No. 849,579. PATENTED APR. 9, 1907.

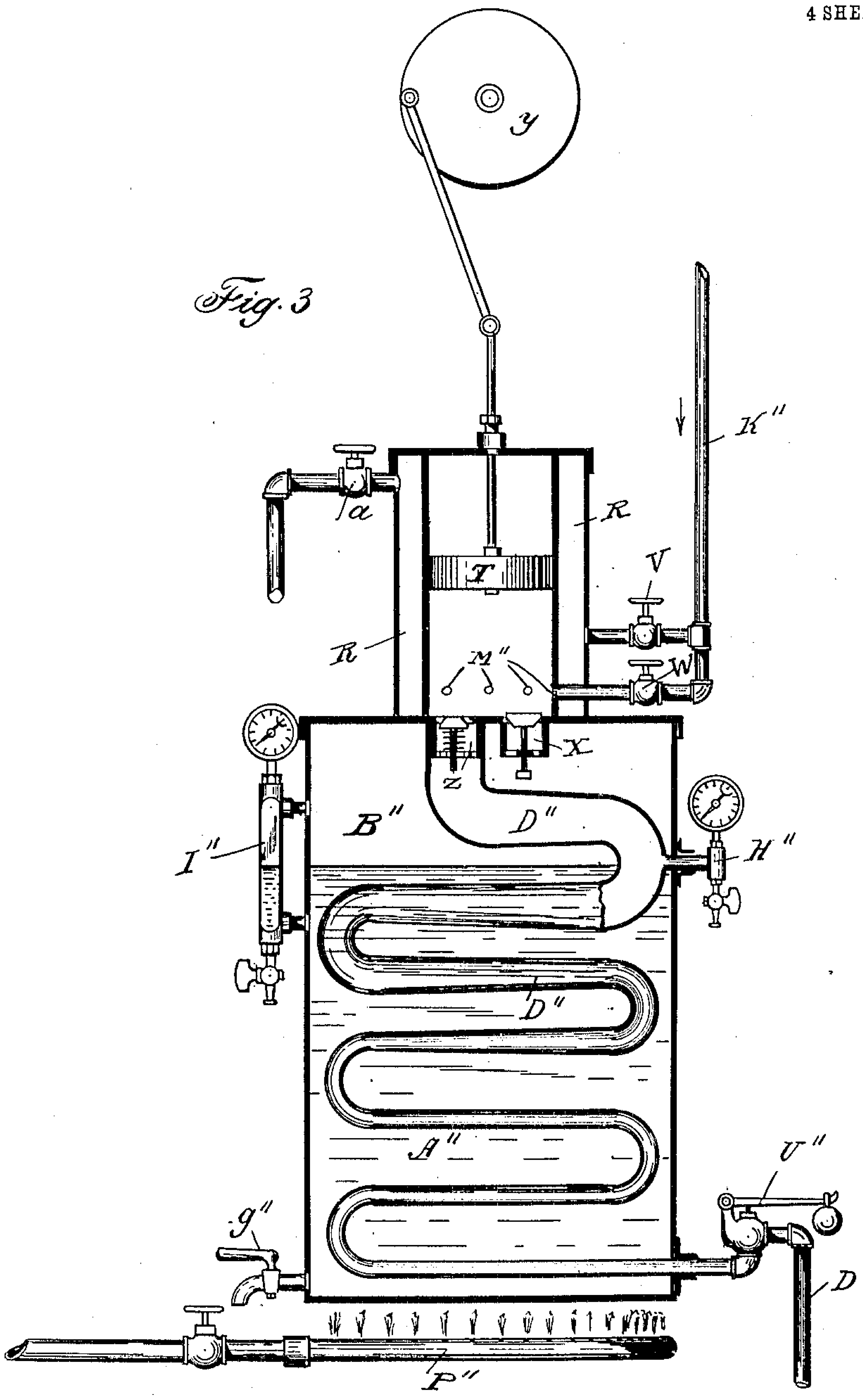
J. E. SIEBEL.

ART OF DISTILLING, CONCENTRATING, AND EVAPORATING LIQUIDS.

APPLICATION FILED APR. 25, 1904.

4 SHEETS—SHEET 3.

Fig. 3



Witnesses

Caroline Siewertsen.

Philip F. Keller

Inventor

John E. Siebel

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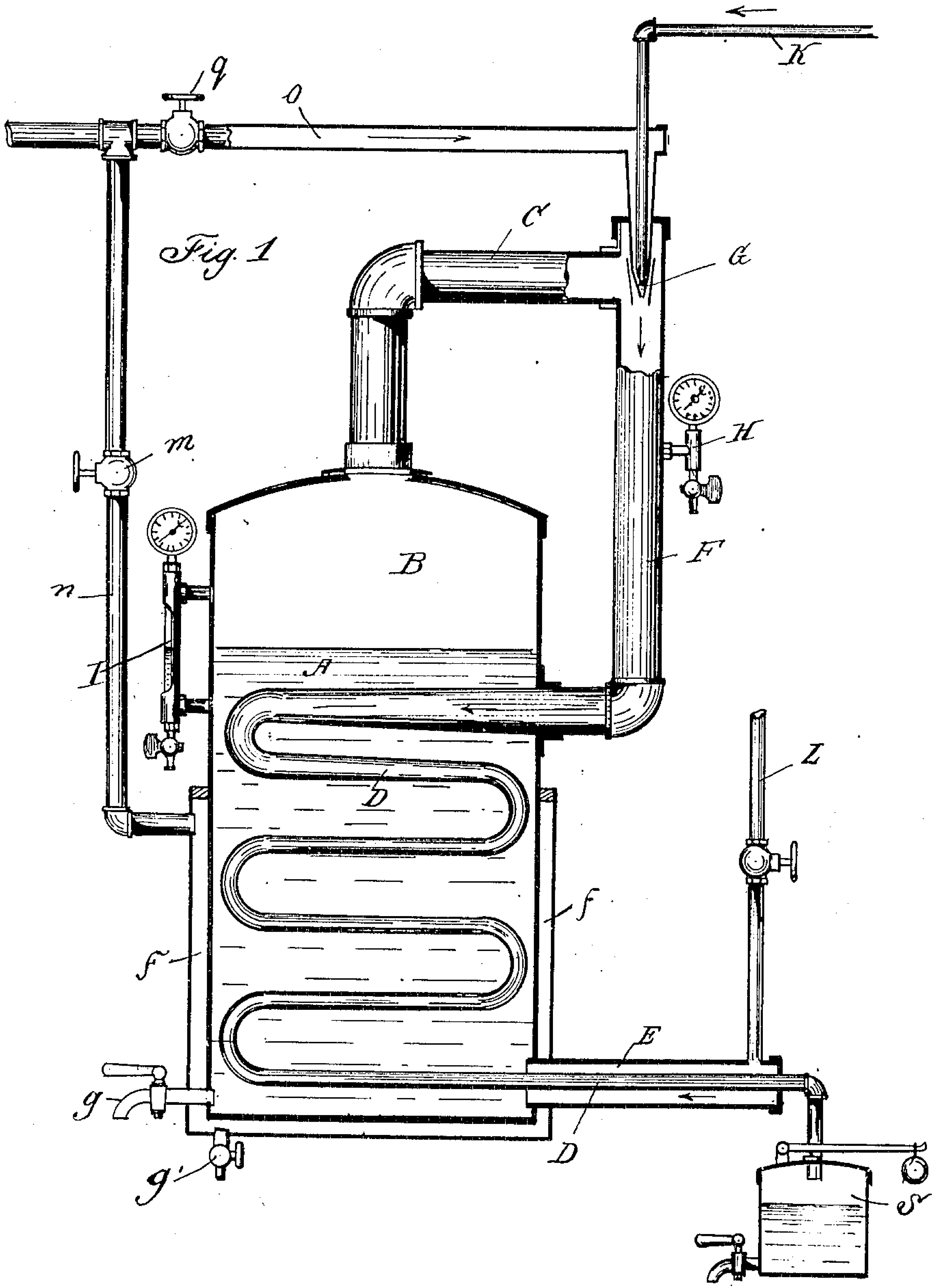

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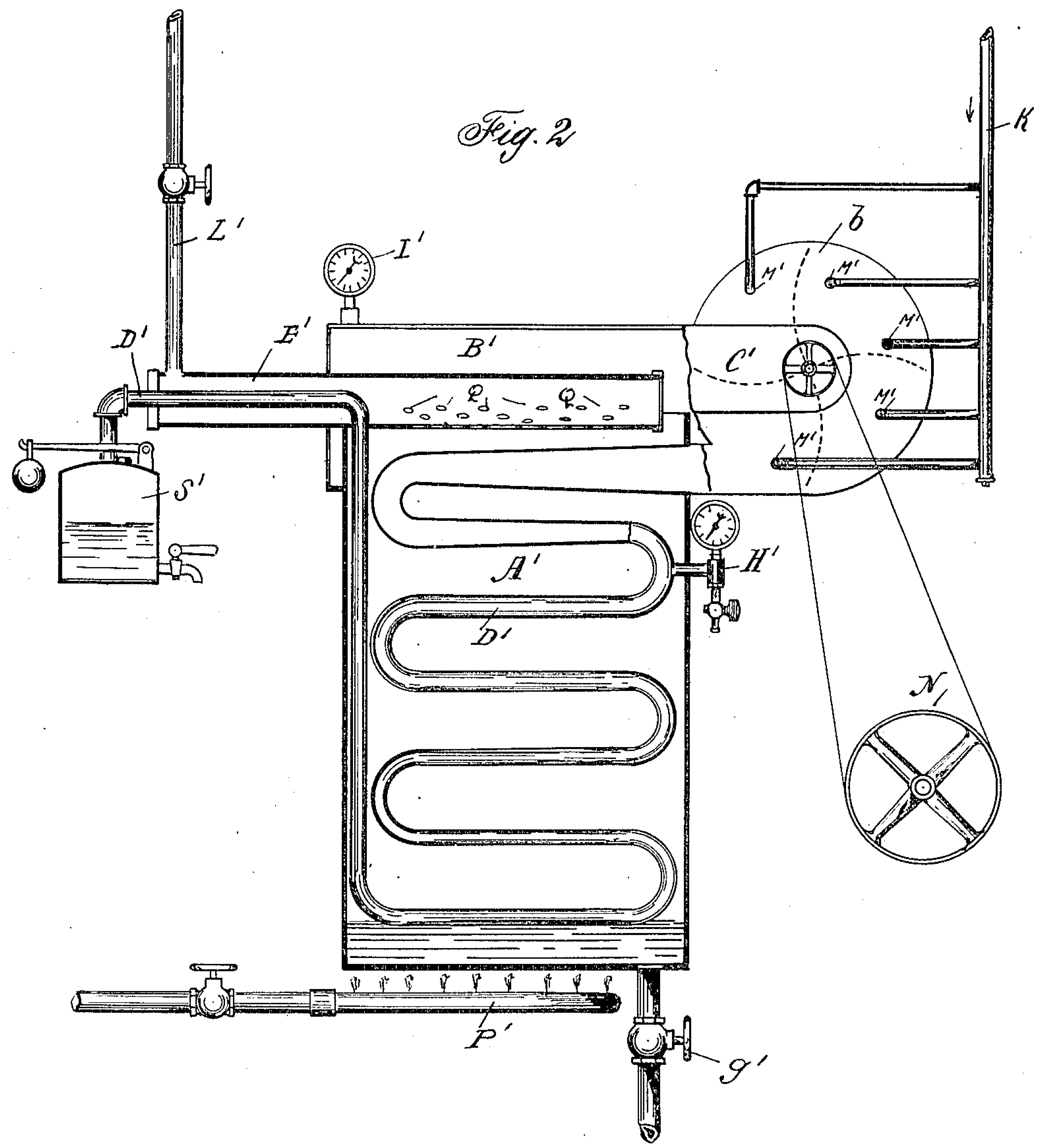
Fig. 2



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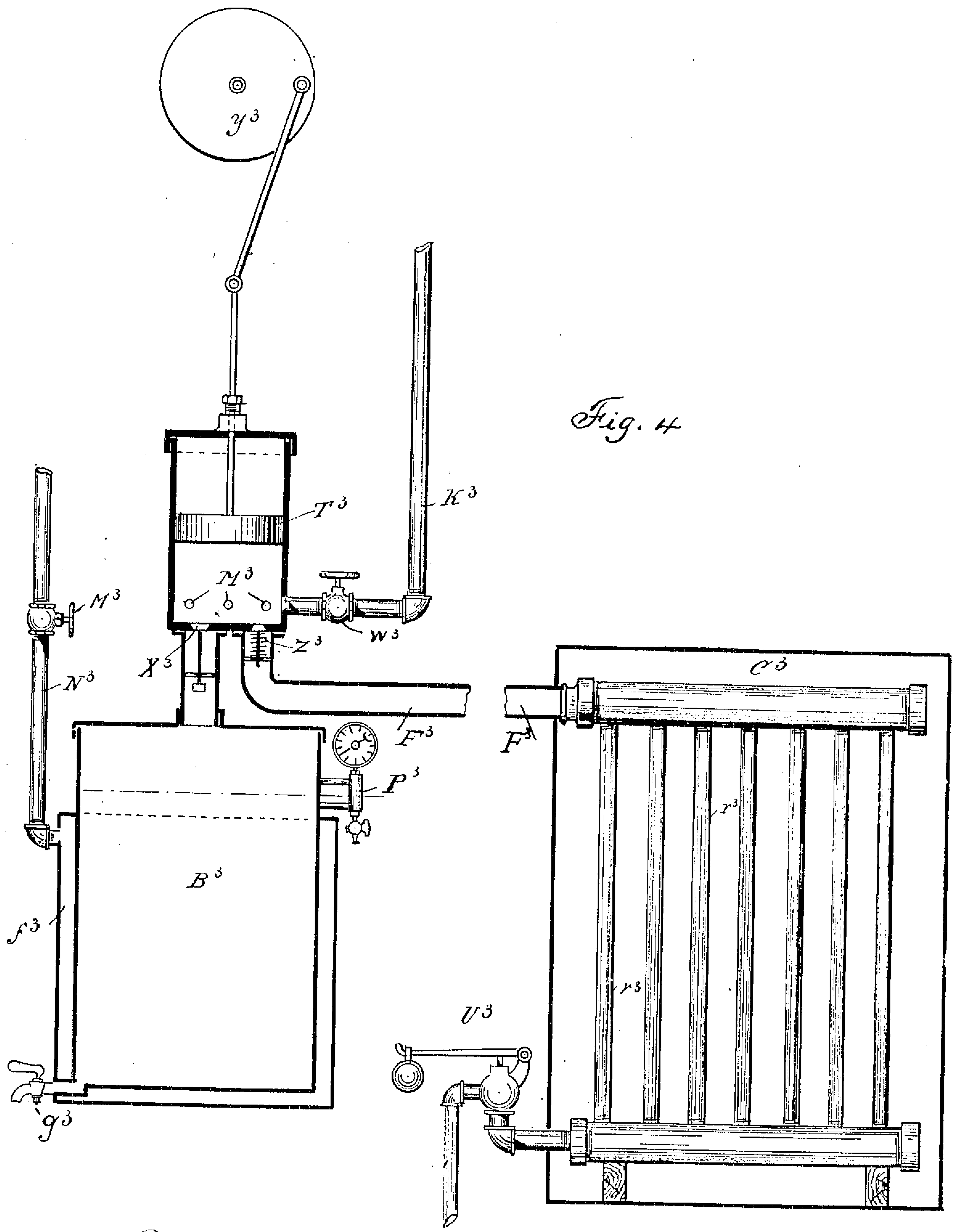
4 SHEETS—SHEET 4.

Fig. 4



Witnesses
Philip F. Keller
Caroline Siewertsen

Inventor
John E. Siebel

UNITED STATES PATENT OFFICE.

JOHN E. SIEBEL, OF CHICAGO, ILLINOIS.

ART OF DISTILLING, CONCENTRATING, AND EVAPORATING LIQUIDS.

No. 849,579. Specification of Letters Patent. **Patented April 9, 1907.**

Application filed April 25, 1904. Serial No. 204,871.

To all whom it may concern:

Be it known that I, John E. Siebel, a citizen of the United States, residing at Chicago, in the county of Cook and State of Illinois, have invented certain new and useful Improvements in the Art of Distilling, Concentrating, and Evaporating Liquids, of which the following is a clear description, which will enable others skilled in the art to make and use the same.

My invention relates to the process of distilling liquids of any kind by means of evaporation, in which the heat of condensation is utilized to assist in the evaporation.

The object of my invention is to provide a process for distilling, evaporating, and concentrating liquids wherein the vapors discharged by the evaporating or distilling liquid are withdrawn from the boiler and conducted through the liquid to be evaporated, thereby transferring their latent heat to the liquid to be evaporated.

My improvement in the process of evaporating, distilling, and concentrating of liquids therefore further consists in applying mechanical means for withdrawing and compressing the vapors formed by the evaporating of the distilling liquid, thereby producing a higher temperature, and thence removing the heat added by compression by the injection of a cooling liquid injected in a continuous stream or in broken sprays, by which the vapors are saturated before passing through conduits located within the liquid to be evaporated, distilled, concentrated, or heated.

My improvement in the process of distilling, evaporating, and concentrating of liquids may be carried out in various ways; but in order to fully set forth my improved process reference will be had to the accompanying drawings, which form part of this specification, and in which—

Figure 1 is a view of a still or boiler, partly in section, showing an injector for withdrawing the vapor and introducing the cooling liquid into the vapor-conduit. Fig. 2 is a view showing mechanical means for withdrawing the vapor and introducing the cooling liquid in the form of broken sprays. Figs. 3 and 4 show different constructions for carrying out my process.

Referring more particularly to Fig. 1 of the drawings, I denote by the letter A a still, boiler, or evaporator having a steam-space B, which terminates in a horizontal pipe C. The pipe C is connected at right angles with the pipe F, which latter pipe leads to a coil or worm D, located within the liquid-space of the boiler or still A, which pipe D terminates in a receptacle S. Before entering S the worm or coil D extends through a pipe E, said pipe E being connected with the boiler or still A. The pipe E is the means for conducting the cold liquid to be evaporated coming through the pipe L into the still A.

The pipe E, conducting the cold liquid to be evaporated, forms a counter cooling medium for the vapors condensed or liquid passing through the pipe D after leaving the still A, and at the same time the condensed liquid transfers its heat to the cold liquid, thereby raising the temperature of said cold liquid to that within the still or boiler, or nearly so.

The tension of the condensed vapors in the vessel or trap S is regulated by the weight of safety-valve secured on the vessel S, and at the same time the degree of compression which the vapors are under while passing through the worm or coil will be regulated by said safety device or valve. The compression of the vapors coming through the pipe C from the boiler B is effected by the higher pressure of live steam entering at G, as hereinafter described.

In order that the import of my invention may be most thoroughly understood, it is necessary to explain in detail the difference between saturated and superheated vapor and their respective properties. When steam or any vapor is confined in a vessel together with the liquid from which it has emanated, it is said to be in a saturated condition for the temperature and pressure under which it then exists. In other words, for any given temperature saturated steam has a certain definite pressure, a given volume has a certain definite weight, and a given volume or its corresponding weight of saturated steam contains a certain definite amount of total internal heat, which is generally expressed in heat units over and above the absolute zero-point. These qualities and quantities which define the nature of saturated steam have been carefully studied, and the results are contained in tables which are universally known and recognized. Saturated steam can also exist separated from the liquid from which it has emanated; but the slightest change of pressure or temperature changes its condition by either causing condensation of some of the steam into liquid (the balance of the steam remaining saturated) or by causing superheating of the steam. The steam is superheated when it contains more internal heat (in a given volume or weight) than that which corresponds to its pressure and temperature at the time, as shown by such steam-tables. Saturated steam is converted into superheated steam by the addition of heat. Superheated steam is also produced when two given amounts (say by weight) of saturated steam of different temperature and pressure are mixed together, for by referring to the steam-tables it can be readily shown that the total internal heat of both constituents of the mixture is greater than the internal heat of the mixed steam would be in a saturated condition, wherefore superheating would take place in pipe F unless liquid were injected thereinto. The reason for removing the superheating of the steam before it is used for heating purposes is to be found in the difference of the capacity for transferring heat between saturated and superheated steam. The heat of superheated steam—the latter being in the nature of a permanent gas—is conveyed through metal pipes or partitions at a much smaller rate than from saturated steam of equal temperature. Hence while in the apparatus described the heating-surface required of the heating-coil within the boiler would have to be impractically great if superheated steam circulated through them, it is permitted to be much smaller and within practical limits if the steam is saturated before it enters the coil, thereby saving much material in constructing and time in operating the apparatus for a given capacity and rendering it practically operative withal. Superheated steam is also produced when saturated steam is subjected to compression, for the work thereby done upon the steam is converted into heat, which amounts to more than the interior heat of the compressed steam would be if only in a saturated condition. Hence the steam is superheated by compression. In the manner just stated superheating would be produced in the apparatus illustrated in Figs. 2, 3, and 4, to be described afterward, if it were not prevented by a water-spray or cylinder water-jacket.

By the term "superheated steam," as used in this specification I refer more particularly to steam which at a given temperature and pressure contains for every pound of steam at least ten B. T. U. more heat than the same amount of steam would contain at the same given temperature and pressure if it were just saturated. This degree of superheating is produced, for instance, if saturated steam at the boiling-point of water and at the pressure of an atmosphere—*i. e.*, about 14.7 pounds gage-pressure—is compressed to about 16.7 pounds gage—*i. e.*, about two pounds higher—whereby it would acquire a temperature of about 218° Fahrenheit and contain in each pound of steam about ten B. T. U. more heat than the same amount of saturated steam contains at that temperature and pressure, for the work of compression converted into heat furnishes this amount of heat over and above that which is contained in saturated steam of the temperature of 218° Fahrenheit and at a gage-pressure of about 16.7 pounds per square inch.

Returning to Fig. 1, a steam-jacket *f* surrounds a portion of the still A containing the liquid to be evaporated, which jacket is supplied by steam through the pipe *n* and valve *m;* but in its place any other means for heating the contents of the still may be employed to add the desired heat to the liquid and to initiate the boiling conditions. An injector G or an equivalent device is employed to withdraw the vapors from the steam-space B of the still and force the vapors thus withdrawn into F and D by means of the injection of steam of a higher pressure than that prevailing in B. The steam enters the injector through the pipe O and valve *q*. The superheating incidental to the mixing of the steam of a higher pressure entering through the pipe O with the steam of a lower pressure entering from the space B is removed by distilled water drawn in by the injector through the pipe K. The steam entering through the pipe O is of practically the same pressure as that in the steam-jacket *f*, as both are drawn from the same source—viz., from an ordinary steam-boiler, for instance. Accordingly, both the steam in pipe O as well as in the jacket *f* must be of a higher pressure and temperature than the steam coming through the pipe C, for the generation of the latter steam is due to the higher pressure and temperature of the steam in the steam-jacket *f*. The vapor in the pipe F, thus saturated and possessing a higher pressure and also a higher temperature than that obtaining within the still or evaporator A, passes through the coil D, where it is condensed, and at the same time its latent heat is transferred to the liquid in the still A, the condensed liquid passing off through the counter cooling device E and entering the vessel S. I also provide a faucet *g*, which serves for the withdrawal of the concentrated liquid or residuary matter from the bottom of the still or evaporating vessel A. H is a pressure-gage showing the pressure in F, and I is a water and pressure gage showing the pressure and the level of the water in the still A. The valve *g'*, Fig. 1, carries off the water of condensation in *f*. For operating and regulating this device the safety-valve on the vessel S is to be adjusted to a pressure about five pounds higher than that shown by gage I, and valves *q* and *m* and liquid inflow through K and L must be so regulated that the pressure on gage H is a little higher than that on vessel S.

The device illustrated in Fig. 2 shows different means for carrying out my process. In this device I substitute a fan *b* for the injector. The suction end of the fan withdraws the vapors from the still or evaporator A′ and compresses them on the pressure side of the fan. The degree of compression which the vapor is subjected to on the pressure side of the fan when forced or compressed into the coil D′ is regulated by the safety-valve on top of the vessel S′, which also determines the pressure in the coil D′. The superheating of the vapor incidental to the compression is removed within the fan by means of liquid, which enters in the form of a spray through the pipes M′ M′ M′ M′, which are supplied through the pipe K′. The vapor coming from the still A′, being thus saturated and possessing a higher degree of pressure and also a higher degree of temperature than that which exists in the still A′, passes now through the pipe D′, where it is deprived of its latent heat and condensed into liquid. The vapor condensed in D′, or rather the liquid formed thereby, is forced upward through a vertical portion of the pipe D′ before it enters the counter cooling device E′, the rising of the liquid upward being effected through the pressure in the pipe D′, caused by the operation of the fan *b*. The liquid to be evaporated enters through the pipe L′, and after the same has become heated in the counter cooling apparatus it passes into the still A′ in the form of a fine spray through the holes O O, the liquid spray trickling over the pipe D′. The pipe D′ being hot, the liquid is partially converted into vapor, and the residue arrives at the bottom of the evaporator in a concentrated condition ready to be drawn off through the faucet *g*′. This device is especially adapted for the continuous evaporation of liquids. The fan is operated by the pulley N′, the other appendages, such as gages I′ and H′ and the vessel S′, having the same function as shown in Fig. 1. In Fig. 2, instead of heating the liquid to be evaporated by the steam-jacket I provide a burner, as shown at P′; but any suitable heating device may be used. As appears from the foregoing, in operating this device the revolution of the fan *b* and the inflow of water through K′ and L′ must be so regulated that the pressure shown by gage H′ is a little higher than the pressure to which the safety-valve S′ is adjusted, the latter to be about five pounds higher than the pressure shown by the gage I.

In the device designed for carrying out my improved process as shown in Fig. 3 a piston-pump or compressor T is used to manipulate the vapors coming from the still or evaporator A″. The vapors issuing from the boiling liquid are withdrawn or taken in from the steam-space B″ by the pump T, which is operated by a crank *y* through the valve *x* and then forced into the pipe D″ through the valve *z*. While the vapors are being compressed in the compressor they become superheated. This superheating is removed by the cooling of the pump-cylinder with cold water admitted through the valve V and circulating through the water-jacket R R and out through the valve *a;* but the saturation of the superheated steam is preferably effected by means of sprays of liquid M″, admitted into the pump-cylinder by means of the valve W, the jacket being an auxiliary cooling device. In order that the distillate may not be contaminated by the liquid injected into the compressed vapors to remove their superheating, such liquid is drawn from the distillate already condensed if the distillate is the object of the operation and from the original liquid if the concentrated liquid or residue in the boiler is the object of the operation. The saturated vapor which enters the pipe D″ has a pressure and temperature higher than that obtaining in the still A″. The degree of compression which the vapor is subjected to in the pump or compressor T while being forced or compressed into the coil D″ is regulated by the valve Z, which is so adjusted that the pressure will be about five pounds per square inch (more or less) higher in the pump or compressor T than in the boiler B″. I do not confine myself to any definite pressure in adjusting the valve Z, as this may be varied; but for the practical proportioning of the different parts of the apparatus I prefer that the steam be compressed by the compressor T to a pressure at least five pounds higher than the pressure in the still B. In that case, assuming, for instance, that water is being distilled or boiled in the still or boiler B at 212° Fahrenheit under atmospheric pressure of 14.7 pounds gage-pressure per square inch, the compressed steam will have a pressure of about twenty pounds per square inch, a temperature of about 227°, and its superheating will amount to about two thousand five hundred British thermal units over and above the heat contained in one hundred pounds of saturated steam at the last-mentioned pressure and temperature. The valve U″, which regulates the outflow of the liquid condensed in D″, should be adjusted to the same pressure as Z, or nearly so. The amount of liquid required to be injected in order to remove the superheating is determined chiefly by the degree of compression of the vapor in each case and can be readily calculated, allowing for the conduction by the pump-cylinder in very close cases. However, an excess in the amount of liquid injected does no particular harm. If the valve Z is adjusted to a pressure about five pounds per square inch higher than the pressure in B″, about 2.5 pounds of liquid must be injected into the compressor T during compression of one hundred pounds of vapor. The valve g'' serves for the withdrawal of the concentrated liquid or other residuary matter from the still A″, and the gage H″ and I″ serve the same purposes as the corresponding attachments in Figs. 1 and 2. In this apparatus I also provide means to perform the initial heating of the liquid in the still A″. These means are indicated by the burner P″; but any other source of heat, as a steam-jacket, &c., may be employed. The liquid to be evaporated or distilled is supplied to the still or boiler A″ either as is shown in Fig. 1 or as it is shown in Fig. 2, and the speed of the pump, the water inflow and outflow valve U″ are regulated the same way as in the devices already described.

The device illustrated in Fig. 4 shows the application of my invention to cases in which spent steam of a certain pressure is to be used for heating purposes in cases where it is to be brought to a higher temperature or pressure, or both, in order to force it through the coils and other conduits. Accordingly, referring to Fig. 4, the steam which is generated in the boiler B^3 by means of the steam-jacket f^3 is taken in by the pump or compressor T^3 and then compressed by the downgoing piston which closes valve X^3, the valve Z^3 remaining closed until the compression has reached the required degree—say five pounds to the square inch higher than the pressure obtaining in the boiler B^3, more or less, as I do not confine myself to any definite pressure. While being compressed the saturated steam confined in the body of the pump or compressor would become superheated, as explained above; but this is prevented by injecting a liquid into the pump-cylinder through the holes M^3 by means of the pipe K^3, as described above. When the pressure of the compressed and saturated steam in the body of the pump or compressor T^3 exceeds the pressure indicated by the valve Z, it is forced through the pipe F, in which it condenses, giving off the latent heat of evaporation while warming the chamber C^3 in which the coil F^3 is placed. The condensed water forming in the coil F^3 is removed through the valve V^3. The water condensing in the steam-jacket f^3 may be withdrawn by an outlet similar to that shown by the letter g' in Fig. 1. The other appendages have the same function as shown in Fig. 1, and the operation of the still or boiler B^3 and the management of its appendages is performed in the manner already described.

What I claim as my invention, and desire to secure by Letters Patent, is—

1. In the process for distilling, concentrating, evaporating and heating liquids, the withdrawal of the vapors formed, increasing their temperature and pressure, saturating them and passing them through the distilling liquid, substantially as set forth.

2. The process of distilling, concentrating and evaporating liquids consisting in heating the liquid to a boiling-point, withdrawing the vapor from said liquid and compressing the same, saturating the compressed vapor and transferring the saturated compressed vapor through a conduit located within the evaporating liquid to a withdrawal-chamber, substantially as set forth.

3. The process of distilling, concentrating and evaporating a liquid, consisting in applying heat thereto to bring it to a boiling-point, then withdrawing the vapor by mechanical means and compressing the same and introducing liquid in the compressed vapor thereby saturating the same, raising its temperature and pressure above that of the boiling liquid, then by conduction transferring substantially the entire latent heat of evaporation to the liquid to be distilled, substantially as set forth.

4. The process of distilling, evaporating and concentrating liquids, consisting in heating the liquid to a boiling-point, withdrawing the vapor by mechanical means and compressing the vapor and saturating the same by introducing liquid in the form of a spray and by conduction transferring the entire latent heat of the compressed vapor to the liquid to be evaporated and withdrawing the condensed vapors, substantially as set forth.

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

JOHN E. SIEBEL.

Witnesses:
CAROLINE SIEWERTSEN,
PHILIP F. KELLER.