Oct. 3, 1939.

F. A. GUNTHER

2,174,558

AUTOMATIC HEAT CONTROL

Filed Dec. 11, 1934

5 Sheets-Sheet 1

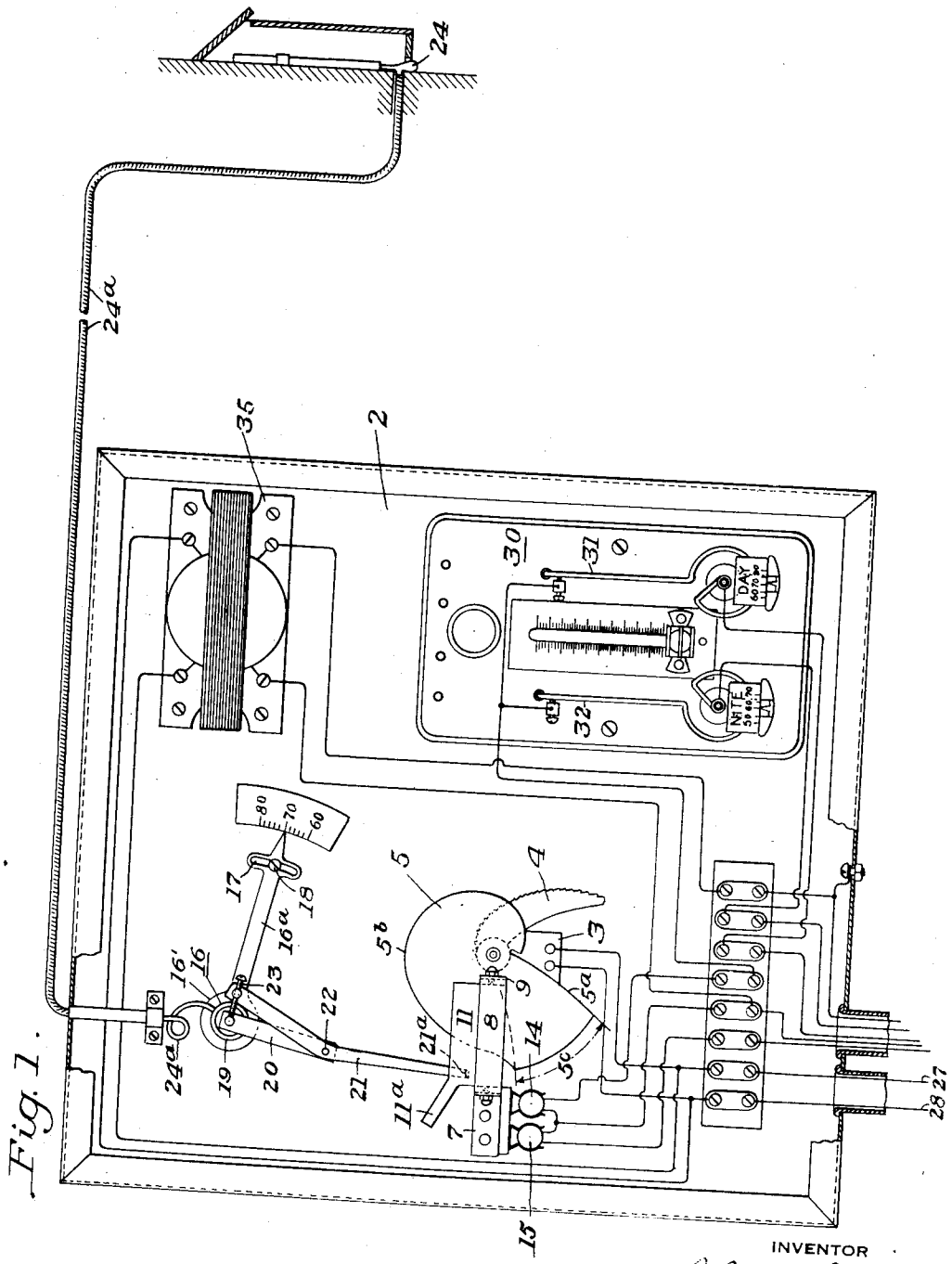



Fig. 1.

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Oct. 3, 1939. F. A. GUNTHER 2,174,558

AUTOMATIC HEAT CONTROL

Filed Dec. 11, 1934 5 Sheets-Sheet 2

Fig. 2.

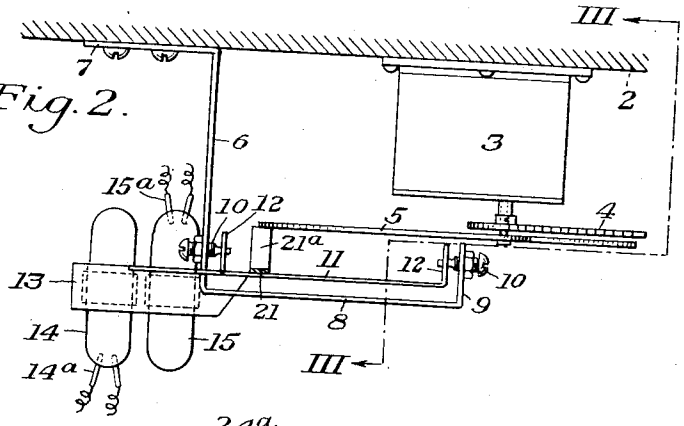



Fig. 3.

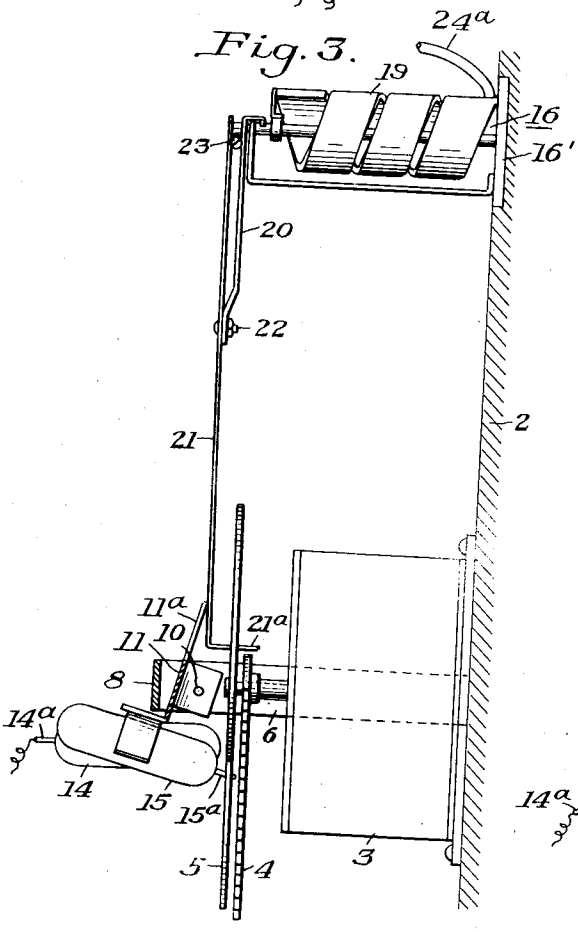
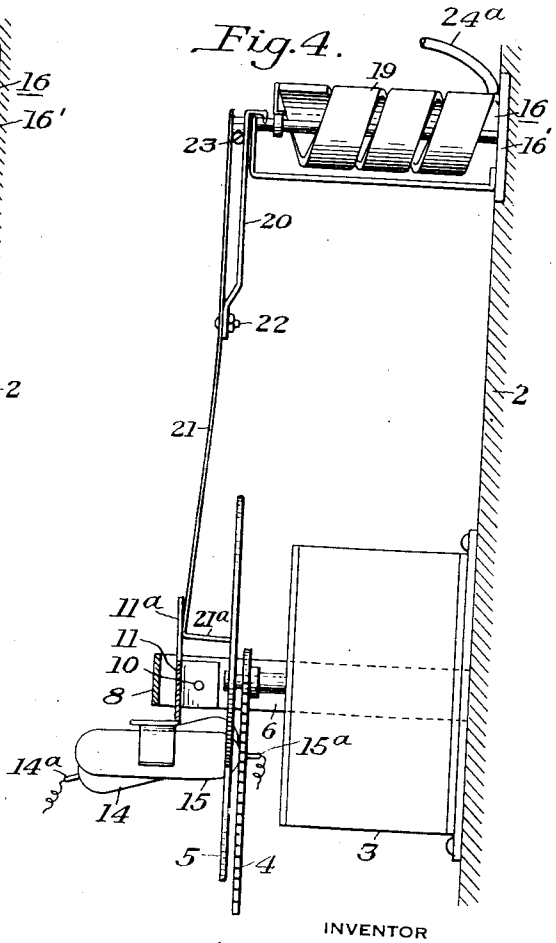



Fig. 4.




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AUTOMATIC HEAT CONTROL

Filed Dec. 11, 1934

5 Sheets-Sheet 3

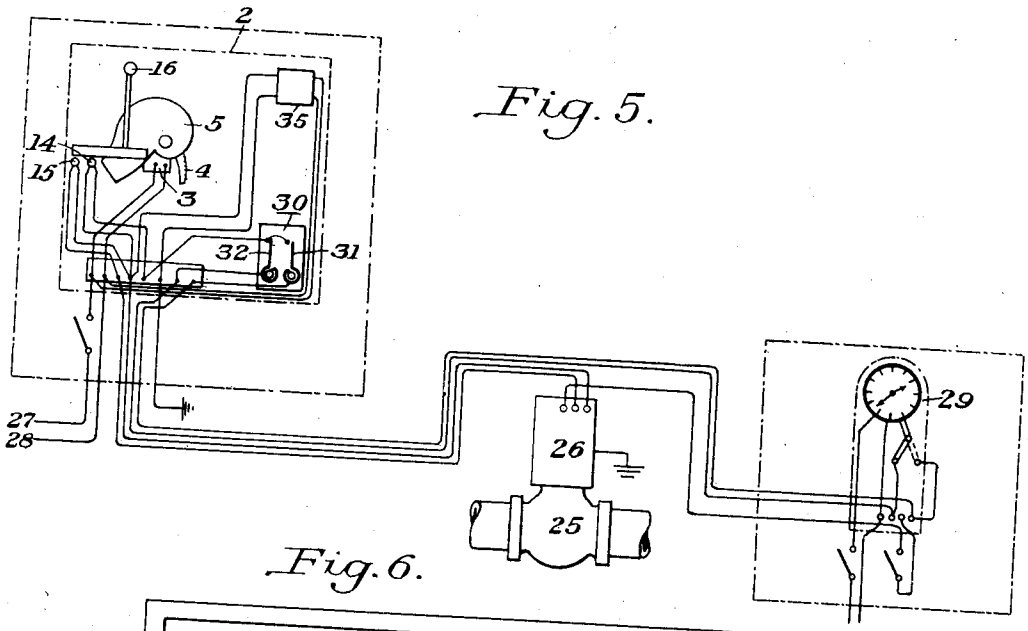
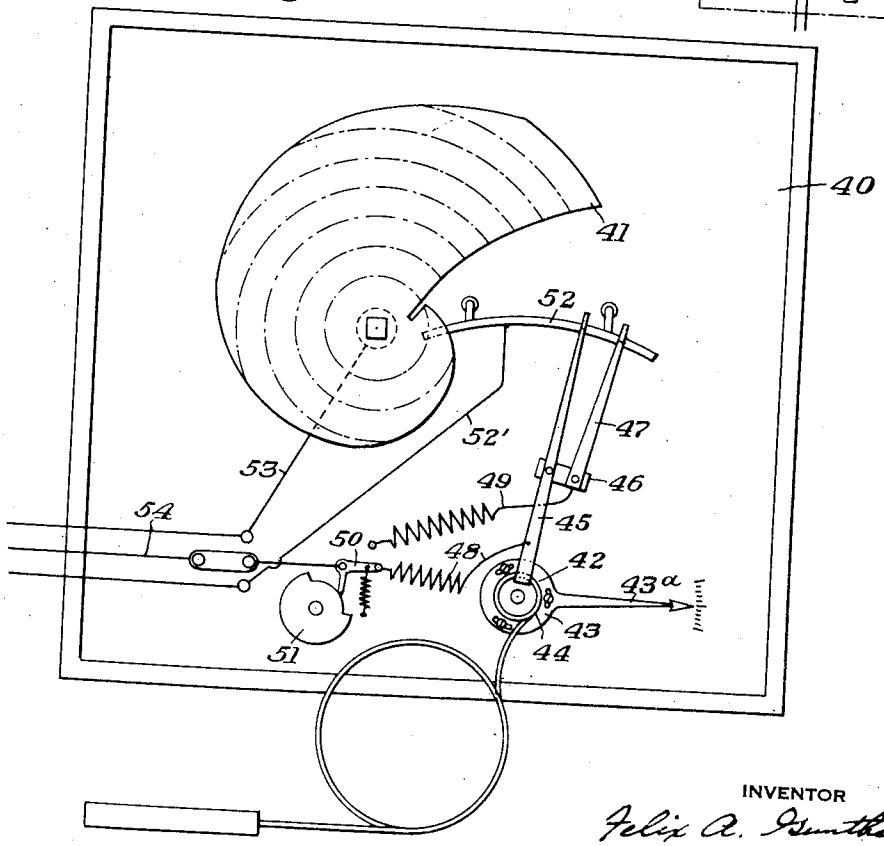



Fig. 5.

Fig. 6.




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Oct. 3, 1939. F. A. GUNTHER 2,174,558

AUTOMATIC HEAT CONTROL

Filed Dec. 11, 1934 5 Sheets-Sheet 4

Fig. 8.

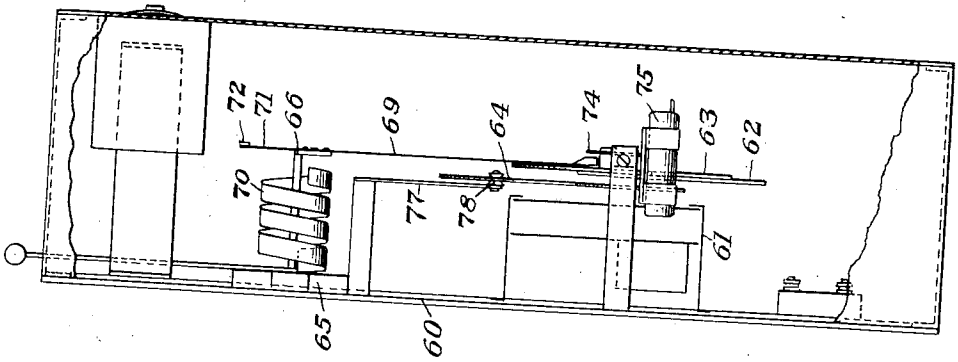
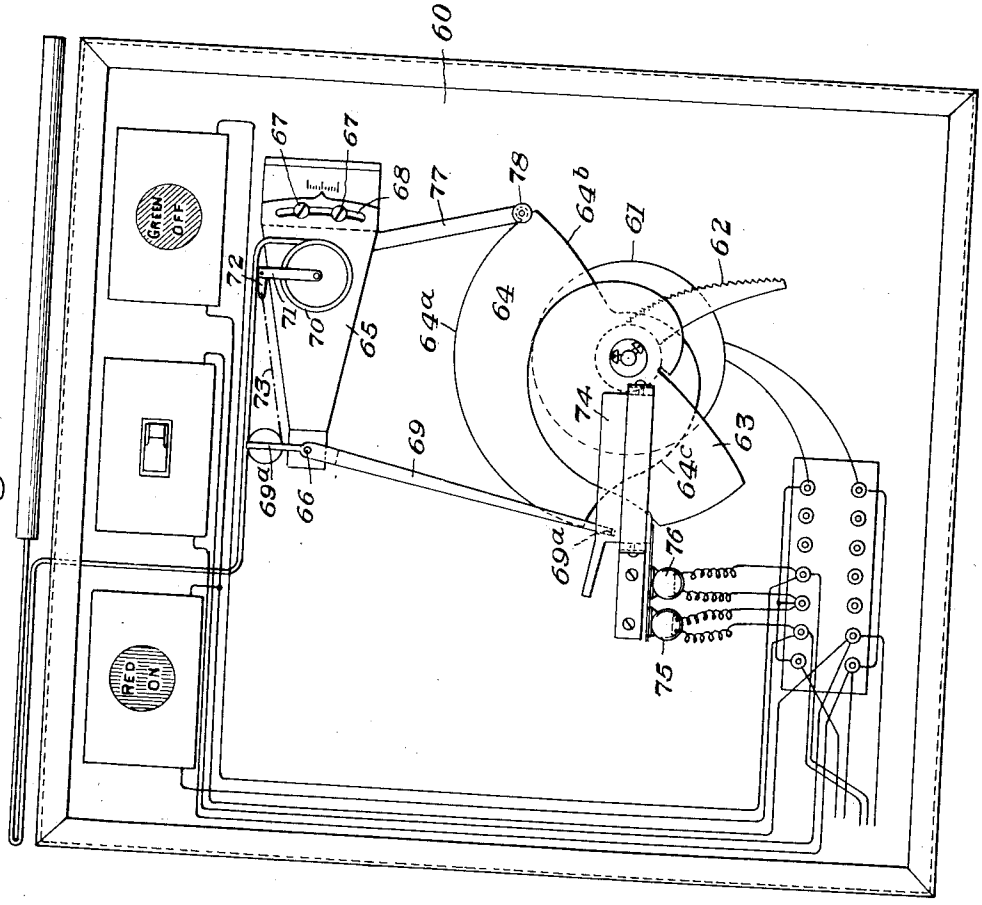



Fig. 7.




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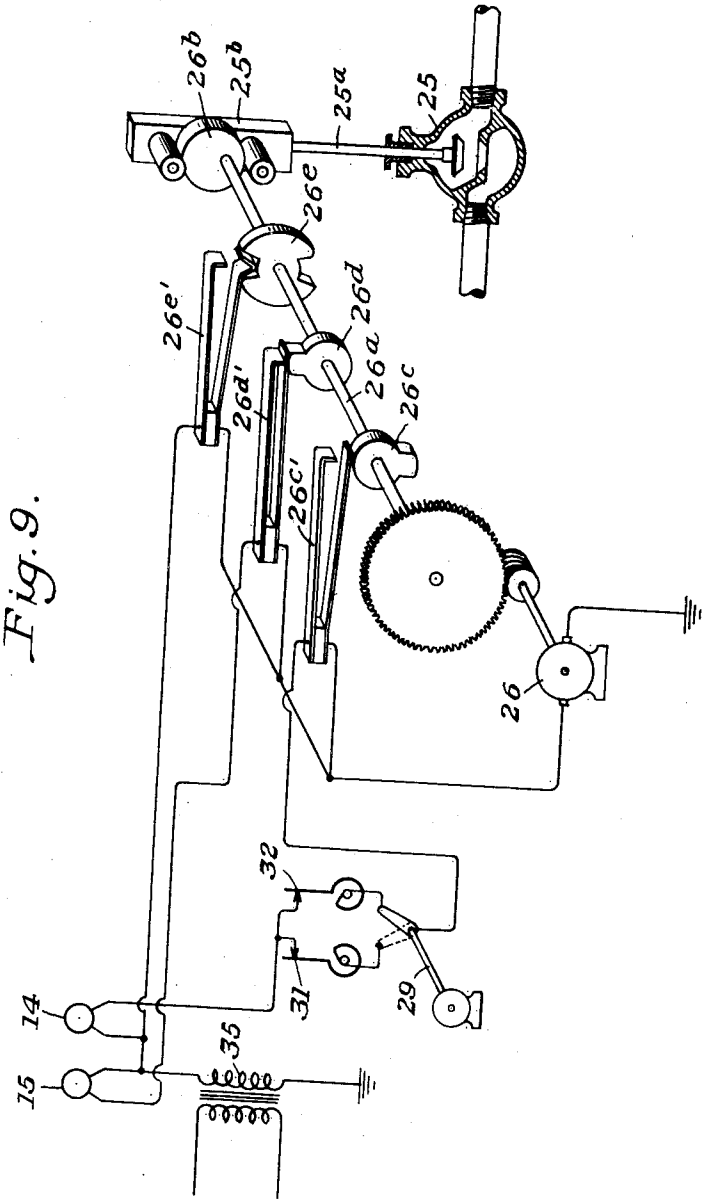
2,174,558

AUTOMATIC HEAT CONTROL

Filed Dec. 11, 1934

5 Sheets-Sheet 5

Fig. 9.




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Patented Oct. 3, 1939 2,174,558

# UNITED STATES PATENT OFFICE

2,174,558

## AUTOMATIC HEAT CONTROL

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Application December 11, 1934, Serial No. 756,966

18 Claims. (Cl. 236—46)

This invention relates to heating systems and is for an automatic control by means of which a heating system can be operated in accordance with variations in outdoor temperature conditions to maintain substantially even indoor temperatures.

The present invention is applicable to various types of heating systems utilizing steam, hot water or hot air or any other fluids. It has particular utility where steam is used as the heating medium and where provision is made for the purchase of steam from a central power plant, and in multiple zone heating systems where the maximum boiler capacity may be kept to a minimum. In the present specification, the invention is referred to primarily in connection with such systems, but this is merely by way of illustration and not by way of limitation. Moreover, the invention has particular utility in connection with the heating of relatively large buildings, where it produces the most advantageous results, but it, of course, is applicable also to the heating of smaller buildings and establishments.

In the heating of buildings, such as hotels and office buildings, where steam is purchased from an outside source, it has been found uneconomical to have the steam radiators continuously connected with the steam supply lines. The reason for this is that individual rooms become overheated, and the occupants, instead of turning off the radiators, open the windows. Individual thermostatic control for each room or for each radiator is not only very expensive, but requires considerable repair work in keeping the individual systems and thermostats in proper adjustment and proper working order. It is, therefore, the practice to turn the steam on intermittently. One way of doing this is to rely upon an engineer to turn a central steam valve at predetermined intervals according to a pre-arranged schedule. Another system in wide usage is to provide a single thermostat in one room of a building. When the temperature in that room drops a predetermined amount, the thermostat turns on the steam for the entire building or for that portion of the building which it is designed to control. When the temperature of the individual room becomes normal, the thermostat shuts off and the supply of heat is discontinued. This system has very definite disadvantages for the reason that the occupant of that room, feeling overheated, may open a window causing the thermostat to call for steam, whereupon the entire building may be excessively overheated. A further disadvantage is that during the night, the building is kept at a low temperature and in the morning the building has to be heated up. The thermostat will not shut off the steam until it has been brought up to temperature. When it reaches temperature, it shuts off the steam, but the steam in the radiators condenses and the metal of the radiator itself has a considerable capacity, so that heat continues to be emitted for a considerable time after the thermostat shuts off, resulting in excessive overheating in the early part of the day.

The present invention contemplates the provision of a control whereby there is a periodical operating means for turning on the steam and whereby the length of time that the steam remains on is controlled by the outside temperature. That is to say, that as the weather outside becomes colder, the rate of heat loss from the building increases. The present invention compensates for this by increasing the length of time for which the steam is turned on during each operating interval with increasingly lower outside temperatures. The invention further contemplates that means may be provided through which the periodical operating means is regulated so that if the inside temperature is such that the building does not require heat for the full time or for any of the time during which the periodical operating means would ordinarily supply heat, the supply of heat will be reduced or the period of operation delayed or the actuation of the supply valve entirely omitted.

In the operation of heating systems, it is also practical to maintain the temperature of the rooms lower at night than during the daytime. This means that in the early morning there must be a heating up period wherein the temperature of the building is brought up to the temperature at which the building is to be maintained during the day. The present invention provides a means operating in conjunction with the first periodic operating means for keeping the heat on during this heating-up period over a long time interval and for a period which varies according to the outside temperature, the heat being turned on longer when the weather is cold than when the weather is moderate.

The invention further contemplates a system whereby an automatic cut-over from the temperature of day operation to the temperature of night operation and back to day operation, is provided according to a pre-arranged schedule. In addition to this, the system is manually adjustable for regulating the inside temperature, so that by manual adjustment more or less heat

can be secured according to the desires of the occupants or as conditions may demand. The means for effecting these results is relatively simple, positive in operation, and can be easily installed on present heating systems, and takes care of infinite variations in the outside temperature from a point well below zero to a point up to the maximum at which artificial heating of the building is required. That is to say, when the outside temperature is such that heat is not required in the building, no heat will be supplied. Over the range of temperatures at which the system is designed to supply heat, it will function over infinite variations. Moreover, the system is so arranged and constructed that it will accurately respond to very slight variations in the outside temperature.

Purchasers of heat are sometimes charged for the service on the basis of the maximum peak demand. If the building at its maximum demand requires a considerable quantity of steam, it is obvious that the power generating station must have a capacity for this maximum. The present invention contemplates a system wherein the maximum demand can be made very much lower, while the same quantity of heat in a given period of time is the same, thus enabling the purchaser to contract for the purchase of heat on the basis of a low maximum demand rather than on the basis of a high maximum demand. A similar saving is also possible in a building heated from its own boilers, as the maximum capacity of the boilers can be materially less.

This is effected according to the present invention by the dividing of the heating system into two or more zones, and the progressively turning on of the heat in the different zones, rather than supplying the maximum amount of steam to the entire system at one time.

The invention may be readily understood by reference to the accompanying drawings, in which

Figure 1 represents a front elevation of a control panel embodying the present invention.

Figure 2 is a top plan view of the mechanism shown in Figure 1.

Figure 3 is a vertical transverse section in the plane of line III—III of Figure 2, showing the temperature arm in a position off the operating cams;

Figure 4 is a view similar to Figure 3 showing the temperature arm engaging one of the cams;

Figure 5 is a more or less schematic layout of the entire system, including the control panel, time switch and motor driven valve;

Figure 6 is a plan view of a modified form of control panel;

Figure 7 is a plan view of still a further modification of a control panel in which a cam instead of a time switch is used for changing from day to night operation, and vice versa;

Figure 8 is a side elevation of a part of the mechanism shown in Figure 7;

Figure 9 is a schematic view illustrating one form of valve operating mechanism and the circuit therefor, this view being complementary to Figure 5.

Referring first to Figures 1 to 5, inclusive, 2 designates a panel or supporting base. Mounted on this panel is an electric or other clock 3 which drives two concentric shafts similar to the two shafts for the hands of an ordinary clock. The outer shaft is a sleeve and carries a cam 4. The inner shaft is in the form of a spindle and it carries a second cam 5. The clock arrangement is such that the cam 4 is rotated through a complete circle every twenty-four hours, while the cam 5 is rotated through a complete circle at more frequent intervals. For purposes of illustration, it may be assumed that the cam 5 is rotated once every hour, although the frequency of rotation can be changed and shortened where desired, according to the demands of the particular building which is being heated. The clock arrangement is conventional and the speed at which the cam 5 is rotated can be determined in the construction of the clock. Ordinarily, however, it is desired that the cam 4 shall have an exact twenty-four hour period of rotation.

Secured to the base 2 is a bracket 6 having a foot portion 7 which rests on the base and through which the screws or bolts which secure it in place are passed. This is best shown in Figure 2. The outer end of the bracket or arm 6 is provided with a horizontally extending portion 8 having an inwardly turned ear 9 at the free end thereof. Carried on this bracket structure and in longitudinal alignment with each other are opposed pivot members 10 which support a tiltable yoke member 11, the member 11 having two ears 12 thereon through which the inner ends of the pivots 10 pass. The tiltable yoke member has a flat extension 13 thereon which carries two clips. In each of these clips are mercury tubes 14 and 15 of a type well known to those familiar with the art. As shown in Figure 2, the tube 14 has its contacts at one end while the tube 15 is arranged with its circuit closing contacts at the opposite end. One of these tubes, as shown in Figures 3 and 4, is always at an angle to the other. The balance of the pivoted yoke member 11 with its contact tubes is such that the member 11 normally assumes the position shown in Figure 3. In this position, the tube 14 is sloped downwardly away from its contacts, designated 14*a*, so that the mercury in the tube does not function to close a circuit through these contacts in this position. The tube 15 is so set that when the tilting yoke is in the position shown in Figure 3, the mercury within the tube closes the circuit across the contacts 15*a* of this tube. The yoke member 11 is somewhat in the form of a vertical plate, and projecting diagonally from one corner thereof is a guiding extension 11*a*, which is best seen in Figure 1.

Supported on the panel 2 is a temperature responsive device designated generally as 16. This device comprises a base member 16' which is pivotally supported on the panel 2 and which has an adjusting arm 16*a* thereon, the arm having a slot 17 which cooperates with an adjusting limit screw 18 on the panel. By movement of the arm 16*a* up or down the whole position of the temperature responsive device can be shifted within the limits permitted by the slot 17 and thereby adjust the control for operation over a higher or lower temperature range as may be desired.

The base 16' carries an actuating means 19 of any known or preferred construction. I have shown it as being of the conventional expansible helix type commonly employed in temperature responsive devices. The member 19 actuates a lever arm 20. Pivotally supported on the outer end of the arm 20 is a second lever 21, the pivotal connection being indicated at 22. A set screw 23 carried on the upper end of the lever arm 21 provides for adjusting the angularity of the member 21 with relation to the member 20 for the purpose of further adjusting and regulat-

ing the temperature responsive mechanism. The arm 21 is provided at its lower or free end with an inwardly turned extension or finger 21a, best shown in Figures 3 and 4, while the end of the arm extends below the vertical plate forming the main portion of the yoke 11.

The temperature responsive unit 16 is connected with an outdoor temperature responsive bulb 24 through a conduit 24a. The bulb 24 is preferably a bulb containing gas, inasmuch as the volume of gases give a maximum response to variations in temperature. The arrangement is such that as the outdoor temperature increases, the volume of gas in the bulb 24 increases. This change of pressure is communicated to the coil 19 which tends to move the arm 20 with its associated lever 21 toward the left, as viewed in Figure 1. With a decrease in outdoor temperature, the arm 20 with its associated lever arm 21 tends to swing toward the right as viewed in Figure 1.

The arm 21 is slightly resilient, and it will be seen by reference to Figures 3 and 4 that the terminal portion 21a of the arm 21 passes through the plane in which the cams 4 and 5 revolve. As the outdoor temperature decreases, this terminal 21a moves in closer to the center of rotation of the cams and as the outdoor temperature increases, it moves away from this center.

Assuming that the arm 21 as viewed in Figure 1, is in the position shown when the cam 5 rotates to a point where the leading edge 5a of the cam engages the terminal portion 21a of the arm 21, it tends to spring the arm 21 outwardly in a direction normal to the plane of the cam. This outward movement of the lever 21, which is a movement toward the left as viewed in Figure 3, causes the yoke 11 to be tilted from the position shown in Figure 3 to the position shown in Figure 4. This movement closes the circuit hereinafter described to be closed through the mercury tube switch 14, and to be opened through the mercury tube switch 15. The terminal 21a will ride on the surface of the cam until it rides off the trailing edge 5b of the cam. Whereas the leading edge 5a is substantially radial but preferably slightly curved, the curvature corresponding to the arc in which the terminal 21a moves, the trailing edge 5b defines an irregular spiral or involute curve, the exact shape of which is determined by the heat dissipating characteristics of the building in which the system is located and the capacity of the heating system to radiate stored heat after the steam has been shut off. The minimum travel which the cam can have in contact with the terminal 21a of the lever 21 is defined by the arc 5c. If the temperature responsive arm 21 is swung to the left beyond the point shown in Figure 1, it will, of course, not engage the cam 5 at all, and if it swings further in toward the center of the cam 5 it will be engaged by the cam 5 for a longer period of time, and if it swings sufficiently far toward the center of the cam 5 it is apparent that it would never be entirely clear of the cam.

When the terminal 21a of the lever 21 clears the trailing edge 5b of the cam 5, it snaps inwardly, which is in a direction toward the right as viewed in Figure 4, allowing the yoke 11 to swing back to the position shown in Figure 3, opening the circuit through the mercury tube 14 and closing it through the mercury tube 15.

In the particular arrangement shown in Figure 5, the supply of heating fluid is controlled by a valve 25. The valve is of a conventional type and is provided with a conventional automatic opening and closing mechanism 26, this mechanism commonly including a motor and gearing which runs a predetermined amount sufficient to open or close the valve before shutting off. The valve and the motor form no part of the present invention. This electrically controlled valve mechanism is connected through the circuit shown in Figure 5 with current supply leads 27 and 28 through the mercury tube switches 14 and 15 and through the circuit indicated, this circuit including in the particular illustration shown in Figure 1 a thermostat mechanism. Where the thermostat mechanism is of the dual type intended to maintain a lower temperature during the night than during the day, the system as shown in Figure 5 also includes a time switch designated generally as 29, for controlling the switch-over from day to night thermostat and vice versa. Figure 9 hereinafter more fully described shows schematically one conventional valve operating arrangement of the character herein referred to, together with the circuit therefor.

The thermostat mechanism, such as the day and night thermostat mechanism just referred to is conveniently carried on the panel 2, as shown in Figure 1. The thermostat mechanism is designated generally as 30. It comprises two thermostatically operated circuit closing arms 31 and 32, the arrangement being well known to those skilled in the art and forming no part of the present invention. The time switch 29 is so connected with the thermostat switches 31 and 32 that during a predetermined period of time during the day the thermostat 31 will be connected to control the switch 26, whereas during the remainder of the twenty-four hours the thermostat 32 designated the night thermostat, will control the operation of the valve 26. Thermostats 31 and 32 are in parallel with each other and are in series with the mercury tube switch 14, the arrangement being such that if the arm 21 is actuated by the cam 5, or the cam 4, to trip the yoke 11 and close a circuit through the mercury tube switch 14, the automatic valve mechanism 26 will not function unless the circuit is completed through the thermostat mechanism, i. e., through the thermostat switch 31 or the thermostat switch 32. If the building to be controlled is already sufficiently warm, the thermostats will not close their switch contacts and the mechanism 26 will not, therefore, be operated. If, however, the building is not up to temperature the thermostat arms 31 and 32 will be in the circuit-closing position shown in Figure 1, and the circuit to the mechanism 26 will be completed. As previously stated, the determination of which of the two thermostats will control, is governed by the time clock unit 29.

The control panel can be designed to operate on any type of current or voltage. The particular panel illustrated is intended for operation on standard 110 alternating current circuits with the clock 3 of the synchronous electric type connected directly to the lines 27 and 28. The voltages through the mercury tube switches and thermostats are preferably lower than 110 volts, and I have shown the control panel as having a step-down transformer 35 through which a low voltage current is supplied to the control system itself. This, of course, can be variously modified as will be well understood by those skilled in the art.

The arm 21 is operated by the cam 4 to trip the yoke 11 the same as it is operated by the cam 5. However, the cam 4 rotates only once every twenty-four hours, which means that it cannot engage the terminal 21a of the arm 21 oftener than once every twenty-four hours. The cam 4, of course, moves very slowly, so that a very few degrees of width on the cam 4 between the leading edge of the cam and the trailing edge, represents a considerably longer time interval than a corresponding number of degrees on the cam 5 would represent. However, at its outer end, the cam 4 has a very appreciable width. This width is determined by the heating system and the width of the cam generally increases toward the center of the cam. The leading edge of the cam is preferably serrated so that when it comes into contact with the terminal 21a of the lever arm 21, it will tend to cam or spring the arm 21. Were it not for these steps the motion of the cam would tend to slide the terminal 21a toward the outer end of the cam, as the arm 21 offers little resistance to movement in an arc since the temperature responsive mechanism is necessarily very delicate and therefore easily forced in one direction or the other. Any such forcing of the temperature arm would obviously destroy the accuracy of the control panel. It will be noted that the leading edge of the cam 4 is the one which curves away from a radius passing through the center and outer end of the cam, the purpose of which is to cause the heating up operation to begin earlier in the morning as the weather becomes colder so that the building will always be ready for occupancy at a predetermined time.

Referring now to Figure 9, this view shows the valve 25 with a valve stem 25a, and a double cam follower 25b for reciprocating it. The motor 26, which is a uni-directional motor, drives a cam shaft 26a through a reducing gear as diagrammatically illustrated, and the cam shaft has a cam 26b thereon engaging the cam follower 25b for operating the valve. The cam shaft 26a also carries three cams; 26c which may be referred to as the "on" cam, 26d which may be referred to as the "off" cam, and 26e which may be referred to as the "maintaining" cam. Cams 26c and 26d are single lobe cams which are 180° out of phase, and cam 26e is a double lobe cam with the low points between the two lobes in phase with the high points of the cams 26c and 26d. Cooperating with each of the cams are spring contact switches 26c', 26d', and 26e' respectively. Switch 26c' is connected with the "on" mercury switch 14 through a circuit which leads from one side of the transformer 35 through the mercury switch 14 and through one or the other of the thermostats 31 and 32 as determined by time switch 29. From the other side of switch 26c' a wire leads to motor 26 and from motor 26 to ground. One side of the "off" switch 26d' is connected to the motor and the other side is connected to the "off" mercury switch 15, the other side of the mercury switch 15 being connected to one side of the transformer. The maintaining switch which is operated by the cam 26e has one side connected to one side of the transformer and the other side connected to the motor 26.

In Figure 9 the valve 25 is open so that heat is being supplied to the heating system. At this time the "off" switch 26d' is closed by the cam 26d while the switches 26c' and 26e' are open. When the outside temperature control calls for the turning off of the heat, mercury tube 15 is rocked to close the circuit therethrough. A circuit is then completed from one side of the transformer through tube 15 through switch 26d' to the motor 26. The circuit is completed from the motor 26 to the transformer through the ground. This starts the motor 26 causing the cam shaft 26a to be rotated. After the motor 26 has operated for a short time, shaft 26a will have turned to a point where the maintaining switch 26e' will be closed and the "off" switch 26d' will be open. The motor will continue to operate through the circuit including the maintaining switch 26e' until the shaft 26a has been turned 180° at which time the valve 25 will be closed and the cam 26c will close the switch 26c'. The motor will be stopped at this point by reason of the switch 26e' riding off the cam lobe. Although the switch 26c' is closed at this point, the motor 26 will not operate because the circuit will not be closed through the mercury switch 14. When the control calls for heat, closing a circuit through the mercury switch 14 and opening the circuit through the mercury switch 15, current will flow from the transformer through the mercury switch 14, through one of the thermostats 31 or 32, as determined by the time switch, through the switch 26c' to the motor 26, and thence to ground thereby initiating the operation of the motor to rotate the cam shaft 26a. After the motor has operated for a short time, the maintaining switch 26e' will be closed and the "on" switch 26c' will open, but the operation will continue until the parts have been returned to the position shown in Figure 9 where the heat will remain on until the next "off" cycle is started. It will be seen that if neither of the thermostats 31 or 32 is calling for heat while the mercury switch 14 is in an "on" position, the valve will not be operated to turn on the steam.

Typical operation of the system may now be described. It may be assumed that the weather is quite cold and that the building under control has been operating through the night at reduced temperature. The cycle of day operation is about to commence. Because the weather is quite cold outside, the arm 21 will be moved considerably toward the right from the position shown in Figure 1. At this hour of the day the cam 4 will just be in a position to engage the terminal 21a of the arm 21. This engagement takes place, and the arm 21 is sprung outwardly, closing the circuit through the mercury tube switch 14. The thermostat 31 is in circuit closing position, and the valve motor mechanism 26 is accordingly operated to turn on the steam to the system. The valve 25 will remain open until the circuit through the tube 14 is opened and the circuit through the tube 15 is closed. Since the arm 21 is, under the conditions just supposed, well in toward the right as viewed in Figure 1, it will take some time for the slowly moving cam 4 to clear the terminal 21a of the lever 21 and allow the yoke to rock back. It may happen that while the terminal 21a is engaging the cam 4, the cam 5 will rotate over the face of the cam 4 one or more times. In this event, the cam 5 serves merely to spring the arm 21 further out, but since the yoke 11 has already been tipped, no further action takes place.

In the assumed conditions of operation, the cam 4 will eventually clear the terminal 21a of the arm 21. Because of the fact that the weather is cold in the assumed operation of the valve, it requires considerable time to bring the building from its night heat up to its day heat. By reason of the fact that the arm 21 is moved in to-

ward the right from the position shown in Figure 1, it engages the cam 4 where the cam 4 is relatively wide and where the velocity of the slowly moving cam is relatively slow. If the temperature is milder, the arm 21 engages the cam nearer its outer end where the velocity is greater and where the width is less, and the heating up period is shorter.

After the initial heating up period, the cam 4 will clear the terminal 21a, and it will not again return to an operating position until the next morning. The cam 5, however, will periodically come into engagement with the terminal 21a and the yoke 11 will thereby be periodically tilted. If the thermostat 31 or the thermostat 32, whichever is connected to the motor 26 through the time switch, is calling for heat when such operation occurs, heat will be turned on. With the cam 5 as with the cam 4, the velocity toward the center is less and, therefore, as the arm 21 moves further over toward the center of rotation of the cam 5 the longer will be the period of engagement between the cam 5 and the terminal 21a, and if the arm 21 moves to the right far enough, it will practically never leave the cam 5. This condition would prevail only, of course, in very severely cold weather. By reason of the shape of the cam, it is obvious that as the outside temperature is warmer and the arm 21 moves to the left, the shorter will be the interval of engagement between the cam and the terminal 21a, and if the outside temperature is warm enough so that no heat is required, the terminal 21a will be entirely beyond the path of travel of the cam 5 and it will not be operated at all.

The purpose of the extension 11a on the yoke 11 is to permit the arm 21 to swing very considerably to the left of the position shown in Figure 1, without becoming disengaged from the yoke 11. In other words, in very warm weather, the arm 21 might move very considerably to the left, and the purpose of the extension 11a is to act merely as a guide strip or keeper to retain the resilient arm 21 in place even when it swings very far to the left.

In any heating system a definite time interval is required for the heating fluid, such as steam, to travel from the source of supply, as the valve 25, to the radiators. The radiators have a definite capacity for storing heat so that a further time element is required after the steam reaches the radiator to bring the radiator up to a point of maximum heat. When the steam is turned off, the stored heat in the radiator will gradually dissipate into the room in which the radiator is located. An important feature of the present system is that both the cams 4 and 5, in any position where they engage the terminal 21a, have a sufficient minimum width to assure of the steam filling the system up to the radiators. In other words, the arc 5c of the cam 5, representing the minimum period of time in which the cam 5 and the member 21a are in engagement, is sufficient to assure of the heat going from the valve 25 into the heating system, filling the heating system up to the radiators but not sufficient to permit of much, if any, steam going into the radiators. Likewise, even at its outer end, the cam 4 is sufficiently wide and the speed of movement sufficiently slow to assure this result.

Once the heating system has been filled with steam, and the metal of the system has been raised to a heat-emitting temperature, the heating fluid can be turned off and the emission of heat will continue for a considerable period. In the case of steam, the steam which is in the system at the time the steam is turned off, condenses, and in so doing gives up heat. Moreover, the capacity of the heating system itself, i. e., the metal is roughly estimated at 100 B. t. u. per sq. ft. of radiation. In a radiator, for instance, having 200 sq. ft. of radiation, it will, roughly estimated, emit 20,000 B. t. u. after the steam is turned off. It is because of this capacity of the heating system that a thermostat generally produces overheating. The cam in the present case in addition to having a portion which takes care of the time required for the heating system to fill up and begin to emit heat, is designed to anticipate the release of stored heat in the system after the heating fluid is turned off, so that it will turn off the heating fluid sufficiently soon to anticipate this further gradual release of heat from the system during the remaining portion of the time interval when the steam is turned off and is subsequently turned on again.

Another factor which determines the shape of the cam is the gradient of outdoor temperature. When the outdoor temperature is low, the rate of heat dissipation from the room or from the building is greater than when the outdoor temperature is high. The trailing edge of the cam, therefore, is designed to take care, in cooperation with the temperature operated arm 21, of outdoor temperature variations. Briefly stated, therefore, the shape of the cam is determined first by the frequency of its operating cycle, the time required for the heating system to fill up to the radiators with heating fluid, the capacity of the system to deliver heat while the radiator is filling and remains full, and after the heating fluid is turned off and, finally, by an outdoor temperature gradient. Based on an average dissipation from buildings and the number of equivalent sq. ft. of radiation in a building, the cams can be laid out to maintain the temperature within the building throughout the day within a fluctuation of a very few, normally only one, degree. By using the cams in combination with a thermostat or thermostats, the cams do not need to be individually designed for each particular building, but can be laid out in graduated sizes so that a heating contractor can select for a given installation a stock size of cam which most nearly meets his requirements. He would select a cam which would assure at all times sufficient heat for the building, and if it would otherwise produce overheating, the thermostat would function as a control to limit overheating. Thus by coupling the cam mechanism and the thermostat mechanism, each effects a governing control over the other. In the ordinary practice of the invention the cam mechanism alone will maintain the temperature so closely within the desired range that the thermostat would not ordinarily function more than once or twice a day. By varying the steam pressure admitted to the heating system the cam may also be compensated for. If a stock size of cam gives too much heat, the steam pressure may be reduced, and vice versa.

While I have shown the device as being coupled in series with one or more thermostats, many heating installations function satisfactorily without resorting to the use of thermostats, and the use of the thermostats is only desired where a very close control of the heat consumed is wanted. Where the thermostat is used, however, it constitutes a means by which the frequency of the

operation of the valve can be modified while the cams operate at a constant speed and it provides a means whereby the time interval between the periods at which steam is turned on may be varied, whereas the cams would otherwise require the same exact time interval from one turning on to the next turning on operation.

In the arrangement previously described, the closing of the circuits is effected through the tipping of the mercury tube switches. The function of the temperature responsive lever **21** is merely to effect the tipping movement of the mercury tube switches. The arm **21** and its associated parts can move freely in accordance with temperature variations. The power available through slight temperature changes for moving the arm **21** is very slight and the fact that the arrangement permits free, unrestricted movement of the arm when it is off the cam, assures accurate movement of the arm in response to temperature changes. In order to assure that even in very cold weather the terminal of lever **21** will be momentarily free to adjust itself with each revolution of the cam, the cam has the leading edge extended by means of a slot as shown to almost the center of the cam. By adjusting the screw **23**, the relative position of the lever **21** with respect to the arm **20** can be changed for adjusting the device within very close ranges. By changing the position of the arm **16***a* the whole position of the temperature responsive unit can be shifted with respect to the cams, securing a simple way of providing a rough adjustment within a limited temperature range. Adjustment of the arm **16***a* can be made by the building operator, while adjustment of the screw **23** would ordinarily be done by one skilled in the calibration of the instrument.

In the arrangement shown in Figure 6, there is a generally similar construction, but instead of the mercury tubes being used, the temperature actuated arm itself and the cam provide circuit closing devices. In the arrangement shown in Figure 6, **40** designates a panel on which is a cam **41** formed of conducting material and corresponding generally to the cam **5** of Figure 1. The cam **41** is arranged to be rotated by a clock mechanism (not shown). At **42** there is designated generally a temperature responsive device comprising an adjustable base member **43** having an arm **43***a* corresponding to the arm **16***a*. The base **43** carries the actuating element **44** on which is a lever **45**. The lever **45** is of conducting material and it preferably has an insulating member **46** thereon or in which is carried a second arm **47**. A lead wire **48** is connected to the arm **45** and a lead wire **49** is connected to the arm **47**. At **50** is a switch which may be operated to connect with either the wire **48** or the wire **49**. A cam **51** is provided for kicking the switch over from one position to another. At **52** there is a contact strip which is supported on the base **40** and a wire **52'** is connected with it. A wire **53** is connected to the cam **41**. With this arrangement, when the cam **41** moves around over the member **52** it lifts the ends of the arms **45** and **47** off the strip **52**, breaking the circuit from wire **54** through switch **50** and conductor **48** or **49** and arm **45** or **47**, as the case may be. A circuit is simultaneously closed from either the arm **47** or the arm **45** through the cam to the wire **53**. The wire **53** is connected to control the opening of the valve while the wire **52'** is connected to effect the closing of the valve. The circuit remains open as long as the temperature responsive arms **45** and **47** are engaging the cam **41**. When the cam **41** rides out from under the arms **45** and **47** they drop back onto the contact **51**. The circuit through the cam is then opened and the circuit is completed through the wire **52'** to close the steam valve.

The two arms **45** and **47** are for day and night operation respectively. During the day the temperature range for the building is higher than during the night. The arm **45** is always closer to the center of the cam than the arm **47** and it therefore always has a longer period of travel in contact with the cam than does the arm **47**. During the day the switch **50** closes the circuit to the arm **45** and during the night the switch **50** closes the circuit to the arm **47**. In this arrangement I have not shown any morning heating up cam corresponding to the cam **4**, but it is obvious that the arrangement permits the use of such a cam. This arrangement is somewhat more simple than the one previously described. It, of course, can be used with or without thermostats, as can the arrangement shown in Figure 1. From a practical standpoint, some difficulty is encountered in keeping the contact between the terminals of the arms **45** and **47** and the disc **41** sufficiently clean to assure of the proper actuation of the valve at low voltage and also to assure the making of a good contact when the arms **45** and **47** ride off the cam onto the strip **52**. The mercury tube switches are more positive in their operation over a long period of time, and for this reason the arrangement shown in Figure 1 is preferred. Moreover, there is some friction produced in maintaining the arms **45** and **47** in circuit closing contact with the conductor **52**, and this interferes to some extent with the free movement of the arm **45** under varying temperature conditions. The system, however, can be cheaply manufactured and can be satisfactorily used.

The modification shown in Figures 7 and 8 represents an embodiment of the invention wherein a cam arrangement is provided for switching from day to night temperatures and from night to day temperatures. In this arrangement, the panel **60** has a clock **61** thereon which drives three cams **62**, **63** and **64**. Cam **62** revolves once every twenty-four hours and corresponds to the cam **4** of Figure 1. Cam **63** revolves at relatively short intercals and corresponds to the cam **5** of Figure 1. Cam **64** revolves once every twenty-four hours.

Pivotally supported on the panel **60** above the clock is a base member **65**, the pivot point for which is located at **66**. Its movement in a vertical arc is limited by screws **67** passing through slots **68** in the base member. The pivot **66** also provides a pivotal mounting for an arm **69** having its lower end terminal portion **69***a* corresponding to the terminal portion **21***a* of Figure 1. The temperature responsive mechanism is designated **70** and is carried on the plate **65**. It is arranged to operate an arm **71** which arm is connected through a link **72** and a wire link **73** with an extension **69***a* on the arm **69**. Movement of the arm **71** transmits motion to the arm **69** to move it back and forth with respect to the cams **62** and **63**. Arranged adjacent the cams **62** and **63** is a tiltable frame **74** corresponding to the frame or yoke **11** of Figure 1. The frame **74** carries two mercury contact tubes **75** and **76** corresponding to the mercury tube contacts **14** and **15** of Figure 1. The arm **69** functions in cooperation with the cams **62** and **63** and in cooperation with the tilting frame **74** the same as the arm **21** of Figure 1 functions and for the same purpose.

Extending down from the tiltable base member **65** is an arm **77** having a roller **78** at its outer

end position to track on the periphery of the cam **64**. The cam **64** has a relatively long, high part **64***a* which is concentric to the center about which the cam rotates and it has an irregularly shaped low part comprising the substantially radial step **64***b*, dropping from the highest point on the cam to the lowest point, and from the base of the edge **64***b* the cam rises more or less regularly and gradually back to the portion **64***a*, this gradually rising edge being designated **64***c*. In operation, the high portion **64***a* of the cam bearing against the roller **78** serves to hold the base member **65** in the position shown in Figure 6. At this time the arm **69** is in the position for cooperation with the cams **62** and **63** for day operation. When the roller **78** engages the drop in the cam, it allows the frame **65** to swing down, carrying with it the temperature responsive mechanism **70** and swinging the arm **69** to the left as viewed in Figure 7, so that it is further from the center of the cams **62** and **63**.

Since the terminal **69***a* of the arm **69** is farther from the center of the cams **62** and **63** at this time, it either clears the cam **63** entirely or engages the cam **63** nearer the periphery of said cam than it does with a corresponding outdoor temperature during the period of day operation. The result of this is that the heat is turned on for a shorter period of time during the cycles of night operation than it is during the cycles of day operation, even though the outdoor temperature should not change. The cam **64**, cooperating with the roller **78**, therefore, serves to change the relative operating range of the arm **69** with respect to the cam **63**, thus allowing the building to be kept cooler at night than during the day. This system can be used where day and night thermostats are not used. The contour of the cam **64** is determined according to how many hours of the day it is desired to maintain the building at normal temperature and how many hours it is desired to keep the building at a lower than normal temperature.

While I have specifically indicated in the foregoing description the turning on of a valve, particularly a steam valve for the supplying of heating fluid, it will be understood that the control panel is not limited to the control of a valve, but in place of a motor-driven valve the control panel may operate upon fuel burning mechanisms such as stokers, oil or gas burners, or otherwise function to periodically cause a heating system to be supplied with heat or to add to the heat already supplied periodically. Various modifications and changes in the detailed construction of the parts also may be made in the apparatus within the contemplation of my invention and under the scope of the following claims.

I claim:

1. A mechanism for use in a heat control system comprising a clock-driven flat cam mounted to revolve in a plane, and a member responsive to variations in temperature mounted for movement in a plane parallel to the plane of the cam, having a portion thereon which extends across the plane of travel of said cam, said cam serving to displace said member in a direction normal to the plane of the cam when the cam moves into engagement with said portion.

2. A mechanism for use in a heat control system comprising a clock-driven flat cam mounted to revolve in a plane, and a member responsive to variations in temperature mounted for movement in a plane parallel to the plane of the cam, having a portion thereof which extends across the plane of travel of said cam, said cam serving to displace said member in a direction normal to the plane of the cam when the cam moves into engagement with said portion, and a switch mechanism operated by the movement of the member in a direction normal to the surface of the cam.

3. A mechanism for use in a heat control system comprising a clock-driven cam mounted to revolve in a plane, an arm for cooperation with the cam, a temperature responsive mechanism for actuating the arm in a plane parallel to the plane in which the cam revolves, said arm having a cam-engaging portion which extends across the plane of travel of said cam, said cam serving to displace the arm in a direction normal to the plane of the cam when the cam engages said portion of the arm, said arm being resilient whereby it springs back into normal position after being displaced by the cam.

4. A mechanism for use in a heat control system comprising a clock-driven cam mounted to revolve in a plane, an arm for cooperation with the cam, a temperature responsive mechanism for actuating the arm in a plane parallel to the plane in which the cam revolves, said arm having a cam-engaging portion which extends across the plane of travel of said cam, said cam serving to displace the arm in a direction normal to the plane of the cam when the cam engages said portion of the arm, the cam having a substantially radially extending step from a portion of minimum diameter to a portion of maximum diameter and having an effective width which decreases outwardly from the center.

5. A mechanism for use in a heat control system comprising a clock-driven cam mounted to revolve in a plane, an arm for cooperation with the cam, a temperature responsive mechanism for actuating the arm in a plane parallel to the plane in which the cam revolves, said arm having a cam-engaging portion which extends across the plane of travel of said cam, said cam serving to displace the arm in a direction normal to the plane of the cam when the cam engages said portion of the arm, the cam having a substantially radially extending step from a portion of minimum diameter to a portion of maximum diameter and having an effective width which decreases outwardly from the center and having an effective width at any point outwardly from the center sufficient to assure engagement of the said portion of the arm for a length of time sufficient to allow for the complete heating up of the heating system in which the mechanism is incorporated.

6. Mechanism for use in a heat control system, comprising a clock-driven cam mounted to revolve in a plane, a mechanism actuated by changes in temperature, an arm member operated by said mechanism and movable by said mechanism in a plane parallel to the plane in which the cam rotates, said arm having a portion thereon which projects across the path of travel of the cam whereby the cam may serve to displace the arm in a direction normal to the plane of the cam when the cam and said portion come into engagement, and means for adjusting the effective operating position of the temperature responsive mechanism and said arm relative to said cam.

7. Mechanism for use in a heat control system, comprising a clock-driven cam mounted to revolve in a plane, a mechanism actuated by changes in temperature, an arm member operated by said mechanism and movable by said

mechanism in a plane parallel to the plane in which the cam rotates, said arm having a portion thereon which projects across the path of travel of the cam whereby the cam may serve to displace the arm in a direction normal to the plane of the cam when the cam and said portion come into engagement, and an adjustable support on which said temperature responsive mechanism is mounted to permit of a relative adjustment between said mechanism and its arm and said cam.

8. Mechanism for use in a heat control system, comprising a clock-driven cam mounted to revolve in a plane, a mechanism actuated by changes in temperature, an arm member operated by said mechanism and movable by said mechanism in a plane parallel to the plane in which the cam rotates, said arm having a portion thereon which projects across the path of travel of the cam whereby the cam may serve to displace the arm in a direction normal to the plane of the cam when the cam and said portion come into engagement, an adjustable support on which said temperature responsive mechanism is mounted to permit of a relative adjustment between said mechanism and its arm and said cam, a second clock-driven cam, and means for transmitting motion from said second clock-driven cam to said adjustable support.

9. Mechanism for use in a heat control system, comprising a clock-driven member movable in a plane, a mechanism responsive to temperature and an arm actuated thereby, said arm being movable by operation of said temperature responsive mechanism in a plane parallel with said clock-driven member, said arm having a portion thereon which intersects the plane of travel of said clock-driven member whereby when said clock-driven member engages said portion said arm is displaced thereby, and a heat control circuit governed by such displacement of the arm.

10. Mechanism for use in a heat control system, comprising a clock-driven member movable in a plane, a mechanism responsive to temperature and an arm actuated thereby, said arm being movable by operation of said temperature responsive mechanism in a plane parallel with said clock-driven member, said arm having a portion thereon which intersects the plane of travel of said clock-driven member whereby said clock-driven member engages said portion of the arm to displace the arm in a direction normal to the plane of said member, said arm being free-floating when clear of said member, said member being so constructed as to assure disengagement of the arm at least once with every revolution of said member, and heat-controlled means governed by the movement of said arm in the direction normal to the plane of said member.

11. Mechanism for use in a heat control system, comprising a clock-driven member movable in a plane, a mechanism responsive to temperature and an arm actuated thereby, said arm being movable by operation of said temperature responsive mechanism in a plane parallel with said clock-driven member, said arm having a portion thereon which intersects the plane of travel of said clock-driven member whereby said clock-driven member engages said portion of the arm to displace the arm in a direction normal to the plane of said member, said arm being free-floating when clear of said member, said member being so constructed as to assure disengagement of the arm at least once with every revolution of said member, and heat-controlled means governed by the movement of said arm in the direction normal to the plane of said member, said last means comprising switch mechanism which is moved by movement of the arm when said portion of the arm is displaced by engagement with said member but which returns by gravity and is free of engagement with said arm when said arm is clear of said clock-driven member.

12. A heat control system comprising a temperature actuated device, a plurality of clock-driven cams operated at different speeds co-operating with the temperature actuated means, one of said cams having a leading edge which is regular and a trailing edge which is irregular to give different periods of time for cooperation with the temperature actuated device, the second cam having its leading edge irregular and its trailing edge regular whereby it will always disengage the temperature actuated device at the same time but may vary the period of initial engagement therewith, and a heat control circuit operated through the engagement and disengagement of said temperature actuated device and cams.

13. A temperature control system comprising a cooperating clock-driven cam and a temperature responsive contact arm, the cam being substantially flat and having an abrupt leading edge and a curve trailing edge, the temperature responsive arm being movable across the face of the cam from the center toward the periphery, the arm moving toward the center of the cam with reducing temperatures and toward the periphery with rising temperatures.

14. A temperature control system comprising a cooperating clock-driven cam and a temperature responsive arm adapted to contact therewith through engagement with the face of the cam and to be displaced by engagement with an edge of the cam, the cam being of a revolving disc type whereby the outer portion moves with a relatively greater velocity than the inner portion, the arm being movable with changes in temperature toward and away from the center of the cam, the arrangement being such that it moves toward the center with decreasing temperatures and away from the center with increasing temperatures.

15. A mechanism for use in a heat control system comprising a circuit-operating means, a temperature-actuated device, and a plurality of clock-driven cams operated at different speeds mechanically cooperating with said temperature-actuated device, said cams being supported for operation in parallel planes and being differently shaped, one being movable periodically across the face of the other, the circuit-operating means being operatively connected for actuation by the co-engagement of the temperature-actuated device with either of said cams.

16. A temperature control device comprising two flat cam-like members which lie in parallel planes and clock-driven means for rotating them in the planes in which they are mounted, a circuit controlling means for engagement with the faces of both of said members and movable in the same plane as said members in an arc toward and away from the centers of said members, temperature responsive means for moving the circuit controlling means in said plane, the faces of the flat cam-like members being of outwardly diminishing arcuate extent whereby the length of engagement between a cam and the circuit controlling means varies according to the position of said circuit controlling means in said plane.

17. A temperature control device comprising a flat plate-like cam member, means for rotating said member in the plane in which it is mounted, an arm adjacent said member mounted for movement in a plane parallel with the plane of rotation of the plate-like cam member and having a terminal portion adapted to ride over a face of the flat cam-like member when such member rotates into position to be engaged thereby, means governed by the engagement and disengagement of said terminal and cam-like member for turning a source of heat on and off, and temperature responsive means for moving the arm in a plane parallel to the plane of rotation of the cam-like member to move said terminal toward or away from the center of rotation of said cam-like member.

18. A mechanism for use in a heat control system comprising a pair of rotatable flat disk-like cams of outwardly decreasing arcuate extent, means for rotating both of the cams at relatively different speeds whereby one of them periodically eclipses the other, a temperature responsive means in the path of movement of both cams for engagement by either and movable, in response to temperature changes, in the plane of rotation of the cams whereby the duration of the engagement between the cam and said means is varied according to the position of said means in said plane, and an electric circuit governed by the engagement and disengagement of said means with the cams.

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