

1,143,380.

G. H. GIBSON.
CONDENSER.
APPLICATION FILED DEC. 14, 1911.

Patented June 15, 1915.
4 SHEETS—SHEET 2.

FIG. 2.

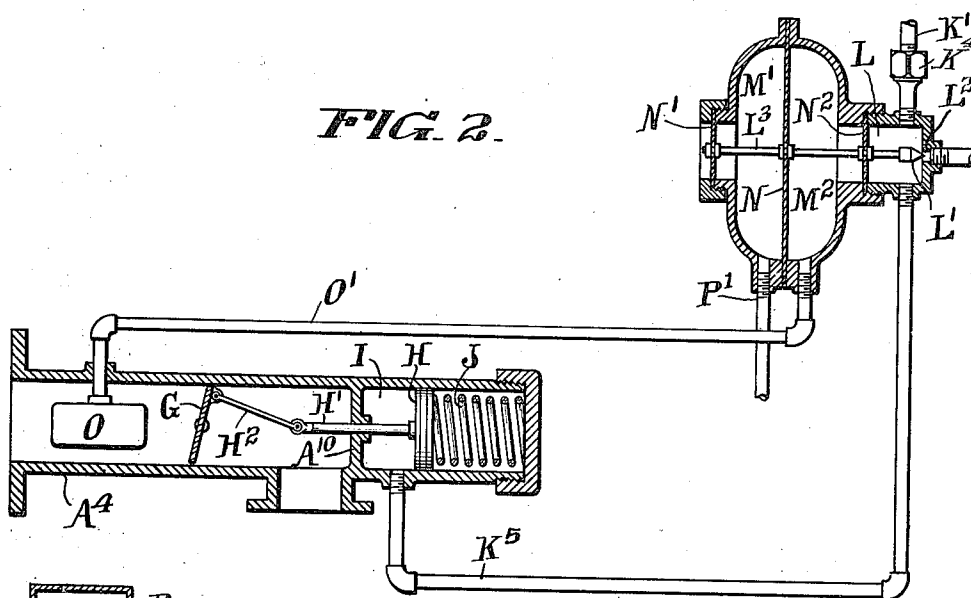


FIG. 3.

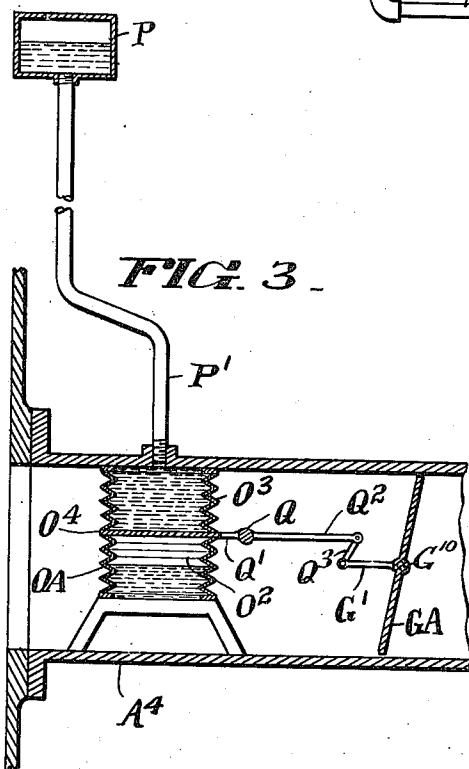


FIG. 4.

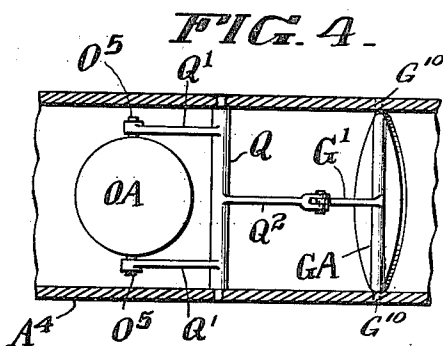
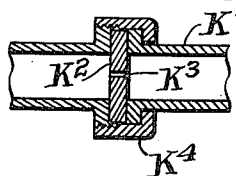


FIG. 5.



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FIG. 6

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4 SHEETS—SHEET 4.

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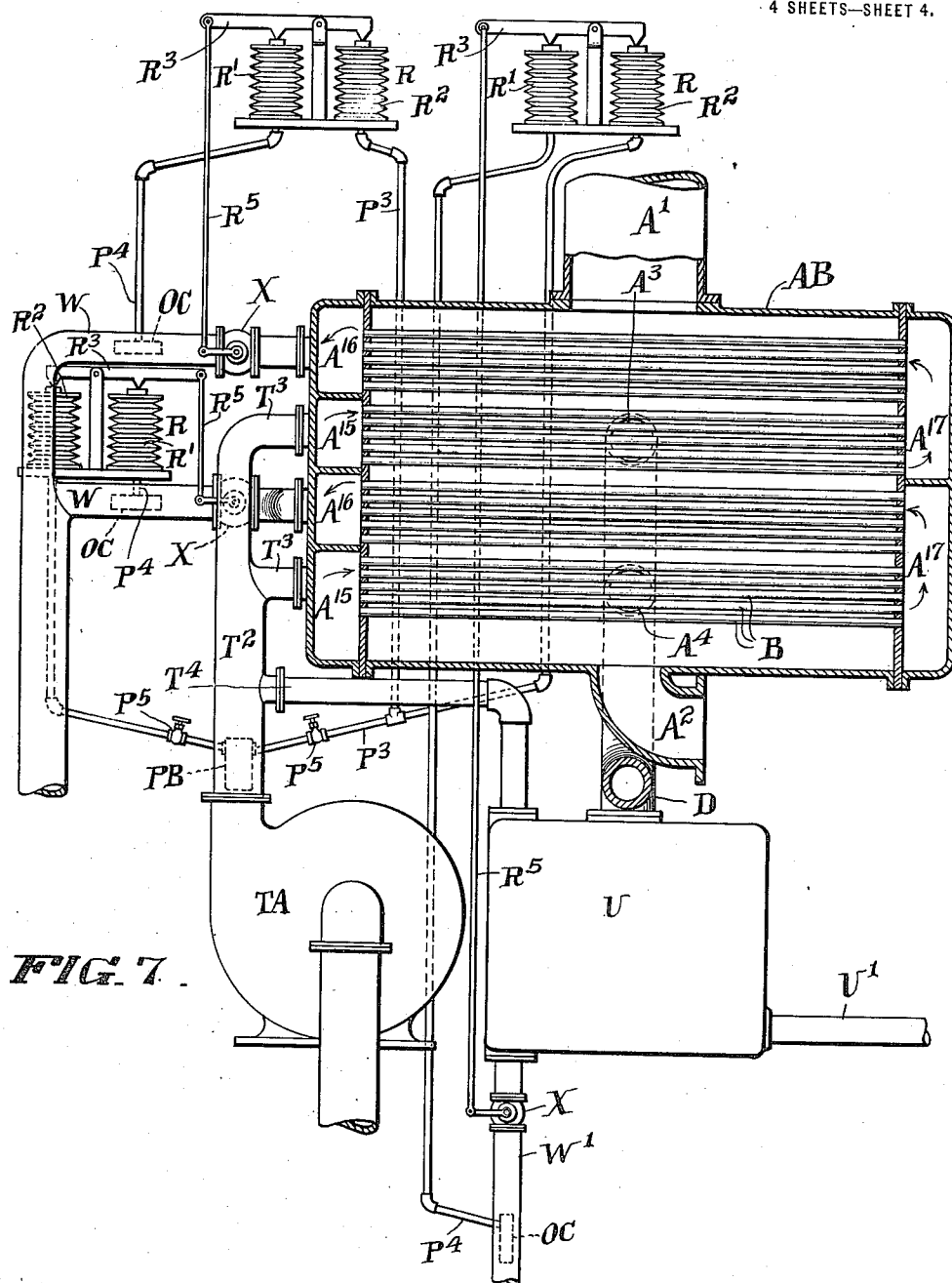


FIG. 7.

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CONDENSER.

1,143,380.

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To all whom it may concern:

Be it known that I, GEORGE H. GIBSON, a citizen of the United States of America, residing in Montclair, in the county of Essex and State of New Jersey, have invented a certain new and useful Improvement in Condensers, of which the following is a true and exact description, reference being had to the accompanying drawings, which form a part thereof.

My present invention relates to condensers such as are employed for condensing exhaust steam from engines, turbines and the like, and the object of the invention is to improve the operation of such condensers by providing effective means for regulating the circulation therein of the fluid cooled or the cooling fluid or both fluids.

The invention in its broader aspects is applicable to surface and injection condensers of various types, but is of especial utility in connection with surface condensers of relatively large size and having two or more outlets through which air, or rather the partially cooled air and steam mixture may be withdrawn from the condensing space of the condenser, and in connection with large sized surface condensers having two or more circulation paths for the cooling water. With such a condenser provisions for automatically regulating the circulation through the steam space by separately regulating the air outlets, or for separately regulating the flow of the cooling water through different portions of the condenser, as conditions require, obviously contribute to the economy and effectiveness of operation of the condenser.

The various features of novelty which characterize my invention are pointed out with particularity in the claims annexed to and forming a part of this specification. For a better understanding of the invention, however, and the advantages possessed by it reference should be had to the accompanying drawings and descriptive matter in which I have illustrated and described various forms in which my invention may be embodied.

Of the drawings, Figure 1 is a somewhat diagrammatic elevation with parts broken away and in section of a surface condenser equipped with one form of my invention. Fig. 2 is a sectional elevation on a larger scale than Fig. 1 of a portion of the apparatus shown in the latter. Fig. 3 is a par-

tial sectional elevation of a condenser equipped with a modified form of air removing apparatus and, Fig. 4 is a plan of a part of the apparatus shown in Fig. 3, with the conduit shown in section. Fig. 5 is a partial sectional elevation of a flow restricting device employed in Figs. 1 and 2. Fig. 6 is a diagrammatic representation partly in sectional elevation of an injection condenser having two air outlets with automatic flow regulation provisions for each, and automatic provisions for regulating the circulation of the cooling water. Fig. 7 is a somewhat diagrammatic elevation partly in section of a surface condenser having two separate circulating paths for the cooling water, and provisions for separately regulating the flow through them and for regulating the flow of the cooling fluid through the air cooler attached to the condenser.

In Figs. 1 and 2 of the drawings I have shown a surface condenser having four air outlets and provisions for automatically regulating the flow through each of these outlets. As shown in Fig. 1, A, represents the shell of the condenser which has a steam inlet A' at its upper end, and an outlet A² for water of condensation at its bottom. A³, A⁴, A⁵ and A⁶ represent the outlets through which the air is withdrawn from the condenser at four different points. B represents the condenser tubes, C represents baffles or rain plates which may be employed to deflect water of condensation formed in the upper portion of the condenser from the lower tubes. D represents piping connecting the various air outlets A³, A⁴, A⁵ and A⁶ to the pump D' by which the air drawn from the condenser may be passed to an air cooler wherein any remaining steam admixed with the air is condensed. Separate regulating means are provided at each of the air outlets A³, A⁴, A⁵ and A⁶ to prevent the air and steam admixed therewith from passing out at too high a temperature. As shown in Fig. 1 the regulating means for the different outlets are all alike and it will only be necessary to describe the means applied to the outlet A⁴ shown in detail in Fig. 2. As shown in Fig. 2 the flow through the outlet A⁴ is directly controlled by a damper or valve G in the form of a pivoted vane. It is to be noted that in general, it is not essential that this damper should ever tightly close the outlet in which it is placed, its

proper function being simply to regulate without absolutely checking the discharge through the outlet. In the form shown, one end of a link H^2 is pivoted to the damper G at one side of the axis of the latter. The other end of the link H^2 is connected to the stem H' of a piston H working in the cylinder space I, formed by the closed outer end of the passage A^4 beyond the partition A^{10} . A spring J acting on the rear end of the piston H tends to move the latter into a position in which the connected damper G substantially closes the air outlet. To move the piston H outward and correspondingly open the damper G means are provided for supplying a pressure fluid, such as compressed air or steam to the inner end of the cylinder space I through a pipe K^5 .

While the invention in its broader aspects does not depend upon the exact character of the pressure fluid employed I prefer to use steam rather than compressed air, because with steam, any leakage which may take place along the piston rod H' into the condenser through the apertured partition A^{10} does not tend to impair the vacuum in the condenser.

In the form of apparatus shown in Figs. 1 and 2 the pipe K^5 leads from a chamber L to which steam or other pressure fluid is continuously supplied through a branch K' of the pressure supply piping K. Each branch K' includes a diaphragm K^2 , see Fig. 5, formed with a restricted orifice K^3 through which the steam or other pressure fluid slowly leaks into the chamber L. The diaphragm is secured in place between adjacent sections of the pipe K by a coupling K^4 . The pressure in the chamber L is regulated by a valve L' which controls a discharge orifice L^2 from the chamber. When the port L^2 is closed the pressure in the chamber L slowly builds up approaching the pressure in the piping K as a maximum and when the port L^2 is open the pressure falls to the pressure of the atmosphere as a minimum.

In the apparatus shown in Figs. 1 and 2 each valve L' is made automatically responsive to the difference between the temperature existing at the steam inlet of the condenser or more accurately, in the construction shown, at a point in the interior of the condenser adjacent the steam inlet, and the temperature prevailing in the particular air outlet to which the particular valve L' pertains. The means by which this is accomplished comprises a pressure chamber M shown as rigidly connected to the chamber L and divided into two main compartments M' and M^2 by a flexible diaphragm N, and having centrally disposed and alined apertures formed in its opposed walls. The apertures are closed by small diaphragms N' and N^2 . The three diaphragms N, N'

and N^2 are rigidly connected to each other and to the valve L' by the stem L^3 of the latter. The diaphragm N^2 serves to separate the compartment M^2 of the pressure chamber M from the chamber L. The pressure chamber M^2 is connected by a pipe O' to a receptacle O located in the corresponding air outlet passage of the condenser, and the compartment M' of each of the various pressure chambers M is connected by piping P' to a receptacle P located within the condenser shell adjacent the steam inlet. As shown the receptacle P is mounted in brackets or ears carried by the condenser shell. The receptacles O and P are each partially filled with a volatile liquid, and the fluid pressure in the compartments M' and M^2 of each pressure chamber M is thus made proportional to the temperatures prevailing respectively in the portion of the condenser in which the receptacle P is located, and in the particular air outlet to which the pressure chamber M pertains. The steam entering the condenser through the steam inlet A' has admixed therewith under normal operating conditions a small percentage of non-condensable vapors and gases commonly designated collectively as "air." As this mixture moves through the condensing space and toward the air outlets, the major portion of the steam condenses, but none of the air condenses. The mixture of steam and air must obviously become richer in air as the distance from the air outlets diminishes. The pressure varies but slightly in different portions of the condensing space and in accordance with well known laws, the temperature of a mixture of a saturated vapor, such as wet steam and a non-condensable gas, at a given pressure decreases as the percentage of the non-condensable gas in the mixture increases. In such apparatus as is shown in Fig. 1, therefore, with a given temperature at the steam inlet of the condenser the temperature at any of the air outlets from the condenser will be less than the temperature at the steam inlet by an amount which will increase as the percentage of air in the steam and air mixture adjacent the air outlet becomes larger. The regulating apparatus should be so adjusted, therefore, that whenever the temperature at any air outlet as compared with the temperature at the steam inlet rises to a value corresponding to a percentage of steam in the fluid passing through the outlet which is greater than is desirable, the corresponding valve L' will be moved to open its port L^2 , thus allowing the pressure in the chamber L and cylinder space I to fall. When this occurs the corresponding damper G begins to close under the action of the spring J working against the piston to which the damper is connected. Conversely, when the temperature in any air outlet as compared with the

temperature at the steam inlet falls to a point indicating an undesirable accumulation of air in the portion of the condenser adjacent that air outlet, the apparatus should be so set that the corresponding valve L' will close its port L^2 and thus permit the pressure in the corresponding chamber L and cylinder space I to build up and force the piston H outward against the action of its spring J to thereby open the damper G to the desired extent.

It will be readily apparent to those skilled in the art that while the difference between the pressures prevailing in the two compartments M' and M^2 of each pressure chamber may be comparatively small, the damper operating pressure maintained in the corresponding chamber L and inner end of the connected cylinder I is equal to the product of this pressure differential multiplied by the ratio of the areas of the diaphragms N and N^2 . In practice, with the apparatus disclosed the pressure differential prevailing on a difference of a degree or so between the temperatures of each cooperating pair of receptacles P and O is ample to effect the operation of the corresponding damper G through its entire range. By employing the diaphragm N to separate compartments M' and M^2 in place of a sliding piston and by employing the similar diaphragm N^2 , I obviate leakage troubles and the effects of variations in the atmospheric pressure.

In some cases it may be unnecessary to employ a pressure augmenting arrangement such as is shown in Figs. 1 and 2, and in Figs. 3 and 4 I have shown apparatus adapted to be used in a condenser, such as is shown in Fig. 1, in lieu of the apparatus shown in detail in Fig. 2. In this modified form the difference between the pressures prevailing in the receptacle P and in a receptacle located in the air outlet of a condenser may be directly employed to actuate a damper GA . As shown in Figs. 3 and 4 a flexible metallic bellows OA having its ends separated by a fixed distance is placed in the air outlet of the condenser. The bellows is divided into two aligned sections or compartments O^2 and O^3 by an interposed diaphragm O^4 . The lower compartment is partially filled with a volatile liquid while the compartment O^3 is directly connected by a pipe P' to the corresponding receptacle P . The diaphragm O^4 is provided with trunnions O^5 engaged by arms Q' carried by a rock shaft Q . The latter is journaled in bearings carried by the air outlet piping and is provided with an arm Q^2 connected by a link Q^3 to the projection G' of the corresponding damper GA , which is pivoted at G^{10} . As the diaphragm O^4 moves upward from the position shown in Fig. 3, the damper GA will open, and on a subsequent

downward movement of the diaphragm the damper will close. The receptacle P will ordinarily be exposed to a somewhat higher temperature than will the bellows OA , and the pressure of the vapor in receptacle P which will correspond to the temperature of the latter will be transmitted to the chamber O^3 . The pressure in the chamber O^3 will thus be equal to the vapor pressure in chamber P plus a substantially constant hydrostatic pressure due to the liquid filling the chamber O^3 and pipe P' , and partially filling the receptacle P . The vapor pressure in the chamber O^2 will obviously correspond to the temperature to which the bellows OA is exposed. The variable pressure resultant acting on the diaphragm O^4 will thus be the differential of the vapor pressure in chamber O^2 and the vapor pressure in receptacle P . The damper GA , diaphragm O^4 and connected parts will be adjusted, of course, so that the diaphragm and damper will move in the desired and predetermined manner in response to changes in the variable differential pressure acting on the diaphragm. With this apparatus it will be apparent therefore that the damper GA will open and close, as the difference between the temperatures prevailing, respectively in the portion of the condenser in which the receptacle P is located, and in the air outlet passage of the condenser increases and decreases.

In the modified form of apparatus shown in Fig. 6 provisions are made for regulating the discharge of air from an injection condenser through two separate air outlets, the regulating provisions being automatically responsive to the difference between the temperature in the steam inlet to the condenser and the temperature in each air outlet, as in the apparatus shown in Figs. 1 and 2. In addition, provisions are made for regulating the supply of cooling water to the condenser in response to the difference between the temperatures prevailing at the water inlet and water outlet of the condenser shell. As shown in Fig. 6, AA , represents the condenser shell, A^7 the steam inlet, A^8 the water outlet at the bottom of the shell, and A^9 the inlet for the cooling water at the top of the shell. A^{10} and A^{10} represent the two air outlets which have regulating provisions employed in conjunction therewith similar to those shown in Figs. 1 and 2 and as corresponding parts are indicated by the same reference symbols, no further description of this portion of the apparatus shown in Fig. 6 need be given. A^{11} represents the various baffles and apertured plates for properly subdividing and distributing the cooling water admitted to the condensing chamber. The cooling water is supplied to the condenser by a suitable pump T . The pump T is

driven by a suitable motor S which, as shown, is a steam engine, S' representing the steam supply pipe and S² a throttle valve regulating the flow therethrough. The valve S² is adjusted by means of a device R, which comprises two bellows members R' and R² the movable upper ends of which are engaged by a lever R³ which has a fulcrum at R⁴ and is connected by a link R⁵ to the operating arm of the valve S². The bellows R' of the device R is connected by a pipe P² to a volatile liquid containing receptacle PA arranged at the mouth of the cooling water inlet A⁹. The other bellows is connected by a pipe O⁵ to a volatile liquid containing receptacle OB arranged in the water outlet A⁹ of the condenser. By means of the provisions described the flow of cooling water may obviously and advantageously be regulated in accordance with the need for such water as the quantity of steam to be condensed varies.

In the modification shown in Fig. 7, AB represents the shell of a surface condenser provided with a steam inlet and air and water outlets, as in Fig. 1, the piping D from the air outlets leading in this case however to an air cooler U of usual form. U' represents the air and water of condensation outlet from the cooler U, and W' represents the cooling water outlet thereof. The tubes B of the main condenser are shown as arranged in four vertical banks which are coupled together in pairs at their right hand ends by the chambers A¹⁷, and open at their left hand ends into the cool-water inlet chambers A¹⁵, and outlet chambers A¹⁶. As shown the first and third banks of tubes, counting from the bottom open to the inlet chambers A¹⁵ and the other banks of tubes open to the outlet chambers A¹⁶. TA represents a pump for circulating the cooling water. The discharge pipe T² of the pump has one branch T⁴ running to the supplementary cooler U and forming the cooling water inlet for the latter and two branches T³ running, one to each of the two inlet chambers A¹⁵. W, W, represent outlet pipe connections from the chambers A¹⁶. In each of the pipes W, W and W' there is placed a regulating valve X having its operating arm connected by a link R⁵ to the lever R³ of a corresponding device R like the device R of Fig. 6. One bellows chamber R² of each of the three devices R is connected by pipe P³ to a volatile liquid containing receptacle PB located in the delivery pipe T² of the pump TA. The other compartment of each device R is connected by a corresponding pipe P⁴ to a volatile liquid containing receptacle OC located in the corresponding outlet pipe W or W'. The apparatus shown in Fig. 7 should be so adjusted that during periods of heavy load the cooling water will pass freely from the pump TA through the air

cooler and through both of the circulating paths of the main condenser. As the load falls off, the duty to be performed by the air cooler U will diminish, and the temperature of the water issuing through pipe W' will fall. This automatically actuates the corresponding device R to more or less completely close the valve in the pipe W'. On a still further diminution in the amount of steam to be condensed the temperature of the water issuing through the lower of the two outlet pipes W will fall and the flow of water therethrough will be correspondingly reduced. Finally at very light loads the temperature of the water issuing through the upper pipe W will fall and the flow of water therethrough will be correspondingly throttled.

It will be understood of course that the pump TA should be of such a character or have such regulating provisions that it will operate with varying deliveries and the consumption of power required to operate it will diminish with the amount of water delivered. This result is obtained automatically of course with a centrifugal pump of the kind conveniently illustrated by the drawing. While I consider it advantageous to regulate the flow of the cooling water in response to the difference between the temperatures prevailing at the inlet and outlet of each circulating path it is to be noted that the temperature range of the outlet water is much greater and much more nearly responsive to conditions of operation than is the case with the air passing through the air outlet from the condensing space of a condenser. Because of this greater range and responsiveness of the outlet water of a surface condenser it is to be noted that it is sometimes advantageous to independently regulate the circulation of the cooling water through the different circulation paths of a surface condenser without making the regulating devices responsive to the inlet temperature of the cooling water. For instance, the apparatus as shown in Fig. 7 may be adjusted to operate without the use of the receptacle PB, which may be entirely removed or effectively cut out of service by closing the valve P⁵ in the branches of the piping P³ leading away from the receptacle PB. Where the container for the volatile liquid is connected to a pressure chamber of a motor valve, as the containers OC and PB are connected, in Fig. 7 for instance, to the pressure chambers R' and R² of the motor valves comprising the motors R and connected valves X proper, I consider it generally advisable, and in some cases highly so, to have the apparatus so arranged that the pressure chamber will drain directly into the volatile liquid container, and to have the vapor outlet from the latter opening above the liquid level therein. With this arrange-

ment the apparatus may be made to operate satisfactorily, both when the motor valve pressure chamber is cooler than the volatile liquid container and the former consequently acts as a condenser for the volatile liquid; and also when the pressure chamber is hotter than the container since the pressure in the connected system is in general responsive in such a system to the temperature of the container for the volatile liquid.

In the apparatus shown by the drawings herein, the drainage is into the upper end of the volatile fluid container in every case except Fig. 3 where the upper bellows compartment O³ is at all times flooded. This arrangement is operative since the container P is in practice always hotter than is the chamber O³, but is open to the objection that the pressure in the chamber O³ is effected under varying temperature conditions by the consequent variations in the weight of the column of liquid in the pipe P' connecting the chamber O³ to the container P.

While in accordance with the provisions of the statutes I have illustrated and described the best form of my invention now known to me, it will be apparent to those skilled in the art that changes may be made in the form of the apparatus disclosed and may be used without departing from the spirit of my invention. It will also be understood by those skilled in the art that under some conditions it may be of advantage to use certain features of the invention without a corresponding use of the others.

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

1. The combination with a condenser having a plurality of air outlets, of means automatically responsive to the temperature of the fluid discharged through each outlet for regulating the rate of discharge through such outlet.

2. The combination with a condenser having an air outlet, of means automatically responsive to the difference between the temperatures prevailing respectively in a high temperature portion of said condenser and in said outlet for regulating the rate of discharge through said outlet.

3. The combination with a condenser having a plurality of air outlets, of separate means for regulating the rate of discharge through each of said outlets, the regulating means for each outlet being automatically responsive to the difference between the temperatures prevailing respectively in a high temperature portion of said condenser and in said outlet.

4. The combination with a condenser having an air outlet, of a damper controlling the flow through said air outlet, a receptacle containing a volatile fluid located in a high temperature portion of the condenser, a second receptacle also containing a volatile fluid located in said air outlet, and means automatically responsive to the difference in the fluid pressure in the two receptacles for opening and closing said damper as the difference in pressure varies.

5. The combination with a condenser having an air outlet, of a damper controlling the flow through said air outlet, fluid pressure operating means therefor, a valve controlling said means, a receptacle containing a volatile fluid located in a high temperature portion of the condenser, a second receptacle also containing a volatile fluid located in said air outlet, and means automatically responsive to the difference in the fluid pressures in the two receptacles for opening and closing said valve as the difference in pressure varies.

6. The combination with a condenser having inlet and outlet connections for the fluid to be condensed and cooled and for the cooling fluid, of means responsive to the difference between the temperature of admission and discharge of one of said fluids for regulating the flow thereof through said condenser.

7. The combination with a condenser having a plurality of air outlets, of separate thermostatic devices responsive to the temperatures prevailing within the condenser for separately controlling the discharges through the different air outlets.

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