Jan. 28, 1958 J. JANSONS 2,821,614

ELECTRICAL STEAM GENERATOR AND METHOD OF STEAM GENERATION

Filed July 22, 1955 2 Sheets-Sheet 1

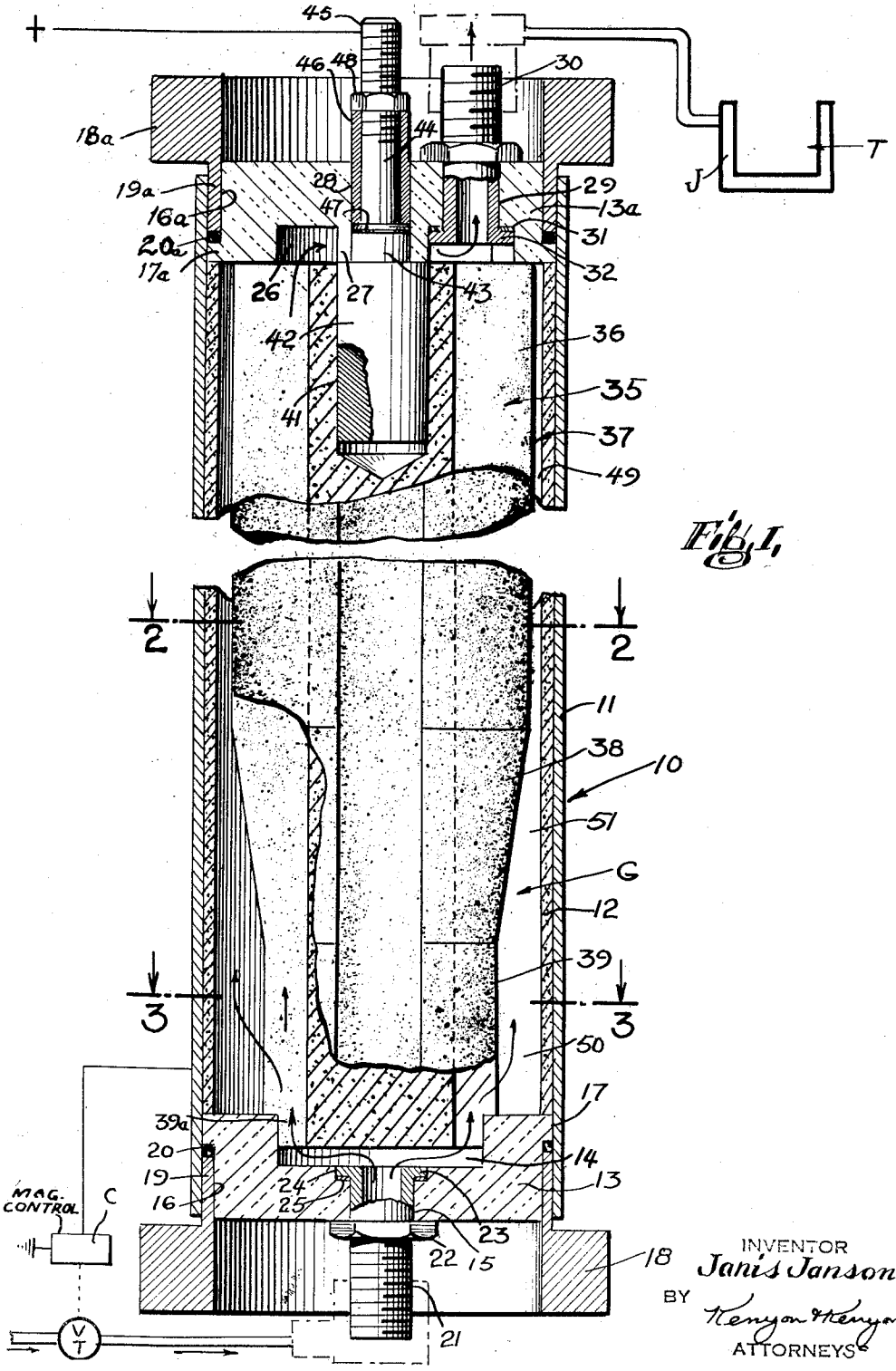


Fig. 1.

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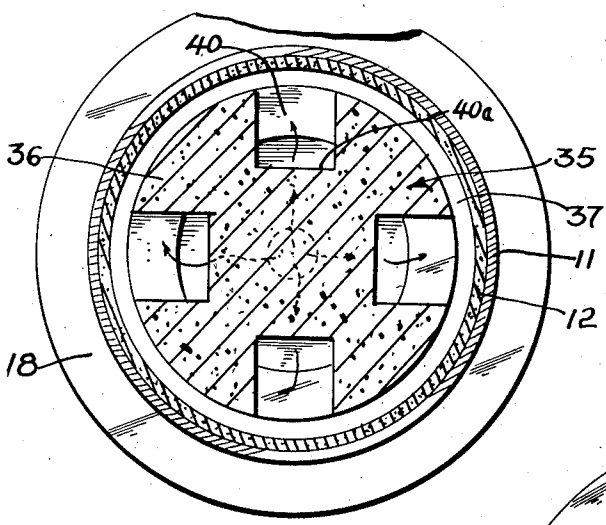


Fig. 2.

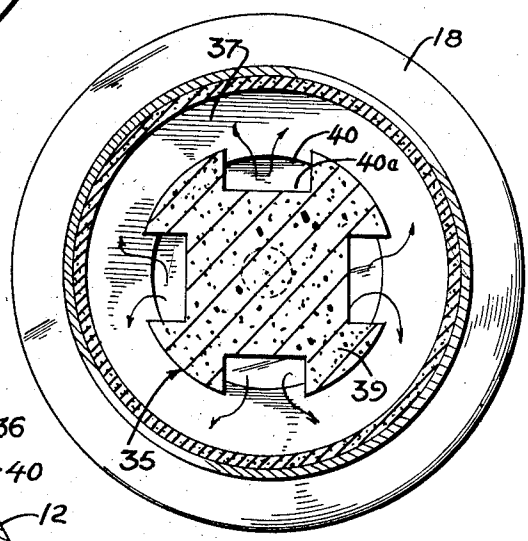


Fig. 3.

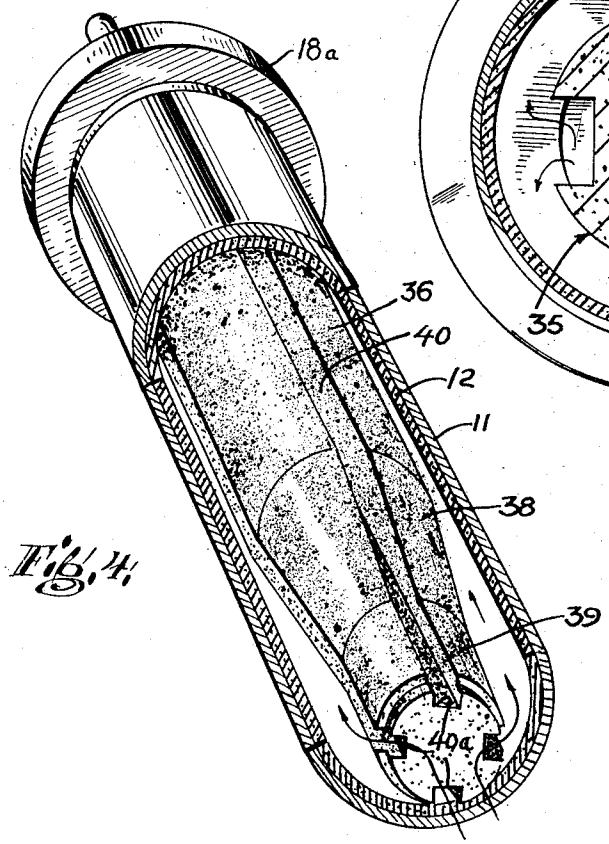


Fig. 4.

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2,821,614

ELECTRICAL STEAM GENERATOR AND METHOD OF STEAM GENERATION

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Application July 22, 1955, Serial No. 523,808

5 Claims. (Cl. 219—40)

This invention relates generally to apparatus and method for heating of liquids or fluids and more particularly to improvements in electrical water heaters that are intended to generate steam especially to provide the steam jackets of heating vessels or steam tables rapidly with an adequate supply of steam, and to improvements in a method of providing steam for such purposes.

Electrical water heaters are known wherein heating is effected by the conduction of electrical currents through the water, the water acting as the resistance. Heaters of this character usually make use of spaced carbon electrodes between which the water circulates. Waters at various localities by reason of their different mineral content possess different electrical resistance or conductivity characteristics. Waters are frequently classified according to degree of hardness, namely, in accord with the extent of mineral content. Usually the higher the mineral content the harder the water. Soft water has the least mineral content. In consequence in the past for a given voltage supply, different waters which were to be heated to the boiling point to supply steam have been found to require different mechanical adjustments in the spacing or effective area between the electrodes.

The problem is of particular importance when the heaters are utilized for steam generation. The adjustment of electrodes heretofore required has been laborious. Moreover, in most cases complex arrangements have been required for providing adjustment in spacing and surface area of contact between the water and the electrodes. These existing arrangements have increased the expense of the heaters extant unnecessarily and in addition have required use of numerous additional parts all subject to mechanical failure.

Objects and features of the present invention are the provision of an improved apparatus for electrical heating of a fluid, such as water for steam generating purposes which is self-compensating for waters of different resistivity, conductivity, mineral content or degrees of hardness without requiring any mechanical adjustment whatsoever or the electrodes used to produce the steam. In other words, principal objects and features of the invention are the provision of a steam generator of the character in question which may be used universally and irrespective of the local water conditions without requiring any mechanical adjustments or structural changes in the electrodes of the apparatus at each different locale for effective operation at rated capacity.

Further objects and features of the invention are the provision of relatively inexpensive and simple structure for practicing the invention.

Wherein the invention is primarily at present utilized as herein described for steam generation purposes, its utility in connection with heating of other liquids or fluids with varying conductivities or resistivities is apparent.

Further objects and features of the invention will become apparent from the following specification and the accompanying drawings wherein:

Figure 1 is a vertical section of an electrical steam generating apparatus made in accord with the present invention;

Fig. 2 is a transverse section taken along the plane of line 2—2 of Fig. 1 and viewed in direction of the arrows;

Fig. 3 is a similar transverse section taken along the plane of line 3—3 of Fig. 1 and also viewed in direction of the arrows; and

Fig. 4 is an isometric view with parts broken away of details of the apparatus embodying the invention.

Referring now to the drawing, the electrical steam generating apparatus made in accordance with the present invention generally comprises a heater assembly **10**. This assembly includes a water heating and steam generating chamber G defined within an open-ended outer casing **11** made of suitable metal, such as copper, and a tubular inner electrode shell **12** made preferably of graphite or carbon. The opposite ends of the electrode shell **12** and the metallic casing **11** are closed off by the respective insulating end closure members **13** and **13***a* which are formed, for example, of ceramic or other insulative heat resisting material.

The end closure member **13** has a centrally disposed recess **14** at its inner face and a centrally located inlet opening **15** extending axially through the body thickness of member **13**. The outer periphery of the member **13** is provided with a portion **16** of smaller diameter than the inner diameter of the casing **11** and with an annular flanged portion **17** substantially of the same diameter as the inner diameter of casing **11**. This end closure member **13** is fitted into the lower end of the casing **11** until annular flange **17** abuts the lower end of the cylindrical electrode shell **12**. The closure member **13** is held in this position by a pressing ring **18** of metallic or other desired material.

The pressing ring **18** has a sleeve-like portion **19** which fits into the space defined between the casing **11** and the reduced portion **16** of the end closure member **13**. Suitable steam packing **20** provides a seal between the annular flange **17** and the sleeve **19** and also serves to prevent leakage of steam outwardly of the casing **11** past the end closure member **13**.

The center opening **15** of the end closure member **13** is fitted with a removable nipple **21** that is secured in place as by the nut **22**. The nipple **21** may be connected in conventional ways to a source of water supply for admitting water into the interior of the casing **11** and shell **12**. The annular flange **23** on the inner end of nipple **21** rests within a recess **24** provided in the end closure member **13** and steam packing **25** serves to prevent leakage in the usual manner.

The upper end closure member **13***a* is provided with an annular ring-like recess **26** surrounding a central axially directed boss **27** arranged at its inner face. The boss **27** includes a central opening **28** which extends axially through the body thickness of the closure member **13***a*. A second opening **29** is provided in the closure member **13***a*. This opening **29** also extends axially through the body thickness of said member **13***a* and is located within the area defined by the annular recess **26**. An outlet nipple **30** is positioned within the opening **29**. Packing **31** between the head **32** of the nipple **30** and body **13***a* eliminates leakage in well-known manner.

The member **13***a* has a portion **16***a* of smaller diameter than the internal diameter of the casing **11** and a portion **17***a* forming an annular peripheral flange of substantially the same diameter as the internal diameter of the casing **11**. The end member **13***a* is inserted into the upper end of the casing **11** until its flange **17***a* abuts the upper end of the carbon shell **12**. A ring-like member **18***a* substantially identical with the ring-like member **18** and

having a sleeve-like portion **19***a* serves to retain the upper end closure member **13***a* in position. Suitable packing **20***a* between the inner end of the sleeve-like portion **19***a* and the flange **17***a* functions identically with the packing **20** to prevent leakage of steam outwardly from the upper end of the casing **11**. The ring-like members **18** and **18***a* after positioning, as herein described, may be held in place by clamps, tie rods or other conventional means (not shown).

The inner shell **12** constitutes one of the electrodes required. The second required electrode **35**, in this instance a core of carbon or graphite, is adapted to be suspended internally of the shell **12** in concentric relationship thereto from the uppermost end closure member **13***a*. This second electrode **35** has generally overall cylindrical shape. The upper and major portion **36** of the core electrode **35** has a uniform diameter which is less than the internal diameter of the shell **12**. A conical frustum or tapered portion **38** immediately adjoins the lower end of the cylindrical portion **36**. The major base of this frustum portion **38** has the diameter of the cylindrical portion **36**. This frustum portion **38** tapers toward a minor base that is substantially smaller than its major base. A second smaller diametered cylindrical portion **39** immediately adjoins the conically-shaped frustum portion **38** and has a diameter substantially equal to that of the minor base of the frustum portion **38**. In effect the electrode **35** thus comprises a cylindrical portion **36** and a second cylindrical portion **39** of smaller diameter joined by an intermediate or connecting portion **38** which is tapered or shaped like a conical frustum.

Longitudinally extending grooves **40** arranged in quadrant positions of the surface of the core electrode **35** extend the full length of the latter and through all of its portions **36**, **38** and **39**. The inner bases **40***a* of the grooves **40** are all parallel with the axis of the electrode **35**. In consequence, each groove **40** has its greatest depth in the larger cylindrical portion **36** of the electrode and its least depth in the second cylindrical smaller portion **39** while in the conically shaped frustum portion **38**, each groove **40** has a varying depth caused by the tapering contour there of the outer surface of the core electrode **35**.

An axially extending centrally located bore **41** is provided at the upper end of the larger cylindrical portion **36**. This bore **41** serves to receive a metallic core shaft **42**. The shaft **42** fits tightly within the electrode bore **41** and has a reduced diametered portion **43** which extends into the boss **27** of the end closure member **13***a*. A second reduced diametered portion **44** of the core shaft **42** threaded at **45** extends through a metallic pressurizing sleeve **46** located within the central opening **28** of the end closure member **13***a*. A conventional steam packing **47** lies between the lower end of sleeve **46** and the portion **43** of shaft **42**. A nut **48** when tightened on the threaded portion **45** serves to mount core shaft **42** rigidly on the end closure member **13***a* and to compress the packing **47** for sealing purposes.

With this described arrangement the second electrode **35** is effectively supported from the end closure member **13***a* in concentric relationship relative to the tubular or shell electrode **12**. Because of the described shape of electrode **35**, the regional annular space **49** defined between its portion **36** and shell **12** is of a uniform width which is smaller than the uniform width of a regional annular space **50** defined between its portion **39** and shell **12**, while the regional annular space **51** defined between its portion **38** and shell **12** varies in conformity with the slope of the walls of said portion **38**. The variation in width of the regional annular spaces **49**, **50** and **51** serves, as will be described, to permit use of the heater without mechanical adjustment in locales whose waters have differing mineral content, resistivity or degrees of hardness.

In a practical embodiment of the apparatus described the metal jacket **11** had an inside diameter of approximately 3". The internal diameter of shell electrode **12** was approximately 2.8" and its outside diameter approximately 3". Overall length of shell electrode **12** was approximately 11¾". The second or central electrode **35** was approximately 12" in length. Its portion **36** was approximately 8⅜" long and 2⅝" in diameter. Its tapered or conic frustum portion **38** had a length of approximately 1⅞", its wider or longer base a diameter of 2⅝" and its narrower or shorter base a diameter of approximately 1.95". The second cylindrical portion **39** had a length of approximately 1½" and a diameter of approximately 1.95". The lowermost end of portion **39** had a short adjoining cylindrical portion **39***a* about ¼" in length and of a diameter of approximately 1.8". Portion **39***a* was provided to fit into the recess **14** of end closure member **13***a* without extending the full depth of said recess so as to center the lower end of the electrode **35**.

Each longitudinal groove **40** of the center electrode **35** spanned its full length and had a width of approximately $^{11}/_{16}$" and a maximum depth in the largest diametered cylindrical portion **36** of approximately $^{9}/_{16}$". These dimensions are by way of example only and are intended to provide adequate steam for the steam jacket J of a conventional steam table T.

With such dimensions a unit operating on a 220 volt electric supply line at current of 60 amps. or approximately at 13.2 klws. is capable of producing approximately 1.34 boiler H. P. and supplying approximately 43 pounds of steam per hour.

When steam is being generated from water of medium hardness the level of water in chamber G lies in spaces **50**, **51** and **49** to approximately half the height of the electrodes **12** and **35**. For softer water the level would be at a higher elevation and for harder water at a lower elevation than the said mid-height position.

The rate of steam supply can range from approximately 40 to 60 pounds per hour with the structure described and adjustments in current, line voltage and liquid level of water during steam generation can be used to control the steam output within the specified range. Steam pressures of from 50 to 100 p. s. i. are usual operating pressures but operation at pressures below or above this range are possible and are contemplated.

In operation of a heater having the structure described water is admitted via inlet **21** at a rate controlled by a conventional throttle valve VT. This valve VT is adjusted either mechanically or automatically in conventional ways to regulate the rate of water flow in accord with the known degree of hardness, resistivity or conductivity characteristics of the water in any particular locale. For example, if the water is very soft its resistivity is high. Since the heating effect of current flow is the product of the square of the current and the resistance, the necessary water level in chamber G to produce a given steam pressure then is higher than that required where the resistivity of the water is low, e. g., with a harder water. Simple adjustment of throttle valve VT to control the level of water in the chamber G permits accommodation of the heater to waters of different degrees of hardness or electrical resistivity.

The throttle valve VT can be manually operated or may be provided with a conventional magnetic control C which is connected in the electric circuit supplying current to the electrodes **12** and **35** so that the extent of valve throttling action can be controlled by the current flowing in the circuit. Thus automatic control of the water level in the chamber G in conformity with the resistivity or hardness of the water may be effected.

The water entering the chamber G via inlet **21**, recess **14** and grooves or slots **40** fills it to the selected level determined by the adjustment of the throttle valve VT and completes the electric circuit between the portions of electrodes **12** and **35** with which the water is in contact. The passage of the current through the water heats it to

the boiling point and the rising steam vapor makes its way upwardly through the boiling water, the regional annular spaces **50**, **51** and **49** in chamber G and the grooves **40** in the center electrode **35** to the recess **26** in end closure **13***a*. The steam entering recess **26** flows outwardly thereof via outlet nipple 30 which may be connected by any appropriate conduit, to, for example, the steam jacket J of a steam table T or to any other heating apparatus requiring steam for heating or other purposes.

The reason the steam generator herein described is effective for universal use without mechanical modification of its electrodes with waters of differing resistivity or conductivity in differing locales is the shape of its electrode **35**. The different herein described dimensional characteristics of its three portions 36, 38 and 39 provide three different zones or regions 49, 50 and 51 whose spacing relative to the other electrode 12 varies as has been described. The heating effect on the water depends upon the magnitude of the voltage applied between the electrodes, and the spacing and the effective area of the opposing electrodes in actual contact with the water. The shape of electrode **35** provides a relatively wide range of spacing variation and effective contact area by simple control of the level of water in chamber G. In consequence, under practical operating conditions waters of substantially any degree of softness or hardness may be utilized effectively for generation of steam within the rated capacity of the apparatus. The elimination of any necessity for mechanical structural changes in the unit either by way of introduction of additional electrodes or by way of removal of electrodes or by way of any change of relative positions of electrodes is an outstanding advantage of the instant invention. The savings in costs for manufacture, installation and maintenance are substantial.

The apparatus described herein and the method of heating practiced therewith are applicable not only for use with water but with any fluids whose conductivity or resistivity may vary under different circumstances. In such event control of the contact between the liquids or fluids and the electrodes and its confinement to selected regions of the differently spaced portions of the fixed electrodes chosen in accord with the specific conductivity or resistivity of a particular liquid are all that are required. No mechanical change is needed.

While a specific embodiment of the invention has been described, variations in structural detail within the scope of the claims are possible and are contemplated. There is no intention, therefore, of limitation to the exact details shown and described.

What is claimed is:

1. Apparatus for heating fluid by electrical conduction comprising a heater assembly including a tubular electrode, end closure members mounted on said electrode for sealing both ends thereof and a core electrode extending axially within the tubular electrode and in spaced relationship therewith, said core electrode having portions of differing dimensions to provide variations in spacing between respective portions of said core electrode and said tubular electrode whereby like heating effect may be produced in fluids of different conductivities by varying the extent of contact of the fluid within the tubular electrode with said portions of said core electrode, and means providing an inlet for water into the space between the electrodes and an outlet for steam generated therefrom.

2. Apparatus for heating water by electric conduction to generate steam comprising a heater assembly including a shell-like electrode, end closure members for said electrode sealed at opposite ends thereof and a core electrode supported from one of said end closures and centrally disposed within the shell-like electrode and in spaced relationship therewith, said core electrode having a plurality of portions of differing dimensions to provide variations in spacing between respective of the said portions

of said core electrode and said shell-like electrode whereby like steam generation may be effected with waters of different degrees of hardness by varying the extent of contact of such waters within the shell-like electrode with said portions of said core electrode, and means providing an inlet for water into the space between the electrodes and an outlet for steam generated therefrom.

3. Apparatus for heating water by electric conduction to generate steam comprising a heater assembly including a tubular electrode, end closure members for said tubular electrode, a core electrode supported by a first of said end closure members and extending axially of the tubular electrode and in spaced relationship therewith, said core electrode having a plurality of successively arranged portions of different dimensions to provide successively differing variations in spacing between respective of the said portions and said tubular electrode and grooves in said core electrode, said first of said end closure members having an outlet for steam generated in said apparatus and the other of said end closure members having an inlet for water and said grooves providing entrance and exit communications respectively with the inlet for water and the outlet for steam.

4. Apparatus for heating water by electric conduction to generate steam comprising a heater assembly including a tubular cylindrical electrode, end closure members for said electrode, a core electrode extending axially and concentrically of the tubular electrode between said end closure members, said core electrode having a first uniformly diametered cylindrical portion, an adjoining frustum portion and a second uniformly smaller diametered cylindrical portion adjoining the frustum portion, said portions all having smaller diameters than the inner diameter of said cylindrical electrode and thereby providing varied spacing between the tubular electrode and the differing portions of said core electrode, one of said end closure members has a recess provided with a water inlet and the other of said end closure members has a recess provided with steam outlet, and said core electrode having axially extending grooves in communication with both of said recesses, and means to secure said core electrode to said other of said end closure members.

5. Apparatus for heating water by electric conduction to generate steam comprising a heater assembly including a tubular cylindrical electrode, end closure means for sealing off opposite ends of said electrode, water inlet means in one of the end closure means and steam outlet means in the other end closure means, a core electrode concentrically disposed within said tubular electrode and spanning the distance between the end closure means and being in spaced relationship with said tubular electrode throughout its length, said core electrode having a first uniformly diametered portion, a second uniformly smaller diametered portion and a frustum portion joining said two first-named portions and thereby providing variations in spacing between the tubular electrode and the respective portions of said core electrode, and said core electrode having longitudinally extending grooves in its surface spanning its length, said grooves providing entrance passageways to the space between the electrodes for water supplied to said inlet means and outlet passageways from said space to said steam outlet means for steam generated in said space, and means for regulating the level of water in said space in accord with its hardness.

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