No. 797,960. PATENTED AUG. 22, 1905.

H. JUNKERS.

APPARATUS FOR HEATING LIQUIDS.

APPLICATION FILED JULY 17, 1902.

2 SHEETS—SHEET 1.

Fig. 1.

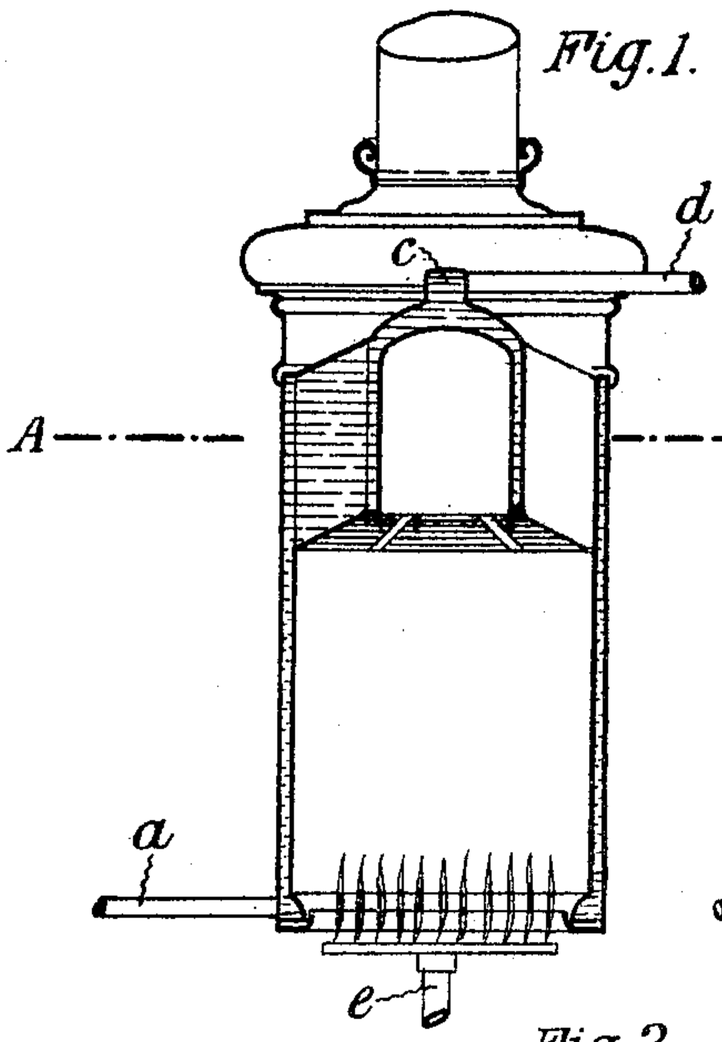

Fig. 3.

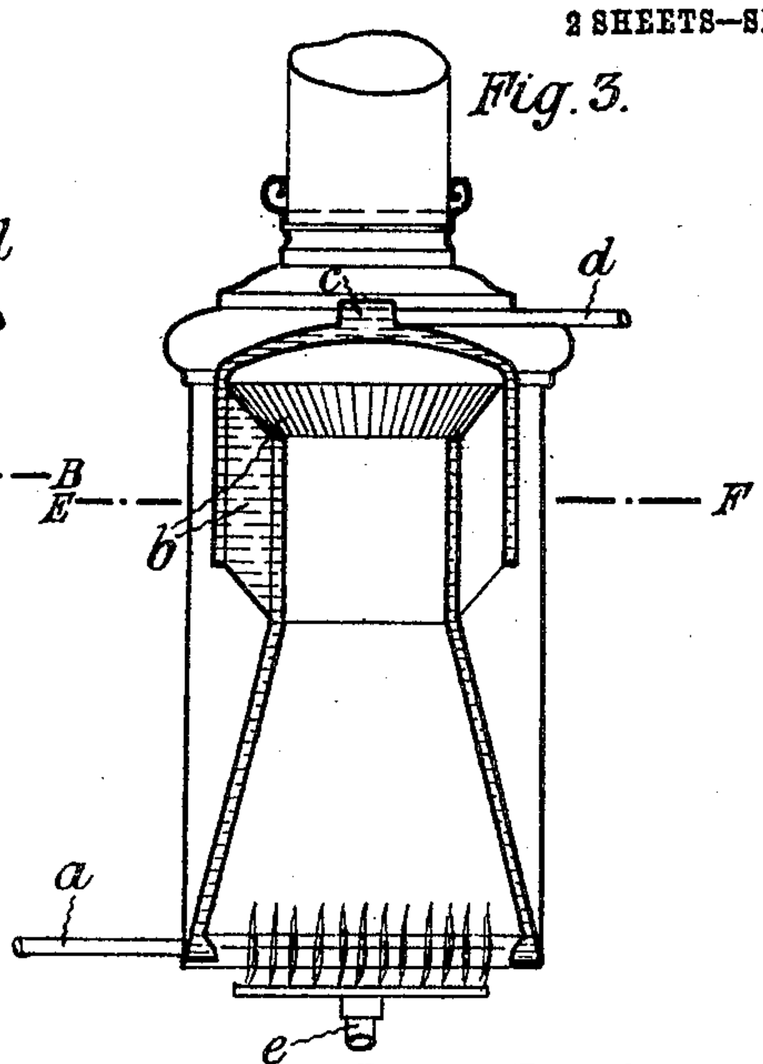

Fig. 2.

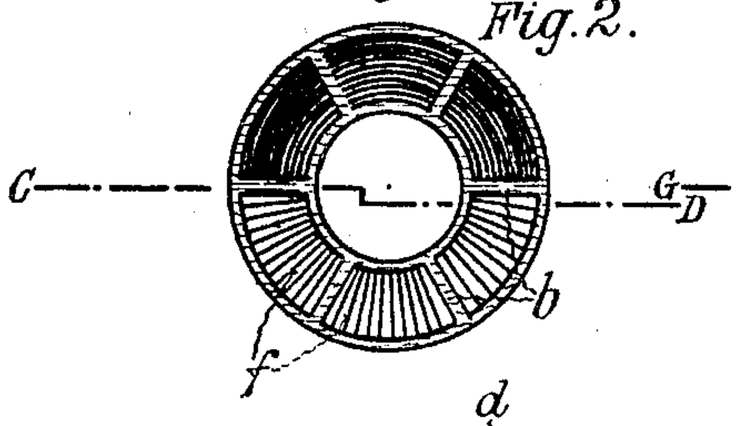

Fig. 4.

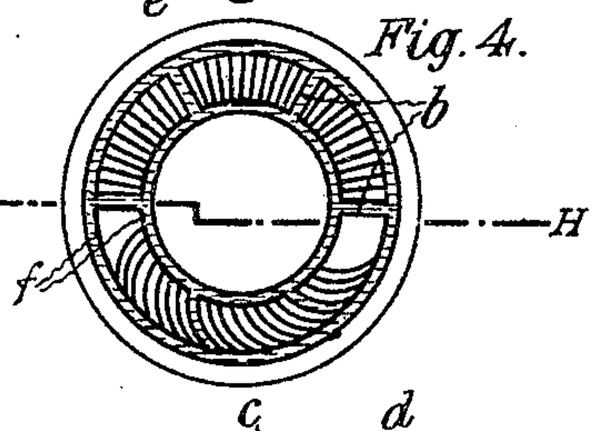

Fig. 5.

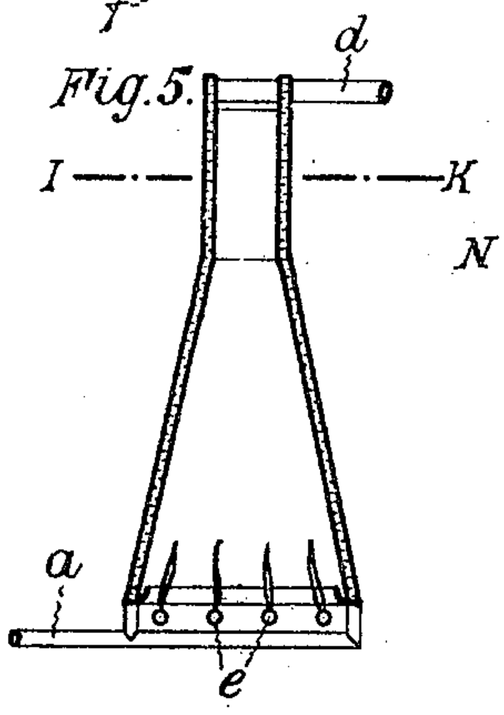

Fig. 7.

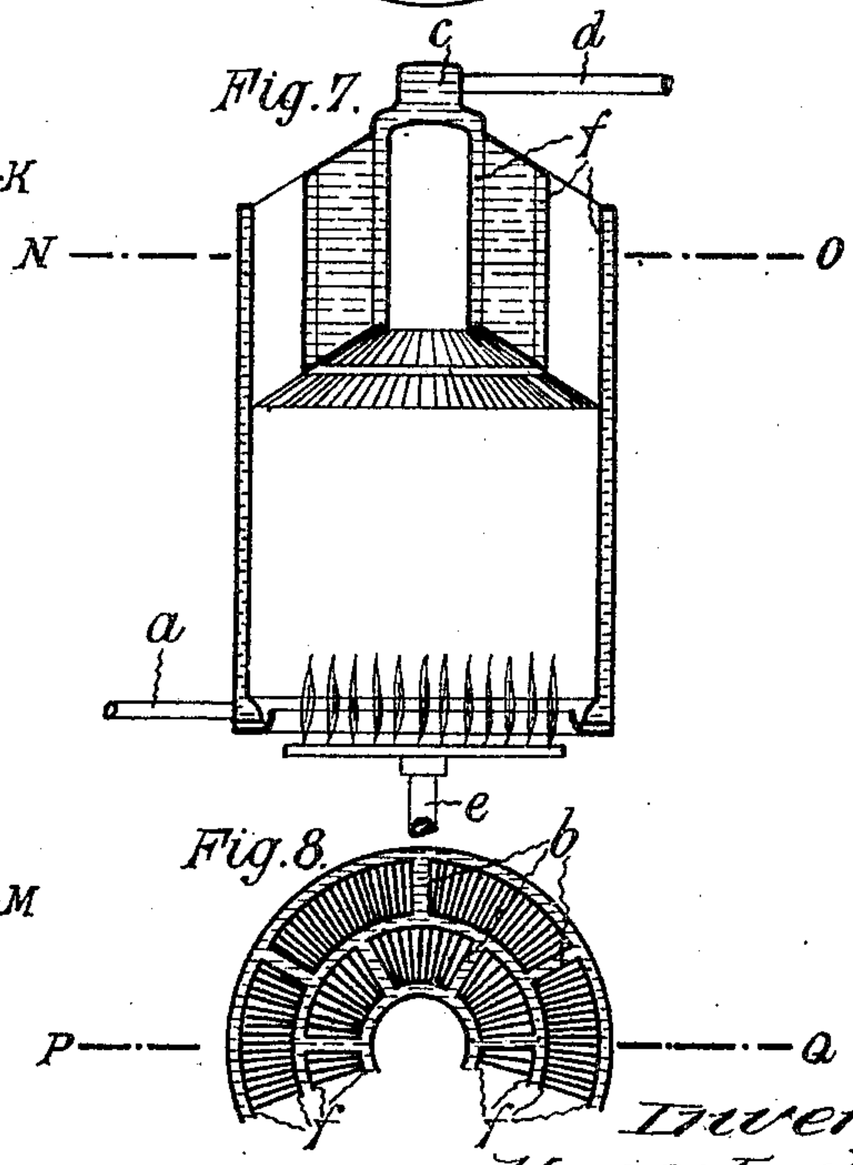

Fig. 6.

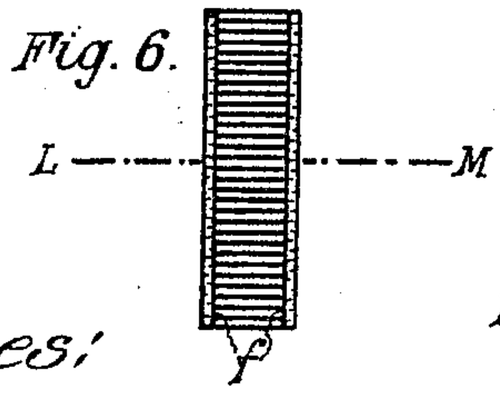

Fig. 8.

Witnesses:

F. B. Keefe

F. R. Ernest.

Inventor

Hugo Junkers

By James L. Norris.

Atty.

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2 SHEETS—SHEET 2.

Fig. 9.

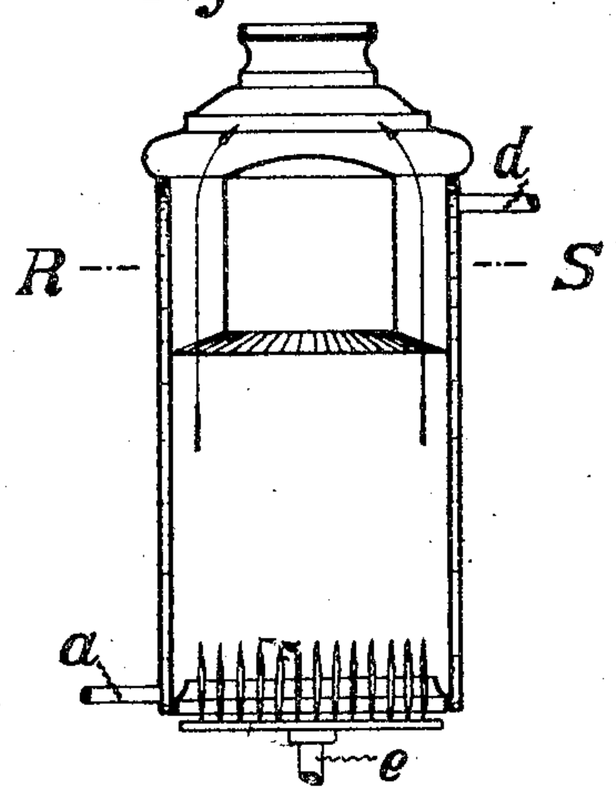

Fig. 11.

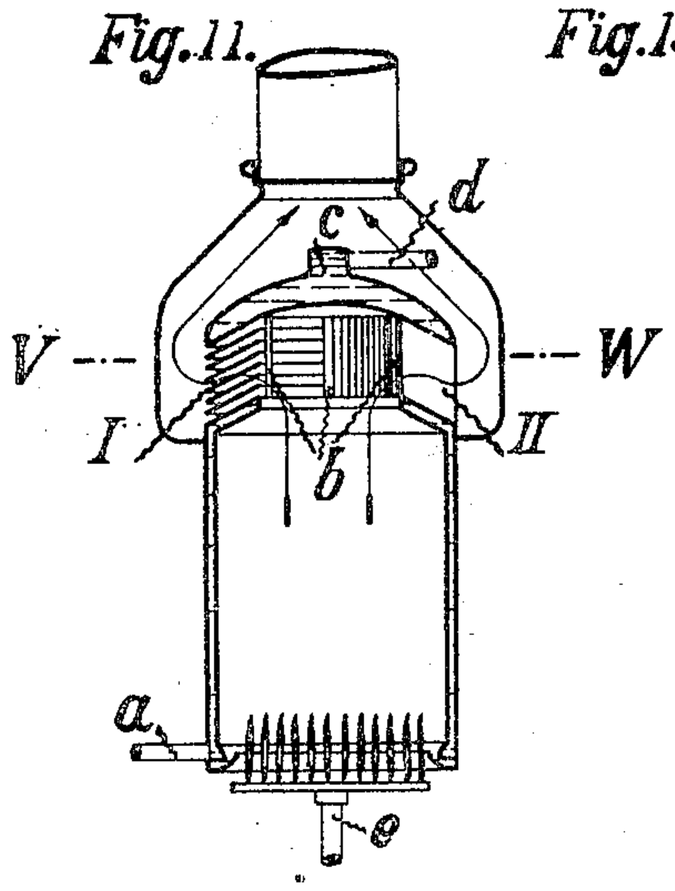

Fig. 19.

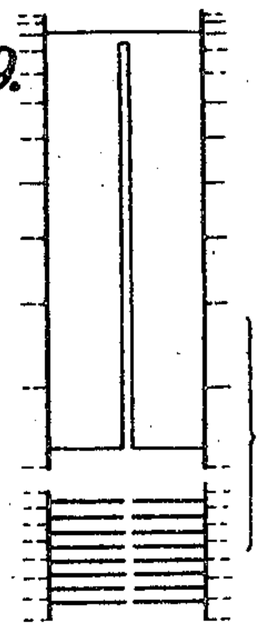

Fig. 20.

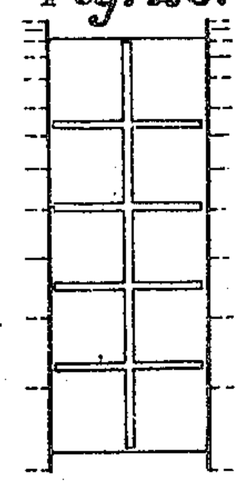

Fig. 10.

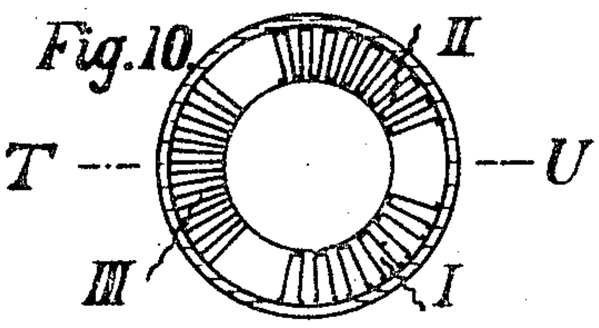

Fig. 12.

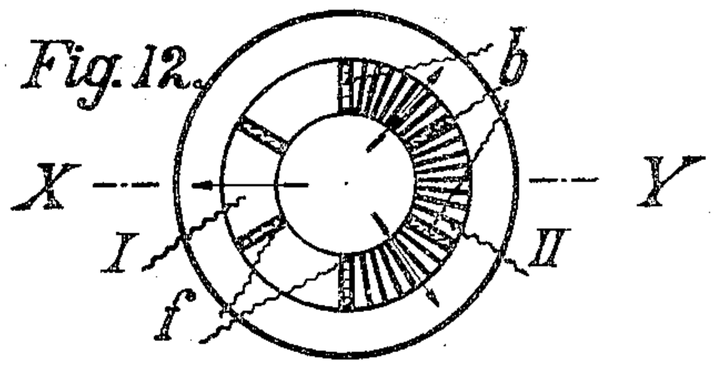

Fig. 21.

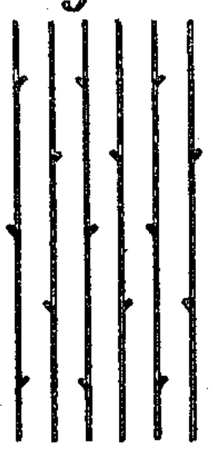

Fig. 13.

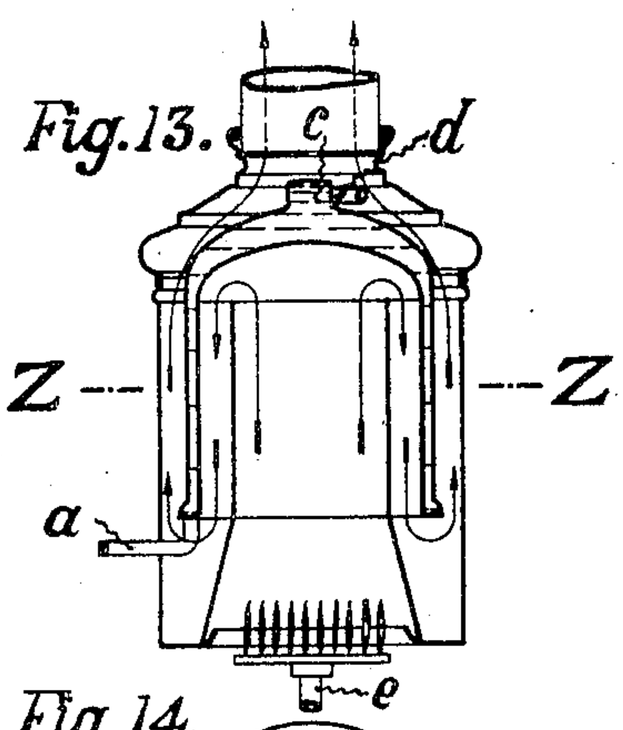

Fig. 17.

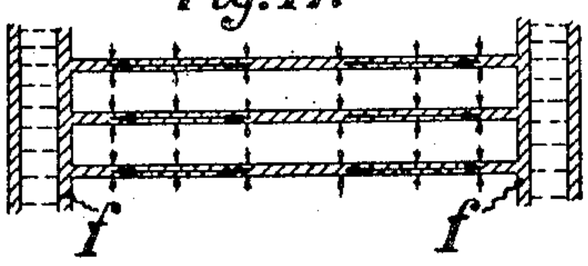

Fig. 18.

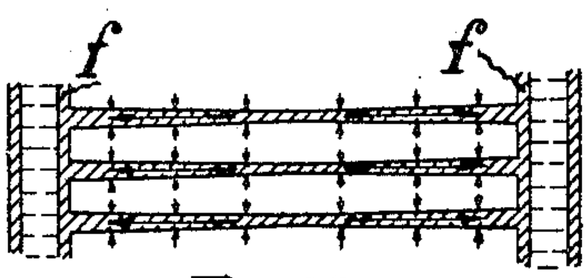

Fig. 22.

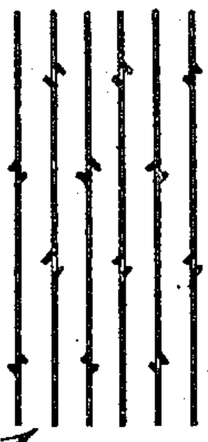

Fig. 14.

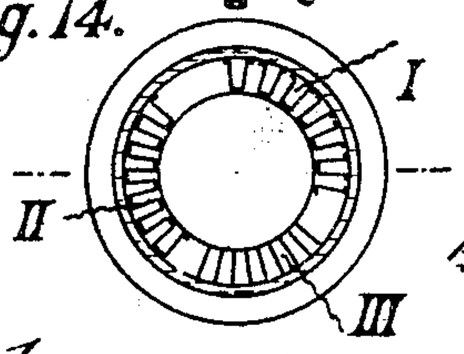

Fig. 15.

Fig. 16.

Witnesses:

James L. Norris, Jr.

C. D. Kesler

Inventor

Hugo Junkers

by James L. Norris, Atty.

UNITED STATES PATENT OFFICE.

HUGO JUNKERS, OF AACHEN, GERMANY.

APPARATUS FOR HEATING LIQUIDS.

No. 797,960. Specification of Letters Patent. Patented Aug. 22, 1905.

Application filed July 17, 1902. Serial No. 115,998.

To all whom it may concern:

Be it known that I, HUGO JUNKERS, a subject of the German Emperor, residing at Aachen, Germany, have invented certain new and useful Improvements in Apparatus for Heating Liquids, of which the following is a specification.

This invention has for its object to improve the interchange of heat between gaseous and liquid heat-carriers—for example, heating gas and water—by causing the heating-gas to give up its heat through metal plates which divide the cross-section of the passage for the heating-gas into thin layers which give up the heat well and as completely as possible. The heating-gases on their part are compelled to pass through the whole of the cross-section of their flue or passage, which is divided into thin layers by the plates. They thus give up the heat to the metal plates, which conduct the heat on both sides to the shells or walls of the water-space of the apparatus, from which it is given up to the water. This new arrangement is based on the known experimental fact that the transfer of heat from gaseous substances to metal is much worse than that from metal to liquids—for example, water—and, further, that gaseous substances give up their heat better accordingly as the layers of heating-gas are thinner. From this it follows that for the taking up of any given amount of heat from heating-gases a very much larger heating-surface is preferably arranged than for the giving up of the same amount of heat from a heating-surface to a liquid. The metal-plate heating-surface arranged in the cross-section of the flue or passage for the heating-gas fulfils this requirement in every case. The metal plates act on both sides, since they take up the heat on both surfaces. The heating-surface is therefore inexpensive. They, moreover, divide the whole cross-section of the flue for the heating-gas into passages in the form of thin layers, these passages being preferably of equal or approximately equal length and width. The heating-gases therefore give up their heat very completely.

In the accompanying drawings a number of examples of heating apparatus of this kind are shown.

Figure 1 is a vertical section on the line C D, Fig. 2, and Fig. 2 a horizontal section on the line A B, Fig. 1. Fig. 3 is a vertical section on the line G H, Fig. 4, and Fig. 4 a horizontal section on the line E F, Fig. 3. Fig. 5 is a vertical section on the line L M, Fig. 6, and Fig. 6 a horizontal section on the line I K, Fig. 5. Fig. 7 is a vertical section on the line P Q, Fig. 8, and Fig. 8 is a horizontal section on the line N O, Fig. 7. Figs. 9 and 10 show a modification in vertical central section and cross-section, respectively. Fig. 11 is a vertical section on the line X Y, Fig. 12, and Fig. 12 a horizontal section on the line V W, Fig. 11. Fig. 13 is a vertical central section, and Fig. 14 a horizontal section on the line Z Z, Fig. 13. The above pairs of figures respectively show various forms of my improved apparatus. Figs. 15, 16, 17, and 18 are horizontal sections illustrating further modified forms of my improved apparatus. Figs. 19 to 22 show various forms of heat-conducting plates.

In the arrangements shown in Figs. 1, 2, 3, 4, 7, 8, 9, 10, 11, and 12 the water enters the cylindrical casing at *a* and passes through suitably-divided chambers *b* into the draw-off chamber *c* and leaves this through the pipe *d*. In Figs. 5, 6, 13, and 14 the chambers *b* are omitted, since no special draw-off chamber is provided. In Figs. 7 and 8, by way of example, two systems of plate-heating bodies are arranged concentrically to each other. The heating takes place, for example, by means of gas in the burner *e*. The heating-gases are drawn by the draft through the heater, which is divided by the metal plates into thin passages, and give up their heat to the two surfaces of the plates. The plates themselves conduct the heat toward both ends, in a direction at right angles to the current of heating-gas, to the walls *f*, limiting the water-space, and these walls finally give up the heat to the water. The plates can be flat, see Figs. 2 (I), 3, 4 (I), 5, 6, 7, 8, 11 (II), 12 (II); suitably curved, for example, cylindrically, see Figs. 1, 2 (II), 9, 10; conical, see Figs. 11 (I) and 12 (I); involute-shaped, Fig. 4 (II); and also of such form that they are connected at both ends to the same layer of water, see Figs. 13, 14 (I, II, III), 15, and 16. The division of the cross-section of the heating-gas flue by plates which are curved in involute-shaped lines has the object of making the several layers of equal width at every place. The construction shown in Fig. 16 is obtained from that shown in Fig. 15 by making the intermediate spaces *x* equal to zero. The position of the plates can be horizontal,

vertical, or inclined at any desired angle. The form of the plates can be varied in two directions: First, in the direction of the current of heating-gas. In the heater, by reason of the giving up of the heat of the heating-gases to the metal-plates, a continuous decrease takes place in the temperature of the said gases. Accordingly, the difference of temperatures between the heating-gases and the liquid also decreases. Account can be taken of this circumstance by altering the thickness of the plates continuously or in stages. Thus the plates can extend throughout the whole length of the current of heating-gas, or they can be divided into two or more sections in the direction of the current of heating-gas, in which arrangement the plates of one section are entirely independent in length, thickness of wall, form, and distance apart from each other of the plates of the other sections, as may appear desirable in view of the production of draft and advantageous construction. Second, it may be advantageous to vary the thickness of the plates in the direction of the current or flow of heat at right angles to the current or flow of the heating-gas. This may be explained as follows: The reception of heat at the plates takes place on both sides over the whole surface. The flowing away of the heat in the plates themselves takes place from the middle toward both ends. With a given fall of temperature between the middle of the plate and the liquid-wall the amount of metal used is the smallest when the thickness of the plate increases from the middle toward the walls of the vessel, Figs. 17 and 18. Finally, the current of heating-gas can be conducted through the apparatus in such a manner that it rises in the spaces *x*, Fig. 15, and descends in the spaces *y*, so that the plates are acted upon on one side by the hottest and on the other side by the cooler gases.

Experience has shown that in the heating by the hot gases of the plates connected at the two long sides to the walls cooled by the liquid the said plates expand longitudinally and transversely. The temperature of the plates is highest at the place where the hot gases enter and decreases from there both in the direction of the length of the plate and also toward both sides from the middle line. Accordingly, the transverse expansion is the greatest at the inlet of the heating-gases and the longitudinal expansion the greatest in the middle line. The expansion caused by the heating of the plates can act injuriously in two directions, according to the magnitude of the difference of temperatures: First, by the expansion in the direction of the breadth of the plates either the walls inclosing the liquid are pressed in or in the event of the said walls not being capable of yielding the plates must assume an undulating form. With intermittent working leakage is liable to be caused by this expansion. Second, by the expansion of the plates in a longitudinal direction a shearing stress is liable to be set up in the contact-surfaces between the hot plates and the cool walls inclosing the liquid in such a manner that the metallic connection between the two parts is broken and the plates are torn away from the said walls. Simple means have already been given above for rendering harmless the thermal expansion. They consist in curving the plates in the direction of their breadth, so that they can yield elastically, and in arranging a number of systems of short plates behind each other in the longitudinal direction, so that the longitudinal expansion can cause no appreciable harm. The thermal expansion can also be rendered harmless by suitably-arranged cuts or slits. In order to render harmless the expansion of the plates in the direction of their breadth, they can be cut or slit from the inlet of the hot gases, as in Fig. 19. In order to render harmless the expansion of the plates in the longitudinal direction, the plates can be also slit transversely to this direction of expansion, as in Fig. 20, so that the plates themselves may consist of comb-like plates having a greater or less number of slits, the separate parts of which can yield freely to the thermal expansion and not endanger the metallic connection of the plates with the walls inclosing the water. The distribution, the length, and the thickness of these plates are preferably made similar to the unslit plates. The transverse slits of the slit metal plates can also be provided with one deflecting edge, Fig. 21, or with two deflecting edges, Fig. 22, so that the heating-gases passing through are thrown into eddies.

What I claim is—

1. An apparatus for heating liquids, comprising shells or walls in contact on one side with the liquid and on the other side with the heating-gases, and metal plates connected at both ends to the sides of said shells or walls in contact with the heating-gases, said plates increasing in thickness from the middle toward their ends, and being arranged at short distances apart, substantially as, and for the purposes, specified.

2. An apparatus for heating liquids, comprising shells or walls in contact on one side with the liquid and on the other side with the heating-gases, and independent groups of metal plates, which plates are connected to the sides of the said shells or walls in contact with the heating-gases and are arranged at short distances apart, substantially as, and for the purposes, hereinbefore described.

3. An apparatus for heating liquids, comprising shells or walls in contact on one side with the liquid and on the other side with the heating-gases, and metal plates provided with slits and connected to the sides of said shells

or walls in contact with the heating-gases, said plates being arranged at short distances apart, substantially as described.

4. An apparatus for heating liquids, comprising shells or walls in contact on one side with the liquid and on the other side with the heating-gases, and metal plates connected to the sides of said shells or walls in contact with the heating-gases, said plates being provided with slits having laterally-turned edges, substantially as, and for the purpose, hereinbefore described.

5. A liquid-heater, consisting of hollow walls which are in contact on one side with the liquid and on the other with the heating-gases and in which the heating-surfaces are formed exclusively of metal plates which, arranged close together, divide the whole cross-section of the heating-gases into thin layers through which the heating-gases must pass uniformly, while the plates take up the heat on both surfaces and give it up to the walls of the vessel and to the liquid, respectively.

6. A liquid-heater, consisting of hollow walls which are in contact on one side with the liquid and on the other with the heating-gases and in which the heating-surfaces are formed exclusively of metal plates which, arranged close together, divide the whole cross-section of the heating-gases into thin layers through which the heating-gases must pass uniformly, while the plates take up the heat on both surfaces and give it up to the walls of the vessel and to the liquid, respectively, said plates contacting with the water-cooled walls with one side or edge only.

7. A liquid-heater, consisting of hollow walls which are in contact on one side with the liquid and on the other with the heating-gases and in which the heating-surfaces are formed exclusively of metal plates which, arranged close together, divide the whole cross-section of the heating-gases into thin layers through which the heating-gases must pass uniformly, while the plates take up the heat on both surfaces and give it up to the walls of the vessel and to the liquid, respectively, said plates having their sides contacting with the water-cooled walls.

8. A liquid-heater, consisting of hollow walls which are in contact on one side with the liquid and on the other with the heating-gases and in which the heating-surfaces are formed exclusively of metal plates which, arranged close together, divide the whole cross-section of the heating-gases into thin layers through which the heating-gases must pass uniformly, while the plates take up the heat on both surfaces and give it up to the walls of the vessel and to the liquid, respectively, said plates contacting with the water-cooled walls, and said plates increasing in thickness toward the water-cooled walls.

9. A liquid-heater, consisting of hollow walls which are in contact on one side with the liquid and on the other with the heating-gases and in which the heating-surfaces are formed exclusively of metal plates which, arranged close together, divide the whole cross-section of the heating-gases into thin layers through which the heating-gases must pass uniformly, while the plates take up the heat on both surfaces and give it up to the walls of the vessel and to the liquid, respectively, and said plates curved to form cylindrical or conical surfaces.

10. A liquid-heater, consisting of hollow walls which are in contact on one side with the liquid and on the other with the heating-gases and in which the heating-surfaces are formed exclusively of metal plates which, arranged close together, divide the whole cross-section of the heating-gases into thin layers through which the heating-gases must pass uniformly, while the plates take up the heat on both surfaces and give it up to the walls of the vessel and to the liquid, respectively, and said plates forming independent groups behind each other.

11. A liquid-heater, consisting of hollow walls which are in contact on one side with the liquid and on the other with the heating-gases and in which the heating-surfaces are formed exclusively of metal plates which, arranged close together, divide the whole cross-section of the heating-gases into thin layers through which the heating-gases must pass uniformly, while the plates take up the heat on both surfaces and give it up to the walls of the vessel and to the liquid, respectively, and said plates provided with suitable slits.

12. A liquid-heater consisting of hollow walls which are in contact on one side with the liquid and on the other with the heating-gases and in which the heating-surfaces are formed exclusively of metal plates which, arranged close together, divide the whole cross-section of the heating-gases into thin layers through which the heating-gases must pass uniformly, while the plates take up the heat on both surfaces and give it up to the walls of the vessel and to the liquid, respectively, said plates provided with suitable slits, and having bent edges in the slits.

In testimony whereof I have hereunto set my hand in presence of two subscribing witnesses.

HUGO JUNKERS.

Witnesses:
PETER LIEBER,
WM. ESSENWEIN.