Improvements in treating, purifying, and sterilizing water or contaminated liquids, and an apparatus therefor / [William Lawrence].

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PROVISIONAL SPECIFICATION.

Improvements in Treating, Purifying, and Sterilizing Water or Contaminated Liquids, and in Apparatus therefor.

I WILLIAM LAWRENCE of 20 Brackley Terrace, Chiswick in the County of Middlesex, Civil and Mechanical Engineer do hereby declare the nature of this invention to be as follows :—

This invention relates to the treating of water or contaminated liquids in such a manner as to remove their objectionable qualities by processes of softening, sterilizing, filtering or depositing.

One of the principal features of this invention is the purifying and softening of water by means of heat so applied that the salts of lime and other matters may be thrown out of solution, or precipitated and caused to aggregate and separate from the water.

Another feature is the preventation of encrustation, upon heating surfaces, of precipitated sedimentary matter by mechanical means, or by setting up galvanic action.

Another feature is the filtering or screening out sedimentary matter from the water.

With regard to the first feature of this invention I have observed that when a liquid is heated in a vessel in the ordinary way, a circulating action is set up and the heated portions rise toward the surface while the parts not heated descend. In this way the whole of the liquid in the vessel is maintained at, practically, a uniform temperature, and only something approaching the boiling temperature is arrived at or reached. In other words the temperature of the liquid does not increase in proportion to its columnar pressure and the descending portions of the liquid abstract the heat from those that are ascending, causing a re-absorption of the gases and vapours that are, for the moment, dispelled.

Again, I have observed that when crude water is heated by stages, gases contained in it pass off in regular order as the temperature increases; those gases that have the least solubility in the water or affinity for substances dissolved in the water passing at the lower temperatures and those that have the greatest, at the higher temperatures. Now since the gases in the water tend to buoy up the articles thrown out of solution and to prevent them from settling, it becomes of the first importance to dispel the gases as much as possible before the salts of lime are thrown out of solution.

Now, an important part of the present invention is the prevention of the natural action of circulation set up by boiling or heating and the dispelling of the gases in regular order.

To effect this I employ a heating or boiling vessel in which there are suitably disposed diaphragms, shelves, plates, trays, or cones that intercept and prevent the circulation of the liquid. I then pass the water in at the top part of the vessel in a cold or partially heated state and cause it to pass down through suitable openings, perforations or passages towards the lower part of the vessel. Then, applying heat at or near the bottom of the vessel I cause the steam arising to pass up through the limited orifices by which the water passes down. By so locating the ebullition the highest pressure due to columnar pressure is attained and the re-absorption of dispelled gases in the lower parts of the heating vessel prevented, the steam being ultimately absorbed in the descending water.

This system of heating liquids I employ in varied and modified forms included generally under the following heads.

1. Apparatus for boiling, softening, and sterilizing water, at the ordinary atmospheric pressure.

2. Apparatus for boiling, softening and sterilizing water under columnar pressure.

3. Apparatus for softening, clarifying and depositing water under steam pressure.

For each of these classes of apparatus I sometimes make use of a heat interchanger by which the heat from the treated water is imparted to the untreated water.

The sterilizing and softening of water at the ordinary atmospheric pressure may be performed either with or without a heat-interchanger, but the saving of fuel and time and the ensuring a constant delivery of cooled, purified water make the use of the heat interchanger most desirable.

A commoner form of apparatus for sterilizing and softening at atmospheric pressure (and one which may be portable and suitable for domestic purposes) may consist of a flat bottomed vessel say 10 inches in diameter and having the shape of a truncated cone at the top, the truncated top measuring about 3 inches and the whole vessel being say 10 inches in height. A pipe about 3 inches in diameter may form an extension to the top of the cone to increase the height of the water line and thereby give a slight additional pressure and temperature in the boiling chamber. The whole vessel would be divided say into 4 or 5 compartments by diaphragms, these being suitably perforated to allow the water to descend by stages through the openings by which the steam would ascend.

The outflow of the water would be from the compartment above the bottom chamber.

In combination with this sterilizing vessel it is preferable (as before stated) to use a heat-interchanger, the heating surfaces of which would by preference be made of folded thin metal plates the foldings running vertically. This metal surface being formed into a water box would be placed in a containing case and both the case and the water box would be fitted with inlet and outlet pipes.

In action, the crude water, entering the water box of the heat-interchanger at the bottom would, in rising, become heated and would flow on to the sterilizing vessel. Passing into this vessel at the highest point it would descend by the apertures in the diaphragms and be heated by successive stages on meeting the ascending steam. The whole of the ebullition being concentrated or located at the apertures in the diaphragms, the gases would be drawn off and the softened water would become clarified. It next would flow out of the vessel to the top part of the containing case of the heat interchanger and would become cool by imparting its heat to the inflowing crude water. The heating medium may be an Argand gas burner used for supplying light. Such a burner would provide heat sufficient to sterilize the water for a moderate sized house since a powerful heat interchanger would heat the incoming water to within 15 or 20 degrees of the boiling point.

Large apparatus may be made to treat the water under atmospheric pressure and rectangular or other shaped vessels will answer the purpose. Trays may be used in place of diaphragms and arranged to locate the ebulition to the spaces between them and to prevent circulation; but as a large vessel implies depth so it brings into play the principle of boiling under columnar pressure.

The softening and sterilizing of water under columnar pressure is performed in a manner similar to that already described as under atmospheric pressure, but the apparatus being applicable to numerous purposes, modifications in accordance therewith are required.

For some of these purposes the combination of the heat interchanger and the boiling system is absolutely necessary. For instance in such cases as in removing the carbonate hardness from water used for baths and washhouses where both hot and cold soft water are required.

A convenient form of heat interchanger is one resembling that already shown for smaller purposes and for private houses. A convenient form of boiling vessel for baths and washhouses and for general purposes for softening and sterilizing water under columnar pressure is the cylindrical form, the depth being 10 or 12 feet or such depth as will give in the boiling chamber a columnar pressure that will raise the boiling temperature 10 or 15 degrees above the atmospheric boiling point. The vessel would be separated into compartments by diaphragms or shelves or trays perforated or with spaces between, and would have in addition a sludge chamber and a depositing chamber. Pressure steam would be the heating medium for adding the heat required over and above that which would be imparted by the heat interchanger. The steam would enter the water above the bottom diaphragm and making its way upwards would be condensed and absorbed in the descending water. The water would then pass through the perforations in the bottom diaphragm into the depositing chamber and being diverted downwards by a baffle plate would rise on the other side and leave the apparatus at the top part of this chamber and return to the heat interchanger.

A heating vessel for softening and sterilizing for house purposes under columnar pressure is a vessel similar to that already described for sterilizing and softening but of increased size according to requirement.

If placed 6 feet or 12 feet or any convenient distance below the delivery tank, the crude water could descend to the boiling vessel from the supply tank and could ascend to the delivery tank by suitable pipes passing to and from the heat interchanger on its way.

Other shaped vessels may be used in treating water under columnar pressure and the waste gases from the furnace may be employed as the heating medium. For example, a series of rectangular pressure tanks stacked one above another and connected by pipes and having spaces for flues between them, may be set in brickwork so as to economise the heat from the furnaces and also soften the water.

An important feature where columnar pressure is a factor is the prevention of encrustation in kitchen boilers.

It is generally supposed that the circulation of water between the kitchen boiler and the supply tank is due alone to a difference of temperature between the columns and that heat is the sole cause of the circulation. This however is not the case. The ascending column rises because it is lighter than the descending column but the cause of the difference is not alone heat but whatever makes one column lighter than another. Liberated air and water mixed are lighter than water; water and steam are lighter than water.

Keeping these facts in view, I employ a circulating cylinder specially made with diaphragms perforated and having a settling chamber with baffle plate as already described. I then circulate the crude water to and from the supply tank to the top part of this chamber and the softened and clarified water between the boiler and the bottom part of this cylinder.

In action, the water owing to ebullition in the kitchen boiler starts in circulation and carries with it the steam evolved; on reaching the circulating vessel the steam and water become separated the steam passing upward and the water passing downward carrying any deposit down with it and then rising to the outflow or return pipe to the boiler.

Thus there is no connection established between the water flowing to and from the boiler to the bottom of the cylinder and to and from the top tank to the top part of the cylinder. But the steam evaporated passing upwards becomes condensed, and the make up water passing downwards becomes softened and deposited. There being then practically a separation of the crude from the softened water by means of the perforated diaphragms, the question of encrustation due to carbonate hardness is satisfactorily disposed of.

It might be objected that a jarring noise such as when steam is blown in to water would result from the system above described, but this would be guarded against by

providing in every case for the steam to come into contact with the water near to the boiling point. For instance an arrangement such as a dome placed inside the cylinder near the top for the steam to pass into would cause a layer of boiling water to be superimposed between the crude water and the steam.

The third mode of treatment or that under steam pressure is for the purpose of softening and clarifying the water in its passage to, and before entering the boiler.

This form of apparatus is intended for the removal of the carbonate hardness and, under certain conditions, the sulphate hardness as well.

The apparatus may conveniently consist of a cylindrical vessel, sufficiently strong to withstand the full pressure of the boiler and it may be placed partly or entirely above the water line of the boiler. It may be fitted with diaphragms or trays perforated as before set forth and having a spindle with arms to disturb and remove the sediment. There would be also a depositing and sludge chamber. The water may be forced into this vessel by a pump or injector. But inasmuch as the softening of the water condenses the steam the water may be made to pass into the boiler by an automatic arrangement, or by one that would close the inlets and outlets for steam and water by mechanical means. In carrying this into effect, the top part of the cylinder would be divided from the lower part by a steam tight diaphragm. A vertical division would divide this compartment into two, and being steam tight, these two compartments would form two vessels for alternate vacuum and pressure. By forming the outside of the top part of the cylinder into an open water supply tank, means for condensing would also be provided. A two way cock furnishing the steam would keep the steam supplied to one or other of these steam tight chambers and a similar two way valve would at the same time open or close one or other of the openings for water to the apparatus, while the vacuum caused by the water in the tank would open the valve between it and the steam compartment. Thus one or other of the steam tight compartments would be under steam pressure and delivering its water into the boiler, while the other would be drawing in water from the supply tanks above. By this apparatus then the water in passing through the orifices in the diaphragms and into the depositing chamber would become softened and clarified as described and shown in the action of similar apparatus previously.

In preventing incrustation upon heating surfaces by mechanical means, I employ as already explained a revolving spindle with arms or attachments.

I also set up galvanic action as a means of preventing encrustation in the heat and for screening or separating out sedimentary matter in the cold by the employment of a mixture of metals such as iron and copper woven together and formed into a screen.

When iron and copper are interwoven and placed in contact with each other and submerged in water, the iron becomes rusted away and a galvanic action is set up, the copper being left intact.

When vessels for heating water are made of copper, discs of iron interwoven with copper wire and placed within the vessel may be used with advantage in the prevention of encrustation.

In screening out or separating sedimentary matter from water in the cold, I make use of a combination of "band" or "wire" iron interlaced or mixed with copper wire, and by forming such material into screens arranged horizontally, vertically, or at an angle and passing the water to be clarified and purified through one or more of such screens, the aggregation of particles is assisted. In dealing with contaminated river waters, a purifying and cleansing process is often necessary before or after softening, and sometimes a slight lime treatment is beneficial to assist in removing the foul matters. The galvanic water screen is then of special service before filtration.

The remaining feature to be dealt with in this invention relates to filtration.

In the general treatment of water whether in the heat or in the cold perfect filtration is most essential. Although in most cases when water containing carbonate

hardness is softened and sterilized by the process already described a brilliant water results under certain conditions and a filter is seldom required, yet when noxious properties exist in the water or where there are nitrites or sulphates or other hardness requiring chemical treatment, then the filtration becomes a prominent question.

This part of the invention is intended to obviate some of the objections in ordinary filters occasioned by the blocking or choking of the filtering medium and the disturbance of the filter bed on cleaning.

This is accomplished by constructing the filter in such a manner as to make the filter, as regards the accumulation upon it, either self delivering or easily cleanable automatically, mechanically, or by reversal of current.

In dealing with large volumes of water the purifying sometimes has to be sacrificed or conducted but imperfectly on account of the difficulty created by blocking of the filter. Thus a process, practical as regards throwing out of solution and aggregating the particles, is of no value unless the after process of filtration can be conducted upon a large scale in a practical way also.

In the ordinary sand filter as used in water works the slimy decomposing matter collecting upon the filter bed is relied upon to form the real filtering medium, when after the filter bed is cleaned, the filtration of the water passing through is not effected until a collection of slimy matter has again formed. In flood times and at certain seasons, the necessity of frequent cleaning and the consequent disturbance of the filter bed prevents the water from being of the standard which should be required.

Now to overcome these various objections, I construct a filter, the filtering walls of which are disposed vertically, then by placing the filter in a vessel which is divided into an under and upper chamber by a perforated floor and attaching or fixing the filtering medium to the perforations, I make use of the under chamber as a settling and sludge chamber and the upper chamber to contain the filtered water.

When the filtering medium is a textile substance or filter cloth, I sometimes use supporting frames but not always, when the cylindrical or round form of filter bag is employed.

When the filter is formed of a number of circular bags and closed at the top each bag covering or being attached to its perforation, then the pressure of the water when the filter is in action will distend the bags. But on drawing off the sludge from the under chamber the bags will reverse automatically and tend to turn inside out and throw off the accumulation.

A similar result will also take place when the filter cloths are made up oblong in form and placed and affixed over oblong perforations. While the pressure of water is in one direction and upward the filter cloths will be strained against their supporting frames, but on reversal of the water current the collapsing of the filter cloths will take place and cause them to turn inside out.

A convenient material for the filter cloth frames is wood partially baked or prepared to prevent rotting.

When the filter is intended to be cleaned mechanically I employ one or more brushes and by preference leave the filter bags open at the top and support them by a top frame to prevent them turning inside out.

The brushes may be fixed vertically to a horizontal rod or bar and passed up and down inside the filter bags either by manual labour or by any convenient travelling mechanical arrangement.

Where large volumes of water have to be dealt with and the filtering medium requires to be of a permanent and lasting nature, then I construct the vertical walls of the filter either circular in plan or oblong or corrugated to give increase of surface. I use as the real filtering medium a thin lining of porous material such as artificial sandstone or a very porous cement coated upon its surface with powdered charcoal or a pulpy or other suitable material.

As a backing to the thin porous layer I employ shingle or for instance gravel roughly concreted.

Thus I form a filtering medium that may be brushed in the manner before described and cleansed by reversal of current at the same time, while the sludge, falling into suitable sludge chambers may be daily removed and the slimy sludge not employed as the filtering medium.

Dated this 12th day of September 1894.

H. J. HADDAN,
Agent for the Applicant.

COMPLETE SPECIFICATION.

Improvements in Treating, Purifying, and Sterilizing Water or Contaminated Liquids, and in Apparatus therefor.

I, WILLIAM LAWRENCE of 20 Brackley Terrace, Chiswick in the County of Middlesex, Civil and Mechanical Engineer do hereby declare the nature of this invention and in what manner the same is to be performed to be particularly described and ascertained in and by the following statement:—

This invention relates to the treating of water or contaminated liquids in such a manner as to remove their objectionable qualities by processes of softening sterilizing, filtering or depositing.

One of the principal features of this invention is the purifying and softening of water by means of heat so applied that the salts of lime and other matters may be thrown out of solution, or precipitated and caused to aggregate and separate from the water.

Another feature is the prevention of incrustation, upon heating surfaces, of precipitated sedimentary matter by mechanical means, or by setting up galvanic action.

Another feature is the filtering or screening out sedimentary matter from the water.

With regard to the first feature of this invention I have observed that when a liquid is heated in a vessel in the ordinary way, a circulating action is set up and the heated portions rise toward the surface while the parts not heated descend. In this way the whole of the liquid in the vessel is maintained at practically, a uniform temperature and only something approaching the boiling temperature is arrived at or reached. In other words the temperature of the liquid does not increase in proportion to its columnar pressure and the descending portions of the liquid abstract the heat from those that are ascending, causing a re-absorption of the gases and vapours that are, for the moment, dispelled.

Again, I have observed that when crude water is heated by stages, gases contained in it pass off in regular order as the temperature increases; those gases that have the least solubility in the water or affinity for substances dissolved in the water passing at the lower temperatures and those that have the greatest, at the higher temperatures. Now since the gases in the water tend to buoy up the particles thrown out of solution and to prevent them from settling, it becomes of the first importance to dispel the gases as much as possible before the salts of lime are thrown out of solution.

Now, an important part of the present invention is the prevention of the natural action of circulation set up by boiling or heating, and the dispelling of the gases in regular order.

To effect this I employ a heating or boiling vessel in which there are suitably disposed diaphragms, shelves, plates, trays, or cones that intercept and prevent the circulation of the liquid. I then pass the water in at the top part of the vessel in

a cold or partially heated state and cause it to pass down through suitable openings, perforations or passages towards the lower part of the vessel. Then, applying heat at or near the bottom of the vessel I cause the steam arising to pass up through the limited orifices by which the water passes down. By so locating the ebullition the highest pressure due to columnar pressure is attained and the re-absorption of dispelled gases in the lower parts of the heating vessel prevented, the steam being ultimately absorbed in the descending water.

This system of heating liquids I employ in varied and modified forms included generally under the following heads :—

(1) Apparatus for boiling, softening, and sterilizing water at the ordinary atmospheric pressure.

(2) Apparatus for boiling, softening and sterilizing water, under columnar pressure.

(3) Apparatus for softening, clarifying and depositing water under steam pressure.

For each of these classes of apparatus I sometimes make use of a heat interchanger by which the heat from the treated water is imparted to the untreated water.

The sterilizing and softening of water at the ordinary atmospheric pressure may be performed either with or without a heat-interchanger, but the saving of fuel and time and the ensuring a constant delivery of cooled, purified water make the use of the heat-interchanger most desirable.

A common form of apparatus for sterilizing and softening at atmospheric pressure, (and one which may be portable and suitable for domestic purposes) may consist of a flat-bottomed vessel say 10 inches in diameter and having the shape of a truncated cone at the top, the truncated top measuring about 3 inches and the whole vessel being say 10 inches in height. A pipe about 3 inches in diameter may form an extension to the top of the cone to increase the height of the water line and thereby give a slight additional pressure and temperature in the boiling chamber. The whole vessel would be divided say into 4 or 5 compartments by diaphragms, these being suitably perforated to allow the water to descend by stages through the openings by which the steam would ascend.

The outflow of the water would be from the compartment above the bottom chamber.

In combination with this sterilizing vessel it is preferable (as before stated) to use a heat-interchanger, the heating surfaces of which would by preference be made of folded thin metal plates the foldings running vertically. This metal surface being formed into a water box would be placed in a containing case and both the case and the water box would be fitted with inlet and outlet pipes.

In action, the crude water, entering the water box of the heat-interchanger at the bottom would, in rising become heated and would flow on to the sterilizing vessel. Passing into this vessel at the highest point it would descend by the apertures in the diaphragms and be heated by successive stages on meeting the ascending steam. The whole of the ebullition being concentrated or located at the apertures in the diaphragms, the gases would be driven off and the softened water would become clarified. It next would flow out of the vessel to the top part of the containing case of the heat interchanger and would become cool by imparting its heat to the inflowing crude water. The heating medium may be an Argand gas metal burner, used for supplying light. Such a burner would provide heat sufficient to sterilize the water for a moderate sized house, since a powerful heat-interchanger would heat the incoming water to within 15 or 20 degrees of the boiling point.

Large apparatus may be made to treat the water under atmospheric pressure and rectangular or other shaped vessels will answer the purpose. Trays may be used in place of diaphragms and arranged to locate the ebullition to the spaces between them and to prevent circulation, but as a large vessel implies depth so it brings into play the principle of boiling under columnar pressure.

The softening and sterilizing of water under columnar pressure is performed in a manner similar to that already described as under atmospheric pressure, but the apparatus being applicable to numerous purposes, modifications in accordance therewith are required.

For some of these purposes the combination of the heat interchanger and the boiling system is absolutely necessary. For instance in such cases as in removing the carbonate hardness from water used for baths and wash-houses where both hot and cold soft water are required.

A convenient form of heat-interchanger is one resembling that already shown for smaller purposes and for private houses. A convenient form of boiling vessel for baths and wash-houses and for general purposes for softening and sterilizing water under columnar pressure is the cylindrical form, the depth being 10 or 12 feet or such depth as will give in the boiling chamber a columnar pressure that will raise the boiling temperature 10 or 15 degrees above the atmospheric boiling point. The vessel would be separated into compartments by diaphragms or shelves or trays perforated or with spaces between, and would have in addition a sludge chamber and a depositing chamber. Pressure steam would be the heating medium for adding the heat required over and above that which would be imparted by the heat interchanger. The steam would enter the water above the bottom diaphragm and making its way upwards would be condensed and absorbed in the descending water. The water would then pass through the perforations in the bottom diaphragm into the depositing chamber and being diverted downwards by a baffle plate would rise on the other side and leave the apparatus at the top part of this chamber and return to the heat interchanger.

A heating vessel for heating and softening and sterilizing for house purposes under columnar pressure is a vessel similar to that already described for sterilizing and softening but of increased size according to requirement.

If placed 6 feet or 12 feet or any convenient distance below the delivery tank, the crude water could descend to the boiling vessel from the supply tank, and could ascend to the delivery tank by suitable pipes passing to and from the heat interchanger on its way.

Other shaped vessels may be used in treating water under columnar pressure and the waste gases from the furnace may be employed as the heating medium. For example, a series of rectangular pressure tanks stacked one above another and connected by pipes and having spaces for flues between them, may be set in brickwork so as to economise the heat from the furnace and also soften the water.

An important feature where columnar pressure is a factor is the prevention of incrustation in kitchen boilers.

It is generally supposed that the circulation of water between the kitchen boiler and the supply tank is due alone to a difference of temperature between the columns and that heat is the sole cause of the circulation. This however is not the case. The ascending column rises because it is lighter than the descending column but the cause of the difference is not alone heat but whatever makes one column lighter than another. Liberated air and water mixed are lighter than water; water and steam are lighter than water.

Keeping these facts in view, I employ a circulating cylinder specially made with diaphragms perforated and having a settling chamber with baffle plate as already described. I then circulate the crude water to and from the supply tank to the top part of this chamber and the softened and clarified water between the boiler and the bottom part of this cylinder.

In action, the water owing to ebullition in the kitchen boiler starts in circulation and carries with it the steam evolved; on reaching the circulating vessel the steam and water become separated the steam passing upward and the water passing downward carrying any deposit down with it and then rising to the outflow or return pipe to the boiler. Thus there is no connection established between the water flowing to and from the boiler to the bottom of the cylinder and to and from the top tank to the top part of the cylinder. But the steam evaporated passing

upwards becomes condensed, and the make up water passing downwards becomes softened and deposited. When the columnar pressure on the kitchen boiler gives too high a boiling temperature it is preferable to place a heat interchanger inside the circulating cylinder and so transmit the heat by conduction from the water from the kitchen boiler to that in circulation to the top tank.

It might be objected that a jarring noise such as when steam is blown into water would result from the system above described, but this would be guarded against by providing in every case for the steam to come into contact with the water near to the boiling point. For instance an arrangement such as a dome placed inside the cylinder near the top for the steam to pass into would cause a layer of boiling water to be superimposed between the crude water and the steam.

The third mode of treatment or that under steam pressure is for the purpose of softening and clarifying the water in its passage to, and before entering the boiler.

This form of apparatus is intended for the removal of the carbonate hardness and, under certain conditions, the sulphate hardness as well.

The apparatus may conveniently consist of a cylindrical vessel, sufficiently strong to withstand the full pressure of the boiler and it may be placed partly or entirely above the water line of the boiler. It may be fitted with diaphragms or trays perforated as before set forth and having a spindle with arms to disturb and remove the sediment. There would be also a depositing and sludge chamber. The water may be forced into this vessel by a pump or injector. By this apparatus then the water in passing through the orifices in the diaphragms and into the depositing chamber would become softened and clarified as described and shown in the action of similar apparatus previously.

In preventing incrustation upon heating surfaces by mechanical means, I employ as already explained a revolving spindle with arms or attachments.

I also set up galvanic action as a means of preventing incrustation in the heat and for screening or separating out sedimentary matter in the cold by the employment of a mixture of metals, such as iron and copper woven together and formed into a screen.

When iron and copper are interwoven or placed in contact with each other and submerged in water, the iron becomes rusted away and a galvanic action is set up, the copper being left intact.

When vessels for heating water are made of copper, discs of iron interwoven with copper wire and placed within the vessel may be used with advantage in the prevention of incrustation.

In screening out or separating sedimentary matter from water in the cold, I make use of a combination of "band" or "wire" iron interlaced or mixed with copper wire, and by forming such material into screens arranged horizontally, vertically, or at an angle, and passing the water to be clarified and purified through one or more of such screens, the aggregation of particles is assisted. In dealing with contaminated river waters, a purifying and cleansing process is often necessary before or after softening, and sometimes a slight lime treatment is beneficial to assist in removing the foul matters. The galvanic water screen is then of special service before filtration.

The remaining feature to be dealt with in this invention relates to filtration.

In the general treatment of water whether in the heat or in the cold perfect filtration is most essential. Although in most cases when water containing carbonate hardness is softened and sterilized by the process already described a brilliant water results under certain conditions and a filter is but seldom required. Yet when noxious properties exist in the water or where there are nitrites or sulphates or other hardness requiring chemical treatment, then the filtration becomes a prominent question.

This part of the invention is intended to obviate some of the objections in ordinary filters occasioned by the blocking or choking of the filtering medium and the disturbance of the filter bed on cleaning. This is accomplished by constructing

the filter in such a manner as to make the filter, as regards the accumulation upon it, either self-delivering or easily cleanable automatically, mechanically, or by reversal of current.

In dealing with large volumes of water the purifying sometimes has to be sacrificed or conducted but imperfectly on account of the difficulty created by blocking of the filter. Thus a process, practical as regards throwing out a solution and aggregating the particles, is of no value unless the after process of filtration can be conducted upon a large scale in a practical way also.

In the ordinary sand filter as used in water works the slimy decomposing matter collecting upon the filter bed is relied upon to form the real filtering medium, when after the filter bed is cleaned, the filtration of the water passing through is not effected until a collection of slimy matter has again formed. In flood times and at certain seasons, the necessity of frequent cleaning and the consequent disturbance of the filter bed prevents the water from being of the standard which should be required.

Now to overcome these various objections, I construct a filter, the filtering walls of which are disposed vertically, then by placing the filter in a vessel which is divided into an under and upper chamber by a perforated floor and attaching or fixing the filtering medium to the perforations, I make use of the under chamber as a settling and sludge chamber and the upper chamber to contain the filtered water.

When the filtering medium is a textile substance or filter cloth, I sometimes use supporting frames, but not always, when the cylindrical or round form of filter bag is employed.

When the filter is formed of a number of circular bags and closed at the top each bag covering or being attached to its perforation, then the pressure of the water when the filter is in action will distend the bags. But on drawing off the sludge from the under chamber the bags will reverse automatically and tend to turn inside out and throw off the accumulation.

A similar result will also take place when the filter cloths are made up oblong in form and placed and affixed over oblong perforations. While the pressure of water is in one direction and upward the filter cloths will be strained against their supporting frames, but on reversal of the water current the collapsing of the filter cloths will take place and cause them to turn inside out. A convenient material for the filter cloth frames is wood partially baked or prepared to prevent rotting. When the filter is intended to be cleaned mechanically I employ one or more brushes and by preference leave the filter bags open at the top and support them by a top frame to prevent them turning inside out. The brushes may be fixed vertically to a horizontal rod or bar and passed up and down inside the filter bags either by manual labour or by any convenient travelling mechanical arrangement.

Where large volumes of water have to be dealt with and the filtering requires to be of a permanent and lasting nature, then I construct the vertical walls of the filter either circular in plan or oblong or corrugated to give increase of surface. I use as the real filtering medium a thin lining of porous material such as artificial sandstone or a very porous cement having upon its surface powdered charcoal or a pulpy or other suitable material.

As a backing to the thin porous layer I employ shingle or for instance gravel roughly concreted. Thus I form a filtering medium that may be brushed in the manner before described and cleansed by reversal of current at the same time, while the sludge, falling into suitable sludge chambers may be daily removed and the slimy sludge not employed as the filtering medium.

In dealing with the question of water-screening it is not alone the prevention of incrustation that is aimed at, but the broad questions of purifying, and assisting the process of filtration. Impure waters generally contain nitrites. Boiling does not suffice to remove these. An iron-process, such for instance, as the "Anderson" process—does remove them. Finely-divided sedimentary matter, held in suspension,

oftentimes accompanies nitrogenous impurities. A slight treatment with hydrate of lime, by removing some of the temporary hardness, also causes aggregation. But lime, added to water, is not quickly removed; a trace remains for a long time, and a sand-filter soon becomes indurated when simply lime is employed. By the combination therewith of an iron-process (such as the "Anderson") any lime remaining is speedily removed, if but a small amount only of metallic iron is added; the action of iron being not only to effect a change in the nitrites, but to reduce very considerably, the time of the lime-treatment.

Therefore, whether it be the removal of the nitrites; the prevention of incrustation in the sterilizing of water; the shortening of the time for the lime-process in softening water; the prevention of induration of filters (whether sand or cloth) or, the simplification of filtration for water works, the water-screening principle becomes obviously desirable.

The combination of iron and copper in the water-screen furnishes an additional factor, by the oxygen thus set free for the removal of the nitrites from contaminated water, or even from sewage.

The combination in the water-screen not only sets up galvanic-action and causes the water to be analysed by electrolysis but it lends itself to the transmission of electric currents, induced from without, and conveyed to the water-screen.

For the prevention of incrustation in boiling vessels the employment of mats of woven copper-and-iron wire cloth, made to suit the vessel, will suffice.

For the removal of nitrites, the surface of the screens must be proportioned to the amount of nitrogenous impurities in the water, and to the rate of water-flow.

For the removal of lime-hydrates (when used) the extent of the screening surface must depend upon the rate of water-flow, and time of treatment. Also upon whether iron in metallic or other form is introduced independently of that derived from the screen.

The action of the water-screen is to form settling and aggregating surfaces that shall be self-cleaning so that particles, being attracted will collect and fall down into suitable receptacles provided.

For water-works the aggregating and separating action of the water-screen obviates the necessity of frequent cleaning of filter-beds.

If only 2 grains of lime per gallon are used the iron treatment combined with that of the lime will give very rapid results. This mode of treatment is applicable especially in flood times.

When however a more complete softening is desired the combined iron and lime treatment will reduce the time for the lime action by about one third of that required when lime by itself is employed.

Not only is this the case but the reactions being rendered rapid and complete the tendency to induration of the filtering media is counteracted.

The induration of the filtering medium is a serious drawback with the lime treatment. Another objection also arises when filtering is not resorted to. After several hours allowed for clarifying of the water in the settling tanks chemical combinations take place which produce coatings and obstructions in the mains for a considerable distance from the pumping stations.

In the accompanying drawings which are intended to illustrate a mode of performing the invention—

Figs. 1 to 6 show a variety of domestic sterilizing apparatus.

Figs. 1 and 2 are elevation and plan of one form of apparatus as described.

Fig. 3 a variation of the same having internal parts removable for cleaning out.

Fig. 4 is a form adapted for steam as the heating medium having trays or cones which are removable.

Fig. 5 and Fig. 6 are elevation and plan of a rectangular form having removable trays more or less above the water line according to the level at which the water outflows. The heating medium in this case is steam but gas-jets or other media will serve.

In all these arrangements it is intended generally to use a heat-interchanger A

in conjunction. In all these figs. *b* is the inlet for water to, and *c* the delivery of water from the boiling-apparatus B, *e* the diaphragms, trays or cones, *g* the heating means, *h* the outer case of heat-interchanger, *j* the heat-interchanger. The plain arrows show the direction of water-flows ; the dotted arrows the direction of the steam.

In action the crude water enters the heat-interchanger by the pipe *a* and becomes heated and flows through pipe *b* into the boiling-vessels ; and, descending through the ebullition-chamber (as shown by the plain arrows) becomes softened and sterilized ; and, passing out by the pipe *c* is re-cooled as it passes outside the heat-interchanger by imparting its heat to the incoming water, flowing-out by the pipe *d*. The lamp *g* supplying the heat necessary to make up the difference of temperature between the inflowing and outflowing waters creates steam which passes upwards in the direction indicated by the dotted arrows. The ebullition being thus located to the limited orifices the gases are driven off from the water which thereby becomes softened and sterilized.

In Fig. 3 the return-water from the boiling-chamber flows upwards, not by a pipe as in Fig. 1 but between the inner removable cylinder and the outer cylinder, passing from one cylinder to the other through the perforations *k*. The steam generated in the lowest boiling-chamber passing upwards through the perforations *l*.

Figs. 7 and 8 show elevation and plan of larger apparatus to work under columnar-pressure. The boiling-vessel may measure from 10 feet to 15 feet or more in height to give an increased temperature in the lowest boiling-chamber. The heat-interchanger is arranged in a rectangular vessel by the side. The letters showing the direction of the water and steam are the same as already used in describing the domestic apparatus. The openings or apertures *o* in the diaphragms for locating the ebullition are projected downwards for about an inch, the projections being perforated to admit the upward passage of the steam. The form of the apertures *o* as shown in the plan, is rectangular.

The apparatus is furnished with a spindle *m* having arms with chains attached, to remove the sediment at intervals, and cause it to fall into the lowest boiling-chamber, whence it may be withdrawn through the sludge-pipe *n*.

The mode of action in this columnar form of apparatus is similar to that already described in the domestic apparatus. The pressure steam entering by the pipe *g* causes ebullition in the lowest chamber as in the domestic apparatus the steam and water-flow being indicated by the dotted, and plain, arrows respectively.

A heating vessel for heating and softening and sterilizing for house-purposes, under columnar pressure is a vessel similar to that already described at Fig. 3 made of sufficient size to yield about fifteen gallons per hour. It might be heated by gas-jets or over a special stove in an upper room. Such apparatus being under pressure would differ from Fig. 3 in requiring to be covered down, with water-tight joints.

Figs. 9. 10 11. 12, show apparatus for the prevention of incrustation in kitchen boilers. Figs. 9 and 10 are elevation and plan of a circulating-cylinder, fitted internally, with the diaphragms *e* furnished with cone-shaped apertures *o*. The flow from, and return to kitchen boiler which is usually on a lower level are *b* and *c* ; the flow and return from the supply tank which is usually on a higher level are *p* and *q*. The crude water may enter at *r* or may be supplied direct to the supply tank according to the arrangement of the tanks and pipes. Sludge-doors are intended for cleaning out each chamber, these it is not necessary to show. In action the water flowing from the kitchen-boiler passes therefrom in at pipe *b* above the bottom diaphragm *e* and deposits sediment, flowing downwards through the orifice *o* in the diaphragm being directed downwards by the baffle-plate o^1, and returns to the boiler through the return-pipe *c*. Likewise, the water from the top or supply tank descends, enters at *p* and deposits sediment upon the top diaphragm before returning through the pipe *q*. Steam generated passes from the bottom chamber to the top chamber or upwards, and heats the water therein but the water

from the boiler, being isolated from the top tank water by the diaphragms, does not mix therewith, the make-up water alone passes downwards; and that, having passed through the boiling-stage parts with its temporary hardness. Consequently, the water supplying the boiler becomes softened and clarified. Fig. 11 is a rectangular form of vessel to suit positions where a circular form is not so convenient. The apertures, in this case are spaces between the trays *e* and the walls of the vessel. The action of this form however, is the same as in the cylindrical form of circulating-vessel. Fig. 12 shows a circulating-cylinder containing a heat-interchanging apparatus. In this apparatus the water in circulation from the kitchen-boiler entering at *b* is cooled, as it passes downwards outside the heat-interchanger, by imparting its heat to the water within the interchanger. The crude water from the storage tank enters the interchanger at *p* and passes out at *q*. Although the top of the interchanger is left open, more or less within the closed exterior vessel, each water is kept separate, since the exit-pipe *q* dipping below the top of the heat-interchanger, locks in the upper part of the exterior vessel the gases arising from the water, and causes them to form a dividing medium. A small perforation j^1 will maintain an equal water-line on both sides of the apparatus. In construction, the circulating cylinder has a removable bottom to which the heat-interchanger is attached. The plug *n* in the ⊤ piece is for removing the sludge.

Figs. 13 and 14 are elevation and plan of apparatus for softening water in its passage to the steam-boiler. Fig. 15 is a modification of the same. The vessels here shown, if measuring from 15 to 30 inches in diameter and of proportionate height may serve for softening from 100 to 800 gallons per hour of ordinary water. The trays and cones shown may be varied in form and increased in number. Also, they may be alternated with others made of iron and copper interwoven, to prevent incrustation.

Fig. 13 represents a vessel made of wrought or cast iron having a movable cover as shown. The internal fittings consist of annular-shaped pans, alternately large and small. The water entering by the pipe *b* and falling from tray to tray passes out at *c*. The steam, entering just above the water-line at *g* passes upwards and escapes (together with the gases driven off from the water) at g^1. The force-pump used in conjunction to pump the water may take its steam from this pipe. The spindle with arms and chains attached, is similar to that shown at Fig. 7.

Fig. 15 is a vessel of the same construction, but the spindle is omitted and a series of cones substituted for the trays. The pipes n^1, n^1, n^1, may be used as sludge-pipes, or, for supplying the water to each cone separately, in which case, the sludge would be drawn off at the bottom of the vessel only at *n*.

Figs. 16 and 17 are side and end elevation of specimen of iron band and copper wire woven material about half natural size. Figs. 18 and 19 full-size side and end elevation of specimen of coiled iron wire and copper rod or wire. Fig. 20 flat band-iron punched with copper pin holding them in position. Fig. 21 roof-like arrangement of wove-iron and copper wire. Various other forms might be shown such as copper wove cloth laced to iron wove cloth, iron and copper wire twisted together and made into fringed curtains, but those already shown illustrate the principle. Fig. 22 is an end elevation of water-screening tank with a variety of forms of screens showing the water in some cases passing through the screen and in others between the screening surfaces.

s, *s*, *s*, are screens, *t* the troughs for catching the sediment, *u* are baffle plates of iron extending above the water line.

Figs. 23 and 24 are end elevation and plan of filtering vessel containing callapsible filter bags attached to perforated floor, and troughs or receptacles for the sediment, also inlet and outlet for water. The water entering at *v* passes upwards and enters the filter-bags and escapes at *z*.

These bags *x*, *x*, *x*, are open at bottom but closed at the top and are attached to the perforated floor *w*. So long as the water is flowing upwards, they being distended, are maintained in a vertical position, but on reversal of water-current

become collapsed and turning inside out discharge their sediment into the troughs *t*, *t*. These figures also serve to illustrate the permanent form of filter, constructed as previously described of porous material such as coarse artificial sandstone faced with fine filtering material, powdered charcoal or the like. The tanks in this case may be built of brickwork or cement and the filters *x* are left open at the top and bottom and supported upon perforated arches of pottery *etc.* resting upon iron girders, the water level in such case being below the tops of the tubes so that the water cannot pass out at their upper ends but must pass through the walls of the tubes.

Having now particularly described and ascertained the nature of this invention and in what manner the same is to be performed, I declare that what I claim is;—

1. The method of heating or boiling water in layers or stages for the purpose of sterilizing it as hereinbefore described.
2. The method of removing the carbonate or temporary hardness from water and driving off the gases by boiling the water in layers or stages, as hereinbefore described.
3. The method of softening or clarifying water and settling out the sediment by heating or boiling it in layers or stages as hereinbefore described.
4. The method of separating and removing the impurities from liquids by boiling such liquids in layers or stages as hereinbefore set forth.
5. The method of treating liquids in continuous flow by heating or boiling them in successive stages whether under atmospheric, columnar or steam pressure, and when desired in conjunction with the method of interchanging the heat from the treated hot liquid outflowing to the cold liquid inflowing as hereinbefore set forth.
6. The method of preventing the incrustation of kitchen boilers by isolating the water in circulation from and to the boiler and circulating cylinder from that in circulation from and to the top tank and circulating vessel, allowing the steam from the boiler alone to come in contact with the water in circulation from the top tank, as hereinbefore set forth.
7. The method of isolating the water from the kitchen boiler from that in use or the general supply by dividing conducting vertical surfaces (Fig. 12.) as hereinbefore set forth.
8. Apparatus for heating or boiling liquids in layers and stages in conjunction with heat interchanging apparatus transmitting the heat from outflowing liquid to that inflowing either under ordinary atmospheric, columnar or steam pressure as hereinbefore set forth.
9. The method of filtering by means of collapsible or reversible filter bags as hereinbefore set forth.
10. Screens composed of copper and iron and vessels containing same for purifying, oxydizing and removal of the hydrate of lime remaining from the lime treatment as hereinbefore set forth.
11. The various apparatus for treating, purifying and sterilizing water or contaminated liquids all substantially as illustrated and described and for the purposes set forth.

Dated this 12th day of July 1895.

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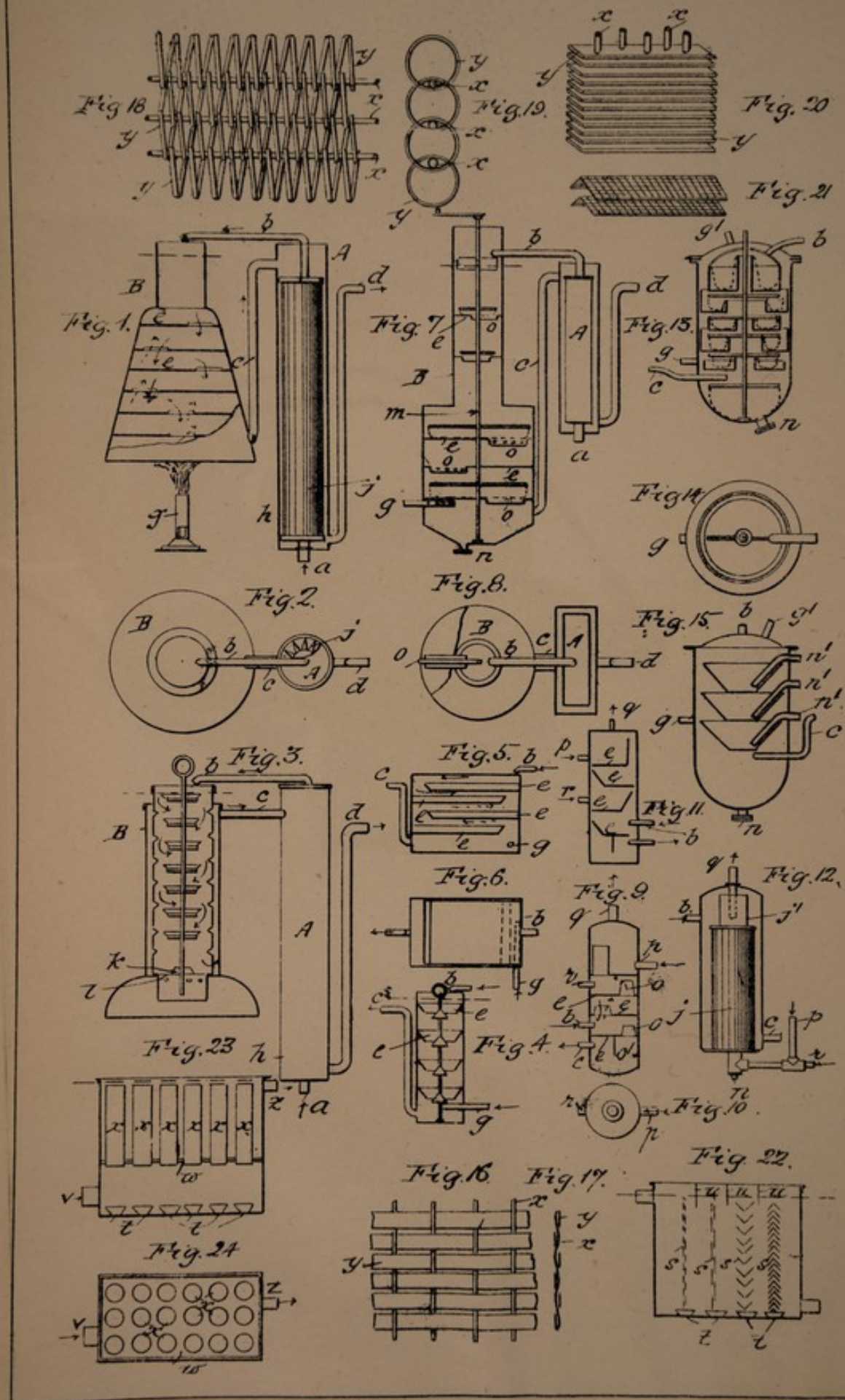

[This Drawing is a reproduction of the Original on a reduced scale]

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