United States Patent

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[54] **IMMERSION HEATER AND METHOD OF MAKING THE SAME**
16 Claims, 10 Drawing Figs.

[52] **U.S. Cl.** **219/335,** 165/133; 219/315, 219/523
[51] **Int. Cl.** **F24h 1/00**
[50] **Field of Search** 219/315, 316, 335, 336, 338, 354, 523, 353, 553; 165/133; 313/40, 44, 45, 110, 317, 109

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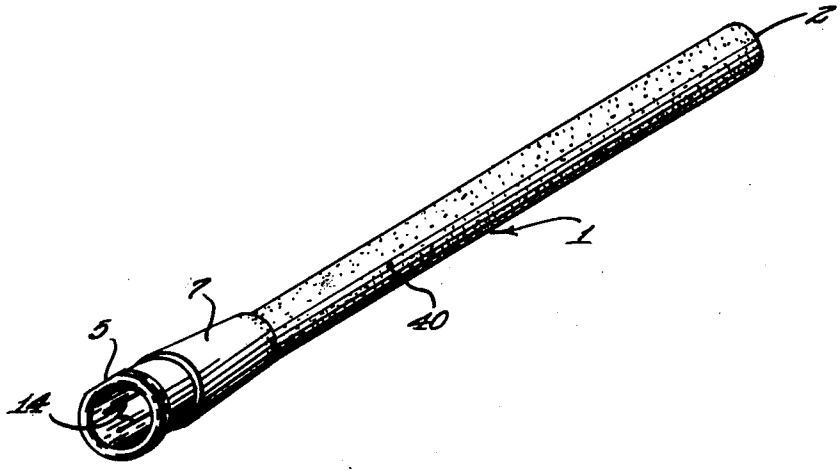
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ABSTRACT: A heating device, particularly for scientific usage as an immersion heater, which employs an electrical element for generating radiant energy, in which the electrical element is enclosed in a shell, which, for example, may be of suitable glass having a relatively low coefficient of absorption with respect to such radiant energy, such shell having disposed at the exterior surface thereof a material with a relatively high coefficient of absorption of such energy whereby such radiant energy from said element will be converted to heat at the exterior surface of said shell and available thereat for substantially direct heating of a fluid in which the shell may be immersed.



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Fig. 1

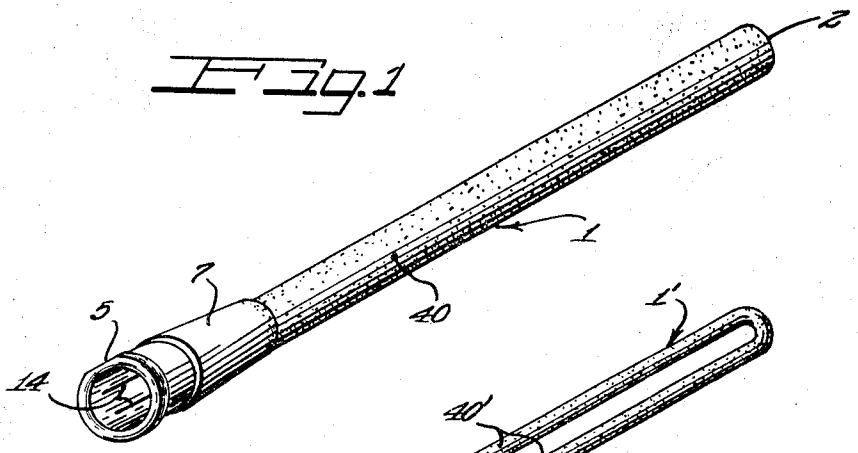


Fig. 2

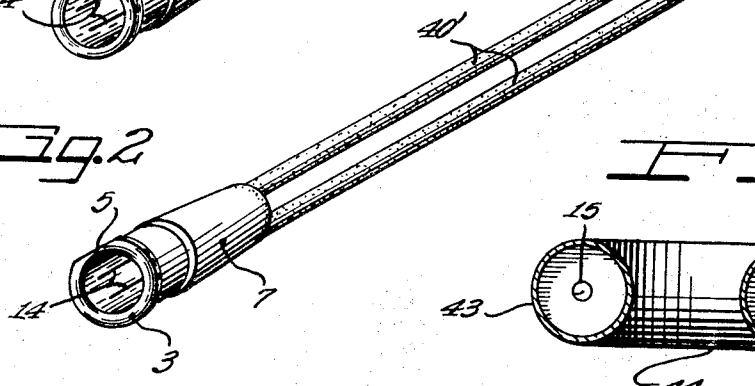


Fig. 10

Fig. 5

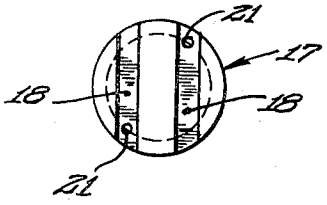
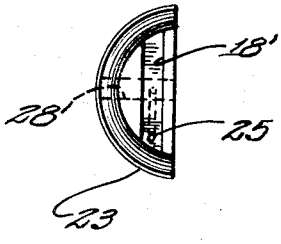


Fig. 7



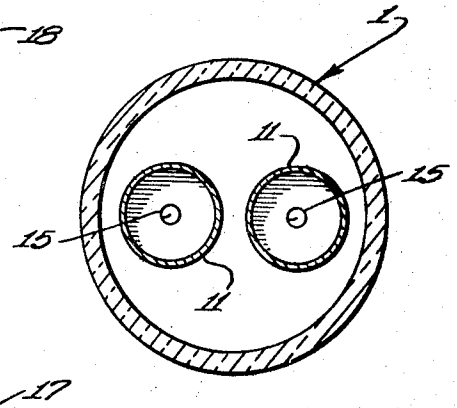
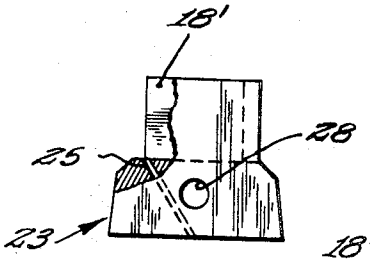


Fig. 4



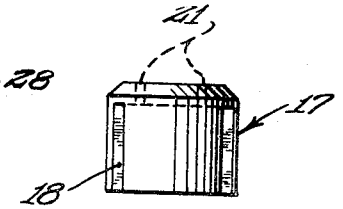


Fig. 8

Fig. 6

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Fig. 3

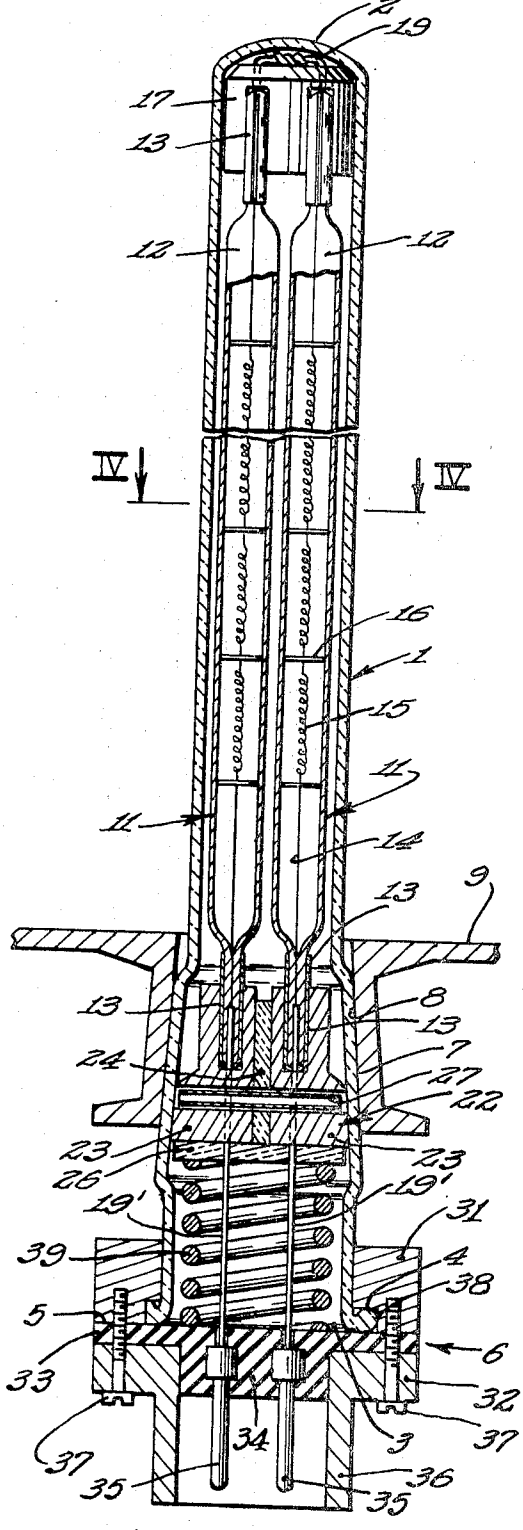
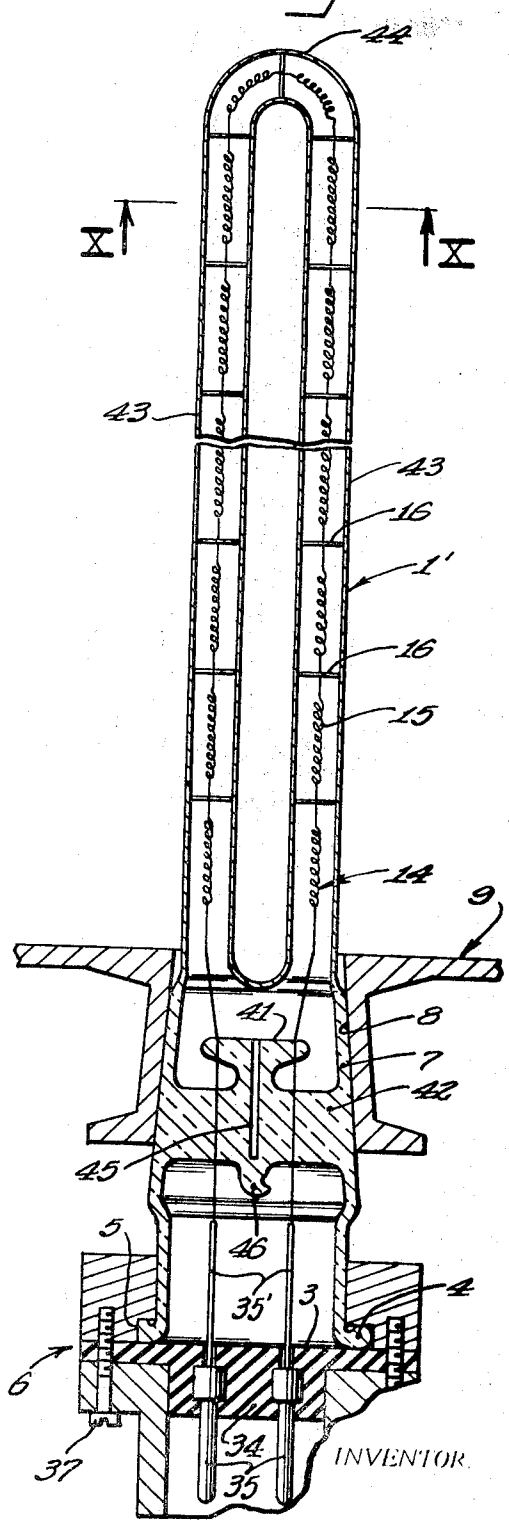


Fig. 9



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IMMERSION HEATER AND METHOD OF MAKING THE SAME

BACKGROUND OF THE INVENTION

The invention is directed to a heating structure, particularly for scientific usage and the like in the form of an immersion heater which may be disposed in a fluid to be heated.

In the past, heaters of this general type have employed quartz shells or jackets in which was disposed a nichrome electrical element consisting of a nichrome wire suitably wound and supported on a ceramic core. During operation, a high thermal gradient existed within the heater structure which had a deteriorating effect on the ceramic core elements whereby the latter often cracked during usage and thus necessitated replacement in the most expensive portion of the heater unit. Likewise, a heater of this construction, with quartz jacket and ceramic core element possesses a relatively large mass which must be brought up to the desired operating temperatures upon actuation of the heater, and results in relatively slow cooling following disconnection of the heater, as a result of which fast responsive control by thermostatic devices was difficult to achieve. Furthermore, in the event of insufficient cooling of the unit, prior nichrome elements usually would not burn out until the quartz jacket ruptured with the possibility of the occurrence of fire and other damage.

The present invention therefore is directed to a lamp structure which eliminates disadvantages in heaters of the prior type and offers additional advantages thereover.

BRIEF SUMMARY OF THE INVENTION

The present invention contemplates the utilization of a structure in which a relatively low thermal gradient will exist within the heater structure during operation, particularly adjacent the inner face of the outer shell or jacket of the heater, enabling the fabrication thereof from a suitable glass, such as borosilicate glass, at the same time also enabling the use of much shorter lead-in conductors than heretofore possible, for a similar wattage, with a consequent reduction in the overall length of the structure and improved efficiency for a given wattage.

Two forms of the invention are illustrated, the first utilizing commercially procurable tungsten-quartz heat lamps, two of which are employed in the embodiment illustrated, which are removably supported within the shell and thus readily capable of replacement if necessary. In the other embodiment of the invention illustrated, the glass shell forms the enclosing envelope for a tungsten element to provide a unitary structure.

In both forms of the invention, the glass shell has disposed at the exterior surface thereof a material which is operative to absorb radiant energy passing through the shell whereby heat developed therefrom is available substantially at the exterior of the shell and available for substantially direct contact with the fluid to be heated.

The mass of the structure thus is reduced to a minimum whereby the structure will heat and cool very rapidly, providing exceptionally responsive heating and cooling cycles so that very close maintenance of a desired temperature may be achieved.

I have found that a very effective energy absorption material for disposition at the exterior of the shell is a silver stain comprising a mixture of iron oxide with a small amount of silver. Such material may be effectively disposed on the shell by application in the form of a suspension in a suitable organic medium with the shell being dipped in such solution and subjected to a heat treatment whereby the stain penetrates the glass shell, darkening such outer surface to a point where it will efficiently absorb the radiation involved.

In the drawings, wherein like reference characters indicate like or corresponding parts, and wherein preferred forms of the invention are illustrated, which, as will be apparent therefrom and the following description, may be capable of various immaterial variations and modifications without departing from the spirit and scope of the novel concepts of the disclosure:

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is an isometric view of one embodiment of the invention employing removable individual heating elements;

FIG. 2 is a similar view of another embodiment of the invention employing a unitary structure;

FIG. 3 is a longitudinal section through the tube illustrated in FIG. 1 and a portion of the mounting structure therefor;

FIG. 4 is a sectional view taken approximately on the line IV–IV of FIG. 3;

FIG. 5 is an end view of a fitting for supporting the inner ends of the individual heating tubes of the construction illustrated in FIG. 1;

FIG. 6 is a side elevational view of the fitting illustrated in FIG. 5;

FIG. 7 is a top plan view of one of two like fittings employed to support the outer ends of the respective heating elements of construction illustrated in FIG. 1;

FIG. 8 is a side elevational view of the fitting illustrated in FIG. 7;

FIG. 9 is a longitudinal sectional view, similar to FIG. 3, of the embodiment illustrated in FIG. 2; and

FIG. 10 is a sectional view taken approximately on the line X–X of FIG. 9.

DETAILED DESCRIPTION

Two embodiments are illustrated in the drawings, one of which, illustrated in FIGS. 1 and 3, utilizes commercially procurable tungsten-quartz heat lamps of a type commercially procurable, as for example, tungsten-quartz infrared heat lamps manufactured by General Electrical Company and identified as GE800T3. The other embodiment illustrated in FIGS. 2 and 9, employs a unitary construction in which the heating element is constructed as a unitary part of the entire structure, and in which case the interior of the device is suitably evacuated or provided with a low-pressure atmosphere in accordance with standard practice for heating elements of this general type.

Both of the constructions illustrated utilize a glass shell, at the outer surface of which is disposed the desired radiation absorbing material, for example, in the form of a stain which penetrates the glass wall of the shell at the exterior surface thereof.

THE CONSTRUCTION WITH REPLACEABLE HEATING ELEMENTS

Referring to the drawings and more particularly to FIGS. 1, 3 and 4—8, the reference numeral 1 designates an elongated hollow tubular shell constructed of a suitable glass, for example a borosilicate glass, having one end thereof closed as indicated at 2 and the opposite end thereof open as indicated at 3. Such open end of the shell is provided with a peripheral flange 4, which as illustrated in FIG. 3, may be provided with one or more flats 5 forming means for effecting proper registration between the end of the shell and a cooperable end assembly indicated generally by the numeral 6. The shell 1 is also provided with a conical or tapered wall portion 7, illustrated in the present embodiment as being disposed adjacent to but spaced from the open end 3 of the shell, with the outer surface of the portion 7 being suitably formed, as for example by grinding, to provide a sealing surface adapted to cooperate with a complementally shaped portion 8 forming a part of a vessel 9 or other structure in which the heater is to be operatively supported.

Disposed in the shell 1 are a pair of heat lamps, each indicated generally by the numeral 11, each of which comprises an elongated tubular bulb 12 of quartz, the ends of which are suitably sealed and capped by terminal members 13, which in the commercial construction are constructed of sheet metal formed about the sealed bulb end and conductively connected to opposite ends of a tungsten wire element 14, the intermediate portion of which is formed in the shape of a small diameter helix 15. The latter, as illustrated, may be formed in

a plurality of sections with suitable spacer elements 16 being disposed between the respective sections operable to support the element 14 in fixed spaced relation with respect to the tubular side walls of the bulb 12.

The inner ends of the respective lamps 11 are supported in a fitting 17, preferably of a material having a good thermal conductivity, as for example aluminum, the fitting 17 being generally cylindrical and having a pair of spaced parallel slots 18 therein which intersect one end of the fitting and are of a size to snugly receive the terminal members 13 at the inner ends of the respective heat lamps. Such heat lamps in their commercial form are provided with respective lead-in conductors 19, of relatively short length which are secured to the respective terminal members 13 and thus to the adjacent end of the associated heating element 14, which conductors, as illustrated in FIG. 3, are adapted to be inserted through axially extending bores 21 in the fitting 17, such bores being located in the bottom wall of the respective slots 18 and positioned to be aligned with the lead-in conductors 19 whereby the latter may be extended substantially straight through the fitting 17 so that upon suitable connection of the two conductors an efficient electrical connection may be made between the adjacent terminals 13. Where the fitting 17 is fabricated of metal, such as aluminum, and so proportioned that the terminal members 13 are snugly received in the slots 18, the fitting 17 likewise may function as an electrical connector between the two terminal members 13.

The terminal members 13 at the opposite ends of the respective heat lamps II are supported in a similar manner from a cooperable structure, constructed in the form of an assembly 22 comprising a pair of members 23, of like construction, cooperable with an intermediate insulating strip 24 to form a generally cylindrical assembly with each member 23 having a slot 18' therein, corresponding to the slots 18 of the fitting 17, into which are received the respective adjacent terminal members 13 of the heat lamps 11. Each of the members 23 is provided with a bore 25 therein, corresponding to the bores 21, suitably placed to receive the lead-in conductor of the adjacent terminal member 13, which, after passing through an insulating disk 26, are extended for connection, exteriorly of the shell 1, with a power line. In the embodiment illustrated, the member 23 and insulating strip 24 are normally retained in aligned assembled relation by a short section of glass tube 27 disposed in aligned bores 28 in the member 23 and a similar bore in the strip 24.

The end assembly 6, in the embodiment of the invention illustrated, comprises a pair of cooperable annular-shaped members 31 and 32, constructed for example of aluminum or other metal, which are assembled with a disk or block of suitable insulating material 33 interposed therebetween, which in the embodiment illustrated is provided with a central portion 34 of increased thickness which carries a pair of pin terminals 35, the lead-in conductors 19' being extended to the member 33 and secured in conductive relation to the terminals 35. The member 32, in the embodiment illustrated is provided with a tubular portion 36, cooperable with the terminals 35 to form an electrical connector by means of which the heating elements may be operatively connected to a power source. The member 32 may be suitably secured to the member 31 by a plurality of screws 37 or the like. As previously mentioned, the flange 4 at the open end of the shell 1 may be provided with a flat 5, with the member 31 being provided with a counterbore 38 therein of a size to receive the flange 4, such counterbore preferably having a shape complemental to the flange 4 including the flat 5 whereby the end assembly 6 is rotationally fixed with respect to the shell 1, thus maintaining the connector structure in proper alignment with respect to the conductor leads 19' from the respective lamps.

Disposed between the insulating disk 33 and the insulating disk 26 is a compression spring 39 operated to urge the entire internal assembly into fixed relation with respect to the shell structure, and in particular to provide a firm seating of complemental portions of the fitting 17 and the fittings 23 in engagement with the inner surface of the shell 1 to provide good heat conduction from such fittings to the walls of the shell, from which the heat may be suitably dissipated.

As illustrated in FIG. 1, the major portion of the shell 1, extending from the tapered portion 7 is provided with a suitable material 40 which will absorb the radiation emitted by the lamps 11.

The material 40 may comprise any suitable components preferably being applicable to the tube in the form of a stain which will penetrate the glass a slight distance and thus forms a permanent part of the shell which cannot be inadvertently removed or damaged other than when associated with destruction of the shell itself.

I have found that a silver stain comprising mainly iron oxide, to which a small amount of silver is added is suitably dispersed in an organic vehicle, as for example, isopropyl alcohol. A suitable stain may also be commercially procured, as for example that known as amber stain 29–346 marketed by the Drakenfield Company, which it is believed is a material corresponding to the iron oxide-silver material above described.

I have found that highly superior results can be achieved in the application of material if the latter takes places in accordance with a specific and accurately controlled process, whereby the finished material is in the form of a stain which penetrates the glass shell at the outer surface thereof, penetrating the latter for a very short distance, as compared with the thickness of the wall, as for example, several thousandths of an inch. In producing such stained layer, the shell preferably is dipped in a solution of the material and then subjected to a heat treatment at a temperature of approximately 1000° F. The exact temperature will depend upon the variables involved, the composition of the glass, proportions of the staining materials, and the vehicle therefor, and may be readily determined by test. I have found that the staining materials apparently are sensitive to overheating, stain tending to fade or wash out when the temperature becomes too high. Consequently, test should be run to determine the point at which deterioration of the stain takes place and then employ a temperature which is adequately therebelow. Depending on such factors, a suitable temperature will fall within approximately 950° F. to 1100° F. Such dipping operation is repeated until the exterior of the glass darkens to such an extent that it appears black in reflected light and a deep thin red by transmitted light, usually with three or four dippings. The thin stained layer so formed absorbs visible light and transmits mainly light in the red and infrared ranges. The heat lamps of the type described radiate over 85 percent of their emitted energy and have a long life expectancy of 5000 hours or more.

It will be appreciated that as most of the energy is radiant, and as air and clear glass absorb very little of the radiated energy, most of such energy travels from the heated tungsten element to the stained layer of the shell with relatively little absorption taking place and thus little heat generation. Tests indicate that the temperature of the shell interior, in a construction as illustrated in FIG. 1, will normally fall within 180° C. to 250° C. However, at the stained layer, most of the radiant energy is absorbed and given off as heat. Consequently, where the shell 1 is immersed directly into the liquid to be heated, the heat is developed substantially directly at the liquid with no conduction travel through the heating structure.

It will also be noted that heat is effectively conducted away from the end seals and terminal members 13 of the heat lamps by the respective fittings 17 and 23 which are in conductive engagement with the inner surface of the shell 1 and are thus operative to conduct heat at such terminals to the shell, from which it may be suitably dissipated. The fittings 17 and 23 preferably are suitably coated, as for example gold plated, to provide a lasting finish thereon which will be highly efficient in reflecting the radiated energy, thereby tending to reduce the formation of heat in such fittings. This is of importance as commercially procurable lamps, such as the one referred to, are so constructed that the end seals of the respective tubes may fail at temperatures above 650° F. thereby permitting en-

trance of air and burning out of the filament. As a result, this construction provides an automatic safety cutoff in the event the temperature of the shell becomes excessive, for example, as the result of improper fluid circulation around the tube. Where two heat bulbs are employed as illustrated, obviously upon failure of one bulb, the other will remain intact and as the internal structure of the device is readily removable from the shell, replacement of a burned out element is no problem.

It will be appreciated that this embodiment of the invention provides a number of distinct advantages over prior types of structures, among which are the fact that the tungsten-quartz lamps are self-supporting and generally cheaper than nichrome elements, which of necessity are wound on expensive thermal shock resisting ceramic cores, etc. and at the same time the nonabsorbed visible emission from nichrome type heaters is greater than that of tungsten type heaters such as here involved, as a result of which nichrome heaters would be less efficient for clear colorless liquids and in same cases might even cause undesirable chemical reactions.

It will also be noted from the above description that the low thermal gradient within the present construction is nonlinear, in general having two peaks, one adjacent the filament and one at the stained layer, with comparatively much lower temperatures in between such peaks. Consequently, much shorter lead-in arrangement is possible with the present invention than with nichrome types of similar wattage, with a corresponding decrease in the overall length of the structure.

Likewise, as previously mentioned because of the absence of relatively large masses which must be heated and cooled, the invention enables the production of a heater which both heats and cools very rapidly enabling the use of relatively short cycles and the maintenance of desired temperatures within very narrow limits.

While I prefer to employ an energy absorbing material in the form of a stain which penetrates the glass, other materials in other forms may be employed, provided that they have reasonably suitable characteristics which should include suitable absorption characteristics, no undesirable reflective characteristics which might tend to reflect energy back into the shell, and which possess adequate durability with respect to retention on the shell surface, etc.

UNITARY HEAT CONSTRUCTION

FIGS. 2, 9 and 10 illustrate an embodiment of the invention in which the shell carrying the energy absorbing material also functions as the envelope for the heating element, and as the shell may be formed from a suitable glass, the use of quartz structures is completely eliminated.

Referring to FIGS. 2, 9 and 10, the shell 1′ is provided with an open end 3, having an outwardly extending flange 4 and a conical shaped portion 7, of similar construction to the corresponding portions of the shell 1 of the construction of FIG. 3, the portion 7 preferably being ground on its external face to provide an efficient mating with the complemental bore 8 in the vessel 9. Likewise, the flange 4 may be provided with one or more flats for cooperation with respective elements of the assembly 6.

In this embodiment, the heating element 14, of tungsten wire or the like, and which may be wound in a relatively tight helical or helical sections 15, is arranged in a substantially U-shaped configuration with the respective ends thereof being secured to a glass stem 41 carried by the glass end wall 42 forming the closure for the adjacent end of the shell. The latter is provided with two spaced, parallel tubular portions 43, of relatively small diameter as compared with the diameter of the corresponding portion of the shell 1, and of a size to suitably enclose the corresponding portions of the heating element 14, with outer ends of the tubes 43 being connected by an intermediate portion 44, and the opposite ends of the tubes secured in sealed relation to the conical portion 7, thereby completely enclosing the heating element. The stem 41 and wall 42 may be provided with an exhaust passage or bore 45 through which the shell may be suitably evacuated or at least partially filled with a suitable gas, following which the outer end portion may be sealed as indicated at 46. The respective sections 15 of the heating element 14, as in the construction of FIG. 3, may be suitably supported in the shell by a plurality of spacer elements 16.

The end assembly 6 may be substantially identical construction with that of FIG. 3, the connector pins 35 however preferably being provided with relatively rigid, inwardly extending portions 35′ to which the free ends of the electrical element 14 are conductively connected.

As will be apparent from reference to FIG. 2, the U-shaped portion of the shell 1′ is stained as indicated at 40′ to provide the desired absorption of radiant energy passing through the shell.

The operation of the embodiment of FIG. 2 is substantially identical with that of FIG. 1 with the exception that the heating element and shell form a single unitary structure. The general operation likewise will be the same, radiant energy from the element 14 passing through the glass shell and being substantially completely absorbed in the stained layer of the shell. While the embodiment of FIG. 2 does not possess the advantage of replaceable elements, it does have the further advantage that the quartz bodies are eliminated with a reduction in the thermal heat developed within the shell and thus providing a greater percentage of the output in the form of radiated energy.

Obviously, where deemed necessary or desirable, the portions 43 and 44 may have a configuration other then U-shaped, and in some cases, it may be desirable to employ a tubular shell similar to that illustrated in FIG. 1.

I claim:

1. An immersion type heating device, particularly for scientific usage, comprising a shell of glass constructed for direct immersion in a fluid to be heated and having high transmission characteristics with respect to radiant energy, an electrical element disposed in said shell, operative to transmit radiant energy through the walls of the latter, and a material having high absorption characteristics with respect to such radiant energy, disposed at the exterior surface of said shell operative to absorb radiant energy passing therethrough whereby radiant energy transmitted from said element, upon striking said material, is thereby converted at said exterior surface into heat utilizable for heating, by conduction, of such a fluid thus providing direct dissipation of heat from said material and supporting shell to such a fluid.

2. A heating device according to claim 1, wherein said shell is constructed of a borosilicate glass and said high absorption material comprises an applied mixture of iron oxide and silver.

3. A heating device according to claim 2, wherein said high absorption material is disposed on said shell in the form of a stain which penetrates the shell material for a distance which is small, as compared with the thickness of said shell.

4. A heating device according to claim 3, wherein said stain penetrates said shell material to a depth of at least several thousandths of an inch.

5. A heating device according to claim 1, wherein said electrical element comprises at least one tungsten-quartz heat lamp, and means for supporting said electrical element in operative relation with respect to said shell.

6. A heating device according to claim 1, wherein said electrical element comprises a tungsten element disposed directly in said shell, with the atmosphere of said shell interior being at a reduced pressure compared with that exteriorly of the shell to form a unitary heat lamp.

7. A heating device according to claim 6, wherein said shell has a tubular portion of U-shaped configuration which contains said tungsten element.

8. A heating device according to claim 7, wherein said material is disposed on the U-shaped portion of said shell.

9. A conduction-type heating device comprising means constructed to generate radiant energy, an enclosing shell for said means constructed of a material having a relatively low ab-

sorption factor with respect to radiant energy generated by said means, and means penetrating into the shell wall at the exterior surface thereof having a relatively high absorption factor with respect to such radiant energy, whereby the usable supply of heat, as a result of such absorption, is generated primarily at the exterior surface of said shell and transmitted by conduction to a liquid in contact therewith.

10. The method of forming an immersion-type heating device utilizing radiant energy, comprising the steps of fabricating a shell of a material that has a relatively low absorption characteristic with respect to the radiant energy to be employed, applying a material capable, upon the application of heat thereto, of forming a layer at the outer surface of said shell which is highly absorbent to the radiant energy involved, upon said shell, subjecting the coated shell to heat to effect a stainlike penetration of the shell at the outer surface thereof, thereafter applying a second coating of said material to the outer surface of said shell and subjecting the same to a like heat treatment, repeating such coating and heating steps until the resultant layer of material penetrated into the shell wall at the exterior thereof is sufficient to provide absorption of at least the major part of such radiant energy normally striking said layer, and thereafter assembling in said shell means for generating such radiant energy.

11. The method according to claim 10, wherein said material primarily comprises iron oxide, to which a relatively small amount of silver powder is added, such mixture being suspended in an organic vehicle, said material being applied to said shell by dipping the latter into such material-containing vehicle.

12. The method according to claim 11, wherein said heating steps are effected at a temperature of approximately 1000° F.

13. The method according to claim 11, wherein said organic vehicle comprises isopropyl alcohol.

14. In a heating device, particularly for scientific usage, the combination of a shell of glass constructed for immersion in a fluid to be heated, said shell comprising an elongated tube closed at one end, an electrical element disposed in said shell, operative to transmit radiant energy through the walls of the latter, said element comprising a pair of tungsten-quartz heat lamps of elongated cylindrical configuration disposed in coextensive parallel relation, said lamps having connecting terminals at each of their respective ends, lamp-supporting means comprising a fitting at the inner end of said shell engaged with the inner end terminals of the respective lamps at the inner end of said shell, such inner end terminals being conductively connected, and a pair of spaced cooperable fittings at the opposite ends of said lamps, each adapted to engage a corresponding adjacent lamp terminal, whereby the latter are supported in spaced insulated relation, and supply leads extending from said terminals for connection to an electrical power source, said fittings being constructed of a heat-conductive material and disposed in heat conductive relation with respect to said shell for dissipating heat at said terminals to said shell, and a material operative to absorb radiant energy passing through said shell, disposed at the exterior surface of the latter, whereby radiant energy from said element utilizable for heating of such a fluid is available therefor at said material.

15. A heating device according to claim 14, wherein said fittings are metallic and are coated with a plating of gold for the efficient reflection of radiant energy away from the end terminals of said lamps, as well as heat conduction from said terminals to said shell.

16. A heating device according to claim 14, comprising in further combination, a flange formed on the open end of said shell, a closure structure secured to the flange end of said shell and a compression spring disposed between said closure structure and the adjacent end fittings operative to apply compression forces thereto for firmly maintaining the latter and associated lamp elements in operative position within said shell.