, see Figures 4 and 5, over which plate 15 is placed so that the legs 7*a* and 7*b* of the tube extend downwardly through this bottom opening in the junction box. Screws 18 and 19 located centrally between the tube legs extend from the top of plate 15 to engage tapped holes 20, 21 in bottom wall 5 to removably secure the sub-assembly unit 16 to the junction box. When desired, the junction box cover 4 may be removed and the entire unit 16 lifted vertically out of the box for inspection and/or replacement.

At each end of plate 15 is a tube receiving hole 23, see Figure 3, which is larger in diameter than the outside diameter of the quartz tube. A rubber grommet 25 within which the end of the tube leg is sealed, spaces the tube from the sides of the opening 23 and overlies the marginal edge of the opening. The shock sensitive quartz tube, therefore, is resiliently supported on the plate. Leads 27, 28 from the heating element in the tube extend through the upper ends of the tube legs for connection to wires W inside the junction box.

In order that the heating unit 16, without a junction box and guard, may be used to heat acid solutions, the entire mounting plate 15, grommets 25, and the portions of the tube 7 and leads 27, 28 adjacent the plate are dip coated in a plastisol capable of giving rise to an acid-resistant, heat-converted synthetic resin P which preferably is baked on these parts. This coating preserves the plate 15 from corrosion and deterioration that would otherwise result from contact with acid solutions and their vapors. If the heating unit 16 is to be used exclusively with a junction box, the coating may be omitted, since the interior of the junction box is fully sealed by a gasket as described below. The length and width of end plate 15 of the heating unit 16 is such that the marginal edges of the plate overlie the top edge of the elongated opening 17 of junction box bottom wall 5 when these parts are assembled as shown in Figure 4.

In order to seal the bottom wall opening 17 in the junction box from vapors rising from the heated solution, I provide a resilient pad or gasket 30, see Figure 4, preferably made of closed-cell sponge rubber which is acid-resistant, and vapor-impervious, between end plate 15 and junction box bottom wall 5. The gasket 30 preferably is slightly longer and wider than plate 15, see Figure 2, and is formed with a pair of tube holes 31, one of which is shown in Figure 6, through which the legs of the U-tube extend. The diameter of each gasket hole 31 is slightly smaller than the diameter of the tube, and hence the gasket seals tightly around the exterior of the tube legs. Additional holes 32 are formed in the gasket for screws 18 and 19, which, when tightened against plate 15 and the bottom wall of the junction box, cause the gasket 30 to be squeezed tightly between the underside of the plate and the upper surface of the bottom wall 5 to fully seal the opening 17 in the bottom wall and to prevent rising vapors from entering the junction box. Gasket 30 is slit at 33 to facilitate its introduction into the sub-assembly. It functions to further shock-proof the connection of the quartz tube to the junction box and to preserve the tube from damage by jolts and impacts transmitted to the assembly.

The height *h* of the U-tube, that is, the distance which the tube extends below the junction box, becomes appreciable, especially for heaters having ratings of 5 kilowatts and above. For example, in an 8 kilowatt U-tube heater, the tube height *h* is approximately two and one-half feet. In order to position the U-tube with the legs 7*a* and 7*b* in a substantially vertical plane so that the lower end of the tube is adequately spaced from the guard and/or the side of the tank, screws 18 and 19, located on opposite sides of the plane of the tube, are adjusted alternately to vary the plane of the tube as suggested in Figure 7. By tightening one of the screws, tube end plate 15 on resilient gasket 30 is inclined relative to the junction box in one direction and causes the entire tube to pivot about the junction box in a corresponding direction. The resilient gasket 30 facilitates this action without, however, impairing its seal. By properly adjusting screws 18 and 19, the tube is moved to the vertical plane as suggested in solid line in Figure 7 for maximum safe spacing of the tube from the guard, and no tube support at the lower end of the guard is required.

The heating element consists of a resistance wire 35, preferably made of a nickel and chromium alloy and sold commercially as "Kanthal" wire, see Figures 8 and 8*a*, which is formed in a helix and which extends through the entire lower portion of the tube 7 in contact with the interior of the tube as shown. Preferably the portion of the tube through which the heating element extends is filled with a mixture of fine mesh granules of dielectric material 37, such as zirconium sand, and carbon powder 38. The sand serves to fill the space within and around the wire coils and being non-conductive, directs the heat generated by the wire radially outwardly from the tube. The sand, in addition to functioning as an insulator, supports and maintains spacing between the coils of the heating element. The carbon powder, being considerably smaller in grain size than the sand, displaces any air in the small voids between the sand particles and facilitates conduction of heat to the quartz tube.

The coiled heating element 35 is inserted in the tube in such a manner that proper disposition of the coils in the tube for maximum heating effect is accomplished. The resistance wire 35 first is formed in the shape of a closed helix having a diameter larger than the internal diameter of the U-tube 7. One of the lead wires 27, 28 is pushed through the entire tube, so that the lead wire extends from both ends of the tube. Then the resistance coil, which is adjacent and outside one end of the tube, is stretched by a tension force applied to both leads 27, 28 connected to opposite ends of the coil. This stretching of the coil opens the helix and reduces the helix diameter to less than the interior diameter of the tube. The coil is then moved longitudinally into the tube under tension until the upper ends of the coil are at the same level in the side legs of the tube. The tension force is then released and the coil springs out against the interior of the tube, maintaining, however, an adequate space between each coil turn of the helix. The mixture of sand and carbon powder is then poured into the tube to completely fill the space within and between the coil turns and is packed around the wire by vibration. In order to absorb any moisture that may be present in the upper unfilled portions of the U-tube, a charge of hygroscopic material 40, such as silica gel, see Figure 3, is placed in the open end of each leg of the tube. The tube with

the resistance wire firmly packed therein is then ready for assembly with end plate **15** as described above.

The method just described insures that the entire length of the resistance coil is in full contact with the interior of the quartz tube, and heat generated by the coil is transferred directly through the quartz tube to the solution on the outside with a minimum of heat loss. Proper spacing of the coil turns also is maintained and the danger of arcing between the turns is eliminated.

The quartz immersion heater embodying my invention not only results in more efficient heating of the solution, but also permits the use of a quartz heater tube having an effective height *h* and cross-sectional dimensions that are considerably smaller than the conventional straight tube quartz heater. Use of the U-tube heater eliminates the need of a core for the resistance wire and the time required to wind the coil on the core. Without a core, the wall thickness of the quartz tube and the inside and outside diameters of the tube are considerably smaller than the straight tube quartz heater. This not only effects economy in the amount of quartz required for a heater, but correspondingly increases the heating capacity of the heater by reason of the thinner tube wall through which the heat is transferred. Moreover, the watt density per unit length of heater is increased by reason of the smaller diameter of the tube.

By way of example and comparison, a quartz immersion heater of conventional straight tube design and rated at 5 kilowatts requires a tube having an outside diameter of 1½", an inside diameter of 1¼", and a wall ⅛" thick. The U-shaped quartz heater rated at 5 kilowatts has a tube with an outside diameter of ½", an inside diameter of ⅜", and a wall thickness of 1/16". The overall height of the 5 kilowatt straight heater tube is 37", whereas the same heater in the U-shaped design has an overall height of 23".

The minimum external dimensions of the U-tube heater design is advantageous also in facilitating the construction of a heater with two or more heater tubes **7'**, **7"**, connected to a common end plate **15'** as illustrated in Figure 9. The multiple tube heating unit may be mounted on one junction box and within a common guard without substantial increase in the size of these parts, and the overall height of the heater unit remains the same for a heater having a rating equal to the sum of the capacity of the several tubes. For example, a 10 kilowatt immersion heater having two U-shaped quartz tubes, each of which is rated at 5 kilowatts, has an effective height *h* of guard and tube of approximately 23". By way of comparison, a 10 kilowatt single straight tube quartz heater has an overall length of guard and tube of approximately 60".

A modified form of my invention is illustrated in Figures 10, 11 and 12 and comprises a U-shaped quartz tube **42** with the upper ends of its legs supported in an acid-resistant resilient bushing **44** within the junction box **3'**. Bushing **44** has a pair of laterally spaced tube receiving openings **46**, **47** within which the tube legs are snugly embraced and firmly secured. The entire outer side surface **48** of bushing **44** is tapered downwardly and inwardly symmetrically of the axis of bushing openings **46**, **47**, as shown in Figures 11 and 12, and seats within a hollow molded resilient fitting **50** which is fitted around the marginal edge of and extends upwardly from the elongated opening **17'** in the bottom wall **5'** of the junction box **3'**. The inner surface **51** of the fitting **50** tapers inwardly and downwardly symmetrically about the vertical plane of the junction box and at the same angle as the tapered outer surface **48** of bushing **44** and, accordingly, the bushing seats snugly and tightly within the fitting when the tube is assembled with the junction box.

The tapered surfaces **48** and **51** of bushing **44** and fitting **50**, respectively, serve a three-fold function. These surfaces mate tightly and form a vapor-tight, air-tight junction and seal between the tube and junction box and

prevent corrosive vapors from entering the junction box through opening **17'**. Since the tapered surfaces of the bushing and fitting are symmetrical with respect to the vertical plane of the junction box, the U-tube is automatically aligned in a vertical plane when assembled with the junction box. The bushing **44** and fitting **50** also fully insulate the quartz tube from shocks transmitted to the junction box and guard. In other respects, the modified form of heater is essentially the same as the heater described above and the heating coil is inserted in the tube substantially as described heretofore.

Modifications and changes to the above-described embodiments of my invention may be made by those skilled in the art without departing from the scope of the invention and hence I wish it understood that these embodiments are given only by way of example. The scope of the invention is defined in the appended claims.

I claim:

1. An immersion heater comprising, in combination, a vapor-tight junction box having a bottom wall with an elongated opening therein, a guard depending from the periphery of said bottom wall, a U-shaped quartz tube of cylindrical cross-section extending within and spaced from said guard and having side legs with upper ends extending through and being spaced from the edge of the said bottom wall opening, resilient sealing means tightly engaging the upper ends of said tube legs and sealing said legs within the opening in said bottom wall, and tube centering means operatively connected to said bottom wall and to said tube legs for centering the lower end of said tube within said guard.

2. The heater according to claim 1 in which said sealing means comprises a grommet on each of said legs of said U-tube, said tube centering means comprising a plate interconnecting the grommets on the respective ends of the tube legs and being vertically spaced from said bottom wall of the junction box, and screw means on opposite sides of the plane of the U-tube adjustably connecting said plate to said bottom wall.

3. The heater according to claim 2 with a resilient gasket between said bottom wall and said plate, said tube legs extending through said gasket and being sealed thereby to said bottom wall.

4. The heater according to claim 1 in which said sealing means comprises a bushing having a pair of tube receiving openings and having a downwardly and inwardly tapering outer side surface, said tube centering means comprising a hollow resilient fitting connected in said slotted opening in the junction box bottom wall and surrounding said bushing, said fitting having a downwardly and inwardly tapered inner side surface, said bushing being disposed within said fitting with the tapered surfaces of said bushing and said fitting engaging each other with a vapor-tight contact.

5. In an electric immersion heater, a continuous one-piece quartz tube having side legs laterally spaced apart at one end of the tube and joined together at the opposite end, means for supporting the spaced ends of said legs, a coil of resistance wire in engagement with the interior of said tube for the full length of the coil, said coil extending from one of said legs to the other through said opposite end of the tube, and, filling the void in the portion of the tube through which said coil extends, a finely divided material having dielectric properties.

6. The heater according to claim 5 in which the portion of said tube through which said coil extends is filled with a mixture of granular dielectric material and powdered carbon.

7. In an electric immersion heater, a one-piece U-shaped quartz heating tube having parallel side legs with spaced upper ends, a mounting plate having a pair of oversize laterally spaced holes through which the respective upper ends of said tube legs extend, a resilient grommet embracing the upper end of each tube leg and dis-

posed in the mounting plate hole between the tube leg and the mounting plate.

8. The heater according to claim 7 with a junction box having a bottom wall with an opening therein, said mounting plate being sealed within said junction box and said tube extending through said opening and projecting downwardly from said bottom wall, and wire means connected to said junction box for energizing the heating tube.

9. An electric immersion heater comprising a plurality of juxtaposed U-shaped open ended quartz tubes in separate parallel planes and arranged with the respective open ends of the tubes adjacent each other, a heating coil in each of said tubes, a junction box, a tube mounting member in said junction box, said ends of said tubes being resiliently connected to said mounting member, wire means connected to a source of power and extending through said junction box and into the ends of said tubes for energizing said heating coils, a guard on said junction box and co-extensive with and encompassing said

tubes in spaced relation therewith, and means associated with said mounting member for centering said tubes within said guard.

10. In a fused quartz immersion heater, the combination of a vapor-tight junction box, a U-shaped fused quartz tube having open ended side legs secured at their ends to and extending from said junction box, said ends of said tube side legs extending into the interior of said box, a vapor-tight air-tight resilient seal between said ends of the tube side legs and said junction box, a heating element in said tube, and means for supplying electric energy to said heating element.

References Cited in the file of this patent

UNITED STATES PATENTS

1,032,267	Bastian	July 9, 1912
1,120,966	Neiman	Dec. 15, 1914
1,365,978	Gallager	Jan. 18, 1921
2,708,233	Moore	May 10, 1955