

Nov. 21, 1944.

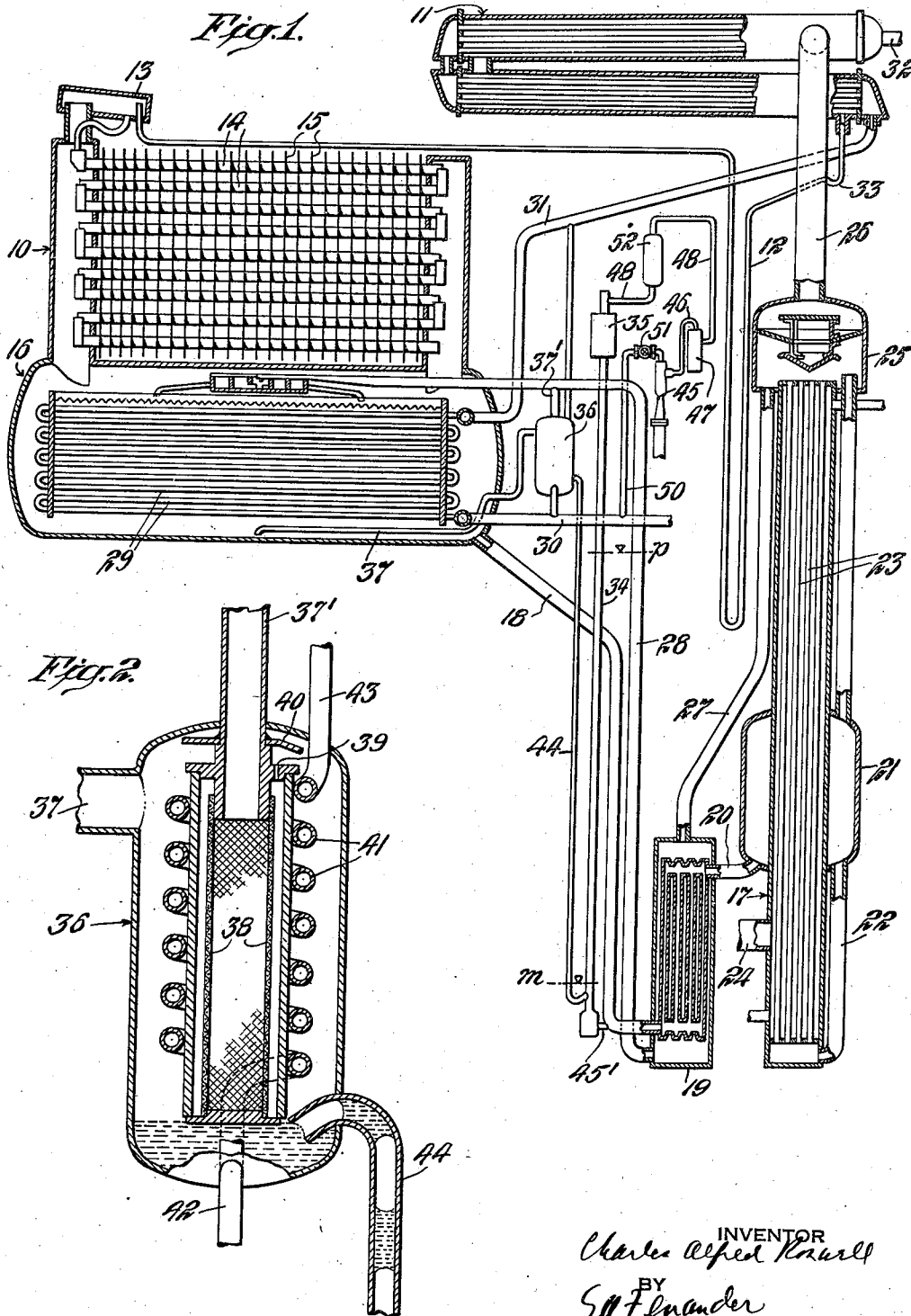
C. A. ROSWELL

2,363,440

VALVE

Filed April 3, 1943

2 Sheets-Sheet 1



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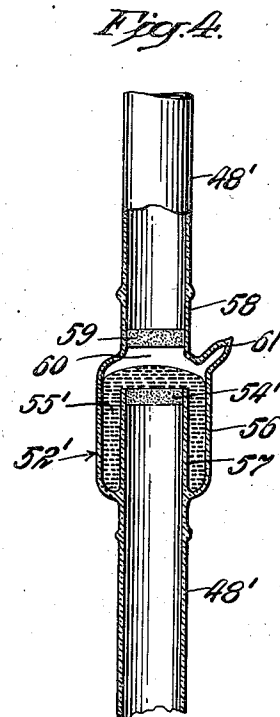
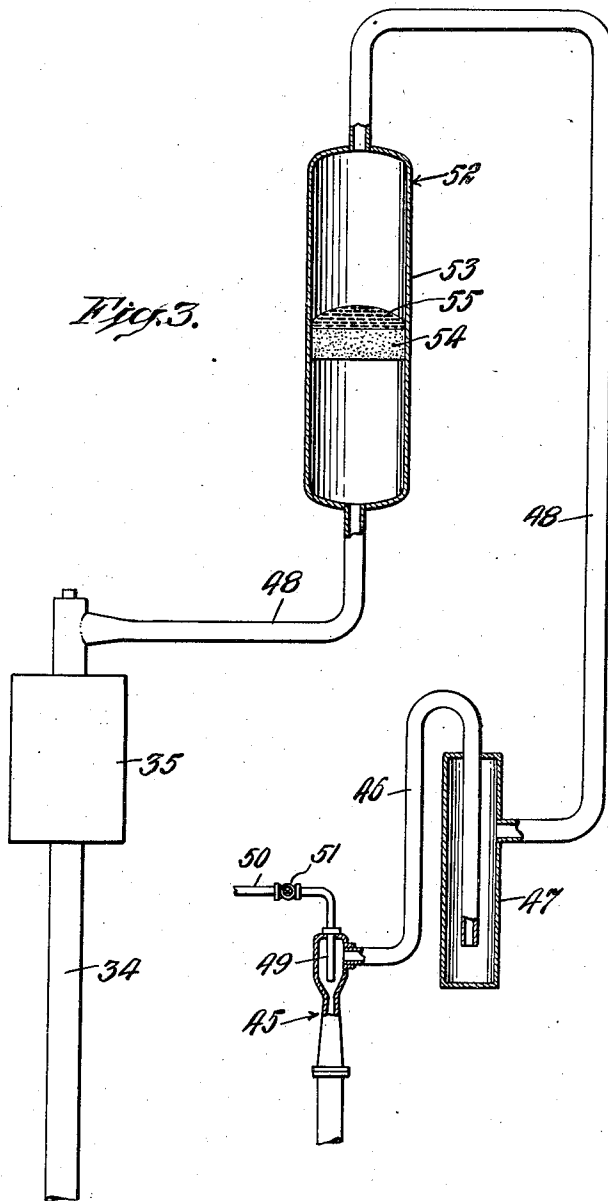
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2 Sheets-Sheet 2



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2,363,440

VALVE

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1 Claim. (Cl. 62—1)

My invention relates to valves, and it is an object to provide an improved valve for gases utilizing a porous plate and a small amount of liquid such as, for example, mercury.

The small amount of mercury, which covers one face of the porous plate, serves to seal the pores or openings in the plate to prevent flow of gas therethrough and yet does not pass through the pores for the maximum pressure differential existing across the plate. The porous plate may be in the shape of a disc and formed of any suitable material such as, for example, ceramic material or sintered or fritted glass. I have found that when a porous plate of the character just described is employed, flow of gas will take place through such a plate even when the pressure differential across the plate is equivalent only to a few millimeters of mercury.

When a porous plate is provided in a vertically extending portion of a tube or conduit and the pressure existing above the mercury and top side of the plate is less than that existing below the plate, gas will flow upward through the porous plate and bubble through the mercury. However, when the pressure existing above the mercury and top side of the porous plate is substantially equal to or greater than that prevailing below the plate, the mercury is effective to close and seal the pores or openings in the plate and prevent flow of gas therethrough.

It is another object of the invention to provide a valve of the character described which can be tilted into any position without losing or spilling mercury and with no leakage of gas through the porous plate. A tiltable valve possesses many advantages in that such a valve may be installed in apparatus at a factory, so that additional installation work on the apparatus in the field or ultimate place of use in order to connect the valve, is avoided. This is particularly true in refrigeration apparatus in which a tiltable mercury porous plate valve can be connected in the apparatus when the latter is being built, whereby the necessity of providing other types of mechanical valves and connections for the apparatus for the transportation period only is eliminated.

It is a further object of the invention to provide a mercury porous plate valve for use in refrigeration apparatus of the kind operating at a partial vacuum and from which non-condensable gases are exhausted to the atmosphere.

The novel features which are believed to be characteristic of my invention are set forth with particularity in the claim. The invention, both

as to organization and method, together with the above and further objects and advantages thereof, will be better understood by reference to the following description taken in connection with the accompanying drawings in which Fig. 1 more or less diagrammatically illustrates a refrigeration system embodying my invention; Fig. 2 is an enlarged fragmentary view, in section, of parts shown in Fig. 1 to illustrate the manner in which non-condensable gases are transferred within the refrigeration system; Fig. 3 is an enlarged fragmentary view, in section, of parts of Fig. 1 to illustrate more clearly the mercury porous plate valve embodying the invention; and Fig. 4 is a fragmentary view illustrating an embodiment of the invention in which the valve can be tilted to any position without spilling or losing mercury.

Referring to Fig. 1, the invention is embodied in a two-pressure absorption refrigeration system like that described in United States Letters Patent No. 2,282,503 of A. R. Thomas and P. P. Anderson, Jr., granted May 12, 1942. In a system of this type liquid refrigerant such as, for example, water, is introduced into the upper part of a cooling element 10 from a condenser 11 through a path of flow including a U-shaped tube 12 and a chamber 13. The liquid refrigerant evaporates in cooling element 10 with consequent absorption of heat from the surroundings, as from a stream of air flowing over the exterior surfaces of the tubes 14 and fins 15 of the evaporator. The refrigerant vapor formed in cooling element 10 flows therefrom to an absorber 16 in which the vapor is absorbed into a liquid absorbent such as, for example, a solution of lithium bromide.

The absorption liquid enriched in refrigerant is conducted from absorber 16 to a generator 17 in a path of flow including a conduit 18, liquid heat exchanger 19, conduit 20, vessel 21 and conduit 22. Within the generator 17 are disposed a plurality of riser tubes 23 enveloped by a chamber formed by the outer shell to which steam is supplied through a conduit 24 from a suitable source of supply. The heating of the riser tubes 23 by the steam causes refrigerant vapor to be expelled from the absorbent, and such expelled vapor is effective to raise liquid absorbent by gas or vapor lift liquid action.

The expelled vapor passes from the upper ends of the riser tubes 23 into a vapor separator 25 and thence flows through a conduit 26 to condenser 11 in which the vapor is liquefied. Liquid refrigerant formed in condenser 11 flows through

U-tube 12 to the upper part of the cooling element 10, as explained above, to complete the refrigerating cycle. The raised absorption liquid, from which refrigerant vapor has been expelled, is conducted from the upper part of generator 17 to absorber 16 to absorb refrigerant vapor, this liquid being conducted to the absorber in a path of flow including a conduit 27, liquid heat exchanger 19 and conduit 28. The heat liberated with absorption of refrigerant vapor in absorber 16 is taken up by a cooling medium such as, for example, water, which flows upward through vertically disposed pipe banks 29 in the absorber. The cooling water is introduced into the lower end of the pipe banks through a conduit 30 and is discharged from the upper end of the pipe banks through a conduit 31. The conduit 31 is connected to condenser 11, so that the cooling water may also be utilized to effect cooling of condenser 11. The cooling water is discharged from condenser 11 through a conduit 32.

The system operates at a partial vacuum with generator 17 and condenser 11 operating at one pressure and cooling element 10 and absorber 16 operating at a lower pressure. The pressure differential between the high and lower pressure sides of the system is maintained by liquid columns, as disclosed in the aforementioned Thomas and Anderson patent, which may be considered as being incorporated in this application and to which reference may be made, if desired, for a detailed description of the refrigeration apparatus.

During operation of the refrigeration system, non-condensable gases may collect therein, and in condenser 11 such gases flow toward the dead-end or bottom part of the condenser. In order to transfer the non-condensable gases from condenser 11 to cooling element 10, a liquid trap 33 is provided in U-tube 12. Liquid formed in condenser 11 flows into trap 33, and, when the trap is completely filled with liquid, such liquid is siphoned from the trap into the downleg of the U-tube 12. The liquid level in the downleg of U-tube 12 is below the trap 33 since the pressure in condenser 11 is considerably higher than the pressure in cooling element 10. Since the liquid level in the downleg of the U-tube 12 is between the trap 33 and extreme lower end, gas above the liquid level in the downleg is trapped by the liquid siphoned from the liquid trap 33. After liquid is siphoned from trap 33, gas can pass from the bottom part of condenser 11 through the open trap into the downleg of U-tube 12. When liquid is again siphoned into the downleg of U-tube 12 from trap 33, gas is again trapped by the siphoned liquid. The gas segregated between successive bodies of liquid siphoned from trap 33 is compressed by the siphoned liquid and passes through U-tube 12 from condenser 11 to cooling element 10.

The non-condensable gases in the lower pressure side of the system, that is, in the cooling element 10 and absorber 16, are carried to the bottom part of the absorber by the sweeping action of the refrigerant vapor. By sweeping action it is meant that the downward movement is imparted to the non-condensable gases by the high velocity refrigerant vapor flowing from cooling element 10 into the absorber 16. The non-condensable gases are swept to the bottom part of absorber 16 to a region substantially mid-way between the ends thereof.

In order to transfer non-condensable gases from absorber 16 to a vertical conduit 34 and vessel 35, which may be referred to as inactive parts of the system, an auxiliary absorber 36 is provided into which the non-condensable gases collecting in the bottom part of the absorber 16 are drawn through a conduit 37.

Absorption liquid is introduced into auxiliary absorber 36 through a conduit 37' which is connected at its upper end to conduit 28. In this way a portion of the absorption liquid flowing to the upper part of absorber 16 is diverted from conduit 28 into conduit 37'. After passing through a screening 38 in auxiliary absorber 36, the diverted absorption liquid passes through an opening 39. The liquid discharged from opening 39 strikes a plate 40 and then flows downward over the exterior surface of a coil 41.

With this arrangement the gases withdrawn from absorber 16 through conduit 37 are brought into intimate contact with diverted absorption liquid in auxiliary absorber 36. Refrigerant vapor accompanying the non-condensable gases withdrawn from main absorber 16 is absorbed into absorption liquid in auxiliary absorber 36. The heat liberated in auxiliary absorber 36 is taken up by cooling water in coil 41 which is supplied through conduit 42 from conduit 30, and which is discharged through conduit 43 to conduit 31.

A vertical tube 44, which may be referred to as a fall tube pump, is connected at its upper end to the bottom part of auxiliary absorber 36 and at its lower end to the bottom part of the vertical conduit 34. Liquid intermittently fills the upper bent end of vertical tube 44 and siphons therefrom, whereby small quantities of non-condensable gases are withdrawn from the bottom part of the auxiliary absorber and trapped between successive bodies or slugs of liquid, as shown in Fig. 2. The internal diameter of tube 44 is such that gas and liquid cannot pass each other while flowing down through the conduit. The non-condensable gases are discharged from the low end of tube 44 into vertical conduit 34 and freely bubble upwardly through liquid in the latter. As the quantity of non-condensable gases trapped in vertical conduit 34 and vessel 35 increases, the liquid level in conduit 34 falls with the gases displacing liquid from the bottom of conduit 34 through a connection 45' into conduit 28.

When the liquid is at a maximum level in conduit 34, as at the level *p*, for example, the pressure in vessel 35 and upper part of conduit 34 is in equilibrium with the vapor pressure of the absorption liquid in the conduit. In a refrigeration system like that described above and having an ice melting capacity of about five tons, and in which a solution of lithium bromide of about 55% concentration by weight is employed, the pressure in vessel 35 and above the maximum liquid level *p* in conduit 34 is less than about twenty-five millimeters of mercury. As liquid in vertical conduit 34 is displaced by non-condensable gases transferred thereto, the liquid in the conduit 34 falls until it reaches the minimum level *m*. When the liquid reaches this minimum level, the pressure in the upper part of vertical conduit 34 and vessel 35 is at a maximum. This maximum pressure in a system of the type just referred to is approximately 100 millimeters of mercury.

The non-condensable gases in vertical conduit

34 and vessel 35 are exhausted from the refrigeration system to the atmosphere by a suitable vacuum pump such as, for example, a simple water aspirator type of pump 45. The vacuum pump 45 is connected by a conduit 46, vessel 47 and conduit 48 to vessel 35 for withdrawing non-condensable gases from the system. The conduit 46 is connected to the converging side of the Venturi tube forming the pump 45. A nozzle 49 is disposed within the vacuum pump 45 and water under pressure is delivered thereto through a conduit 50. The conduit 50 is connected to conduit 30 through which cooling water is delivered to absorber 16, and in the conduit 50 is connected a valve 51 for controlling the operation of the vacuum pump.

In conduit 48 connecting the vacuum pump 45 to the vessel 35 is provided a valve 52 embodying my invention which is effective to maintain the system at a low pressure and at the same time allows non-condensable gases to pass there-through when the vacuum pump 45 is operated.

As shown most clearly in Fig. 3, the valve 52 comprises an elongated vertical vessel 53 to the inner wall of which is secured a porous plate or disc 54. A small body 55 of a liquid such as, for example, mercury, rests upon the porous plate 54. The vessel 53 may be formed of non-porous glass and the disc 54 may consist of a porous body of ceramic material, fritted or sintered glass particles, or glass strands. Porous plates formed of fritted or sintered glass are well known and described in United States Letters Patent Nos. 1,620,815, 2,115,748 and 2,136,170.

When it is desired to effect removal of non-condensable gases from the refrigeration system, the valve 51 is opened so that water will be supplied to nozzle 49 of the vacuum pump 45. The water passing through the nozzle 49 acquires a high velocity, whereby a suction effect is produced in the upper part of valve 52 which is in communication with the pump through a part of conduit 48, vessel 47 and conduit 46. Assuming that the liquid level is at *m* in conduit 34, and the pressure in vessel 35 is about 100 millimeters of mercury, non-condensable gases will pass upward through the porous plate 54 and bubble through the body 55 of mercury when the partial pressure produced by the vacuum pump 45 is only a few millimeters of mercury below that existing in vessel 35. Thus, when the depth of the body of mercury is about two millimeters and the pressure in the upper part of valve 52 is approximately 95 millimeters of mercury while the pressure in vessel 35 is about 100 millimeters of mercury, the non-condensable gases will pass through the porous plate 54, conduit 48, vessel 47 and conduit 46 to the vacuum pump 45 from which the non-condensable gases are discharged to the atmosphere.

As the non-condensable gases are withdrawn from vessel 35 and conduit 34, the liquid level rises in the latter until the upper or maximum liquid level *p* is reached. When this occurs, the valve 51 is closed to shut off the vacuum pump 45. When the vacuum pump is shut off, water in the venturi may be forced into conduit 46 by the atmospheric pressure which is momentarily greater than the pressure existing in that conduit. It is for this reason that conduit 46 includes an inverted U-shaped portion having one leg thereof extending downwardly within vessel 47 and terminating in the lower part thereof, as shown in Fig. 3. With this arrangement vessel 47 serves as a water trap, so that there will not

be any likelihood of water being drawn up through conduit 48 into the upper part of the valve 52.

With the vacuum pump 45 no longer operating, the body 55 of mercury in valve 52 is then subjected to atmospheric pressure while the pressure in vessel 35 and below the porous plate 54 is very small and in the neighborhood of about 25 millimeters of mercury. A very small pressure in this range can readily be produced with a water type aspirator pump to which water at a temperature as high as 90° F. is supplied at a line pressure of about 30 pounds per square inch.

Hence, the pressure existing across the porous plate 54 is approximately one atmosphere and for this pressure differential the body 55 of mercury effectively seals and closes off the pores or openings in the porous plate. In order that mercury will not flow through the pores in the porous plate 54 when the pressure existing across the plate is about one atmosphere, I have found that the average diameter of the pores or openings in the porous plate should be about 20 microns or less. While I have successfully used mercury for sealing the pores of porous plates formed of fritted or sintered glass, it should be understood that other suitable liquids may be employed. The only requirement is that the porosity of the plate or disc should be such that, for the maximum pressure differential existing across the plate, the pressure will be insufficient to break the surface tension of the liquid and cause such liquid to pass through the pores or openings in the porous plate.

In Fig. 4 I have illustrated a valve 52' which differs from that shown in Fig. 3 and described above in that such valve is tiltable to any position. The valve 52' is connected in a conduit 48' corresponding to conduit 48 in Figs. 1 and 3. The valve 52' includes an enlarged cylindrical portion 56 within which extends a tubular hollow stem 57. The diameter of stem 57 is substantially the same as that of conduit 48' to which the bottom of the valve is connected.

The hollow stem 57 terminates in the upper part of the enlarged cylindrical portion 56 and is closed by a porous plate 54' of about the same porosity as the plate 54 in Fig. 3. Above the porous plate 54' and at the narrow portion 58 of valve 52' is provided a second porous plate or disc 59. Both the porous plates 58' and 59 may be formed of suitable porous material, such as the fritted or sintered glass referred to above, for example, and fused to the non-porous glass portions 57 and 58 of valve 52'.

The valve 52' is so proportioned that the space 60 above the hollow stem 57 and body 55' of mercury is relatively small after the enlarged portion 56 is charged with mercury through the tap 61. By keeping the space 60 small, the body 55' of mercury will always cover the porous plate 54' irrespective of the position of valve 52'. While the pores in the porous plate 54' in the instant embodiment should be 20 microns or less in diameter, so that the mercury will not pass through the pores for the maximum pressure differential of about one atmosphere across the plate 54', the porous plate 59 can be of greater porosity such as 100 microns, for example, because it is only provided to keep mercury from spilling from valve 52' when the latter is tilted from the vertical. Further, by employing a porous plate 59 having as high a porosity as possible, the resistance developed by valve 52' to flow of gas therethrough

is kept at a minimum when the vacuum pump is operating.

In view of the foregoing, it should now be understood that an extremely short mercury column of only about two millimeters depth is necessary in valves 52 and 52' to maintain a pressure differential of approximately one atmosphere across the porous plates 54 and 54', respectively. Valves of this character have the additional advantage that they are self-regulating, that is, the height of the body of mercury above the porous plate can determine the minimum pressure that can be produced below the porous plate, even though the vacuum pump is capable of producing a pressure below that minimum pressure. The valve 52', of course, possesses the additional advantage that it can be tilted to any position without permitting flow of gas therethrough and with no loss of mercury. By keeping the body 55' of mercury trapped between the porous plates 54' and 59, the mercury is always kept clean. Since the valve 52' can be tilted to any position, this valve can be connected in the refrigeration apparatus at the factory, whereby the necessity of making temporary connections at the factory and subsequently installing the mercury porous plate valve in the field, is eliminated. While the valve 52' can be tilted to any position, I prefer to use the

valve in an upright or vertical position in the manner illustrated in Fig. 4.

While several embodiments of the invention have been shown and described, it will be apparent to those skilled in the art that various modifications and changes may be made without departing from the spirit and scope of the invention, as pointed out in the following claim.

What is claimed is:

10 In refrigeration apparatus operable below atmospheric pressure and having a part in which non-condensable gases are collected, a vacuum pump, a conduit connecting said pump and said part, said vacuum pump being operative to exhaust non-condensable gases from said part to the atmosphere when the pressure produced by said pump is less than the pressure prevailing in said part, valve structure hermetically sealed in said conduit for preventing atmospheric air from entering said part when said pump is no longer operating, said valve structure comprising a porous body and a body of mercury covering a surface of said body, and said valve structure being so constructed and arranged that mercury cannot spill therefrom and will always cover the surface of said porous body irrespective of the position of said valve structure.

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