

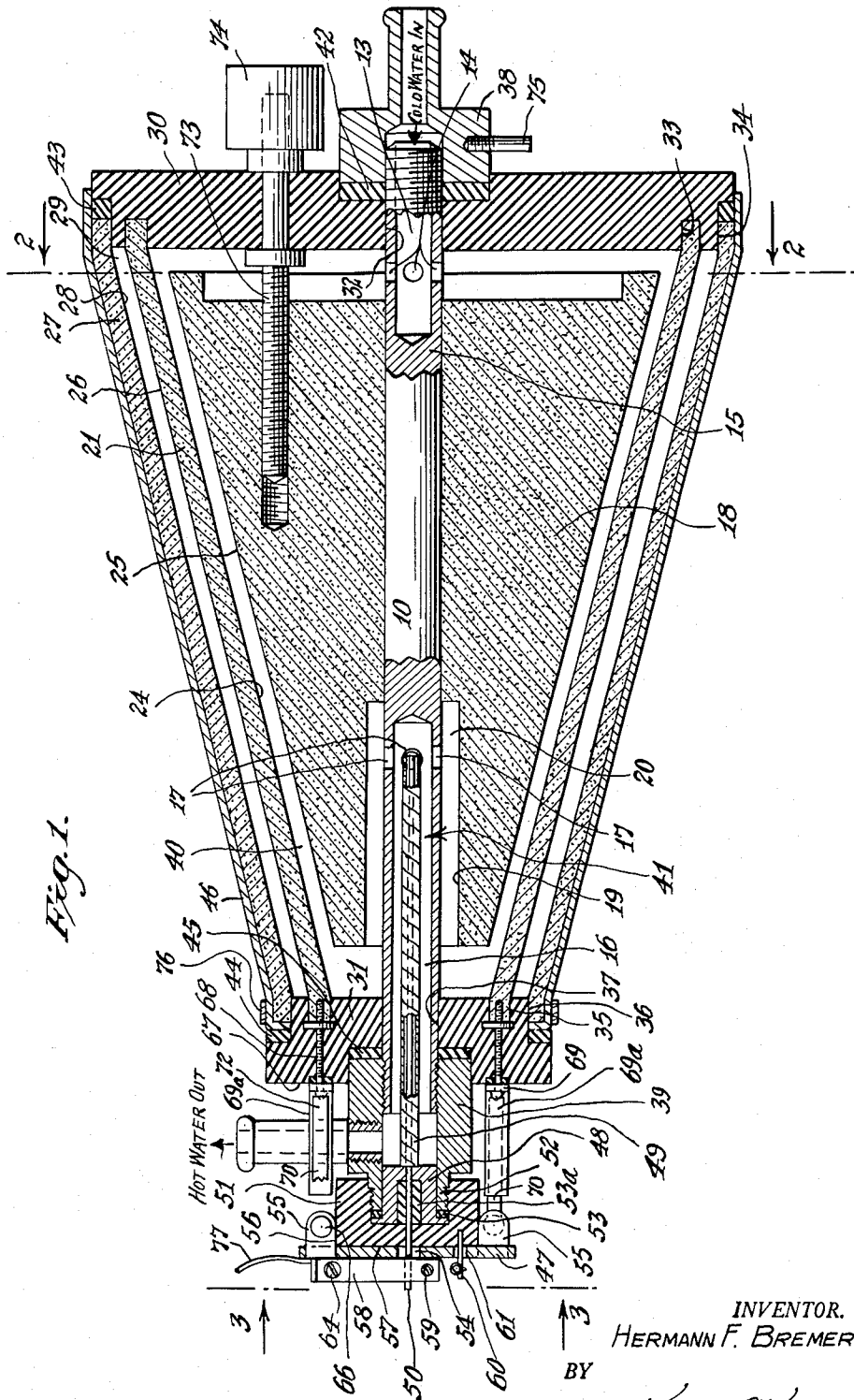
May 29, 1956

H. F. BREMER
APPARATUS AND METHOD FOR HEATING A
LIQUID BY ELECTRICAL CONDUCTION

2,748,253

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3 Sheets-Sheet 1



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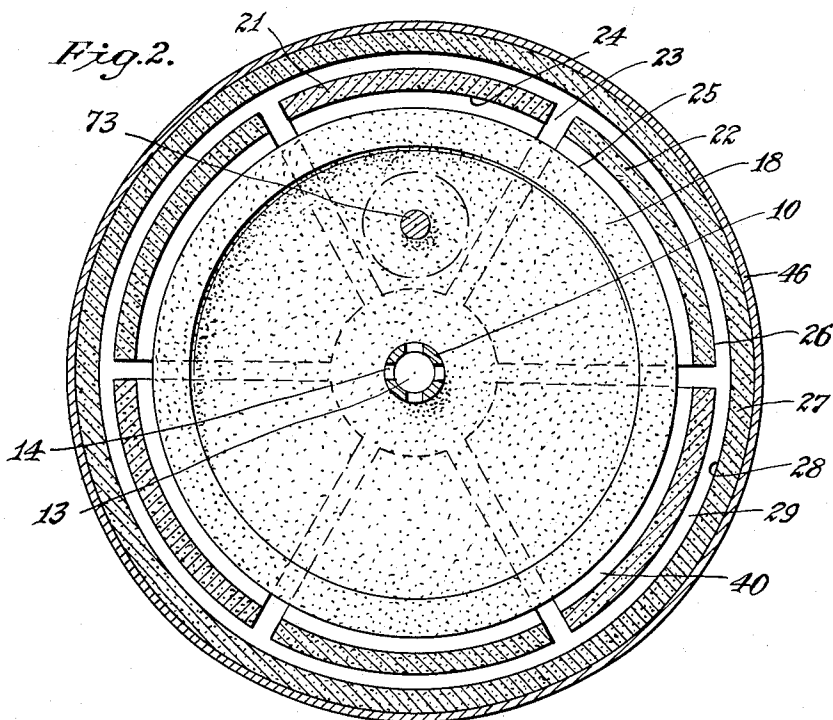
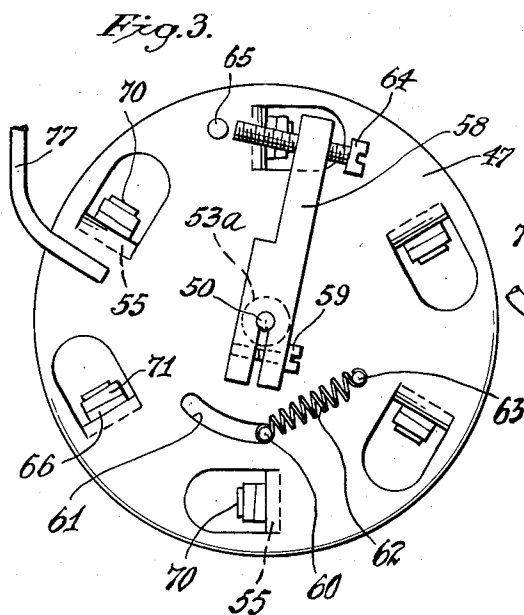
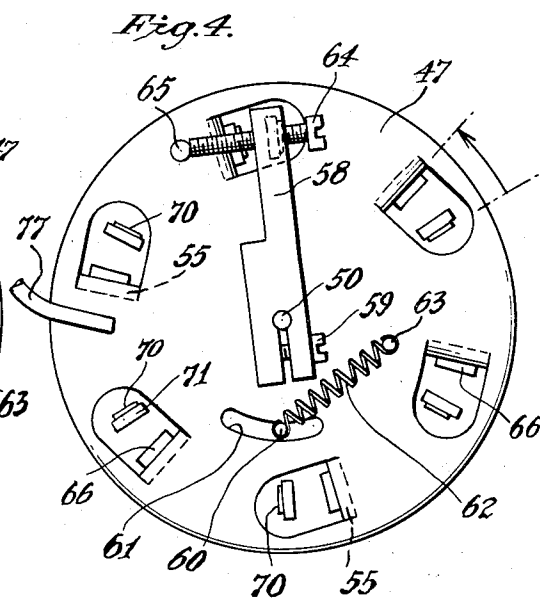
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Fig. 5.

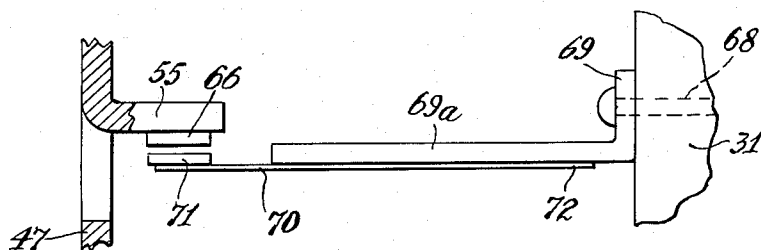
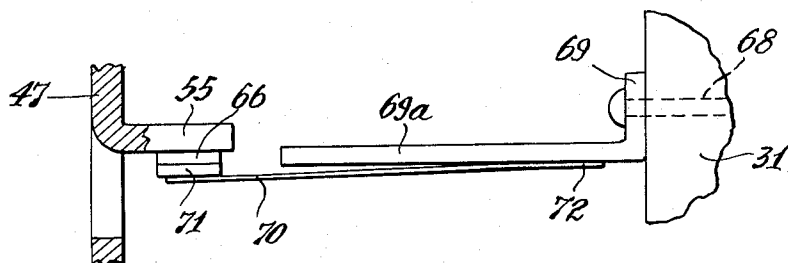


Fig. 6.



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APPARATUS AND METHOD FOR HEATING A LIQUID BY ELECTRICAL CONDUCTION

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14 Claims. (Cl. 219—40)

This invention relates to a method and apparatus for the electrical heating of liquids, more particularly water.

Electrical hot water heaters, for use in immediate association with a hot water faucet or the like, have heretofore not been widely accepted or used, one reason being that to raise a rapidly flowing and sizable stream of water, say 4 gallons per minute, from about 20° to from 70° to 100° C. requires from 90 to 120 amperes, and current of this density presents major problems of arcing when switch contacts are opened. The silver contacts commonly used in light household electrical switching elements can break a current of up to about 20 amperes without arcing. If the current is of greater density, arcing begins to appear, and especially in delicate thermostatically-controlled apparatus may result in fusing the contacts. Increasing the area of contact does not decrease arcing, since such tendency is always localized at the final point of metallic separation. Elaborate circuits for current limitation, the use of oil for quenching, and other expedients, are too costly and impracticable for use in simple household installations, in beverage dispensing machines, and the like.

An object of the present invention is to provide means and a method for heating a flowing stream of water at current densities which, if confined to a single contact, would produce prohibitive arcing, and to accomplish this in a manner which is free of arcing.

Referring to the drawings annexed to and forming part hereof:

Fig. 1 is a section through the longitudinal axis of a heater made in accordance with the present invention and illustrating one form of apparatus capable of being used in accordance with the method of this invention.

Fig. 2 is a vertical section in the plane 2—2 of Fig. 1.

Fig. 3 is an end elevation of thermostatically-actuated plate 47 as seen from the direction indicated by the line 3—3 in Fig. 1, showing the plate in the position it assumes when the thermostat is cold and the contacts are closed.

Fig. 4 is the same as Fig. 3 except that it shows plate 47 in the position it assumes when the thermostat is heated above the predetermined temperature and the contacts are open.

Fig. 5 is a fragmentary elevation of a pair of contacts when open.

Fig. 6 is similar to Fig. 5, when the contacts are closed.

Referring to the annexed drawings wherein like reference characters indicate like parts, the description which follows is given for the purpose of illustrating one form of apparatus embodying the invention, or which may be used in accordance with the process.

The apparatus comprises, in general, a heater and certain electrical switches associated therewith. These parts will be described in that order:

The heater

Referring to Figs. 1 and 2, central shaft 10 of steel

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is drilled to provide an axial bore 13 at its inlet end and holes 14 communicating with bore 13. The central portion 15 of shaft 10 is solid metal. At the outlet end of shaft 10 is an axial bore 16 with which holes 17 are in communication.

Slidably mounted upon shaft 10 is an inner cone-shaped electrode 18, preferably machined from a block of solid carbon. An enlarged bore 19 at the smaller end of the cone forms an annular space 20 at that end of the cone between the internal surface of bore 19 and the external surface of shaft 10.

Around inner electrode 18 is positioned a plurality of segmental intermediate electrodes 21, 22, etc., which surround the conical surface of electrode 18 but do not make contact therewith. Each electrode 21 and 22, as seen in cross section (Fig. 2), is arc-shaped. In a direction parallel to shaft 10 each such segment is wider at the end corresponding to the larger base of electrode 18, and smaller at the end corresponding to the smaller base of electrode 18. Collectively the segments, including the spaces 23 which separate them one from another, form an inner conical surface 24 in registry with, and spaced from, the outer conical surface 25 of electrode 18, forming an annular space 40. The outer faces of intermediate electrodes 21, 22, including spaces 23 which separate them, form an outer conical surface 26. The number of segments 21, 22, etc., to be used in any given case will depend upon the current loading requirements as hereafter discussed. To illustrate the invention there is here shown and described an arrangement in which there are six segments 21, 22, etc., equally spaced from each other and from the axis of shaft 10, and arranged generally parallel to the outer conical surface 25 of the inner electrode 18. These segmental intermediate electrodes are, like inner electrode 18, preferably machined from solid carbon.

Surrounding the segmental intermediate electrodes 21, 22, etc., is an outer electrode 27, also preferably machined from a block of carbon to form a unitary structure having an inner conical surface 28. Electrode 27 is adapted to be assembled with segmental intermediate electrodes 21, 22, etc., in such manner that its inner conical surface 28 defines, with outer conical surfaces 26 of electrodes 21, an annular space 29.

The inner electrode 18, intermediate electrodes 21, 22, etc., and outer electrode 27 are adapted to be mounted and secured in assembled relation by means of end discs 30 and 31 of insulating material. Larger end disc 30 has a central drilling 32 slidably engaged upon shaft 10. The ends of segmental intermediate electrodes 21, 22, etc. are received in annular segmental slots 33 near the periphery of disc 30, and the end of outer electrode 27 is received in a continuous annular slot 34 around the periphery of disc 30. Smaller end disc 31 has annular segmental slots 35, and an annular slot 36, corresponding respectively to the slots 33 and 34. Disc 31 has a central drilling 37 adapted to engage upon shaft 10. Metallic nipple 38 makes screw-threaded engagement with the intake end of shaft 10 and metallic nipple 39 makes screw threaded engagement with the discharge end of shaft 10. Each nipple includes means whereby hose or piping may be attached to the device for supply and delivery of water.

When water supply and delivery lines are connected to nipples 38 and 39, the flow of water through the heater is as follows. Water entering nipple 38 passes to bore 13, and thence through holes 14 to the space adjacent the inner surface of disc 30. Thence the water passes into the annular space 40 between inner electrode 18 and intermediate electrodes 21, 22, etc., in a direction towards the smaller end of cone-shaped electrode 18. At the same time the water passes radially outward through

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spaces 23 separating segmental intermediate electrodes 21, 22, etc., into the annular space 29 between segmental electrodes 21, 22, etc., and outer electrode 27, and there flows in a direction generally parallel to the axis of shaft 10 towards the smaller end of the conical structure. Water reaching the last-mentioned end of the device where it is adjacent the inner surface of disc 31 passes into annular space 20 surrounding shaft 10 where the flow is in the opposite direction. Water reaching holes 17 passes through them to axial bore 16 where the flow is reversed to its original direction, and the water then passes longitudinally of bore 16, and in contact with thermostatic element 41, to nipple 39 where it is discharged to an appropriate delivery line.

Thus discs 30 and 31, each mounted upon shaft 10, serve as the mounting and spacing means for the several segmental intermediate electrodes 21, 22, etc. and for outer electrode 27. Nipples 38 and 39, screwed up tightly on the ends of shaft 10, constitute the securing means for the assembly. Inner electrode 18 rides on shaft 10. The water-tight integrity of the structure is assured by packing material such for example as that indicated at 42, 43, 44 and 45 and elsewhere.

Surrounding outer electrode 27 is a conical case 46, preferably of steel, to afford mechanical protection for the electrodes. If desired, the outer surface of case 46 may be covered with an insulating paint, not shown.

Electrical conductors and switches

The flow of current to electrodes 18, 21, etc. and 27 is controlled by a thermostatically-actuated plate 47 (see Figs. 1, 3 and 4) which operates in gang a plurality of relatively movable switch contacts equal in number to the number of segmental intermediate electrodes 21, 22, etc. Each of the last-named electrodes is electrically connected to a relatively stationary switch contact, and each of the relatively movable contacts co-acts with one of the relatively stationary contacts. Thus, while all of the segmental electrodes 21, 22, etc., are energized at the same potential and may all be energized at once, the circuits to the several segmental electrodes and the switch-pair in each such circuit are disposed in parallel in the circuit, and the switches are mechanically operated by a common actuating mechanism.

Within the open end of nipple 39 is inserted the base 48 of a thermostatic element generally designated as 41 and comprising a bimetallic coil 49 secured at one end as by soldering to base 48 and, at the other end, secured in similar manner to thermostat shaft 50 coaxial with coil 49. Coil 49 is disposed within axial bore 16 of central shaft 10, extending almost or substantially to the holes 17. It is thus under the influence of the temperature of water leaving the heater through holes 17 and bore 16, and passing towards the outlet of nipple 39. The arrangement is such that when the temperature of the water in bore 16 exceeds a predetermined temperature, shaft 50 rotates in a counter-clockwise direction (as seen in Figs. 3 and 4) in order, thus, to break the gang contacts hereinafter mentioned. Base 48 is secured in position within the bore of nipple 39 by a cap 51 of insulating material screw threadedly engaged upon a boss 52 forming part of nipple 39. Packing material 53 and 53a prevents escape of water at the points where shown.

Upon the outer end of cap 51 is positioned thermostatically-actuated plate 47 having a central opening 54 substantially larger than the diameter of shaft 50 so that plate 47 is not in electrical connection with shaft 50. Around the periphery of plate 47 a plurality of ears 55 are struck from the plate at right angles to the plane thereof. The number of such ears is equal to the number of segmental intermediate electrodes 21, 22, etc., and in the example here shown there are six such ears. Ears 55 are at a common distance from the central axis of plate 47, so that they slide freely around but are guided by the cylindrical outer surface 56 of cap 51. Thus, cap

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51 serves to support and guide plate 47 when the latter is rotated about the axis of shaft 50. Plate 47 is held against the end face 57 of cap 51 by arm 58, made of insulating material, which is affixed to the projecting end of shaft 50 by any suitable means as, for example, by screw 59 (see Figs. 3 and 4). The arrangement is such that arm 58 maintains plate 47 and ears 55 in assembled relation with cap 51, but free to rotate about the axis of shaft 50 in response to movements of said shaft transmitted to plate 47 by the means hereinafter described.

A pin 60 affixed to the end face 57 of cap 51 projects through curved slot 61 in plate 47. To the exposed end of pin 60 is secured a coiled spring 62, the opposite end of which is secured to a pin 63 (see Fig. 3) affixed to plate 47. The arrangement of pins, slot and coiled spring is such that spring 62 tends to urge plate 47 to rotate in a clockwise direction as seen in Figs. 3 and 4, that is, in a direction tending to close the contacts hereinafter mentioned. At the end of arm 58 remote from its point of securement to shaft 50 is a thermostat-adjusting screw 64 whose end is adapted to engage a pin 65 secured in plate 47. The arrangement of these parts is such that the amount of rotation of thermostat shaft 50 which is required to open the contacts can be manually adjusted by turning screw 64. This constitutes the means by which the temperature of water delivered by the heater can be predetermined.

On each of ears 55 (see Figs. 5 and 6) is secured a contact disc 66 of suitable material, for example, silver. To the exposed face 67 of end disc 31 are affixed, by means of pins 68, a series of L-shaped brackets 69, equal in number to the number of segmental intermediate electrodes 21, 22, etc. Each pin 68 passes through disc 31 and penetrates one of the segmental intermediate electrodes 21, 22, etc., making electrical connection therewith, and serving to conduct current between said electrode and the L-shaped bracket 69 to which it is connected. Each bracket 69 has a long leg 69a extending towards movable contact 66, and terminating just short thereof. Attached to long leg 69a of the bracket is a spring 70 having secured thereto near one end a contact disc 71 adapted to engage contact disc 66. The opposite end 72 of spring 70 is soldered or otherwise securely affixed to the longer leg 69a of the bracket near the base thereof. The arrangement is such that the intermediate portion of spring 70, remote from the point of attachment at 72, can be resiliently deflected out of contact with leg 69a, as shown in Fig. 6, by the pressure of movable contact 66 on stationary contact 71. When that pressure is removed, spring 70 tends to return into contact with leg 69a, as shown in Fig. 5. Thus, when contact 66 moves from the position shown in Fig. 6 to the position shown in Fig. 5, leg 69a serves as a stop and as contact 66 moves away, contact 71 is thus affirmatively prevented from following by engagement of spring 70 with bracket 69.

Adjustment for water condition

In order to adapt heaters made in accordance with this invention to installation in regions where the water supply differs materially in salt content, and hence in heating response to a given amount of current, it is desirable to provide means for varying the distance between the electrodes and to do this in such a way that the distance may be changed without disassembling the heater.

The means provided for this purpose includes rotatable shaft 73 making screw-threaded engagement with electrode 18. Shaft 73 passes through disc 30 where it is rotatably secured against axial movement in any suitable manner. An adjusting button 74, secured upon the exposed outer end of shaft 73, permits manual rotation thereof which causes electrode 18 to slide longitudinally upon shaft 10 within limits permitted by available clearances in the device. In this way the water gap between segmental intermediate electrodes 21, 22, etc., and inner

electrode 18 can be varied at will, and consequently the heater may be adjusted for differing water conditions.

Electrical supply

The external source of electrical current may be connected to the heater in various ways, depending upon the nature of the available current. The leads from an external source of current, not shown, may be connected to pin 75 which is in electrical communication with inner electrode 18; to ring 76 which is in electrical communication with outer electrode 27 through metallic outer case 46; and through flexible wire 77 electrically connected to plate 47.

If the available current is D. C., pin 75 and ring 76 may be grounded and wire 77 represents the "hot" side of the circuit. In this event, inner and outer electrodes are grounded and the intermediate electrodes are energized.

If the available current is A. C. 2-phase, the connections may be similar to those given for D. C. and the result is similar. If the available current is A. C. 3-phase, each of pin 75, ring 76 and wire 77 is connected to one lead of the incoming supply and the several electrodes are oppositely poled in accordance with the phase relation of the supplied current. In this case, as will be understood, opening of all the gang switches will not interrupt the supply of current to outer and inner electrodes.

Operation

Ordinarily, when water is not flowing, it is contemplated that the switches will be closed and potentials will be applied to the several electrodes. Residual water from a previous cycle of operation is thereby vaporized and, since current will not flow when there is no water in the heater, the device cools. When water is permitted to flow through the heater, an electrical path is established between the carbon electrodes, current flows, and the water is heated. When the temperature of water passing in contact with thermostatic element 41 rises, shaft 50 rotates in a counterclockwise direction, as seen in Fig. 3. When such motion brings adjusting screw 64 into contact with pin 65, counterclockwise rotation is thereby imparted to plate 47. As plate 47, with its integral ears 55, moves in a counterclockwise direction contacts 66 begin to retreat from their engagement with contacts 71 (an upward direction as seen in Figs. 5 and 6). The latter follow the retreating contacts 66 until springs 70 come into engagement with legs 69a of brackets 69 whereupon the following movement of contacts 71 is checked, and as contacts 66 continue to move a positive separation between them is brought about. Thus, in the form of device here shown, the current is shut off simultaneously, or substantially so, in each of the several segmental intermediate electrodes 21, 22, etc., and further heating is checked until a fall in the temperature of the water causes the contacts to close again. By small alterations in the spacing of brackets 69 the switches can be made to open seriatim as plate 47 rotates, if desired.

The described heater is adapted to handle a current of about 90 amperes, divided into six parallel circuits in each of which the amperage is approximately 15. Thus, the number of amperes passing through each pair of contacts 66, 71 is low enough so that substantially no arcing occurs having any deleterious effect upon the contacts.

The method hereinafter claimed is not dependent upon the use of any particular apparatus. The apparatus herein shown and described is suitable for use in carrying out the method. Nor is the apparatus here shown by way of illustration the only form in which the invention may be embodied. The invention comprehends such variance of the foregoing disclosure as may be equivalent thereto and within the scope of the following claims.

What is claimed is:

1. Apparatus for heating water by electrical conduction comprising a primary electrode and at least two second-

ary electrodes insulated from each other, all of said electrodes being adapted to be in contact with the water, a source of current, a relatively stationary switch contact electrically connected to one of said secondary electrodes, a second relatively stationary switch contact electrically connected to the other of said secondary electrodes, said relatively stationary switch contacts being electrically insulated from each other, a pair of relatively movable switch contacts, a movable element mechanically and electrically interconnecting said movable contacts together and adapted to shift said contacts towards and from said relatively stationary contact members to make and break the electrical circuits therethrough, means thermally responsive to the temperature of the water in contact with said electrodes to actuate said movable element and means connecting the source of current across the primary electrode and said element.

2. Apparatus for heating water by electrical conduction comprising a primary electrode and at least two secondary electrodes insulated from each other, all of said electrodes being adapted to be in contact with the water, a source of current, a relatively stationary switch contact electrically connected to one of said secondary electrodes, a second relatively stationary switch contact electrically connected to the other of said secondary electrodes, said relatively stationary switch contacts being electrically insulated from each other, a rotatable conducting disc supporting at least two relatively movable switch contacts and adapted by its rotation to move the same into and out of engagement with said relatively stationary contacts, and means connecting the source of current across the primary electrode and said conducting disc.

3. Apparatus for heating water by electrical conduction comprising a primary electrode and at least two secondary electrodes insulated from each other, all of said electrodes being adapted to be in contact with the water, a source of current, a relatively stationary switch contact electrically connected to one of said secondary electrodes, a second relatively stationary switch contact electrically connected to the other of said secondary electrodes, said relatively stationary switch contacts being electrically insulated from each other, a rotatable conducting disc supporting at least two relatively movable switch contacts and adapted by its rotation to move the same into and out of engagement with said relatively stationary contacts, means connecting the source of current across the primary electrode and said conducting disc, and thermostatic means responsive to the temperature of water flowing from contact with said electrodes to rotate said disc.

4. Apparatus for electrical heating of water comprising a metallic shaft, a cone-shaped primary electrode axially slidable upon said shaft and in electrical contact therewith, means independent of said shaft and controllable from the exterior of said apparatus for adjusting the longitudinal position of said primary electrode on said shaft, a secondary electrode whose inner conical surface surrounds and corresponds to the conical outer surface of the primary electrode, means defining inlet and outlet ducts for said apparatus via said shaft, and a plurality of intermediate electrodes interposed between said conical surfaces of said primary and secondary electrodes and insulated from each thereof.

5. Apparatus for electrical heating of water comprising a metallic shaft axially and radially drilled near each of its ends and of solid metal between said drillings, said end drillings defining inlet and outlet ducts for said apparatus, a cone-shaped primary electrode slidable upon said shaft and in electrical contact therewith, a secondary electrode whose inner conical surface surrounds and corresponds to the conical outer surface of the primary electrode, a plurality of intermediate electrodes interposed between said conical surfaces and insulated from each thereof, the gap between said primary electrode and said other electrodes defining an annular water channel in communication with said inlet and outlet ducts and ad-

justing means controllable from the exterior of said apparatus adapted to cause said primary electrode to slide axially along the shaft and thus to vary the gap between its outer conical surface and said other electrodes.

6. Apparatus for electrical heating of water comprising a metallic shaft, a cone-shaped primary electrode slidable upon said shaft and in electrical contact therewith, a secondary electrode whose inner conical surface surrounds and corresponds to the conical outer surface of the primary electrode, means defining inlet and outlet ducts for said apparatus via said shaft, a plurality of intermediate electrodes interposed between said conical surfaces and insulated from each thereof, end discs of insulating material engaged upon the ends of said metallic shaft adapted to support the ends of said intermediate and secondary electrodes in spaced relation with respect to said primary electrode and to form with said electrodes a chamber for the heating of water, and a rod threadably engaging a threaded recess in said primary electrode and extending through the upper of said end discs to the exterior of said apparatus, said rod being rotatable to effect an adjustment of the longitudinal position of said primary electrode on said shaft.

7. In apparatus for electrical heating of water, the combination comprising a metallic shaft axially and radially drilled near each of its ends and of solid metal between said drilling to define inlet and outlet ducts for said apparatus, a primary electrode supported on said shaft and in electrical contact therewith; and a secondary electrode surrounding said primary electrode and spaced therefrom to define a water gap communicating between said inlet duct and said outlet duct.

8. In apparatus for electrical heating of water, the combination comprising a metallic shaft axially and radially drilled near each of its ends and of solid metal between said drillings to define inlet and outlet ducts for said apparatus, a conical primary electrode having a central bore, said primary electrode being slidably supported on said shaft, a portion of said central bore being enlarged to provide an annular space in communication with said outlet duct, and a stationary secondary electrode surrounding said primary electrode and spaced therefrom to define an annular water gap communicating between said inlet duct and said outlet duct through said annular space.

9. Apparatus for electrical heating of water comprising a metallic shaft axially and radially drilled near each of its ends and of solid metal between said drillings to define inlet and outlet ducts for said apparatus, a cone-shaped primary electrode slidable upon said shaft and in electrical contact therewith, a secondary electrode whose inner conical surface surrounds and corresponds to the conical outer surface of the primary electrode, a plurality of intermediate electrodes interposed between said conical surfaces and insulated from each thereof, adjusting means controllable from the exterior of said apparatus adapted to cause said primary electrode to slide axially along the shaft to vary the gap between its outer surface and said other electrodes and temperature-responsive electrical-switching means to apply operating potentials to said electrodes and including an elongated thermostatic element concentrically disposed within said outlet duct.

10. Apparatus for electrical heating of water comprising a metallic shaft, a cone-shaped primary electrode slidable upon said shaft and in electrical contact therewith, a secondary electrode whose inner conical surface surrounds and corresponds to the conical outer surface of the primary electrode, a plurality of intermediate electrodes interposed between said conical surfaces and insulated from each thereof, end discs of insulating material engaged upon the ends of said metallic shaft adapted to support the ends of said intermediate and secondary electrode and to form with said electrodes a chamber for the heating of water, a rod threadably engaging a threaded recess primary electrode and extending through the upper of said end disc to the exterior of said apparatus to effect

adjustment of the longitudinal position of said primary electrode on said shaft, and temperature-responsive electrical-switching means to apply operating potentials to said electrodes and including an elongated bimetallic element concentrically disposed within said outlet duct and switching means provided with an actuating disc operatively coupled to said element and rotatably mounted on said lower of said end discs.

11. Apparatus for heating water by electrical conduction comprising a conical primary electrode and a plurality of secondary electrodes circumferentially arranged about said primary electrode and spaced therefrom to define a water gap, a source of current, a like plurality of relatively stationary and mutually insulated switch contacts each electrically connected to a respective secondary electrode; a rotatable conducting disc supporting a like plurality of relatively movable switch contacts and adapted by its rotation to move the same into and out of engagement with said relatively stationary contacts, means connecting the source of current across the primary electrode and said conducting disc, and thermostatic means responsive to the temperature of the water in said gap to rotate said disc.

12. Apparatus for electrical heating of water comprising a water chamber, an electrode assembly disposed in said chamber and including a central shaft, primary electrode mounted on said shaft in electrical connection therewith and a secondary electrode spaced from said primary electrode, means to impress a potential difference between said shaft and said secondary electrode to effect heating of the water in said chamber, means defining inlet and outlet ducts for said apparatus via said shaft and means independent of said shaft and controllable from the exterior of said chamber to shift the position of said primary electrode relative to said secondary electrode, thereby to adjust the temperature of the water.

13. Apparatus for electrical heating of water comprising a water chamber, an electrode assembly disposed in said chamber, and including a central shaft, a primary electrode mounted on said shaft in electrical connection therewith and a plurality of secondary electrodes circumferentially surrounding said primary electrode and spaced therefrom, means to impress a potential difference between said shaft and said secondary electrodes to effect heating of the water in said chamber, means defining inlet and outlet ducts for said apparatus via said shaft and means independent of said shaft and controllable from the exterior of said chamber to shift the position of said primary electrode relative to said secondary electrodes, thereby to adjust the temperature of the water.

14. Apparatus for electrical heating of water comprising a water chamber, an electrode assembly disposed in said chamber and including a central metallic shaft, a primary electrode slidably mounted on said shaft and in electrical contact therewith and a secondary electrode spaced from said primary electrode, means to impress a potential difference between said shaft and said secondary electrode to effect heating of the water in said chamber, means defining inlet and outlet ducts for said apparatus via said shaft and means independent of said shaft and controllable from the exterior of said chamber to shift the position of said primary electrode relative to said secondary electrode, thereby to adjust the temperature of the water.

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