United States Patent [19]

Gass-Erb

[11] **3,766,358**

[45] **Oct. 16, 1973**

[54] **IMMERSION HEATER**

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[22] Filed: **Apr. 27, 1972**

[21] Appl. No.: **248,000**

[30] **Foreign Application Priority Data**

April 28, 1971 Austria........................ A 3680/71

[52] **U.S. Cl.**................. **219/322,** 219/328, 219/331, 219/335, 219/481, 219/501, 219/538

[51] **Int. Cl.**... **F24h 1/06**

[58] **Field of Search**...........219/280–281, 316–317, 219/322, 328, 330–331, 335, 338, 481, 538

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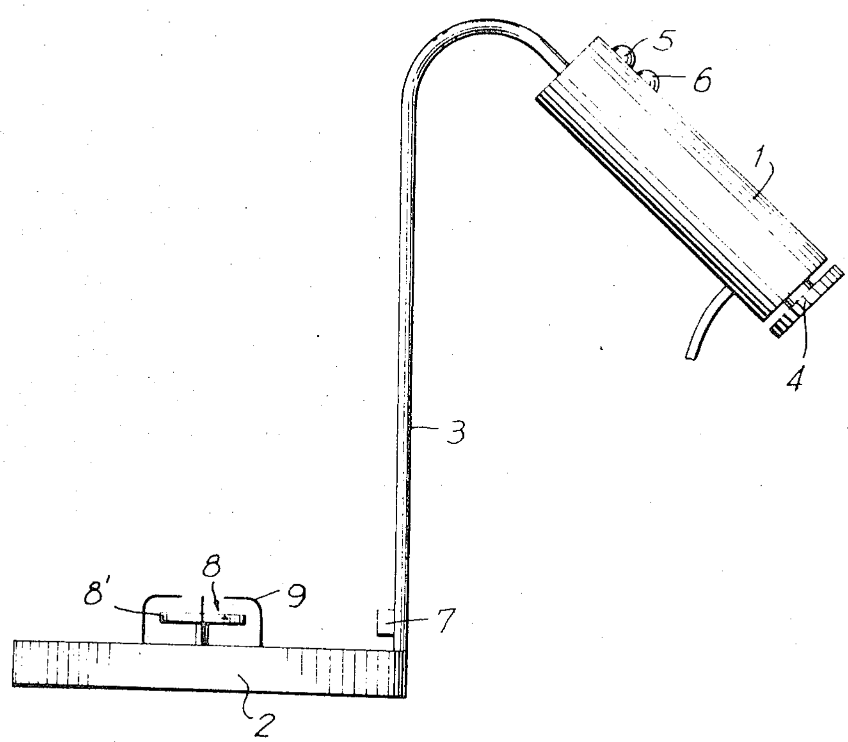
Attorney—Eric H. Waters et al.

[57] **ABSTRACT**

An immersion heater including a heating element immersible in a fluid for heating the latter, and a mixing device for agitating the fluid mounted on the heating element. The mixing device is reciprocable in response to energization of an electromagnetic drive, and may be connected into the electrical circuit for the heating element so as to be operable in conjunction with the operation of the heating element or responsive to temperature levels sensed in the heating element.

25 Claims, 12 Drawing Figures



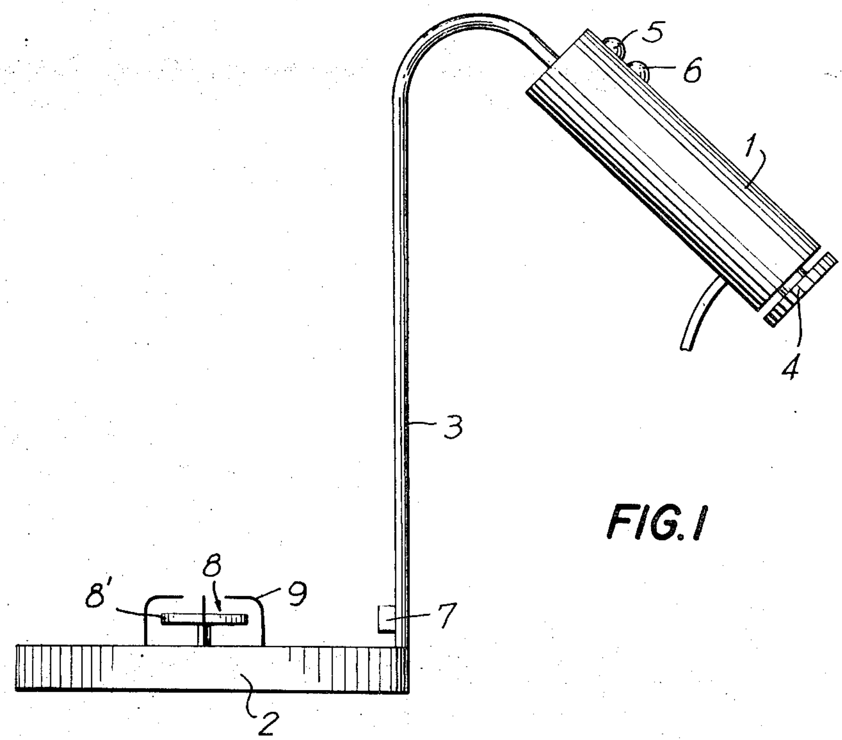
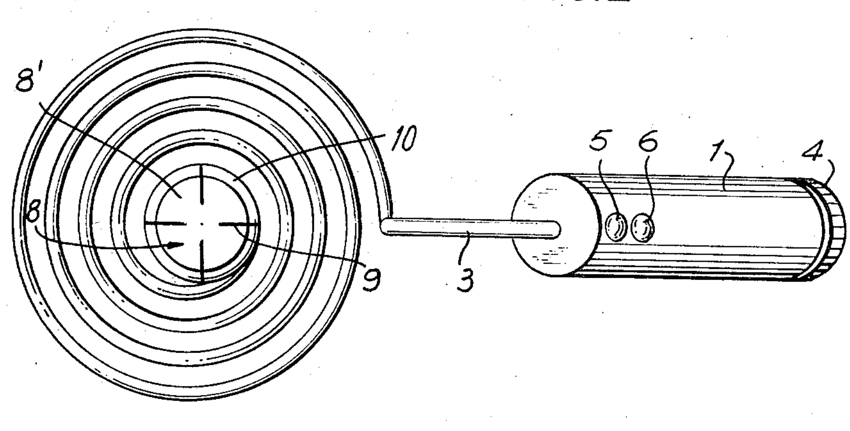


FIG.1

FIG.2



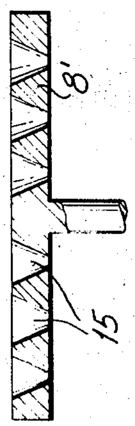


FIG.6

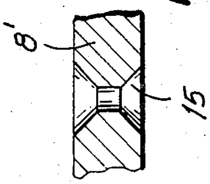


FIG. 7

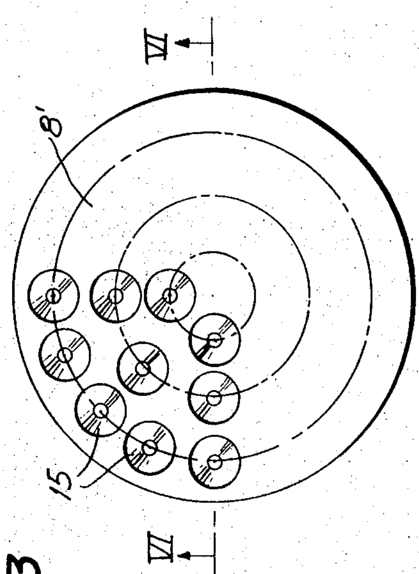


FIG.5

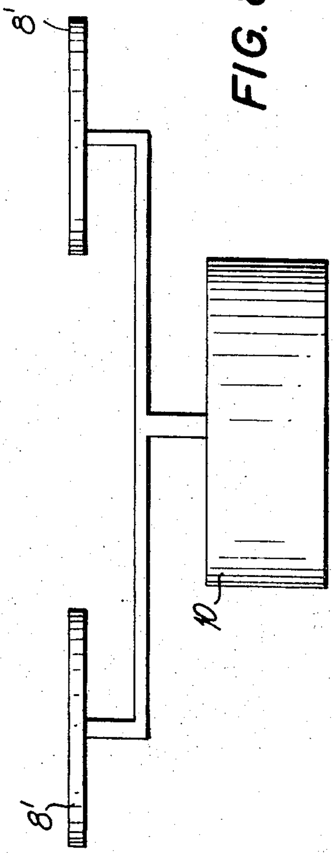


FIG. 8

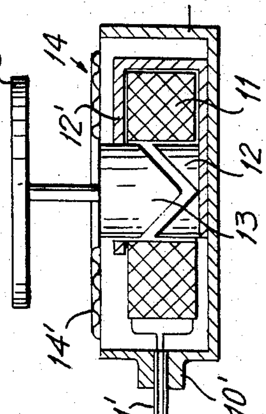


FIG.3

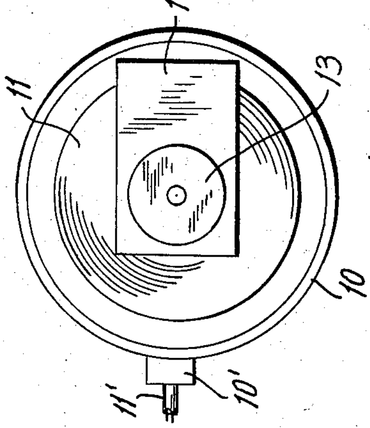


FIG.4

FIG. 9

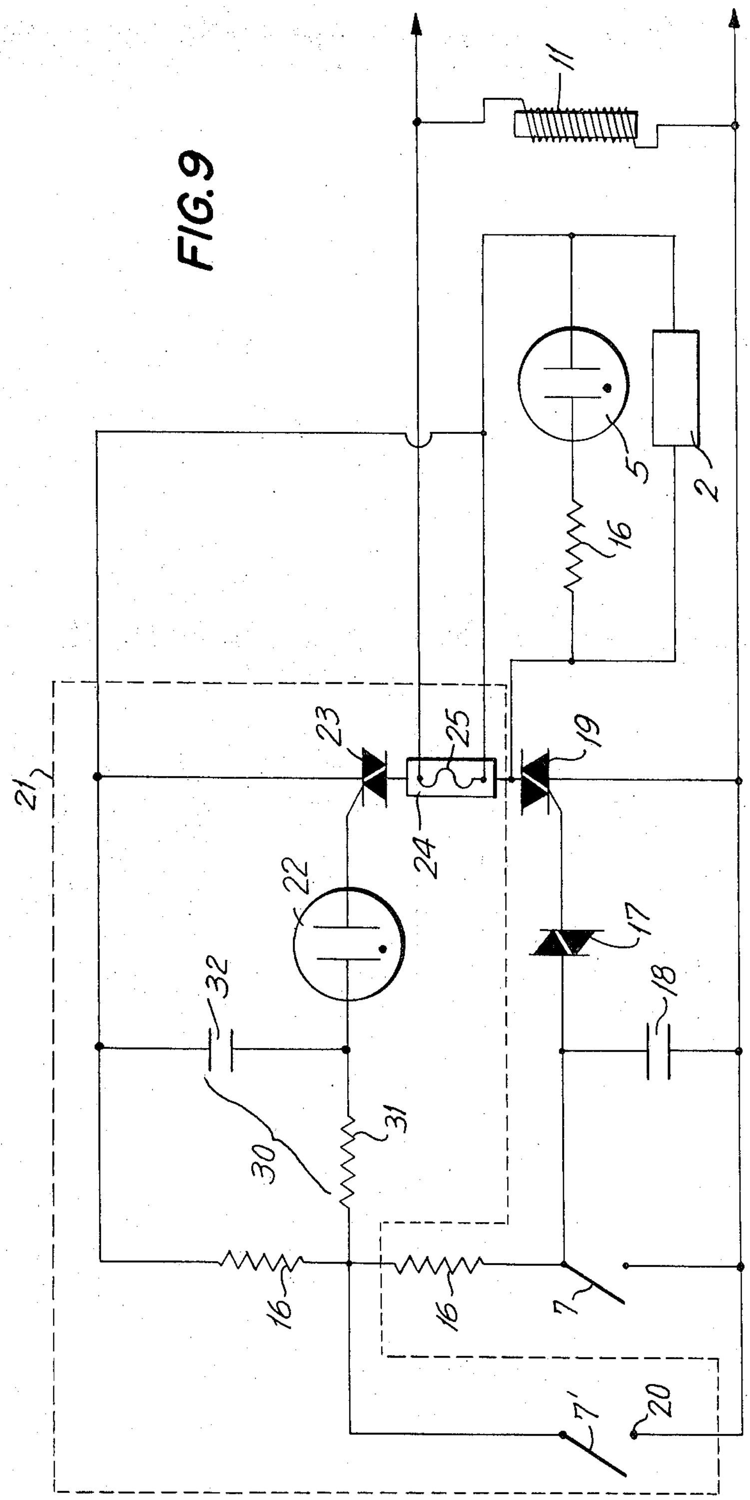
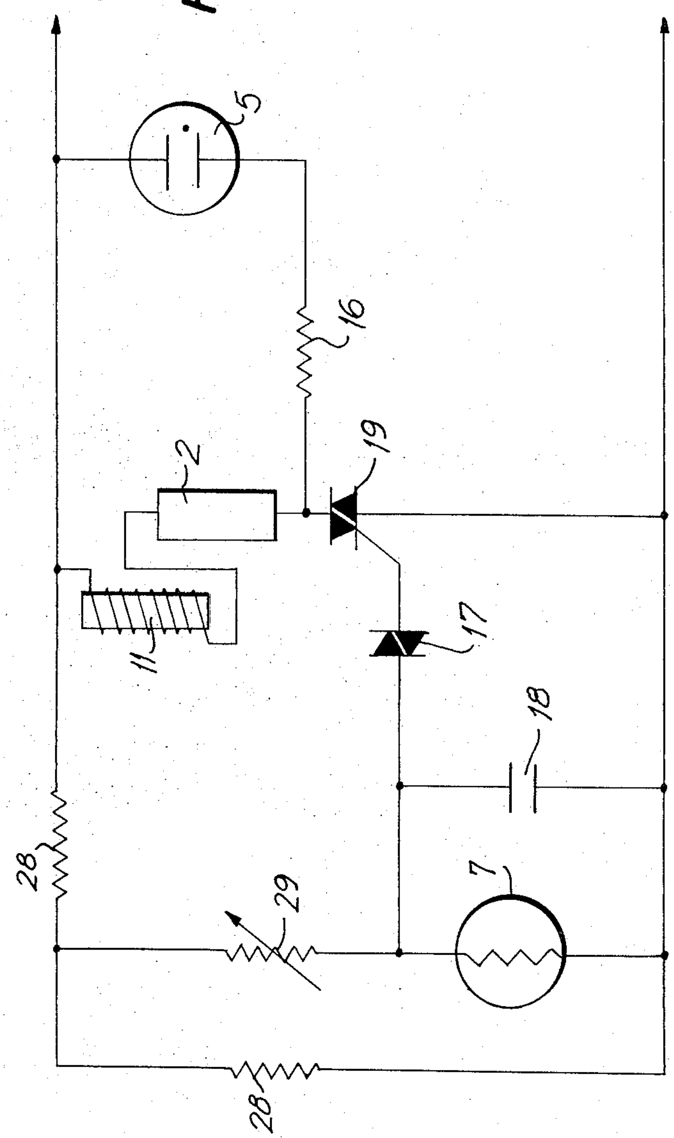
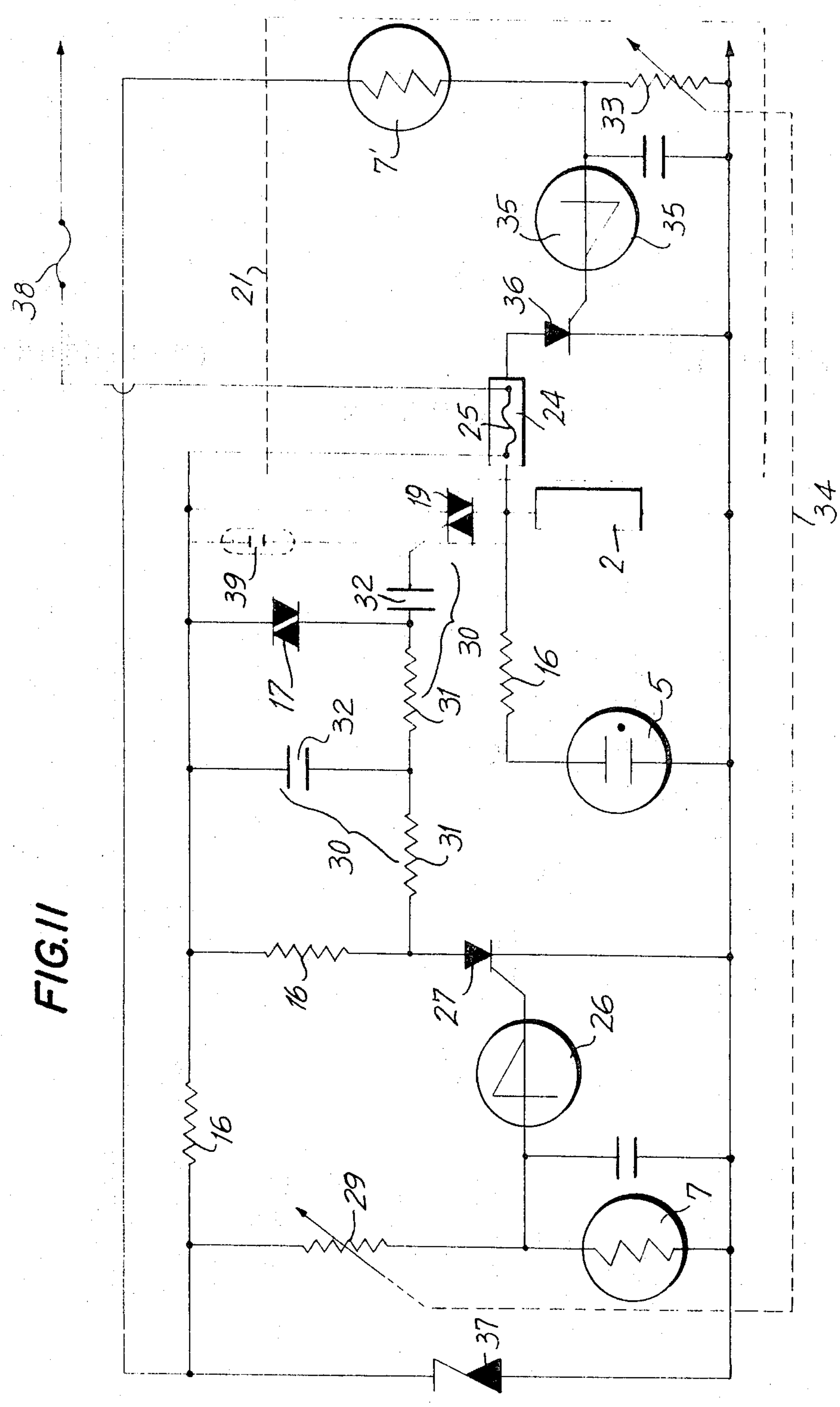


FIG.10




38
21
7'
33
35
35
36
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24
34
19
2
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17
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16
5
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31
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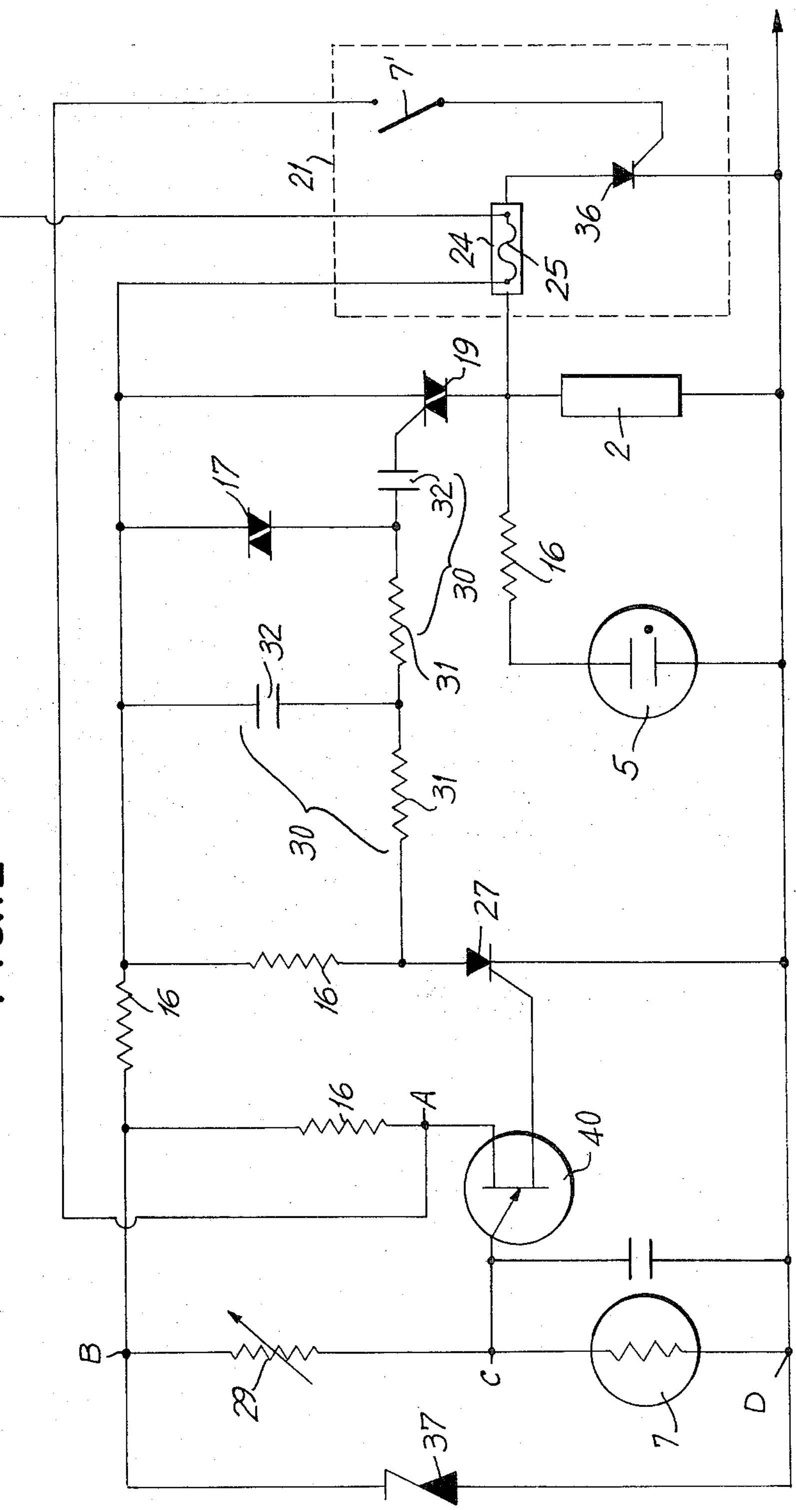
FIG.11

FIG.12



IMMERSION HEATER

BACKGROUND OF INVENTION

1. Field of the Invention

This invention relates to an immersion heater and, more particularly, to a heater having an automatic temperature control in which further heating is interrupted upon the heater reaching a predetermined maximum temperature.

2. Description of Prior Art

Heretofore, known immersion heaters of the above type have had the disadvantage in providing an unequal temperature distribution throughout the fluid being heated. In particular, when the heating element of the immersion heater fails to reach the lowermost layers of the fluid, the further generation of heat is frequently interrupted before these lowermost fluid layers can attain their required operating temperatures.

Furthermore, in prior art immersion heaters incorporating contact thermometers, if the contact thermometer fails to reach the heating spiral, the danger of overheating is created in which temperature deviations of up to 20° C may be encountered. In particular, in the chemical industry such temperature fluctuations are generally undesirable and not permissible since reactions of an unpredictable nature may be encountered, or in the carrying out of fractional distillations, clean separation of the elements of the mixture cannot be obtained.

Heretofore, in order to eliminate the shortcomings of prior art immersion heaters, agitation of the fluid being heated has been effected manually or through a separate stirring device. In the last instance, the related costs are relatively high, and furthermore, special supports are required for mounting the stirring devices in the vessel, making these inapplicable for rapid changes of the installation from one vessel to another. In particular, when applied to distillation plants, the limitations of space-consuming stirring devices become quite evident, since the vessels containing the fluid baths must be made relatively large in order to afford sufficient space for the stirring device. However, larger fluid baths require correspondingly greater energy supplies, thereby adversely affecting the economic operation of the plants. Additionally, such prior art plants or installations are relatively complex, and require a considerable amount of time for mounting and preparation.

SUMMARY OF THE INVENTION

Accordingly, the present invention contemplates the provision of an immersion heater which, in addition to incorporating advantageous and versatile temperature controls also provides for an optimum and equal temperature distribution throughout the fluid. In addition to the foregoing, the inventive immersion heater operates automatically and, furthermore, does not require servicing during operation.

The foregoing object of the present immersion heater is attained by providing, within the ambit of the electrical control current circuit of its heating element, a mixing device for the heated fluid.

Additionally, the immersion heater according to the present invention is formed of a compact constructure and operates essentially uninterruptedly. Another feature of the immersion heater lies in that the mixing device is rigidly fastened to the upper surface of the heating element and preferably is encompassed by a protective arrangement which permits unhindered flow of the fluid therethrough.

BRIEF DESCRIPTION OF THE DRAWINGS

A more complete understanding of the invention may be readily ascertained from the following description of exemplary embodiments taken in conjunction with the accompanying drawings, wherein:

FIG. **1** illustrates an elevational view of an immersion heater according to the present invention;

FIG. **2** shows a plan view of the immersion heater of FIG. **1**;

FIG. **3** shows a sectional view through a drive for a mixing device utilized with a heater according to the present invention;

FIG. **4** shows a plan view of the drive of FIG. **3**;

FIG. **5** shows an enlarged detailed plan view of a portion of FIG. **3**;

FIG. **6** illustrates a sectional view along line **6—6** in FIG. **5**;

FIG. **7** shows an enlarged fragmentary sectional view of another embodiment of the arrangement of FIG. **3**;

FIG. **8** illustrates a schematic view of a further embodiment of a mixing device used with a heater according to the present invention; and

FIGS. **9 – 12** illustrate four embodiments of wiring diagrams for an immersion heater according to the present invention.

DETAILED DESCRIPTION

Referring now in detail to the drawings, FIG. **1** illustrates a basic embodiment of the inventive immersion heater wherein a handgrip **1** is connected to a heating element **2** by means of a hollow rod **3** which is bent to provide a suspension arrangement for immersion of the heating element into fluid contained within a vessel. The hollow rod **3** concurrently provides a passageway for the electrical power conduit for heating element **2**. Suitable elements constituting the temperature control installation are positioned in handgrip **1**, the former of which may be formed of a contactless switch. This will effectively eliminate the risk of any sparks igniting flammable fluids or vapors emanating therefrom.

The contactless switch incorporates its own electrical control current circuit and a safety switching circuit, which will be described in greater detail herebelow with reference to the circuit diagrams.

A rotatable control knob **4** for an adjustable control resistance, a control lamp **5** for the control current circuit, and a control lamp **6** and **22** for a safety switching circuit **21**, are each located on the handgrip. Each position of the rotatable knob **4** corresponds to a predetermined desired maximum operating temperature for heating element **2**. Upon the operating temperature being attained, the flow of electrical current to heating element **2** is interrupted by means of a temperature sensor **7** which may be, for example, a thermistor. In the event that, through some operative defect, the heating cycle is not terminated, the safety switching circuit is actuated to thereby prevent excessive overheating of the fluid. A mixing device **8** is fastened to the upper surface of heating element **2**, and is protected by a protective arrangement **9** so as to provide protection against damage not only during operation of the immersed heater, but also during storage and handling.

The protective arrangement **9** may be, as is shown in the drawings, constructed of four bent wires which extend over the mixing device. However, numerous other constructions readily lend themselves to the formation of the protective arrangement. Thus, for example, a housing of a wide-mesh grillwork may be stapled over the mixing device. In each instance it must, however, be noted that unhindered access of the fluid to the mixing device **8** must be provided by the protective arrangement.

As illustrated in FIG. **2**, the heating element **2** is formed as a heating spiral having the mixing device **8** centrally positioned thereon.

The drive or actuator and detailed construction of the mixing device **8** is illustrated in FIG. **3** of the drawing. As an agitator for the fluid, a preferably circular plate **8'** may be utilized which is reciprocable in an axial direction. This construction eliminates the need for the commonly used rotating elements in mixing devices, which must be constantly serviced and which are subject to a high degree of wear.

The drive or actuator for plate **8'** operates pursuant to electromagnetic principles and is sealed within a housing **10.** The main element of the drive consists of an induction coil **11** which is provided with electrical current through an electrical conduit **11'**. Accordingly, the coil **11** may be connected, for example, in series with the heating coils, and with the electrical control current circuit of the immersion heater. In this instance, upon a maximum predetermined temperature being attained, the mixing sequence is terminated concurrently with the flow of electric current to the heat coils of the heating element.

It is also possible to directly connect the induction coil **11** into the electrical circuit of the immersion heater to thereby provide a mixing device which, independently of the predetermined maximum operating temperature, is deactivated only upon the shutting-off of the immersion heater.

It is noted that in the first instance the winding of the induction coil **11** must be made in conformance with the current intensity required by the heating coils of the immersion heater, and is thereby formed of heavy copper wire, whereas in the second instance, the winding is formed pursuant to the supply voltage and is constituted of thin copper wire having a corresponding larger number of windings.

A stationary iron core **12** is located within housing **10,** and is fastened to induction coil **11**; with coil **12** having a portion **12'** extending over coil **11,** as shown in FIG. **4,** so as to provide a guide for a movable iron core **13** which is rigidly connected to plate **8'**. Plate **8'** is connected wtih a return motion element **14.** The latter may take the form of a membrane **14'** constituted of corrugated sheet metal, which concurrently forms the cover for housing **10.** Preferably, the movable iron core **13** is fastened to the inner wall surface of membrane **14'** and serves concurrently as support member for the plate **8'**. The electrical conduits **11'** extend into housing **10** through connecting sleeve **10'** and are sealed in the housing so as to permit the latter to protect the drive for the mixing device from corrosion and dirt.

The basic mixing device, in effect, plate **8'**, is provided with nozzles **15** extending in the direction of its reciprocating movement and parallel to the axis thereof, the nozzles being spaced about the entire surface of plate **8'**.

As shown in FIG. **5,** the nozzles **15** in plate **8'** may have the form of concentric, ring-shaped rows of apertures, or may be formed as axially widening tapered bores in FIG. **6,** or centrally narrowed bores as shown in FIG. **7.** In the construction according to FIG. **6,** the nozzles **15** may have their enlarged openings either upwardly or downwardly directed.

The operation of the mixing device is as follows:

Upon conduction of an alternating current through the copper windings of induction coil **11,** the movable iron core **13** is axially displaced in the direction of stationary iron core **12.** In response to movement of iron core **13,** the membrane **14'** and plate **8'**, which are rigidly fastened thereto, are correspondingly axially displaced.

Upon the alternating current moving through its "zero point," the membrane **14'**, and concurrently plate **8'** and iron core **13**, are snapped-back into the initial position thereof. This process is repeated in correspondence with the frequency of the current, for example at 50 Hertz, 50 times each second. Through this movement, in addition to the agitation of the fluid, a secondary advantageous mixing or agitating effect is provided through the nozzles **15** of plate **8'**. In this instance, in view of the funnel-shaped nozzles **15** the fluid is always recaptured and forced through the nozzles.

In order to further improve the mixing of the fluid, in accordance with the embodiment of FIG. **8,** two or more mixing plates **8'** may be combined for actuation by a single drive.

A simple switching circuit for the inventive immersion heater is disclosed in FIG. **9** of the drawing. The current flows through resistances **16,** which also form current limiters, toward trigger diode **17.** The trigger diode, with the aid of condensators **18,** switches through and concurrently ignites alternating current thyristor **19.** In response to the energy supply, the heating element **2** is heated and also, through the fluid, contact thermometers **7** and **7'** which serve as temperature sensors. The thermometer **7'** is located in a safety switching circuit **21** shown in chain-dotted lines in the circuit diagram. The actuating temperature of the safety switching circuit is somewhat higher than that of the thermometer **7** of the control current circuit. When the preset operating temperature is sensed by thermometer **7,** current flow through trigger diode **17** is terminated. Responsively, thyristor **19** prevents the flow of current through the heating element, thereby interrupting the further generation of heat, and concurrently turns off control lamp **5.**

In the event of a defect occuring, for example a break in thermometer **7,** which would prevent the shutting-off the heat upon reaching the required maximum operating temperature, the temperature at first rises to the temperature designated at contact thermometer **7'**. Upon this temperature being attained, contact **20** closes and the current thereby becomes insufficient to switch trigger diode **17,** thusly interrupting the heating sequence. Concurrently, upon contact **20** being closed by contact thermometer **7'**, the safety switching circuit **21** is actuated. The glow tube **22,** which serves a function which is similar to a trigger diode, and is furthermore also utilized as a control lamp **6,** triggers thyristor **23.** Since the current supply to trigger diode **17** and to alternating current thyristor **19** has been simultaneously interrupted, no current can flow across resistance **24.**

An excessive voltage in the circuit of alternating current thyristor 19 may damage the latter so as to prevent the closing thereof. Consequently, the temperature will then further rise until the preset temperature at contact thermometer 7' is reached. At that instance, as previously mentioned, thyristor 23 is triggered by glow tube 22. The resistance 24 warms itself, and wire 25 as a segment of the current supply conduit which extends across resistance 24, thereby melting the wire at a predetermined maximum temperature to thereby terminate the current supply. Similarly, wire 25 is adapted to melt upon experiencing an excessive ambient temperature. The melting wire 25 should be formed of an alloy having a low melting point, and may be commercially obtained for different heater temperature requirements. The wire may be readily introduced through a suitable aperture in resistance 24.

In this circuit arrangement, the induction coil 11 is directly connected to the electrical circuit for the mixing device. As previously mentioned, this requires numerous windings formed of thin wire and is operative independently of the operating temperature for the heater.

Another advantageous circuit is disclosed in FIG. 10, illustrating essentially only the control current circuit. Concurrently, this also shows that the induction coil 11 may be connected to the control current circuit 21 of the induction heater, and particularly in series with the electrical winding of heating element 2. In that case the coil 11 is designed in accordance with the required current intensities for the immersion heater, and is composed of a lesser number of windings of relatively thicker copper wire. The mixing or agitating process is, in this instance, terminated upon the heating coils reaching their required operating temperature concurrent with the shutting-off of the current supply.

In lieu of the contact thermometer, in this particular switching circuit, a thermistor formed of, for example, an NTC-resistance, may be employed as temperature sensor 7, so as to render the immersion heater easier to manipulate. The voltage is reduced by means of a voltage divider 28, which is constructed so that no internal heating of the NTC-resistance 7 takes place.

In this case the triggering of thyristor 19 is somewhat more difficult since the operative efficiency of the immersion heater, upon the temperature at which a potentiometer 29 is approached, reaches only approximately 40 percent in response to the phase reduction.

Through the introduction of a corresponding RC-element 30, which is formed of one or more resistances 31 and at least one condensator 32, the operative efficiency may be raised to 85 percent and up to a maximum of 95 percent. Furthermore, the resistances 31 provide for a desirable decrease in the circuit voltage thereby reducing the load on thermistor 7 and providing protection for triggers 17 and 22. These latter may only be actuated by means of relatively low current intensities.

The phase cuts, however, cause intensive radio disturbances, particularly in the medium and high frequency range. In order to prevent the foregoing, transmission rectifying members must be incorporated, which generally consist of a transmission rectifying valve and condensators. These valves are, however, extremely large, and cannot be practically incorporated in the gripping device for the immersion heater.

Accordingly, referring now to the design of the connecting circuit in FIG. 11, in which the phase cutting angle is relatively small, the requirement for transmission rectifying members is eliminated. The thyristor 19 is herein completely switched. The schematic also includes a safety switching circuit 21. A thermistor is utilized as a second temperature sensor 7', having a control resistance 33 together with a potentiometer 29 for the control current circuit, mounted on a common axis therewith, so as to form a tandem-potentiometer 34. Clearly, the temperature sensor 7' and the control resistance 33 must be so coordinated with each other, to prevent the premature actuation of the safety switching circuit.

The trigger diode 35 which is utilized in safety switching circuit 21, and concurrently operative trigger diode 26 and thyristor 27 provided in the control current circuit, the flow of current in only one direction, and similarly does thyristor 36. Trigger diode 17 and alternating current thyristor 19 permit the flow of current in both directions. Consequently, a Zener diode 37 is required for the circuit, in accordance with FIG. 11, which shunts-off the negative voltage and concurrently provides for the stabilization of the control voltage. In order to provide for the stabilization while concurrently avoiding circuit voltage fluctuations, suitable voltage reference tubes, Zener reference diodes and the like may be employed in addition to Zener diode 37. This becomes necessary when it is desired to obtain temperatures in excess of 100° C, since at such higher temperatures the resistance changes of thermistors 7, and 7' are lessened, whereby the voltage deviations result in large temperature deviations.

In order to prevent internal heating of thermistors 7 and 7' these should not be excessively loaded, since any such heating of the thermistors will adversely affect the accuracy of the temperature control.

In order to provide protection for the apparatus, a high-speed safety installation 38 may be provided, which is adapted to cause the short-circuiting of the heating element. If thyristors only are utilized, it becomes advantageous to incorporate excess voltage shunts, for example, a transmission conduit 39. In general, however, the alternating current thyristors (Triacs), are designed so that upon excess voltages being sensed these are switched through without being triggered, and without being damaged thereby. However, thyristors may be damaged in the direction of closing, whereby they must be essentially designed that their closing voltage is higher than the transmission voltage of the Triacs.

Another embodiment of the temperature control is disclosed in FIG. 12 of the drawing, and essentially corresponds to the circuit diagram illustrated in FIG. 11. However, it is apparent that a contact thermometer 7' of the safety switching circuit, or a transistor 40 of the current control circuit may be utilized as the trigger for a pn-transmission. Furthermore, it is known that as a transistor-trigger it is particularly useful to utilize a transistor having a single transmission, a so-called Unijunction-Transistor (UJT). Again, as previously discussed, the safety switching circuit incorporates a thyristor 36, a resistance 24, and a thermal safety device incorporating the wire 25. The remaining elements of the safety circuit may correspond with those in FIG. 11, or reversely.

The transistor **40** replaces trigger diode **26** and receives a control voltage from point A. At point A the voltage is led at one side toward thermistor **7**, and at the other side toward contact thermometer **7'**. The advantage of this circuit lies in that between points C and D the voltage reaches only approximately 3 to 4 volts, thereby permitting the utilization of currently available thermistors. Furthermore, in lieu of using the NTC-resistances as thermistors, it is also possible to utilize resistors having positive temperature-coefficients (PTC-resistors). However it must be noted that in this instance, the thermistor **7** and the related potentiometer **29** must be reversed. This also applies to the safety switching circuit **21** in accordance with FIG. **11** for thermistor **7'** and control resistance **33.**

The various circuits may be utilized for all voltage ranges. However, individual elements, and particularly resistances **24, 28, 31** and thyristors **23, 27** and **36** must be selected in accordance with the predetermined operative voltage. Furthermore, the alternating current thyristor **19**, the heat resistance of heating element **2** and the electrical coils for the drive of mixing device **8** must also be selected in conformance with the required operative parameters.

While there has been shown what is considered to be the preferred embodiment of the invention, it will be obvious that modifications may be made which come within the scope of the disclosure of the specification.

What is claimed is:

1. Immersion heater including an automatic temperature control; comprising a heating element adapted to be immersed in a fluid for heating thereof, and a fluid mixing device operatively connected to said heating element for imparting agitating motion to said heated fluid, said fluid mixing device comprising a circular plate member, said plate member being axially reciprocable in directions extending normal to the surface thereof.

2. Immersion heater as claimed in claim **1**, comprising a source of electrical control current connected to said heating element, including temperature sensing means, the electrical control current flow to said element being responsive to said temperature sensing means, safety switch circuit means positioned in the electrical control current circuit of said heating element, said electrical control current circuit and said safety switch comprising a contactless switch including at least one thyristor, said thyristor having a trigger.

3. Immersion heater as claimed in claim **2**, the electrical current supply to said heating element being controlled by the relationship between a variable current value responsive to said temperature sensing means and a predetermined operating current value, and at least one regulating resistance for determining said operating current value.

4. Immersion heater as claimed in claim **1**, wherein said plate member comprises at least one nozzle aperture extending in the direction of movement of said plate member.

5. Immersion heater as claimed in claim **4**, wherein said nozzle aperture comprises a tapered bore diameter extending along the length of said aperture.

6. Immersion heater as claimed in claim **4**, wherein said nozzle aperture comprises an intermediate reduced-diameter orifice portion.

7. Immersion heater as claimed in claim **1**, said fluid mixing device comprising an electrical induction coil, said induction coil including a movable iron core fastened to said plate member for imparting axial movement thereto in response to energization of said coil.

8. Immersion heater as claimed in claim **7**, comprising a stationary iron core in proximate relationship with said movable iron core, said induction coil being rigidly fastened to said stationary iron core.

9. Immersion heater as claimed in claim **8**, said stationary iron ore having a recessed portion, said movable iron core having portions thereof extending into said recessed core portion.

10. Immersion heater as claimed in claim **1**, comprising means for imparting reverse axial movement to said plate member.

11. Immersion heater as claimed in claim **10**, wherein said reverse movement imparting means comprises a membrane.

12. Immersion heater as claimed in claim **11**, said membrane being formed of corrugated sheet metal.

13. Immersion heater as claimed in claim **9**, comprising a membrane means connected to said plate member for imparting reverse axial movement thereto, receptacle means encompassing said induction coil and said movable and stationary iron cores, said membrane means comprising a cover fastened to said receptacle so as to form jointly therewith a sealed housing for said induction coil and said iron cores.

14. Immersion heater as claimed in claim **7**, comprising a plurality of said plate members adapted to be axially moved in response to energization of said induction coil.

15. Immersion heater as claimed in claim **1**, said heating element having an upper and a lower surface, said fluid mixing device being rigidly fastened to the upper surface of said heating element.

16. Immersion heater as claimed in claim **3**, comprising a first one of said regulating resistance in the electrical control current circuit, and a second regulating resistance in said safety switch circuit means, said first and second resistances forming a tandem-potentiometer.

17. Immersion heater as claimed in claim **2**, said thyristor trigger including a glow tube forming a control lamp.

18. Immersion heater as claimed in claim **2**, said thyristor trigger comprising a contact thermometer.

19. Immersion heater as claimed in claim **2**, said thyristor trigger comprising a transistor.

20. Immersion heater as claimed in claim **19**, said transistor comprising a transistor having a single pn-transition.

21. Immersion heater as claimed in claim **2**, comprising a condensator-type RC-element, and a resistance in said safety switch circuit means providing for instantaneous actuation of the trigger and thyristor.

22. Immersion heater as claimed in claim **2**, comprising at least one resistance for reducing the circuit current intensity required for the safety switch circuit means actuating current.

23. Immersion heater as claimed in claim **2**, comprising current stabilizers, current reference tubes, Zener reference diodes, and Zener diodes for reducing the operating circuit current intensities, and providing for elimination of current fluctuations.

24. Immersion heater as claimed in claim **2**, comprising a low-temperature melting member, said member receiving electrical current flowing across a resistance of said safety switch, said member adapted to be melted upon heating during current flow so as to interrupt flow of current to said heating element.

25. Immersion heater as claimed in claim **2,** comprising instantaneously-operative safety means in the current supply circuit of said heating element, said safety means shutting-off said heater by short-circuiting of said heating element.

* * * * *