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[54] **METHOD OF CHARGING A THERMOSTATIC SYSTEM WITH A CONDENSIBLE AND A NONCONDENSIBLE MEDIUM**

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[51] **Int. Cl.** **B65b 31/02**
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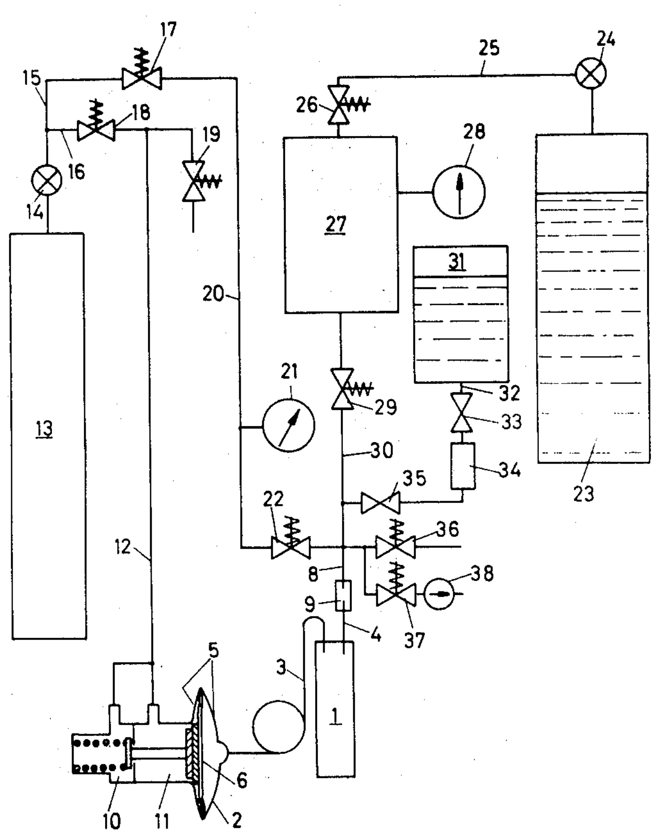
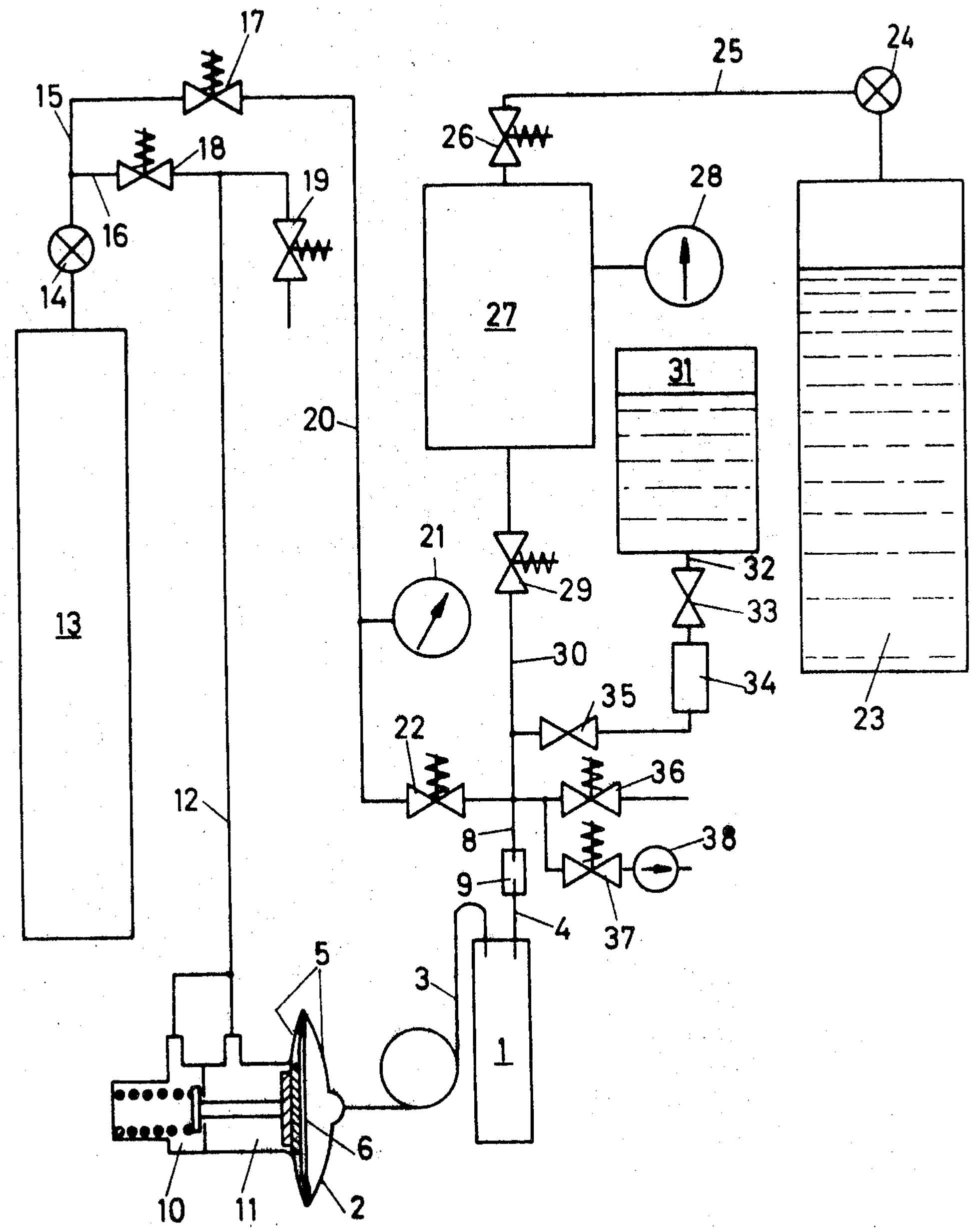
[57] **ABSTRACT**

The invention relates to a method and apparatus for charging a thermostatic system with condensible and noncondensible mediums such as Freon and nitrogen. The noncondensible medium is introduced first at a predetermined partial pressure followed by the introduction of a measured quantity of the condensible medium. An aspect of the invention involves a preliminary flushing of the system with nitrogen at the system testing pressure such that not only is the system purged of air but the system is tested at the same time.

1 Claim, 1 Drawing Figure

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METHOD OF CHARGING A THERMOSTATIC SYSTEM WITH A CONDENSIBLE AND A NONCONDENSIBLE MEDIUM

The invention relates to a method of charging a thermostatic system with a condensible and a noncondensible medium, and to a charging apparatus for performing this method.

In the case of thermostatic systems which consist for example of a temperature sensor and a working element connected thereto by way of a capillary tube, it is known to use charge materials which consist of a medium which is condensible over a working temperature range and of a medium which is not condensible over a working temperature range. Among the condensible media are sulphur dioxide and halogenized hydrocarbons such as methyl chloride or the substances marketed under the trade names Freon or Frigen. Nitrogen or another inert gas is used as the noncondensible medium.

For the purpose of charging the thermostatic system, it is first evacuated, filled with the condensible medium in vapor form and then charged with the noncondensible medium to the point at which the required total pressure is reached. Surprisingly, in the majority of cases the required temperature-pressure curves that would be expected as the result of the charged quantity of condensible medium, have not been obtained. Frequently, the curves obtained have even diverged from each other.

The object of the invention is to provide a charging method which provides perfectly reproducible results and enables the performance of the method to be still further simplified.

According to the invention, this object is achieved by first charging the noncondensible medium into the system and then the condensible medium.

The invention is based upon the heretofore unobserved fact that the condensible medium, which is first filled into the system and is in vapor form, partially condenses under the pressure at which the noncondensible medium is charged into the system so that the condensible medium thus undergoes considerable reduction in volume. Consequently, a higher proportion of noncondensible medium is charged into the system than corresponds to the required quantitative ratio. Furthermore, the quantity of the condensate is very much dependent upon temperature. Slight changes in the charging conditions, e.g. in the room temperature, lead to clearly differing temperature-curves. If on the other hand, in accordance with the invention, the system is first charged with the noncondensible medium, this risk is no longer run, since its volume can diminish only in dependence upon the charging pressure but not as a result of condensation. Thus there arise no difficulties in filling the thermostatic system with a measured quantity of the condensible medium.

This can be done for example by charging the noncondensible medium into the system up to a partial pressure corresponding to the required mix ratio and then charging the condensible medium in a measured quantity. For example, a quantity of liquid condensate, measured in a measuring chamber, can be charged into the thermostatic system. For practical purposes it is simplest to measure the condensible medium in the superheated condition and to fill it into the system.

A particular advantage is obtained here if at least part of the thermostatic system is cooled. This ensures that the condensible medium is condensed at this cooled part and passes into the thermostatic system rapidly and as completely as required.

The normal use of nitrogen as the noncondensible medium offers particular advantages. The system can then be flushed with nitrogen before being charged with the required quantity of nitrogen. This avoids the need for the considerably more expensive evacuation of the thermostatic system. Flushing does not need to be carried out with very great intensity, since the air previously filling the system will have already had a nitrogen content of approximately 78 percent.

It is for example sufficient if the flushing operation is carried out by charging the system with nitrogen at an excess pressure and then relaxing the pressure. The flushing operation can be repeated several times if required. During each flushing operation parts of the unrequired gases are mixed with pure nitrogen and parts of this mixture are blown out again during the subsequent relaxation of pressure, so that the unrequired gases are reduced to a fraction of the proportion previously present each time.

If the flushing pressure is raised to the test pressure for the system, not only is a particularly good flushing effect achieved, but the compressive strength of the system is tested at the same time.

After at least one flushing operation, a pressure of similar magnitude can be applied to the other side of the movable part of the system, e.g. the diaphragm or bellows. This reinforces the flushing action, since a pumping action is applied to the contents of the system by the return movement of the diaphragm or of the bellows. Furthermore, the properties of the material of the diaphragm or bellows are improved by the application of pressure on both sides as compared with unilateral loading.

A charging apparatus for performing the method of the invention is characterized by a first container for the pressurized noncondensible medium and a first pipe which extends therefrom and to which a pressure gauge is connected, in addition to a charging head, and which can be blocked by means of valves when the pressure gauge indicates a predetermined value, the apparatus also being characterized by a second container for pressurized condensible medium, from which container a second pipe, incorporating a measuring device which can be blocked by means of valves, runs to the charging head. By actuating the valves in the first pipe in dependence upon the value indicated by the pressure gauge, the noncondensible medium can be charged into the thermostatic system through the charging head at a predetermined pressure. Actuation of the valves in the second pipe enables the system, with the help of the metering device, then to be charged with the required quantity of condensible medium.

The second pipe can be connected to the second container at the bottom for example, and the metering device can consist of a liquid-measuring vessel. This arrangement is particularly suitable when fairly large quantities of the condensible medium have to be filled into the system. In an alternative arrangement, the second pipe can be connected to the top of the second container and the metering device can consist of a measuring chamber with a pressure gauge connected thereto. If superheated medium is introduced into the measuring chamber, which has a predetermined volume, until a first pressure that can be read off on the pressure gauge is reached, and is then passed into the thermostatic system until the pressure has dropped to a predetermined second value, this ensures that a precisely defined quantity of the condensible medium has passed into the thermostatic system. This metering device is particularly suitable for introducing small quantities of the condensible medium. This is desirable for example in the case of thermostatic systems in which it is intended to limit pressure by completely vaporizing the condensible medium at a limiting value for temperature that is somewhat beyond the working range.

The charging operation can also be rendered automatic if the pressure gauge actuates contacts which close the inlet valve at a predetermined first pressure and, if required, open the outlet valve and, at a predetermined lower second pressure, close the outlet valve and open the inlet valve.

Expediently, a reducing valve is fitted on the output side of the second container. In this way the condensible medium can be stored in the liquid state and under a relatively high pressure, and after relaxation of the pressure in the reducing valve, the medium is always available with a sufficient degree of superheat.

The invention will now be described in more detail by reference to equipment suitable for the charging method. This equipment is illustrated schematically in the drawing.

A thermostatic system consists of a sensor **1**, a working element **2**, a capillary tube **3** connecting these two components, and a capillary charging port **4**. The working element comprises a case **5** and a diaphragm element **6**. The diaphragm can bear against the two halves of the case in its two end-positions. For charging purposes, the sensor is connected to a charging head **9** by way of the capillary charging pipe **4**. This head **9** is connected to a pipe **8**. The working element controls a valve having two compartments **10** and **11**. These two compartments communicate with a connecting pipe **12**.

Nitrogen under very high pressure, and in particular the test pressure for the thermostatic system, is present in the container **13**. This nitrogen container **13** is connected to each of the pipes **15** and **16** by way of a reducing valve **14**. The pipes **15** and **16** contain magnetic valves **17** and **18**, the magnetic valve **18** monitoring the connecting pipe **12**. Fitted in the connecting pipe **12** is a further magnetic valve **19** which opens to atmosphere. This magnetic valve **19** is used for discharging nitrogen and air mixed therewith which is flushed from the system. The magnetic valve **17** communicates with the charging pipe **8** by way of a pipe **20**, to which is connected a pressure gauge **21**, and by way of a magnetic valve **22**.

A container **23** is partly charged with the condensible medium. The vapor which corresponds to the pressure at room temperature, passes by way of a reducing valve **24** to a pipe **25**, which is connected to a measuring container **27** by way of a magnetic valve **26**. Connected to the measuring container **27** is a pressure gauge **28**. The outlet of the container is connected to a pipe **30** through a magnetic valve **29**. The container **23**, the measuring container **27** and the associated parts can also be replaced by another container **31** to the base of which is connected an outlet pipe **32** which leads, by way of a valve **33**, to a measuring container **34** for fluid. The outlet of this container is connected to the pipe **30** through a valve **35**. The charging pipe **8** also communicates with the atmosphere through a valve **36** and, if required, can be connected to a vacuum pump **38** by way of a further valve **37**. The charging operation can proceed in the following way: Firstly it is assumed that the thermostatic system is connected to the charging apparatus through its charging port **4**. The valves **17** and **22** are then opened. The pressure is automatically determined by the reducing valve **14**; the pressure so established obtains in the pipes and thus also in the sensor **1** and in the entire thermostatic system. This pressure can be as great as 28 atmos. for example, this corresponding to the test pressure for the system. The air contained in the pressure is therefore compressed to a fraction of its original volume. The air thus mixes with the nitrogen. The valve **22** is then closed and the valve **36** opened. Part of the nitrogen-air mixture can escape therethrough, and the pressures drops to that of the atmosphere. At this moment only about one-thirtieth of the unrequired atmospheric air is contained in the charge gas. Where nitrogen is used as the charge gas, the proportion of gases other than nitrogen is less than 1 percent. This quantity is generally permissible. On the other hand however the proportion of foreign gases can be still further reduced by a further similar flushing operation. At the same time the magnetic valve **18** is opened, nitrogen flowing at the same pressure into the compartments **10** and **11** by way of the pipe **12**. This pressure is maintained while the valve **36** is opened. In this way this pressure reinforces the emptying of the diaphragm case by way of the sensor and magnetic valve **36**. Here, it is of particular advantage for this to take place in the diaphragm casing from which, in the normal way, atmospheric air is most difficult to remove.

These high pressures also enable a simultaneous check to be carried out to determine whether the system is fluid-tight. If the case **5** is loaded with the same pressure on both sides, then by simply immersing the entire valve body in a liquid, it is possible to ascertain whether leaking elements are present, since gas bubbles will occur if they are. Furthermore, the test pressure provides the very considerable advantage that the stresses, which may occur during the welding of a diaphragm element, are compensated by these pressure conditions. The service life of the element is extended by this compensation of the stresses.

The partial pressure of the nitrogen in the system is then adjusted to the required value. For this purpose, the magnetic valve **18** is closed and the magnetic valve **19** opened. If the thermostatic system is now under excess pressure and the magnetic valve **17** is closed, the pressure gauge **21** can be used to set the pressure if a partial pressure of the nitrogen above that of the atmosphere is required. If this pressure is to be below atmospheric pressure, then instead of the valve **36**, a vacuum pump **38** can be connected by way of the magnetic valve **37**, the desired reduced pressure being produced, whereafter the valve **36** or **37** and the valve **22** are closed again.

The system can now be charged with the condensible medium. If the system is charged with a liquid condensible medium, a quantity of liquid is allowed to flow from the container **31** through the valve **33** and into the measuring container **34**, the valve **35** being closed. As little as a few $cm.^3$ or even fractions of a $cm.^3$ can be measured in the measuring container. When a certain charge level is reached, the valve **33** is closed. Thereafter, the valve **35** is opened until the charge level has dropped to a point at which it corresponds to the required charge quantity. The condensate then flows through the charging port **9** into the sensor **1** and is there mixed with the noncondensible medium present. In certain cases it is advisable to cool the sensor or the thermostatic system in proportion to the room temperature, so that the condensible medium can also pass into the thermostatic system in a reliable manner.

A still more advantageous method can be used in the case of small quantities of condensible medium, e.g. when pressure-limited valves are used, by measuring off superheated vapor. This takes places in the following manner: a liquid condensible medium is present in the container **23** at room temperature. Saturated vapor is formed above this medium and the pressure thereof corresponds to the room temperature. This saturated vapor can now flow into the pipe **25** through an automatically-operating pressure-reducing valve, the saturated vapors becoming superheated and passing through the open magnetic valve **26** into the measuring container **27**. The pressure gauge **28** fitted at this point shows what is the pressure of the superheated gas at room temperature. The magnetic valve **26** is then closed and the magnetic valve **29** opened. The superheated gas can then flow from the container **27** to the thermostatic system, an at a certain drop in pressure, indicated by the pressure gauge **28**, the magnetic valve **29** is closed again. In this case it is advisable to keep the sensor below room temperature, e.g. by means of a cooling device. This superheated gas then immediately condenses on the cooler part of the system, and it passes into the thermostatic system in a reliable manner. In this way, very small quantities can be readily determined, since the volume of the container **27** is adapted to suit the quantity of condensible medium that is to be charged into the system, and thus a measurable quantity is reached based on the known equation of state for the gases. Compared with direct charging with the liquid medium, this method offers the advantage that even when the required quantity is very small and almost incapable of being measured, very accurate charging can be achieved since occasionally droplets can adhere to the walls of the measuring container due, for example, to adherence of liquid to the container walls. In the case of a thermostatic expansion valve with a pressure limit directly at freezing point, this is of considerable advantage since often only a spot of condensate will be present in the subsequently closed thermostatic system.

Thereafter, the charging port **4** is clamped together by means of jaws and is then soldered up. In this system there is no need to check whether the correct quantity has in fact entered, since it is not possible for the noncondensible medium now to compress the superheated vapor of the condensible medium and thus for an uncontrolled quantity of noncondensible medium to be charged into the system. It is obvious that the pressure in the container **27** must be higher than the pressure at the pressure gauge **21** after the noncondensible medium has been introduced. Thus a very accurate charge quantity is obtained in the thermostatic system, since the volume of the system is known and is first charged only with superheated gas in the form of nitrogen. Then, the rest of the charge, which can simply be read off from the pressure-drop at the container **27**, is introduced.

If the pressure gauge **28** is provided with contacts, it can directly control the valves **28** and **29**. If the valve **26** is opened and the valve **29** closed, the pressure in the container **27** rises until the pressure gauge reaches an upper limiting value. At this value, the valve **26** is closed. When the valve **29** is later opened for charging the thermostatic system, the pressure in the container **27** drops until, at a lower limiting value, the valve **29** is closed. When charging takes place on an assembly line, the pressure gauge **28** can also open the valve **29** at the upper limiting value and the valve **26**, possibly after a time-lag, at the lower limiting value.

I claim:

1. A method of charging a thermostatic system with a condensible medium and a noncondensible medium comprising the steps of firstly charging the system with said noncondensible medium and secondly charging said system with said condensible medium, said noncondensible medium being charged into said system at a predetermined pressure, said condensible medium being charged into said system in a measured quantity, said noncondensible medium being nitrogen, the method including the step of flushing said system with nitrogen at least once prior to said step of charging said system with said noncondensible medium, said system including a working element having a moving part with chambers on opposite sides thereof and a sensor bulb connected with a capillary tube to one of said chambers, said method including the step of directing nitrogen to the other of said chambers subsequent to said step of flushing said system.

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