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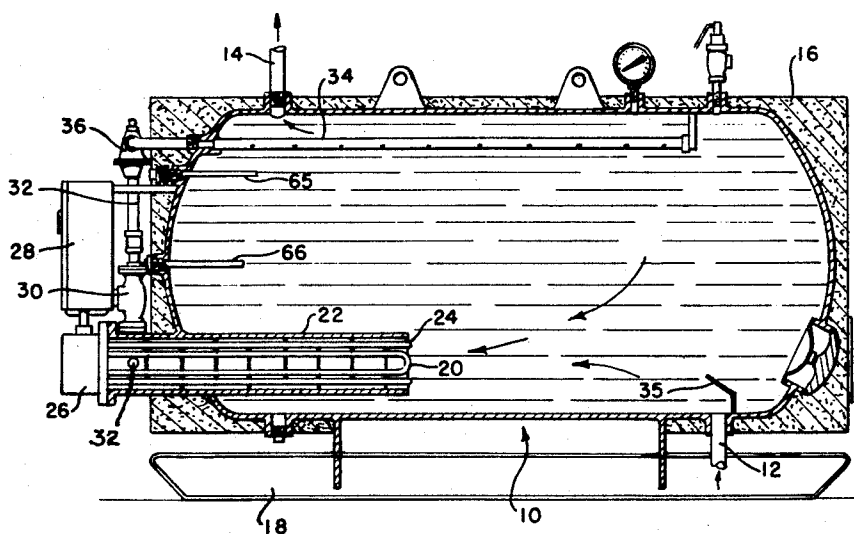
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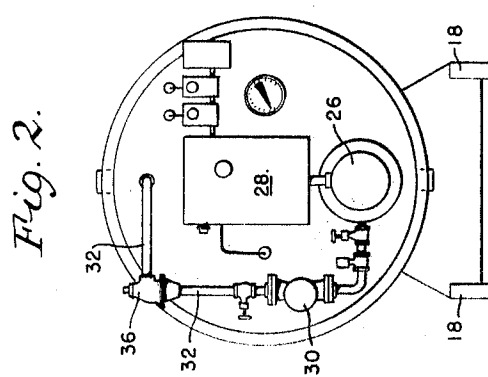
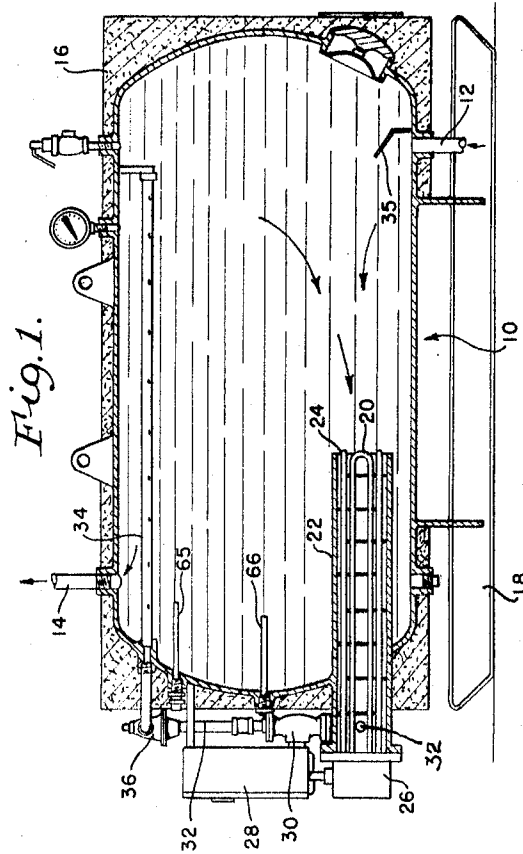
- [54] POWER COMSUMPTION RATE MONITORED
ELECTRIC WATER-HEATING SYSTEM
11 Claims, 4 Drawing Figs.**

- [52] U.S. Cl..... 219/321,
122/32, 161/108, 219/312
[51] Int. Cl..... F24h 1/20
[50] Field of Search..... 219/312,
316, 321; 165/108; 122/32; 126/362

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| [56] | | References Cited |
| | | UNITED STATES PATENTS |
| 2,429,408 | 10/1947 | Earley et al. |
| 3,276,517 | 10/1966 | Low..... |
| 3,315,735 | 4/1967 | Stranko |

ABSTRACT: A power consumption rate-monitored electric water-heating system featuring provision, in functional combination; a water storage tank; an electric immersion heater device shrouded and extending into the lower portion of the tank; the heater shroud being open at its inner end and in communication at its outer end with the intake of a pump which is arranged to discharge through a distributor conduit into the uppermost level of the tank; a heated water takeoff connection located at the top of the tank; a cold water inlet connection located at the bottom of the tank; a waterflow-rate-regulating valve in the line between the shroud and the distributor conduit; and an electric power supply monitoring mechanism operative to limit the power consumption rate during normal periods to a prescribed maximum which is much less than the total power which may be consumed by the heating device so as to limit the total power consumption of "offpeak" periods when the power price rate is lowest. The waterflow-regulating valve is arranged to be automatically responsive to temperature changes.



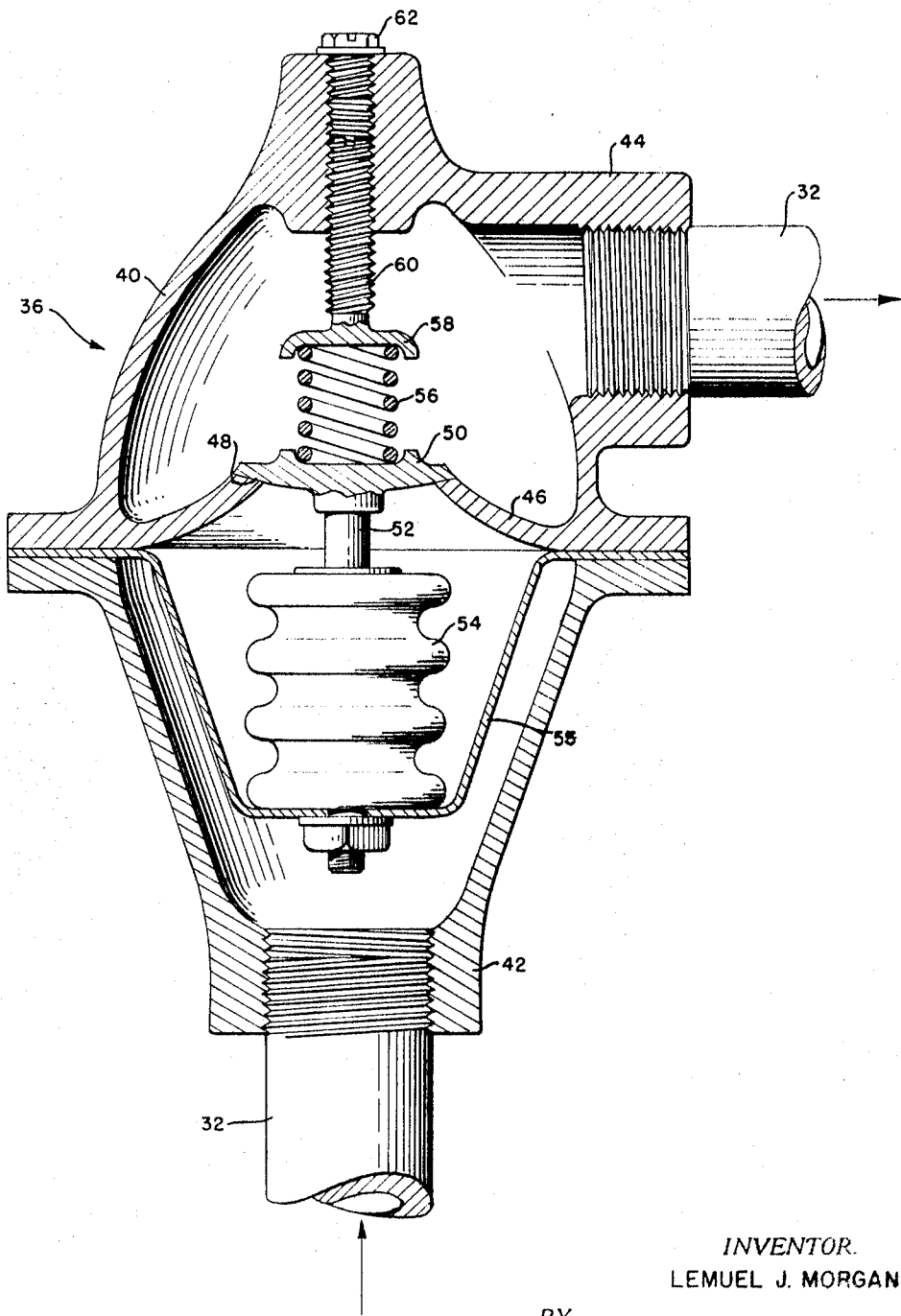


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Fig. 3.



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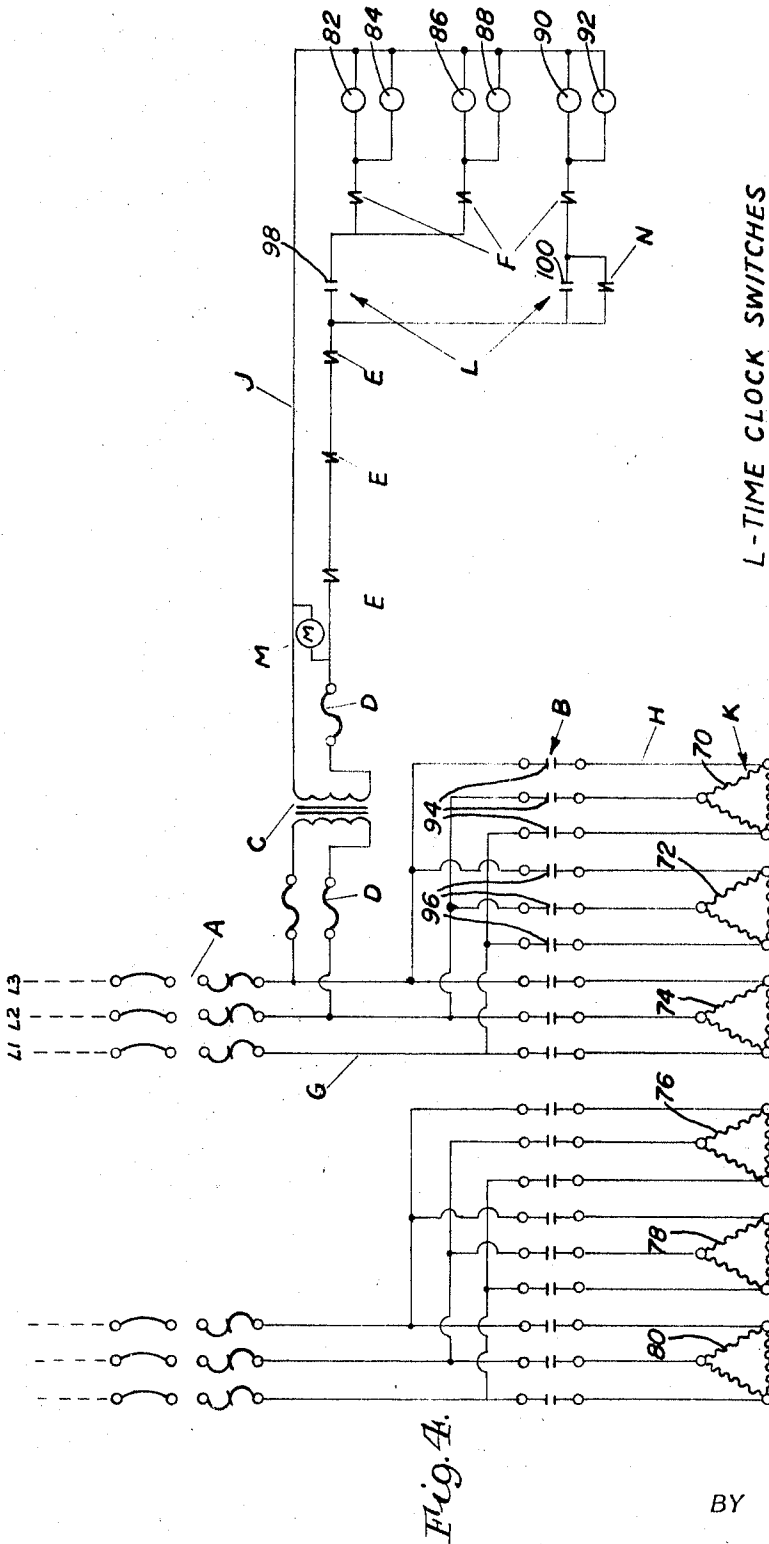


Fig. 4.

BY

L-TIME CLOCK SWITCHES
M-TIME CLOCK MOTOR
N-TIME CLOCK OVER-RIDE T' STAT

A-CIRCUIT BREAKER
B-MAGNETIC CONTACTORS
C-CONTROL CIRCUIT TRANSFORMER
D-FUSES
E-LIMIT SWITCHES
F-CONTROL THERMOSTAT
G-PANEL WIRING
H-HEATING ELEMENT WIRING
J-CONTROL CIRCUIT WIRING
K-HEATING ELEMENTS

TYPICAL OFF-PEAK WIRING DIAGRAM

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POWER CONSUMPTION RATE MONITORED ELECTRIC WATER-HEATING SYSTEM

BACKGROUND AND OBJECTS OF THE INVENTION

Electric power supply facilities typically offer very favorable offpeak hour price rates. For example, whereas the normal daytime rates may be of the order of 2 cents per kilowatt or more, the offpeak hour rates may be as low as 0.4 cents per kilowatt. Such low rates are of course more than economically competitive with the more conventionally used fuels for institutional water-heating purposes, or the like. Such low rates are typically available say from 11—12 p.m. to 6—7 a.m.; the period during which the typical utility has power to spare. In consequence, it is economically desirable to employ a water-heating system wherein the main electric heaters and circulator pumps operate only during the offpeak hours, to heat the contents of the hot water storage system to such temperature that it will meet the heated water demand throughout the entire 24-hour period. Then, during the peak load (daytime) period the circulators and water heaters are kept inoperative, except of course in cases where emergency override arrangements are provided. Also, it is often advantageous to in any case limit the power consumption rate to a prescribed maximum.

Many arrangements have been previously proposed for taking advantage of the so-called "offpeak" electric utilities power rates as explained hereinabove; the basic concept being to timeclock overcontrol the heating cycles of the electric heater system so as to limit its power consumption to the offpeak hours. In consequence, such systems typically contemplate employment of oversize storage tanks so as to accommodate sufficient volumes of water as may be heated during the offpeak hours which will satisfy (in the role of a hot water storage facility) the demand for heated water during the peak hot water demand hours. However, such systems have heretofore proved to be less than satisfactory for several reasons.

For example, a basic system of this type embodying an adequate safety factor with respect to the volume of stored heated water would require an exorbitant capital investment. Therefore, such systems are usually engineered to minimum oversize factors and include inadequate provisions to accommodate unexpected accidents or misuse of the heated water supply. Furthermore, such prior-type offpeak water-heating systems are typically propense to pump agitation and thermal-siphon induced stirrings of the storage tank contents, whereby water at only approximately the mean temperature of the tank contents is usually available at the takeoff connection.

The present invention distinguishes from the prior art in that it provides a simple and accurately functioning system for ensuring delivery of the desired supply of water at the desired temperature to the storage tank takeoff connection, while at the same time being monitored from the power consumption rate standpoint so as to take advantage of the currently available power supply utility offpeak price rates.

Furthermore, the invention contemplates a water-heating apparatus which lends itself with improved results to installations employing discriminating power-supply-monitoring systems such as automatically limit the power service to the water-heating apparatus to periods when the other (preferred) loads on the same meter are heavy. Thus, penalties or so-called "kilowatt demand overcharges" such as are usually imposed by the supply utilities for any power consumption over certain scheduled rates during prescribed periods, may be avoided.

BRIEF DESCRIPTION OF THE DRAWING FIGURES

FIG. 1 is a vertical sectional view through a heated water supply apparatus of the present invention;

FIG. 2 is a left-hand end elevational view thereof;

FIG. 3 is an enlarged scale fragmentary sectional view through an automatic waterflow-rate-regulating valve such as may be employed as a component of the mechanism; and

FIG. 4 is a wiring diagram illustrating a typical power supply and control system for an apparatus of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

As illustrated by the drawing herewith at FIGS. 1, 2, the invention may be embodied in a heated water supply system including a water storage tank 10 having a cold water inlet connection 12 at the bottom level thereof, and a heated water takeoff connection as indicated at 14 through the "ceiling" portion of the tank. The tank is preferably heat insulated as indicated at 16; and for transport purposes is shown as being mounted on parallel skids 18—18.

In accord with the present invention a system of immersion-type electric heater elements as indicated at 20 is shrouded as indicated at 22 and so positioned as to extend through a lower wall portion of the tank; the inner end of the shroud 22 being open as indicated at 24. At its outer end the shroud 22 is enclosed by a bonnet 26 into which the terminals of the heating elements 20 extend for electrical connections to their power supply leads coming from the nearby control panel 28, the contents of which will be explained hereinafter.

It is a particular feature of the present invention that a water-circulating pump as indicated at 30 is arranged to have its intake in open communication with the interior of the shroud 22 adjacent the outer end thereof, and is automatically controlled to operate whenever the heater elements 20 are energized. The outlet of the pump 30 connects by means of a conduit 32 into a distributor conduit 34 which extends into the interior of the tank 10 just under the ceiling portion thereof, and is therefore disposed closely adjacent to the takeoff connection 14. Hence, it will be appreciated that operation of the pump 30 will cause water from the lower interior of the tank 10 to be drawn into and through the shroud 22 in heat exchange relation with the elements 20; and thence through the pump and into the distributor conduit 34 for discharge into the uppermost level of the tank.

As indicated at 35 (FIG. 1) an inflow deflector is preferably provided to baffle and guide the direction of flow of incoming cold water, whenever heated water is withdrawn through the outlet. This ensures that the cold water flows inwardly and horizontally across the bottom floor portion of the tank, and does not project upwardly into the main body of water in the tank, such as would agitate it and break down the normally present temperature stratifications therein.

It is another particular feature of the invention that a flow-regulating valve device such as is illustrated as 36 (FIGS. 1—3) is connected in the line of the conduit 32 to control the flow of water through the heater in response to operation of the pump. The function of the valve 36 is to tailor the rate of water transmission through the heat exchanger shroud according to the temperature of the water being drawn through the shroud, so that the water being delivered by the pump into the uppermost level of the tank is at the desired temperature for withdrawals through the outlet 14. This result is attained by employment of a flow-regulator-type valve which is automatically responsive to the temperature of the water passing therethrough so as to constantly adjust and readjust the rate of waterflow through the heat exchanger so that the water delivered by the pump will at all times be at the prescribed temperature.

As shown by way of example at FIG. 3, a suitable regulator valve for this purpose may comprise a bulb-shaped casing 40 having a water inlet connection as indicated at 42 and an outlet port as indicated at 44; and an intermediately disposed partition 46 which is centrally apertured to provide an annular valve seat 48. A circular valve 50 is provided to cooperate with the valve seat portion 48 and is carried by a valve stem 52 extending from one end of a heat-extensible bellows device as indicated at 54; the bellows 54 being based at its other end upon a support bracket designated 55. For convenience in manufacture and assembly the valve casing 40 may be of two-part form as illustrated herein, whereby the bellows support

bracket is conveniently mounted between the valve body parts as shown. A valve-performance-regulating device is provided in the form of a compression spring 56 which seats at one end against the valve disc 50 and at its other end against a retainer 58 which is carried by an adjustment screw 60 which is threaded through a wall portion of the casing 40. A supplemental closure screw as indicated at 62 is preferably provided to cover the entrance to the adjustment screw 60. Thus, it will be understood that the action of the thermostat valve unit 50—54 may be readily adjusted by simply removing the cover screw 62 and inserting a screwdriver to engage the adjustment screw 60.

FIG. 4 illustrates the power supply and wiring diagram of a typical control system for the apparatus of the present invention. As shown, the heater 20 of FIG. 1 comprises a bank K of separate heating elements 70, 72, 74, 76, 78, and 80 selectively connected to the powerlines by means of the magnetic contactors indicated generally by the reference character B. In the control portion of the system, shown at the right-hand side of FIG. 4, there is a bank of actuators 82, 84, 86, 88, 90 and 92 which control the magnetic contactors B. Thus, the actuator 82 controls the contactors 94, the actuator 84 controls the contactors 96, and so on so that each actuator controls one of the heating elements 70—80. It will be noted that controls for the bank of heating elements are separated into two parallel groups, one of which contains the actuators 82, 84, 86 and 88 and the other of which contains the actuators 90 and 92 so that, for the system shown, the heating elements 70, 72, 74 and 76 may be controlled as a group whereas the two remaining heating elements 78 and 80 may be controlled as another group under control by the respective actuators 90 and 92. The control circuit includes two normally open timeclock switches L, one such switch 98 being used to assure that none of the actuators 82, 84, 86 and 88 may be operated except during offpeak time, whereas the other switch 100 is provided with an override control switch N in parallel with it so that the actuators 90 and 92, and consequently their corresponding heating elements 78 and 80, may be operative at any time. The switch N corresponds to the normally closed contacts of the override thermostat 65 in FIG. 1.

To complete the control switch system, the prime thermostat switches F are provided, which correspond to the normally closed contacts of the prime thermostat 66 of FIG. 1.

In operation, it will be appreciated that the timeclock motor M causes the switches 98 and 100 to be closed only during the offpeak periods, at which time operation of all of the heating elements is effected provided, of course, that the prime thermostat switches F are also closed. The switches F control the maximum water temperature and are set to open at temperatures above about 140° F. and so would normally be closed at the beginning of any offpeak period when the water would be relatively cold. The switch N is set to open at temperatures higher than about 120°—125° F. and since this switch, when closed, will cause the pump to operate and allow the heater elements 78 and 80 to operate at any time that the water temperature drops below this temperature range, the water temperature at the beginning of the offpeak period should be at least within this range.

Thus, there is provided a water-heating system which is operative so that although when the offpeak period begins and the tank is nearly depleted of hot water, water being processed will be heated and immediately pumped to the top of the tank and delivered into the region of the hot water outlet. This water will have thereby been brought automatically up to proper temperature by reason of the operation of the heating system and special control valve as explained hereinabove. This heated water will of course be of lower density, and will therefore remain at the top of the tank and in position to be first drawn from the tank, as required.

The valve 36 operates to control the rate of pumping and delivery of the water to the outlet fixture in such manner as to match the temperature control requirements. For example, if the heater 20 were capable of raising 25 g.p.m. from 40° F. to

140° F., and it is desirable to discharge the water into the top of the tank at 140° F., the pump and the valve combination should circulate 25 g.p.m. through the heater. This would be typical of the operation at the beginning of the offpeak period when the majority of the water in the tank is relatively cold. Then, when the offpeak period is nearly over, the tank should be nearly full of hot water, and the water entering at the heater shroud would be of the order of 120° F. The valve system should now permit 125 gallons of water to be circulated per minute since the heater need only raise the water 20°, and it is therefore capable of heating five times as much water as when the offpeak period began.

It is quite common in offpeak water-heating systems to provide a thermal override control so that some hot water will be available from the outlet when the heated water supply is depleted, so as to provide for some accommodations to plumbing accidents or wasteful misuse of water from the tank. In some cases, to protect against such eventualities, arrangements are made whereby say one-third of the components of the electric heater unit are energized; such as for example whenever the water temperature drops down to the vicinity of 120° or 125°. Energization of all of the electric heater elements is avoided because that would increase the operator's peak electrical demand rate, which would result in a higher monthly billing rate. Thus, in conventional systems the heater will under such conditions deliver only partially heated water. However, in a situation as above described, in the case of the present invention the power supply control mechanism will turn on only enough electricity to produce 8 gallons of properly heated water per minute. The valve and the pumping system will then regulate themselves so that only that much water is pumped through the unit per minute, and therefore water is delivered to the top of the tank at 140° F.

Thus, it will be understood that the present invention features a water-heating system which includes a single compact storage tank and a self-regulating temperature-controlled valve responsive to the temperature of the water passing through the pump to control the rate of water displacement through the electrical heater unit. As the water exits from the heater it is delivered directly into the region of the tank outlet, and thus the immediately deliverable water supply is maintained at the desired temperature. Therefore, the invention provides an improved electric water-heating system which lends itself uniquely and with improved facility to an electric power supply overcontrol arrangement limiting power consumption primarily to offpeak hours, and/or operates in any case to limit the power consumption rate to a prescribed maximum. This is because whenever the prime control thermostat calls for more heat, whatever power is available (as monitored by the override thermostat) will be applied directly and only to the water being delivered directly to the tank outlet. Hence, the most efficient use is made of whatever power is available under marginal power supply conditions.

By way of further explanation of the power supply and heater control system as diagrammed at FIG. 4 herewith, it should be noted that provision of the timeclock override device N is optional. The limit switches E-E-E (or equivalents) are typically provided to monitor the temperatures at successive levels in the tank and to shut down the system in event a prescribed maximum is exceeded; such as would indicate a dangerously low water level, or other trouble.

What I claim as my invention is:

1. An electric water-heating system including a water storage tank having a cold water inlet connection into its bottom level and a heated water outlet connection leading from its uppermost level,

a shroud extending into said tank and being open at its inner end,

an electric immersion heater unit disposed within said shroud,

a heated water delivery conduit conducting water from a portion of said shroud remote from its open inner end and back into said tank at a position in close proximity to said heated water outlet connection,

a water pump in the line of said conduit,
and a waterflow-rate-regulating valve in the line of said conduit,

said valve being automatically responsive to changes in the temperature of the water passing therethrough so as to appropriately throttle the rate of flow of water flowing through said shroud in heat exchange relation with said heater unit so as to maintain the water being delivered to said outlet connection at a prescribed temperature.

2. A heating system as set forth in claim 1 wherein a prime control thermostat is disposed in the upper level portion of said tank and is operable to regulate operations of said heater and said pump in accordance with the temperature of the water in the upper level of said tank.

3. An electric water-heating system comprising, in combination;

a water storage tank having a cold water inlet into its bottom level and a heated water outlet connection leading from its uppermost level;

a shroud extending into said tank and having an open inner end located in the bottom level of the tank;

electric heating means within said shroud;

pump means for circulating water from the bottom level of the tank through said open inner end of the shroud and over said heating means to a discharge region in the vicinity of said heated water outlet;

control means for energizing said heater means and said pump means only during offpeak electrical supply periods; and

waterflow-rate-regulating means for controlling the rate of circulating water flowing over said heater means so as to maintain the water circulated to said outlet connection at a prescribed temperature.

4. The electric water-heating system according to claim 3 wherein said heating means comprises a plurality of heating elements; and including override thermostat means for energizing said pump means and less than all of said heating elements at any time that the temperature of the water in said tank falls below a predetermined temperature.

5. The electric water-heating system according to claim 3 wherein said control means includes time-control switch mechanism and prime control thermostat mechanism; said heating means comprises a plurality of heating elements controlled by said control means; and including override thermostat means for overriding said time-control switch mechanism to energize less than all of said heating elements at any time that the temperature of the water in said tank falls below a predetermined temperature.

6. A water-heating system comprising, in combination;

a heated water storage tank having a cold water inlet connection into its bottom level and a heated water outlet connection leading from its upper level, said outlet connection being adapted to supply a system which may demand hot water intermittently or continuously at any time;

a shroud in said tank and having an opening located in the bottom level of the tank;

heating means within said shroud;

pump means for circulating water from the bottom level of the tank through said opening in the shroud and over said heating means to a discharge region in the vicinity of said heated water outlet;

control means for periodically operating said pump means and said heating means to build up a supply of heated water within said tank which may be depleted progres-

sively during time intervals between periods in which said pump means and said heating means are being operated; and

waterflow-rate-regulating means for controlling the rate of circulating waterflow over said heating means so as to maintain the water delivered to said outlet connection at a prescribed temperature whenever said pump means and said heating means are being operated, whereby an increasing supply of heated water at said prescribed temperature is circulated to said discharge region during periods in which said pump means and said heating means are being operated.

7. The water-heating system according to claim 6 wherein said heating means comprises a plurality of heating elements; and including override thermostat means for energizing said pump means and less than all of said heating elements at any time that the temperature of the water in said tank falls below a predetermined temperature.

8. The water-heating system according to claim 6 wherein said control means includes time-control switch mechanism and prime control thermostat mechanism; said heating means comprises a plurality of heating elements controlled by said control means; and including override thermostat means for overriding said time-control switch mechanism to energize less than all of said heating elements at any time that the temperature of the water in said tank falls below a predetermined temperature.

9. A water-heating system comprising, in combination;

a heated water storage tank having an outlet connection adapted to supply water at a selected temperature to an external system which may demand heated water at any time and having a cold water inlet connection for supplying cold water to the bottom region of said tank to replenish water withdrawn from the tank by the external system and means associated with said inlet connection for ensuring that cold water when supplied does not project upwardly into the main body of water in the tank such as would break down the normally present temperature stratification therein;

a shroud having an inner end in flow communication with said bottom region of the tank;

a plurality of electric heating elements in said shroud for heating water flowing through the shroud;

conduit means including pump means for circulating water from the bottom region of said tank, through said shroud in heat transfer relation to said heating elements and then into the top of said tank, whereby progressively to build up a reservoir of heated water in said tank from the top region thereof downwardly toward the bottom region thereof so that water at said outlet is at said selected temperature whereas water entering said shroud is relatively cool throughout a substantial portion of such buildup; and

temperature-sensitive control means for controlling the heat input per volumetric unit of water passing through said shroud to maintain said water delivered to the top region of the tank at said selected temperature.

10. The water-heating system as defined in claim 9 wherein said temperature-sensitive control means is responsive to different selected water temperature to selectively energize said heating elements.

11. The water-heating system as defined in claim 9 wherein said temperature-sensitive control means includes a temperature-responsive valve in said conduit means.

UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,597,589 Dated August 3, 1971

Inventor(s) Lemuel J. Morgan

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

In the Abstract, line 16, "of" should read -- to --; line 19, after "changes" insert -- in the water as delivered by the pump, in such manner as to adjust the circulating flow rate in accordance with that required to permit the heater to raise to a prescribed temperature the water delivered by the pump directly into the upper level of the tank. Thus, the water moving in heat exchange relation with the heater is drawn from the body of the tank and delivered directly into the region of the heated water take-off connection at the prescribed temperature. At all times the valve is also operative to automatically adjust to the temperature of the major body of the water in the tank so as to regulate the water circulation rate, thereby to attain maximum and efficient heating of the storage water, as monitored by the power supply control mechanism --.

Signed and sealed this 27th day of June 1972.

(SEAL)

Attest:

EDWARD M. FLETCHER, JR.
Attesting Officer

ROBERT GOTTSCHALK
Commissioner of Patents