No. 798,964. PATENTED SEPT. 5, 1905.

H. F. HODGES & J. KUEN.

METHOD OF PURIFYING WATER.

APPLICATION FILED MAR. 14, 1902.

5 SHEETS—SHEET 1.

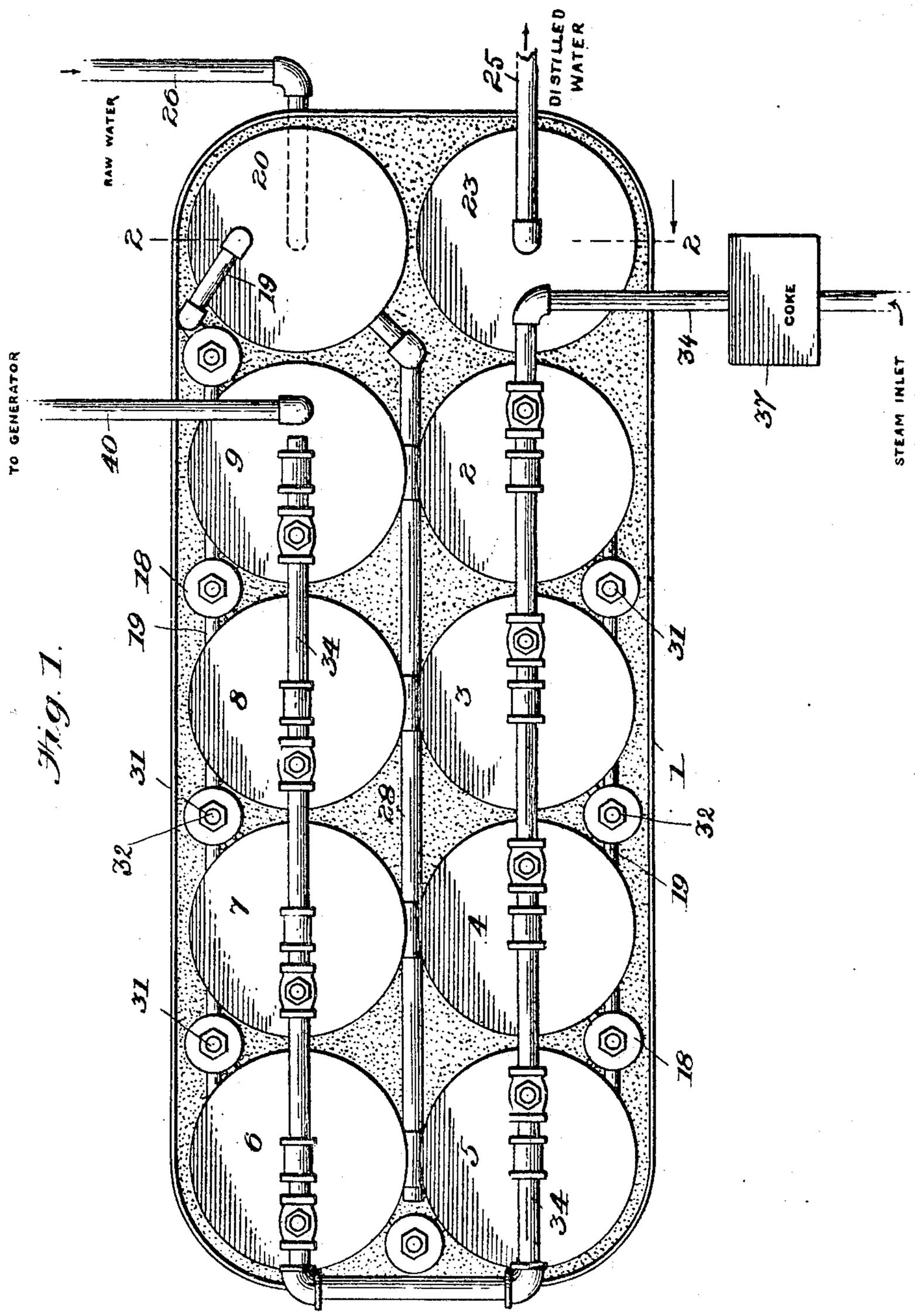

Fig. 1.

Witnesses.

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5 SHEETS—SHEET 2.

Fig. 2.

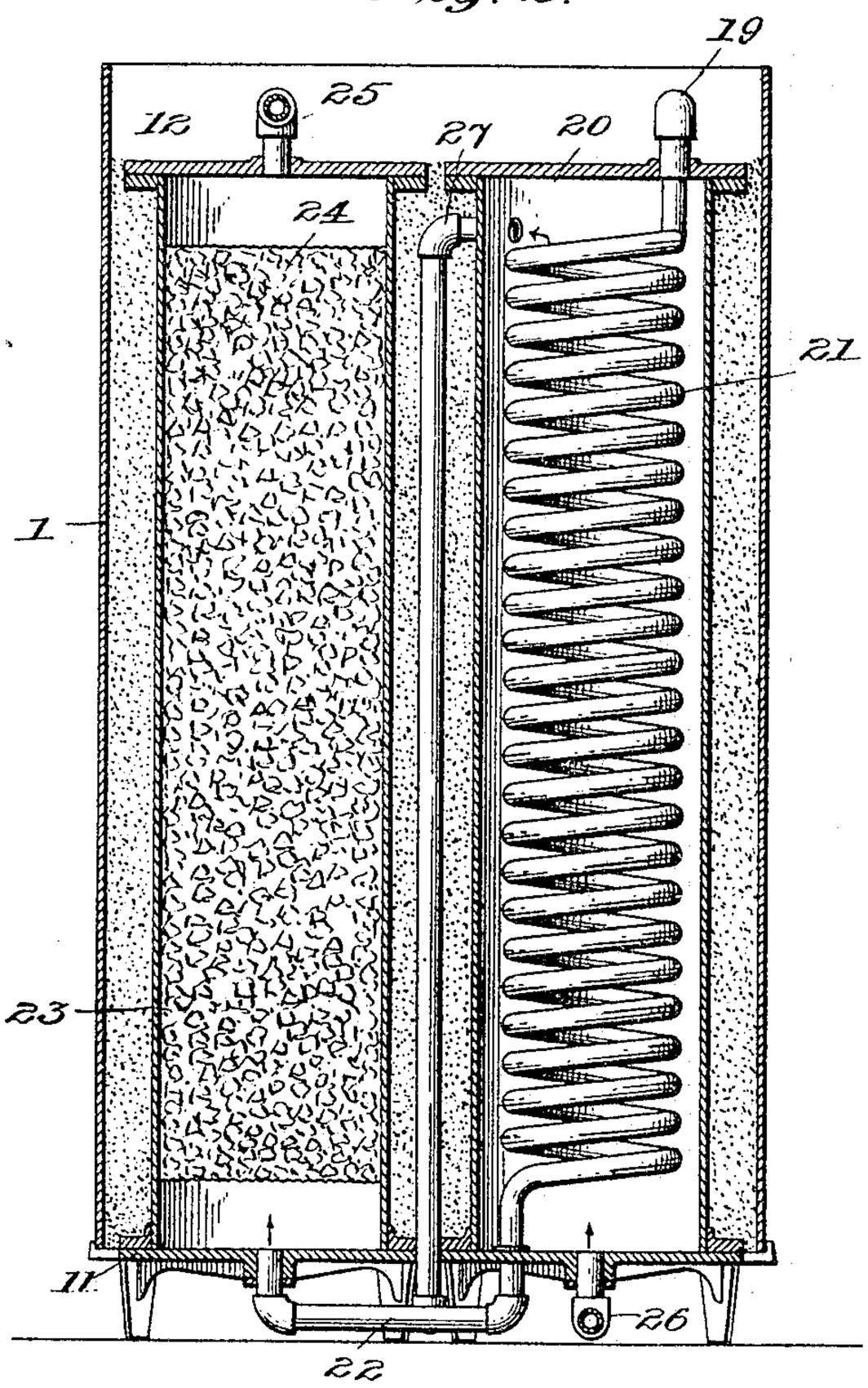


Fig. 6.

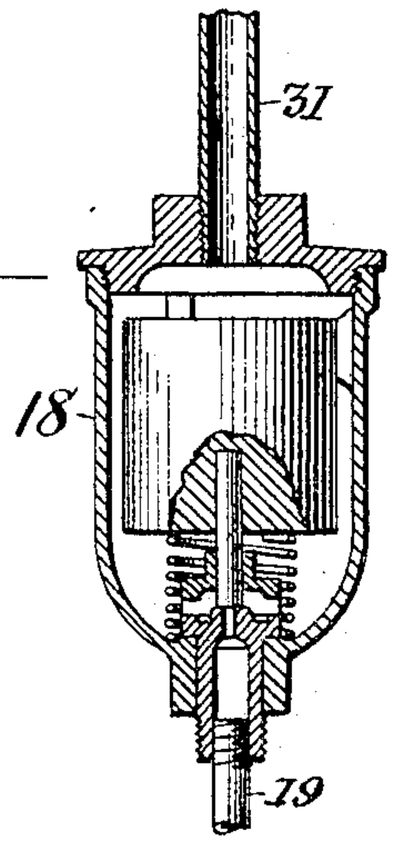
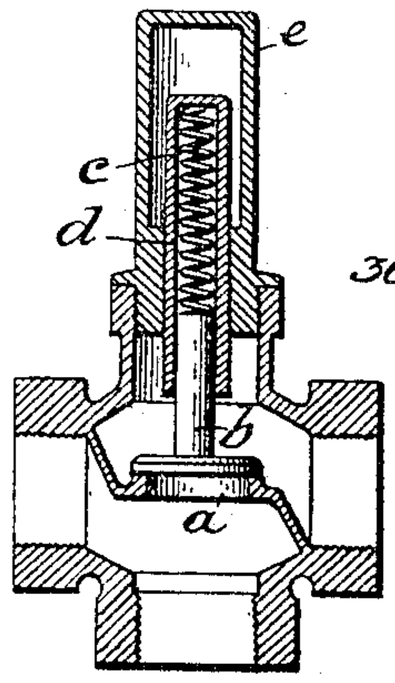


Fig. 5.



Witnesses.

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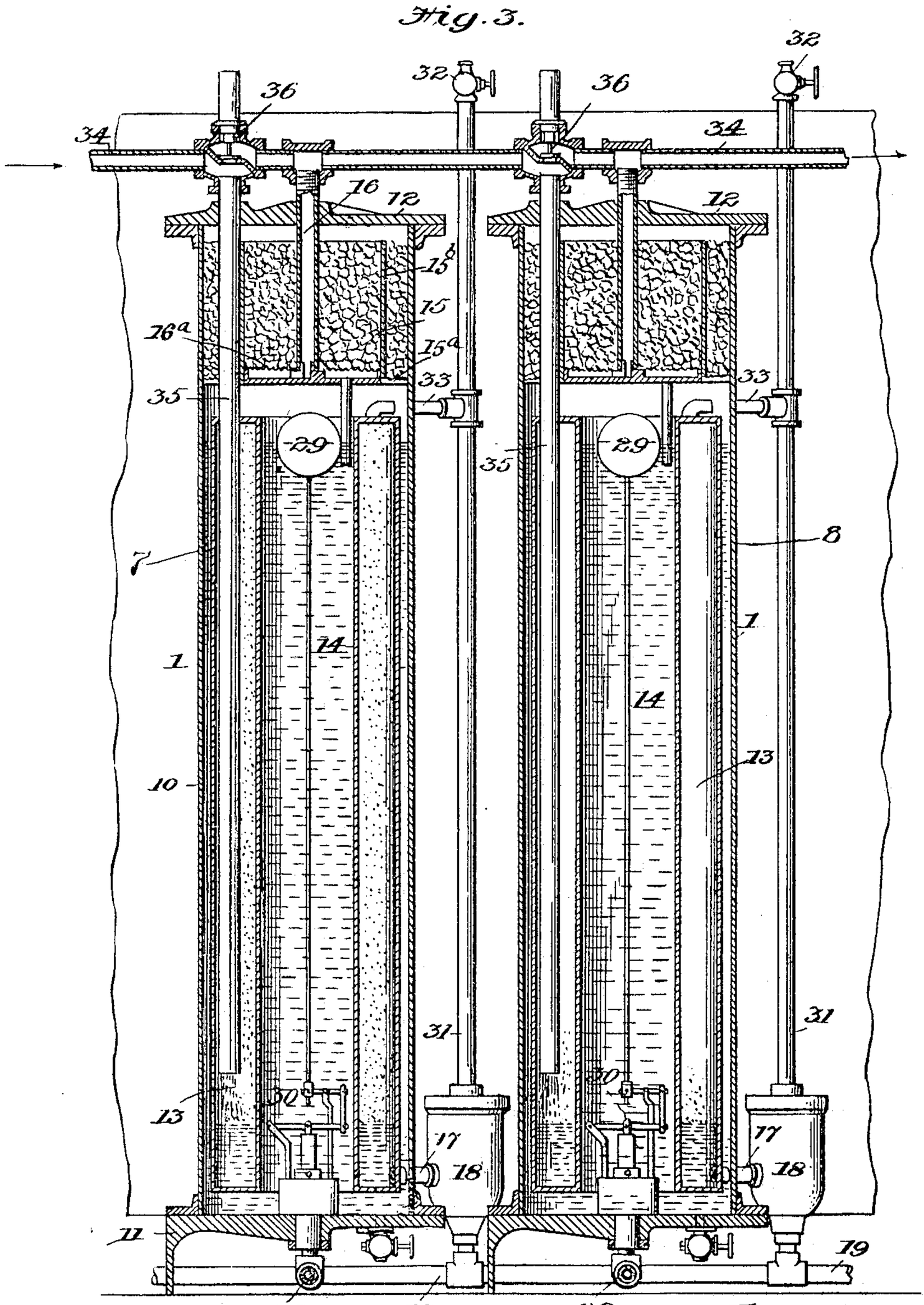
5 SHEETS—SHEET 3.

Fig. 3.



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5 SHEETS—SHEET 4.

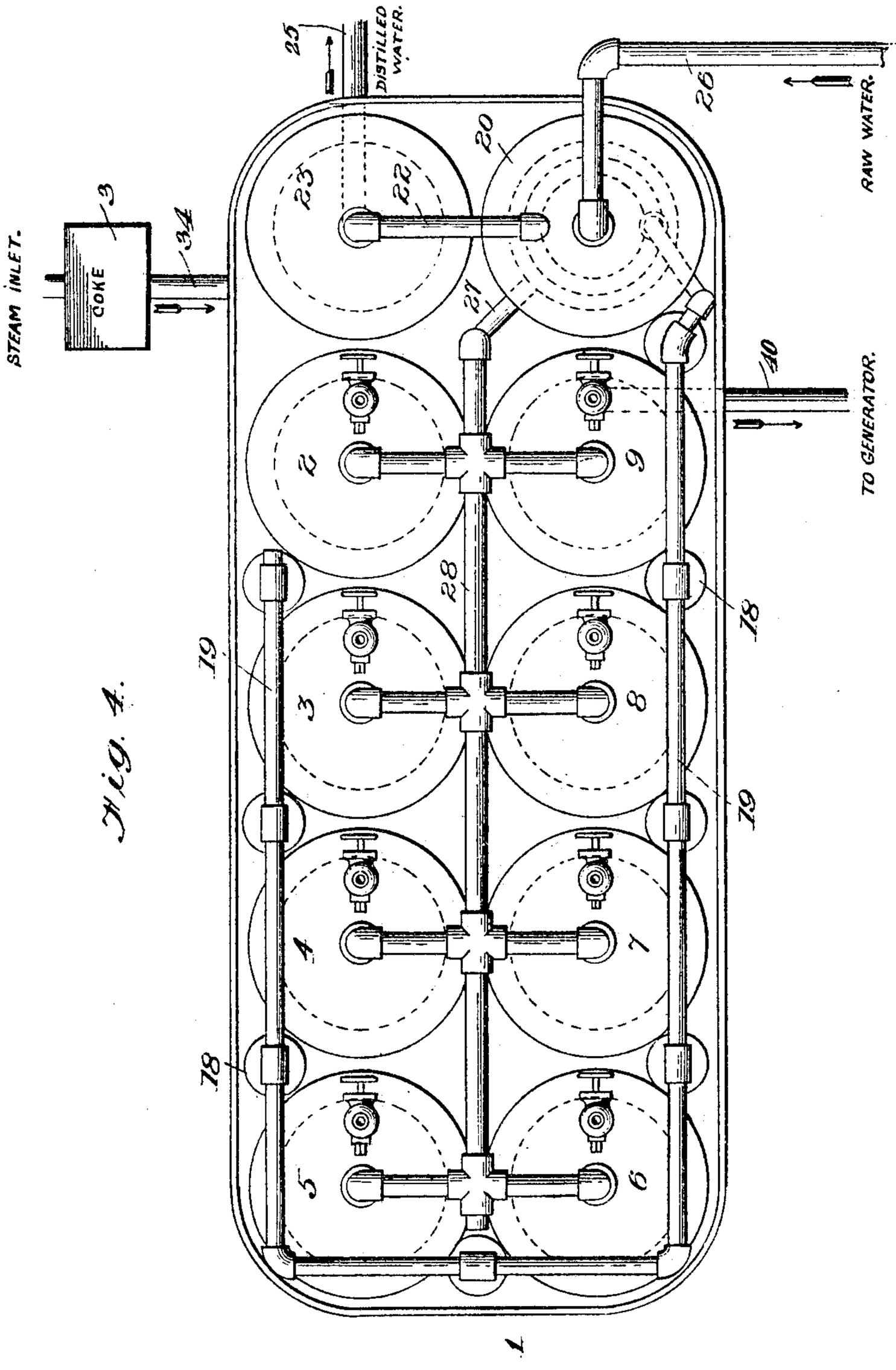

Fig. 4.

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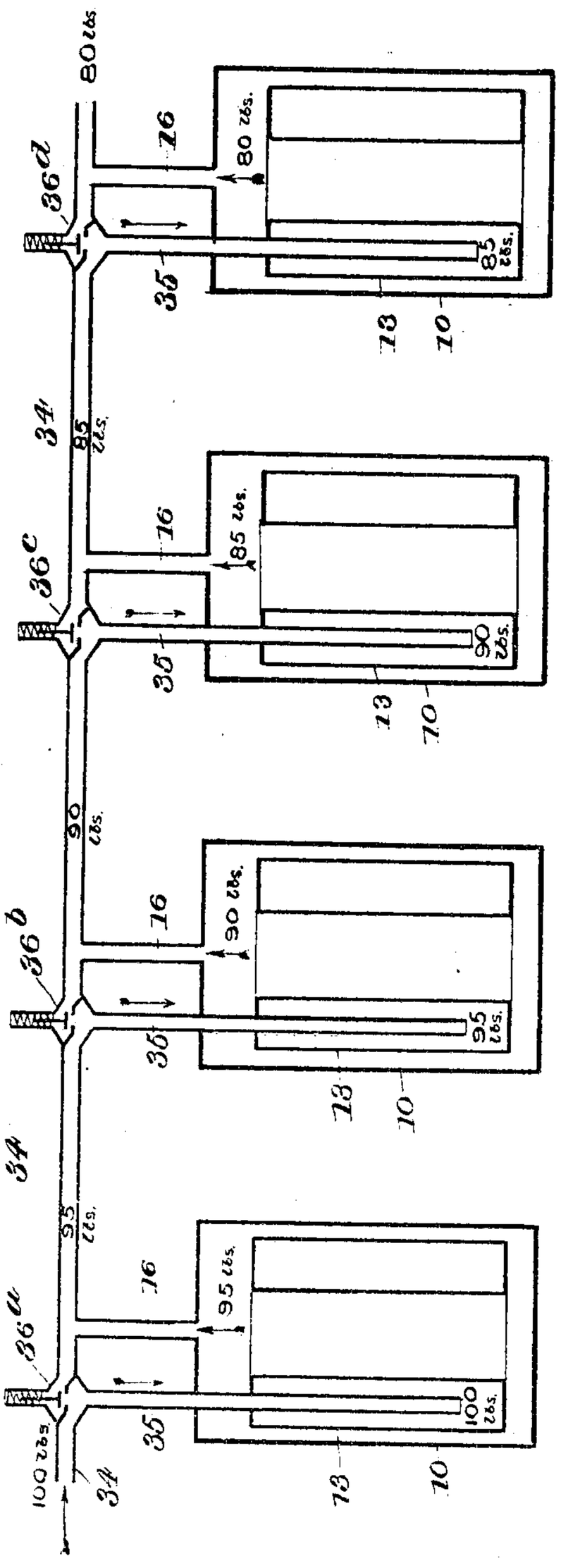
5 SHEETS—SHEET 5.

Fig. 7.

(DIAGRAM)



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METHOD OF PURIFYING WATER.

No. 798,964. Specification of Letters Patent. Patented Sept. 5, 1905.

Application filed March 14, 1902. Serial No. 98,204.

To all whom it may concern:

Be it known that we, HORACE F. HODGES and JOSEPH KUEN, citizens of the United States, and residents of Philadelphia, in the county of Philadelphia and State of Pennsylvania, have invented certain new and useful Improvements in Methods of Purifying Water, of which the following is a full, clear, and exact description, reference being had to the accompanying drawings, forming part of this specification.

This invention has relation to an improved method of purifying water, primarily by distillation, whereby the water is entirely relieved of all impurities, whether of a solid, liquid, or gaseous nature.

Ordinary methods of distillation easily remove mineral or earthy impurities, which do not pass over with the vapor, but are precipitated or remain in the residuum. It is a well-known fact, however, that the ordinary distilled water has a flat or bitter taste, which renders it unpalatable, and we have found through investigation and experiments that this is due to the absorption by the distillate of certain volatile vapors or gases resulting from the destructive distillation of organic and other impurities in the water, and we have also found that if water is distilled in such a manner that these gases are not absorbed from the steam by the distillate then these objectionable flavors will be entirely eliminated from the product.

The main object of this invention is therefore to provide a process of purifying water which will render it absolutely free from all impurities and at the same time give to it its natural sweet taste, thereby rendering it more palatable for table use.

The expense attached to the usual method of purifying water by distillation has been great by reason of the great amount of heat found necessary to carry out the process; and one of the objects of our invention is to very materially reduce the costs of the purified product by utilizing a primary body of heat to evaporate successive bodies of water in such a manner that the consumption of fuel for this purpose is greatly decreased. These results are accomplished by submitting the water or steam to a number of distinct but connected steps forming this process, as follows: First, a portion of the water to be purified is evaporated into steam by any appropriate means and at any temperature and pressure that the succeeding steps of the process may require; second, the resultant steam is caused to pass through a body of porous and insoluble material, such as foundry-coke or similar substance, for the double purpose of removing the entrained water and oil which the steam may contain and for condensing and holding back certain gases formed from the impurities in the water, which only exist as gases at high temperatures; third, the steam is condensed in such a manner that its gases are allowed to escape from the condensing-chamber, while the surface of the distillate is never allowed to become cool to such an extent as would allow of said distillate reabsorbing such gases; fourth, passing this distillate at the appropriate temperature through a body of charcoal, whereby any gases which might have entered the said distillate may be absorbed and removed.

In order to utilize the heat employed in carrying out our process to its fullest extent, we employ what is known as the "multiple-effect method"—that is to say, we surround a condensing-chamber with a body of water in an inclosing casing, such water preferably entering at the bottom of said inclosing chamber and said chamber being insulated as perfectly as possible to prevent the escape of heat therefrom. The heat of the steam in the inner or condensing chamber will pass through its wall and enter the surrounding water at a rate depending on the differences in temperature between the said water and steam until the water evaporates and forms a second body of steam at a pressure and temperature slightly below that of the first body of steam, which latter will be condensed into water again. This second body of steam is then led into a second apparatus similar in most respects to that just described and evaporates water therein at a further slight reduction in pressure, is itself condensed, while the resultant steam will enter a third apparatus of similar construction, and so on until the pressure of the resultant steam can be no further reduced, when the last body of water will simply be heated to near its boiling-point, but not evaporated, which water is then forced into the primary steam-generator

and the subgenerators of the series, thus utilizing its heat in the initial step of this process. From the above it will be seen that a certain loss of heat must here result from radiation, which will be the total loss of heat to be supplied in the first instance, and that the more perfectly heat is prevented from escaping from the apparatus used the more economical will be the result. Heat flows between two bodies directly in proportion to the difference in temperatures. Therefore in order that heat may flow from the steam in the condenser to the raw water surrounding it, such difference of temperature must be maintained; but owing to the small amount of heat required to increase the temperature of steam a small amount of radiation from the walls of the vessel containing it causes a rapid fall in said temperature. In our method of using heat repeatedly it is very desirable that an excessive fall of temperature should not take place, because thereby the number of possible multiplied effects would be lessened. It is our object to maintain a positively-fixed difference of temperature between each condenser and its surrounding water-chamber. This is accomplished by providing a steam-main connected with the primary generator and common to all of the working cells of the apparatus having two connections to each cell, the first of which enters the condenser, the second entering the water-space surrounding said condenser and forming the evaporator. Between the two connections to each cell is provided an automatic valve adapted to be opened by the pressure of the steam having access to the first of said connections and in which the pressure requisite to open said valve can be varied or regulated at will. It will be observed that the pressure existing in the main beyond the said valve will be less than the first-named pressure by the amount necessary to open said valve, and should this pressure fall below said amount the valve will open and admit steam to maintain such secondary pressure. The pressure in the water-chamber will correspond to the said secondary pressure by reason of its connection with the main, thus establishing the required difference of temperature between the condenser and its surrounding water-chamber. By varying the resistance of the valve the said difference in temperature is also varied. In a like manner the steam from the main pipe and first water-chamber once reduced is admitted to the condenser of the second cell and is there condensed, the heat of which evaporates a second body of water in the second cell into steam, which steam passes to the condenser of the third cell. The automatic valve of the second cell serves to maintain a fixed relation of pressure in the second cell between the condenser and water-chamber by again automatically admitting steam from the primary generator, and this process is repeated to the end of the series.

The apparatus for carrying out our improved method is illustrated in the accompanying drawings, in which—

Figure 1 is a top plan illustrating a number of cells in multiple effect. Fig. 2 is a vertical section taken on the line 2 2 of Fig. 1. Fig. 3 is an enlarged sectional view taken through two consecutive cells and numerals 7 and 8 of the series. Fig. 4 is a bottom plan view of the apparatus. Fig. 5 is a detail section of one of the automatic reinforcing-valves. Fig. 6 is a sectional view of the float-valve controlling the outflow of the distillate, and Fig. 7 is a diagrammatic illustration of that portion of my process relating to the automatic maintenance of a constant difference in pressure between the condensers and evaporators.

Referring by characters to the said drawings, 1 designates an outer casing protected from outside radiation by an appropriate insulating material within which the apparatus is inclosed. Located within this casing in close proximity to each other are a plurality of subgenerators 2, 3, 4, 5, 6, 7, 8, and 9, each of which consists of an outer cylindrical casing 10, mounted on a suitable base 11 and having a suitable top or covering, as 12. In each of the cells 10 is provided the cylindrical condenser 13, (see Fig. 3,) closed at its top and bottom and having a central passage 14, which with the outer casing forms a water-chamber. The upper end of the condenser stops a suitable distance from the top of the outer cell, and in this space is provided a coke-receptacle 15, which has a pipe 16 opening into its lower portion, the upper end of said pipe being connected with a steam-pipe 34, running from the primary generator, (not shown,) the said steam-main being connected to all of the cells of the series, as will be hereinafter described. The lower portion of the condenser 13 extends to within a short distance of the bottom 11 of the cell and is connected, by means of a pipe 17, with an external casing 18, containing a suitable float-valve, (see Fig. 6,) which is adapted to open when the distillate in the condenser reaches a certain height and remains open until the said distillate falls below a fixed water-level. These valves in the casing 18 are in communication with a pipe 19, which is common to all of the cells of the series. This pipe 19 starts from the valve of the first cell 2 (see Fig. 4) of the series and after communicating with each of said valves is directed into the upper end of a cell 20, Fig. 2, where it communicates with a coil 21, provided in said cell. The lower end of this coil is connected with a pipe 22, which communicates with an adjacent cell 23, containing wood-charcoal, as illustrated at 24, so that the distillate after passing from the condensers in each of the cells is carried through the coil 21, which serves as a cooler, and through the purifying material 24 in the cell

23 and is conducted through the pipe 25 to any suitable point. The raw water is admitted through the pipe 26 to the coil-cell 20 and passes upwardly around the outside of said coil, thus serving to cool the distillate passing through the coil, and escapes through a pipe 27, Figs. 2 and 4, to a pipe 28, Figs. 1 and 4, which communicates with the water-chambers of all the condensing-cells of the series. The raw water is thus admitted to each of the cells from the bottom thereof and fills the water-chamber surrounding the condensers, the admittance of this water being regulated by the float 29, Fig. 3, which actuates a valve 30, formed at the water-entrance in the bottom of each cell. The valve-casing 18 is provided with a pipe 31, extending above the top of the cells and having provided in its upper end a vent-cock 32. A branch pipe 33 connects the upper end of the condensing-chambers 13 with the pipe 31 for the purpose of allowing the gases which collect in the top of the condenser to escape through the cock 32. Located above the cells is a steam-main 34, which starts from the primary generator and has a connection by means of pipes 35 with the condensers in each of the cells. The pipe 16, which opens into the lower portion of the coke-chamber 15, is connected at its upper end with the steam-main 34 a short distance beyond the connection of the pipe 35. A pressure-valve 36 is provided between these two connections, which is adjusted so as to open automatically for the purpose of reinforcing the volume and temperature of the steam in the water chamber and pipe 16 as it passes to the next cell of the series, so that the heat lost by unavoidable radiation may be compensated for. This automatic valve (see Fig. 5) comprises a seat *a* and a valve with stem *b*. A tubular housing *d* contains a spiral spring *c*, that presses down upon the valve, and this housing is adjustably inclosed within a screw-cap *e*, so that by turning *d* within *e* the tension of the spring may be varied. The initial steam coming from the primary generator passes through a coke-chamber 37 (illustrated in Fig. 1) before it is admitted into the first cell of the series.

In operation (see Figs. 1 and 3) the steam is admitted from the primary generator through the medium of the pipe 34 to the pipe 35, which extends into the generator 13 of the first cell of the series to a point a short distance above the bottom of the said condenser. In the meantime water has been admitted into the cells from the bottom thereof, and the water-chamber surrounding the condensers is filled to the proper height, when its inflow will be cut off by the float-valves 29 30. The heat from the condenser 13 coming in thermal contact with the water in the surrounding water-chamber gradually heats said water until it evaporates into steam of a pressure slightly less than that in the condenser 13. This flow of heat causes the steam in the condenser to condense into water, and the distillate thus formed accumulates in the bottom of said condenser and passes off through the medium of the pipe 17 and the automatic valve in casing 18 to the pipe 19, which is common to all of the condensers and through which it is conveyed to the cooling-cell and thence to the charcoal-cell, after which it is ready for use. The surface of the distilled water in the bottom of condenser 13 is close to the outlet end of the steam-inlet pipe 35, and this surface is thus always maintained very hot, so that it has a repellent action on the gases mingled with the steam, which are thus prevented from being absorbed by the distillate. As the outlet-pipe 17 is below the surface-level of the distillate, the hottest surface layer is always maintained. The second body of steam which has been generated in the upper portion of the water-chamber 10 passes through opening 15^a and over partition 15^b through the coke in the chamber 15, where any entrained water and certain gases therein are eliminated, and thence it passes through screen 16^a and up the pipe 16 to the main 34 and pipe 35 of the next cell to the condenser 13 of that cell, where the said steam is condensed and generates a third body of steam from the surrounding water. This last body of steam passes in a like manner to the next succeeding cell and the process gradually extends through each cell of the series until it reaches the last cell 9. This last-produced steam may have been so reduced in pressure and temperature as to be insufficient to evaporate its surrounding body of water, but will serve to heat said water to a high temperature, and this water is conveyed through the medium of a pipe 40 to the primary generator, so that the heat contained therein can be utilized in said primary generator.

One important feature of our process consists in maintaining automatically a constant difference between the downwardly-stepped temperatures and pressure between the condenser and evaporator of each cell. This is accomplished by correcting any accidental variation from this difference by the automatic introduction to each evaporator of a fresh reinforcing body of primary steam at the exact constant of difference in temperature and pressure which it is desired to maintain between the condenser and evaporator of each cell. This will be made clear by reference to the diagram Fig. 7. In this view for simplicity sake only the annular condenser 13 and inclosing evaporator 10 are shown coupled to the steam-supply pipe 34 by pipes 35 and 16 and the several automatic pressure-valves 36^a 36^b 36^c 36^d of the several cells. Now if steam be taken at one hundred pounds and it is desired to have a difference of pressure and tem-

perature of five pounds between the condenser 13 and evaporator 10 of each cell then all the valves 36^a 36^b 36^c 36^d are set to open at a difference of five pounds between the pressures on the opposite sides of each valve. Then in the first cell the pressure will be one hundred pounds in the condenser 13 and ninety-five pounds in the surrounding evaporator 10. In the second cell the pressure will be ninety-five pounds in the condenser and ninety pounds in the surrounding evaporator, and so on throughout the entire series. This permits an almost indefinite extension of the multiple effect if such constant difference can be maintained. It has been found, however, that there are various contingencies which make it impossible to maintain this exact constant of difference without the automatic valve 36. For instance, if, due to the peculiar location and the excessive exposure to external drafts, any one cell is locally affected by loss through external radiation more than the others or there be a leak in the evaporator, then the constant difference in the cells is destroyed and the efficiency of the extended series is lost. Our process provides the automatic reinforcement of any such loss in pressure in any one evaporator by direct accession of primary steam from the pipe 34 at the exact constant of difference which should exist between the condenser and evaporator of each cell. This is done by the automatic pressure-valves 36^a 36^b 36^c 36^d. To illustrate, suppose the second cell should be so placed that its evaporator loses by radiation, leakage, or otherwise ten pounds of its legitimate pressure. It is obvious that an equal effect is produced in all the succeeding cells, with a corresponding loss in efficiency in the series. Now with our process in such case the valve 36^b were it not automatic would have ninety-five pounds on one side and only eighty on the other; but being automatic it opens until the eighty pounds of the evaporator 10 of the second cell is brought up to ninety, or, in other words, there is an automatic or self-adjusting reinforcing of the steam of this evaporator from the primary source through pipe 34 until the exact constant of difference amounting to five pounds is reached, and then the predetermined adjustment of the spring of automatic valve 36^b causes it to close. Not only does this maintain automatically an exact or constant difference of pressure between the condenser and evaporator of each cell, but it permits steam to be drawn off at will from any part of the pipe 34 between the cells without affecting the constant difference, and thus makes available steam for any other useful purpose at a great variety of pressures without affecting the perfect action of this apparatus.

It is obvious that the initial pressure and temperature of the steam and the number of cells may be so selected that the working range of the distilling apparatus and process may be carried on between any limits of pressure and temperature. When the range of temperature and pressures used is high, steam will be generated in the last subgenerator, and this may be utilized in any device such as an engine. In this case the difference in pressure and temperature between the first and last cell will represent the heat utilized in the purifying or distilling process.

By our above-described process it will be seen that we are enabled to utilize the heat employed to its fullest extent and also to economize the amount of fuel used, and consequently greatly reduce the fuel cost of the product, besides giving to the water a pleasant taste and properties and qualities which have not heretofore existed in distilled waters.

It is not essential to this method that the particular form of apparatus herein shown and described should be used, as other forms could undoubtedly be used with equally good results.

Having thus described our invention, what we claim, and desire to secure by Letters Patent, is—

1. In a system of multiple-effect distillation, the method of maintaining a predetermined and constant difference between the downwardly-stepped temperature and pressure between the condenser and evaporator of each cell, which consists in correcting any variation from this constant difference by the automatic introduction to each body of generated steam of successively lower pressure, a fresh reinforcing body of primary steam at a pressure and in quantity sufficient to maintain the constant of the predetermined difference in pressure between the said condensers and evaporators of the cells.

2. The method of distillation, which consists in evaporating water into steam, next conveying said steam to a condensing-chamber in which liquefaction takes place, next causing said steam at its entering temperature to be directly impinged upon the surface of the distillate to maintain its high temperature and consequent repellent action on the gases and then in conducting away the thereby-separated gases from the steam and distillate.

3. The method of distillation, which consists in evaporating water into steam, next conveying said steam to a condensing-chamber and liquefying the same, maintaining a definite level of the liquefied distillate, causing the incoming steam at its entering temperature to directly impinge upon the surface of this distillate to maintain its high temperature and repellent action on the gases, conducting away the thereby-separated gases from the steam and distillate, and conducting away the distillate from a point below its surface level to maintain the hot upper stratum of the same.

4. The method of distillation which consists in evaporating water into steam, next conveying said steam to a condenser-chamber in which liquefaction takes place, next maintaining the high temperature of the distillate by the direct impingement of the hot initial steam thereagainst, next conducting any gases thus rejected from the condensing-chamber, and then conducting said distillate through purifying material.

5. The method of distillation which consists in evaporating water into steam, next conveying the said steam and its gases so liberated through a detergent material whereby certain gases of high temperature are condensed and they with any entrained water are held back, next conveying said steam to a condenser in which liquefaction takes place, next maintaining the surface of the accumulated distillate at a high temperature by the direct impingement of the entering high-temperature steam to prevent the distillate from absorbing any gases which the said steam may contain, and then conducting said gases away from the condensing-chamber.

6. The method of distilling water, consisting in admitting steam under high pressure to thermal but not actual contact with a body of water at a less pressure, causing it to condense and said body of water to evaporate, successively thereafter repeating this last-mentioned act with other bodies of water until the temperature of the last-produced steam is reduced to a desired point, and maintaining automatically by reinforcement with primary steam a positively-fixed difference of temperature between each condensing-chamber and its surrounding water-chamber through all contingent losses of heat.

7. The method of distillation consisting of conducting high-pressure steam into thermal but not actual contact with another body of water at a less pressure, causing it to condense and said body of water to evaporate, successively thereafter repeating this last-mentioned act with other bodies of water until the temperature of the produced steam is reduced to a desired point and automatically compensating for radiation by reinforcing the successive bodies of steam from the primary generator.

8. The herein-described method consisting of passing high-pressure steam into a condenser, submerging said condenser in a body of water by which means the steam is condensed, utilizing the heat radiated from the condenser to evaporate the said water into steam of a less pressure, conducting the steam so generated into an adjacent condenser surrounded by water with like results, repeating this operation in successive cells until the heat radiated from the last condenser is reduced to a desired point, and automatically reinforcing each subgenerator with additional steam for compensating for the heat lost by radiation in the preceding cell, whereby the temperature and volume of the steam are maintained

9. The method of purifying water, consisting in first evaporating the water into steam of high pressure, percolating said steam through coke, or its equivalent, conducting said steam thereafter to thermal contact with another body of water by which means said steam is condensed and the said water evaporated into steam of a lower pressure and density, passing such condensation through a purifying material, successively repeating this operation with other bodies of water until the temperature and pressure of the last-produced steam has become reduced to a desired point and then utilizing said steam for other purposes.

10. The herein-described method consisting of passing steam from a primary generator into a number of subgenerators, condensing the initial steam in each subgenerator and generating new steam therein, conducting this new steam to each succeeding subgenerator with like results as in the first until the last-produced steam is reduced to the desired pressure and temperature, withdrawing the distillate from the various condensers, passing the same through a cooling-cell receiving the incoming raw water, utilizing the heat contained in said distillate to heat the incoming water, and lastly forcing the said distillate through a purifying medium.

11. The method of purifying water which consists in first evaporating water into steam, next conveying said steam through a detergent material, next causing the steam to condense and to evaporate another body of water into steam of less pressure, condensing the new steam in a second condenser with like results as in the first, successively thereafter repeating this operation until the last-produced steam is reduced to the desired pressure and temperature, withdrawing the distillate of each of the condensers, cooling the same, and finally passing such distillate in its cooled condition through a purifying medium.

12. The method of purifying water, which consists in generating steam, condensing the same and causing it to evaporate another body of water, conducting away the gases during condensation of the first steam, then passing the newly-evaporated steam through a detergent material, then causing it to evaporate another body of water, and then cooling the distillate and passing the same through charcoal.

13. In a water-purifying process, the step of maintaining a constant difference of pressure and temperature between the outer and inner sides of a steam-condenser, jacketed with water, which consists in automatically admitting steam from a primary source to said water-jacket.

14. In a water-purifying process, the method of economizing steam which consists in caus-

ing primary steam to evaporate a body of water into secondary steam, automatically introducing into this secondary steam a reinforcing body of primary steam and maintaining an available temperature and pressure of the resulting commingled steam for other purposes.

In witness whereof we have hereunto set our hands this 10th day of March, A. D. 1902.

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