May 26, 1942. C. BOL 2,284,036

METHOD AND APPARATUS FOR EXHAUSTING AND FILLING DISCHARGE DEVICES

Filed May 12, 1941

Fig. 1.

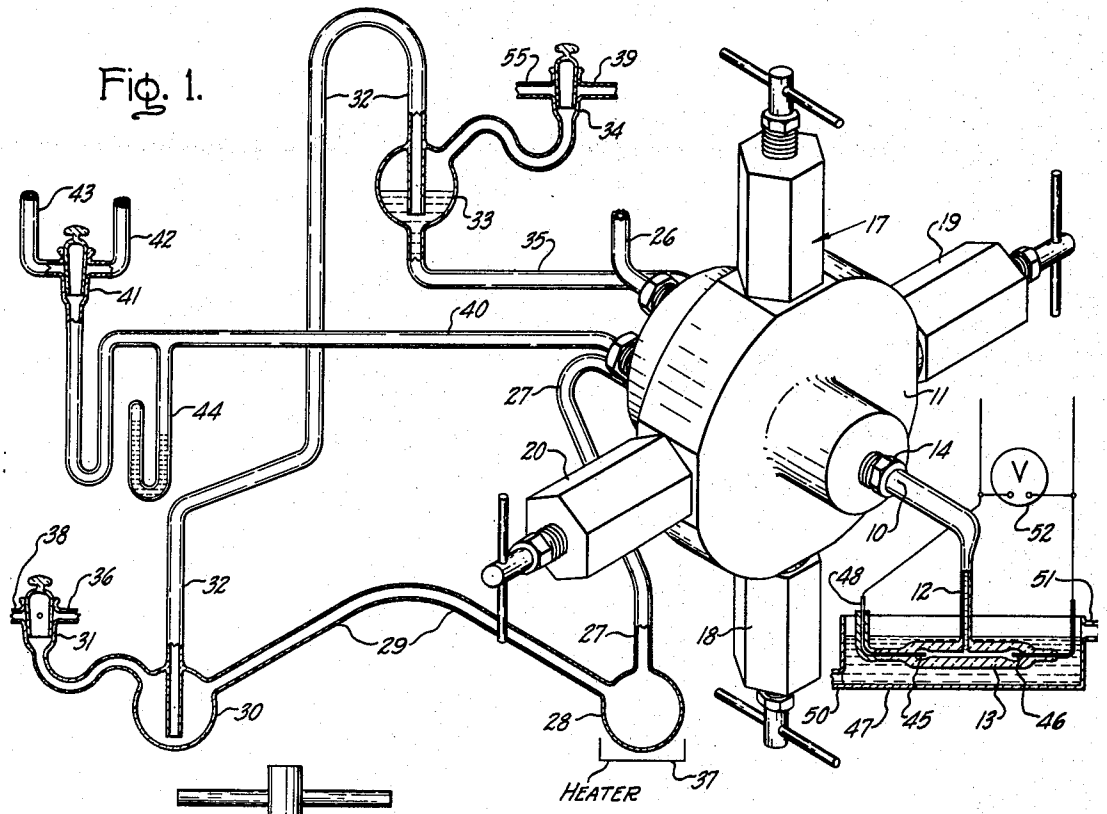


Fig. 2.

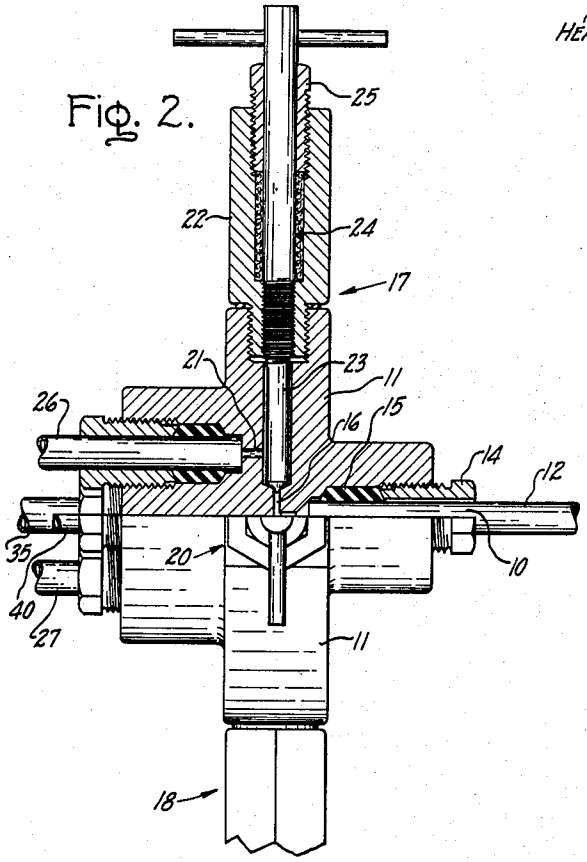
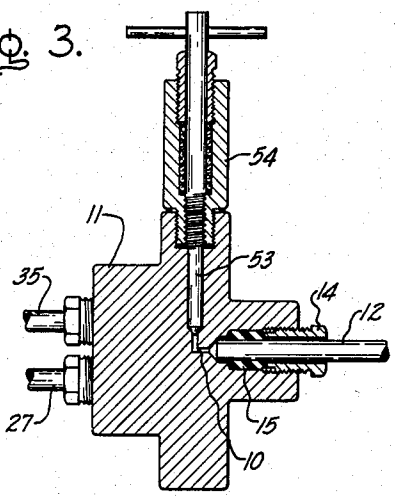


Fig. 3.



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2,284,036

METHOD AND APPARATUS FOR EXHAUSTING AND FILLING DISCHARGE DEVICES

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13 Claims. (Cl. 176—2)

My invention relates to a method and apparatus for exhausting, filling and sealing discharge devices and more particularly to a method and apparatus for exhausting all contamination from said devices, for introducing gaseous and vaporizable materials into said devices and for sealing definite proportions of said material therein.

The exhaust phase of my invention provides for the removal of the occluded gases and other contamination from the parts of the discharge device as well as the exhaustion of the interior thereof. The gas-tight connection established during the exhaust phase must function until the discharge device is filled and sealed.

The filling phase of my invention provides for the insertion of the proper amounts of gaseous and/or vaporizable materials constituting the discharge supporting components of the discharge device. The gaseous and vaporizable components establish, to a large degree, the operating characteristics of the discharge device and are provided in definite amounts in order to develop definite pressures, etc., therein. In the filling operation great care must be exercised to prevent contamination from being carried into the discharge device with the gaseous and vaporizable materials.

Certain types of discharge devices, such as those generally referred to as capillary lamps, are made of quartz or hard glass and, being very difficult to work to definite dimensions, normally vary somewhat from each other. These variations are usually very minute but must be taken into account when the lamps are filled or said lamps will differ greatly in their operating characteristics. Prior to my present invention, it was necessary to compensate for these variations after the lamp was sealed and tested since no method or apparatus was known which could introduce the correct amounts of these materials into the lamp in every instance. The method of compensation consisted in providing the exhaust tubulation adjacent one of the electrodes and in sealing off said tubulation a short distance from the envelope so that storage space was provided for an excess of the vaporizable material at said location. Tests were then conducted to determine the operating characteristics of the lamp whereupon an estimated compensation was made by reducing the size or length of the tubulation so as to force some of the vaporizable material condensed therein into the immediate interior portion of the lamp. A second test had to be made to determine the effect of the adjustment after which other adjustments and tests often had to be made to cause the lamp to operate as desired. The above method of manufacture, which is disclosed in detail in U. S. Patent No. 2,094,694, dated October 5, 1937, is somewhat objectionable since it is indirect and costly and since a considerable portion of the exhaust tubulation must remain on the lamp.

One object of my invention is to provide a method and apparatus of exhausting and filling discharge devices in a more satisfactory and ready manner than practiced heretofore. My method allows the effective exhaustion of the device and the proper proportioning and ready introduction of uncontaminated filling materials.

Another object of my invention is to provide a method and apparatus of exhausting and filling discharge devices which provides for the proportioning of the filling materials in relation to the construction of said discharge devices. The method and apparatus permits the operating characteristics of the discharge device to be established before it is sealed and causes said devices to have definite operating characteristics when completely manufactured. The method and apparatus eliminates prior cumbersome methods of operation and the need for a tubulation or tip on the device. The tubulation interferes with the application of said devices and the flow of the cooling medium about the device.

Other objects and advantages of my invention will appear from the following detailed description of a method and apparatus comprising my invention which is used in the manufacture of capillary lamps.

In the drawing; Fig. 1 is a schematic illustration of apparatus comprising my invention; Fig. 2 is a side elevation of manifold and control valves thereof from which a quarter section has been taken; and Fig. 3 is a section through means for forcing additional vaporizable material to the discharge device according to a modification of my invention.

According to the preferred method of operation, the whole apparatus must be evacuated for a time before the exhaustion of a discharge lamp is attempted, so as to rid the apparatus of materials contaminating a discharge lamp. The exhaust operation is brought about when a closed tube is attached to the central opening 10 in the manifold 11 in place of the capillary exhaust tube 12 of the discharge lamp 13 shown so that the apparatus is in effect a closed system sealed from further contamination. The closed tube in the opening 10 most generally is the portion of the exhaust tube 12 tipped off from a discharge lamp 13 during the preceding cycle of operations and is sealed to the manifold 11 by the pressure of the compression nut 14 against the rubber gasket 15 (Fig. 2). The opening 10 extends into the manifold 11 but a short distance and connects with four transverse pas-

sages like that at 16 which are controlled by separate needle valves 17, 18, 19 and 20. The transverse passages are at 90 degree intervals and are for the purpose of conducting fluids to and from similarly spaced passages or outlets on the back of the manifold 11, corresponding to the passage or outlet 21 (Fig. 2), as the control valves 17, 18, 19 and 20 may demand. Each control valve is a duplicate of the others and consists of a stem 22 screwed into an opening in the manifold 11, a valving needle 23 screwed into the stem 22 and engaging a seat in said manifold 11, packing 24 and packing nut 25. In this particular instance, the packing 24 is of leather which has been impregnated by anhydrous lanum and beeswax in vacuum.

At the time the exhaust cycle which clears the contamination from the apparatus is in effect, all four valves 17, 18, 19 and 20 are turned to their open positions and a source of vacuum connected to the manifold 11 through pipe 26, outlet 21 and valve 17 is permitted to draw on the central opening 10 in said manifold 11 closed by the tube and each of the auxiliary systems controlled by the valves 18, 19 and 20. If the apparatus is being placed in operation after an inactive period, it is preferred that the different parts thereof be heated to cause all possible contamination to be liberated and exhausted. The length of time the exhaust cycle is carried on depends upon the prior usage of the complete system and is terminated, after the valves 18, 19 and 20 are closed, by closing valve 17.

The apparatus is not in condition to start exhausting the discharge lamp until it is provided with a supply of the vaporizable material, the non-gaseous component of the filling. The vaporizable material, which is mercury in this particular instance, readily absorbs the atmosphere and other materials which could contaminate a discharge lamp and considerable care must be exercised to prevent contamination from being carried into the discharge lamp with said material. The preferred method of operation consists in introducing the mercury into a particular auxiliary system of the apparatus in as clean and uncontaminated a state as possible, and to treat said mercury in said system so as to rid it of all possible contamination. The preferred method of introducing the mercury into the system consists in sucking the mercury into the apparatus through a second downwardly bent tube (not shown) inserted in the central opening 10 of the manifold 11 in place of the closed tube. The lower end of the bent tube is immersed in a dish of clean distilled mercury whereupon valve 18 is opened so that the auxiliary system including pipe 27, reservoir 28, pipe 29, reservoir 30 and stopcock 31 are connected to said tube. The remainder of the auxiliary system includes tube 32, reservoir 33, stopcock 34 and pipe 35 which are connected to valve 19 of the manifold 11 and is completely sealed as stopcock 34 and valve 19 are now at the closed position. The mercury is sucked up through the bent tube, the manifold 11 and into the reservoir 28 by turning the stopcock 31 so that a source of vacuum connected thereto at 36 can draw on the auxiliary system. When the reservoir 28 is sufficiently filled, valve 18 and the stopcock 31 are closed. This method of operation keeps the auxiliary system from being opened to the atmosphere while the mercury is introduced therein.

The next step in the method is to distill the mercury over into reservoir 30 by the application of heat to reservoir 28 so that the mercury is separated from any less volatile material it may contain. The electric heater 37 provides the means of heating reservoir 28 which retains the less volatile materials. The stopcock 31 is now turned so that an inert gas, preferably argon, is admitted into the auxiliary system from the connection 38 and the mercury in the reservoir 30 is forced up the tube 32 to the reservoir 33. Stopcock 31 is then turned so that vacuum is again applied to the system whereupon stopcock 34 is turned so that an inert gas connection is made to the reservoir 33 from the pipe 39. These operations transfer the mercury to reservoir 33 and are only successful in that tube 32 has an upwardly extending loop therein, of 85 centimeters in height for instance, which holds a sufficient column of mercury to block any movement thereof with the difference in pressures produced within the system.

In certain instances, it may be possible to introduce sufficiently clean distilled mercury directly into the reservoir 33 to satisfy the requirements of the discharge device being treated, but even at such times it is preferred that the mercury be heated in reservoir 33 while under vacuum to remove certain undesirable contaminating elements which can be drawn off with the exhaust. In such cases, the tube 32, reservoirs 28 and 30 and the remainder of the auxiliary system are not required.

In any case, the apparatus is now ready to exhaust and fill the the discharge device and accordingly the exhaust capillary or tube 12 of the capillary discharge lamp 13 which is to be treated is connected to the central opening 10 in the manifold 11. When this has been done, the valve 17 is opened so that the lamp is drawn on by vacuum, and heat is applied to the lamp 13 to drive out all gases contained within the lamp assembly. Although the lamp 13 is quartz, it is preferred that it be heated as hot as possible without danger of collapsing. When the lamp 13 is believed to be thoroughly exhausted, the valve 17 is closed and the heating is stopped.

The filling operation is now brought about by opening valve 20 thereby admitting the gas conducted thereto through tube 40 and stopcock 41. Two connections 42 and 43 are made to the stopcock 41 so that a choice of two different gases, usually argon or neon or mixtures thereof, can be supplied the lamp 13. A monometer 44 is also connected to the tube 40 in order that the lamp 13 can be filled to a known pressure, said pressure in the ordinary instance being such that the internal pressure of the lamp after receiving its charge of mercury is equivalent to a 2 cm. column of mercury.

To the filling in the lamp 13 is now added a specific amount of mercury, the non-gaseous component, which is contained within the reservoir 33. The mercury comprising this component must be admitted to the lamp in such a manner that very definite conditions will be established within the lamp after it is sealed despite the fact that each successive lamp being filled varies somewhat from the predecessors. Absolute control over the size of the interior of the lamp has, as yet, been impossible as the enclosing envelope is either of quartz or hard glass which is difficult to work and as the interior is so small as to be materially affected by very slight variations in all parts of the lamp 13. According to my method of operation, the valve 20 is closed sealing off the gas filled portion of

the apparatus and the valve 19 is opened permitting the mercury to flow through the manifold and the capillary tube 12 to the lamp 13. The movement of the mercury, of course, forces the gas contained within the manifold 11 and the capillary tube 12 into the lamp 13 and is preferably controlled so that the gas is at a pressure equivalent to a 2 cm. column of mercury when the valve 19 is closed and the filling operation is terminated. An excess of mercury is then contained within the lamp 13 or is evaporated thereunto by heating the exhaust capillary 12 which is now filled with mercury and a very subnormal discharge started between the electrodes 45 and 46 of said lamp 13. The lamp 13 is then permitted to cool, whereupon the trough 47 containing cool water is raised over it and the normal discharge is created in it. The lead 48 which is connected to one end of the lamp 13 is insulated to prevent a discharge of current through the water which is, in turn, circulated through the trough from the inlet 50 to the outlet 51.

Since there is too much mercury within the lamp 13, it is now operating incorrectly and the voltage of the electrical energy across the terminals thereof, as indicated by the voltmeter 52, is above normal. The valve 19 is then turned back very slightly so that the pressure of the mercury vapor within the lamp 13 which has now increased to several atmospheres pressure can escape into the exhaust capillary 12 by forcing the mercury within the exhaust capillary 12 to back away from said lamp 13. The electrical voltage across the electrodes 45 and 46 of the lamp 13 drops as the pressure drops and finally the lamp 13 is operating as desired and the valve 19 is closed. As such times, the mercury fills the entire exhaust capillary 12 and should be just at the verge of entering the lamp 13.

If the method of manufacture has been such that the lamp 13 contains less than the desired amount of mercury, the method of operation must be varied somewhat. In such instances, the additional mercury is introduced into the lamp 13 in either of two ways; one being by discontinuing the operation of the lamp 13 and forcing in more mercury from reservoir 33 by increasing the pressure of the gas introduced through stopcock 34, and the other being by mechanically forcing more mercury into the lamp 13 while it is still operating. In the latter instance, it is preferred that a plunger 53, like that shown in Fig. 3, be provided in the manifold 11 between valves 17 and 19 so that sufficient pressure can be supplied to the mercury to force it into the lamp 13 against the 200 to 300 atmospheres of pressure therein. The plunger 53 is sealed into the manifold 11 in the same manner as the metering needle 23 of the valves 17, 18, 19 and 20, and is operated by screwing it in or out of the stem 54.

The next operation is to disconnect the electrical circuit from the lamp 13 whereupon it cools and the mercury vapor in it condenses on the walls of the envelope reducing the pressure therein. The mercury in the exhaust capillary 12 does not move into the lamp 13 as it is incapable of expanding with the change in pressure within said capillary 12, but must be drawn away from the lamp 13 a little distance before said capillary 12 can be sealed and tipped off. The mercury is drawn back in the exhaust capillary 12 by turning the stopcock 34 so that the vacuum connection 55 can draw on the mercury in the reservoir 33 and opening the valve 19 slightly for an interval. The drawing back of the mercury only causes a change in the amount of the gaseous component of the filling in the lamp 13 which change can be provided for in the original supply of said component introduced into said lamp 13, and is relatively unimportant with respect to the non-gaseous component of said filling. The exhaust capillary 12 is now tipped off as close to the lamp 13 as the water in the bath will permit.

The method of operation develops a small tip at the middle of the lamp 13 which is much less objectionable than the longer tube and tip developed at the end of the lamp 13 by prior methods of operation. The present tip can, however, be reduced in size still further so as to virtually be non-existent if desired. To shorten the tip, the lamp 13 must first be placed in a suitable bath, molten tin or lead, at a temperature such that it increases the pressure within the lamp 13 to about one atmosphere, whereupon the tip can be treated by a flame in any manner required. A lamp manufactured in this way is both stronger and better looking and offers less resistance to the flow of the cooling water in which it is operated.

The mercury in the reservoir 33 and connecting pipe 35 is preferably returned directly to the reservoir 28 so that it is kept out of contact with all contamination and can be distilled again before being drawn on in a succeeding filling operation. The movement of mercury is brought about by opening needle valves 18 and 19 which permits the mercury to flow downward from reservoir 33 to reservoir 28.

What I claim as new and desire to secure by Letters Patent of the United States is:

1. The method of exhausting and filling a discharge device which comprises connecting the device to exhausting and filling apparatus, exhausting said device, introducing a vaporizable material into said device, creating a discharge therein, establishing the operating characteristics of the device by readjusting the amount of vaporizable material within the device and thereafter sealing said device from the exhausting and filling apparatus.

2. The method of exhausting and filling a discharge device which comprises connecting the device to exhausting and filling apparatus, exhausting said device, introducing an excess of a vaporizable material into said device, creating a discharge in said device, establishing the operating characteristics of the device by releasing the excess vaporizable material therefrom and thereafter sealing said device from the exhausting and filling apparatus.

3. The method of exhausting and filling a discharge device which comprises connecting the device to exhausting and filling apparatus, exhausting said device, introducing a vaporizable material into said device, creating a discharge therein so as to determine the operating characteristics of the device, discontinuing the operation of the device to cause the pressure therein to be reduced, introducing additional vaporizable material into said device, recreating a discharge in said device, establishing the operating characteristics of the device by releasing the excess vaporizable material therefrom and thereafter sealing said device from the exhausting and filling apparatus.

4. The method of exhausting and filling a discharge device which comprises connecting the device to exhausting and filling apparatus, ex-

hausting said device, introducing a vaporizable material into said device, creating a discharge therein, so as to determine the operating characteristics of the device, forcing additional vaporizable material into said device until definite operating characteristics are established by said device and thereafter sealing the said device from the exhausting and filling apparatus.

5. The method of exhausting and filling a discharge device which comprises connecting the device to exhausting and filling apparatus, exhausting said device, filling the device to a definite pressure with a gaseous atmosphere, introducing a vaporizable material into said device, creating a discharge therein, establishing the operating characteristics of the device by readjusting the amount of vaporizable material within the device and thereafter sealing said device.

6. The method of exhausting and filling a discharge device provided with an exhaust tube which comprises connecting the exhaust tube of the device to exhausting and filling apparatus, exhausting said device, filling said device to a definite pressure with a gaseous atmosphere, introducing a vaporizable material into said device, creating a discharge in the device to determine the operating characteristics thereof, adjusting said characteristics to definite values either by adding or releasing vaporizable material from the device through the tube and thereafter sealing and tipping off said tube adjacent the device to separate said device from the exhausting and filling apparatus.

7. The method of exhausting and filling a discharge device which comprises connecting the device to exhausting and filling apparatus, exhausting said device, heating the device externally to cause the liberation of any contamination so that it is drawn off with the exhaust, filling the device with a gaseous atmosphere, introducing a vaporizable material into said device, creating a discharge therein, establishing the operating characteristics of the device by readjusting the amount of vaporizable material within the device and thereafter sealing said device from the exhausting and filling apparatus.

8. The method of exhausting and filling a discharge device provided with an exhaust tube which comprises connecting the exhaust tube of the device to exhausting and filling apparatus, exhausting said device, filling the device with a gaseous atmosphere, introducing a sufficient quantity of a vaporizable material into the tube to provide an excess thereof over the amount vaporized by a discharge in the device and to cause the gas within the device to be compressed to a definite pressure and a portion of said material to enter the device, creating a discharge in the device to determine the operating characteristics thereof, establishing definite operating characteristics for the device by permitting the excess vapor therein to re-enter the tube, and thereafter sealing and tipping off the tube adjacent the device to separate the device from the exhausting and filling apparatus.

9. Apparatus for exhausting and filling a discharge device provided with an exhaust tube comprising a manifold having a plurality of outlets adapted to be connected to sources of vacuum and the different filling materials, means for connecting the exhaust tube of the device to said manifold and needle valves connected to the outlets of the manifold for controlling the exhausting and filling operations.

10. Apparatus for exhausting and filling a discharge device provided with an exhaust tube comprising a manifold having a plurality of outlets adapted to be connected to sources of vacuum and the different filling materials, means for connecting the exhaust tube of the device to said manifold, a reservoir connected to one of said outlets adapted to hold a vaporizable material, means connected to said reservoir for varying the pressure therein and the tendency of said vaporizable material to travel toward the manifold, and needle valves connected to the outlets of the manifold for controlling the exhausting and filling operations.

11. Apparatus for exhausting and filling a discharge device provided with an exhaust tube comprising a manifold having a plurality of outlets adapted to be connected to sources of vacuum and the different filling materials, means for connecting the exhaust tube of the device to said manifold, a reservoir connected to one of said outlets, a second reservoir connected to said first reservoir adapted to hold a vaporizable material, heating means for said second reservoir to distill the vaporizable material into the first reservoir, and needle valves connected to the outlets of the manifold for controlling the exhausting and filling operations.

12. Apparatus for exhausting and filling a discharge device provided with an exhaust tube comprising a manifold having a plurality of outlets adapted to be connected to sources of vacuum and the different filling materials, means for connecting the exhaust tube of the device to said manifold, a reservoir connected to one of said outlets, a second reservoir connected to a second outlet and to said first reservoir adapted to hold a vaporizable material, means of connecting the second reservoir to a source of vacuum to permit the vaporizable material to be drawn in it through the manifold, heating means for said reservoir to distill the vaporizable material into the first reservoir, and needle valves connected to the outlets of the manifold for controlling the exhausting and filling operations.

13. Apparatus for exhausting and filling a discharge device provided with an exhaust tube comprising a manifold having a plurality of outlets adapted to be connected to sources of vacuum and the different filling materials, means for connecting the exhaust tube of the device to said manifold, a reservoir connected to one of said outlets, a second reservoir connected to a second outlet and to said first reservoir adapted to hold a vaporizable material, means of connecting the second reservoir to a source of vacuum to permit the vaporizable material to be drawn in it through the manifold, heating means for said reservoir to distill the vaporizable material into the first reservoir, means connected to said first reservoir for varying the pressure therein and the tendency of said vaporizable material to travel toward the manifold, and needle valves connected to the outlets of the manifold for controlling the exhausting and filling operations.

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