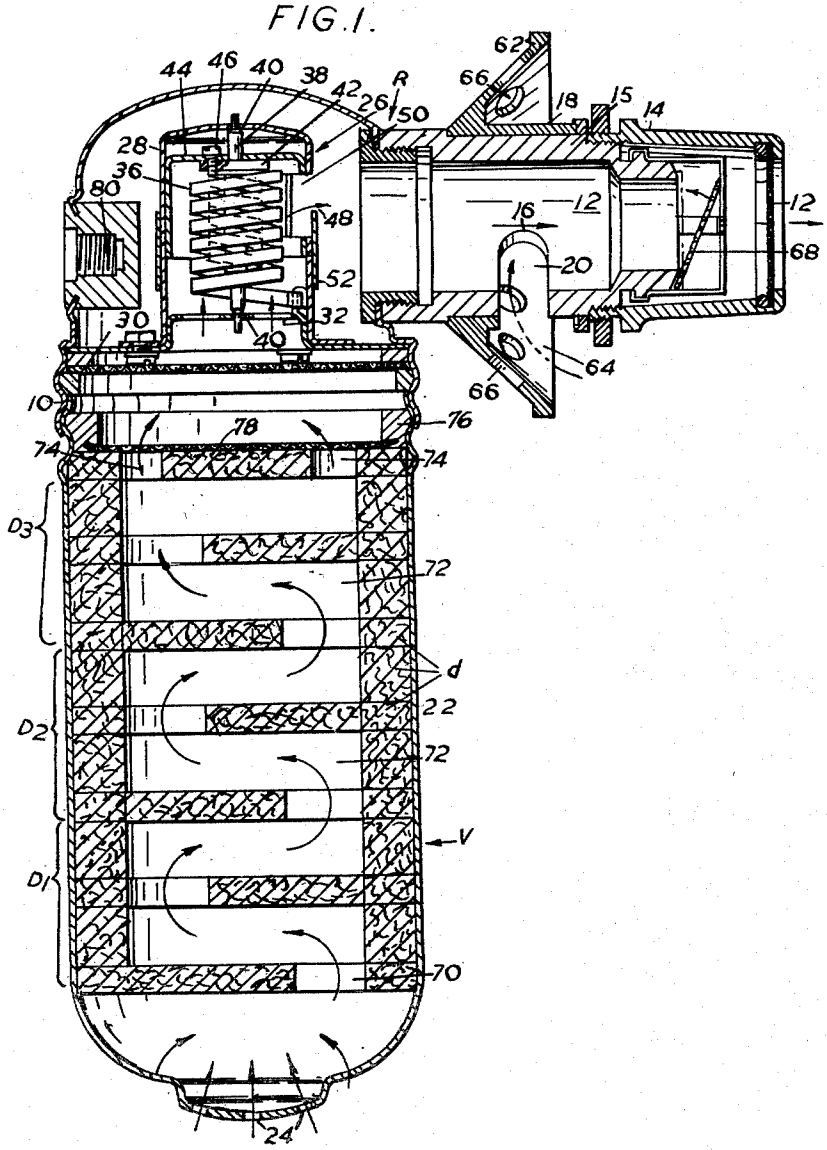
April 13, 1954 L. A. COX 2,674,999

CONTROLLING THE SUPPLY OF VAPORS OF VOLATILE LIQUIDS

Filed April 10, 1950 3 Sheets-Sheet 1

FIG. 1.



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CONTROLLING THE SUPPLY OF VAPORS OF VOLATILE LIQUIDS

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FIG. 2.

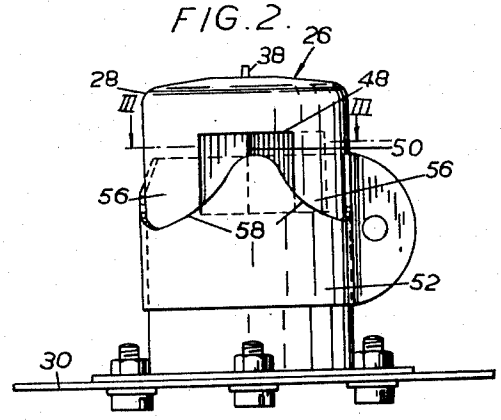


FIG. 3.

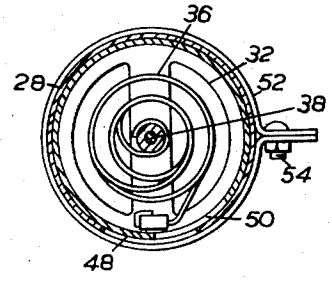
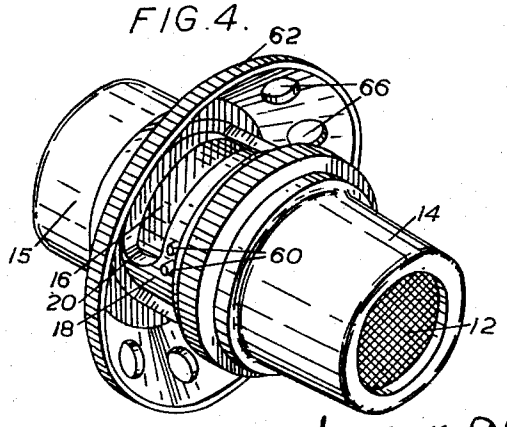


FIG. 4.



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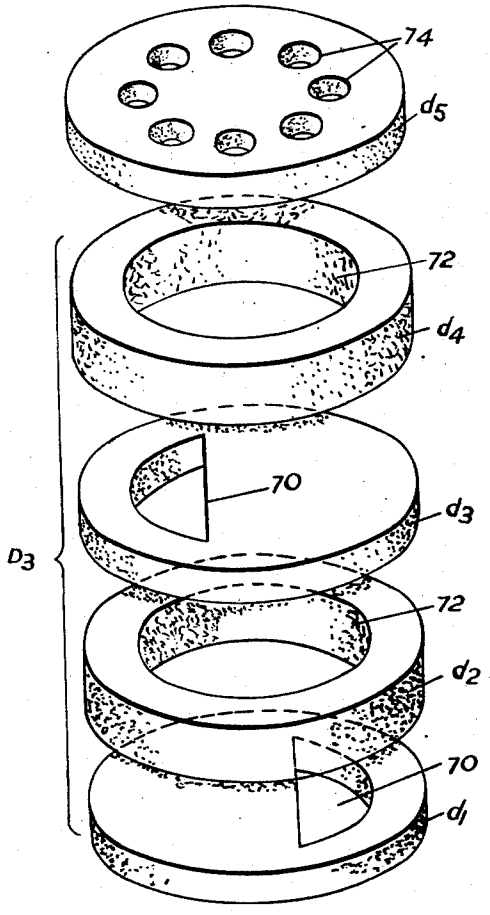
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CONTROLLING THE SUPPLY OF VAPORS OF VOLATILE LIQUIDS

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FIG. 5.



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CONTROLLING THE SUPPLY OF VAPORS OF VOLATILE LIQUIDS

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11 Claims. (Cl. 128—195)

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The invention relates to inhaling devices for use in the administration of volatile liquid anaesthetics which are carried by a stream of air or other gas.

An object of the invention is to provide an inhaler having an outlet through which the patient can draw air simultaneously directly from the atmosphere called "primary air" and through a vaporiser and thus be anaesthetic laden, called the "secondary" air.

A further object is to provide inhalers for anaesthetics with a temperature-sensitive valve for regulating the flow of secondary air and, consequently, the concentration of the mixture administered to the patient.

According to yet another feature of the invention, the vaporiser is made up of a pile of absorbent discs which have openings in them defining for the secondary air a tortuous path free from constrictions or bottlenecks and bounded substantially wholly by absorbent surfaces.

An example of an inhaler in accordance with the invention which has been designed for use by midwives and doctors in the administration of trichlorethylene for analgesia will now be described with reference to the accompanying drawings in which:

Fig. 1 is a vertical section through the inhaler, certain parts being shown somewhat diagrammatically for the sake of clearness.

Fig. 2 is an outside elevation of the secondary air valve.

Fig. 3 is a section taken on the line III—III in Fig. 2.

Fig. 4 is a perspective view of the delivery end of the inhaler showing the primary air intake and

Fig. 5 is an exploded view of part of the vaporiser.

The inhaler shown in the drawings has two main parts, viz. a vaporiser V and a respiratory head R which are screwed together as shown at 10.

The respiratory head R has an outlet passage 12, formed by tubes 14, 15 which can be connected to the patient's respiratory system through a delivery tube or face piece as is common in the administration of anaesthetics.

The outlet passage 12 communicates directly with the atmosphere through an intake port 16 formed in the wall of the tube 15. The air which enters through the port 16 will be referred to as primary air. A valve in the form of a sleeve 18 mounted to turn on the tube 15 has a port 20 in it so that the effective size of the primary air intake 16 can be adjusted. Thus, when the patient breathes primary air will be drawn through the port 16 and out through the outlet passage 12.

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The vaporiser V comprises a container 22 having at its end a series of holes 24 for the intake of what will be referred to as "secondary" air. Within the container, there is a pile of absorbent discs d which will be described in detail later on. For the present, it is sufficient to say that they are impregnated with the anaesthetic (assumed to be trichlorethylene) and that they have openings in them which define for the secondary air drawn in through the intake holes 24 the tortuous path indicated by the arrows in Fig. 1.

The secondary air intake 24 is connected to the outlet passage 12 through the vaporiser and a secondary air valve 26. This valve has a housing or stator 28 which is in the form of a flanged thimble fixed to a disc 30 having holes 32 in its central portion within the thimble which provide the only means of egress from the vaporiser. The stator 28 houses a known form of temperature sensitive valve comprising a double bi-metallic coil 36 anchored at one end to the fixed disc 30 and at the other end to a spindle 38. The spindle 38 is mounted for rotation in bearings 40 in the disc 30 and the stator 28 and has a collar 42 to which is fixed a thimble or rotor 44 by means of a screw 46. With this arrangement, the coil 36 tends to coil up or to uncoil with changes of temperature and, consequently, to turn the rotor in one sense or the other according as the temperature rises or falls.

The stator 28 has in its wall a port 48; the rotor 42 has in its wall a similar port 50. The parts are adjusted so that at normal temperature the two ports 48 and 50 coincide.

If, at normal temperature suction is applied to the outlet passage 12, primary air will be drawn into it directly from the atmosphere through the valve 18 and secondary air will be drawn into it from the atmosphere through the intake holes 24, the vaporiser V and the valve 26. The secondary air will, of course, be charged with trichlorethylene. For a given degree of suction, the rate of flow of primary and of the secondary air through the outlet passage 12 to the patient will depend upon the size of the openings provided by the valves 18 and 26. The concentration of the anaesthetic charged air which reaches the patient depends on the relative rates of intake of primary and secondary air. Accordingly, for a given opening of the ports 48 and 50 of the secondary air valve 26, the concentration of the

anaesthetic mixture can be regulated by adjustment of the primary air valve 18.

However, the rate of evaporation in the vaporiser is dependent upon the temperature therein, which temperature varies in accordance with the ambient temperature and also tends to rise during use of the inhaler. A single setting of the primary air valve 18, therefore, will not ensure that the concentration of the mixture inhaled by the patient will remain constant. It is for that reason that the temperature-sensitive valve 26 is provided.

When the temperature rises above normal and the temperature-sensitive coil 36 tends, in consequence, to coil up or uncoil (according to its inherent characteristics) the rotor 42 is turned so that the ports 48 and 50 come out of coincidence. The effective size of the outlet formed by these ports is, therefore, decreased and the flow of secondary or trichlorethylene-charged air is consequently reduced while the flow of primary air is correspondingly increased. The increase in primary air intake expressed proportionally to the total intake is small and, for practical purposes, the primary air intake can be considered to be constant. Thus, the increased rate of evaporation of the anaesthetic as a result of rise of temperature is compensated by a reduction in the intake of secondary air, and, therefore, the concentration of the mixture supplied to the patient remains substantially constant.

Clearly, in order that the concentration may remain absolutely constant, the rate at which the rotor 42 is turned in accordance with temperature variations, the rate at which the effective area of the outlet 48, 50 changes in accordance with rate of rotation of the rotor, the rate at which resistance to flow through the outlet 48, 50 changes with velocity of the gas and the rate at which the evaporation of the anaesthetic varies with temperature must all be matched. The ports 48 and 50 shown in the drawings are rectangular. For a constant rate of rotation of the rotor 42 the rate of change of the effective area of the port 48, 50 will be linear. In most cases, that will suffice to ensure an acceptable degree of constancy of the concentration of the mixture supplied to the patient. It is, however, advantageous for it to be possible for the manufacturer to adjust the rate of variation of the effective area, at least approximately, in accordance with the factors set out above. This is achieved very simply by the provision of a mask 52 which is clamped around the stator 28.

The mask 52 is movable on the stator 28 both axially and circumferentially and can be held in any adjusted position by means of a clamping screw 54. It has a pair of notches 56 cut in it the edge 58 of which is curved. As will be seen from Fig. 2, adjustment of the mask will vary both the size and the shape of the port 48 in the stator and it will be understood that this will enable the rate of change of the effective area of the outlet from the valve 26 for a given rate of rotation of the rotor 44 to be varied quite considerably.

The shape of the notch or notches in the mask can be designed in accordance with any particular requirements.

It is emphasized that adjustment of the mask 52 is intended to be a manufacturer's adjustment and not a user's adjustment.

The full adjustment made possible by the mask described above may not always be required. It may be, for example, possible to change the rate of change of effective port area with change of temperature while keeping a linear relationship between these two factors. In that case, the mask could have a plain rectangular notch and be arranged exclusively for axial adjustment. Alternatively, the mask could be dispensed with and the rotor and stator be arranged for relative axial adjustment.

As already indicated, adjustment of the concentration by the user is effected by adjustment of the primary air valve 18. If the anaesthetic is to be administered by an unskilled person or by a semi-skilled person such as a midwife, it is advisable that a safe upper limit of concentration be provided for; in other words, the possibility of complete or substantially complete occlusion of the primary air port 16, 20 must be prevented. Stops 60 (Fig. 4) are therefore provided which limit the rotational adjustment of the sleeve 18. Provision is also made for minimising the possibility of accidental obturation of the port 16, 20. For this purpose, the sleeve 18 is provided with a conical collar 62 leaving an opening 64 (Fig. 1) which is too small to allow the port 16, 20 to be closed by the finger, for example. Holes 66 are provided in the collar 62 to ensure free access for air to the port.

If the inhaler is made for use by skilled persons such as doctors and hospital staff, the precautions just mentioned are not essential.

The collar 62 is a convenient means on which to make calibration marks giving an indication of the concentration obtainable for a given setting of the primary air valve 18. The nature of the calibration will vary with the intended use to which the inhaler is to be put.

It is advisable to prevent the entry of the patient's exhalations into the inhaler. For this purpose, a non-return valve such as a simple mica disc as shown at 68 can be provided in the outlet passage 12. A similar valve can be provided, if desired, between the vaporiser and the secondary air valve.

The form of the vaporiser is important. The capacity of the vaporizer, that is to say, its ability to hold a quantity of the volatile anaesthetic for a given overall size, must be substantial; the possible rate of evaporation when the secondary air is drawn through it must be substantial; it must be such that it can be readily re-charged with anaesthetic and such that it cannot be over-charged; it must not unduly resist the passage of air through it.

The vaporiser shown in the drawings has been designed so as to have those characteristics.

As already stated, it consists essentially of a pile of absorbent discs d. The pile is made up of three identical sets D1, D2, D3 (Fig. 1) each of four discs d_1, d_2, d_3, d_4 (Fig. 5) surmounted by a disc d_5. The set D3 and the disc d_5 are shown "exploded" in Fig. 5.

It will be seen that the discs d_1 and d_3 are identical and have segmental holes 70 in them which are set at 180° to each other; the discs d_2 and d_4 are identical and have large circular holes 72 so that they constitute rings or washers. Thus, each set of four discs provides a tortuous path for the air which enters through the holes 24, which path is bounded entirely by absorbent surfaces. Throughout its path through the vaporiser, the air is in contact with surfaces from which it can induce evaporation.

The top disc d_5 has a ring of holes 74 in it, the total area of which is at least as great as that of one of the holes 70. The holes 74 serve to dis-

tribute the secondary air charged with anaesthetic as it leaves the vaporiser.

It will also be seen from an inspection of Fig. 1 that the smallest dimension at right angles to the direction of flow of the air is fairly constant at all points along the path of flow. There are no constrictions or bottlenecks which might place an undue strain on the patient who has to draw the air through the vaporiser by inhalation.

To recharge the vaporiser, the container **22** is screwed off the respiratory head and liquid trichlorethylene is poured into it until the absorbent discs are saturated. It is not possible to charge the vaporiser to excess. After the discs are saturated, any further liquid which is poured in flows out of the holes **24**. This is important because if there were any free liquid in the vaporiser, the rate of evaporation could be dangerously high.

The washers d to d_5 can be made of any absorbent material but are preferably made of felt. If, at any time, they have to be replaced, this is easily effected by unscrewing a ring **76** to which is attached a gauze **78** and which holds the pile of discs in the container **22**.

The provision of an air path through the vaporiser which is bounded entirely by absorbent material is an ideal condition which need not necessarily obtain. For example, if the discs d_2, d_4 were made of non-absorbent material, the capacity of the vaporiser and the rate of evaporation would not be seriously impaired.

In order to give the discs d_1, d_3, d_5 more rigidity and to preclude the possibility of their sagging, they can be provided with metal pins or wires (of stainless steel, for example) which pass radially through them.

It will be understood, of course, that a gaseous medium other than air might be admitted through the primary and secondary intake ports and that the references to air herein and in the appended claims do not preclude the use of the inhaler with such other gaseous medium.

The inhaler described above has many important practical advantages other than those accruing from its efficiency as an inhaler. Among these, are its small size and its small weight. In the form shown, it can be made to weigh about 8 oz. and of a size enabling it to be held comfortably in the hand. That is a big advantage for example, during confinements when it may be desirable that an analgesic be self-administered. On the other hand, the inhaler can very readily be supported in a clamp. Or, it may have a clamp fitted to it (for which purpose, a screwed hole **80** is provided in the inhaler shown in the drawings) by means of which it can be attached to a stationary part such as a bed rail.

In order to obtain an idea of the size of the inhaler shown in the drawings, the diameter of the vaporiser can be assumed to be a little under 2 inches.

While the inhaler described has, as already stated, been designed primarily for use in analgesia, it could be used for anaesthesia.

I claim:

1. An inhaler for use in the administration of anaesthetics comprising a vaporiser for a volatile liquid anaesthetic and a respiratory head having an inlet connected to said container and an outlet adapted to be connected to the patient's respiratory system, said vaporiser and said respiratory head having a passage establishing communication between said outlet and the atmosphere through said vaporiser and a temperature controlled valve in said passage adapted to control the flow of anaesthetic laden air through said passage, said valve comprising a ported stator, a ported rotor adapted on rotation, to vary the effective port area of said stator, a bi-metallic coil connecting said rotor to said stator whereby on change of temperature of said coil, said rotor is caused to rotate and means for varying the shape of the port in said stator.

2. An inhaler as claimed in claim 1 in which said means comprises a mask mounted for adjustment on said stator whereby partially to obturate said port in said stator to a predetermined extent.

3. An inhaler as claimed in claim 1 in which said means comprises a mask mounted for adjustment on said stator in two directions at right angles to each other whereby to vary the size and shape of said port in said stator.

4. An inhaler as claimed in claim 1 in which said rotor and said stator are cylindrical and each has in its wall a similarly shaped port and in which said means comprise a sleeve mounted for rotational and axial adjustment on said stator whereby to alter the shape of said port in said stator.

5. An inhaler for use in the administration of anaesthetics comprising a container for a volatile liquid anaesthetic and a respiratory head having an inlet connected to said container and an outlet adapted to be connected to the patient's respiratory system, in which an air intake is provided connecting said outlet directly to the atmosphere for the supply to the patient of primary air and a further air intake is provided connecting said outlet to the atmosphere through said container for the supply of anaesthetic-charged or secondary air and means for controlling the supply of primary and secondary air comprising a manually adjustable valve controlling said primary air intake, a valve controlling said secondary air intake and means responsive to temperature change for automatically adjusting said valve, said respiratory head comprising a tubular portion through which said primary air and said secondary air flow to said outlet and having a port formed in its wall and said manually controlled valve comprises a ported sleeve mounted for rotational adjustment on said tubular portion whereby to vary the effective size of said port in said tubular portion.

6. An inhaler as claimed in claim 5 in which said respiratory head comprises a tubular portion through which said primary air and said secondary air flow to said outlet and having a port in its wall forming said primary air intake and in which said manually controlled valve comprises a ported sleeve mounted for rotational adjustment on said tubular portion whereby to vary the effective size of said primary air intake and having a flange projecting therefrom at an acute angle over said primary air intake whereby the guard against accidental obstruction of said primary air intake.

7. An inhaler as claimed in claim 6 in which said flange is provided with openings in it to ensure free passages of air to said primary air intake.

8. An inhaler for use in the administration of anaesthetics comprising a vaporiser for a volatile liquid anaesthetic, a respiratory head having an inlet connected to said container and an outlet adapted to be connected to the patient's respiratory system, said respiratory head having a passage connecting said outlet to said va-

porizer and air intake connecting said outlet directly to the atmosphere for the supply to the patient of primary air, an adjustable valve controlling said primary air intake, and an air intake to said vaporizer, said vaporizer comprising a container in which are housed a closely packed pile of absorbent discs, said discs being formed with openings defining through said pile a tortuous path of invariable length for the air from said intake to said passage; an opening for drawing air from the atmosphere to said passage and temperature controlled means in the path of flow of the anaesthetic laden air from the vaporiser, but out of the path of flow of the air from the atmosphere, said temperature controlled means to adjust said valve for quantitatively controlling the flow of anaesthetic laden air.

9. An inhaler for use in the administration of anaesthetics comprising a container for a volatile liquid anaesthetic and a respiratory head connected to said container and manually removable therefrom, said container being provided with an air intake at its end remote from said respiratory head and containing a closely packed pile of absorbent discs adapted to hold said volatile liquid anaesthetic and formed with openings defining a tortuous path of invariable length for air from said intake to said respiratory head and said respiratory head containing a valve and means responsive to temperature changes for adjusting said valve whereby to control quantitatively the flow of air from said container to said respiratory head in accordance with the ambient temperature, and said respiratory head being provided with an air intake on the side of said valve remote from said container.

10. An inhaler for use in the administration of anaesthetics comprising a vaporiser for a volatile liquid anaesthetic and a respiratory head having an inlet connected to said vaporiser and an outlet adapted to be connected to the patient's respiratory system, said vaporiser being provided with an air intake and containing absorbent discs stacked directly on each other and formed with openings defining a tortuous passage of invariable length for air from said intake through the vaporiser and said respiratory head being formed with a passage connecting said outlet to said vaporiser, said last mentioned passage containing a valve and means responsive to temperature

changes for adjusting the opening of said valve whereby to control the flow of air from said vaporiser to said outlet in accordance with the ambient temperature and being provided with an air intake on the side of said valve remote from said vaporiser and also with a non-return valve adapted to prevent the inflow of the patient's exhalations.

11. An inhaler for use in the administration of anaesthetics comprising a vaporiser for the anaesthetic and a respiratory head having an inlet connected to said vaporiser and an outlet adapted to be connected to the patient's respiratory system and manually detachable from said vaporiser, said vaporiser comprising a container provided with an air intake at its end remote from said respiratory head and a pile of felt discs stacked directly on each other within said container and formed with openings defining a tortuous passage of invariable length for the air passing from said intake to said respiratory head and said respiratory head being formed with a passage connecting said vaporiser to said outlet and having located in it a valve and means responsive to temperature changes for adjusting the opening of said valve for controlling the flow of air from said vaporiser through said passage to said outlet and being also provided with an air intake on the side of said valve remote from said vaporiser, said last mentioned intake being provided with a manually controlled valve and said manually adjustable means associated with first mentioned valve for varying the rate of change of rate of flow past said valve for any given setting thereof in accordance with change in temperature.

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