

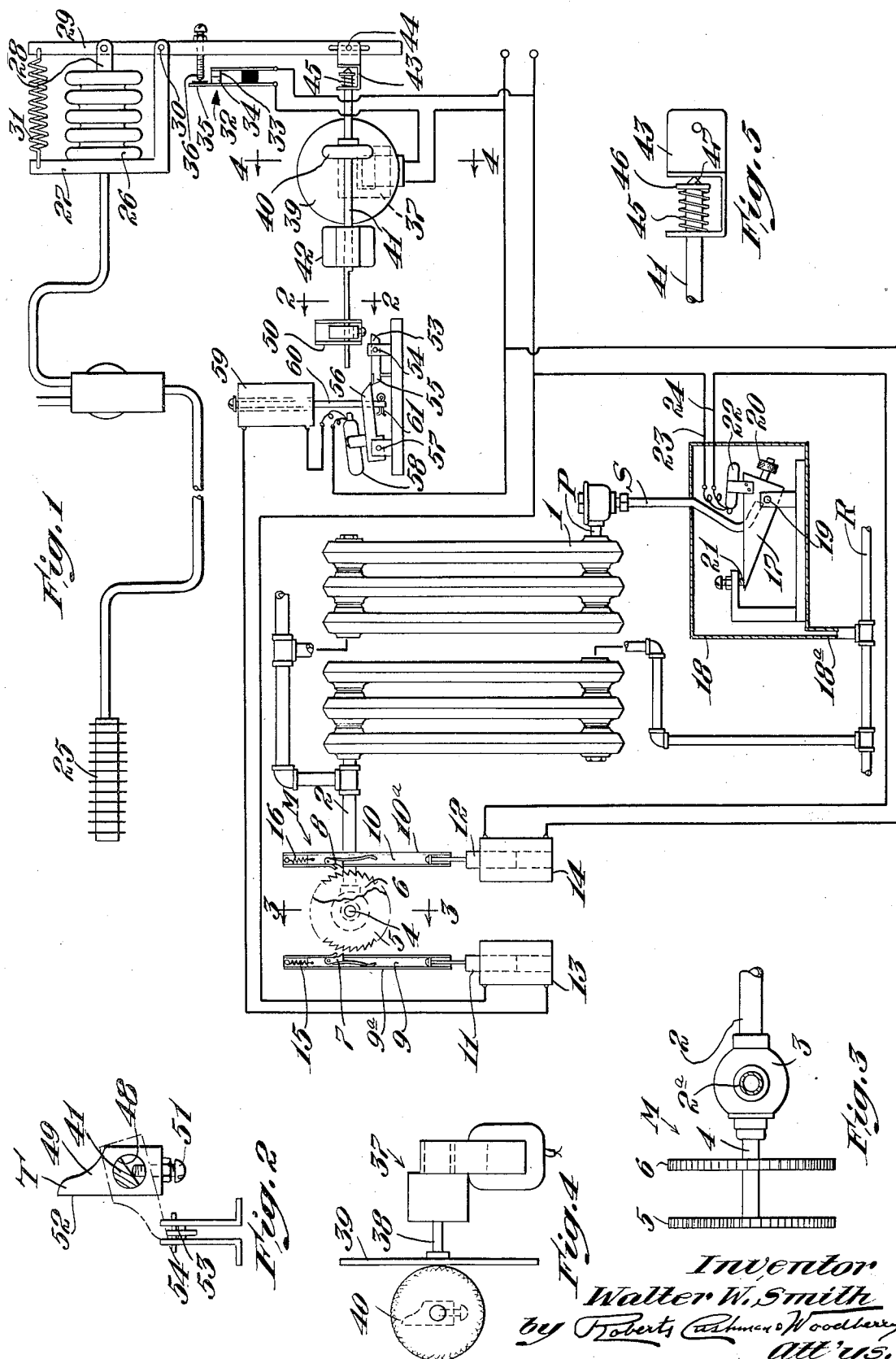
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CONTROL FOR STEAM HEATING SYSTEMS

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CONTROL FOR STEAM HEATING SYSTEMS

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This invention pertains to heat exchange systems, for instance, heating or cooling systems wherein a hot or cold fluid gives up or receives heat during the operation of the system. In many such systems, the fluid is condensable and is condensed, during the operation, from vaporous or gaseous form in order that its heat units may be available as a source of heat; or, in other instances, the fluid, in vaporous or gaseous form, is exposed to the action of a refrigerant merely to convert the fluid to liquid form, and sometimes, as a concomitant to such conversion, to produce reduction in pressure.

As examples of the utility of the present invention may be mentioned its application to industrial kiers wherein material, for instance textile goods, is heated for chemical or other treatment and usually under pressure, by the direct admission of hot steam; textile tenter-frames, cloth or other drying apparatus or the like where steam is admitted to a bank of pipes constituting a single large radiator; steam heating systems for heating buildings where many radiators are usually employed; condenser apparatus for condensing steam in steam power plants; and stills for alcohol, petroleum products, etc. In certain more specific applications of the invention, for example in drying apparatus, heating systems and some types of power-plant condenser, the rate of condensation may depend to a substantial degree upon some variable and, in some instances, wholly uncontrollable condition, for instance, the temperature of the outside atmosphere; and for such conditions the present invention contemplates a dual type of control whereby, if desired, the supply of fluid to be condensed or the amount of refrigerant employed may be varied automatically in response to such conditions, thereby producing a substantially uniform amount of condensate regardless of such varying factors.

In accordance with the present invention the supply of heat (which may be derived from a hot vapor or gas or from the burning of a liquid or gaseous fuel) is varied in accordance with the effects produced. Thus the amount of one of the fluids delivered to heat exchange apparatus, wherein one fluid is condensed by loss of heat to another, is so varied in accordance with variations in the amount of condensate produced as to maintain a substantially predetermined ratio between the quantity of available heat delivered (for instance, in the form of a hot fluid) and the amount of condensate produced per unit of time; for specific instance, in a steam condenser the

amount of steam supplied may be varied in accordance with the rate at which the same steam is condensed to water by the action of a refrigerant fluid such as water or atmospheric air.

While the invention is of broader utility as just above suggested, it is herein specifically disclosed for purposes of illustration and by way of example as employed in a novel and improved method of controlling the amount of steam supplied to the radiator or radiators of a steam heating system, and to novel apparatus for use in the practice of such a method.

In the early days of steam heating one of the most urgent problems was to devise efficient means for transferring the heat from the steam generated in the boiler to the air in the room to be heated, but that early problem has been so well solved that the heating engineer is now confronted with the problem of controlling the emission of heat from the radiators so as to avoid overheating.

In steam heating systems for buildings, the radiators are designed to be of such capacity as to warm the room to approximately 70° F. during the coldest weather which may be expected in the locality in which the system is installed. However, such extreme cold weather prevails for only a few days during the entire heating season, and, thus the rooms will be overheated most of the time unless some means be provided for restricting the heat output of the radiators during the milder weather. For example, in Boston, Massachusetts, it is customary to design the heating system to have sufficient radiating capacity to warm the building to approximately 70° F. inside when the outside temperature is 0°, although the average outdoor temperature in that locality for the season between October 1 and May 1 is 38.1° F. (American Society of Heating and Ventilating Engineers' Guide for 1941). Since the heating capacity of the system remains constant, it is obvious that the building will be very much overheated most of the time unless the heat output from the radiators can be controlled proportionately to the variations in outdoor temperature.

In a steam heating system all of the heat emitted from the radiators must necessarily come from the steam which is supplied. Thus it is obvious that by varying the quantity of steam supplied to the radiators, the amount of heat emitted may be controlled. In calculating radiation, it is customary to consider that radiators will condense one-quarter pound of steam per square foot per hour in a room where the

temperature is 70° F. Thus a radiator having forty square feet of radiating surface will condense ten pounds of steam per hour when it is hot all over. Manifestly, if only five pounds of steam per hour were admitted to the radiator, only one-half of the capacity of the radiator would be required to condense it, or, in other words, the original radiator would be only half heated. Thus, for example, considering a forty-foot radiator, if the entire radiator is necessary to heat a given room on a zero day, then one-quarter pound of steam per square foot of radiator will be condensed each hour or, in other words, ten pounds of steam per hour must be supplied to the radiator to keep it hot all over. On the other hand, when the outdoor temperature is 35° F., only one-half the capacity of radiator is required to maintain the same inside temperature of 70° F., and the admission of five pounds of steam per hour to the radiator would be sufficient. It is thus highly desirable to provide some automatic control of the amount of steam supplied to the radiator in order not only to avoid overheating and discomfort to the occupants of the building, but also for economy in operation.

The copending application of William T. Jones, Serial No. 444,313, filed May 25, 1942, discloses broadly a novel method of controlling the admission of steam to a steam condensing apparatus, for example a radiator, by gradually closing a steam supply valve in direct response to increase in the amount of liquid condensed per unit of time in the radiator, and gradually opening said supply valve in direct response to decrease in the amount of liquid condensed per unit of time in the radiator, the unit of time being varied in accordance with variations in the outdoor temperature. In the specific embodiment of means disclosed in the Jones application, the volume of the condensate is the determining factor, the condensate being collected in a suitable receptacle from which it escapes under a substantially constant head through an orifice valve controlled by a thermostat, the liquid level in the receptacle being the determining factor in setting the admission valve. Such an arrangement is simple, inexpensive and very useful and desirable in controlling the admission of steam to heating apparatus comprising a very large radiator or a bank of radiators and wherein a substantial volume of liquid is condensed, but when applied to a single radiator of medium or small size or to any other steam-using appliance wherein the quantity of condensate is small, there is some difficulty in metering the condensate by volume, since under such conditions the orifice valve becomes of such small capacity that it is very easily clogged with dirt.

The present invention has for its principal object the provision of a novel method and means whereby the supply of heat to heat exchange apparatus wherein a fluid is condensed to liquid form is automatically controlled proportionately to the amount of condensate (according to the Jones principle) but which is equally applicable to small and large radiators. Specifically the present invention contemplates metering the condensate by weight, and since it is possible to construct very delicate weighing means, the invention is useful in systems or in association with apparatus wherein the amount of condensate produced per unit of time is quite small.

Other and further objects and advantages of the invention will be pointed out in the follow-

ing more detailed description and by reference to the accompanying drawing, wherein

Fig. 1 is an elevation, mostly diagrammatic, illustrating one desirable embodiment of the invention;

Fig. 2 is a fragmentary section, to larger scale, substantially on the line 2—2 of Fig. 1;

Fig. 3 is a fragmentary section substantially on the line 3—3 of Fig. 1;

Fig. 4 is a fragmentary section, substantially on the line 4—4 of Fig. 1; and

Fig. 5 is a fragmentary detail elevation, to larger scale, illustrating certain parts shown in Fig. 1.

Referring to the drawing, the numeral 1 designates a steam radiator or other apparatus or appliance to which steam is delivered and in which the steam is condensed. The steam condensing means thus referred to may be a single radiator or appliance or it may be a group or bank of radiators or other steam condensing devices, all of which are supplied with steam from the same source, the size and condensing capacity of the radiator or other apparatus having little, if any, effect upon the operation of the present control system. When several radiators are included in the system—and supplied by the same supply valve—each radiator should be provided with an inlet orifice in order to balance distribution and to insure that each radiator will receive its proportionate amount of steam.

As here illustrated, the radiator 1, which may be a "key" or controlling radiator for a heating system, is supplied with steam by the main 2, and the amount of steam delivered to the radiator is determined by the supply valve 3 (Fig. 3), which may be arranged to deliver steam to as many radiators as desired. This valve 3 may be of any desirable type, but comprises the actuating stem 4. This stem is turned in one direction or the other by means of a reversible motor device M. Any desired motion-imparting device, whether mechanical, electrical or fluid-pressure, may be interposed between the motor and valve stem. As here shown the valve stem 4 and the motor shaft are integral. The motor device, here chosen by way of illustration, comprises two ratchet wheels 5 and 6 fixed to the motor shaft 4 and which have cooperating pawls 7 and 8, respectively. These pawls 7 and 8 are carried by vertically sliding bars 9 and 10 arranged to slide in suitable fixed parallel guideways 9^a and 10^a, respectively. The lower ends of these bars 9 and 10 are connected to the cores 11 and 12, respectively, of solenoids 13 and 14, the arrangement being such that when either solenoid is energized its core is drawn downwardly, thereby moving the corresponding bar 9 or 10 downwardly. Such downward movement of either bar engages the corresponding pawl with its ratchet wheel and thereby the shaft 4 is turned in one direction or the other, dependent upon which solenoid is energized. Each time one of the solenoids is energized, its pawl is moved downwardly, thereby to turn its ratchet wheel through a predetermined angle, and if a given solenoid is repeatedly energized, its ratchet wheel will be turned progressively step-by-step in the same direction. Springs 15 and 16 tend constantly to lift the bars 9 and 10 and thus to restore the cores and pawls to their upper inactive positions. Obviously, if desired, the solenoids might be inverted, so that the return of the pawls would be by gravity action.

The condensate which collects within the

radiator 1 flows out through the pipe P (Fig. 1) and is delivered by the downwardly directed spout S into a self-dumping pan 17, preferably contained within a receptacle 18. This pan 17 is pivoted at 19 and is provided with an adjustable counterbalance 20 designed to keep the left-hand end of the pan, as viewed in Fig. 1, in normal contact with an adjustable stop screw 21. A switch device closes an electrical circuit each time the pan tips to dump its contents. As here shown, the switch is a mercury switch 22 mounted on the pan and so arranged that whenever the pan tips to dump its contents, the switch closes the circuit, including the conductors 23 and 24 and the coils of solenoid 14. The pan is so balanced that it automatically dumps whenever a predetermined weight of water has been collected in the pan. The water which is thus collected, is dumped into the bottom of the receptacle 18 and escapes through a pipe 18^a which is connected to the return main R of the heating system.

The control system also includes a thermostat device (Fig. 1) including a bulb 25 (which is exposed outside of the building) and the motor device 26, here shown as an expandable metallic bellows having one end fixed to the frame 27. The opposite or movable end of this bellows is provided with a bracket 28 which is pivotally connected to the upper arm of a motion-transmitting lever 29 pivoted to the frame 27 at the point 30. A spring 31, connected to the upper end of the lever 29, tends constantly to swing the upper arm of the lever in a counterclockwise direction.

A switch 32 comprises contacts 33 and 34, which are normally urged toward each other by suitable spring means. An arm 35 connected to contact 34 may be engaged at times by an adjustable screw 36 carried by the lower arm of the lever 29, thereby to separate the contacts 33 and 34 and thus to break the electric circuit through those contacts. This switch is designed automatically to break this circuit whenever the outdoor temperature rises above a predetermined point, for example during the summer time when it is desired to keep the automatic control mechanism out of action.

The switch 32 controls the circuit of a synchronous electric motor 37 (Figs. 1 and 4), whose shaft 38 carries the friction disk 39. So long as the circuit through the motor 37 is closed, this disk 39 is driven at a substantially constant predetermined speed, for example one revolution per minute.

A driven roll 40, preferably having a friction rim, for instance a rubber tire, bears against the face of the disk 39 and is frictionally driven by its contact with the disk 39. This roll 40 is fixed to a shaft 41 which turns, with freedom to slide axially, in a bearing 42. The right-hand end portion of this shaft 41 turns in a bearing in a bracket 43 (Figs. 1 and 5) which is provided with a pin 44 extending through an elongate slot in the lower arm of the motion-transmitting lever 29. A spring 45 bears at one end against the bracket 43 and at its other against a collar 46 fixed to the shaft 41, the spring thus tending to keep the extreme end 47 of the shaft in contact with a vertical surface of the bracket 43. With this arrangement any swinging movement of the lever 29 tends to slide the shaft 41 axially in its bearing 42 and thereby shift the position of the roller 40 radially of the disk 39.

The left-hand portion of the shaft 41 is preferably slabbled off (Fig. 2) at 48, and on this por-

tion of the shaft is mounted the tappet device 49. This tappet device is loose on the shaft but is held in proper position, longitudinally of the shaft, by a fixed housing 50. A set screw 51 carried by the tappet projects into the opening in the tappet which receives the shaft 41 and is designed, at times, to contact the flat surface 48 of the shaft so that as the shaft rotates, the tappet is picked up and caused to rotate with the shaft. However, when the tappet arrives at the position shown in Fig. 2, so that its surface 52 is substantially vertical, any slight further rotation of the shaft (anticlockwise, Fig. 2) causes the tappet to overbalance and turn suddenly in response to the eccentric weight of its striker portion T. When the tappet thus swings, its striker portion T delivers a sharp blow to the short arm 53 of a switch-actuating latch which is pivoted at 54 and which has a longer arm 55 which is normally disposed beneath and supports the beveled end 56 of a switch lever pivoted at 57. This switch lever supports a switch device 58, here shown as a mercury switch. When the switch is closed, a solenoid 59 is energized and its core is lifted. The core of the solenoid supports a rod 60 which extends down through an opening in the switch-carrying lever 56 and which is provided at its lower end with a lifter member 61 which, whenever the solenoid core is raised, engages the under surface of the switch-carrying lever 56 and thus raises it so as to move its end above the latch 55, thereby resetting the parts.

The circuit which is closed by the switch 58 is that which energizes the solenoid 13.

As illustrative of the operation of the apparatus, let it be assumed that the radiator is rated at 240 square feet of radiation. It would then condense 60 pounds of water per hour, or one pound of water per minute, when the outdoor temperature is at the minimum for which the heating system is figured, for example 0° F. Assuming that the disk 39 is driven at the rate of one revolution per minute, the parts are so designed that a 0° F. outside temperature the roll 40 is so located by the operation of the thermostat that it also turns at the rate of one revolution per minute. Each time the roll 40 turns, the tappet 49 makes one revolution and thus, once per minute, the switch 58 is closed, thereby sending an impulse to the solenoid 13. This causes the ratchet wheel 5 to be stepped around in a counterclockwise direction (Fig. 1) one notch per minute. This direction of rotation of shaft 4 is such as to tend to open the steam supply valve 3 more and more, thus supplying more and more steam to the radiator. The steam condenses in the radiator and is delivered by the spout S to the weighing pan 17. Suppose this pan be designed to tip whenever one pound of condensate has collected therein, then each time that a pound of steam condenses in the radiator, this pan will tip and in consequence the switch 22 will close and send an energizing impulse to the solenoid 14, thus moving the pawl 8 downwardly. At each such impulse, the ratchet wheel 6 is stepped around one notch in the clockwise direction, thus tending to close the steam-admission valve. If, in the above example, the radiator be of the size suggested, then the pan 17 will dump once each minute and thus one impulse per minute will be sent to the solenoid 14. Since the number of impulses thus sent to the solenoid 14 equals the number sent to the solenoid 13, the two pawls 7 and 8 will be actuated the same num-

ber of times per minute and the net result will be that the steam-admission valve 3 will remain in the same position.

If it now be supposed that the temperature outside gradually rises, the thermostat will so move the actuating lever 29 as gradually to shift the roll 40 toward the center of the disk 39. This will gradually slow down the shaft 41 so that it no longer makes one revolution per minute, and thus the rate at which the switch 58 is actuated will be less and the number of impulses per minute sent to the solenoid 13 will be less per unit of time. The pawl 8 will thus gain on the pawl 7 and the valve stem 4 will be progressively turned in a direction to close the steam supply valve 3, and this will continue until the lesser amount of condensate delivered by the radiator similarly causes a slowing down of the rate at which the pan is dumped, thus again restoring the condition in which both pawls 7 and 8 are actuated at the same rate.

The control system is thus dependent upon the rate of condensation in the radiator and in no way upon the pressure at which the steam is supplied, or upon the pressure in the return main, since the valve 3 will automatically be set to meet changing pressure differentials, and the amount of steam supplied is directly dependent upon the amount of liquid which condenses in the radiator per unit of time, such unit of time being determined by the outdoor thermostat.

It is obvious that other adjunctive features of the usual heating system may be provided, such for example as optional manual control for use under special conditions; that an indoor thermostat may likewise be provided; and that vacuum or condensate pumps may be employed, all without in any way affecting the operativeness or the manner of operation of the device herein disclosed, so long as the automatic control be left free to operate.

Obviously, means, such for example as a program-clock, may be provided for cutting out the automatic operation and substituting manual control, as is common in steam heating systems of prior types; it is further obvious that the thermostat bulb may be located at any desired point, either outdoors or indoors, and that reversible motors of other kinds may be employed if preferred.

While one desirable embodiment of the invention has here been disclosed by way of example, it is to be understood that the invention is not necessarily limited to this precise embodiment but is to be regarded as broadly inclusive of any and all equivalent devices which fall within the scope of the appended claims.

I claim:

1. That method of controlling the amount of condensate produced in a heat exchange apparatus wherein one fluid is condensed by loss of heat to another and whereto heat is supplied at a variable rate, said method comprising as steps collecting the condensate in a measuring receptacle, emptying the receptacle as often as it is filled, and varying the amount of heat supplied in substantially inverse ratio to the number of times the receptacle is emptied per unit of time.

2. That method of controlling the amount of heat lost by one fluid to another in a heat exchange apparatus wherein one fluid is condensed by loss of heat to another and to which one of the fluids is supplied hot at a regulable rate, said method comprising as steps collecting the condensate in a measuring receptacle, emptying the receptacle as often as it is filled, and

varying the amount of hot fluid supplied to the apparatus in substantially inverse ratio to the number of times the receptacle is emptied per unit of time.

3. Apparatus of the class described including a condensor to which a heated condensable fluid is delivered at a regulable rate and wherein said fluid is condensed by loss of heat to a cooler fluid, characterized in having a self-emptying measuring receptacle which receives the condensate fluid, and means operative to vary the amount of one of the fluids supplied to the apparatus at a predetermined definite ratio to the number of times the receptacle empties itself per unit of time.

4. A steam-heating system of the kind having a radiator and means operative to supply steam to the radiator, characterized in having a self-emptying receptacle which receives the condensate from the radiator, and means operative to vary the amount of steam delivered to the radiator in substantially inverse ratio to the number of times the receptacle empties itself per unit of time.

5. A steam-heating system of the kind having a radiator and an adjustable steam admission valve for controlling the amount of steam delivered to the radiator, characterized in having a receptacle which automatically dumps itself when filled to a predetermined level and which is arranged to receive the condensate from the radiator, and means including a timing device operative to adjust the steam admission valve to a greater or lesser capacity in substantially inverse ratio to the number of emptyings of the receptacle per unit of time.

6. A steam-heating system of the kind having a radiator and wherein the amount of steam supplied to the radiator is controlled by an adjustable valve, characterized in having a self-emptying receptacle arranged to receive the condensate from the radiator and which automatically empties itself whenever the liquid level rises to a predetermined point within it, and means including a synchronous motor operative automatically to adjust the valve to a greater or lesser flow capacity whenever the dumpings of the receptacle per unit of time are less or greater, respectively, than a predetermined number.

7. That method of controlling the amount of heat emitted by the radiator of a steam-heating system independently of the pressure at which the steam is supplied to the radiator, which comprises as steps varying the amount of steam delivered to the radiator in substantially inverse ratio to the weight of liquid which condenses in the radiator per unit of time, and varying said unit of time in inverse ratio to variations in outdoor temperature.

8. In a steam-heating system having a radiator and motor-actuated regulating means for determining the amount of steam delivered to the radiator, characterized in having a self-emptying receptacle arranged to receive the condensate from the radiator, means operative automatically to adjust the regulating means in substantially inverse ratio to the number of times the receptacle empties itself per unit of time, and means operative to vary the length of said unit of time in inverse ratio to increase in out-of-doors temperature.

9. In a steam-heating system having a radiator and wherein the amount of steam supplied to the radiator is determined by an adjustable steam admission valve, characterized in having a recep-

tacle which automatically dumps itself when filled to a predetermined level, said receptacle being arranged to receive the condensate from the radiator, means operative to adjust the admission valve to a greater or lesser capacity in substantially inverse ratio to the number of dumpings of the receptacle per unit of time, and means including a thermostat operative to vary the length of said unit of time in inverse ratio to increase in out-of-doors temperature.

10. In a steam-heating system having a radiator and wherein the amount of steam supplied to the radiator is controlled by a valve actuated by a reversible motor, characterized in having a self-dumping receptacle which receives the condensate from the radiator and which tips when the fluid level within it rises to a predetermined point and thereby dumps its contents, means operative momentarily to energize the motor to turn in one direction at each tipping of the receptacle, means operative momentarily to energize the motor to turn in the opposite direction at regular intervals of time, and means operative to vary the length of such intervals of time in inverse ratio to increase in out-of-doors temperature.

11. In a steam-heating system of the continuous flow type having a radiator and wherein the amount of steam supplied to the radiator is controlled by a valve actuated by a reversible motor, characterized in having a receptacle which receives the condensate from the radiator and which is so constructed and arranged as to tip and dump its contents when the fluid level within it rises to a predetermined point, means operative so to energize the motor as to cause the latter to turn in one direction at each tipping of the receptacle, and means operative at regular intervals of time tending to turn the motor in the opposite direction.

12. In a steam-heating system of the continuous flow type having a radiator and wherein the amount of steam supplied to the radiator is controlled by a valve actuated by a reversible motor, characterized in having a dumping receptacle arranged to receive the condensate from the radiator, the parts being so constructed and arranged that the receptacle is automatically emptied as soon as the fluid level within it rises to a predetermined point, means operative to send an energizing impulse to the motor each time the receptacle is emptied thereby tending to cause the motor to turn in such a direction as to decrease the amount of steam supplied to the radiator, means operative to send an energizing impulse at regular intervals of time to the motor thereby tending to cause the latter to turn in the opposite direction, and means for varying the length of said time intervals in accordance with variations in temperature outside of the structure being heated.

13. Control means for a heat exchange apparatus wherein one fluid is condensed by loss of heat to another, said apparatus including motor actuated regulating means for determining the amount of heat supplied to the apparatus, the control means including a self-dumping receptacle arranged to receive the condensate, and connections between the receptacle and the regulating means, including a part which turns at substantially constant speed and a part driven thereby whose speed may be varied, the connections being so constructed and arranged that the regulating means acts to vary the amount of heat supplied in substantially inverse ratio to the number of times the receptacle dumps per unit of time.

14. In a steam-heating system including a radiator and a steam-admission valve, a reversible motor for opening and closing the admission valve, a thermostat, means operative to dispatch successive energizing impulses to the motor such as to cause it to close the admission valve, the frequency of such impulses depending upon the rate of condensation in the radiator, and means operative to dispatch successive energizing impulses to the motor such as to cause it to open the admission valve, the frequency of said latter impulses being determined by the thermostat.

15. In a steam-heating system including a radiator and a steam-admission valve, a reversible motor for opening and closing the admission valve, a thermostat, means operative to dispatch successive energizing impulses to the motor such as to cause it to close the admission valve, said means including a self-dumping receptacle into which the condensate from the radiator is delivered and which initiates such a motor-energizing impulse each time it is dumped, and means operative to dispatch successive energizing impulses to the motor such as to cause it to open the admission valve, the frequency of said latter impulses being determined by the thermostat.

16. In a steam-heating system including a radiator and a steam-admission valve, a reversible motor for opening and closing the admission valve, a thermostat, means operative to dispatch successive energizing impulses to the motor such as to cause it to close the admission valve, the frequency of such impulses depending upon the rate of condensation in the radiator, and means operative to dispatch successive energizing impulses to the motor such as to cause it to open the admission valve, said latter means including a rotary part which initiates such an impulse at each rotation, and means controlled by the thermostat for determining the rate of rotation of said part.

17. In a steam-heating system including a radiator and a steam-admission valve, a reversible electric motor for opening and closing the admission valve, a thermostat, means operative to dispatch successive energizing impulses to the motor such as to cause it to close the admission valve, said means including a self-dumping receptacle into which the condensate from the radiator is delivered, a switch so connected to said receptacle as to send such an impulse to the motor each time the receptacle is dumped, and means operative to dispatch successive energizing impulses to the motor such as to cause it to open the admission valve, the frequency of said latter impulses being determined by the thermostat.

18. In a steam-heating system including a radiator and a steam-admission valve, a reversible electric motor for opening and closing the admission valve, a thermostat, means operative to dispatch successive energizing impulses to the motor such as to cause it to close the admission valve, the frequency of such impulses depending upon the rate of condensation in the radiator, and means operative to dispatch successive energizing impulses to the motor such as to cause it to open the admission valve, said latter means including a rotary drive disk turning at substantially constant speed, a shaft having thereon a driven, friction roll whose periphery engages the face of the disk and which is bodily movable diametrically of the disk, switch means actuated at each rotation of the roll to initiate such a

motor-energizing impulse, and means actuated by the thermostat for determining the position of the driven roll diametrically of the disk.

19. In a continuous-flow steam-heating system including a radiator and a steam-admission valve, a reversible electric motor for opening and closing the admission valve, a thermostat, means operative to dispatch successive energizing impulses to the motor such as to cause it to close the admission valve, the frequency of such impulses depending upon the rate of condensation in the radiator, and means operative to dispatch successive energizing impulses to the motor such as to cause it to open the admission valve, said latter means including a rotary drive disk, synchronous motor means for driving the disk at a substantially constant rate, a shaft having thereon a driven friction roll whose periphery engages the face of the disk, said roll being bodily movable diametrically of the disk, a tappet mounted on the shaft, a switch arranged to be actuated by the tappet at each rotation of the shaft thereby to initiate such a motor-energizing impulse, a transmission member which is caused to move in one direction or the other by the thermostat in response to variations in tem-

perature, means so connecting the transmission member and the roll as to shift the roll diametrically of the disk in accordance with temperature fluctuations thereby to determine the rate of rotation of the shaft, and a switch actuated by said transmission member thereby to cut off current to the synchronous motor so long as the temperature remains above a predetermined degree.

20. In a continuous-flow steam-heating system including a radiator and a steam-admission valve, a reversible motor for opening and closing the valve, a thermostat, said motor including a shaft having a pair of ratchet wheels fixed thereto, a pair of pawls arranged respectively to turn the ratchet wheels in opposite directions, a solenoid for moving each pawl respectively, means operative to dispatch successive energizing impulses to one of said solenoids, the frequency of such impulses depending upon the rate of condensation in the radiator, and means operative to dispatch successive energizing impulses to the other solenoid, the frequency of said latter impulses being determined by the thermostat.

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