May 9, 1933. E. ALTENKIRCH 1,908,277

ABSORPTION MACHINE

Filed July 23, 1930 2 Sheets-Sheet 1

Fig. 1

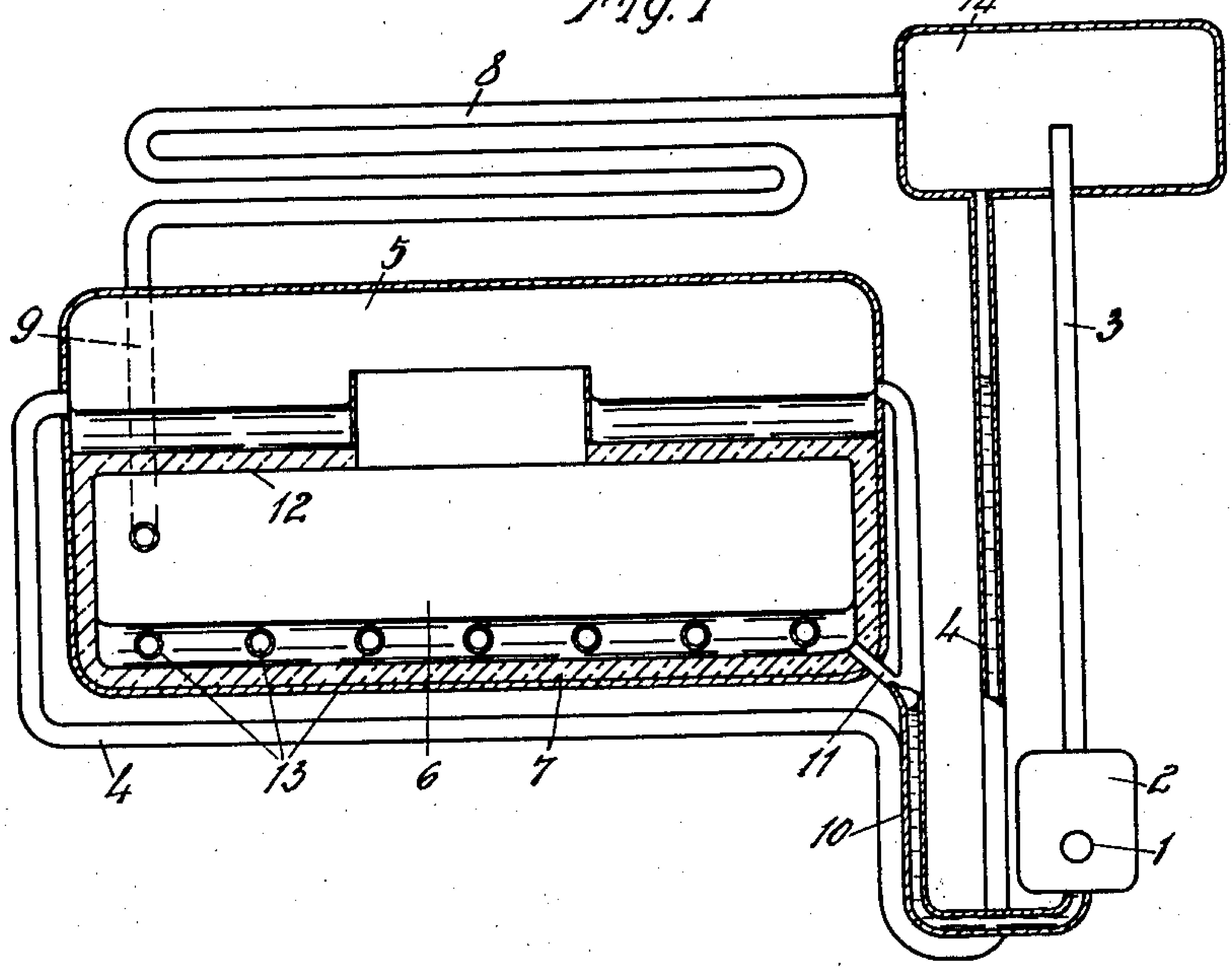


Fig 3

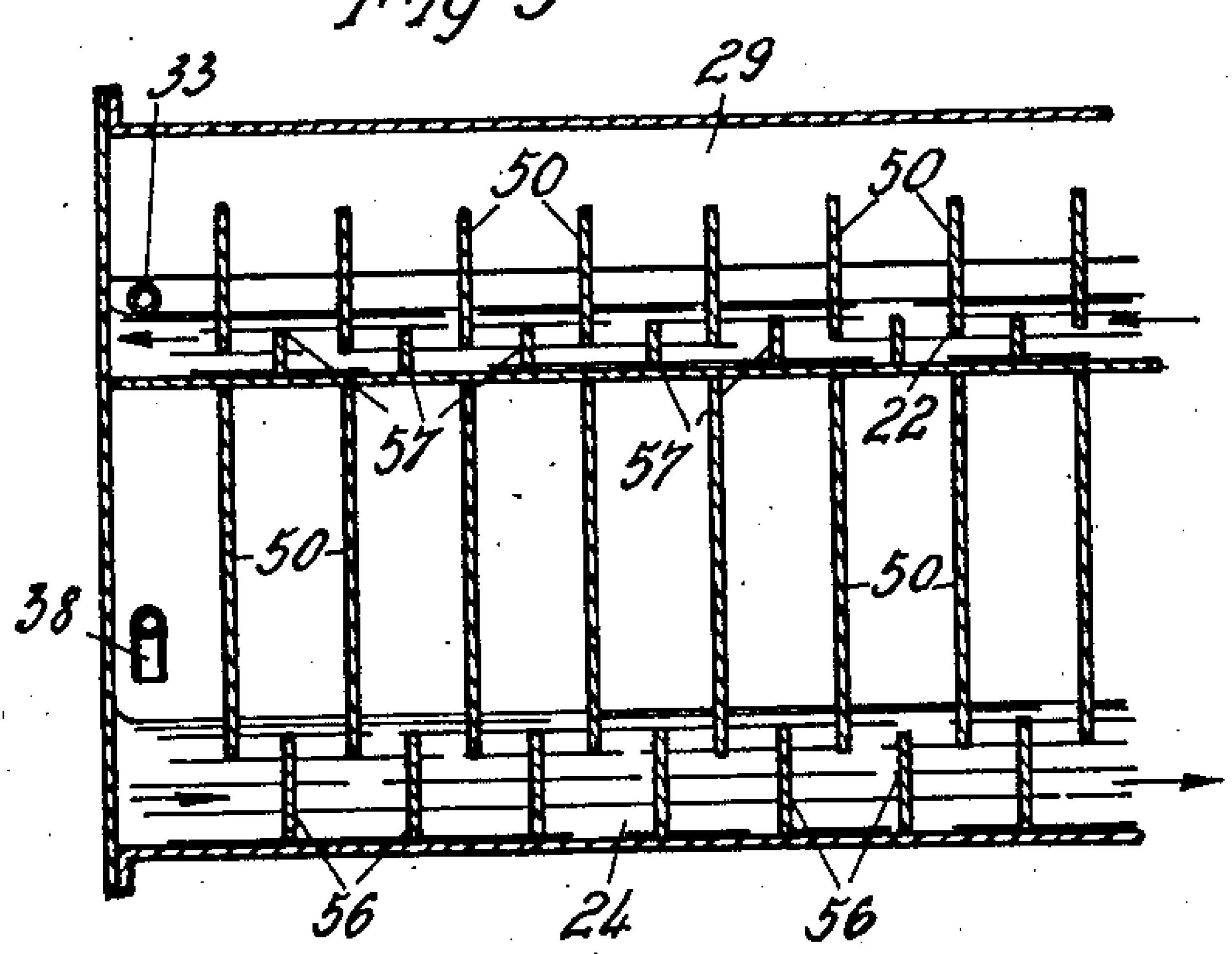
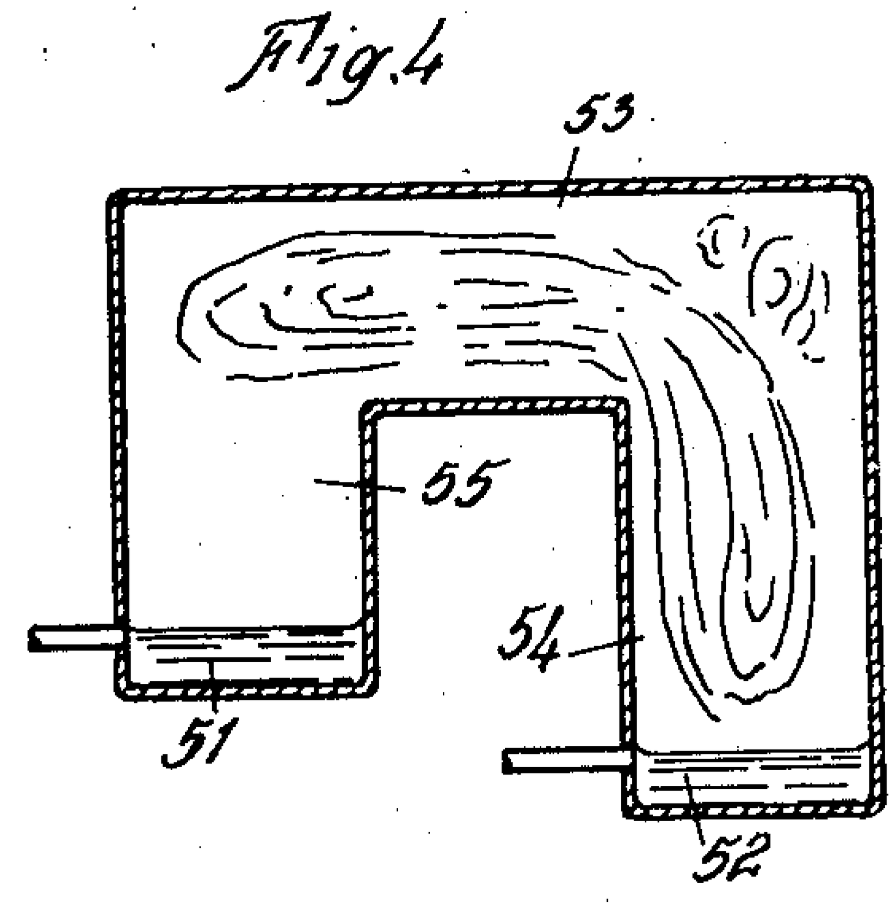


Fig. 4



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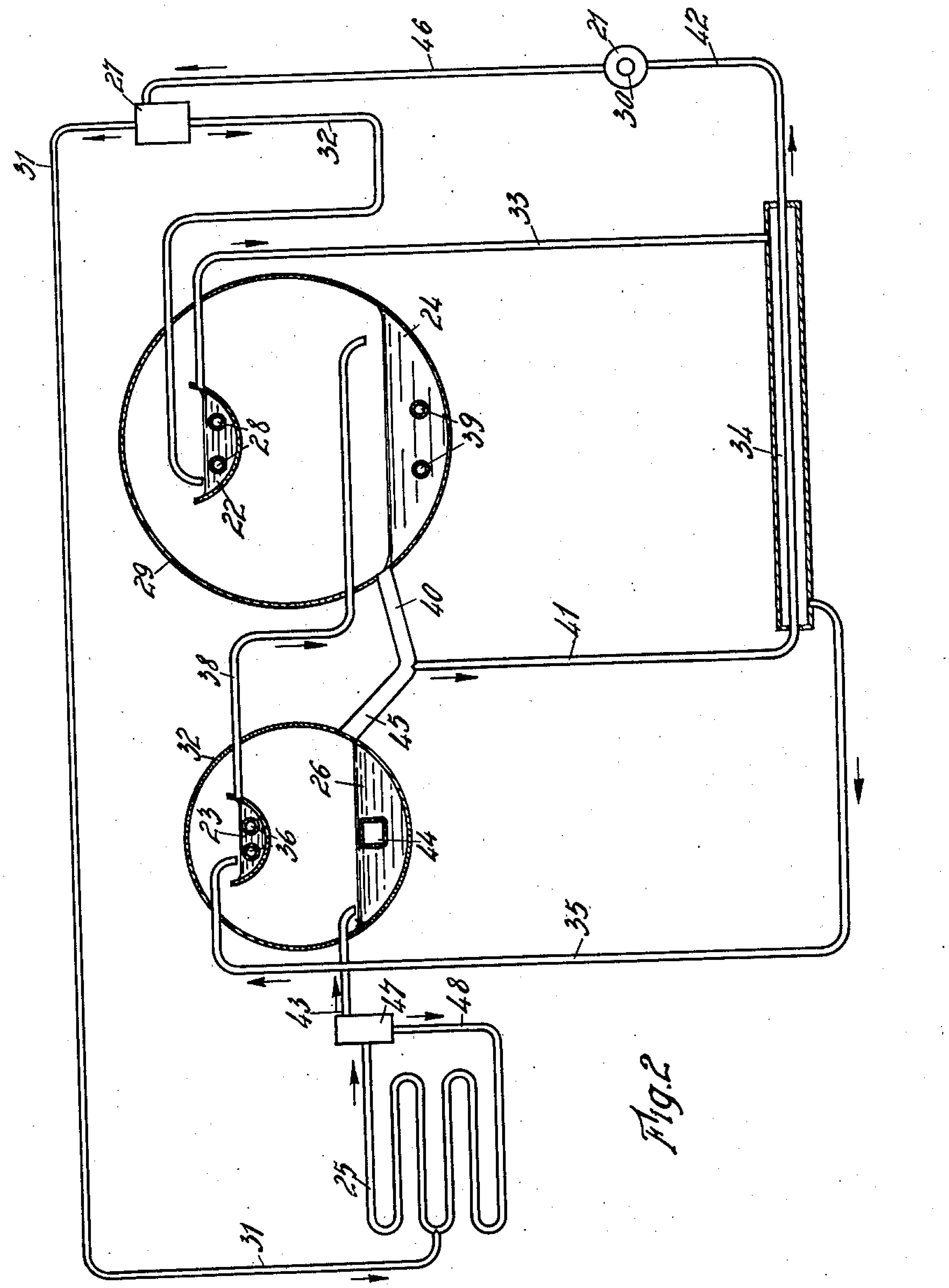

Fig. 2

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UNITED STATES PATENT OFFICE

EDMUND ALTENKIRCH, OF NEUENHAGEN NEAR BERLIN, GERMANY, ASSIGNOR, BY MESNE ASSIGNMENTS, TO THE HOOVER COMPANY, OF NORTH CANTON, OHIO, A CORPORATION OF OHIO

ABSORPTION MACHINE

Application filed July 23, 1930, Serial No. 469,935, and in Germany July 25, 1929.

My invention relates to an absorption machine in which a neutral gas is mixed with the gaseous working medium.

It is well known to operate absorption machines in such a manner that the difference of pressure necessary for the production of cold or heat is altogether or partly balanced by the admixture of a neutral gas.

In absorption machines of this type, however, the neutral gas is always in motion, circulating between two vessels which have a considerable difference in temperature, so that heat is conveyed to the evaporator and cold is carried away from the evaporator, both of which occurrences impair the efficiency of the machine.

It is the purpose of the present invention to prevent this undesirable carrying of heat and cold. According to the invention the problem is solved by developing within a vessel operating medium vapor at one point in the presence of a neutral gas and absorbing at another point of the same vessel this developed vapor from the neutral gas mixture by means of an absorption solution, and by providing a gas mixture space between the two points of the vessel, of such character that the medium vapor passes from one point to the other solely by diffusion through the neutral gas. This gas space or gas mixture connection is designed so that it has an ascending portion in which a stagnant layer of neutral gas remains. By this provision the advantage is attained over machines of the character described hereinbefore that the amount of heat carried from the warmer to the colder portions of the machine and the amount of cold carried from the colder to the warmer portions is considerably reduced. This undesired heat exchange occurs mostly through the neutral gas which either intentionally or unintentionally circulates between the absorber and the evaporator in the prior art machines.

I have illustrated in the drawings a number of modifications by which my invention may be reduced to practice. In these drawings

Fig. 1 illustrates more or less diagrammatically a complete continuous absorption refrigerating machine provided with an absorber situated immediately above the evaporator, a gas mixture connection being provided between the two vessels,

Fig. 2 shows a similar machine in which the operating medium is twice expelled and twice absorbed,

Fig. 3 shows diagrammatically the details of a vessel such as for instance 37 in Fig. 2 in longitudinal section, and in which medium vapor is evaporated and absorbed in the presence of a neutral gas, the vessel being provided with means for bringing about the evaporation and absorption in a number of steps, and

Fig. 4 shows diagrammatically a different form of connecting an evaporator and an absorber by means of a gas space.

Referring more particularly now to Fig. 1, it is assumed that ammonia liquor is used as an operating medium. This liquor is heated in the boiler 2 by means of a suitable heating unit 1. The bubbles produced from the expelled ammonia vapor carry the solution through the rising pipe 3 along into the gas separation chamber 14. From there the impoverished solution flows through the pipe 4 into the absorber 5. The bottom of this absorber is provided with a wide opening leading into the evaporator 6. The walls of the evaporator 6 are insulated towards the outside by the insulating material 7 and towards the absorber 5 by the insulating material 12. The absorber 5 is on the contrary provided with walls which conduct heat well and give up the heat produced by the absorption to the surrounding air. The ammonia gas coming from the gas separation chamber 14 passes into the condenser 8, where it is condensed by cooling through the surrounding air, and is then conveyed by the pipe 9 into the evaporator 6. The space inside of the absorber 5 and of the evaporator 6 is filled with a neutral gas, the specific gravity of which is not considerably higher than that of ammonia, for instance, methane, hydrogen, helium or a gas mixture fulfilling the said condition. The medium to be cooled is conveyed through pipes 13 leading through the evaporator 6. The evaporating ammonia gas collects at first above the surface of the liquid in the evaporator 6 but passes owing to diffusion into the absorber 5, where it is absorbed by the weak absorption solution. A movement of the neutral gas between the evaporator and the absorber does not take place, since the gas in evaporator 6 located at a lower level, can by being cooled only become heavier but never lighter. Even if the neutral gas should be a little heavier than the ammonia gas, a flow of neutral gas, mixed with ammonia and therefore lighter, from the evaporator 6 into the absorber 5, can only last at the beginning of the operation until the operating temperature difference between the two vessels is established when the difference in specific gravity, which had up to then caused the flow vanishes.

The solution enriched in the absorber 5 returns to the boiler 2 through the pipe 10, which it is practical to combine with the pipe 4 to form a heat exchanger. A connecting pipe 11 conveys liquid which does not evaporate in the evaporator 6 into the pipe 10 and thereby back to the boiler 2.

Among the gases, which are suitable as neutral gases for carrying out the invention, hydrogen takes an exceptional position, because it is the most favourable for the diffusion of the working medium. Its disadvantage, as compared with other suitable neutral gases, is its good heat conductivity. For this reason, other gases are in many cases preferable; the diffusion is in their case, it is true, less intense, but this disadvantage is more than compensated by their lower heat conductivity.

The invention may also be applied to convey the working medium from an expeller, in which it is evaporated at a high temperature into an absorber, in which it is absorbed at a lower temperature.

An example in which both forms of the invention are applied is shown in Fig. 2. The machine is to serve for producing a low temperature, even if the available heating temperature is not as high as is usually required for producing such a low temperature.

In the boiler 21 ammonia vapors are expelled from an aqueous ammonia solution. As a source of heat exhaust steam passing through the heating tube 30 is used. The liberated ammonia bubbles carry along the working solution through the pipe 46 up into the gas separation chamber 27, from where the expelled gas flows through the pipe 31 into the condenser 25, whereas the weak solution drains through the pipe 32. At the comparatively low temperature of the exhaust steam, the absorption liquid has not been so extensively deprived of its gas as would be necessary for producing the desired low temperature in the evaporator 26.

For this reason, the ammonia solution is next led through the pipe 32 to a second expeller 22 which is heated by the steam pipe 28. This expeller is arranged in a large container 29, having the shape of a tube, which is filled with a mixture of helium and neon. The mixture is chosen such that its specific gravity is about that of ammonia vapor. Owing to the presence of this neutral gas mixture the partial pressure of the ammonia inside the vessel 29 is reduced to such a degree that the temperature of the heating steam is sufficient to evaporate further quantities of ammonia from the solution. The weakened solution flows from the expeller 22 through the pipe 33, a heat exchanger 34 and the pipe 35 into the absorber 23. Here it is cooled by cooling water flowing in the pipes 36 so that it can absorb the ammonia from the surrounding gas mixture. The absorber is located inside a tub like vessel 37, which is filled with the same gas mixture as the vessel 29. The enriched solution flows from the absorber 23 through a pipe 38 back into the vessel 29, at the bottom part of which it forms a second absorber 24. There the liquid is cooled by cooling pipes 39 so that it can absorb the ammonia from the surrounding gas mixture. It then flows through the pipes 40 and 41, the heat exchanger 34, and the pipe 42 back into the boiler 21.

The expelled ammonia gas has passed from the gas separation chamber 27 through the pipe 31 into the condenser 25, which is also cooled so that the ammonia condenses. The ammonia gas is introduced into the condenser below the surface of the condensate (in this case at the middle of pipe coil 25) so that the entering gas bubbles produce a circulation of the liquid through the pipe of the condenser 25, which is also provided with a gas separation chamber 47 and a circulation pipe 48. The liquid ammonia passes through the pipe 43 into the vessel 37 at the bottom of which it forms the evaporator 26. It gasifies into the surrounding neutral gas mixture and the cold produced thereby freezes the articles to be frozen in the freezing chamber 44. Superfluous quantities of liquid drain out of the vessel 37 through an overflow into the pipe 45 and flow, together with the absorption solution coming from the absorber 24, through the pipes 41 and 42 back into the boiler 21. The pipes 40 and 45 have a sufficiently large diameter so that they can also serve for the equalization of pressure between the two vessels 29 and 37 and so that a liquid surface can only form further down in pipe 41.

The gasification of the condensed ammonia 26 is only possible if the partial pressure of the ammonia gas within the vessel 37 remains sufficiently low. This is cared for by the absorption solution in the absorber 23, which solution is so weak in consequence of ammonia having been expelled twice, that it can absorb ammonia even at the existing low partial pressure.

The ammonia expelled in the second expeller 22 passes by way of diffusion into the second absorber 24 where it is absorbed by the absorption liquid 24. In order that absorption of ammonia can take place in this absorber at the same temperature as in 23, the partial pressure of the ammonia in the vessel 29 must be higher than in the vessel 37. This is readily to be obtained by proportioning the quantity of the added neutral gas mixture. The composition of the mixture takes place automatically in service, as superfluous quantities of the neutral gas can pass through the pipes 40 and 45 into the vessel 37. In the absorption process the absorption solution 24 is enriched to such a degree that the comparatively low heating temperature in the boiler 21 suffices to drive off sufficient ammonia to properly supply condenser 25.

Inside of vessel 29, the ammonia gas is developed in the upper part 22 and absorbed in the lower part 24, whereas inside of the vessel 37, the ammonia gas is developed in the lower part 26 and absorbed in the upper part 23. This arrangement is chosen in order that the colder part should always be below the warmer one. If it were otherwise, i. e. if the colder gas were developed at the top, the specific gravity would then, owing to the lower temperature, be increased at the top, whereby a flow of gas might be produced, which is just what, according to the invention, is to be avoided. Owing to the different proportions of mixture inside of one and the same vessel, the specific gravity of the gas mixture cannot be considerably influenced in any case, since the neutral gas mixture of helium and neon is so composed as to have approximately the same specific gravity as the ammonia gas.

If the neutral gas mixture were considerably lighter than ammonia gas, then the ammonia gas developed from the liquid in 22 would make the mixture heavier. The heavier mixture formed in this manner would descend and by coming into contact with the absorbing liquid 24 become lighter again and so perform a constant circulation. If, on the contrary, the neutral gas mixture were heavier than the ammonia gas, it would, by being enriched above the evaporating ammonia liquid 26 in the vessel 37 become lighter and rise. By giving up ammonia to the liquid 23 it would again become heavier and consequently descend so that in the vessel 37 a circulation of the gas would take place, which is just what is to be avoided. In order to prevent with certainty circulation of the gas mixture both in the vessel 29 and in the vessel 37, the specific gravity of the neutral gas mixture must be made as nearly as possible the same as that of the ammonia gas. It is of course also possible to work with different neutral gases in the two vessels 29 and 37, but it is then not possible to connect the two vessels with one another by an equalizing pipe 40 and 45. The equalizing pipe 40, 45 has not only the advantage that the partial pressures in the two vessels can equalize themselves to the correct value, but it also has the advantage of keeping the absolute pressures at the same value in the two vessels. As soon as this equality in the absolute pressure is disturbed, the circulation of the absorption liquid through the two vessels becomes uncertain if other arrangements are not made.

For my invention it is only important that heat is not carried through movements of the neutral gas from a warm part to a colder part of the machine. It is not absolutely necessary that movements of the neutral gas, which do not involve such a conveyance of heat, should be prevented altogether. Whirling movements, for example, which are restricted to the space close to the surface of a liquid and which are for the greater part horizontal movements do not cause any heat losses.

In absorption machines of this kind, it is often of importance to conduct the liquids in counterflow. For example, the solution which has traversed almost completely expeller 22 and has, therefore, become rather weak should be brought into gas exchange relation with parts of the solution in absorber 24 in the same vessel 29, which have just entered the vessel 29 and are, therefore, sufficiently capable of absorbing more readily gas from the lean solution leaving expeller 22. For carrying the counterflow into effect, the vessel 29 is formed as a somewhat long tube, as shown in section in Fig. 3. As indicated there by the arrows, the solution flows in the absorber 24 from left to right, and in the expeller 22 from right to left. The solution at the end of the expeller 22, where it is already weak, is capable of giving up further quantities of gas to the neutral gas mixture only at a low partial pressure. This part of the gas mixture is, for this reason, brought into contact with portions of liquid in absorber 24, which have not been yet too much enriched and can, therefore, absorb ammonia even at the low partial pressure.

In order to maintain this effect of the counterflow, transverse partitions 50, as shown in Fig. 3, are arranged, which prevent eddying movements of the gas mixture, or a diffusion extend longitudinally of the tube, from producing an equalization of the partial pressure over the whole length of the tube-shaped vessel 29. Only at the top of the transverse partitions, a longitudinally extending space is left along the upper part of the tube, through which the pressure within the tube can equalize. The partitions 50 should only have a low heat conductivity, to prevent their carrying the heat from the expeller 22 to the absorber 24. The transverse partitions 56 and 57, spaced between the partitions 50 in the manner shown, serve as baffle plates to bring always new parts of the absorption solutions to the surface.

There are also cases in which whirling movements of the gas mixture may, without bad effect, be permissible, so long as they do not cause a harmful conveyance of heat. In Fig. 4, two vessels are shown, in one of which, 51, cold absorption solution absorbs ammonia gas from a neutral gas mixture, and in the other of which, 52, ammonia gas is developed from a warm absorption solution. The warmed gas can rise above the surface of the liquid in 52 into the vertical tube 54 and produce eddies or whirls as shown, which may perhaps even extend through the horizontal tube connection 53. But the warmer gas cannot descend into the vertical tube 55 above the vessel 51. The neutral gas contained in the latter tube therefore remains quiescent. It conveys the ammonia gas solely through diffusion and cares for the heat insulation between the two vessels 51 and 52.

In an arrangement of this kind it is thus also possible to dispose the surface of the warmer liquid in chamber 52 at a lower level than that of the surface of the colder liquid in chamber 51. This may be of importance for the circulation of the absorption solution if the circulation is to be maintained solely through the difference in specific gravity.

I claim as my invention:

1. In an absorption machine for continuous operation a vessel containing an absorption solution, an operating medium and a neutral gas and having means for evaporating said operating medium at one vessel portion in the presence of a neutral gas, and means for absorbing said vapor at another vessel portion from said neutral gas into said absorption solution, means for forming a rising vapor path between said points permitting the diffusion of the vapor through said neutral gas from the evaporation to the absorption point, said points being located with respect to the vessel so that a stagnant layer of neutral gas remains in said rising path.

2. An absorption machine for continuous operation comprising a vapor generator, a liquefier, an evaporator and an absorber, a working medium and means for guiding said medium between said vessels, and a neutral gas mixed with the generated vapor in portions of some of said vessels, the gas mixture containing vessel having a higher temperature being located higher than the gas mixture containing vessel having a lower temperature, whereby the vapor passes between said vessels by diffusion through said neutral gas, and the neutral gas remains substantially stationary due to the relative position of said two vessels.

3. An absorption machine for continuous operation including an evaporator and an absorber and connections between said vessels for evaporating an operating medium contained in the evaporator, and absorbing the vapor by an absorption solution contained in the absorber, and a neutral gas mixed with the vapor in said vessels and having a specific weight substantially the same as that of the vapor, the absorber being located at a higher level than the evaporator, whereby the vapor of the medium diffuses from the evaporator through the neutral gas into the absorber, and the neutral gas remains substantially stationary due to the relative position of and temperature difference between the vessels.

4. An absorption machine for continuous operation comprising a vapor generator, a liquefier, an evaporator and an absorber, a working medium and an absorption solution therefor, and means for guiding said medium between said vessels, and a neutral gas having a specific weight substantially the same as the vapor and being mixed with the generated vapor in at least two of said vessels, one being a vapor expelling vessel and the other a vapor absorption vessel, the vapor absorption vessel being located at a higher level than the vapor expelling vessel, whereby expelled vapor diffuses from the expelling vessel through the neutral gas into the absorption vessel, and the neutral gas remains substantially stationary due to the relative position of, and the temperature difference between said vessels.

5. An absorption machine for continuous operation comprising a vapor generator, a liquefier, an evaporator and an absorber, a working medium and an absorption solution therefor, and means for guiding said medium between said vessels, and a neutral gas having a specific weight substantially the same as the vapor, and being mixed with the generated vapor in at least two of said vessels, one being a vapor expelling vessel and the other a vapor absorption vessel, the vapor absorption vessel being located at a higher level than the vapor expelling vessel, whereby expelled vapor diffuses from the expelling vessel through the neutral gas into the absorption vessel, and the neutral gas remains substantially stationary due to the relative position of, and the temperature difference between said vessels, means for conducting the gas generating liquid in the expelling vessel in counterflow to the gas absorbing liquid in the absorption vessel, and spaced vertical partitions of low heat conductivity extending along the counterflow path between said two vessels and dipping into the absorption liquid to prevent premature horizontal equalization of the different partial pressures existing in the gas mixture along the counterflow path.

6. In an absorption machine for continuous operation, an evaporating vessel containing

a liquid rich in operating medium, an absorption vessel containing a liquid lean in operating medium and adapted to absorb medium vapor evaporated in said evaporating vessel, a vertical tube extending from each vessel, and a horizontal tube connecting the upper ends of said vertical tubes to permit the passage of medium vapor from one to the other vessel, said tubes containing a neutral gas mixed with the vapor and permitting the vapor to diffuse through it from one to the other vessel, whereby a stagnant zone of neutral gas remains between said two vessels due to the difference in temperature between said two vessels.

7. In an absorption machine for continuous operation, an evaporating vessel at a lower level containing a liquid rich in operating medium, an absorption vessel at a higher level containing a liquid lean in operating medium and adapted to absorb medium vapor evaporated in said evaporating vessel, a vertical tube extending from each vessel and a horizontal tube connecting the upper ends of said vertical tubes to permit the passage of medium vapor from one to the other vessel, said tubes containing a neutral gas mixed with the vapor and permitting the vapor to diffuse through it from one to the other vessel, whereby a stagnant zone of neutral gas remains between said two vessels due to the difference in height and in temperature between said two vessels.

In testimony whereof I affix my signature.

EDMUND ALTENKIRCH.