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EP-A- 222 972
FR-A- 1 497 608
GB-A- 2 160 967

PATENT ABSTRACTS OF JAPAN, vol. 9, no. 226 (M-412)[1949], 12th September 1985;& JP-A-60 82 716 (TOUTOU KHKI K.K.) 10-05-1985

PATENT ABSTRACTS OF JAPAN, vol. 9, no. 272 (M-425)[1995], 30th October 1985;& JP-A-60 117 046 (TOUTOU KIKI K.K.) 24-06-1985

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Description

This invention relates generally to a method of controlling the capacity of an integrated heating system and to an integrated heating system for space heating and domestic hot water heating and concerns more particularly a capacity control system for an infrared burner module of an integrated space heating and hot water heating system.

In heating systems for homes and commercial buildings, central furnaces to heat a space all operate on the same general principle. Air for a space to be heated circulates through a closed system generally comprising sheet metal ductwork, and is heated either as it passes through a heat exchanger in contact with a burning fuel, or as it passes in contact with a secondary fluid which has been heated by a burning fuel. Since burning the fuel results in the production of noxious combustion gases having exhaust temperatures which can exceed 260°C (500°F), it is necessary to exhaust the combustion gases through a chimney or flue to the atmosphere. These systems are relatively inefficient as evidenced by the high exhaust temperatures of the flue gases, and costly due to the construction of the necessary flue or chimney.

Indirect fired furnaces, ones in which the air being heated is not contacted directly by the combustion gases generated, are generally used in both forced air systems and hydronic systems.

A forced air system consists primarily of a heat exchanger having combustion chambers arranged in relation to the flow of air to be heated such that fuel is introduced at one end of a chamber where a flame causes heat to be generated. The heat passes through a series of internal baffles before exiting through the other end of the combustion chamber into the flue or chimney. Simultaneously, circulated space air passes around the outside of the heat exchangers to absorb heat through conduction and convection.

A hydronic system consists primarily of a firebox having a heat exchanger therein. The heat exchanger is in a closed loop for continuously circulating water, a water glycol solution or other suitable heat exchange medium from the heat exchanger to a remote radiator in the space to be heated. However, this system is also relatively inefficient and expensive due to the combustion gas temperatures at the outlet of the firebox and the cost of the chimney.

Thus, the inefficient home heating system is generally the largest consumer of energy with the domestic hot water system being the second largest consumer of energy. In supplying domestic hot water for homes and commercial buildings, potable hot water systems with ordinary glass-lined, hot water storage tanks are generally used. It is com-

mon for these systems to have an enclosed water tank in which are spiraled coils of tubing through which flows the water to be heated. At the lowermost portion of the tank there is normally a burner whose heat is allowed to pass over the coils, thereby heating the water in the tank for use within the home or building. Again, as in the space heating systems for homes and buildings, the heat which is not transferred to the heat exchanger during demand "on-time" and also during standby "off-time", is exhausted at the top of the tank into a flue or chimney to the atmosphere as well as being lost through the tank jacket. Thus, a domestic hot water system is also inefficient because a great portion of the heat is lost directly up the chimney to the atmosphere.

Because of the rising costs of energy, the incentives to conserve energy are increasing. Consequently, there is currently considerable interest in recovering energy, such as waste heat from combustion heaters which is usually injected into the atmosphere without recovery.

In an attempt to reclaim reject heat, heat exchanger coils have been installed in the flue of a furnace to transfer some of the waste heat to domestic hot water heaters, thus recovering some usually wasted heat.

However, a drawback to conserving energy by reclaiming reject heat from a furnace for use by domestic hot water heaters is that both systems are controlled independently, and the energy saved is limited by the temperature of the water in the hot water tank for potable use and typically maintained between 49°C (120°F) and 71°C (160°F), the average being at or above the flue gas condensing temperature therefore limiting the efficiency of recovery at or up to a maximum threshold of the product of 88% to 90%. The necessity for dual control schemes for semi-integrated furnaces and hot water heaters is due to the blue flame burners used by both systems. In semi-integrated appliances dual controls are necessary because there is not true integration of a common heating loop that provides capacity at different required temperatures for both heating and hot water. This requires a rapid on-off response with modulation of input and flow controls and blue-frame burners by nature are not capable of controlling modulation this way effectively and therefore are limited to operation at some fraction of full input during continuous operation. Capacity of these burners cannot be reduced as demand for hot water is reduced but are fired at full capacity under all operating conditions.

An integrated heating system according to the precharacterizing portion of independent method claim 1 or independent apparatus claim 2 is disclosed in GB-A-2 160 967. In the known heating unit the space heating coil and the domestic water

heating coil are connected in parallel. The domestic water heating coil heats the domestic water contained in a tank.

Reference is also made to JP-A-60 82 716 and JP-A-60 117 046 both of which disclosing intermittently feeding fuel gas to a blue flame burner so that the gas is intermittently burnt.

The object of the invention is to provide a method for efficiently controlling the capacity of an integrated heating system having a radiant burner, and an integrated heating system having a liquid-backed gas-fired heating module with a radiant burner which will control the heat output of the burner to match the rate at which energy is required for either space heating or domestic water heating, or both.

According to the invention, to achieve this, there is provided a method of controlling the capacity of an integrated heating system for space heating and domestic hot water heating, comprising the steps of using an infrared burner for supplying heat directly to a primary heating fluid loop having a space heating coil therein, and transferring heat from said primary heating fluid loop to a secondary domestic hot water loop, characterized by providing a tankless heat exchange relation between said primary and secondary loops, sensing the presence of domestic hot water flow in the secondary domestic hot water loop, sensing the temperature of the fluid in the primary heating fluid loop; and controlling a pulse width of an "on" pulse of a constant pulse period of said burner to maintain the temperature of the fluid in said primary heating fluid loop within desired limits in response to the sensed domestic hot water flow and the temperature of the fluid in the primary heating fluid loop.

In further accordance with the invention, there is provided an integrated heating system for space heating and domestic hot water heating having an infrared burner, a coil for receiving heat from the burner, a primary heating fluid loop connected to the coil and having a first heat exchanger for transferring heat to a space and a second heat exchanger for transferring heat from the primary heating fluid loop to a secondary domestic hot water loop, characterized in that the coil for receiving heat from the burner, the first heat exchanger and the second heat exchanger are serially connected in the primary heating fluid loop, that the second heat exchanger is a tankless tube-in-tube heat exchanger, and that there is provided a capacity control system for said burner, said capacity control system having a burner flame control system for controlling the pulsing of repeated ignition and combustion termination of the burner, said burner flame control system including a flow switch for detecting absolute fluid flow in the secondary domestic hot water loop and providing a first signal to

a microcomputer means indicative of presence of hot water flow in the secondary domestic hot water loop, and a temperature sensor means for detecting the temperature of the fluid in the primary heating fluid loop at an outlet of the coil receiving heat from the burner and providing a second signal to the microcomputer means indicative of the temperature of the fluid in the primary heating fluid loop whereby said microcomputer provides an output signal to control the pulsing of said repeated ignition and combustion termination of the burner so that the fluid in the primary heating fluid loop is maintained at a desired temperature.

Accordingly, the object of the invention is attained by providing a capacity modulated control for a heating system for heating a space in a building and domestic hot water. The heating system having a liquid-backed heating module with a quick response and a tankless domestic hot water system, permits maximum radiant heat transfer capacity to be reached quickly, thus allowing pulsing of the burner to maintain heating module liquid temperatures within desired limits.

For a better understanding of the invention, its operation and specific advantages attained by its use, reference should be had to the accompanying drawings and descriptive matter in which there is illustrated and described a preferred embodiment of the invention.

In the accompanying drawings forming a part of the specification, and in which reference numerals shown in the drawings designate like or corresponding parts throughout the same,

Figure 1 is a schematic diagram of an integrated space heating and hot water system embodying the control of the present invention;

Figure 2 is a graph of the transient domestic hot water temperature response to a call for domestic hot water in an integrated space heating and domestic hot water system;

Figure 3 is a graph of the percentage output capacity versus the percentage of the on time of the pulse period of an integrated space heating and hot water system embodying the control of the present invention; and

Figure 4 A-E is a comparison of full capacity control with the pulsed control of the present invention.

Referring now to Figure 1 there may be seen a schematic view of residential heating system 10 using a liquid-backed heating module 12 for supplying energy to a primary or series heating fluid loop including a tube-in-tube heat exchanger 50 and a fan coil 14 forming a further heat exchanger for transferring heat to a space. The fluid loop further includes a liquid pump 16 for circulating fluid therethrough and an expansion tank 28 to provide for the volume increase of the heated fluid

and for dampening any pressure surges in the fluid loop. The fluid loop arrangement consists of discharge pipe 52 which extracts hot fluid from heating module 12 on demand. The heated fluid flows through the tube-in-tube heat exchanger 50 of conventional construction. The fluid then flows through pipe 54 and through a three-way diverting valve 56. In a first position the three-way valve 56 allows the fluid to flow directly to the liquid pump 16 through pipe 55 and back to the heating module 12 through pipe 57. In a second position the three-way valve 56 allows the fluid in the loop to flow through pipe 58 into fan coil 14 and through pipe 59 back to the suction side of liquid pump 16.

Further, as shown, the secondary domestic hot water loop includes cold water inlet pipe 62 connected to the inlet of tube-in-tube heat exchanger 50 and outlet pipe 64 which discharges hot domestic water to tap 43 after passing through flow switch 66. A mixing valve 60 connects pipe 64 to bypass pipe 65. Mixing valve 60 is preferably a temperature responsive valve which mixes the hot water flowing through the heat exchanger 50 and the cold water flowing through the bypass pipe 65 to ensure that the hot water flowing from the tap 43 is at a desired set temperature.

As further illustrated, the heating module 12 includes a gas line 30 having a regulator 32 for supplying fuel to the module. Further, air is supplied to the module through line 34. The air/fuel mixture is ignited and burned on the infrared burner 18 located centrally within housing 20. The air/fuel is 100% premixed, thus, no secondary combustion occurs. The heat exchange means 17 is located in spaced relation to the infrared burner 18 to receive heat from the infrared burner. The heat exchange means is generally in the form of a helical coil and has the fluid flowing therethrough which absorbs heat from the infrared burner, which in turn transfers this heat to the domestic hot water and the space to be heated.

Further, Figure 1 illustrates the integrated domestic hot water/space heating system having a control system in accordance with the principles of the present invention. This control system comprises a microcomputer system 80, a system interface board 82, and a power supply 83. The microcomputer system 80 may be any device, or combination of devices, suitable for receiving input signals, for processing the received input signals according to preprogrammed procedures, and for generating control signals in response to the processed input signals. The control signals generated by the microcomputer system 80 are supplied to control devices which control operation of the integrated heating system in response to control signals provided to the control devices from the microcomputer system 80.

As shown in Figure 1, the system interface board 82 is connected by ribbon cable 89 to the microcomputer system 80. The system interface board 82 includes switching devices for controlling electrical power flow from the main power supply 83 to three-way valve 56, liquid pump 16, inducer blower (not shown), gas valve 32, and ignition device 40. Preferably, the switching devices are electronic components, such as relays, which are controlled in response to control signals from the microcomputer system 80 which are supplied through the ribbon cable 89 to the electronic components on the system interface board 82.

The control system determines when to operate the integrated heating system to satisfy the need for space heat and/or domestic hot water. For the purpose of this disclosure "pulsing" shall mean turning the infrared burner on and off repeatedly while the inducer fan runs continuously during the pulse period. Further, "pulse period" shall mean the sum of one "on" and one "off" pulse. The infrared burner 18 of the module 12 has the unique feature that it has a quick response time which allows the maximum radiant heat transfer capacity to be reached quickly, e.g. in about one second, thus transferring its entire output energy to the liquid loop in a short period. More specifically, the temperature of the space to be heated is sensed by a thermostat 85 and a signal indicative of this temperature is provided by way of electrical line 91 to the microcomputer system 80. Further, the flow of domestic hot water flowing through tap 43 is sensed by flow switch 66 and a signal indicative of this flow is provided by way of electrical line 29 to the microcomputer system 80. Still further, the temperature of the series fluid loop is sensed by temperature sensor 68 at the outlet of the heat exchange means 17 and a signal indicative of this temperature is provided by way of an electrical line 26 to the microcomputer system 80.

Turning now to Figures 2 and 3, there is exemplified the quick response time which allows continuous use of domestic hot water and the output capacity of the infrared burner as a percentage of "on" time.

In Figure 2, curve 70 indicates the water temperature with respect to time for a 3.8 l/min (one GPM) flow through tap 43 while curve 70' indicates the temperature per time for a 7.6 l/min (2 GPM) flow.

In Figure 3, the output capacity of the infrared burner 18 is shown as a percentage of the burner on time.

Turning now to Figures 4 A-E, there is shown the output capacity of a burner from a first time (T_1) at which demand was initiated and a second time (T_2) at which time demand was terminated. Thus, Figure 4A shows a burner at 100 % capacity,

Q, from initiation time to termination time, without modulation. Specifically, Figure 4B shows a 50 % capacity, $0.5Q$, made up of three normally equal capacities Q' , Q'' and Q''' where $Q' + Q'' + Q''' = 0.5Q$. In Figure 4C, there is shown a burner at 25% capacity using pulse width capacity modulation of the present invention. Accordingly, the pulse period is maintained constant while the "on" pulse of the burner is modulated to vary the capacity. Moreover, as shown in Figures 4 D-E the frequency of the pulse period is varied to obtain a 25 % capacity and 17 % capacity respectively. Thus, under the frequency modulation scheme a minimum on-pulse width is maintained and the off-pulse width is changed to vary the capacity. The frequency modulation of Figures 4 D-E may be necessary in those circumstances where a minimum on-pulse width is required by a code agency.

Each time it is desired to energize the heating module, for example, when the flow sensor 66 detects flow through tap 43, the microcomputer system 80 provides another control signal by way of the ribbon cable 89 to the appropriate switching device on the system interface board 82 to supply power from the power supply 83 through the system interface board 82 to the ignition device 40. The microcomputer system determines the domestic hot water demand as a function of the temperature of the closed loop liquid leaving the module 12 and adjusts the pulse period of the infrared burner so that the domestic hot water is maintained at a desired temperature. Moreover, if the demand at the tap 43 is decreased then the on-pulse may decrease from that shown in Figure 4B to that shown in Figure 4C.

While the preferred embodiment of the present invention has been depicted and described, it will be appreciated by those skilled in the art that many modifications, substitutions, and changes may be made thereto without departing from the scope of the claims. For example, flow sensor 66 could be located in line 62 or 64.

Claims

1. Method of controlling the capacity of an integrated heating system for space heating and domestic hot water heating, comprising the steps of:
 - using an infrared burner (18) for supplying heat directly to a primary heating fluid loop (52-59) having a space heating coil (14) therein, and
 - transferring heat from said primary heating fluid loop to a secondary domestic hot water loop, (62,64,43)
 - characterized by:
 - providing a tankless heat exchange rela-

tion (50) between said primary and secondary loops,

sensing (66) the presence of domestic hot water flow in the secondary domestic hot water loop,

sensing (68) the temperature of the fluid in the primary heating fluid loop; and

controlling a pulse width of an "on" pulse of a constant pulse period of said burner (18) to maintain the temperature of the fluid in said primary heating fluid loop within desired limits in response to the sensed domestic hot water flow and the temperature of the fluid in the primary heating fluid loop.

2. Integrated heating system for space heating and domestic hot water heating having an infrared burner (18), a coil (17) for receiving heat from the burner (18), a primary heating fluid loop (52-57) connected to the coil (17) and having a first heat exchanger (14) for transferring heat to a space and a second heat exchanger (50) for transferring heat from the primary heating fluid loop to a secondary domestic hot water loop (62,64,43),

characterized in that the coil (17) for receiving heat from the burner (18), the first heat exchanger (14) and the second heat exchanger (50) are serially connected in the primary heating fluid loop (52-57), that the second heat exchanger (50) is a tankless tube-in-tube heat exchanger (50), and that there is provided a capacity control system for said burner (18), said capacity control system having a burner flame control system for controlling the pulsing of repeated ignition and combustion termination of the burner (18), said burner flame control system including a flow switch (66) for detecting absolute fluid flow in the secondary domestic hot water loop and providing a first signal to a microcomputer means (80) indicative of presence of hot water flow in the secondary domestic hot water loop, and a temperature sensor means (68) for detecting the temperature of the fluid in the primary heating fluid loop at an outlet of the coil (17) receiving heat from the burner (18) and providing a second signal to the microcomputer means (80) indicative of the temperature of the fluid in the primary heating fluid loop whereby said microcomputer provides an output signal responsive to said first and second signals to control the pulsing of said repeated ignition and combustion termination of the burner (18) so that the fluid in the primary heating fluid loop is maintained at a desired temperature.

3. Integrated heating system according to claim 2, characterized in that the secondary domestic hot water loop further includes a thermal mixing valve (60) provided to control the domestic hot water temperature at the desired temperature and that said flow switch (66) is located between the outlet of the tube-in-tube heat exchanger (50) and a hot water tap (43) in the secondary domestic hot water loop.

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Patentansprüche

1. Verfahren zum Regeln der Kapazität eines integrierten Heizsystems zur Raumheizung und Haushaltswarmwasserbereitung, beinhaltend die Schritte:

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Benutzen eines Infrarotbrenners (18) zum Zuführen von Wärme direkt zu einer Primärheizfluidschleife (52-57), die eine Raumheizschlange (14) enthält, und

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Übertragen von Wärme von der Primärheizfluidschleife auf eine Sekundärhaushaltswarmwasserschleife (62, 64, 43)

gekennzeichnet durch:

Vorsehen einer tanklosen Wärmeaustauschbeziehung (50) zwischen der Primär- und Sekundär- schleife,

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Erfassen (66) des Vorhandenseins einer Haushaltswarmwasserströmung in der Sekundärhaushaltswarmwasserschleife,

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Erfassen (68) der Temperatur des Fluids in der Primärheizfluidschleife; und

Steuern einer Impulsbreite eines "Ein"-Impulses konstanter Impulsperiode des Brenners (18), um die Temperatur des Fluids in der Primärheizfluidschleife aufgrund der erfaßten Haushaltswarmwasserströmung und der Temperatur des Fluids in der Primärheizfluidschleife innerhalb gewünschter Grenzen zu halten.

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2. Integriertes Heizsystem zur Raumheizung und Haushaltswarmwasserbereitung, mit einem Infrarotbrenner (18), einer Schlange (17) zum Empfangen von Wärme aus dem Brenner (18), einer Primärheizfluidschleife (52-57), die mit der Schlange (17) verbunden ist und einen ersten Wärmetauscher (14) zum Übertragen von Wärme auf einen Raum und einen zweiten Wärmetauscher (50) zum Übertragen von Wärme aus der Primärheizfluidschleife auf eine Sekundärhaushaltswarmwasserschleife (62, 64, 43) hat,

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dadurch gekennzeichnet, daß die Schlange (17) zum Empfangen von Wärme aus dem Brenner (18), der erste Wärmetauscher (14) und der zweite Wärmetauscher (50) in der Primärheizfluidschleife (52-57) in Reihe geschaltet sind, daß der zweite Wärmetauscher

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(50) ein tankloser Rohr-in-Rohr-Wärmetauscher (50) ist und daß ein Kapazitätsregelsystem für den Brenner (18) vorgesehen ist, wobei das Kapazitätsregelsystem ein Brennerflammensteuersystem zum Steuern des Impulsbetriebes von wiederholter Zündung und Verbrennungsbeendigung des Brenners (18) hat, wobei das Brennerflammensteuersystem einen Strömungsschalter (66) aufweist zum Erfassen der absoluten Fluidströmung in der Sekundärhaushaltswarmwasserschleife und zum Abgeben eines ersten Signals an eine Mikrocomputereinrichtung (80), das das Vorhandensein einer Warmwasserströmung in der Sekundärhaushaltswarmwasserschleife anzeigt, und eine Temperatursensoreinrichtung (68) zum Erfassen der Temperatur des Fluids in der Primärheizfluidschleife an einem Auslaß der Schlange (17), die Wärme aus dem Brenner (18) empfängt, und zum Abgeben eines zweiten Signals an die Mikrocomputereinrichtung (80), das die Temperatur des Fluids in der Primärheizfluidschleife angibt, wodurch der Mikrocomputer ein Ausgangssignal liefert, das auf das erste und zweite Signal anspricht, um den Impulsbetrieb der wiederholten Zündung und Verbrennungsbeendigung des Brenners (18) zu steuern, so daß das Fluid in der Primärheizfluidschleife auf einer gewünschten Temperatur gehalten wird.

3. Integriertes Heizsystem nach Anspruch 2, dadurch gekennzeichnet, daß die Sekundärhaushaltswarmwasserschleife weiter ein thermisches Mischventil (60) enthält, das vorgesehen ist, um die Haushaltswarmwassertemperatur auf der gewünschten Temperatur zu steuern, und daß der Strömungsschalter (66) zwischen dem Auslaß des Rohr-in-Rohr-Wärmetauschers (50) und einer Warmwasseranzapfung (43) in der Sekundärhaushaltswarmwasserschleife angeordnet ist.

Revendications

1. Procédé de commande de la capacité d'un système de chauffage intégré pour le chauffage d'un espace et le chauffage d'eau chaude domestique, comprenant les étapes consistant à utiliser un brûleur infrarouge (18) pour fournir directement de la chaleur à une boucle de fluide de chauffage primaire (52-59), comportant, dans cette boucle, un serpentin (14) de chauffage de l'espace, et à transférer de la chaleur à partir de cette boucle de fluide de chauffage primaire vers une boucle d'eau chaude domestique secondaire (62,64,43), caractérisé en ce qu'il comprend les étapes

consistant à prévoir une relation d'échange thermique sans cuve (50) entre les boucles primaire et secondaire, à détecter (66) la présence d'un débit d'eau chaude domestique dans la boucle d'eau chaude domestique secondaire, à détecter (68) la température du fluide dans la boucle de fluide de chauffage primaire, et à commander une largeur d'impulsion d'une impulsion "marche" d'une période d'impulsion constante du brûleur (18) de manière à maintenir dans des limites désirées la température du fluide dans la boucle de fluide de chauffage primaire, en réponse au débit détecté d'eau chaude domestique et à la température du fluide dans la boucle de fluide de chauffage primaire.

2. Système de chauffage intégré pour le chauffage d'un espace et le chauffage d'eau chaude domestique comportant un brûleur infrarouge (18), un serpentin (17) pour recevoir de la chaleur à partir du brûleur (18), une boucle de fluide de chauffage primaire (52-57) reliée au serpentin (17) et comportant un premier échangeur de chaleur (14), pour transférer de la chaleur vers un espace, et un second échangeur de chaleur (50), pour transférer de la chaleur à partir de la boucle de fluide de chauffage primaire, vers une boucle d'eau chaude domestique secondaire (62,64,43), caractérisé en ce que le serpentin (17) recevant la chaleur provenant du brûleur (18), le premier échangeur de chaleur (14) et le second échangeur de chaleur (50) sont branchés en série dans la boucle de fluide de chauffage primaire (52-57), en ce que le second échangeur de chaleur (50) est un échangeur de chaleur sans cuve (50) du type "tube dans tube", et en ce qu'il est prévu un système de commande de capacité pour le brûleur (18), ce système de commande de capacité comportant un système de commande de la flamme du brûleur, pour commander périodiquement le déclenchement de l'allumage et l'achèvement de la combustion répétés du brûleur (18), ce système de commande de la flamme du brûleur comportant un interrupteur détecteur de débit (66) pour détecter un débit de fluide absolu dans la boucle d'eau chaude domestique secondaire et pour fournir un premier signal à un micro-ordinateur (80), ce signal indiquant la présence d'un débit d'eau chaude dans la boucle d'eau chaude domestique secondaire, et un capteur de température (68) pour détecter la température du fluide dans la boucle de fluide de chauffage primaire, à l'endroit d'un orifice de sortie du serpentin (17) recevant de la chaleur à partir du brûleur (18), et pour

produire un second signal appliqué au micro-ordinateur (80), ce second signal représentant la température du fluide dans la boucle de fluide de chauffage primaire, de telle façon que le micro-ordinateur délivre un signal de sortie, en réponse aux premier et second signaux, afin de commander périodiquement le déclenchement de l'allumage et l'achèvement de la combustion répétés du brûleur (18), pour que le fluide dans la boucle de fluide de chauffage primaire soit maintenu à une température désirée.

3. Système de chauffage intégré suivant la revendication 2 caractérisé en ce que la boucle d'eau chaude domestique secondaire comporte en outre une vanne de mélange thermique (60) prévue pour commander la température de l'eau chaude domestique pour qu'elle soit égale à la température désirée et en ce que l'interrupteur détecteur de débit (66) est situé entre l'orifice de sortie de l'échangeur de chaleur (50) du type "tube dans tube" et une prise d'eau chaude (43) dans la boucle d'eau chaude domestique secondaire.

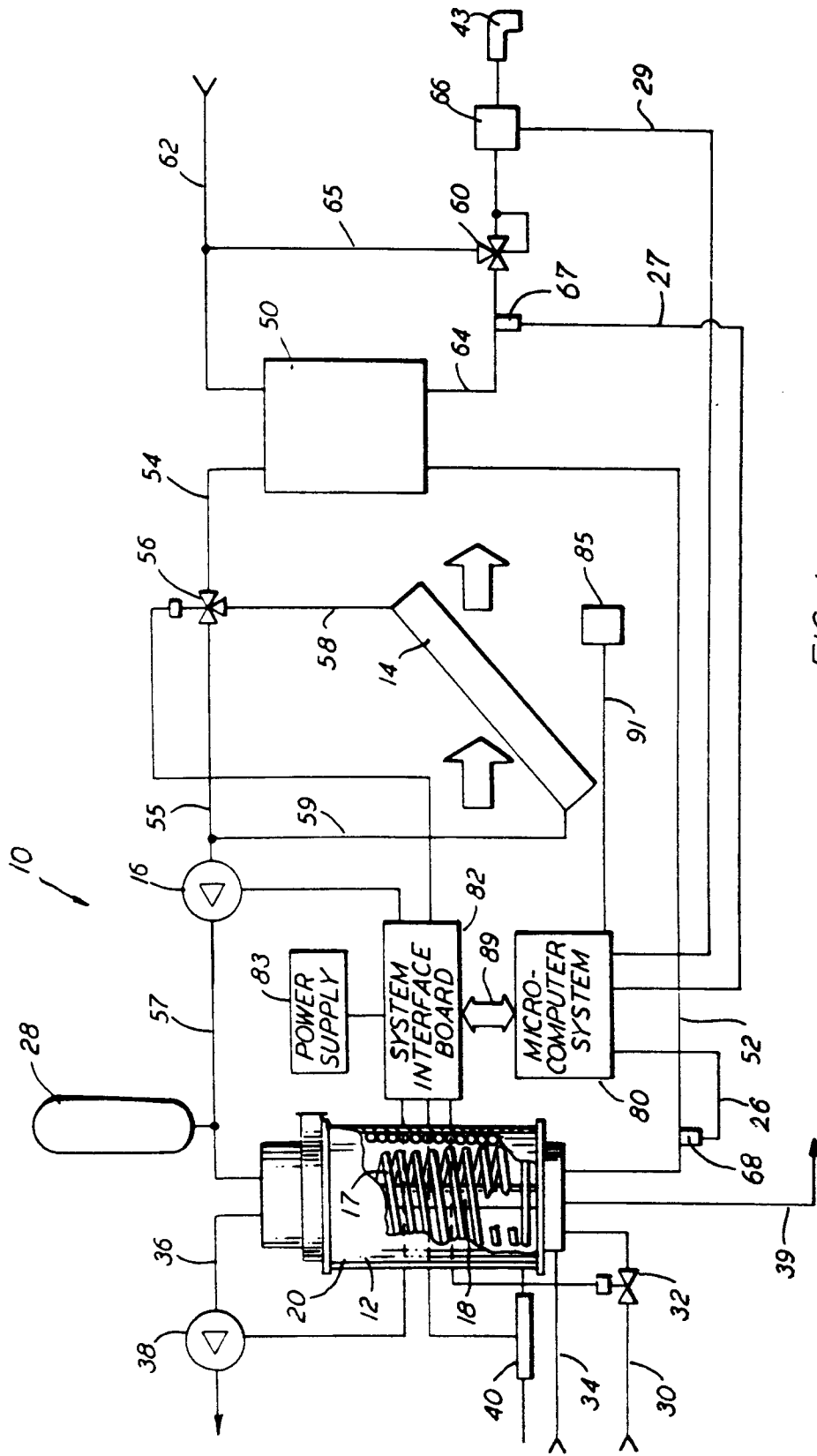


FIG. 1

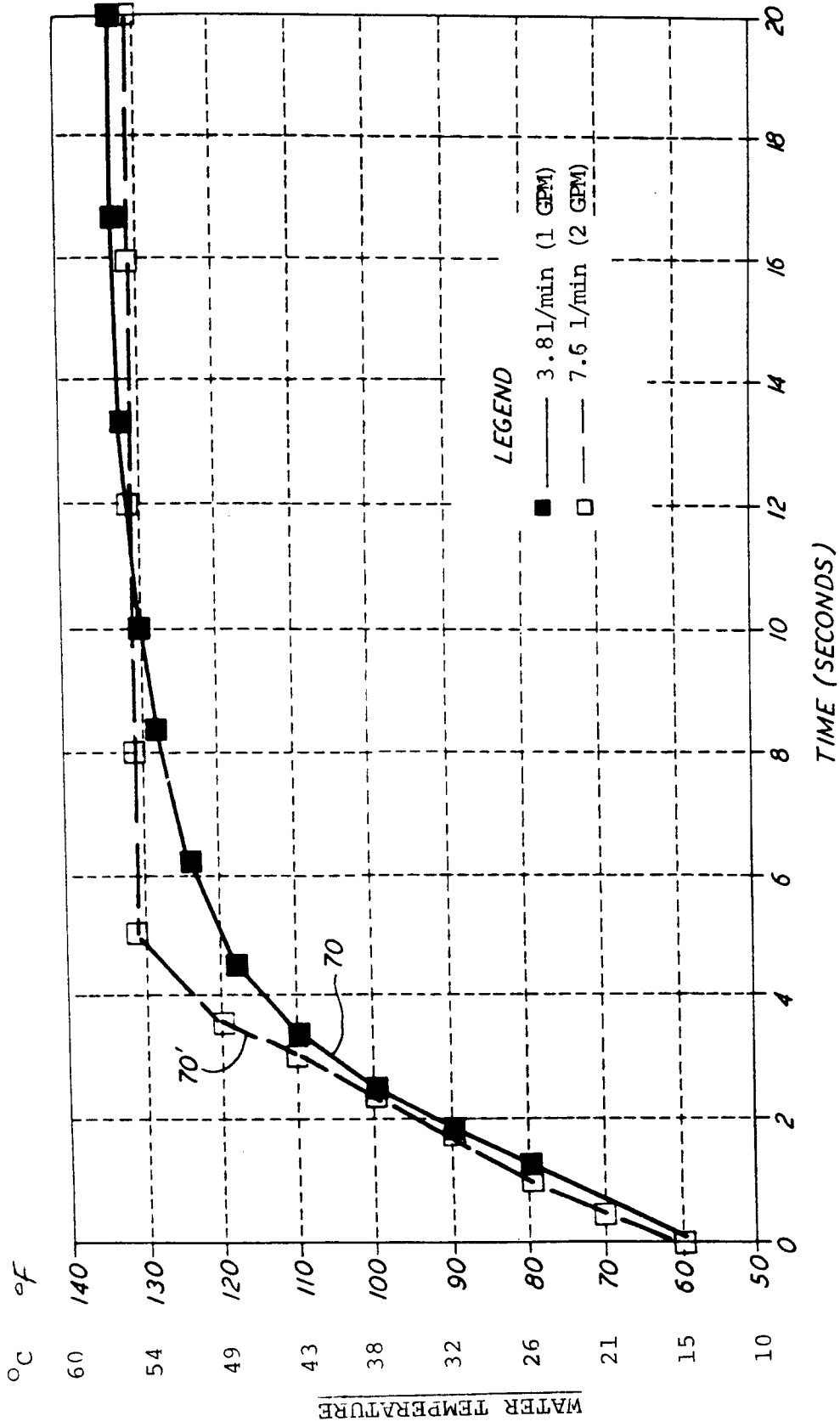


FIG. 2

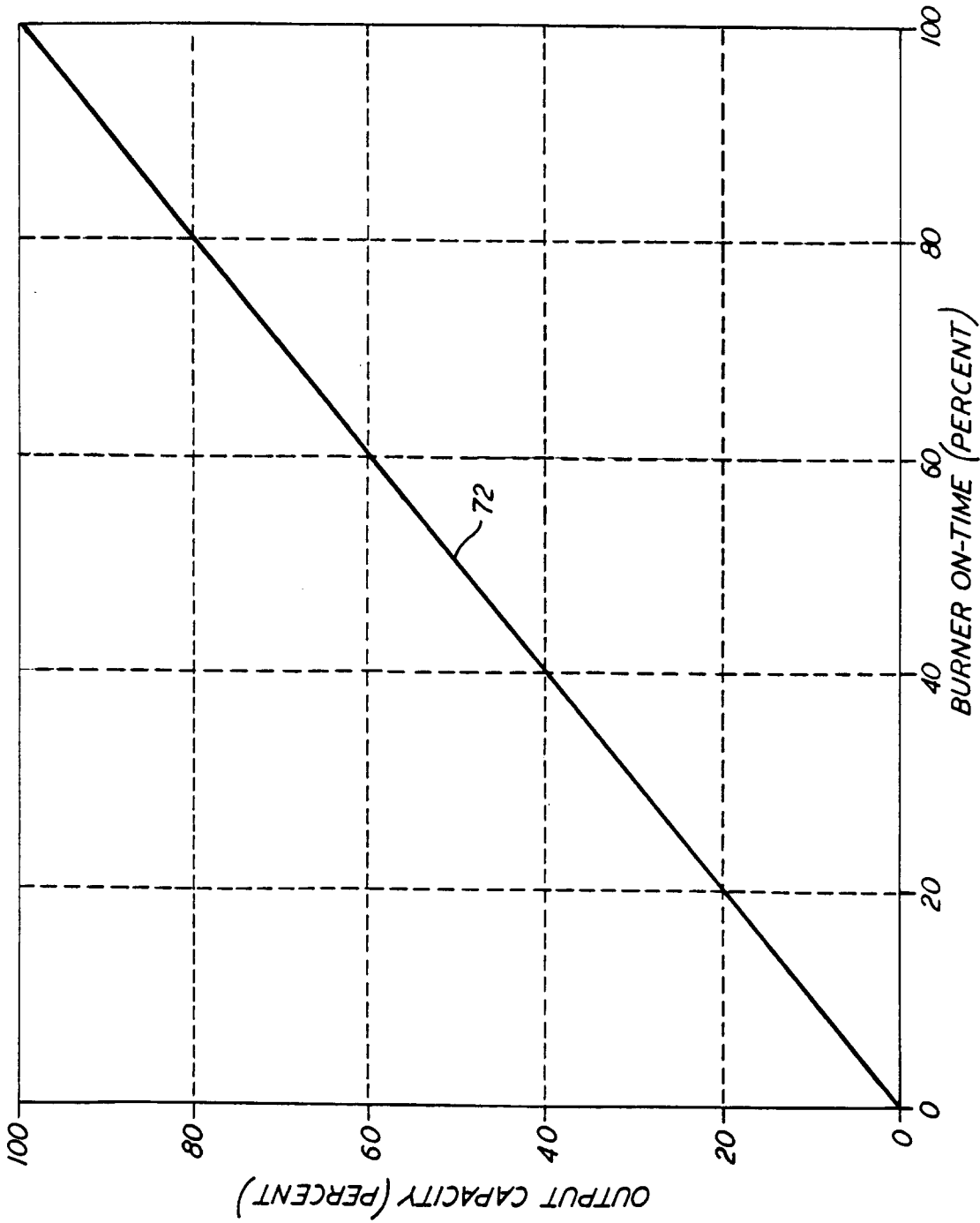


FIG. 3

