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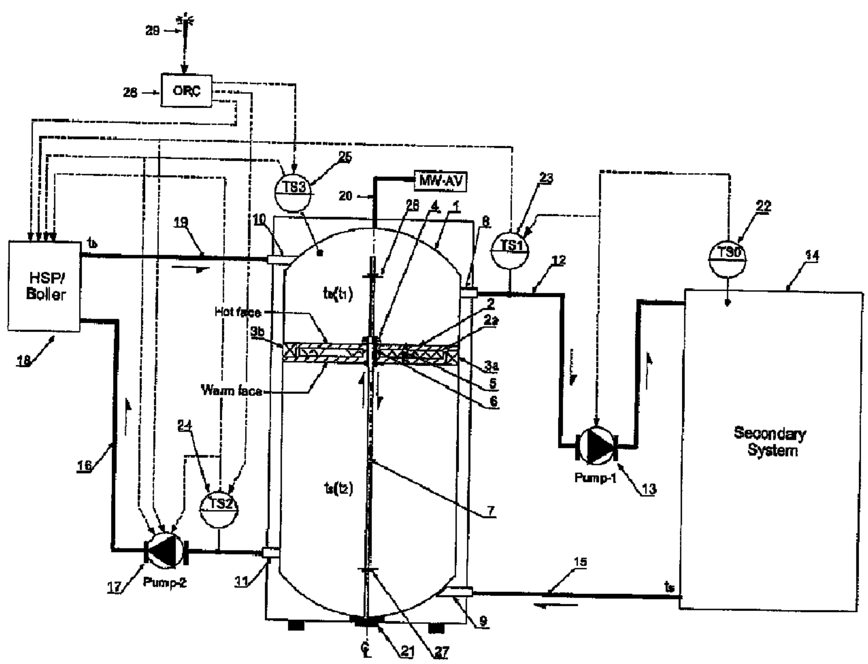
(54) Titre : SYSTEME DE CHAUFFAGE OU DE REFROIDISSEMENT A RESERVOIR-TAMPON DIVISE
(54) Title: HEATING OR COOLING SYSTEM FEATURING A SPLIT BUFFER TANK



1- Split buffer tank
2- Separation disk (Disk)
2a- Disk core insulation
3a- Warm-side bypass
3b- Hot-side bypass
4- Counterweight plates
5- Pressure release check valve
6- Separation disk hub
7- Guide bar
8- Buffer hot outlet
9- Buffer warm inlet
10- Buffer hot inlet
11- Buffer warm outlet
12- Buffer system supply line
13- Pump-1/System pump
14- Secondary system
15- Buffer system return line
16- Buffer HSP/boiler supply line
17- Pump-2/HSP/boiler pump
18- Heat Source Provider (HSP)/boiler
19- Buffer HSP/boiler return line
20- Water/brine make-up & Air vent connection
21- Guide bar attachment
22- TS0/Secondary system temperature sensor
23- TS1/Buffer system supply temperature sensor
24- TS2/Buffer HSP/boiler supply temperature sensor
25- TS3/Split buffer temp sensor
26- Top position disk stopper
27- Bottom position disk stopper
28- Outdoor reset control
29- Outdoor temperature bulb sensor

(57) Abrégé/Abstract:
This invention relates to a heating/cooling system operating on the basis of a novel SPLIT BUFFER TANK; representing an efficiency improvement alternative to HVAC systems functioning with existing commercial buffer tanks. Currently, commercial

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buffers have the heat source provider (HSP)-return and system-return discharging to a common buffer/vessel. Novel SPLIT BUFFER is provided with a SEPARATION DISK placed inside the tank as mechanical way of separating the hot water inflow from the HSP from the warmer water inflow from system return. The disk moves up and down along the tank driven by water supply and return. Pump-1 circulates hot water from the hot section of the buffer to the secondary system claiming for heat. Pump-2 circulates warmer water from the warmer section of the buffer through the HSP where it is reheated, and subsequently stored in the hot section of the buffer to reinitiate this cycle again.

ABSTRACT

This invention relates to a heating/cooling system operating on the basis of a novel SPLIT BUFFER TANK; representing an efficiency improvement alternative to HVAC systems functioning with existing commercial buffer tanks. Currently, commercial buffers have the heat source provider (HSP)-return and system-return discharging to a common buffer/vessel. Novel SPLIT BUFFER is provided with a SEPARATION DISK placed inside the tank as mechanical way of separating the hot water inflow from the HSP from the warmer water inflow from system return. The disk moves up and down along the tank driven by water supply and return. Pump-1 circulates hot water from the hot section of the buffer to the secondary system claiming for heat. Pump-2 circulates warmer water from the warmer section of the buffer through the HSP where it is reheated, and subsequently stored in the hot section of the buffer to reinitiate this cycle again.

HEATING OR COOLING SYSTEM FEATURING A SPLIT BUFFER TANK

FIELD OF THE INVENTION

The present invention relates generally to a heating/cooling system featuring a buffer tank, and more particularly to such a system employing a split buffer tank configured to separate hot heat source provider flow return from warm secondary system flow return.

BACKGROUND OF THE INVENTION

To better illustrate the nature of the invention take for instance the case of a condensing boiler as HSP. It is common to find all variety of brands and models operating at steady-state-efficiency levels from 70-80% for non-condensing to 82-98% for condensing. Steady-state Efficiency - refers to a measuring parameter for boiler maximum efficiency capability assessed under a controlled steady test and carried out by recognizable standard certification bureau. In the test, parameters such as air-intake temperature and volume, air/gas mixture, water/brine temperature/flow entering/leavening the boiler, system heat demand, and some others, are all fixed during boiler firing to obtain a better judgment of its efficiency at artificial steady state conditions. *Test Standards for Gas-Fired Boilers. CGA P.2-1991 (R1999)/ENERGY START Canada*, and the *U.S. Department of Energy's/Title 10/Code of Federal Regulations for the Energy Conservation Program for Consumer Products*, make indications that during the steady state testing of a condensing boiler water outlet temperature shall be at 180^0F/82^0C and inlet temperature shall be at 80^0F/26.7^0C at all times.

Drifting away from the stationary conditions dictated by the test, it arrives at the real world, a different place. A world loaded with always changing conditions where lab subsets are not so frequently encountered during the operating life span of the boiler. To complicate matters, there appears the need for adding buffer capacity in order to eliminate problems associated with excessive cycling, poor temperature control, and erratic system operation. The HVAC industry learned a long time ago that it was by adding a buffer tank to the boiler-system that they resolved all these problems. However, one issue remains unsolved. That is, the loss of the boiler high efficiency during continuous operation due to the water mixing inside the tank. But with no solution on hand, they were forced to look the other way.

In today's commercial buffers (See FIG.2), boiler water-return at temperature t_b and secondary system water-return at temperature t_s easily get mixed in the buffer because of the lack of mechanical medium capable of isolating the encountering of the two flows inside the tank (See also FIG.4). This mixed water at temperature equal t_{mix} when going to the boiler produces the same effect on efficiency behavior as the one depicted in FIG.3. There, and independent study (by Jim Cooke) shows how condensing and non-condensing boilers thermal efficiency gets influenced by water return temperature during steady-state conditions. Cooke's study also shows thermal efficiency behavior for a condensing boiler at three different firing rates (33/67/100%).

FIG.4 shows some water/brine supply/return hydraulic connections for some brand name buffer tanks and their prevailing flow pattern when all intakes/outlets are in used. Water/brine motion inside the buffer not only gets affected by physical characteristics of the system such as pumps flow, buffer diameter and height, inlet/outlet configuration, among other variables, but also by changing set of dynamic conditions regulated by DCS (Distributed Control System). Flow patterns in the buffer are chaotic and unpredictable with limited opportunities for creating stratification conditions. For this to occur pumped flow coming from HSP/boiler and/or secondary system need to be slowed down to such extent that entering speed must be close to laminar flow. Only such minimal disturbance in the body of water inside the tank will have no major mixing effect in the natural convection phenomenon associated with stratification. From a design stand point this may lead to uneconomical alternatives such as having a much bigger diameter for piping inlet/outlet connections, otherwise designed with acceptable velocity of 2.1 ± 0.9 m/s (7 ± 3 ft/s) for normal liquid service applications, with maximum velocity of 2.1 m/s (7 ft/s) at piping discharge points. Perhaps even requiring a buffer tank with oversize uneconomical dimensions in diameter and/or height. This, without mentioning the time factor to allow the stratification process to evolve and settled.

The more realistic assumption is that any flow leaving the buffer will do so at a temperature t_{mix}.

From FIG.2 and FIG.4 it may be concluded that:

$$t_{mix} = (t_b + t_s) / 2$$

t_b	Water/brine temperature at boiler outlet. Considered equal to t_1 (See FIG.1) when no heat losses occur in pipe connection between boiler and buffer
t_s	Water/brine temperature at system return. Considered equal to t_2 (See FIG.1) when no heat losses occur in pipe connection between system and buffer
t_{mix}	Water/brine temperature from the mixture of warm and hot water if there is no separation disk (as it happens in existing commercial buffers). Water temperature going to the boiler
t_1	Water temperature from hot section of the buffer to the secondary system
t_2	Water temperature from Secondary System to warm section of the buffer
t_1-t_2	Delta temperature. $Q = W \times C_p \times (t_2 - t_1)$
Q	Secondary system heat demand. $Q = W \times C_p \times (t_2 - t_1)$

Using data results from chart on FIG.3 and applying the same analogy to evaluate water return/supply configuration on boiler efficiency for the typical commercial buffer connections on FIG.4; It may be proven that when water gets mixed in the buffer and returned to the boiler at mixed temperature t_{mix}, it will produce the same effect on the thermal efficiency of the boiler. As flow pattern and temperature of the mix evolve over time, the rising temperature of the water/brine will increasingly hamper its ability to quickly regain thermal energy when recirculating through the boiler, resulting in longer less efficient runs with increasingly unnecessary consumption of energy resources (See FIG.6). This in turn will force chimney gases to escape the boiler without fully rendering their caloric load.

When dealing with condensing boilers it is crucial to realize that continuous 80^{0}F/26.7^{0}C water-return and below is the determinant factor in achieving continuous outstanding higher efficiencies (See chart on FIG.3); and that, boilers serving a buffer/system in which mixed water return temperature does not fall below 80^{0}F/26.7^{0}C will never meet the necessary temperature requirements for achieving such continuous performance. Ignoring this fact, when justifying a boiler selection, will result in having a boiler that cost 50% more than necessary (comparing to condensing boiler) and achieves, from time to time, just above condensing boiler performance.

Currently buffer technology has not corrected the problems created with usual configurations such as the one on FIG.4 (and the like); and as a result, its usage just exacerbate the sub-utilization of condensing boilers in boiler/buffer/systems that ONLY occasionally allow condensation to occur.

SUMMARY OF THE INVENTION

According to a first aspect of the invention there is provided a heating/cooling system comprising a heat source provider, a secondary system, a split buffer tank, and hydraulic connections interconnecting the split buffer tank to the heat source provider and the secondary system, the split buffer tank comprising a separation disk inside the split buffer tank and freely movable upward and downward within the split buffer tank to make room for hot and warm fluid storage on opposite sides of the disk, and two disk flow bypasses on the disk for respective loop flow functionality between the split buffer tank and each of the heat source provider and the secondary system.

Preferably buffer heat source provider return line serves as hydraulic connection to convey hot fluid from the heat source provider into a hot section of the split buffer tank on a hot side of the disk.

Preferably a buffer heat source provider supply line serves as hydraulic connection to convey warm fluid from a warm section of the split buffer tank on a warm side of the disk to the heat source provider.

Preferably a buffer system supply line serves as hydraulic connection to convey hot fluid from a hot section of the split buffer tank on a hot side of the disk to the secondary system.

Preferably a buffer system return line serves as hydraulic connection to convey warm fluid from the secondary system to a warm section of the split buffer tank on a warm side of the disk.

Preferably the split buffer tank comprises the following:

(a) a hot-outlet hydraulically connected to a buffer system supply line to convey stored hot fluid from the split buffer tank to the secondary system to satisfy demand for heat;
(b) a warm-inlet hydraulically connected to a buffer system return line to convey secondary system return warm fluid to split buffer tank for storage;
(c) a hot-inlet hydraulically connected to a buffer heat source provider return line to convey hot fluid from the heat source provider to the split buffer tank for storage;

(d) a warm-outlet hydraulically connected to a buffer heat source provider supply line to convey stored warm fluid from the split buffer tank to the heat source provider for reheating;

(e) the separation disk, which functions to hydraulically separate hot fluid inflow from the heat source provider from warm fluid inflow from the secondary system, and to serve as an insulating wall for thermal separation between hot and warm sections of the tank, the separation disk comprising the following:

i) an insulating core which functions to thermally insulate the hot section of the split buffer tank from the warm section;

ii) a separation disk warm-side bypass to allow a pump-1 to recirculate fluid in a system loop during positioning of the disk in a top position;

iii) a separation disk hot-side bypass to allow pump-2 to recirculate fluid in a heat source provider loop during positioning of the disk in a bottom position; and

iv) a pressure release check valve hydraulically connecting a hot face of the disk with a warm face of the disk in order to eliminate pressure differential between the hot and warm sections of the tank that may arise from a make-up fluid connection on the split buffer tank;

f) a guide bar inside the split buffer tank in the form of a center guide squared bar to guide the separation disk up and down along the split buffer tank and to prevent rotation of the disk from causing misalignment of the warm-side bypass with the hot outlet (8), or the hot-side bypass with the warm outlet, at an edge of the separation disk, the disk being displaceable up and down along the center guide bar to allow hot and warm fluid accumulation during thermal recharging and discharging of the split buffer tank;

g) a separation disk hub to secure the separation disk to the center guide bar and to accommodate a set of counterweight plates;

h) the set of counterweight plates balancing buoyancy of the separation disk to make the separation disk effectively weightless when placed inside the split buffer tank;

i) a top position disk stopper to limit displacement of the disk when going to the top position lining up the warm-side bypass with the hot outlet;

j) a bottom position disk stopper to limit displacement of the disk when going to the bottom position, lining up the hot side bypass with the warm outlet;

k) a guide bar attachment to mechanically secure the guide bar to a bottom of the split buffer tank; and

l) a pressurized fluid make-up & air vent connection to maintain continuous fluid supply to the system and to allow for allocation of air vent equipment in association with the split buffer tank.

Preferably there is provided a Distributed Control System (DCS) logic that is arranged to work independently or in conjunction with additional DCS controllers and comprises the following:

a) a demand-based sensor/selector inside the Secondary System perimeter which functions to monitor an inner temperature and call for heat, starting a Pump-1 operable between the buffer tank and the secondary system, if the inner temperature falls below a preset value;

b) a fluid temperature sensor/selector located at a buffer system supply line, between a hot outlet of the buffer tank and the pump-1, the temperature sensor/selector registering a first point fluid temperature, operating only when the pump-1 is ON, and if the first point fluid temperature falls below a set point, signaling to start first a pump-2 operable between the buffer tank and the heat source provider and, with a time delay, start the heat source provider to reload the split buffer tank with hot fluid; and

c) another fluid temperature sensor/selector located at a buffer heat source provider supply line, between a buffer tank warm outlet and pump-2 to register a second point fluid temperature and shut-off the pump-2, and with time delay, shut off the heat source provider if the second point fluid temperature rises to a second preset value.

The split buffer tank is preferably provided with medium to high pressure capabilities and suitable to operate at higher than normal temperatures.

The heat source provider may feature any direct heating device such as gas/oil boiler, heat pump, solar plant (solid fuel), wood pellet/log and/or any district heating, or indirect heating device operated via integrated heat exchangers or external flat plate heat exchanger.

The secondary system may feature any HVAC applications for office buildings, industrial facility or any other closed environment, where safe and healthy building conditions are regulated with temperature and humidity, as well as "fresh air" from outdoors. Also any industrial thermal processes involving cooling/heating applications.

Preferably there is provided a guide bar arranged inside the split buffer tank to guide the separation disk up and down along the split buffer tank.

According to a second aspect of the invention, a split buffer tank comprises two outlets, a separation disk inside the split buffer tank and freely movable upward and downward within the split buffer tank toward opposite ones of said outlets to make room for hot and warm fluid storage on opposite sides of the disk, and two disk flow bypasses on the disk that each communicate a respective side of the disk with a respective one of the outlets not on said respective side of the tank when the bypass aligns with said outlet under sufficient disk movement of the disk theretoward.

BRIEF DESCRIPTION OF THE DRAWINGS

In the following drawings, which illustrate the exemplary embodiments of the present invention:

FIG.1 schematically illustrates a heating/cooling system operating with the novel invention of a split buffer tank

FIG.2 schematically illustrates a prior art boiler/system operating with an existing commercial buffer tank

FIG.3 shows a simplified chart for condensing and non-condensing boilers steady-state thermal efficiency as function of return water temperature

FIG.4 schematically illustrates prior art water/brine supply/return hydraulic connections for some commercial buffer tanks showing prevailing flow patterns.

FIG.5 shows boiler/buffer/system connections effect on time thermal efficiency

FIG.6 shows split buffer Vs commercial buffer connection effect on energy savings

FIG.7a schematically illustrates a commercial buffer tank connection for a geothermal heat pump.

FIG. 7b schematically illustrates a split buffer tank connection for a geothermal heat pump

FIG.8 shows geothermal heat pump/buffer/system connection effect on energy savings

FIG.9 is a cross-sectional view of a split buffer/separation disk operating at a top position

FIG.10 is a cross-sectional view of the split buffer/separation disk operating at a bottom position

FIG.11 is a plan view of the separation disk

FIG.12 shows separation disk hub details, including cross-sectional view A-A with details on counterweight plates and a pressure release check valve. Separation ring insulating core (2a in FIGS. 9 & 10) is not shown, to simplify the drawings.

DETAILED DESCRIPTION

1. General Character Of The Invention

The present invention relates to a heating/cooling system operating on the basis of a SPLIT BUFFER TANK, as shown in FIG.1. Its design includes a mechanical disk (2) in order to separate the hot HSP flow return (19) from the warmer secondary system flow return (15). Because both sections get thermally and hydraulically isolated one from each other, it favours the separation of the two bodies of water with different thermal properties. This in turn, allows the independent supply of water/brine to secondary system at a steady high temperature serving the demand for heat, and steady low water/brine temperature to the HSP for reheating. Since steady state conditions for both flows are possible with this new invention, its use will maximize thermal operating efficiency for existing HVAC large sets of manufactured equipment. It alone will allow not only the step down on equipment sizes for a given set of thermal conditions but also the decrease in the use of non-renewable natural resources and in the increasing maintenance costs. HSP and the Secondary System work in a closed loop interconnected through the buffer/vessel. The term "water" or "brine" will be used indistinctively meaning the fluid. The name "System" also applies to the Secondary System.

2. Inventive Idea

In the case of the split buffer (refer to FIG.1), boiler water-return at temperature t_b will never encounter system water-return at temperature t_s. Therefore, a constant flow of water to the boiler at t_2 will remain unchanged throughout the heat-loading operation allowing the boiler to perform at very stable conditions closely mimicking lab subsets. With boiler operating at continuous high efficiency levels buffer reloading will be carried out in shorter periods with saving in non-renewable energy resources, and time operation will be minimized reducing boiler wearing and operational costs. On the system side, because now water/brine to the system can be delivered at continuous targeted high temperature, system HVAC equipment will see a significant improvement in their thermal transfer units (because of higher MLDT). This alone will favor downsizing when considering the use of split buffer during initial phase of HVAC system design.

Additional desirable key features can be added to the system that now can operate at continuous buffer system delivery targeted temperature and work with much lower water return temperature to the boiler. For example, less volume of water/brine will be needed to be pumped in order to be capable of carrying a bigger load to the system, smaller piping diameter with reduced pressure drops, smaller handling systems with reduced heat exchangers, it would make sense to put effort in designing a system with water return temperature as low as possible since its purpose will not be defeated by buffer mixing. And lastly, it would be expected to have a smaller required boiler capacity more responsive to system loads and less costly to operate.

FIG.5 shows the hypothetical effect of boiler/buffer connection configuration on thermal efficiency for the three scenarios considered in FIG.4 with some additional considerations. The same boiler with best/middle/worst connections arrangement now working in a time evolving water mixing situation where the slope in the chart will indicates the speed of change by which thermal efficiency drops down for a given best/middle/worst case scenario. The dashed line at 120 seconds marks the time at which such boiler will finish thermal loading when operating with a novel split buffer (280 seconds when operating with commercial buffer). It can be observed that the split buffer operation provides an advantage when compare to commercial buffers. The elimination of water return mixing allows it to consistently perform (at 98% efficiency) enabling thermal reloading in shorter boiler time operation, see FIG.6 (with lower energy resource spending, more rapid system response and less mechanical maintenance cost on the boiler).

In the case of a water-to-water geothermal heat pump (GHP) (see FIG.7a, 7b), operating with any commercial buffers from FIG.4, GHP brine return at temperature t_b and system brine return at temperature t_s; again, easily get mixed in the buffer because of the lack of mechanical medium capable of isolating the encountering of the two flows inside the tank. This mixed water at temperature equal $t_{mix} = (t_b + t_s) / 2$

when going to the GHP evaporating coil (FIG.7a) will produce an MLDT much lower than the one generated when operating with the split buffer (1), with no mix (FIG.7b). MLDT reduction will hamper the ability of the brine to quickly regain thermal energy and transport a higher load to the buffer in a shorter period of time; resulting, in longer GHP runs with increasing consumption of energy and equipment wearing. During buffer thermal loading operation, as t_{mix} approaches t_b, MLDT tends to zero making the heating transferring process to become more critical. At this time, the rate of heat transfer via evaporator to the GHP brine will approximate slowly to zero forcing the GHP to operate for a longer period time until $t_{mix} = t_b$ at time t10 (See chart on FIG.8), and the system shuts-off.

Split buffer (1) offers operational advantages to GHP due to the ability to maintain a constant flow of low water temperature (high water temperature during reverse cycle) going to the GHP evaporator accelerating heating-loading time. The results, a more efficient GHP operation with lower running time, less energy consumption and lower maintenance cost. Special consideration should be given to Split Buffer (1) Distributed Control System which now needs to be reconditioned in order to perform not only on heating but cooling reverse cycle.

Similar analysis may be carried out for other Heat Source Providers (HSP) as part of any HVAC system with the same positive improvement in their operation.

2.1. <u>Sequence of Operation</u>

Heating/cooling cycle for the system in FIG.1 initiate with demand-based sensor/selector inside secondary system perimeter TS0 (22) sensing the need for heat and sending a signal to start pump-1 (13). At this moment in time, secondary system (14) temperature is below TS0 (22) set point.

With Pump-1 (13) running and water/brine flowing from split buffer (1) to secondary system (14), low temperature sensor/selector TS1 (23) located at buffer hot outlet

(8) registers point water temperature. If water/brine temperature is above set point, there will be no signal to start pump-2 (17) and HSP/boiler (18). Split buffer (1)/pump-1 (13) will continue supplying hot water and pushing separation disk (2) to top position until warm-side bypass (3a) gets aligned with hot outlet (8). At that point, pump-1 (13) will recirculate warm water along system loop **"split buffer (1) → buffer system supply line (12) → secondary system (14) → buffer system return line (15) → split buffer (1)"** until any excess heat remaining in the water is released into the secondary system (14) and TS1 (23) registers a water temperature falling below set point. TS1 (23) will then triggers on pump-2 (17), and with time delay, HSP/boiler (18). Pump-1 (13) will run continuously until secondary system (14) temperature reaches TS0 (22) indicating that the demand for heat is mitigated.

Once demand in secondary system (14) gets satisfied, TS0 (22) will shut off pump-1 (13). HSP/boiler (18)/pump-2 (17) will continue running/loading split buffer (1) with hot water/brine until separation disk (2) reaches bottom position aligning hot-side bypass (3b) with buffer warm-outlet (11). At that point, pump-2 (17) will continue recirculating water along the HSP/boiler loop **"split buffer (1) → buffer HSP/boiler supply line (16) → HSP/boiler (18) → buffer HSP/boiler return line (19) → split buffer (1)"** until water/brine temperature reaches high temperature sensor TS2 (24) set point, dictated by the outdoor reset control ORC (28). TS2 (24) then will shut-off HSP/boiler (18), and with time delay, pump-2 (17). This will leave split buffer (1) thermally loaded and resting for the next cycle.

When running concurrently, pump-1 (13) and pump-2 (17) will create an operational valet on the separation disk (2) that now moves up and down inside the split buffer obeying HSP/boiler (18) and secondary system (14) water flow demand and return. Both served by pump-1 (13) and pump-2 (17). Pump-1 (13) and pump-2 (17) operate concurrently with no discharge counterpressure (other than loop pressure losses) that forces any of the pumps to fight. Pump-1 (13) is always discharging in the suction section of pump-2 (17) and vice versa.

Low temperature sensor/selector TS1 (23) will operate only when pump-1 (13) is on. This prevents pump-2 (17) and HSP/boiler (18) from operating when supply line (12) gets cold and the secondary system is not calling for heat.

Split buffer (1) thermal reloading cycle will not only be initiated by a new demand for heat for secondary system (14); but also, by additional high temperature sensor (TS3) (25), NOT CLAIMED UNDER PRESENT INVENTION, added to split buffer (1) to maintain a high water/brine temperature during long resting periods. It should be used only if additional extra time for secondary system recovery is not allowed by the HVAC system. High temperature set point for TS3 (25) is dictated by the outdoor reset control ORC (28).

Outdoor reset control ORC (28), NOT CLAIMED UNDER PRESENT INVENTION, is a commonly used microprocessor-based control designated to regulate supply water/brine temperature based on outdoor temperature. Automatic reset ratio calculation sets the relationship between outdoor temperature and supply water/brine temperature (heating curve) to provide optimum control and comfort. As the outdoor temperature changes, the control adjusts firing rate or running time to compensate for exterior heat loss.

ORC (28) will automated high temperature set point for TS2 (24) and (TS3) (25). And because it matches heat loss from the secondary system with HSP/boiler required output, it will optimize energy conservation in a system that will operate at the lowest practical return water temperature.

2.2. <u>Operation Notes</u>

Bypass connection (3a) and (3b) in the separation disk (2) (as it is shown in FIG.9, 10, 11) allow pumps to bypass flow during top or bottom disk positions. During top position (FIG.9), with pump-1 (13) running, warm-side bypass (3a) will line up with hot outlet (8) allowing water/brine to freely recirculate along system loop. Once low temperature sensor TS1 (23) registers recirculating water/brine temperature being below set point, it will start pump-2(17), and with time delay HSP/boiler (18), to reinitiate thermal loading. During bottom position (FIG.10) with pump-2 (17) running, hot-side bypass (3b) will line up with warm outlet (11) allowing hot water/brine to freely recirculate along HSP/boiler loop. Once high temperature sensor TS2 (24) registers recirculating water/brine temperature being on target, it will shut-off thermal reloading sending the system to a temporary rest. Both loops operate independently and complementing one another.

Top position disk stopper (26) and bottom position disk stopper (27) will limit the separation disk run along guide bar (7). During disk top position (see FIG.9), it allows disk warm-side bypass (3a) to line up with hot outlet (8). During disk bottom position (see FIG.10), it allows disk hot-side bypass (3b) to line up with warm outlet (11).

Because separation disk (2) and the insulating manufacturing material injected in the core (2a) of the disk will vary in density when compared to water/brine or any other liquid been used, weight balancing must be carried out through a set of counterweight plates positioned in hub (6) (as seen in FIG.12) in order to counterbalance the buoyancy effect of the disk. The purpose is to make the disk as weightless as possible when placed inside the tank (Buoyant force – counterweight = 0), eliminating its tendency to float to the top or sink to bottom position. This may happen when system is resting for long period of time. In any case, split buffer will maintain its operability due to the configuration in hydraulic connections (12), (15), (16), (19) and to DCS instructions that maintains sequence of operation at any disk position.

Separation disk is provided with pressure release check valve (5) (See FIG.12) to balance any pressure differential that may arise from make-up water/brine feeding through the make-up/air vent connection line (20) (see FIG.1, 9, 10). Pressure release check valve (5) allows forward flow from hot section atop to the warm section in the bottom and closes to block reverse flow. This prevent separation disk to sink during pressure balancing when system is resting.

CLAIMS:

The embodiments of the invention in which an exclusive property or privilege is claimed are defined as follows:

1) A heating/cooling system comprising a heat source provider, a secondary system (14), a split buffer tank (1), and hydraulic connections (12), (15), (16), (19) interconnecting the split buffer tank to the heat source provider and the secondary system (14), the split buffer tank comprising a separation disk inside the split buffer tank and freely movable upward and downward within the split buffer tank to make room for hot and warm fluid storage on opposite sides of the disk, and two disk flow bypasses (3a, 3b) on the disk for respective loop flow functionality between the split buffer tank and each of the heat source provider and the secondary system (14).

2) The heating/cooling system according to claim 1, in which a buffer heat source provider return line (19) serves as a hydraulic connection to convey hot fluid from the heat source provider (18) into a hot section of the split buffer tank (1) on a hot side of the disk.

3) The heating/cooling system according to claim 1 or 2, in which a buffer heat source provider supply line (16) serves as a hydraulic connection to convey warm fluid from a warm section of the split buffer tank (1) on a warm side of the disk to the heat source provider (18).

4) The heating/cooling system according to claim 1, in which a buffer system supply line (12) serves as a hydraulic connection to convey hot fluid from a hot section of the split buffer tank (1) on a hot side of the disk to the secondary system (14).

5) The heating/cooling system according to any one of claims 1 to 4, in which a buffer system return line (15) serves as a hydraulic connection to convey warm

fluid from the secondary system (14) to a warm section of the split buffer tank (1) on a warm side of the disk.

6) The heating/cooling system according to claim 1, in which the split buffer tank (1) comprises the following:
   a) a hot-outlet (8) hydraulically connected to a buffer system supply line (12) to convey stored hot fluid from the split buffer tank (1) to the secondary system (14) to satisfy demand for heat;
   b) a warm-inlet (9) hydraulically connected to a buffer system return line (15) to convey secondary system (14) return warm fluid to split buffer tank (1) for storage;
   c) a hot-inlet (10) hydraulically connected to a buffer heat source provider return line (19) to convey hot fluid from the heat source provider (18) to the split buffer tank (1) for storage;
   d) a warm-outlet (11) hydraulically connected to a buffer heat source provider supply line (16) to convey stored warm fluid from the split buffer (1) tank to the heat source provider (18) for reheating;
   e) the separation disk (2), which functions to hydraulically separate hot fluid inflow from the heat source provider (18) from warm fluid inflow from the secondary system (14), and to serve as an insulating wall for thermal separation between hot and warm sections of the tank, the separation disk comprising the following:
      i) an insulating core (2a) which functions to thermally insulate the hot section of the split buffer tank (1) from the warm section;
      ii) a separation disk warm-side bypass (3a) to allow a pump-1 (13) to recirculate fluid in a system loop during positioning of the disk in a top position;
      iii) a separation disk hot-side bypass (3b) to allow a pump-2 (17) to recirculate fluid in a heat source provider loop during positioning of the disk in a bottom position; and

iv) a pressure release check valve (5) hydraulically connecting a hot face of the disk with a warm face of the disk in order to eliminate pressure differential between the hot and warm sections of the tank that may arise from a make-up fluid connection (20) on the split buffer tank;

f) a guide bar inside the split buffer tank in the form of a center guide squared bar (7) to guide the separation disk up and down along the split buffer tank (1) and to prevent rotation of the disk from causing misalignment of the warm-side bypass (3a) with the hot outlet (8), or the hot-side bypass (3b) with the warm outlet (11), at an edge of the separation disk (2), the disk being displaceable up and down along the center guide bar (7) to allow hot and warm fluid accumulation during thermal recharging and discharging of the split buffer tank (1);

g) a separation disk hub (6) to secure the separation disk to the center guide bar (7) and to accommodate a set of counterweight plates (4);

h) the set of counterweight plates (4) balancing buoyancy of the separation disk, to make the separation disk effectively weightless when placed inside the split buffer tank (1);

i) a top position disk stopper (26) to limit displacement of the disk (2) when going to the top position lining up the warm-side bypass (3a) with the hot outlet (8);

j) a bottom position disk stopper (27) to limit displacement of the disk (2) when going to the bottom position, lining up the hot side bypass (3b) with the warm outlet (11);

k) a guide bar attachment (21) to mechanically secure the guide bar (7) to a bottom of the split buffer tank (1); and

l) a pressurized fluid make-up & air vent connection (20) to maintain continuous fluid supply to the system and to allow for allocation of air vent equipment in association with the split buffer tank.

7. The heating/cooling system according to claim 1 in which a Distributed Control System (DCS) logic arranged to work independently or in conjunction with additional DCS controllers comprises the following:
   a) a demand-based sensor/selector (TS0) (22) inside the Secondary System (14) perimeter which functions to monitor an inner temperature and call for heat, starting a pump-1 (13) operable between the buffer tank and the secondary system, if the inner temperature falls below a preset value;
   b) a fluid temperature sensor/selector (TS1) (23) located at a buffer system supply line (12), between a hot outlet (8) of the buffer tank and the pump-1 (13), the temperature sensor/selector registering a first point fluid temperature, operating only when the pump-1 (13) is ON, and if the first point fluid temperature falls below a set point, signaling to start first a pump-2 (17) operable between the buffer tank and the heat source provider and, with a time delay, start the heat source provider (18) to reload the split buffer tank (1) with hot fluid; and
   c) another fluid temperature sensor/selector (TS2) (24) located at a buffer heat source provider supply line (16), between the pump-2 (17) and a warm outlet (11) of the buffer tank to register a second point fluid temperature and shut-off the pump-2 (17), and with time delay, shut off the heat source provider (18) if the second point fluid temperature rises to a second preset value.

8. The heating/cooling system according to claim 1, in which the heat source provider is a direct heating device.

9. The heating/cooling system according to claim 1, in which the heat source provider is an indirect heating device.

10. The heating/cooling system according to claim 8, in which the direct heating device is a boiler.

11. The heating/cooling system according to claim 8, in which the direct heating device is a heat pump.

12. The heating/cooling system according to claim 8, in which the direct heating device is a solar heating arrangement.

13. The heating/cooling system according to claim 8, in which the direct heating device is a solid fuel heating device.

14. The heating/cooling system according to claim 8, in which the direct heating device is a wood fuel heating device.

15. The heating/cooling system according to claim 9, in which the indirect heating device comprises at least one heat exchanger.

16. The heating/cooling system according to claim 1, in which the secondary system comprises an HVAC system for regulating conditions of an enclosed environment.

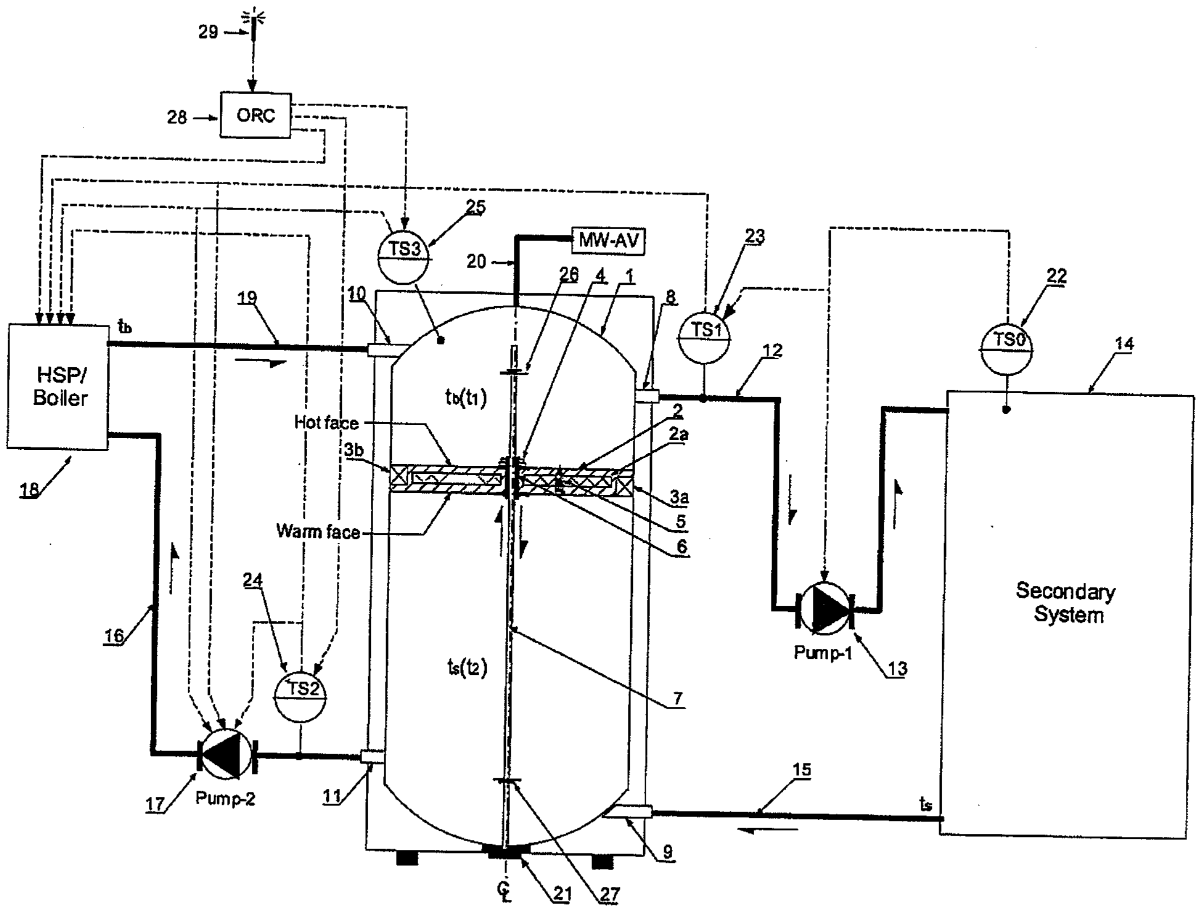
17. The heating/cooling system according to claim 1, in which the secondary system is associated with industrial thermal processes involving cooling/heating applications.

18. The heating/cooling system according to any one of claims 1 to 5 and 7 to 17 comprising a guide bar arranged inside the split buffer tank to guide the separation disk up and down along the split buffer tank.

19. A split buffer tank (1) comprising two outlets, a separation disk (2) inside the split buffer tank and freely movable upward and downward within the split buffer tank toward opposite ones of said outlets to make room for hot and warm fluid storage

on opposite sides of the disk, and two disk flow bypasses (3a, 3b) on the disk that each communicate a respective side of the disk with a respective one of the outlets not on said respective side of the tank when the bypass aligns with said outlet under sufficient movement of the disk theretoward.

20. The split buffer tank according to claim 19 comprising a guide bar arranged inside the split buffer tank to guide the separation disk up and down along the split buffer tank.

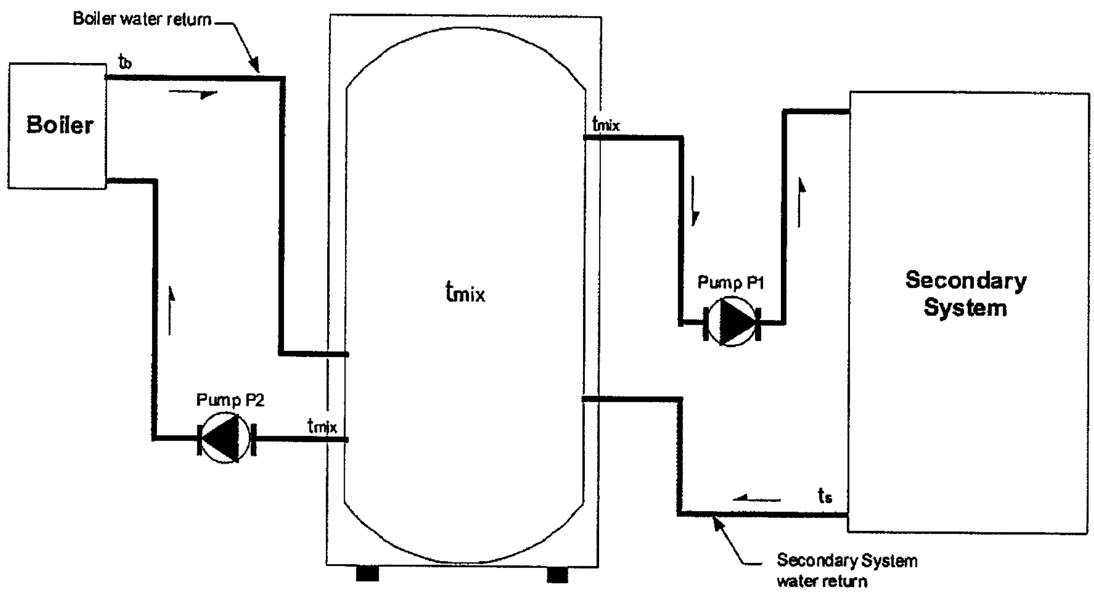


1- Split buffer tank
2- Separation disk (Disk)
2a- Disk core insulation
3a- Warm-side bypass
3b- Hot-side bypass
4- Counterweight plates
5- Pressure release check valve
6- Separation disk hub
7- Guide bar
8- Buffer hot outlet
9- Buffer warm inlet
10- Buffer hot inlet
11- Buffer warm outlet
12- Buffer system supply line
13- Pump-1/System pump

14- Secondary system
15- Buffer system return line
16- Buffer HSP/boiler supply line
17- Pump-2/HSP/boiler pump
18- Heat Source Provider (HSP)/boiler
19- Buffer HSP/boiler return line
20- Water/brine make-up & Air vent connection
21- Guide bar attachment
22- TS0/Secondary system temperature sensor
23- TS1/Buffer system supply temperature sensor
24- TS2/Buffer HSP/boiler supply temperature sensor
25- TS3/Split buffer temp sensor
26- Top position disk stopper
27- Bottom position disk stopper
28- Outdoor reset control
29- Outdoor temperature bulb sensor

FIG.1

PRIOR ART

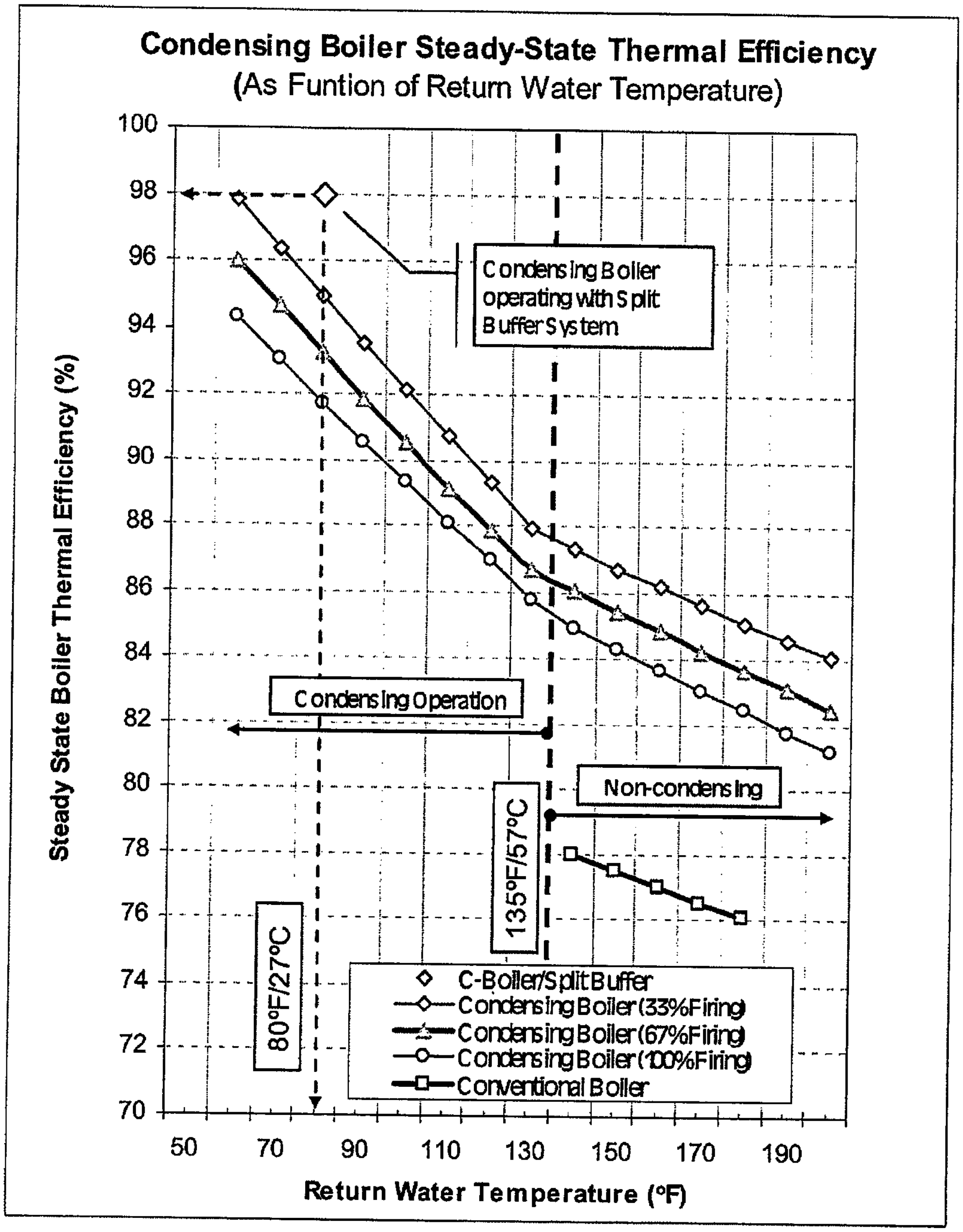


$t_{mix} = (t_b + t_s) / 2$

t_b	Water/brine temperature at boiler outlet. Considered equal to t_1 (See Figure-1) when no heat losses occur in pipe connection between boiler and buffer
t_s	Water/brine temperature at system return. Considered equal to t_2 (See Figure-1) when no heat losses occur in pipe connection between system and buffer
t_{mix}	Water/brine Temperature from mixture of warm and hot water if there is no separation disk (as it happened in existing commercial buffers).

FIG.2

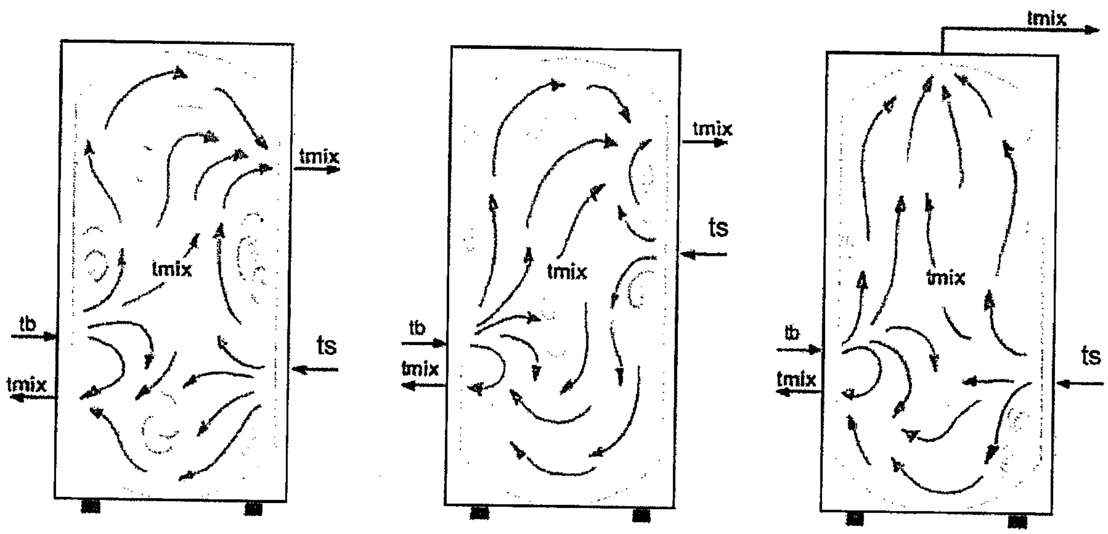
PRIOR ART



Simplified Condensing Boiler Steady-State Thermal Efficiency As A Function Of Return Water Temperature.
Cooke 2005. *"Condensing Boiler Technology"*. Presentation made by Jim Cooke of Mechanical Systems NorthWest to the Puget Sound ASHRAE Chapter in Nov 2005. Available at <www.pugetsoundashrae.org/PDF_files/AshraeCondensingtechnology.ppt>. Accessed November 22, 2009

FIG.3

PRIOR ART



Case (a)　　Case (b)　　Case (c)

FIG.4

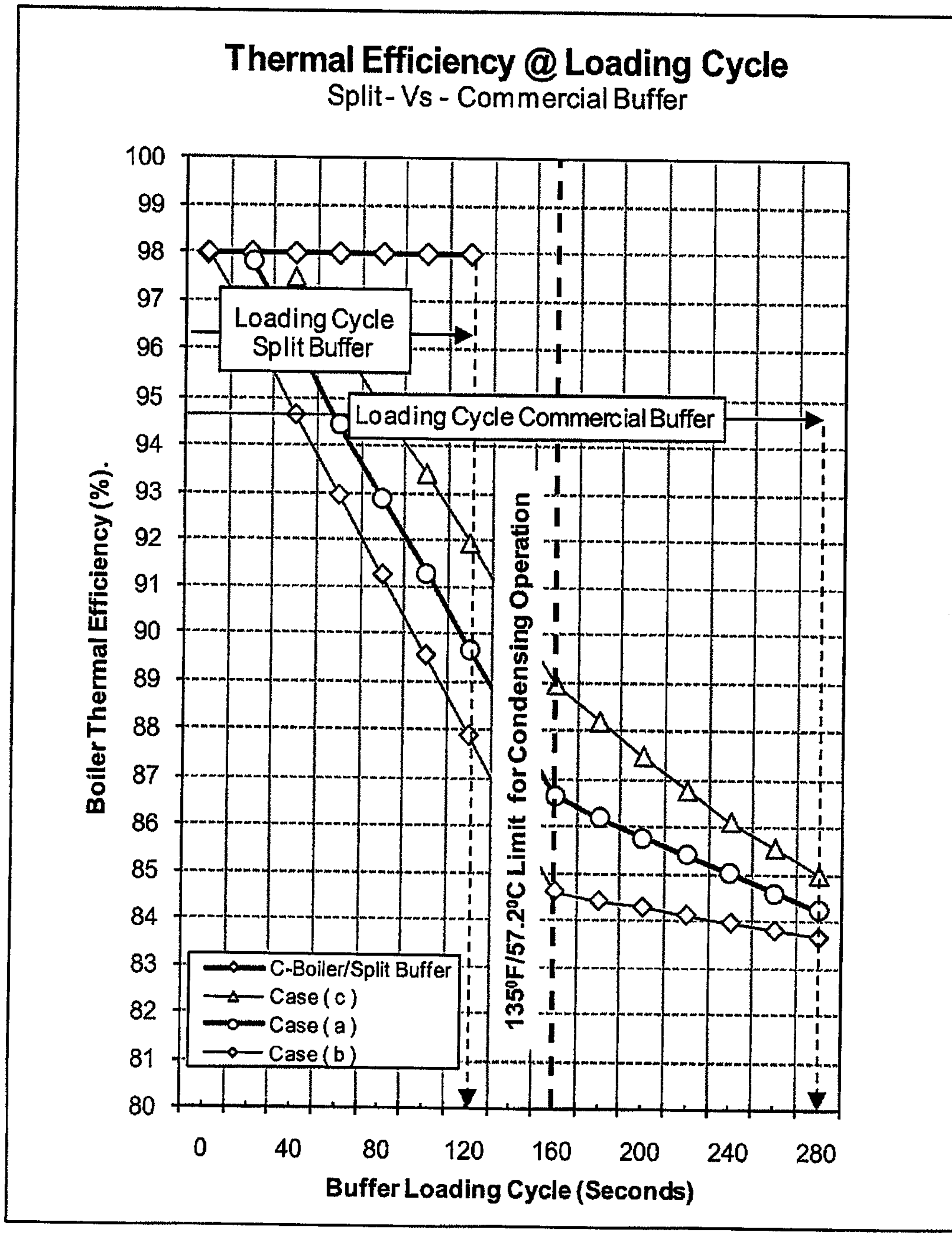
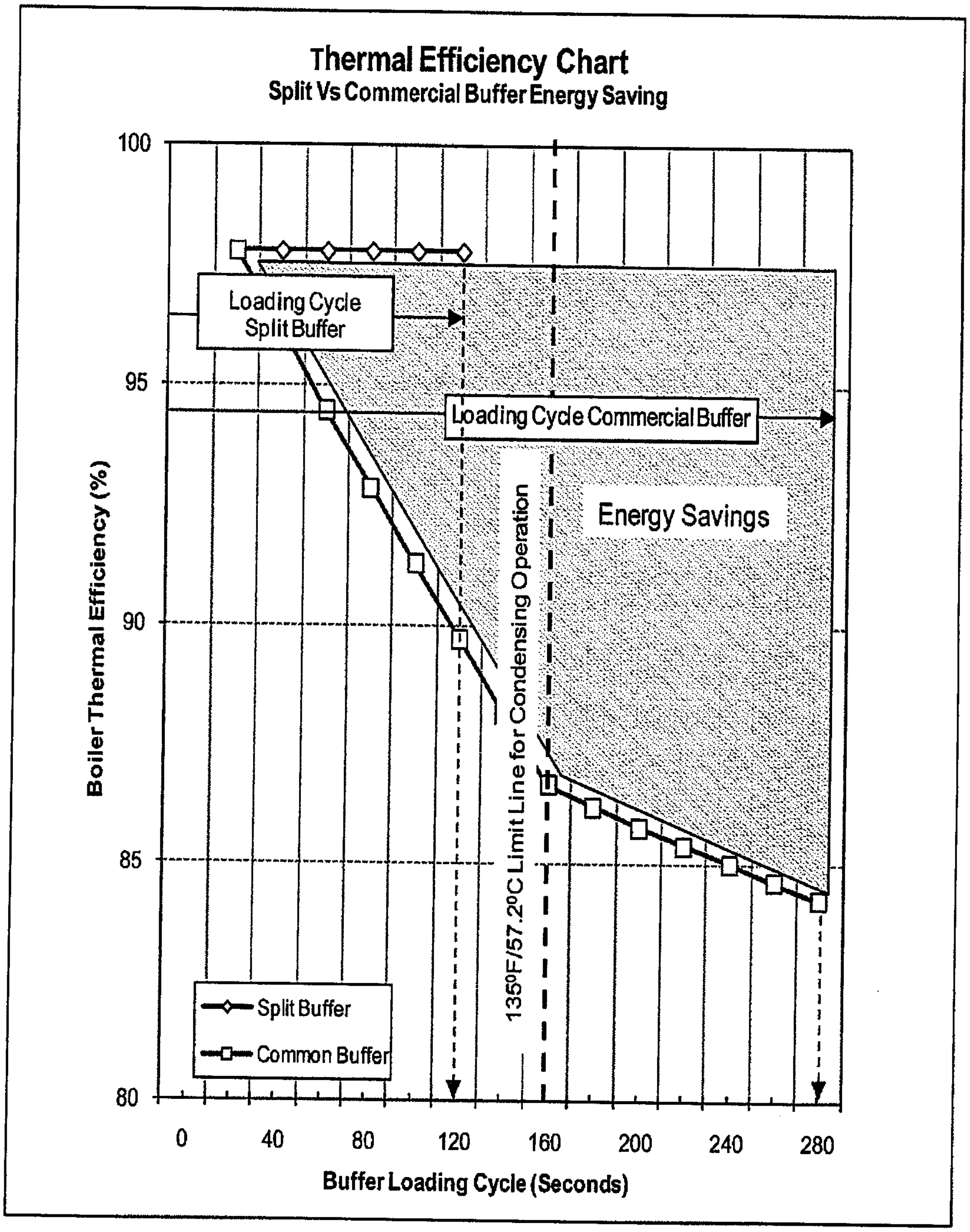
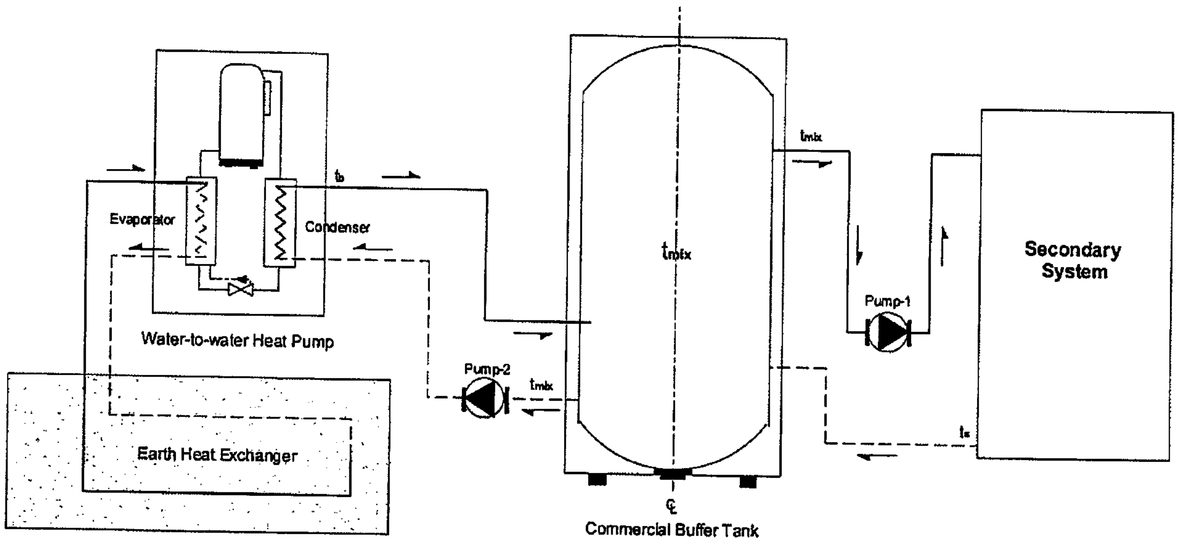

Thermal Efficiency @ Loading Cycle
Split- Vs - Commercial Buffer
Loading Cycle Split Buffer
Loading Cycle Commercial Buffer
135⁰F/57.2⁰C Limit for Condensing Operation
Boiler Thermal Efficiency (%).
Buffer Loading Cycle (Seconds)
C-Boiler/Split Buffer
Case (c)
Case (a)
Case (b)
100
99
98
97
96
95
94
93
92
91
90
89
88
87
86
85
84
83
82
81
80
0
40
80
120
160
200
240
280

FIG.5



Thermal Efficiency Chart
Split Vs Commercial Buffer Energy Saving
100
95
90
85
80
Boiler Thermal Efficiency (%)
Loading Cycle
Split Buffer
Loading Cycle Commercial Buffer
Energy Savings
135⁰F/57.2⁰C Limit Line for Condensing Operation
Split Buffer
Common Buffer
0
40
80
120
160
200
240
280
Buffer Loading Cycle (Seconds)

FIG.6



PRIOR ART

FIG.7a

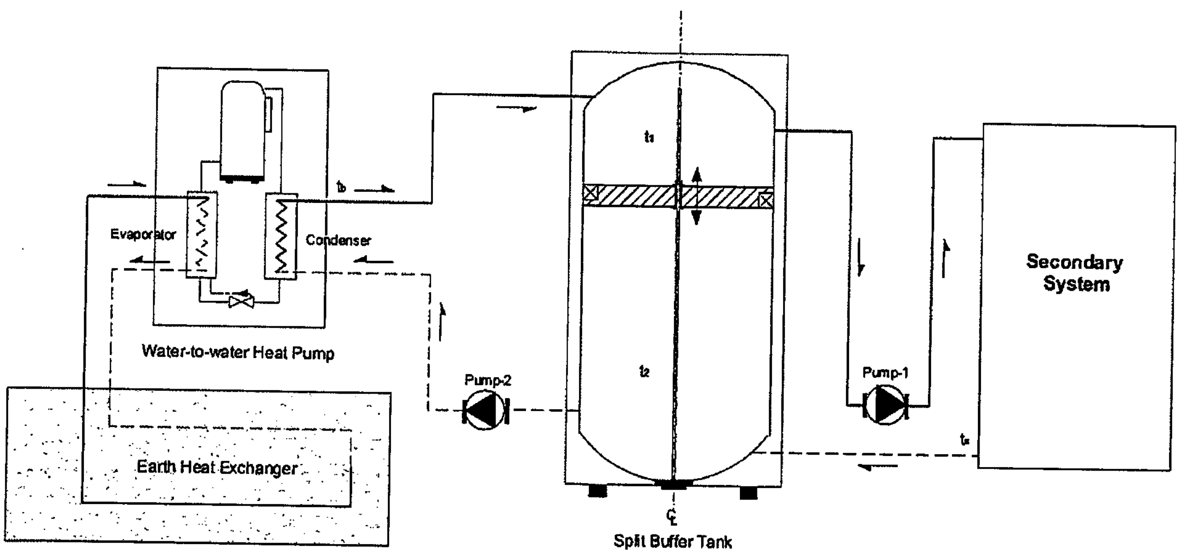


FIG.7b

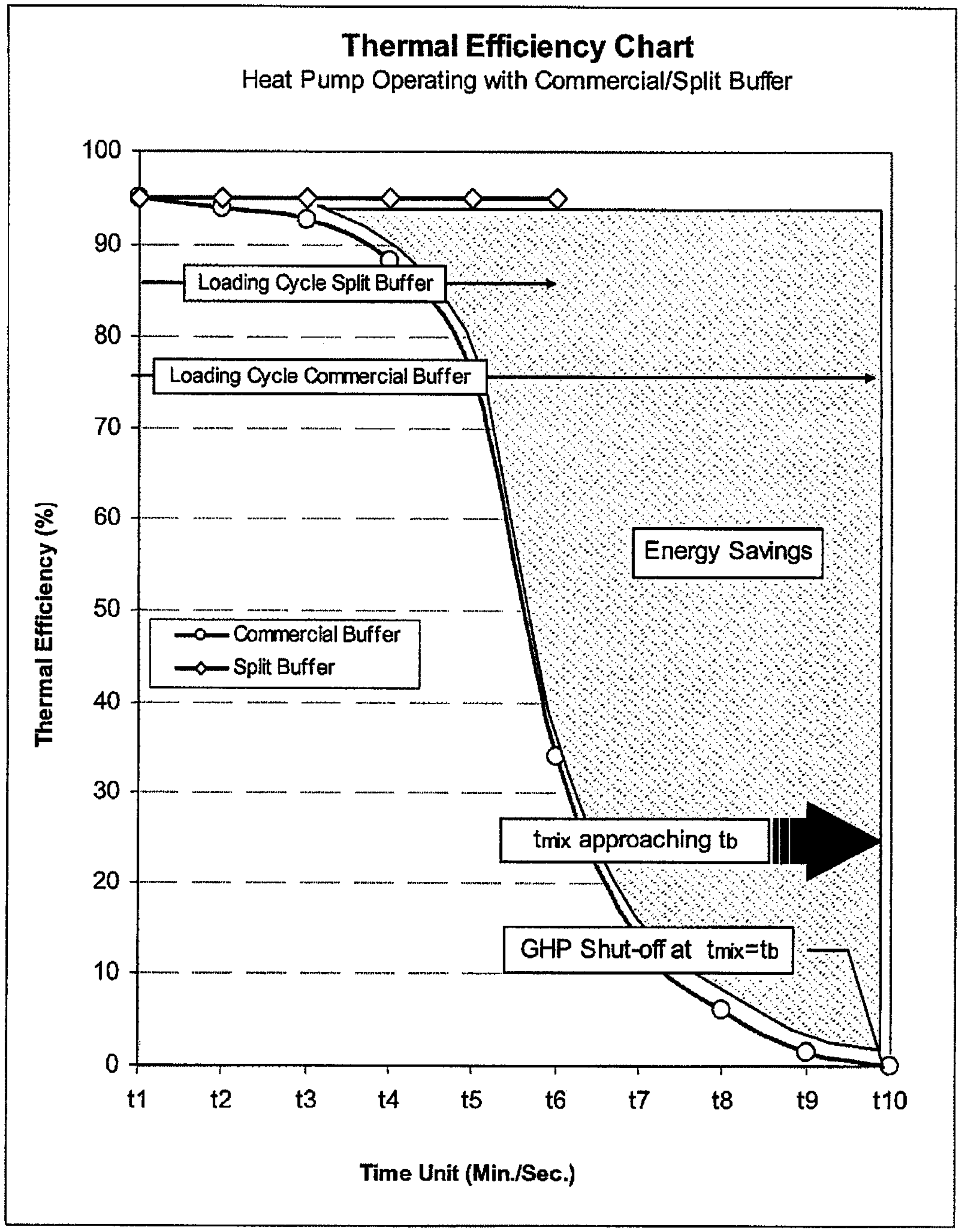

Thermal Efficiency Chart
Heat Pump Operating with Commercial/Split Buffer
100
90
80
70
60
50
40
30
20
10
0
Thermal Efficiency (%)
Loading Cycle Split Buffer
Loading Cycle Commercial Buffer
Energy Savings
Commercial Buffer
Split Buffer
tmix approaching tb
GHP Shut-off at tmix=tb
t1
t2
t3
t4
t5
t6
t7
t8
t9
t10
Time Unit (Min./Sec.)

FIG.8

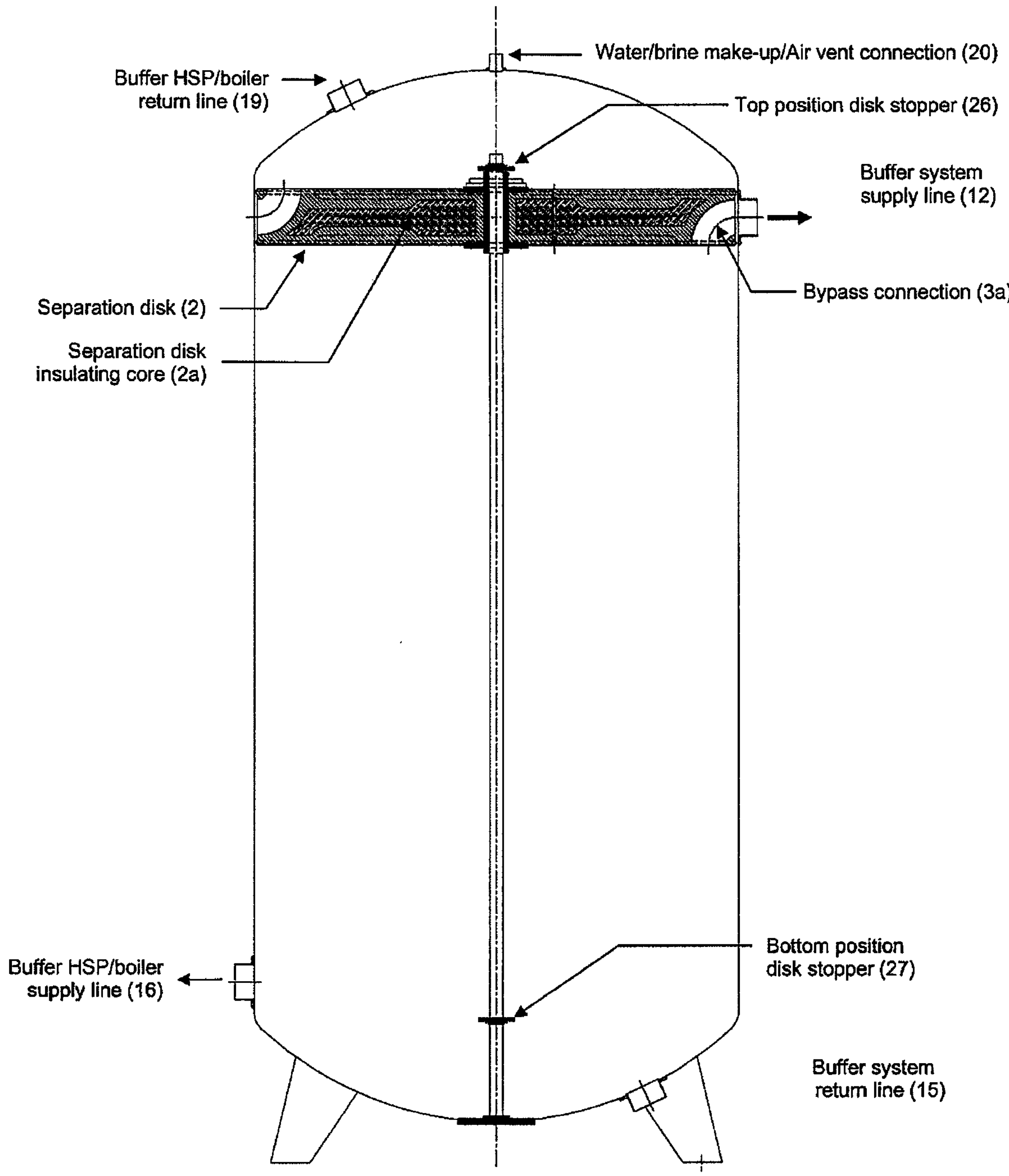

Water/brine make-up/Air vent connection (20)
Buffer HSP/boiler return line (19)
Top position disk stopper (26)
Buffer system supply line (12)
Bypass connection (3a)
Separation disk (2)
Separation disk insulating core (2a)
Bottom position disk stopper (27)
Buffer HSP/boiler supply line (16)
Buffer system return line (15)

FIG. 9

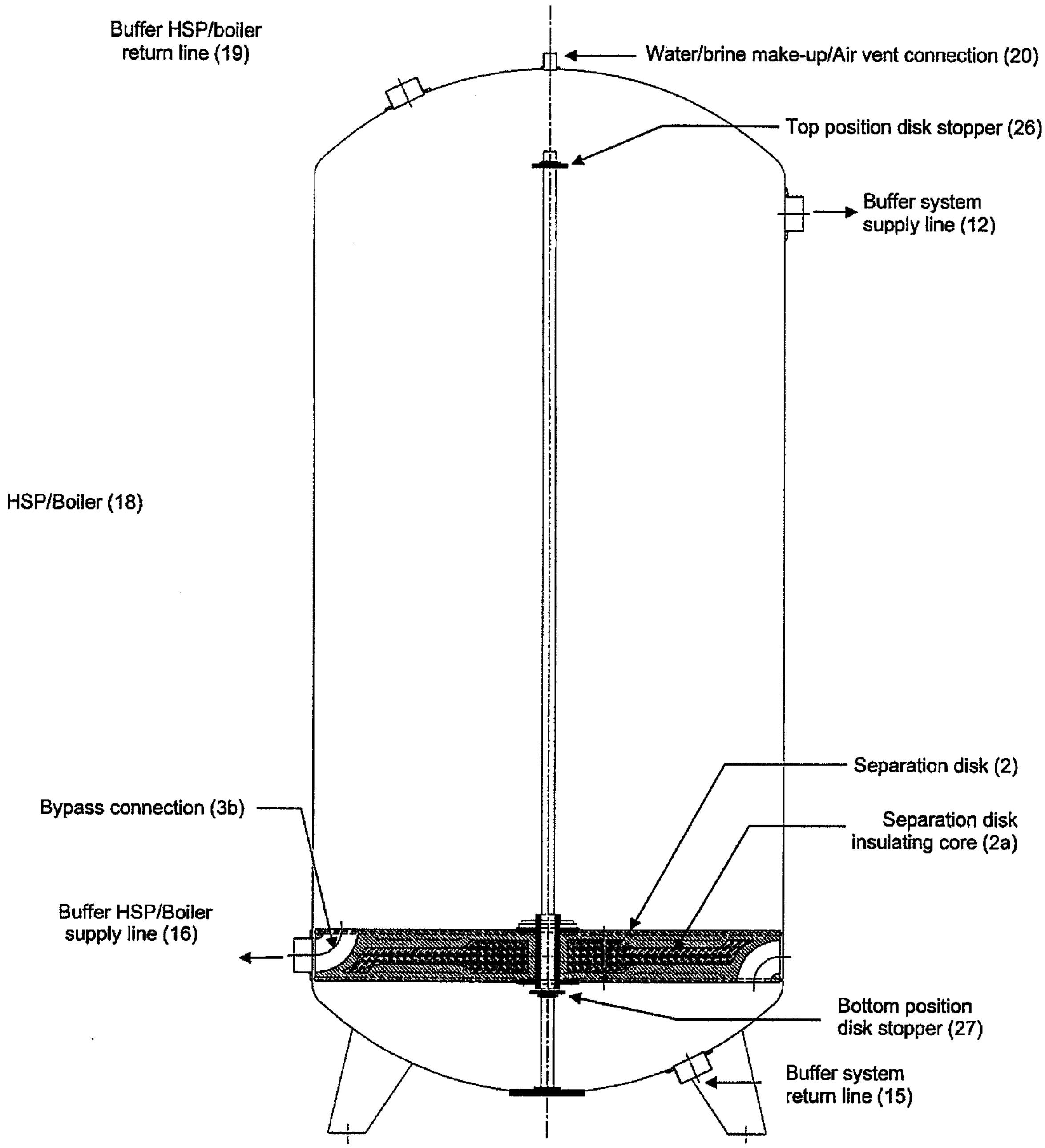

Buffer HSP/boiler
return line (19)
Water/brine make-up/Air vent connection (20)
Top position disk stopper (26)
Buffer system
supply line (12)
HSP/Boiler (18)
Separation disk (2)
Bypass connection (3b)
Separation disk
insulating core (2a)
Buffer HSP/Boiler
supply line (16)
Bottom position
disk stopper (27)
Buffer system
return line (15)

FIG. 10

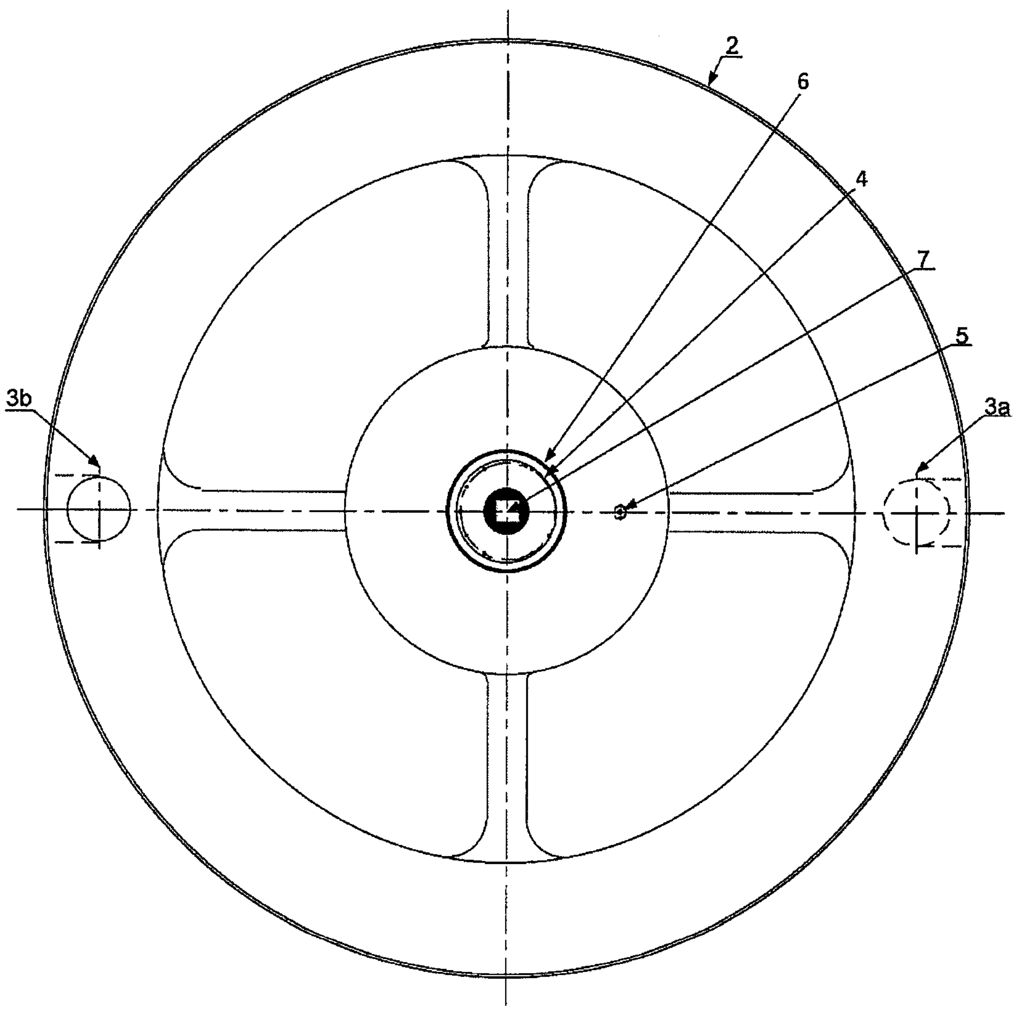
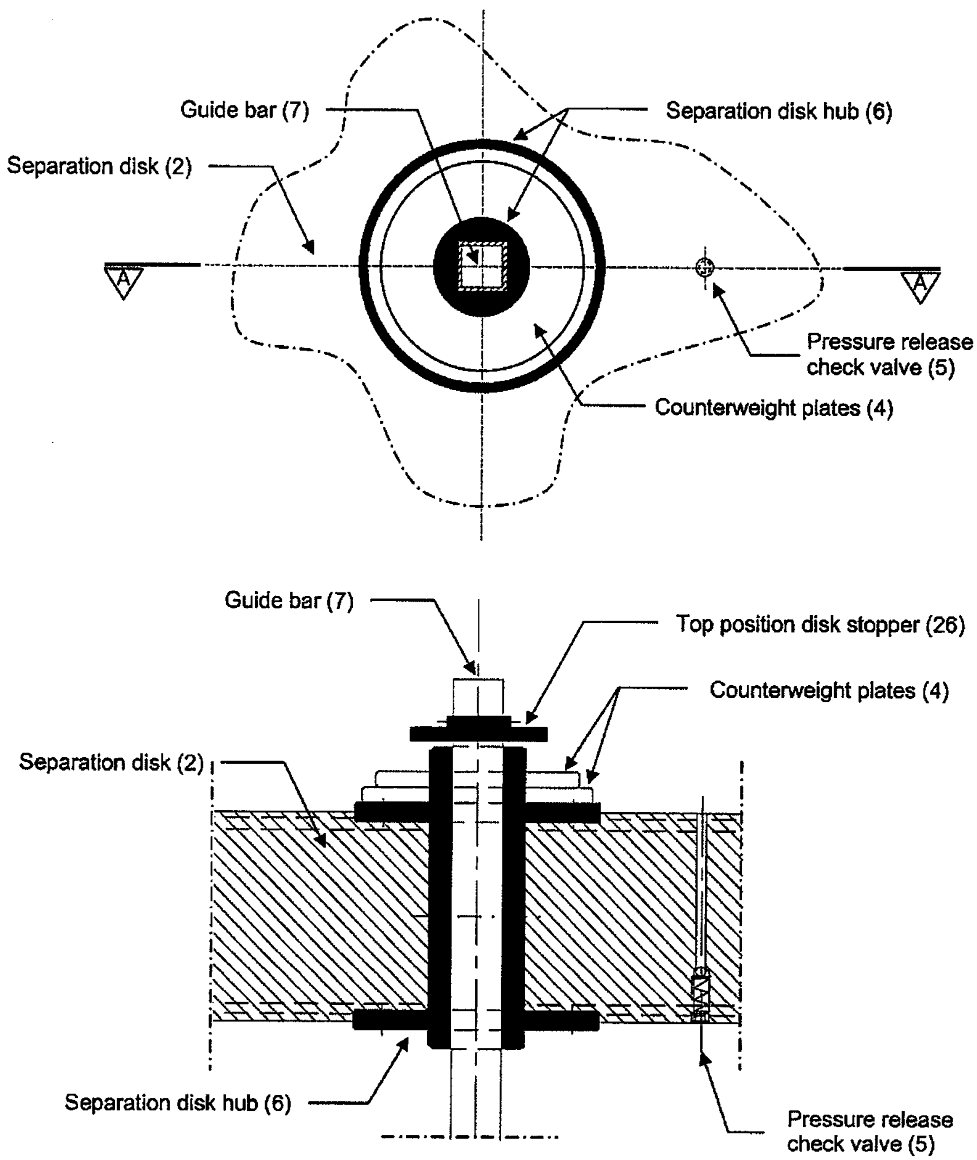


FIG. 11



Cutaway A-A

FIG. 12