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OFF-PEAK WATER HEATING SYSTEM

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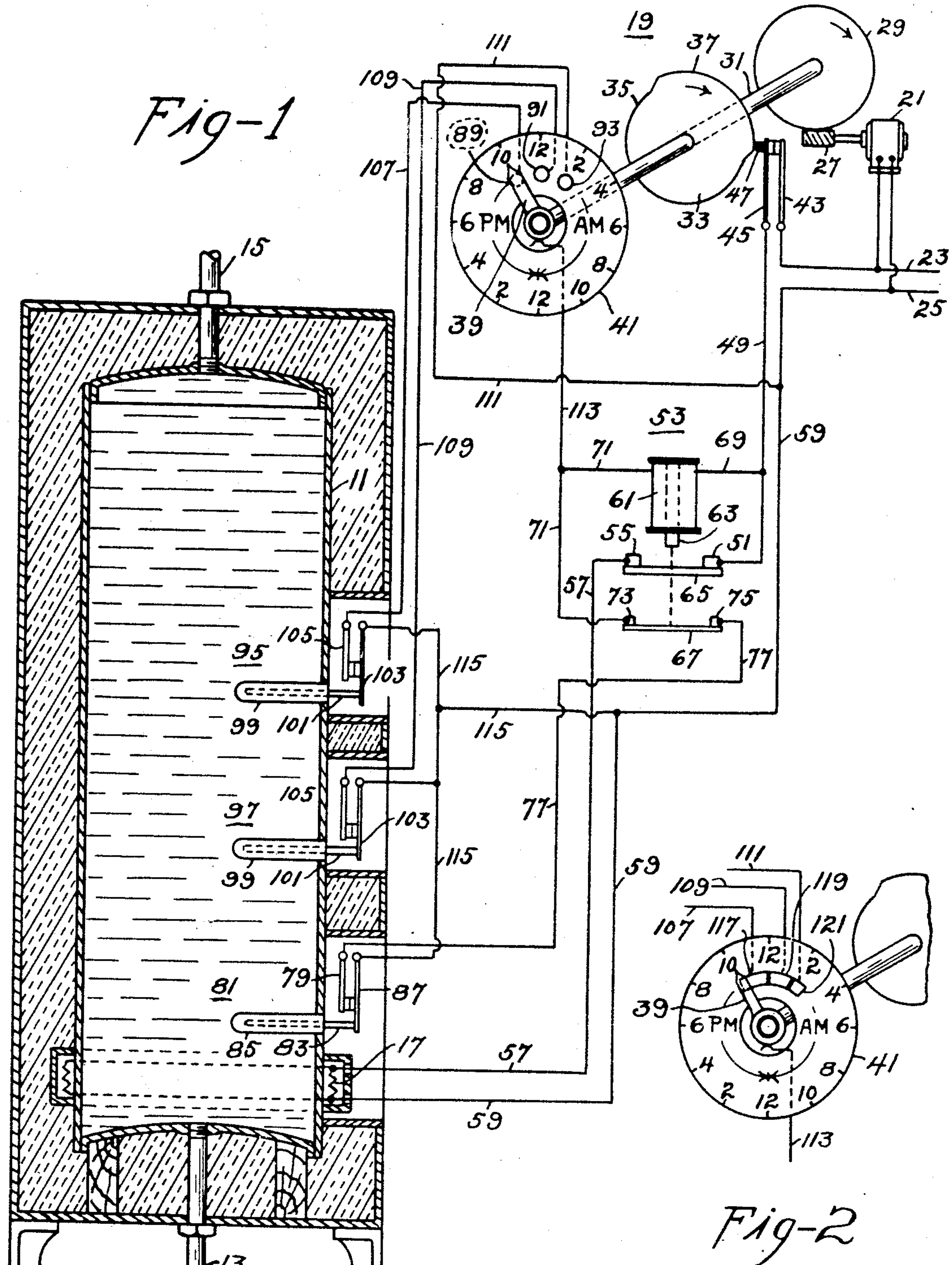

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OFF-PEAK WATER HEATING SYSTEM

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9 Claims. (Cl. 219—39)

My invention relates to water heating systems and particularly to off-peak water heating systems.

An object of my invention is to provide a relatively simple control system for delaying the start of the heating of water in a water-containing tank for predetermined fixed lengths of time after the start of the off-peak period, the delay increasing in proportion to the amount of hot water in the tank.

Another object of my invention is to provide a relatively simple and efficient control system for a water tank that shall be rendered operative during only the off-peak period.

Still another object of my invention is to provide an off-peak water heating system that shall cause the heating period to occur during substantially the middle part of the off-peak period and to be terminated by the action of thermal control means.

Other objects of my invention will either be apparent from a description of one form of system embodying my invention or will be pointed out in the course of a description thereof and particularly in the appended claims.

In the drawing,

Figure 1 is a view in vertical section of a hot water tank and a diagram of connections of the timer and of the various thermally-actuable switches controlled thereby, and

Fig. 2 is a fragmentary view of a modified form of timer contact means.

A domestic hot water tank 11 is of the usual cylindrical type having a height several times greater than its diameter and is provided with a cold water inlet pipe 13 and a hot water outlet pipe 15. While I have illustrated the tank 11 sectionally only, I desire it to be understood that it may be covered with suitable heat-insulating material, may also be provided with an outer protective casing and may be supported in any suitable or desired manner, all of these details constituting no part of my invention and further detailed illustration and further description thereof being therefore thought unnecessary.

A clamp-on electric heater 17 is shown schematically only and while I prefer to use the flexible clamp-on heater disclosed and claimed in my co-pending application Ser. No. 315,890, I do not desire to be limited thereto although it may be pointed out that I prefer to use a clamp-on heater rather than to provide and use a heating unit inserted into the tank through a suitable opening in its wall.

A timing means designated generally by the numeral 19 may comprise a small synchronous motor 21, the terminals of which are connected by suitable conductors to supply circuit leads 23 and 25. The motor 21 operates a worm 27 which is in operative and driving engagement with a circular disc 29 mounted on a shaft 31. The shaft 31 has mounted thereon a cam disc 33 which has one part 35 thereof of a given outer radius, while another part of the peripheral surface of the disc 33 has a larger outer radius and is designated by 37. This portion 37 of the periphery is shown to extend for substantially one-third of the periphery of the disc and since the shaft 31 and the member 29 are desired to be rotated through one full revolution in twenty-four hours, the time extent of portion 37 will be substantially eight hours. It may be here pointed out that this length of time is that of the usual off-peak period and may be considered, for instance, to extend from 10 p. m. to 6 a. m. I desire to point out further that the disc 33 may be constructed to provide an off-peak period which is less than eight hours or which is greater than eight hours and that it may be so mounted on the shaft 31 that the beginning of this off-peak period will occur at some other time than 10 p. m.

The shaft 31 has also mounted thereon a contact arm 39 which is adapted to move over a dial 41 which dial may be supported in any manner now well known in the art. While I have not shown any supporting means for the shaft 31 and for the driving motor 21, these are, of course, to be provided and may take any form and construction now well known in the art.

While I have illustrated an electric motor as part of the timing means, I do not wish to be limited thereto as any other timing means, such as a clock, may be used by me.

A timer or clock-actuated heater control switch comprises a substantially rigid contact arm 43 and a resilient contact arm 45, the latter being normally biased away from its cooperating contact arm 43 and being forced into engagement therewith when the portion 37 of the disc 33 has been turned into substantially the position shown in the drawing where this portion engages a lug 47 on contact arm 45 to cause the latter to move into engagement with contact arm 43. The supply circuit conductor 23 is electrically connected to contact arm 43, while contact arm 45 is connected through a conductor 49 to a main contact member 51 of a contactor designated generally by the numeral 53. The other main contact member 55 is connected by a conductor 57 to one terminal of the electric tank heater 17, while the other terminal thereof is connected through a conductor 59 to the other supply circuit lead 25.

The contactor 53 includes also a coil 61 which is adapted to energize an armature core 63 having connected therewith a main contact bridging member 65 as well as an auxiliary contact bridging member 67 which latter is adapted to close a holding circuit for the contactor as will be hereinafter described in detail. One terminal of the coil 61 is connected by a conductor 69 to the conductor 49 while the other terminal of coil 61 is connected by a conductor 71 with an auxiliary contact member 73. The other auxiliary contact member 75 is connected by a conductor 77 with a substantially stationary or rigid contact arm 79 of a thermally-actuable switch 81. This thermally-actuable switch 81 includes an expansion rod 83 which may be encased in a tubular member 85 mounted in the wall of the tank 11 and extending into the tank to be immersed in the water therein and, as shown in Fig. 1 of the drawing, this thermally-actuable switch 81 is positioned in the lowermost part of the tank. The switch 81 includes also a substantially resilient contact arm 87 which is adapted to be engaged with and disengaged from the contact arm 79 by means of the expansion and contraction of the rod 83. It is to be understood that the contact arm 87 is normally biased into engagement with the contact arm 79 when permitted to do so by reason of the subjection of the expansion rod 83 to cold water causing the expansion rod to contract and permit engagement of the contact arms 79 and 87.

The dial 41 has mounted thereon a plurality of fixed contact members 89, 91 and 93 and while I have shown these contact members as being positioned on the dial to be engaged by the contact arm 39 at 10 p. m., 12 p. m. (midnight) and 2 a. m., I do not desire to be limited thereto and it is to be understood that these contact members may be positioned at any desired points peripherally of the dial and with any desired space between adjacent contact members.

I provide further a plurality of auxiliary thermally-actuable switches and I have shown two such switches, 95 and 97, each of which includes a tubular member 99, an expansion rod 101 therein, a substantially resilient contact arm 103 and a substantially rigid contact arm 105, arm 103 being normally biased into engagement with arm 105 when permitted to do so by reason of the contraction of expansion rod 101 when the tube 99 is immersed in cold water or in water having a temperature below a predetermined value. Contact member 89 is connected by a conductor 107 with contact arm 105 of the uppermost thermally-actuable switch 95. Contact member 91 is connected by a conductor 109 with contact arm 105 of the next lower thermally-actuable switch 97. Contact member 73 of the contactor 53 is connected through a conductor 113 with contact arm 39.

I wish to point out that I have shown the thermally-actuable switches 81, 95 and 97 schematically only and as comprising expansion members but I desire it to be understood that this is done for illustrative purposes only and that I may employ any known kind of thermally-actuable members for the intended purpose. Further, I have illustrated the dial 41 and the rotating contact arm 39 generally only and the same comments as to the actual construction thereof as made with regard to the thermally-actuable switches apply here also. It may be here pointed out further that the contact arm 39 indicates the time of day.

The operation of my system is substantially as follows: the timer motor 21 is operative at all times when the supply circuit, including particularly the leads 23 and 25 is energized, and the contact arm 39 will therefore be effective to indicate the time of day. If it be assumed that the central station operator prefers to have the off-peak period extend from 10 p. m. to 6 a. m., the peripheral extent of the portion 37 of disc 33 will be for one-third of the entire periphery and the disc 33 will be so mounted on the shaft 31 that contact arm 45 will be moved into engagement with contact arm 43 at substantially 10 p. m. At substantially the same time contact arm 39 will engage fixed contact member 89 and an energizing circuit will be closed through coil 61 of contactor 53 if only the very uppermost portion or part of tank 11 is filled with hot water, the cold water in the lower part of the tank extending upwardly therein to such a height as to submerge the tube 99 of thermally-actuable switch 95. The energizing circuit through coil 61 will extend from supply circuit lead 23 through contact arms 43 and 45, conductor 49, conductor 69, coil 61, conductor 71, conductor 113, contact arm 39 to contact 89, conductor 107 to contact arm 105 of thermal switch 95, to contact arm 103 and through a conductor 115 to conductor 59 and from there to the other supply circuit lead 25. As stated above, this circuit is established if the thermally-actuable switch 95 is immersed in cold water or in water the temperature of which is below a predetermined value.

The energized coil 61 will cause upward movement of armature core 63 and simultaneous upward movement of contact bridging members 65 and 67. Contact bridging member 65 will engage contacts 51 and 55 to thereby cause closing of the electric circuit including the electric heater 17 which will therefore be energized and will start to heat up the cold water in the lower portion of the tank.

As it is obvious that contact arm 39 will move out of engagement with fixed contact member 89 in a relatively short time, it is necessary to have a holding circuit for the coil 61 of contactor 53 and this circuit is established as follows: from supply circuit lead 23 through contact arms 43 and 45, conductors 49 and 69, coil 61, conductor 71, contact 73, contact bridging member 67, contact 75, conductor 77 to contact arm 79 of the lowermost thermally-actuable switch 81, through contact arm 87 and from there through conductors 115 and 59 to the other supply circuit lead 25. This will cause continuous closure of the contact members of the contactor 53 to thereby continue energization of the heater 17.

The capacity in watts of the electric heater 17 has been so selected that the cold water in the tank will be heated to a pre-decided higher temperature within the eight hour period during which the circuit, including particularly the contactor and the electric heater, is conditioned or prepared for the hereinbefore described operative condition. That is, I prefer to cause deenergization of the tank heater 17 by the lowermost thermally-actuable switch 81 and I desire to here point out that the contacts of this switch are connected in the holding circuit of the contactor, as hereinbefore described.

Let it be assumed that the uppermost auxiliary thermally-actuable switch 95 is immersed in hot water so that contact arm 103 will be out of engagement with contact arm 105, in which case the hereinbefore described circuit through the electric heater 17 prepared by closure of the first mentioned switch including contact arms 43 and 45, effected by the timing means will not have occurred and energization of the electric heater 17 will be delayed for a predetermined fixed time. If the tank contains enough hot water in the upper part to surround thermal switch 95, but not to surround thermal switch 97, contact member 91, mounted on dial 41 to be engaged by contact arm 39 at 12 p. m. (midnight), will cause the hereinbefore described operation of the contactor to occur. Energization of the electric heater 17 will therefore begin at substantially 12 p. m. and it may be here pointed out that the amount of cold water in the tank is less than that which would cause energization of the electric heater to be effected at 10 p. m.

The position of the plurality of auxiliary thermally-actuable switches 95 and 97 has been or will be so selected and the adjustments of not only these thermally-actuable switches but also of the lowermost thermally-actuable switch 81 will be made such that, in cooperation with the heating capacity of the heater 17, heating of the cold water in the tank will be effected before the expiration of the off-peak period and opening of the mechanically-actuable switch comprising contact arms 43 and 45.

Contact member 93 has hereinbefore been described as being mounted on the dial 41 at a point thereon to be engaged by contact arm 39 at substantially 2 a. m. and if the quantity of hot water in the upper portion of the tank was such as to submerge both thermally-actuable switches 95 and 97 in hot water whereby contact arms 103 in each were out of engagement with their cooperating contact arms 105, engagement of arm 39 with contact 93 would cause energization of heater 17 through the following circuit and in the following manner. A circuit would be established from supply circuit lead 23 through contact arms 43 and 45, conductors 49 and 69, coil 61, conductors 71 and 113, contact arm 39 to contact member 93 and from there through conductors 111 and 59 to the other supply circuit lead 25. Energization of coil 61 would result in the same actions as have hereinbefore been described as occurring because of operation of either the uppermost thermally-actuable switch 95 or the next lower thermally-actuable switch 97 whereby to cause an energizing circuit through the heater 17, or, as hereinbefore set forth in detail.

It may be pointed out here that the system shown in Fig. 1 is not arranged to recognize changes in the amount of hot water in the tank when these changes occur after 10 p. m. and before 12 midnight or after 12 midnight and 2 a. m. Let it be assumed, for example, that the amount of hot water in the upper part of the tank was such that thermally-actuable switch 95 was submerged in hot water at 10 p. m. when contact arm 39 engaged contact 89, but that such a quantity of hot water was drawn from the tank, say at 10:15 p. m., that switch 95 was then submerged in cold water. While immediate energization of the heater 17 would be desirable this can not be effected until 12 p. m. midnight.

Referring now to Fig. 2 of the drawing I have there shown a modified control dial which will permit energization of the tank heater at any instant between predetermined time limits if hot water is withdrawn from the tank as above described. I provide fixed contacts 117 and 119, each of arcuate shape, adapted to be initially engaged by contact arm 39 at 10 p. m. and 12 p. m. midnight respectively. The peripheral lengths of the contacts is such that contact 117 extends substantially up to contact 119 and contact 119 extends substantially up to a third contact 121 (2 a. m. contact) this latter contact taking the place of contact 93. The connections of contacts 117, 119 and 121 are the same as hereinbefore described for contacts 89, 91 and 93.

It is evident that if, at 10 p. m., thermally-actuable switch 95 is surrounded by hot water, the tank heater 17 will not be energized at that time, but if, by reason of the withdrawal of hot water from the tank at 10:15 p. m. or at any time before 12 p. m. midnight, switch 95 is surrounded by cold water, the system including the dial of Fig. 2 will cause energization of the tank heater as soon as switch 95 is submerged in cold water. The delay in energization of the tank heater is not a predetermined length of time determined by the positions of the fixed contact members, but by the amount of hot water remaining in the tank during the early part of the off-peak period.

While I have shown an electric motor as operating the timing means, I do not desire to be limited thereto since any other form of continuously operative timing means such as a mechanical clock may be utilized by me. However, it is, of course, evident that a timing means driven by a small synchronous electric motor constitutes a relatively simple and continuously operative timing means. Further, as has already been hereinbefore stated, while I have shown the use of expansion rods as the thermal elements, I do not desire to be limited thereto so long as thermally-actuable elements operative in a similar manner to obtain the hereinbefore described results is to be assumed as included in my invention.

The system embodying my invention thus comprises in one modification, a relatively simple means for delaying energization of an electric heater associated with a hot water tank for predetermined but different times of delay, in accordance with the amount of cold water in a tank, it being understood, however, as has already been hereinbefore noted, that the construction and capacity of the elements and particularly of the electric heater, are such that all of the water in the tank will be heated to a relatively high temperature and the electric heater will be deenergized before the expiration of the off-peak period. It is evident that the adjustments of the various cooperating elements in my system may be made such that the period of energization of the heater 17 may be made to coincide substantially with the mid-portion of the off-peak period. It is, of course, also evident that the service man having charge of a number of such systems can so arrange them that the sum total of the current loads provided by such systems will be distributed as noted above, that is, substantially at the mid-portion of the off-peak period whereby no additional overload at the beginning of the off-peak period or at the end of the off-peak period will be caused on the circuits of the central station.

Various modifications may be made within the scope of my invention and it is desired that all modifications clearly coming within the scope of the appended claims shall be considered to be covered thereby.

I claim as my invention:

1. In an off-peak water heating system adapted for a water-containing tank having an electric heater and an electric circuit including said heater, a continuously operative timing means, a first switch for said heater actuable by said timing means and closable thereby for a predetermined length of off-peak time, an electromagnetic switch for said heater in series circuit with said first switch, a contact arm continuously movable by said timing means in accordance with time, a fixed contact on said timing means positioned to be engaged by said contact arm at the beginning of said off-peak period, a thermostatic switch on the tank subject to the temperature of the water in the upper portion only of the tank and electric connections between said thermostatic switch, said electromagnetic switch, said contact, said contact arm and said electric circuit whereby said thermostatic switch is effective to cause energization of said electric heater when said contact arm engages said fixed contact and the temperature of the water operatively engaging said thermostatic switch is below a predetermined value.

2. In an off-peak water heating system adapted for a water-containing tank having an electric heater and an electric circuit including said heater, a continuously operative timing means, a first switch for said heater actuable by said timing means and closable thereby for a predetermined length of off-peak time, an electromagnetic switch for said heater in series circuit with said first switch, a contact arm continuously movable by said timing means in accordance with time, a fixed contact on said timing means positioned to be engaged by said contact arm at the beginning of said off-peak period, a thermostatic switch on the tank subject to the temperature of the water in the upper portion of the tank and electric connections between said thermostatic switch, said electromagnetic switch, said contact, said contact arm and said electric circuit whereby said thermostatic switch is effective to cause energization of said electromagnetic switch and closure thereof when said contact arm engages said fixed contact and the temperature of the water operatively engaging said thermostatic switch is below a predetermined value and a second thermostatic switch effective to cause deenergization of said electromagnetic switch and opening thereof in case substantially all of the water in the tank is hot before the end of an off-peak period.

3. In an off-peak water heating system adapted for a water-containing tank having an electric heater, an electric circuit including said heater, a continuously operative timing means, a first switch in said circuit for controlling said heater and closable by said timing means for a predetermined length of off-peak time, an electromagnetic switch in said circuit and in series circuit with said first named switch for controlling said heater, a contact arm continuously movable by said timing means in accordance with time, a first fixed contact on said timing means adapted to be engaged by said contact arm at substantially the beginning of the off-peak period, a thermally-actuable switch having a thermostat subject to the temperature of the water in only the upper part of the tank, electrical connections between the switch and said first contact, said thermally-actuable switch being effective to prevent energization of the electromagnetic switch and of the electric heater when the contact arm of said timing means engages said fixed contact and the temperature of the water in the upper part of the tank is above a certain value and a second fixed contact so positioned relatively to said first fixed contact as to be engaged by said contact arm a fixed length of time after it engaged said first fixed contact to thereby cause energization of said electromagnetic switch and of said electric heater.

4. In an off-peak water heating system adapted for a water-containing tank having an electric heater, an electric circuit including said heater, a continuously operative timing means, a first switch in said circuit for controlling said heater and closable by said timing means for a predetermined length of off-peak time, an electromagnetic switch in said circuit and in series circuit with said first named switch for controlling said heater, a contact arm continuously movable by said timing means in accordance with time, a first contact on said timing means adapted to be engaged by said contact arm at substantially the beginning of the off-peak period, a thermally-actuable switch having a thermostat subject to the temperature of the water in only the upper part of the tank and electrically connected to said first contact, said thermally-actuable switch being effective to prevent energization of the electromagnetic switch and of the electric heater when the contact arm engages said fixed contact and the temperature of the water in the upper part of the tank is above a certain value and a second fixed contact so positioned relatively to said first fixed contact as to be engaged by said contact arm a fixed length of time after it engaged said first fixed contact to thereby cause energization of said electromagnetic switch and of said electric heater and a second thermally-actuable switch effective to cause deenergization of said electromagnetic switch and of the electric heater in case substantially all of the water in the tank has been heated to a certain temperature before the end of an off-peak period.

5. In an off-peak water heating system adapted for a water-containing tank having an electric heater, an electric circuit including said heater, a continuously operative timing means, a first switch in said circuit for controlling said heater and closable by said timing means for a predetermined length of off-peak time, an electromagnetic switch in said circuit and in series circuit with said first named switch for controlling said heater, a contact arm continuously movable by said timing means in accordance with time, a plurality of peripherally spaced contact members on said timing means adapted to be engaged in sequence by said moving contact arm, a plurality of thermally-actuable switches on said tank at longitudinally different points thereon, electric connections between the thermally-actuable switches and the contact members such that the topmost thermally-actuable switch is connected with the contact member engaged first by the moving contact arm, energization of the electromagnetic switch and of the heater being effected by engagement of the contact arm with that contact connected to that thermally-actuable switch subject to cold water, whereby energization of the heater is delayed for lengths of time increasing with the amount of hot water in the tank.

6. In an off-peak water heating system adapted for a water-containing tank having an elec-

tric heater, an electric circuit including said heater, a continuously operative timing means, a first switch in said circuit for controlling said heater and closable by said timing means for a predetermined length of off-peak time, an electromagnetic switch in said circuit and in series circuit with said first named switch for controlling said heater, a contact arm continuously movable by said timing means in accordance with time, a plurality of peripherally spaced contact members on said timing means adapted to be engaged in sequence by said moving contact arm, a plurality of thermally-actuable switches on said tank at longitudinally different points thereon, electric connections between the thermally-actuable switches and the contact members such that the topmost thermally-actuable switch is connected with the contact member engaged first by the moving contact arm, energization of the electromagnetic switch and of the heater being effected by engagement of the contact arm with that contact connected to that thermally-actuable switch subject to cold water, whereby energization of the heater is delayed for a preselected fixed length of time increasing with the amount of hot water in the tank and an additional thermally-actuable switch positioned in the lowermost part of the tank effective to cause deenergization of said electromagnetic switch and of the electric heater in case the temperature of the water in the lowermost part of the tank has been raised to a certain value before the end of an off-peak period.

7. In an off-peak water heating system for a water containing tank having an electric heater, an electric circuit including said heater, a continuously operative timing means including a continuously movable contact arm indicating the time of day, a mechanically actuable switch in said circuit for controlling said heater and closable by said timing means for a predetermined length of off-peak time, an electromagnetically-actuated switch in said circuit and in series circuit with said first named switch for controlling said heater, contact members controlled simultaneously with said electromagnetically-actuated switch for controlling a holding circuit therefor, a contact on said timing means engageable by said moving contact arm at substantially the beginning of the off-peak period, a thermally-actuable switch having a thermostat subject to the temperature of the water in only the upper part of the tank and electrically connected to said contact, said thermally-actuable switch being effective to cause energization of the electromagnet, closure of the heater switch and of the holding circuit contact members to energize the heater and maintain energization of the electromagnet when the contact arm is moved out of engagement with said fixed contact when the temperature of the water in the upper part of the tank is below a certain value and a second thermally-actuable normally closed switch having a thermal element subject to the temperature of the water in the lowermost part of the tank and connected in said holding circuit and effective to open said holding circuit and cause opening of said electromagnetically-actuated switch in case the temperature of the water in the lowermost part of the tank has been raised to a certain value before the end of an off-peak period.

8. A device as set forth in claim 3 in which the peripheral extent of said first contact is appreciable to cause engagement theerof by the moving contact arm during a relatively long fixed time period and resultant energization of the tank heater at any time instant during such engagement between the contact arm and the first contact when withdrawal of hot water from the tank causes said thermally-actuable switch to be operatively engaged by cold water in the tank.

9. A device as set forth in claim 6 in which the peripheral extent of each of said contacts is appreciable to cause engagement thereof by the moving contact arm during a relatively long fixed time period and resultant energization of the tank heater at any time instant during such engagement between the contact arm and the first contact when withdrawal of hot water from the tank causes said thermally-actuable switch to be operatively engaged by cold water in the tank.

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