

Dec. 24, 1957

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2,817,401

TIME CONTROL SYSTEM AND APPARATUS

Filed May 11, 1953

3 Sheets-Sheet 1

FIG. 1.

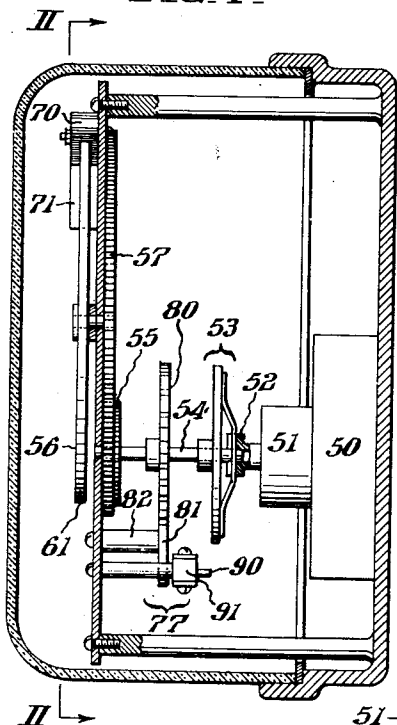


FIG. 4.

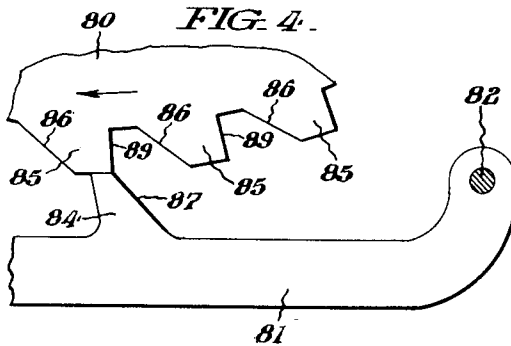


FIG. 3.

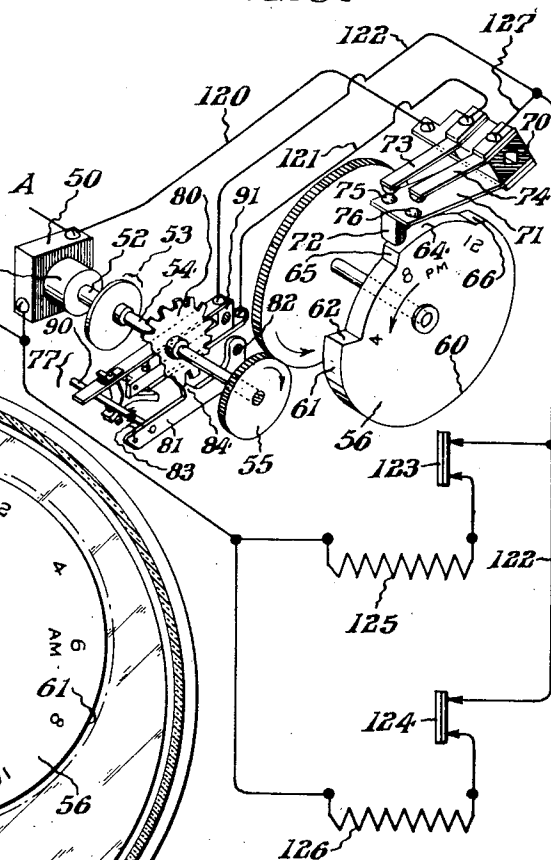
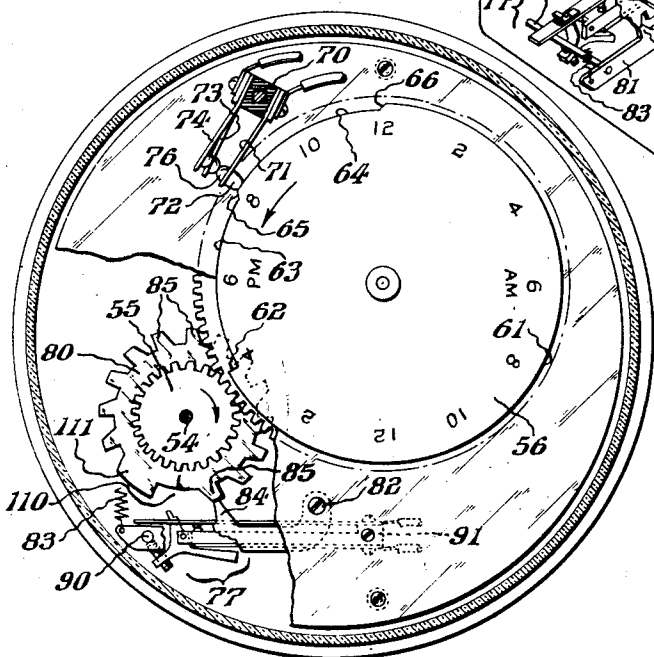


FIG. 2 - B



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FIG. 5 -

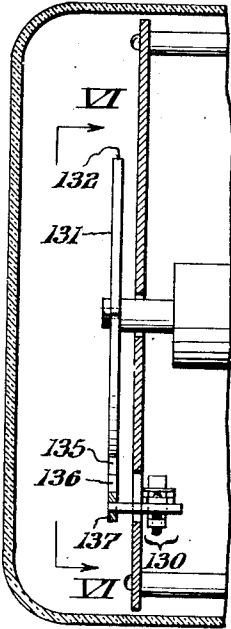


FIG. 6 -

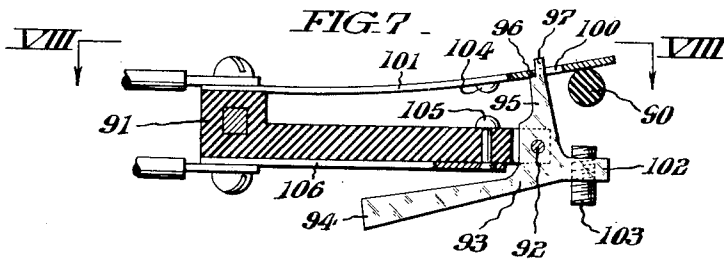
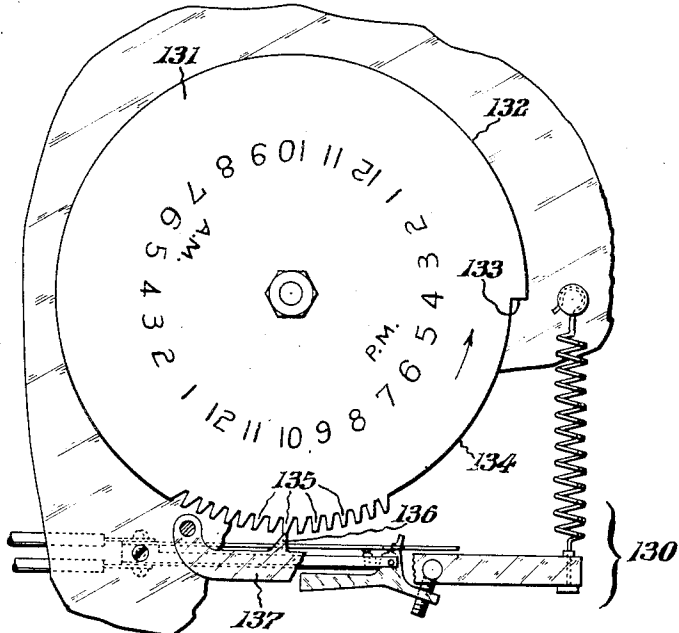


FIG. 8 -

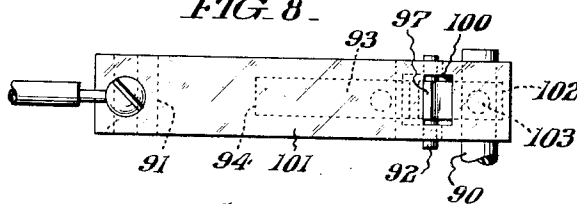
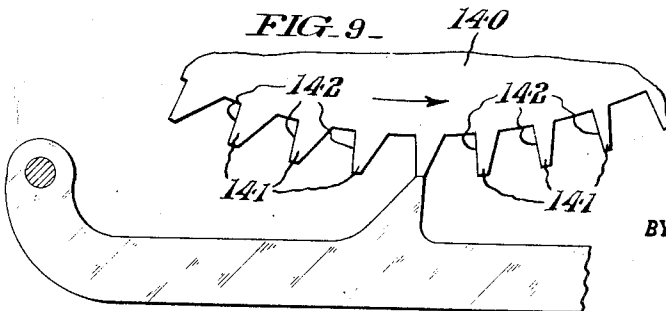


FIG. 9 -



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FIG. 12.

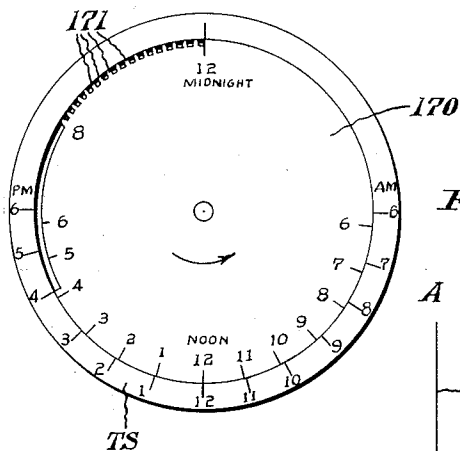


FIG. 10.

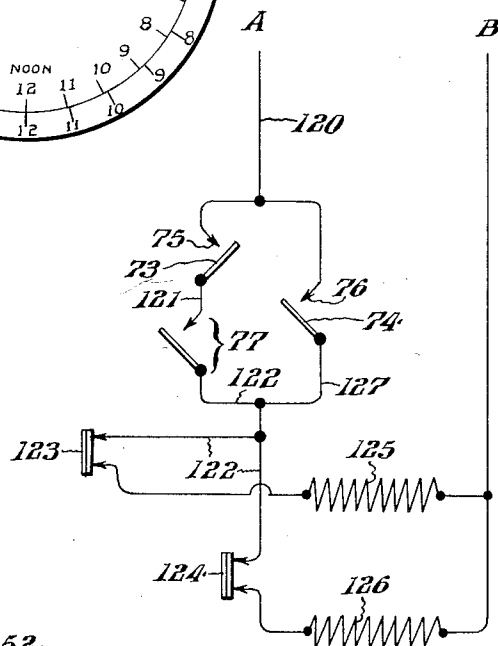
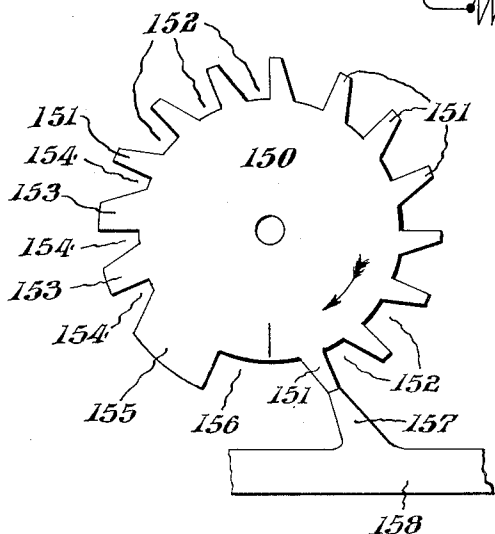


FIG. 11.



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TIME CONTROL SYSTEM AND APPARATUS

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3 Claims. (Cl. 161—1)

This invention relates to an apparatus for controlling the peak demand upon an electric circuit which is subjected to varying demands. More particularly it concerns a method and apparatus for timing the electric power consumption of domestic and other appliances such as electric hot water heaters and the like, and for controlling this consumption in timed relation to the overall or total existing demand upon the power source.

Power for domestic water heaters is generally supplied at such a low cost that very little additional capital investment should be incurred by the power company for this purpose. Therefore it is essential that the peak load of residential power customers shall not be increased by reason of the water heater load. The peak electric power load for residential customers in most communities, excluding that of water heaters, occurs at about 6:00 p. m. due to the high demand of electric ranges. This load falls off steadily from about 7:00 p. m. until 6:00 a. m.

In order to avoid exceeding the peak load occurring at 6:00 p. m., it is a customary practice of power companies to disconnect the electrically operated hot water heaters, by time switches or other means, from about 4:00 p. m. until about 10:30 p. m. This accomplishes the desired result if only a few electric hot water heaters are connected to the power system. When the number of such heaters becomes large the total residential load at 10:30 p. m., after all the hot water heaters have been connected, tends to become greater than the 6:00 p. m. load. This peak load condition requires additional power capacity in the system. The system of water heater control herein described prevents this undesirable occurrence.

I have found that the residential load curve for practically all power companies is such that, if the water heater load occurring at the time of reconnecting the heaters should be reduced from 40 to 60 percent, the 6:00 p. m. load will not be exceeded regardless of the numerical ratio of ranges to water heaters connected into the power system, and regardless of any reasonable change to be expected in the future in the use of electric appliances. The preferred means by which such load reduction is accomplished in accordance with this invention is a time switch connected in the heater circuit in such manner that it energizes and deenergizes the heater repeatedly for short intervals of time. The method employed for reducing the load of a group of heaters by a certain percentage is to disconnect each heater for that percent of each such short time interval, which may be 7½ minutes out of each 15 minute period, for example.

The peak loads of most power companies are recorded by instruments which measure the average load over a period of either 15 minutes or 30 minutes. Momentary peak loads lasting less than 15 minutes do not require excess load capacity for the electrical system. Therefore, if all of the water heaters are turned on for 7½ minutes and turned off for the next succeeding 7½ minutes, the average load for the 15 minute period is 50 percent of the total load. Therefore, if the time switch is constructed

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so that it will open and close the electric circuit supplying its heater every 7½ minutes for a predetermined portion of the day, the integrated electric load for any 15 minute period during this portion of the day cannot exceed 50 percent of the load which would occur if all heaters were turned on for the 15 minute period.

It is accordingly an object of this invention to provide a novel apparatus and method for attaining the foregoing advantages. Another object is to provide a method and means for reducing to some preselected value the total electric power supplied to an electric appliance in a power system during a predetermined portion of the day, without completely disconnecting such appliance. Other objects and advantages of the invention, including the simplicity and economy of the same, and the ease with which it may be applied to existing power systems, will further appear hereinafter and in the drawings whereof:

Fig. 1 represents a view in vertical section showing a timing switch in accordance with this invention;

Fig. 2 represents a face view of the timing switch represented in Fig. 1, taken as indicated by the lines and arrows II—II which appear in Fig. 1;

Fig. 3 represents a view in perspective of the timing switch represented in Figs. 1 and 2 together with a wiring diagram indicating how the timing switch may be connected to a domestic hot water heater in accordance with this invention;

Fig. 4 represents an enlarged view of portions of the intermittent timing mechanism represented in Figs. 1–3 of the drawings;

Fig. 5 represents a vertical sectional view similar to Fig. 1 showing a modified form of the time switch in accordance with this invention;

Fig. 6 represents an enlarged face view of a portion of the time switch of Fig. 5, taken as indicated by the lines and arrows VI—VI which appear in Fig. 5;

Fig. 7 represents an enlarged elevation of the intermittent switch device embodied in the timing switches of Figs. 1–3, 5 and 6;

Fig. 8 represents a plan view taken as indicated by the lines and arrows VIII—VIII which appear in Fig. 7;

Fig. 9 represents an enlarged view of portions of the intermittent switching mechanism of a modified timing device comparable to those represented in Figs. 2, 3, 5 and 6 of the drawings;

Fig. 10 represents a wiring diagram showing how a timing switch in accordance with this invention may be connected to a domestic hot water heater;

Fig. 11 represents a modified intermittent switch actuating device in accordance with this invention; and

Fig. 12 represents a face view of a modified disc for a time switch.

Turning now to the embodiment of the invention selected for illustration in Figs. 1–3 of the drawings, a synchronous motor 50 is mounted in a suitable casing. Motor 50 is connected through a conventional gear train 51 to drive a shaft 52. Through a friction plate 53, shaft 52 drives another shaft 54. Rigidly connected to shaft 54 is a spur gear 55 which drives a rotatable control disc 56 through a gear 57. As shown, the gear 57 is so proportioned that shaft 54 makes six revolutions for each revolution of disc 56. Preferably, disc 56 rotates once every 24 hours.

The disc 56 has a peripheral edge 60 the major portion 61 of which is circular. Edge 60 has a radial face 62 and a pair of curved faces 63, 64 each of which is an arc of a circle whose center is the axis of rotation of the circular plate 56. Face 63 is closer to the center of rotation than is face 64. The plate edge 60 also includes a pair of inclined flat faces 65, 66 disposed respectively between the faces 63, 64 and 64, 61. Fixed

to the time switch casing is an insulating block 70. The block 70 is disposed adjacent to the edge 60 of circular plate 56. Fixed to the lower face of block 70 is a resilient contact plate 71 carrying a cam follower 72 which is continuously resiliently urged against the peripheral edge 60 of the circular plate 56. Spaced apart on the upper face of block 70 are a lower contact strip 73 and an upper contact strip 74. The plate 71 is provided with two contact points 75, 76 which are aligned respectively with similar contact points on the strips 73, 74.

It will be appreciated that, as the circular plate 56 revolves the lower plate 71 follows the contour of its peripheral edge 60. When cam follower 72 is in contact with face 63, both switches 73, 74 are open. When cam follower 72 is in contact with surface 64, the contacts 75, 73 are closed. When cam follower 72 is in contact with surface 61, both sets of contacts 75, 73 and 76, 74 are closed.

In accordance with this invention an intermittent switch comprehensively designated 77 is provided for limiting the power during the period from 8 p. m. to 12 midnight for example. Mounted on the shaft 54 for rotation therewith is a toothed wheel 80 which rotates continuously under the influence of synchronous motor 50. A lever 81 is pivoted at 82 for rocking movement within the casing. A spring 83 anchored to the casing continuously urges the free end of lever 81 upwardly toward the toothed wheel 80. Lever 81 has an upwardly extending tooth 84 which, as shown more particularly in Fig. 4, is shaped to fit within the spaces between the teeth 85 of the toothed wheel 80. Teeth 85 have inclined faces 86 which bear upon the inclined face 87 of tooth 84 thereby camming the tooth 84 downwardly out of this space in response to the rotation of the toothed wheel 80. Accordingly it will be apparent that the lever 81 rocks downwardly about the fixed pivot 82 in response to the rotation of the toothed wheel 80, and suddenly snaps upwardly as the tooth 84 passes over a lagging edge 89 of a tooth 85.

Fixed to the lever 81 near its free end is an actuating pin 90. The pin 90 reciprocates up and down in response to the rocking movement of lever 81 in such manner as to actuate an intermittent time switch, as will further become apparent.

Referring more particularly to Figs. 7 and 8 of the drawings, as well as Figs. 1-3, the intermittent time switch shown in the drawings is supported on a piece of insulating material 91 which is secured within the time switch casing. At one end of the block 91 is a pivot pin 92 which carries an overbalanced rocker 93. Into rocker 93 is incorporated a laterally extending weight 94 which overbalances the rocker with respect to its pivot 92. At its upper end the rocker has an upwardly extending shoulder projection 95 having a shoulder 96 and an extremity 97 which extends through a slot 100 in a resilient contact strip 101 which is fixed to the insulating block 91. The rocker 93 has a lateral projection 102 which extends in a direction opposite to weight 94 and carries an adjusting screw 103 which can be adjusted upwardly and downwardly toward and away from the actuating pin 90. The switch also has a pair of contacts 104, 105 the latter being connected electrically to a stationary contact strip 106.

It will be apparent that, when the pin 90 moves upwardly to the position shown in Fig. 7 of the drawings the weight 94 causes the rocker 93 to tilt, bringing the shoulder 96 under the resilient contact strip 101. This retains or latches the strip 101 in its upper position whereby the contact 104 is spaced away from contact 105, thus maintaining the switch in open position. As the actuating pin 90 moves slowly downwardly, the switch remains open. However when the actuating pin 90 contacts the upper face of adjusting screw 103, the shoulder projection 95 swings to the right as viewed in Fig. 7

thus bringing the shoulder 96 into slot 100, permitting the resilient contact strip 101 to snap suddenly downwardly thereby suddenly closing the circuit through contacts 104, 105. The cycle is completed when actuating pin 90 snaps upwardly, permitting the weight 94 to swing the shoulder 96 under the contact strip 101. Accordingly it will be appreciated that means are thus provided for opening and closing the circuit repeatedly in accordance with a predetermined time cycle which may be relatively short in duration. The character of the cycle is controlled by the shape and spacing of the teeth 85 of wheel 80. Preferably the switch shown in Fig. 7 remains open for approximately 7½ minutes and remains closed for approximately 7½ minutes but this may advantageously be varied, as will further appear.

Referring more particularly to Figs. 3 and 10 of the drawings, current flows from source A through wire 120 to the resilient contact plate 71. From contact strip 73 a wire 121 is connected to one side of intermittent switch 77. From the other side of intermittent switch 77 wire 122 leads to thermostats 123, 124 of upper water heater element 125 and lower water heater element 126 which are connected in parallel and to the source B. From contact strip 74 a wire 127 is connected directly to the wire 122. Thus it will be appreciated that no current can flow to either heater element 125 or 126 during the peak-load demand period from 4 to 8 p. m. At 8 p. m. the switch contacts 75, 73 are gradually closed. However, the rotation of wheel 80 is synchronized with disc 56 in such manner that the circuit through the intermittent switch 77 is open at 8 p. m. when the contacts 75, 73 are closing. Otherwise, undesirable arcing would take place at these contacts which would tend to render them inoperative after a short time.

To insure that the intermittent switch 77 will be open at 8 p. m. when the switch contacts 73, 75 are closing, the wheel 80 is provided with a large gap 110 between teeth 85, 111. The tooth 84 of actuating lever 81 is located in the large gap 110 for several minutes before and after 4 and 8 o'clock, thus serving the purpose mentioned above. However, the inclined face 66 is so located on disc 56 that the intermittent switch 77 is closed while contacts 74, 76 are closing. Since the heating coils 125, 126 are already energized the gradual closure of contacts 74, 76 does not cause any arcing. In view of the relatively long period of no-flow resulting from the long gap 110, a long tooth 111 is preferably provided immediately adjacent the gap 110. Thus a relatively long period of flow is provided, compensating for the relatively long period of no flow, for each 4-hour cycle corresponding to one revolution of wheel 80.

Accordingly it will be understood that, during the peak load period (from 4 p. m. to 8 p. m. as illustrated in the drawings, for example) both heater elements 125, 126 are deenergized. From 8 p. m. to 12 midnight the heater elements 125, 126 are intermittently alternately energized and deenergized in accordance with a predetermined repetitive cycle determined by the intermittent switch 77. At 12 midnight the circuit through contacts 74, 76 short circuits the intermittent switch 77, and the power supply is continuous. Intermittent switch 77 continues to operate, but its operation has no effect.

Preferably the current is turned on and off every 1½ minutes during the intermittent current supply period, but this value may of course be varied within wide limits provided it is relatively short in relation to the total time period of intermittent operation. In four hours of operation, with 7½ minute periods, the current will be turned on or off eight times per hour, or 32 times during the four hour period. Preferably the total time the current is supplied equals the total time the current is off during this four hour period, but this may be varied as well. It will be appreciated that the heater elements of the appliance are provided with thermostats which open the circuit when there is no demand. But, in referring to the operation of

the switch means, I consider this as a period of power supply, since the current is available to the heater, whenever a heating demand exists, during this period.

Referring to Figs. 5 and 6, the intermittent switch 130 is substantially the same as intermittent switch 77 but the toothed wheel 131 is geared to revolve once every 24 hours. Its outer edge 132 is generally circular but has a radial portion 133 connecting to an indented curved portion 134. As shown, portion 134 corresponds to the peak-load period from 4 p. m. to 8 p. m. The wheel 131 also has a series of closely spaced teeth 135 which engage the tooth 136 of lever 137 which operates the intermittent switch in the manner already described in connection with Figs. 1-3.

From Figs. 5 and 6 it will be understood that the intermittent switch 130 may if desired be utilized without any other switches (such as switches 73, 75 and 74, 76 of Figs. 1-3) to control the operation of an electric hot water heater or other appliance. However since the wheel 134 is a 24-hour wheel the teeth 135 are much more closely spaced than teeth 85 of wheel 80.

Referring now to Fig. 9 of the drawings, the wheel 140 corresponds to wheels 80 and 131. However the spaces between its teeth 141 gradually decrease in size from right to left as viewed in Fig. 9. The teeth 141 are equally spaced, their lagging edges 142 being equally spaced. Accordingly, when wheel 140 rotates in the direction indicated by the arrow in Fig. 9, the ratio of open circuit time to closed circuit time is initially quite low and gradually increases with passage of time. In this manner the time ratio of load to no-load may be varied throughout the period of operation of the intermittent switch. Preferably, at and just after 8 p. m. the periods of energization are much shorter than the periods of deenergization. In this manner the water heater load is only gradually applied to the power system. The periods of energization are preferably increased in relation to the periods of deenergization and may be much longer toward the end of the intermittent current period. For example, the teeth 141 may advantageously be so constructed that the current is off 65% of the time and on 35% of the time at 8 o'clock p. m. with the ratio gradually shifting to on 70% and off 30% at 1 o'clock a. m. The specific characteristics determined to be most desirable for any given power system may readily be attained simply by providing teeth such as 141 of the proper size and spacing.

It will be apparent that large numbers of time switches of this character are intended to be utilized in a common power system. Of course it would be undesirable, during the intermittent power supply period, for all the switches to open and close at precisely the same time. This would result in alternate periods of peak demand and no demand. However, due to inherent inaccuracies as to adjustment not all the switches 77 would, in actual practice, open or close at the same time. However any such possibility may be effectively eliminated by dividing all the time switches into two groups, with one group set to operate earlier than the other group. This may readily be accomplished by preparing two sets of discs 56, one set having the time graduations displaced with respect to the inclined face 65; the other set having accurate time graduations. In each case, see Fig. 2 for example, the rotation of the toothed wheel is synchronized with the rotation of disc 56 in such manner that the intermittent switch closes a certain predetermined number of minutes after contacts 73, 75 are closed. Thus, one set of intermittent switches will close at about 8 o'clock p. m. while the other set of intermittent switches will close a predetermined number of minutes later. For example, the teeth of all the intermittent switches may be shaped to provide a closed circuit for 6 minutes followed by an open circuit for 9 minutes, one group (hereinafter referred to as group A) being set 7½ minutes ahead of the other group (hereinafter referred to as group B). Thus, group A would be energized for 6 minutes, then for 1½ minutes all the

switches would be open, then the switches of group B would be energized for 6 minutes, then for 1½ minutes all the switches would be open, and this cycle would repeat. Such a cycle substantially eliminates the possibility that both groups of switches might be closed at the same time.

Fig. 11 shows a modified intermittent switch wheel 150 which is similar to toothed wheel 80 with the exception that teeth 151 are all equally spaced with identical gaps 152 extending about 270 degrees around the wheel. The teeth 153, having shorter gaps 154, extend around about 45 degrees of the wheel, while one enlarged tooth 155 and one enlarged gap 156 complete the wheel. It will be recalled that the intermittent switch is closed when tooth 157 of lever 158 is on the teeth of the wheel, and open when tooth 157 is in the gaps of the wheel.

The structure of Fig. 11 provides a substantial period of time, say 8 p. m. to 11 p. m., wherein the switches are open for longer periods of time than they are closed. It also provides a relatively short time, say 11 p. m. to 11:30 p. m. when the switches are closed for longer periods of time than they are open. From 11-11:45 p. m. or thereafter all the intermittent switches are closed, and near the end of this latter period the discs 56 close the circuit supplying power continuously to all the appliances in the system. Thereafter, until 8 p. m. the following day, the intermittent switches continue to revolve without any effect on the circuit supplying power to the appliances.

It will be appreciated that switches having the wheels 150 of Fig. 11 may be divided into two or more groups, and that the operations of the various groups may be staggered in order to prevent any simultaneous energization of all the appliances in the system during the critical periods of the day, all as heretofore described.

Fig. 12 shows a twenty-four hour disc 170 having a plurality of teeth 171. This disc is connected to a suitable switch, preferably in a manner comparable to wheel 131 of Fig. 6. Forming no part of the structure, and illustrated for purposes of comparison only, is a time scale TS on which the twelve hours of the day from 6 a. m. to 6 p. m. are correctly calibrated. The disc 170 has calibrations for the same hours, such calibrations being somewhat incorrect. The 6 a. m. calibration is opposite about 6:15 on the scale TS while the 12 noon calibration is correct. The calibrations on the disc 170 are uniform; thus the 7 a. m. calibration is opposite 7:12½, 8 a. m. is opposite 8:10, 9 a. m. opposite 9:07½, 10 a. m. opposite 10:05, and 11 a. m. is opposite 11:02½. The afternoon scale is similarly arranged, but it will be obvious that other arrangements may be utilized, the point being that errors of different magnitudes are made by the field personnel in setting the time switches, depending upon the time the setting is made. In an electric power system of any reasonable size the switch-setting personnel are continuously at work moving from house to house checking and setting time switches. Accordingly, the time switches in a given system are set at substantially all hours of the working day, which usually falls within the period from 6 a. m. to 6 p. m. In accordance with the modification illustrated in Fig. 12 an intentional error is introduced in the setting of each switch, and the magnitude of the error varies depending upon the actual time the switch is set. Accordingly, in a power system of any appreciable size, the individual switches will not all be energized or deenergized at the same time. In fact, their energization and deenergization will be spread out uniformly over a period of about 30 minutes in the system shown in Fig. 12, wherein the intentional error ranges from plus 15 minutes at 6 a. m. to minus 15 minutes at 6 p. m. This spread eliminates the possibility of a sudden peak load at 8 p. m., when the intermittent switching period is begun.

While I have shown in the drawings an apparatus and method for controlling two heater elements connected in parallel, it will be appreciated that this invention is

applicable to the control of one heater element or of a plurality of heater elements operating in accordance with different cycles. For example, the upper heating elements in some hot water heaters are arranged to give quick heating of a small volume of water when the water in the top of the tank has become cool. In such heaters the lower heating elements serve to heat additional water for storage prior to use. For such heaters, it may be preferred during certain periods to short-circuit the intermittent switch for supplying current continuously to the upper coil, while current is supplied intermittently, through the intermittent switch, to the lower heater element. This can readily be attained by modifying the circuit shown in Fig. 3, with the use of an appropriate snap switch for connecting and disconnecting the upper heating coil.

It will also be appreciated that the relative velocities of rotation of the timer wheels may be varied within wide limits, and that the shape and arrangement of the switch actuating teeth or cams may be suitably modified in order to provide cycles having the desired characteristics.

While several specific forms of the invention have been illustrated in the drawings, it will be appreciated that the form of these and other elements may be varied by the substitution of equivalent devices serving a similar purpose. Moreover certain features of the invention may be used independently of the use of other features, and parts and method steps may be reversed, all within the spirit and scope of the invention as defined in the appended claims.

Having thus described my invention, I claim:

1. In an apparatus for controlling the electric power supplied from a power system to an electrical appliance, said power system furnishing electricity to a large number of said appliances and being subject to periods of peak and off peak electric demand, each of said appliances including a thermostatic means which demands or rejects electric current supply in accordance with a predetermined temperature variable, the combination which comprises a switch having a control disc provided with a peripheral portion for closing the circuit to said appliance and thereby supplying the full power demand of the appliance during the off peak period of the system, said disc having another peripheral portion for opening the circuit to said appliance at the end of the off peak period and thereby disconnecting the current supply from said appliance during said peak demand period, and said disc also having another peripheral portion for alternately and positively opening and closing the circuit to said appliance during a predetermined time immediately suc-

ceeding said peak period, said switch comprising contact means through which said power to said appliance is arranged to flow, said contact means including a movable contact arm arranged to move toward and away from another contact between an open and closed position, means for rotating said control disc, a rocking member pivotally mounted on a support adjacent said disc, a tension spring connected to urge said rocking member toward said peripheral portions of said disc, said rocking member and the peripheral portions of said disc being so shaped that the rotation of the disc causes the rocking member to rock periodically about its pivot toward and away from the center of said disc, an auxiliary rocker pivotally mounted for swinging movement with respect to said rocking member, and a projection on the rocking member to raise the contact arm to be latched by the auxiliary rocker when said rocking member moves in one direction and to engage the auxiliary rocker to unlatch the contact arm when said rocking member is moved in the opposite direction.

2. The apparatus defined in claim 1, wherein one of said peripheral portions of said disc includes toothed projections extending along its periphery.

3. The apparatus defined in claim 2, wherein said disc has at least four of said toothed projections per $\frac{1}{24}$ of its circumference.

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