H. B. GALE.

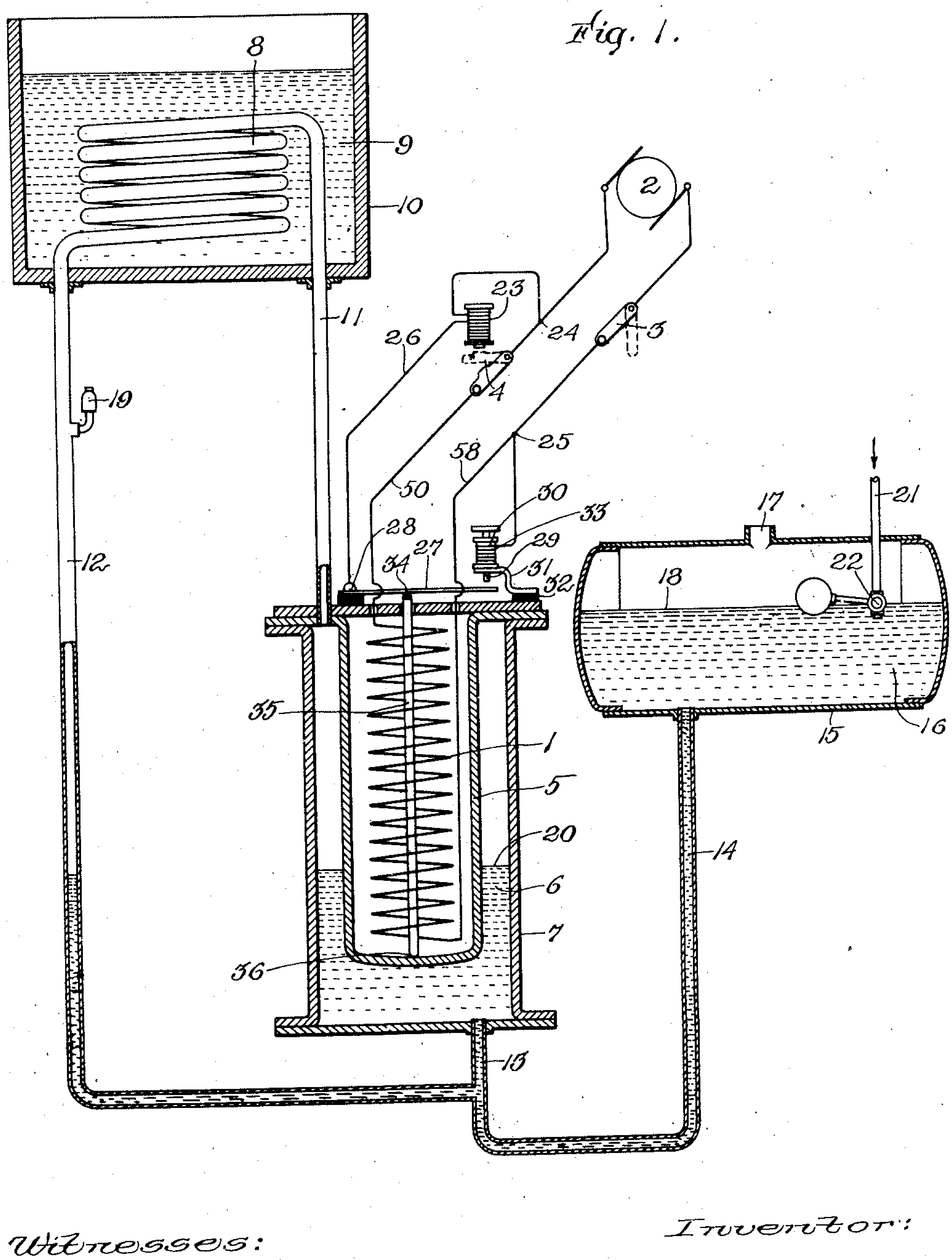
METHOD AND APPARATUS FOR EQUALIZING TEMPERATURE.

APPLICATION FILED SEPT. 19, 1910.

983,548. Patented Feb. 7, 1911.

3 SHEETS—SHEET 1.

Fig. 1.



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3 SHEETS—SHEET 2.

Fig. 2.

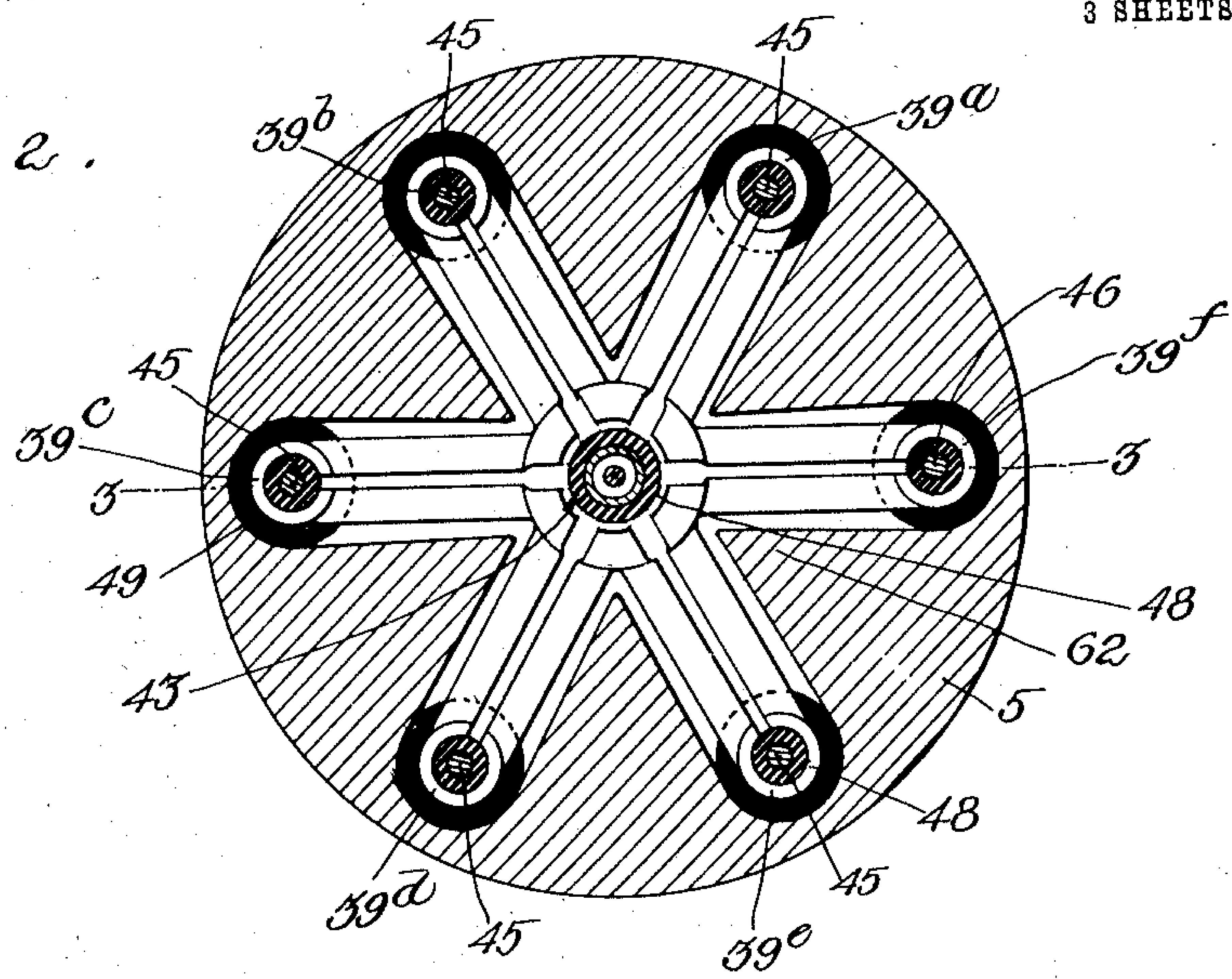
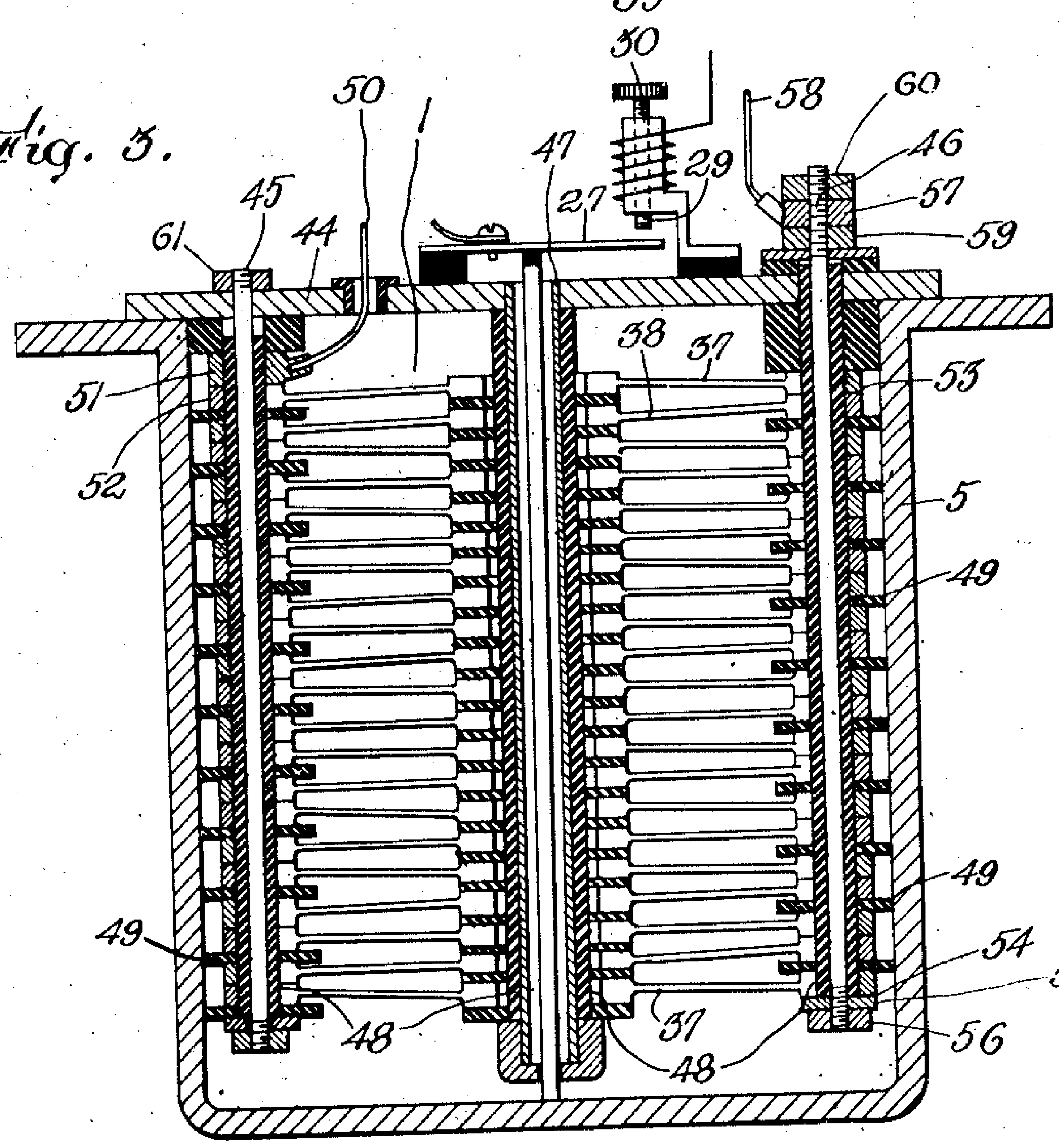


Fig. 3.



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3 SHEETS—SHEET 3.

Fig. 4.

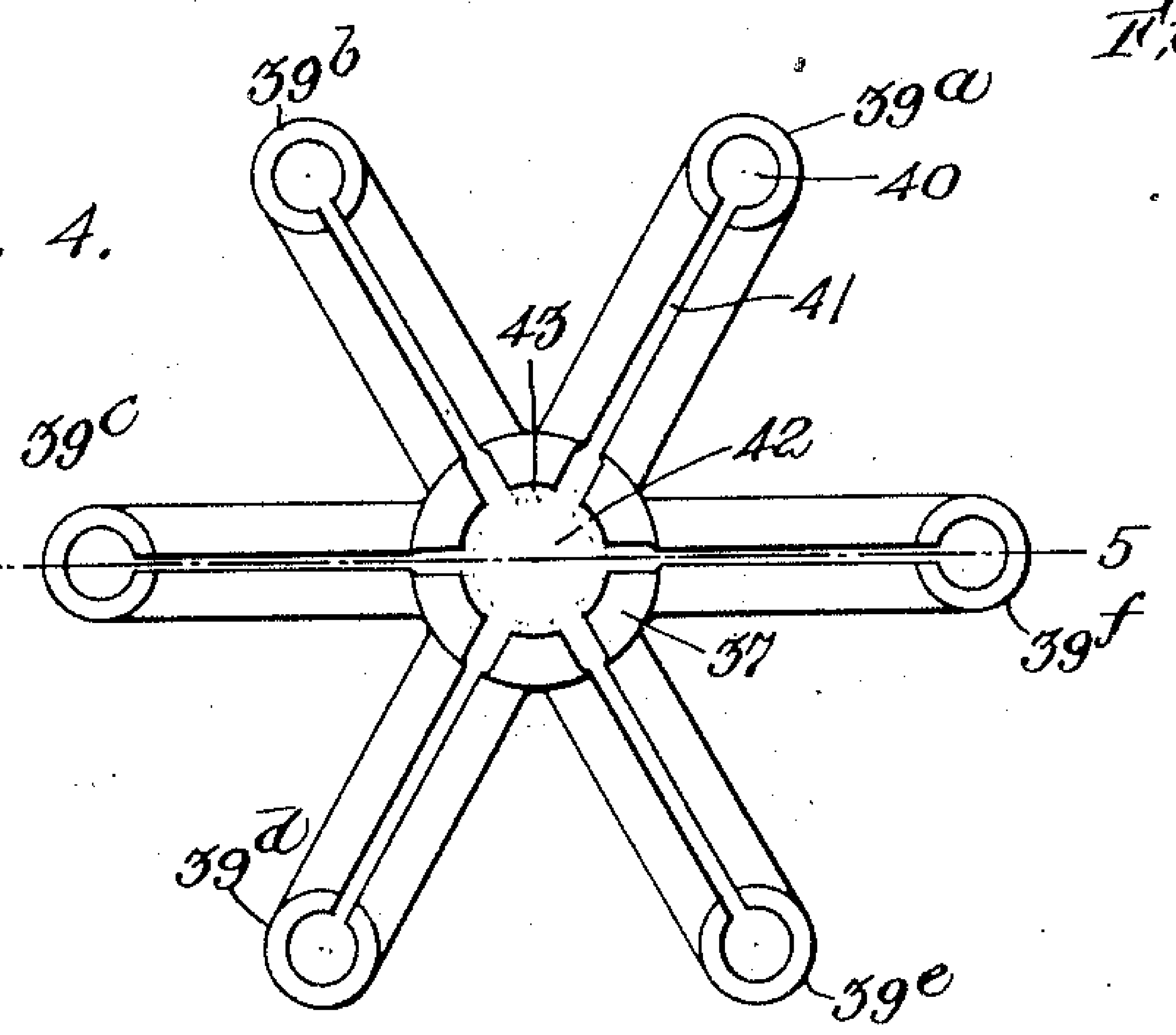


Fig. 5.

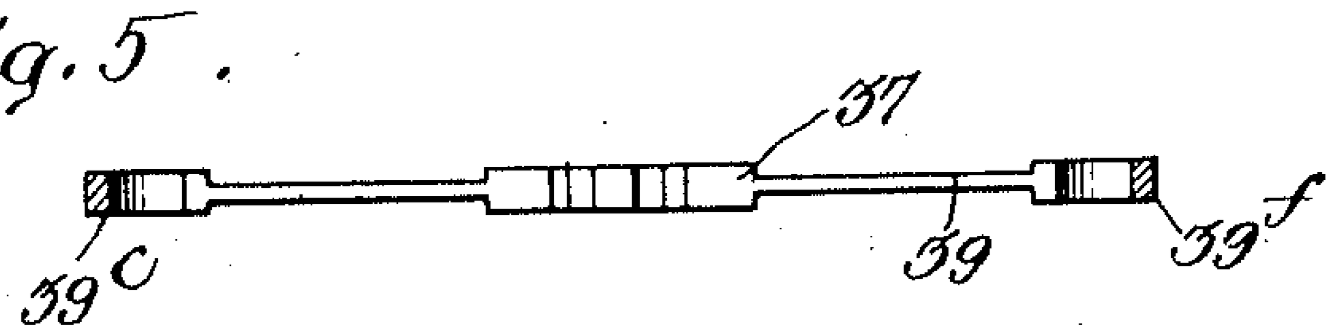


Fig. 6.

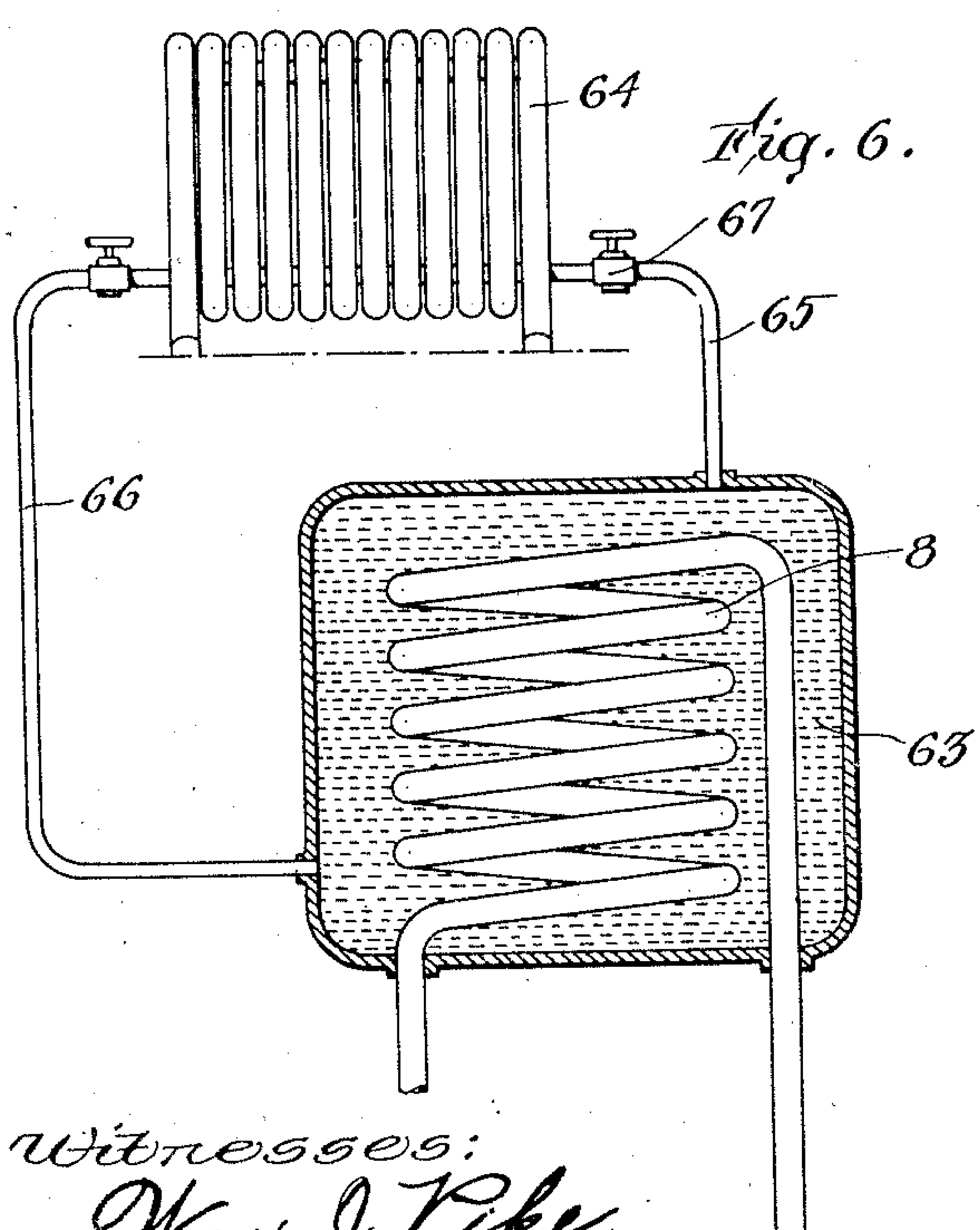
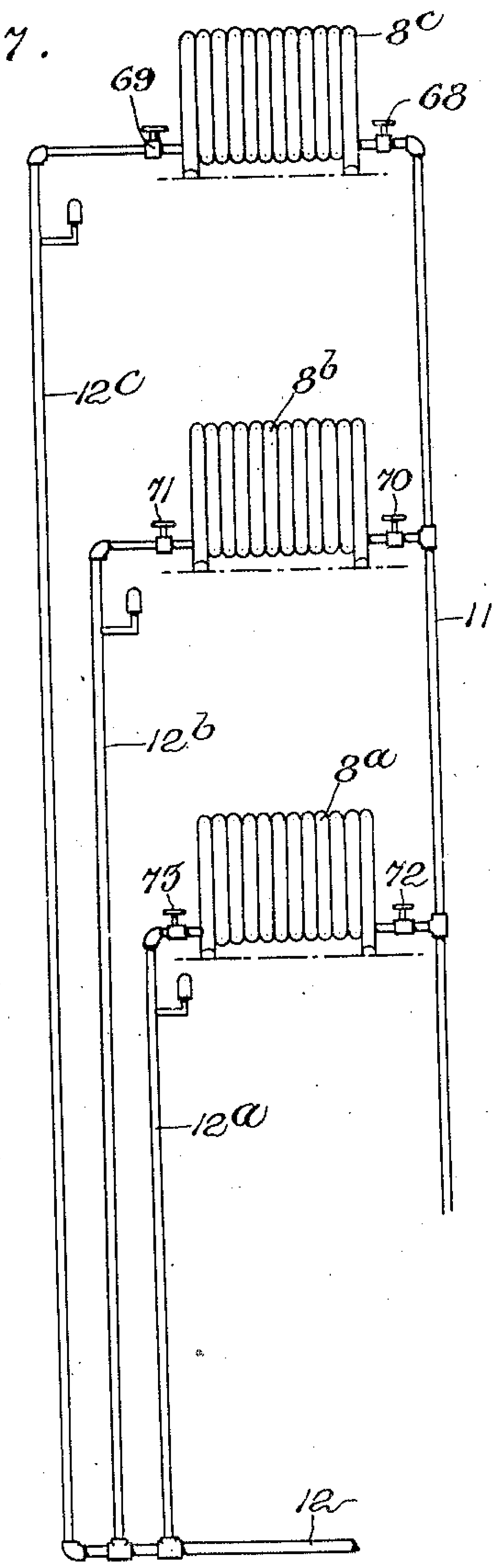


Fig. 7.



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UNITED STATES PATENT OFFICE.

HORACE B. GALE, OF NATICK, MASSACHUSETTS, ASSIGNOR TO SIMPLEX ELECTRIC HEATING COMPANY, OF CAMBRIDGE, MASSACHUSETTS, A CORPORATION OF MASSACHUSETTS.

METHOD AND APPARATUS FOR EQUALIZING TEMPERATURE.

983,548. Specification of Letters Patent. Patented Feb. 7, 1911.

Application filed September 19, 1910. Serial No. 582,753.

To all whom it may concern:

Be it known that I, HORACE B. GALE, a citizen of the United States, residing at Natick, in the county of Middlesex and State of Massachusetts, have invented an Improvement in Methods and Apparatus for Equalizing Temperature, of which the following description, in connection with the accompanying drawings, is a specification, like letters on the drawings representing like parts.

My invention is a novel method and improved means for producing an even or regulated temperature especially adapted for use with electric energy. While having a wide field of application, it may be conveniently disclosed in connection with cooking apparatus, and domestic electric appliances. At the present day electricity has been adapted to nearly all the requirements of kitchen work, laundry work and other domestic and kindred uses, and accordingly my invention relates to the regulation of the heating means in such and kindred lines of work. While my invention is particularly adapted however to such lines of electric work, it is to be understood that it is not limited thereto except as expressly required by certain of the claims.

The invention will be better understood by first explaining the general principle thereof, made clear by reference to one or more practical illustrations.

In a usual electric heater the temperature of the heat transmitting or radiating surface depends chiefly upon the momentary balance between the electric energy put into the heater and the heat energy given out or withdrawn,—if the two are equal the temperature of the surface remains constant, and my invention, roughly stated, may be said to reside in rendering this balance more elastic and conserving the heat energy by interposing a preferably elastic heat transmitting medium in connection with an automatic control whereby, for instance, instead of applying a cooking utensil or the like directly to the initial electric heating element, the heat of the latter is transmitted by said medium to a point remote from the initial electric heating element, where the heat is applied to said cooking utensil or whatever other heat consuming utensil or device is to be heated, and this is done in such a manner and by such means as to maintain the heat under absolute control, and preferably automatic control. If an electric heater supplied with current at a constant voltage, be immersed directly in oil, there will be a constant input of electric energy without regard to the demands thereon, which are usually variable; thus when a large mass of cold material is immersed in the oil the temperature of the heater will fall too low for effective service. On the other hand if the bath is allowed to stand idle for a time while the input of electric energy exceeds the demand for heat, the temperature may become dangerously or destructively high. The usual method which has been employed for regulating temperature in such cases has been to vary the input of electrical energy to balance the variable demand for heat, thermostatic devices being employed to open the electric circuit or interpose resistance upon a slight rise of temperature, and close it, or cut out resistance upon a slight fall in temperature. Such devices are delicate in construction, and when applied to the control of large heating currents, become complicated with relays and expensive mechanism quite liable to derangement. They are objectionable also in putting an intermittent load on the circuit, causing fluctuations in voltage and reducing the efficiency of the generator. To obviate these objections, and to provide a simple and reliable means of maintaining an approximately uniform temperature at the surface where the heat is applied to the work (or body to be heated) I interpose a quantity of volatile liquid and vapor between the electric heating resistance or source of heat and the surface whose temperature is to be regulated, hereinafter called "the working surface". To regulate the temperature of this surface I automatically adjust the extent of heat transmitting surface between the resistance device or other source of heat, and the liquid, to correspond with the demand for heat. By this method the working surface is maintained within the desired limits of temperature, while the quantity of heat supplied to the work and the temperature of the heating resistance and adjacent parts may vary through a wide range. My method of regulation, as will appear in the following description, requires no accurately adjusted thermostat for frequent changes in current supply, as the temperature of the working surface is maintained independent of such adjustments, and it is necessary only to cut off or reduce the current or other supply of heat in the extreme case of the temperature of the heater itself becoming high enough to threaten the destruction of its own material. In order to vary automatically the extent of the heat transmitting surface between the liquid and the heat supplying surface, in accordance with the demands for heat, I preferably make use of the pressure of the vapor from the heated liquid, which, as the device is arranged, conveys the heat to the working surface and has a fixed relation to the temperature thereof.

Referring to the drawings, wherein a preferred embodiment of the invention is illustrated, Figure 1 is a sectional diagram illustrating the general plan of construction of the device and the method of controlling the temperature of the working surface; Fig. 2 is a horizontal section of a preferred construction of heater; Fig. 3 is a central vertical section on the line 3—3 Fig. 2; Fig. 4 is a plan view of one of the units which make up the heating resistance; Fig. 5 is a section thereof on line 5—5 Fig. 4; Fig. 6 is a sectional diagram illustrative of a certain special application of the device; and Fig. 7 is a further diagrammatic showing of a system wherein the invention may be advantageously employed.

Referring to Fig. 1, 1 designates conventionally an electric resistance device connected in circuit with a source of electric energy 2, this typifying in a broad aspect of the invention a suitable source of heat energy which it may be found desirable to employ. A hand switch for opening the circuit is indicated at 3, and an automatic switch whose operation is explained farther on, at 4. The resistance device 1 is surrounded by a water-tight metallic casing 5, and this is in contact with a liquid 6, preferably water, inclosed in a receptacle 7.

The working surface or medium or body whose temperature is to be regulated is shown for illustration in the form of a coiled pipe 8 immersed in a bath of liquid 9, for example oil (for instance in which doughnuts or potato chips are fried), in a tank or receptacle 10, this typifying any heat absorbing and consuming body to which the working surface delivers its heat. The upper end of the coil 8 is connected by a pipe 11 with the top of the annular space between the closed receptacle 7 and the casing 5, and the lower end of the coil may be connected by pipes 12 and 13 with the bottom of the receptacle 7. The bottom of the receptacle 7 is also connected by pipes 13 and 14 with a reservoir 15 partially filled with liquid as at 16, in which a definite pressure is maintained. Any of numerous well known methods of regulating this pressure may be employed, but I prefer the simplest method, which consists in admitting the pressure of the atmosphere to the reservoir 15 by means of an opening 17 in the top, as shown. By this means the pressure on the surface 18 of the water in the reservoir 15 is kept constant, and when the apparatus is cold the water will either fill the receptacle 7 or will stand at the same level in this receptacle and in the pipe 12 as in the reservoir 15.

Starting with this condition and with the automatic switch 4 closed and the hand switch 3 open, the operation of the device is as follows: Upon closing the switch 3, current from the source 2 is allowed to flow through the resistance device 1, heating it and the surrounding metal case 5. The case 5 imparts heat to the body of water 6 throughout their surfaces of contact, and vapor is generated which fills the upper part of the receptacle 7, the pipe 11, coil 8, and a portion of return pipe 12. An automatic air release valve 19 of any well known type is preferably connected to the pipe 12. This allows the steam pressure to drive out any air there may be in the system, closing when the steam itself reaches the valve 19 after filling the coil 8. The pressure of the confined steam tends to increase, particularly if heat is not taken up by the heat absorbing body 8 fast enough to condense the same. But as it does so, a part of the water in the receptacle 7 is driven out through pipes 13 and 14 into the reservoir 15, thus lowering the level in receptacle 7 and diminishing the area of the surface of contact by which heat is transmitted from the heater 1 to the water 6. This checks the generation of steam and prevents the pressure from exceeding a fixed limit equal to the pressure (shown as atmospheric) maintained on the surface 18 plus the pressure due to the elevation of the surface 18 above the surface 20 of the body of water 6. The surface 20 of the water in the receptacle 7 must always be somewhat above the bottom of the heater case 5, otherwise there would be no contact between the heater and the liquid, and practically no steam would be generated. It is evident that the level of the surface 20 of the water in the receptacle 7 will be automatically maintained at a point where the rate of steam generation is just sufficient to supply the demands of the system, the said level rising and immersing more surface of the heater case 5 if the rate of condensation in the coil 8 increases, owing to increased demands thereon by the heat absorbing body 9, and falling with corresponding diminution of the heat transmitting surface if the rate of condensation diminishes. The water due to the condensation of steam in the coil 8 may be returned by gravity, as for example through the pipes 12 and 13, to the bottom of the receptacle 7; this return of the water of condensation is not essential however, as any losses by leakage or otherwise may be made up by supplying water to the system for example by supply pipe 21 with a controlling float valve 22 in the reservoir 15.

When the apparatus is in operation, as described, the pressure of the steam in the coil 8 will be maintained normally constant, the extreme limits of variation being measured by the fluctuation of the head of water at the surface 20, the change of one foot for example causing a variation of less than one pound pressure. The temperature of the working surface 8 therefore will be practically constant, corresponding to the temperature of condensing steam of a definite pressure determined by the construction of the apparatus. The temperature of the heater 1 and casing 5 will however vary between wide limits. The temperature of the immersed portion of the case 5 will be but slightly greater than that of the surrounding water 6, while the part of the case above the surface 20 being immersed in dry steam,—a poor conductor of heat,—will become much hotter. In the normal operation of the apparatus, this surface is cooled at intervals by the rise of the water around it, whenever a temporary increase of the demand for heat causes an increase in the condensation of the coil 8; but, if the supply of electric energy should exceed the average demand for heat for a sufficiently long time, the upper part of the heater 1 and case 5 might become overheated so as to injure or destroy the heater. This can be guarded against by turning off the current by the hand switch 3 when the danger point is reached and turning it on again when the heater has been cooled to a safe temperature by the rise of the water 6 around the case 5, but I prefer to make this operation automatic in the manner to be described.

The switch 4 is arranged to be opened by an electromagnet 23 whose circuit is made between two sides of the main supply circuit of the heater at 24, 25, through the wire 26 and a movable contact in the form of a flat steel spring 27 mounted on an insulating support 28, and whose free end is adapted to make contact with an adjusting screw 29. This screw is fitted to turn in a soft iron support 30 mounted on a bracket 31 insulated at 32. From this support the circuit is completed through the wire 33 coiled around the soft iron core 30 to the main supply circuit 25. The movable contact spring 27 presses down upon an insulating block 34 carried on the end of a rod 35 which extends through the length of the heater case 5 in proximity to the heating resistance 1. This rod is preferably made of some material such as brass, which has a higher rate of expansion by heat than the metal of the case 5, which is preferably made of iron. The lower end of the rod 35 is attached to the case 5 at 36 and when the heating resistance reaches its limit of safe temperature the expansion of the rod bends the spring 27 so that it makes contact with the screw 29, thus closing the circuit through the coil of the magnet 23. The magnet is thus energized and opens the switch 4, cutting off the current from the heater 1 but leaving the circuit closed through the magnet coil 23. As the heating resistance 1 cools under the influence of the water 6 rising around the case 5, the rod 35 contacts and diminishes the pressure of the support 34 against the spring 27, but the latter does not immediately move out of contact with the screw 29, because the iron core 30 is magnetized by the current flowing through the wire 33, and holds the spring 27 in contact with the screw 29 until the contraction of the rod 35 has relieved the pressure on the spring by an amount corresponding to the holding power of the magnet 30. Then the spring 27 suddenly breaks away from the contact screw 29, opening the circuit of the magnet 23 and allowing the switch 4 to close, which it may do by gravity or otherwise, restoring the current in the heating resistance 1. The strength of the magnet 30 is so adjusted with reference to the spring 27 and the expansion rod 35, that the circuit through the heating resistance 1 is restored when its temperature has fallen to the lower limit desired.

It it evident that the temperature of the heater may be allowed to vary within wide limits, and that there is no need of exactness or delicacy in the adjustment of the thermostat and automatic switch. Moreover, the switch 4 has to be operated only at infrequent intervals and the current is not continually being turned on and off as is the case where a close adjustment of temperature is attempted by thermostatic adjustment of the current alone. While the heater itself is subject to these wide fluctuations of temperature, the temperature of the working surface 8 is regulated as closely as may be required, by the automatic adjustment of the water level in the receptacle 7 as previously described.

I have described thus in detail my preferred means of controlling automatically the current in the heater 1, but it will be evident to anyone skilled in the art of the electric control of temperature, that these details may be greatly varied. As already stated, the automatic control of the heating current is not necessary to the successful operation of the device in regulating the temperature of the working surface 8. It is evident also that the successful operation of the apparatus in a broad aspect is not limited by any special form or construction of heater 1 or by any special shape of the case 5 or receptacle 7. The case 5 and receptacle 7 may be in one piece, provided only that the receptacle will hold a quantity of water 6 in heat conductive relation to the resistance and permit of automatically varying the area of heat conducting surface between them in the manner described. It is further evident that while as explained my improved method has special advantages in coöperation with the particular electric heater disclosed, still broadly considered the same method of regulating the temperature of the surface 8 is applicable if some other source of heat is employed instead of the electric resistance device, as for example a gas flame. Therefore I do not limit my invention to any automatic current controlling device or any special form of heater or casing.

Referring to Figs. 2, 3, 4 and 5, I have illustrated more in detail a special construction of heater 1 and case 5, which are specially adapted to the purpose of my invention where currents of considerable magnitude are required. The heater 1 consists of a number of similar metallic sections 37, 38, etc., each cast in the form of a continuous strip or bar bent into the desired shape and extended in one plane so as to have a generally flat form, as most clearly shown in Figs. 4 and 5, with a series of radiating arms 39^a, 39^b, 39^c, 39^d, 39^e, 39^f. These arms have their ends cut out as at 40 to form ring portions, and from said cut out portions, slots 41 extend to a central cut out portion 42, the center or hub 43 being thus in the shape of a broken ring. The casing 5 as shown in Figs. 2 and 3 is externally a closed metal cylinder, water-tight except at the top. The resistance 1, consisting of the plates 37, 38, etc., is suspended from the cover plate 44 by means of rods 45, 46, and a central tube 47, the rods and tube being surrounded and protected from contact with the resistance units by insulating material 48. The resistance units 37, 38, etc., are slipped over the rods 45, 46, and the tube 47, which with their protective insulation 48 pass through the ring shaped portions 40 and the central cut out portion 42 respectively. The sections 37, 38, etc., are also separated by insulating washers 49 except at points where electrical contact between them is desired.

When the switches 3 and 4 are closed, the current flows to the heater through the wire 50, which is connected to a lug 51 surrounding one of the rods as 45. The lug is insulated from the rod as shown but in contact with the first resistance section 37 of the heater at the point 52 where the current enters this section. The first resistance section 37 is insulated from the second section 38 except at the point 53 opposite the point 52, the insulating washer being omitted between these sections on the rod 46. The current therefore entering the section 37 at the point 52 divides into two equal portions, one half passing by way of the points 39^a, 39^b, and the other half by way of points 39^d, 39^e uniting again at point 53, where it passes into section 38 and likewise divides in going therethrough. It is apparent that by omitting the insulating washers 49 at alternate opposite points between the successive resistance sections, the current will be made to traverse all of said sections in series to the last one, which is in contact at point 54 with a metal washer 55 resting on a nut 56 on the rod 46. The current therefore finally enters the rod 46, which is connected at its upper end to lug 57, forming a terminal for the wire 58 by which the circuit is completed to the source 2. Nuts 59 and 60 are threaded on the top of the rod 46, and a nut 61 is threaded on the top of rod 45; by adjusting these nuts the sections of the heater can be clamped firmly together so as to insure good contact.

The internal surface of the case 5 is preferably made in a scalloped section, as shown at 62 in Fig. 2, in order to bring all parts of the heating resistance into as close proximity as possible to the heat absorbing surface thereof, and to facilitate heat transmission between the resistance 1 and the case 5 by providing the largest practical extent of transmitting surface within a given space. The resistance section in the form of a scalloped and slit ring with radiating arms presents a form which has a considerable length of conductor in a compact space, every portion of the conductor moreover being exposed on the outside to free radiation of heat to the opposite surface of the case 5 and also free to expand toward the center when heated. This form is also adapted to be easily cast and economically insulated and supported by suspension rods in the case, as shown. If desired, the entire resistance device 1 may be lifted out of the case 5 by raising the cover plate 44, and inspected without loosening screws or other parts. The washers 49 project beyond the outside of the heater 1 and thus insulate the units 37, 38, etc., from the sides of the case.

Fig. 6 illustrates a useful embodiment of the device, in which the working surface 8 in the form of a coil is immersed in the closed tank 63 of a circulating water heating system such as is commonly used for heating dwelling houses. A hot water radiator is indicated at 64 with a supply pipe 65 therefor coming from the top of the tank 63, and a return pipe 66 entering the tank

63 near the bottom. A valve 67 permits the rate of flow of water to be adjusted so as to produce the desired temperature in the radiator 64 while the temperature at the surface 8 is kept constant in the manner already described. Fig. 7 is another application, in which the working surface 8 is divided into various sections 8^a, 8^b 8^c, which represent similar radiators connected to the common supply pipe 11 and with separate return pipes 12^a, 12^b, 12^c, united in the common return pipe 12. These radiators are provided with valves 68, 69, 70, 71, 72, 73. By closing the valves 68 and 69 for example, the steam is shut off from the radiator 8^c, but the temperature and pressure of the steam in the other radiators 8^a, 8^b, is maintained uniform independently of the total demand for heat, by the method already described.

Having described my invention, what I claim as new and desire to secure by Letters Patent is,

1. The herein described method, which consists in interposing between the source of heat and the body or surface to be heated a body of liquid, and automatically regulating the extent of surface through which heat is transmitted from the source to the liquid responsively to changes in the vapor pressure of the liquid.

2. In a heating system, the method of controlling the generation of steam which consists in continuously regulating the area of water-heating surface of the generator responsively to the demand for heat.

3. In a heating system, the method of controlling the rate of generation of steam responsively to the demand, which consists in diminishing the area of water-heating surface in the generator upon an increase of pressure and enlarging the surface of said area upon a diminution of said pressure.

4. The herein described method, which consists in supplying heat to a conductive surface, interposing between said surface and the body or working surface to be heated a body of liquid, and automatically adjusting the extent of contact between said conductive surface and said liquid in accordance with the amount of heat taken from the working surface.

5. The herein described method, which consists in heating a conductive surface, interposing between said surface and the body or working surface to be heated a body of volatile liquid, and automatically adjusting the extent of surface engagement between said conductive surface and said liquid in accordance with changes in vapor pressure on the liquid.

6. The method of regulating temperature, which consists in heating a conductive surface, interposing between said surface and the body or working surface to be heated a body of volatile liquid, transmitting the heat to the working surface in gaseous or vapor form, and adjusting the extent of contacting surface between said conductive surface and liquid responsively to changes in the pressure of said gas or vapor.

7. A heating apparatus, comprising a conductive surface, means for supplying heat thereto, means for holding a body of liquid in contact with said surface and forming therewith a closed receptacle, a working surface having connection with said receptacle, and means to vary the area of contact between said liquid body and said conductive surface in accordance with the absorption of heat from said working surface.

8. A heating apparatus, comprising a conductive surface, means for supplying heat thereto, means for holding a body of liquid in contact with said surface and forming therewith a closed receptacle, a working surface having connection with said receptacle, and means to vary the area of contact between said liquid body and said conductive surface in accordance with the gaseous pressure in said receptacle.

9. A heating apparatus, comprising a conductive surface, means for supplying heat thereto, means for holding a body of liquid in contact with said surface and forming therewith a closed receptacle, a working surface having connection with said receptacle, means to vary the gaseous pressure in said receptacle in accordance with the absorption of heat from said working surface, and means for supplying liquid to said receptacle under predetermined yielding pressure.

10. The combination of an electric heater, a working heating surface separated therefrom, an intermediate body of liquid in heat-conductive relation to the electric heater, and automatic means responsive to variations in the temperature of the working surface, whereby the extent of heat-conducting surface between the heater and the liquid is adjusted so as to regulate the temperature of the working surface.

11. The combination of an electric heater, a working heating surface separated therefrom, a body of liquid and vapor intermediate between the electric heater and the working surface, and automatic means responsive to changes in the vapor-pressure whereby the extent of heat-conducting surface between the heater and the liquid is adjusted so as to regulate the temperature of the working surface.

12. The combination of an electric heater, a working heating surface separated therefrom, a receptacle adapted to hold a liquid in heat-conductive relation to the electric heater, and means responsive to changes in temperature at the working surface whereby the extent of heat-conducting surface be-

tween the heater and the liquid may be adjusted so as to regulate the temperature at the working surface.

13. The combination of an electric heater, a working heating surface separated therefrom, a receptacle adapted to hold a liquid in heat-conductive relation to the electric heater, and means responsive to changes in the vapor-pressure of the liquid whereby the extent of heat-conducting surface between the heater and the liquid may be adjusted so as to regulate the temperature at the working surface.

14. The combination of an electric heater, a working heating surface separated therefrom, a receptacle adapted to hold a liquid in heat-conductive relation to the electric heater, a fluid-circulating system connecting the said receptacle and the working heating surface, and means responsive to changes in the vapor-pressure of the liquid whereby the extent of heat-conducting surface between the heater and the liquid is adjusted so as to regulate the temperature of the working surface.

15. The combination of an electric heater, a working heating surface separated therefrom, a receptacle adapted to hold a liquid in heat conductive relation to the electric heater, a closed fluid-circulating system connecting the said receptacle and the working heating surface, and a pressure-regulating tank connected with the bottom of the said receptacle, substantially as set forth.

16. The combination of an electric heater, a working heating surface separated therefrom, an intermediate body of liquid in heat-conductive relation to the electric heater, automatic means responsive to variations in temperature of the working surface whereby the extent of heat-conducting surface between the heater and the liquid is adjusted to regulate the temperature of the working-surface, and automatic means responsive to changes in temperature of the heater, whereby the supply of electric current to the heater is controlled, substantially as set forth.

In testimony whereof, I have signed my name to this specification, in the presence of two subscribing witnesses.

HORACE B. GALE.

Witnesses:
MacAllaster Moore,
Elizabeth M. Conlin.