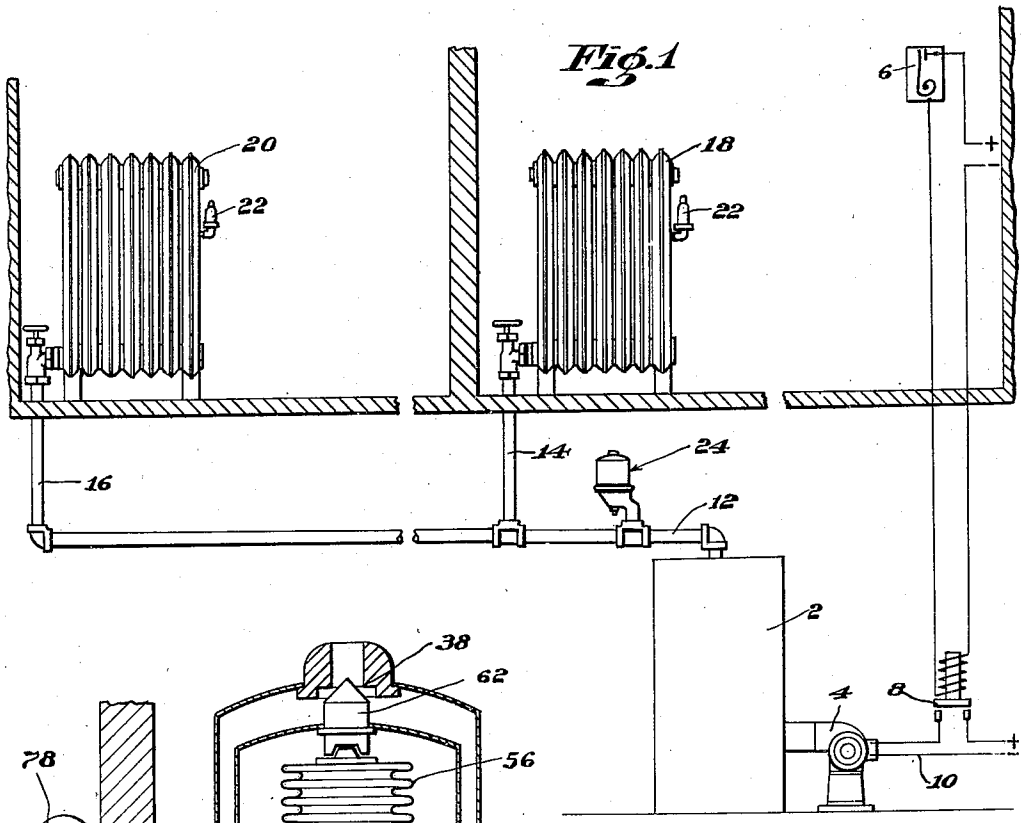
July 15, 1941. W. T. FERGUSON 2,249,706

HEATING SYSTEM

Filed Aug. 2, 1938

Fig. 1



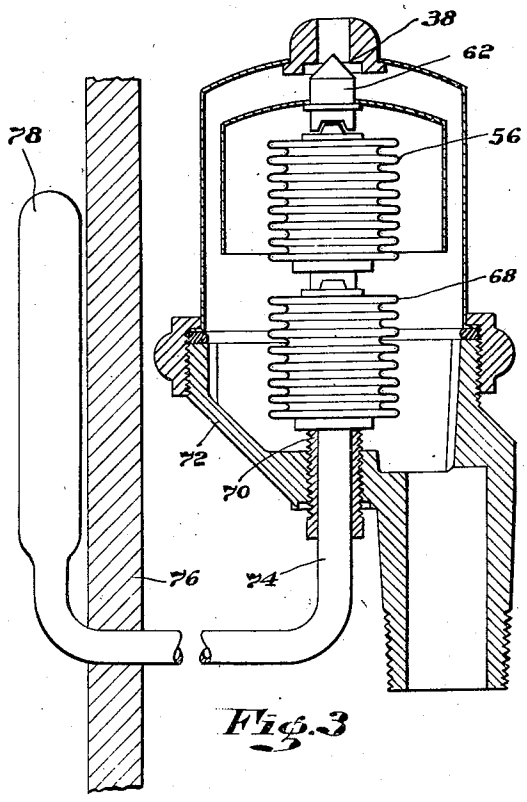


Fig. 3

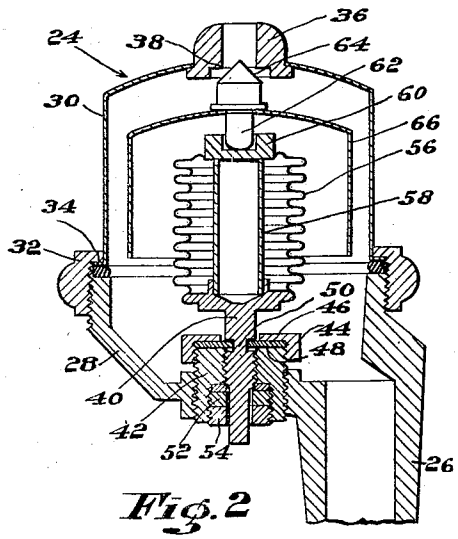


Fig. 2

INVENTOR

Warren T. Ferguson

BY C. Yardley Chittick

ATTORNEY

Patented July 15, 1941 2,249,706

UNITED STATES PATENT OFFICE

2,249,706

HEATING SYSTEM

Warren T. Ferguson, Waban, Mass., assignor to Anderson Products, Inc., Cambridge, Mass., a corporation of Massachusetts

Application August 2, 1938, Serial No. 222,604

18 Claims. (Cl. 237—9)

This invention relates to steam heating systems.

One of the objects of my invention is to provide a steam heating system which will be low in cost and efficient in operation. In the average heating system there is considerable loss of efficiency due to unequal heating of the rooms. This may be caused by several factors. The size of the radiators may be incorrect, or the radiator vents may permit the air to escape too rapidly or too slowly, with the result that certain radiators receive steam sooner or later than others. When conditions of this type are present, a building will be heated unequally; that is to say, some of the rooms will be too warm, other rooms too cold.

In the ordinary situation where the system is automatic, heat being supplied in successive cycles, a thermostat is provided in one room, and the rise and fall of temperature in that one room controls the operation of the source of steam.

It is obvious, therefore, that unless the system is carefully balanced so that on each heating cycle the proper amount of steam will be supplied to the various radiators to produce proper temperatures in all the rooms, the heating of the building in general will be unsatisfactory.

In the heating system of which a typical form is disclosed in the accompanying drawing, I show a so-called one-pipe system in which a single pipe is used to convey steam to the radiators and condensate from the radiators back to the boiler. My invention, however, could be used with a so-called two-pipe system in which an additional pipe is provided at the other end of the radiators for the return of condensate.

In the system disclosed I contemplate using air vents on the radiators of the so-called vacuum type; that is to say, the valves are of the type which permit the escape of air, but close when heated by steam and which stay closed under the influence of a negative pressure in the system.

In the ordinary vacuum system of this type, if the piping and other fittings are tight, a substantial negative pressure will develop between heating cycles due to condensing of the steam, and unless this negative pressure is dissipated before the start of the next heating cycle, the air valves on the radiators will not function to vent air on the subsequent heating cycle, so that such steam as may be generated will float through the system more or less aimlessly, with a corresponding uncertain supply of heat to the radiators.

If, on the other hand, at the start of each cycle, the system is recharged with air at atmospheric pressure, this air must be driven from the system and the radiators before the steam can reach the latter. Because of this fact, through the use of valves on the radiators, which may be adjusted to vary the venting rate, the steam distribution on any given heating cycle may be accurately controlled, and in this way, uniform heating through a building may be obtained.

A further object of my invention, therefore, is to provide means whereby the system may be recharged with air at atmospheric pressure prior to the start of the next heating cycle. One means for accomplishing this result is disclosed in the patent to Ferguson et al., No. 2,062,565, issued Dec. 1, 1936, in which an electrically operated valve is provided to break the vacuum at the start of each heating cycle. In Ferguson et al. the system is opened to the atmosphere regardless of the temperature or pressure that may prevail at the commencement of the cycle.

This invention constitutes an improvement thereover in that means is provided for opening the system to the atmosphere whenever the general temperature of the system falls to a predetermined point; and it is contemplated that by suitable adjustment of the means provided, the system will be opened prior to the commencement of the next cycle which, of course, is under the control of a room thermostat.

When reference is made to reopening of the system prior to the start of the next heating cycle, it is immaterial whether or not the opening of the system takes place exactly at the time that the heat source is placed in operation. The start of the cycle is reached when steam is liberated in such quantities that distribution thereof to the radiators commences.

Another object of my invention is to provide a valve so constructed that when it opens to admit air to the system at a selected predetermined falling temperature, the valve will be opened to full capacity quickly so that the pressure in the system may be rapidly brought back to atmospheric.

Another object of my invention is to provide automatic means whereby the temperature at which the system is reopened may be varied in accordance with the rate of radiation from the rooms of the building to the surrounding medium. The rate of radiation in the ordinary situation varies with the outside temperature, and it is contemplated by my invention that when the outside

temperature is low and the rate of radiation is high, my valve will open at a higher temperature to admit air to the system than that at which it will open when the outside temperature is lower.

A further object of my invention is to provide a suitable valve which may be adjustable so that the opening and closing temperatures may be accurately controlled.

A further object of my invention is to provide a valve which, having automatically opened to permit recharging the system with air, will automatically close upon the generation of steam and remain closed until the temperature again falls to a predetermined point, at which point it will open, provided the negative pressure within the system is not greater than a predetermined amount, determinable by the valve construction. If the negative pressure is excessive at the time the temperature has fallen to the aforesaid predetermined point, then the valve will not open until the negative pressure has been dissipated to a sufficient degree.

These and other objects of my invention will appear as the description progresses with the aid of the accompanying drawing in which

Fig. 1 is a diagrammatic showing of a heating system including my invention.

Fig. 2 is a vertical section of my automatic valve.

Fig. 3 is a vertical section of my automatic valve combined with an automatic adjustment operable in accordance with outside temperature conditions.

Referring now to Fig. 1, 2 is a source of steam which may be supplied with heat through any suitable means, as, for example, an oil burner 4. The oil burner 4 is caused to operate automatically and periodically by use of a thermostat 6 positioned in one of the rooms to be heated. When the thermostat 6 closes, it operates a relay 8 which, in turn, closes the circuit 10 to the oil burner, causing the latter to supply heat to the boiler 2 to generate steam.

A steam main 12 extends from the boiler, connecting with risers 14 and 16, to which are attached radiators 18 and 20. The number of radiators is immaterial.

On each radiator is provided an air vent 22 of the so-called vacuum type. It is believed unnecessary to show in detail the construction of such vents, as they are well known and procurable in the open market. It is merely necessary that these valves vent air until heated by steam, at which time they automatically close; and they must thereafter remain in closed position when a negative pressure develops in the system. A typical valve of this type is shown in the Ferguson et al. patent above referred to in Fig. 3.

The radiators 18 and 20 are customarily positioned in separate rooms, but this likewise is immaterial. They may be grouped as desired.

On the main 12 is positioned my new valve, generally referred to as 24. The detailed construction is shown in Fig. 2, in which there is a vertical nipple 26 adapted to be threaded into a connection on the main 12. The nipple 26 extends to a base 28 on which is mounted a shell 30 secured to the base by a lock nut 32 which engages a flanged lower edge 34 of the shell 30, to form a fluid tight connection. In the center of the top of the shell is a vent 36 forming at 38 a valve seat.

In the center of the base is mounted a supporting stem 40 which is adjustable vertically a limited amount. The particular construction disclosed is as follows: Threaded into the base is a sleeve 42 which is internally threaded to receive the threaded portion of stem 40. Clamped to the top of the sleeve 42 by a nut 44 having an inwardly extending flange 46 is a split washer 48 which straddles stem 40 at the reduced portion 50.

It will be observed that the reduced portion 50 is of a length somewhat greater than the thickness of washer 48, so that the stem 40 may be screwed up and down within sleeve 42 an amount equal in distance to the difference between the length of the reduced portion 50 and the thickness of washer 48. The purpose of this construction will presently become apparent.

In order to seal the construction just described against leakage, a gasket 52 and lock nut 54 are provided within the lower end of sleeve 42.

Carried on the upper end of stem 40 is a sealed bellows 56 which is maintained at a minimum predetermined length by a tubular stop member 58. This stop may be of any suitable construction, it merely being intended to hold the bellows against collapse below a predetermined point.

The bellows that I use must be of construction sufficiently strong to withstand large differences in pressures, as I contemplate that my bellows shall normally carry a very substantial negative pressure; that is to say, before the bellows is sealed, it shall be evacuated sufficiently so that the vacuum will be greater than 20" of mercury. A small amount of water or other volatile liquid is in the bellows, from which steam will be generated when heat is supplied.

On the upper end of bellows 56 is a suitable seat 60 on which rests a valve pin 62 which terminates in a conical form, as at 64, for suitable engagement with valve seat 38. Valve pin 62 carries an inverted open bottom diving bell type float 66 which extends downwardly about bellows 56.

By having a high vacuum in bellows 56, I have found that it is possible to control within a few degrees the temperature at which bellows 56 will begin to expand or contract regardless of the surrounding pressure, provided, of course, it is not greater than the negative pressure within the bellows itself. With a bellows which is not vacuum packed, accurate control of expansion at a predetermined temperature is difficult, and from a manufacturing standpoint it is almost impossible to make a large number of bellows all of which will commence to expand at a particular temperature.

By evacuating the bellows, however, to a high degree, I have found that they may be made in quantity so that all will commence expanding at substantially the same predetermined temperature within manufacturing tolerances. That is to say, when a high vacuum is present in the bellows, the effect of surrounding negative pressures is substantially eliminated, and the temperature is the dominating influence. In bellows not using a high vacuum, elongation and contraction is affected not only by temperature but also by the surrounding pressure of the system. This I consider an outstanding feature of my invention, as it permits accurate control.

In ordinary operation the highest temperature to which the bellows 56 will be subjected is about 212° F. or slightly above, so that sleeve 42 must be adjusted with respect to the base 28 so that when the stem 40 is screwed to its downmost position, the expansion of bellows 56 at 212° or

thereabouts will be sufficient to cause the closing of valve 38.

It is believed apparent that if the valve stem 40 is then screwed upwardly so that valve pin 62 is brought closer to valve seat 38, the valve will close or open as the case may be at a temperature below 212°. Thus, if it is desired to close or open the valve at a temperature, for example, of 170°, it is merely necessary to screw stem 40 upwardly until the expansion of bellows 56 at 170° will be sufficient to move valve pin 62 into contact with valve seat 38.

I might point out at this time that the contraction of bellows 56, sufficient to open the valve, takes place at substantially the same temperature at which the valve closed, and thus, through this vacuum packed construction, it is possible to provide valves in quantity, all of which will open at a given setting, allowing for manufacturing tolerance, at any predetermined falling temperature.

Having described the elements of my system, I will now set forth a typical cycle of operation and the method of adjustment to secure different results.

Let us assume that the temperature outdoors is moderately cold, say, for example, 40° F. The room in which the thermostat 6 is located cools, thermostat 6 closes, and oil burner 4 is put in operation. Steam is in due course generated in boiler 2 and passes along main 12.

Valve 24 being cold, is open, and the entire system prior to the generation of steam is at atmospheric pressure.

Steam, on reaching the valve 24, passes upwardly through nipple 26 into engagement with bellows 56, which expands as the temperature rises. If it is desired that valve 24 close and open at, for example, 178° F., the distance between valve seat 38 and valve pin 62 must be adjusted to a position such that when the bellows 56 is at 178° F., the expansion will be sufficient to close the port.

Thus, shortly after the generation of steam and before the steam has reached the radiators, valve 24 will automatically close. The steam then passes along main 12 to the risers 14 and 16, driving before it the air in the system, which in turn is forced through the radiators and out into the atmosphere through vents 22. While this is taking place, the system pressure will rise, ordinarily, only a few ounces, as this is sufficient to force the steam to all of the radiators. Occasionally, however, the rate of steam generation may be such that the pressure will rise somewhat higher, but in any event, the pressure in the system during the time steam is supplied is positive.

In due course, the radiators will be filled with steam and vents 22 will close. The radiators will give up their heat to the surrounding air so that the room temperature will rise, with the result that in time thermostat 6 will function to stop the operation of oil burner 4 and the generation of steam in boiler 2.

As the radiators cool, the steam in the system will condense and a negative pressure will develop. The speed with which the negative pressure develops is controlled by the rate of condensation and the tightness of the system. If the system is tight, as it should be, the negative pressure will in the ordinary case develop to at least 10 inches of mercury, and generally goes considerably beyond, even to 20 or 25 inches of mercury.

The bellows 56 is vacuum packed for the express purpose of enabling the valve to open under conditions of high negative pressure. That is to say, unless the negative pressure within the bellows, combined with the contractive force of the bellows structure when in elongated position, is greater than the elongating force caused by the negative pressure surrounding the bellows, the valve will not open.

As the radiators cool and the temperature of valves 22 falls, these valves, being of the vacuum type, remain closed because of the negative pressure in the system, and air cannot re-enter the radiators through these vents. Only a small negative pressure, ordinarily not over one inch of mercury, is necessary to hold this type of valve closed.

As the temperature of the radiators falls, the temperature of the entire system in general falls and at valve 24 the temperature, which, at the time the oil burner 4 ceased operation, was in the neighborhood of 212° F., will also commence to drop. In the situation described, valve 24 will reopen at approximately the temperature at which it originally closed, namely 178° F., provided at that time the prevailing temperature and negative pressure in the system are less than that necessary to maintain bellows 56 in elongated position.

If, then, the temperature has dropped below 178° F., the temperature necessary to maintain the valve closed, and the negative pressure in the system is less than 20 inches of mercury (if that is the critical pressure at which the bellows will contract by virtue of the vacuum packing), then valve 24 will open and air will pass into the system through vent 36, which will be opened quickly to full capacity as the cool inrushing air passes bellows 56, dropping the temperature and negative pressure and causing rapid contraction of the latter.

Sometimes, when the temperature has decreased to the point at which the bellows is actuated, for example, 178° F., the negative pressure at that time will be less than the critical controlling pressure for the bellows. This being so, it will be seen that the temperature at the bellows is the controlling factor.

However, another situation generally arises when the vacuum breaking valve 24 is used in connection with a steam system which is exceptionally tight, in that a higher than usual vacuum is created during the cooling part of the cycle. I have found that the negative pressure in some systems will develop so rapidly and to such a degree that the valve will not open at the time the temperature thereat has fallen below the reopening temperature, 178° F., for example, because the negative pressure surrounding the bellows at that time is greater than the contractive force exerted by the negative pressure within the bellows plus the contractive tendency of the bellows itself when in elongated position.

That is to say, the negative pressure in the system may be even greater than the extent of the negative pressure within the bellows, in which case the bellows will be held in elongated position to maintain the valve closed, even though the temperature has fallen below the normal opening point. In such cases, however, the negative pressure in the system will be dissipated either by slow leakage or by the generation of vapors in the boiler after the application of heat thereto. Upon the dissipation of some of the negative pressure in the system, a point will

be reached where the negative pressure in the vacuum packed bellows will be sufficient to overcome the elongating effect of the decreasing surrounding negative pressure of the system, and the valve at this point will reopen.

depending on the particular system, the outdoor temperature, the time between cycles and the radiation characteristics of the heated space, but may be considered as representative of the conditions that quite often prevail.

	At start of cycle	At closing of valve 24	At end of heating cycle	At opening of valve 24 to atmosphere
Boiler water temperature	150° F.	212° F.	212° F. to 215° F.	180° F.
Temperature at valve 24	125° F.	178° F.	212° F.	150° F.
Temperature of heated space	68° F. to 70° F.	69° F. to 70° F.	72° F.	72° F. to 68° F.
Pressure within system if valve 24 opened prior to start of burner.	Atmospheric 0 lbs.	0 lbs. to less than 1 lb.	0 lbs. to 1 lb.	Negative but less than 15" Hg.
Vacuum condition within system if burner started prior to opening of valve 24.	Negative 18" Hg.	0 lbs.	1 lb.	Negative 14½" Hg.

Thus, using a valve **24** of my construction, the system will always be open whenever the temperature at the valve is less than the operating temperature thereof, as determined by construction and setting, and the negative pressure of the system is less than that necessary to maintain bellows **56** in elongated position. In some cases, the opening of the valve may be caused by the temperature falling below the critical point, with the negative pressure at that time also being below the critical point; or in other cases, the decreasing negative pressure may control the reopening as it passes the critical point, the temperature having previously fallen below the critical point of, for example, 178° F.

The critical point for pressure control is determined by the characteristics of the particular heating system, and degree of vacuum packing of the bellows is adjusted to conform therewith. The critical negative pressure should be at least 10 inches of mercury, for when the negative pressure drops below that point, the heat transfer characteristics are such that maintenance of a vacuum is no longer justified. In a reasonably tight system in proper operating order, the negative pressure developed during the off part of each cycle should reach at least this degree of negative pressure. If the bellows is packed to operate at a critical pressure of, for example, 20 inches of mercury, and the system with which the valve is used never reaches as high a negative pressure as that, it is obvious that the temperature at the valve will control the reopening. If, on the other hand, the bellows is vacuum packed to have a critical operating temperature at 10 inches of mercury, then in the ordinary case the system pressure will control the reopening, for the temperature will have fallen below the critical temperature point before the negative pressure of the system will have fallen below the critical pressure point.

Thus, through the use of the vacuum packed bellows, the system is maintained closed as long as either the negative pressure or temperature is in excess of its respective critical point, and reopens only when both the pressure and temperature are below the respective critical pressure and temperature.

The valve **24** is adjusted so that regardless of whether the falling temperature or decreasing negative pressure controls the reopening, the negative pressure at the time of reopening will be not less than about 10 inches of mercury.

The following figures are illustrative of a typical cycle of operation of a heating system in which the critical operating temperature of valve **24** is 178° F. and the critical negative operating pressure of the vacuum packed bellows is 15 inches of mercury. The figures given will vary,

It is contemplated that valve **24** will be so adjusted that it will open prior to the commencement of the next heating cycle which is under the control of thermostat **6**. Obviously, on a cold day the next cycle will be inaugurated by thermostat **6** sooner than on a warm day; and therefore in cold weather valve **24** will be adjusted to close and open at a higher temperature than on a warm day. Thus, if the temperature outside should now fall to zero, it is contemplated that the stem **40** would be screwed downwardly to move valve pin **62** and valve seat **38** farther apart so that the temperature at the valve will have to rise to a higher point before the valve will close, and conversely the temperature will have to fall only a few degrees before the valve will open.

Thus, regardless of the outside temperature, valve **24**, if properly adjusted, will always open to bring the pressure in the system back to zero before the start of the next heating cycle. It has been found that through the ordinary range of temperatures, a single setting of valve **24** will suffice; that is to say, the temperature at valve **24** always drops sufficiently far to cause the reopening of the valve before the start of the next cycle within the range of ordinary winter temperatures. In cases of extreme cold, where heating cycles are very frequent, I have found that it is unnecessary to reopen valve **24** at all, as the radiators, under such circumstances, may be hot continuously.

Thus, by my invention I have provided a simple, economical and accurately operating valve whereby the system is automatically recharged with air before the commencement of each cycle. This is, as previously pointed out, essential where the distribution of steam through the radiators is controlled by the rate of venting of air through the adjustable vents **22**. Furthermore, by the use of my valve no limit is placed on the vacuum that may be developed in the system, and the reopening is controlled principally by the falling temperature. As previously set forth, however, where the system is exceptionally tight, it is possible that the vacuum created in the system may exceed the vacuum of the bellows, so that the falling temperature in such cases is not the sole control. These circumstances, however, prevail only in special instances.

A modified form of my valve **24** is shown in Fig. 3. With respect to opening to recharge the system with air prior to the start of each cycle and closing after the generation of steam, the operation of the form shown in Fig. 3 is identical with that shown in Fig. 2.

The principal difference resides in the provision of automatic means for adjusting the position of the thermostatic bellows **56** vertically as

the outdoor temperature fluctuates. As previously pointed out, it is desirable on cold days that the valve close and open at a high temperature and on warmer days at a lower temperature. This condition is automatically provided for in the construction I have devised.

In Fig. 3 it will be observed that the thermostatic bellows 56 instead of being mounted on an adjustable stem, is carried by another bellows 68. There is a suitable support on the top of bellows 68 to maintain bellows 56 in a proper position so that valve pin 62 will remain in correct alignment with valve seat 38.

Bellows 68 is mounted on a sleeve 70 which is in adjustably threaded engagement with base 72. Extending downwardly through sleeve 70 is a hollow tube 74 which is in connection with the interior of bellows 68. The tube 74 is carried in any convenient manner to the wall 76 of the building and extends therethrough to terminate in the elongated bulb 78. The bellows 68, tube 74, and bulb 78 form a sealed unit and are completely filled with any suitable liquid. Alcohol, for example, would be satisfactory, as it will not freeze under such conditions as would be normally encountered.

It is apparent that as the temperature drops, the liquid in bulb 78 will contract, thereby drawing liquid from the bellows 68 through tube 74. This necessarily causes contraction of bellows 68 and lowers the position of valve pin 62 with respect to valve seat 38, making it necessary for the thermostatic bellows 56 to expand a greater amount before the valve will close. This means the lower the outside temperature, the higher the temperature at which the valve will open and close.

Conversely, as the temperature outside rises, the liquid in bulb 78 will expand, forcing part of the liquid through tube 74 into bellows 68 which will thereupon be elongated to move thermostatic bellows 56 and valve pin 62 upwardly, reducing the amount of movement required to close the valve. Thus, at higher outdoor temperatures the valve will open and close at lower temperatures than would be the case when the outdoor temperatures were low.

It is believed from the foregoing explanation that the operation of this automatic control is apparent. On cold days the heating cycles, due to more rapid heat radiation, will be more frequent than on warm days; that is, the time interval between the cessation of operation of burner 4 and the commencement of operation on the next cycle will be less than when the temperature outdoors is higher. Therefore, it is essential that valve 24 operate to open the system to the atmosphere sooner on cold days than on warm days. By proper adjustment I have found that it is possible to correlate the time of opening of valve 24 to the commencement of the subsequent cycle, so that valve 24 will always open a substantial time after the cessation of the previous cycle, but an adequate time before the start of the next cycle.

In this way I am enabled to maintain a negative pressure in the system through that portion of the off cycle, which is most important. By that I mean that toward the end of the cycle, even though there may be a large negative pressure in the system, the heat transference is quite limited, and as a practical matter it makes but little difference whether the vacuum is broken at the start of the subsequent cycle or some time before. It appears that the most desirable time to break the vacuum is when the temperature has fallen to a predetermined point in relation to the outside temperature.

Since my valve operates to open when the temperature has fallen to a predetermined point, regardless of the negative pressure in the system, provided, of course, that the negative pressure is not so great that it is enabled to overcome the contractive effect of the vacuum-packed bellows, and since the temperature at which it opens is varied in relation to the outside temperature either through the manual adjustment of Fig. 2 or the automatic adjustment of Fig. 3, I am enabled to insure, by proper initial adjustment, opening of the system toward the end of the off portion of the cycle. Thus, the system is recharged at a suitable time so that the adjusted vents 22 may come into play to give the proper distribution of steam on each cycle.

While I have shown a preferred form of my system and valves which are used to carry out the method of heating described, I wish it to be distinctly understood that I do not intend to be limited thereby but only by the appended claims.

I claim:

1. A method of heating by steam in which each cycle comprises the following steps, setting a source of steam in operation at a predetermined falling enclosed space temperature, supplying radiators with steam, sealing the system, discontinuing the supply of steam, then allowing the steam to condense to create a substantial negative pressure, thereafter opening said system to the atmosphere at a point remote from said radiators to recharge the system with air, said opening taking place only when the temperature at said remote point is less than a predetermined degree, and while the pressure in said system is still substantially negative, but is less negative than a predetermined negative amount, and thereafter setting said steam source in operation to commence a second cycle as the temperature in said enclosed space falls again to said predetermined temperature.

2. A method of heating enclosed spaces by steam, utilizing a system which normally vents air from the radiators during each heating cycle, comprising the steps of setting a source of steam in operation, conveying the steam to the radiators, sealing the system, discontinuing the supply of steam, then allowing the steam in said system to condense to create a substantial negative pressure, reopening said system to the atmosphere, while said negative pressure still exists, said reopening taking place at a point remote from said radiators and occurring when the temperature thereat has fallen below a substantially predetermined degree and the negative pressure in said system is considerably less than atmospheric and becoming more negative, but is less negative than a predetermined negative amount, and thereafter resetting said steam source in operation at a predetermined falling enclosed space temperature.

3. A method of heating enclosed spaces by steam, utilizing a system which normally vents air from the radiators during each heating cycle, comprising the steps of setting a source of steam in operation, conveying the steam to the radiators, sealing the system, discontinuing the supply of steam, then allowing the steam in said system to condense to create a substantial negative pressure, reopening said system to the atmosphere at a point remote from said radiators while said negative pressure still exists, and when the

temperature thereat has fallen below a substantially predetermined degree and the negative pressure in said system is considerably less than atmospheric and becoming less negative, and is less negative than a predetermined negative amount, and thereafter resetting said steam source in operation at a predetermined falling enclosed space temperature.

4. A method of heating enclosed spaces by steam, utilizing a steam boiler, a source of heat, a plurality of radiators positioned in said enclosed spaces, and pipes for conducting steam from said boiler to said radiators, in which each cycle comprises the following steps, setting said source of heat in operation at a predetermined falling enclosed space temperature, supplying said radiators with steam, venting air from said radiators through air vents thereon, sealing the system, discontinuing the supply of steam, then allowing the steam to condense to create a negative pressure in said system, maintaining the system sealed until the pressure within has fallen below a substantial predetermined negative degree, then positively opening the system at a point remote from said radiators to recharge the system with air, said opening arranged to take place after the negative pressure has receded to a degree slightly less negative than said predetermined negative degree, and thereafter closing said system at said remote point at a predetermined rising temperature less than the temperature of the water in said boiler at that time, whereby each heating cycle will comprise the provision of a positive pressure in the system while steam is being supplied, a negative pressure in the system after the supply of steam is discontinued until the system is opened for recharging, and a return to atmospheric pressure prior to delivery of steam to said radiators during the next heating cycle.

5. A method of heating enclosed spaces by steam, utilizing a steam boiler, a source of heat, a plurality of radiators positioned in said enclosed spaces, and pipes for conducting steam from said boiler to said radiators, and a negative pressure breaking valve remote from said radiators, in which each cycle comprises the following steps, setting said source of heat in operation at a predetermined falling enclosed space temperature, supplying said radiators with steam, venting air from said radiators through air vents thereon, sealing the system, discontinuing the supply of steam, then allowing the steam to condense to create a negative pressure in said system, maintaining the system sealed thereafter until the temperature and pressure at said negative pressure breaking valve conform to the following requirements, that the temperature is less than a predetermined degree which is considerably in excess of the temperature of said enclosed spaces and less than the temperature of the water in said boiler, and the pressure is negative a substantial degree but not more negative than a predetermined amount, then opening said valve so that the pressure within said system may be returned to atmospheric.

6. A method of heating by steam, utilizing the so-called vacuum type system which includes a steam boiler, comprising the step of reopening the system to the atmosphere during each heating cycle when the pressure in the system is negative a substantial but definitely limited degree and the temperature in the system is much higher than the spaces to be heated but substantially lower than the temperature of the water in said steam boiler.

7. A steam heating system comprising a steam boiler and heating means and radiators to which steam is supplied intermittently by connecting pipes, a vacuum relief valve positioned on said pipes and connecting said system with the atmosphere, thermostatic and pressure operated means for maintaining said valve closed after the termination of the heating portion of each cycle, said thermostatic and pressure operated means including an expansible, hollow, sealed unit operable both by temperature and pressure cooperating to open said valve when the temperature at said valve has dropped to a predetermined degree and the pressure in said system is substantially negative but less negative than a predetermined negative amount, said thermostatic means operable to close said valve when the temperature thereat has risen to approximately said predetermined degree.

8. A heating system for heating enclosed spaces, comprising a steam boiler, a source of heat, radiators connected by piping to said water boiler, vents on said radiators, means for closing said vents when the pressure within said radiators is less than atmospheric, and a valve including an expansible, hollow, sealed unit affected by both temperature and pressure remote from said radiators and attached to said piping and operable to open said system to the atmosphere when the temperature at said valve is very much greater than the temperature in said enclosed spaces but less than a predetermined temperature, which latter temperature is less than the temperature of the water in said steam boiler at the time of reopening of said valve and the pressure within said valve is negative a substantial amount but less negative than a predetermined negative degree.

9. In a steam heating system for heating enclosed spaces, in combination, a steam boiler and a source of heat, a plurality of radiators, pipes for conducting the steam to said radiators, air vents on the radiators permitting the steam to reach said radiators at predetermined times, and means for opening said system to the atmosphere, said means comprising a valve remote from said radiators and attached to one of said pipes, a combined temperature and pressure operated, expansible, sealed unit operatively related to said valve, said valve opened by the actuation of said unit under the influence of the falling temperature of the system, said falling temperature at the time of opening of said valve being substantially greater than the temperature of said enclosed spaces but less than the temperature of the water in said steam boiler, said valve closed by the actuation of the same unit under the influence of steam generated after said valve is opened, the temperature at which said valve is closed always being less than the temperature of the water in said water boiler at the time of closing, said unit also actuated by the system pressure to prevent opening of said valve whenever the system pressure is more negative than a predetermined substantial negative amount.

10. In a steam heating system for heating enclosed spaces, in combination, a steam boiler and a source of heat, a plurality of radiators positioned in said enclosed spaces, pipes for conducting steam created in said boiler to said radiators, air vents on said radiators, means controlled by the temperature of one of said enclosed spaces for starting and stopping the said source of heat, means for insuring atmospheric pressure within said system prior to the distribution of steam on

each heating cycle, said means comprising a combined temperature and pressure controlled valve positioned on said system remote from the said enclosed spaces and adapted to open said system to the atmosphere at a predetermined high falling system temperature considerably above that of said enclosed spaces if the pressure at said valve is less than a predetermined negative degree, the temperature at which said valve opens always being less than the temperature of the water in said boiler, the pressure control of said valve providing means for preventing the opening of said valve whenever the negative pressure in said system is in excess of said predetermined negative degree, said temperature control arranged to close said valve at a temperature always less than the temperature of the water in said boiler at the time of closing.

11. In a steam heating system for heating enclosed spaces, in combination, a steam boiler and a source of heat, a plurality of radiators positioned in said enclosed spaces, pipes for conducting steam created in said boiler to said radiators, air vents on said radiators, means controlled by the temperature of one of said enclosed spaces for starting and stopping the said source of heat, means including said air vents for sealing the system after steam has been generated, and means for reopening the system to the atmosphere after the supply of steam has been discontinued, said system opening and sealing means comprising a valve having a combined thermostatic and pressure operated element the thermostatic phase of said element adapted to close said valve upon the application of heat above a substantially predetermined degree and adapted to open said valve when the temperature thereat has fallen below said substantially predetermined degree, the pressure phase of said element adapted to prevent said thermostatic phase from opening said valve when the pressure in said system is more negative than a predetermined substantial negative amount.

12. In a steam heating system for heating enclosed spaces, means for opening and closing said system to the atmosphere under certain conditions, said means comprising a valve connected to said system, thermostatic and pressure differential operated means related to said valve, said thermostatic means subject to system temperatures at the valve location for opening the valve when the temperature thereat is less than a predetermined degree, said pressure differential operated means operative to maintain said valve closed only when the system pressure is more negative than a preedtermined substantial negative amount, said thermostatic means thereby being subject to control in part by said pressure differential operated means.

13. In a steam heating system for heating enclosed spaces, in combination, a steam boiler and a source of heat, a plurality of radiators, pipes for conducting the steam to said radiators, air vents on the radiators permitting the steam to reach said radiators at predetermined times, and means for opening and closing said system to the atmosphere, said means comprising a valve remote from said radiators and connected to one of said pipes, having a vacuum-packed bellows therein operable to open under the influence of a falling system temperature provided the negative system pressure does not exceed a predetermined negative degree and operable to close under the influence of steam generated after said valve is opened, the temperature at which said valve opens or closes always being less than the boiler water temperature but substantially greater than the temperature of said enclosed spaces.

14. A heating system for heating enclosed spaces, including a steam boiler and a source of heat, comprising radiators with vents thereon, pipes connecting said boiler to said radiators; means for closing said vents when the pressure within said radiators is less than atmospheric, and a valve remote from said radiators and connected to one of said pipes to open and close said system to the atmosphere, said valve comprising a vacuum-packed bellows arranged to expand at a predetermined valve temperature substantially in excess of the temperature of said enclosed spaces, but less than the boiler water temperature, to close said valve, and arranged to contract at substantially said predetermined valve temperature substantially in excess of the temperature of said enclosed spaces but less than the boiler water temperature, at which falling temperature the resultant effect of the pressure within and without the bellows is insufficient to hold the bellows elongated, said bellows also arranged to contract at a substantial determinable negative system pressure when the system pressure is decreasing, at which pressure the resultant effect of the pressure within the bellows as determined by the bellows temperature at the time and the said negative system pressure is insufficient to hold said bellows elongated, thereby to open said system to the atmosphere.

15. A method of maintaining a substantially uniform temperature in an enclosed space by steam, comprising the steps of setting a source of steam in operation at a predetermined falling space temperature, transmitting said steam to a radiator to raise said space temperature, sealing said system, discontinuing the supply of steam at a predetermined rising space temperature, allowing the steam in said system to condense to create a substantial negative pressure in the system, and thereafter reopening said system to permit entrance of air therein at a point remote from said radiator when the temperature at said remote point is less than a predetermined temperature but in excess of said space temperature and while a substantial negative pressure less than a predetermined greater negative pressure prevails in said system, and thereafter resetting said steam source in operation at the initial predetermined falling space temperature.

16. In a steam heating system for heating enclosed spaces, in combination, a steam boiler and a source of heat, a plurality of radiators, pipes for conducting the steam to said radiators, air vents on the radiators permitting the steam to reach said radiators at predetermined times, and means for opening and closing said system to the atmosphere, said means comprising a valve remote from said radiators and connected to one of said pipes having a vacuum packed bellows therein operable to open under the influence of a decreasing negative system pressure when the pressure has decreased to a point less than a substantial predetermined negative pressure, provided the temperature at said valve does not exceed a predetermined degree, said predetermined degree being less than the boiler water temperature, but substantially greater than the temperature of said enclosed spaces.

17. The method of maintaining a substantially uniform temperature in an enclosed space by steam, comprising the steps of supplying steam

after the space temperature has fallen to a predetermined point, transmitting said steam to a radiator to raise said space temperature, sealing said system, discontinuing the supply of steam after the space temperature has risen to a predetermined point, allowing the steam in said system to condense to create a substantial negative pressure in the system, reopening said system to permit entrance of air therein at a point remote from said radiator when the temperature at said remote point is less than a predetermined temperature but in excess of said space temperature and while a substantial negative pressure less than a predetermined greater negative pressure prevails in said system, and supplying steam again after the space temperature has fallen to the said predetermined point.

18. The method of maintaining a substantially uniform temperature in an enclosed space by steam, comprising the steps of supplying steam after the space temperature has fallen to a predetermined point, transmitting said steam to a radiator to raise said space temperature, sealing said system, discontinuing the supply of steam after the space temperature has risen to a predetermined point, allowing the steam in said system to condense to create a substantial negative pressure in the system, and thereafter reopening said system to permit entrance of air therein at a point remote from said radiator when the temperature at said remote point is less than a predetermined temperature but in excess of said space temperature and while a substantial negative pressure less than a predetermined greater negative pressure prevails in said system.

WARREN T. FERGUSON.