Galt House East Hotel and Waterfront Office Building

Marion E. Pinckley, Pinckley Engineering, Inc., Louisville, Kentucky

Key words. district heating, *air conditioning,* hotel, Kentucky

Largest Geothermal heating and cooling system in **U.S.A.:**

1. 4500 tons cooling
2. 67 MM btu/hour heating
3. Economical to build
4. Easy to maintain
5. Extremely economical to operate
6. Environmentally beneficial

Heating and air conditioning is provided for (600), 750 square foot hotel rooms, (100), 1800 square **foot** apartments, 150,000 square feet of meeting rooms, ballroom and public space, and 960,000 square feet of office building totaling 1,740,000 square feet (Fig. 1). The system can extract 2800 gallons per minute of ground water from four wells at 58°F and can either remove energy from the well water for heating or add heat to the well water from the air conditioning. The water is then discharged into a storm water system. Construction and operation costs are extremely low compared to other systems commonly installed in a similar complex. Simplicity and reliability have been the most common opinions expressed by those who have observed the system.

Basic System:

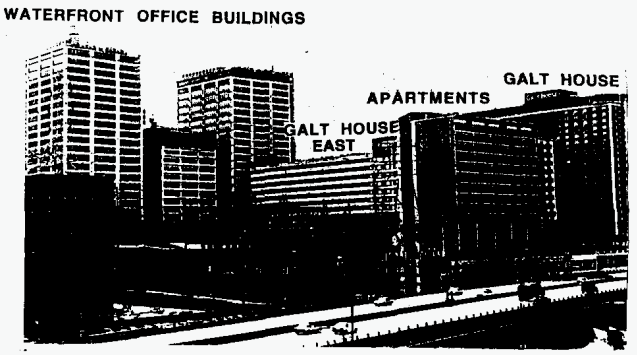

Fig. 1

Hotel rooms are conditioned with one ton capacity **stacked** heat pumps. The apartments, meeting rooms, ball room, and public areas are conditioned by heat pumps varying from 3 tons to 20 tons. Total heat pump connected load is approximately **1700** tons for the hotel and apartments.

The office building complex has (2) 25 story towers and one 15 story tower with total area of 960,000 square feet with a heat pump connected load of approximately 3000 tons.

Ground water at 58°F is pumped into a reservoir under the mechanical room. Water, from the reservoir, then flows into a storm sewer system which flows into the Ohio river. The wells are 130 feet deep and provide 700 gpm each with 15 horsepower pumps. Water from the reservoir is circulated through plate and frame heat exchangers which separate the ground water from closed loop circulation systems in the buildings. The closed loops are connected to water **source** heat pumps which can extract heat from the loop water or inject heat into the loop water depending **on** the requirement **of** that space. Each space therefore can have heating or cooling at any time.

There is a total of 65,000 gallons of water flowing through the entire loop system, 25,000 gallons in the hotel loops and 40,000 gallons in the office building loops. During a typical summer, water is stored at an approximate temperature of 80°F while maintaining an average temperature of 55°F in the winter. During spring and fall energy can be simply removed from the buildings during the day and put into the loops and 140,000 gallon reservoir to be used at night. The Galt House East has a high internal load due to its occupants; therefore, incorporating geothermal heat pumps with the use of thermal storage has proven *to* be very efficient. The use of thermal storage allows the controls to shut down the well pumps (sometimes for as long as a week) and use the BTUs stored in the reservoir during the day, with a net cooling load, to heat the building during the night if necessary.

If the reservoir and loops reach 80°F during the day and reduce to 60°F at night stored energy will be:
205,000 gallons x (80° - 600) x 8.33 pounds per gallon = 34,153,000 btu. This does not include energy stored in piping, heat exchangers, pumps, heat pumps, etc.

The office buildings are conditioned with package heat pumps of 10 to 20 ton capacity for interior areas. The exterior is conditioned by stacked vertical units for each bay. Exterior zones are defined as approximately the outer twelve feet.

Controls:

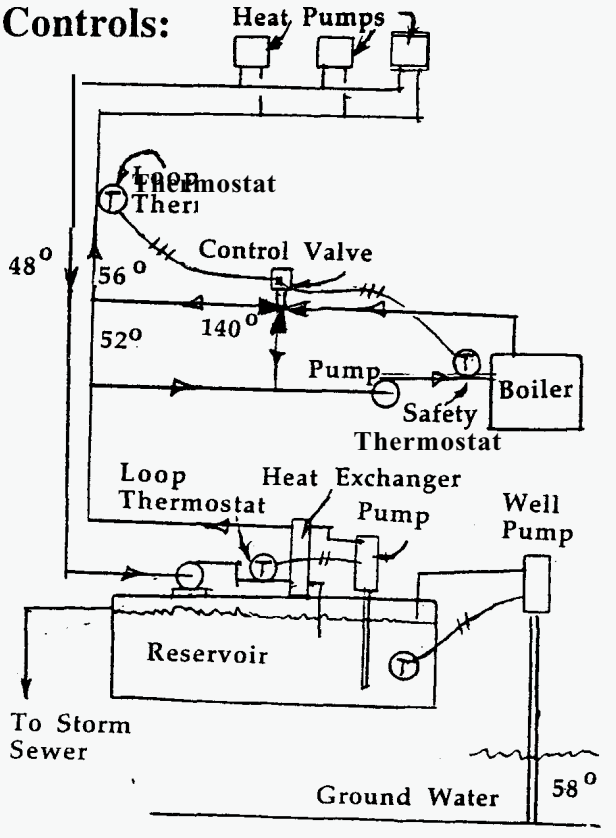

Fig. 2

A. Well pumps are activated by the reservoir temperature. If the temperature rises above 85°F (summer) or below 57°F (winter) four pumps are activated in the sequence of one for each degree above the summer set point or one degree below the winter set point.

B. Heat exchanger pumps on each of four loops are activated by the return water temperature from that loop of 86°F (summer) or 56°F (winter).

C. Each loop recirculation pump is driven by a variable frequency drive. The drive is controlled by the required loop water pressure difference across the most distant unit by the signal from a pressure differential transducer.

D. Each heat pump has a refrigerant pressure control valve to meter the quantity of loop water to be used. On cooling the quantity of water through the unit is controlled by unit head pressure. For heating, suction pressure controls water flow. When the unit is off, water flow is off.

E. An energy management system controls temperatures in meeting rooms and in hotel tenant rooms when they are not occupied. Apartments are not externally controlled due the owner's concern for tenant desires. Each meeting room has a normal manual thermostat with a temperature sensor installed in it. When the energy management system is activated it deactivates the room thermostats and uses the signal from the added sensor to control the room temperature. If the energy management system is down for any reason, the room thermostats regain control. The room thermostats also provide the political advantage by giving tenants something to change. The energy management system for the office buildings is basically the same. Interior spaces are controlled by the central system. However, each floor has a timed override button for tenants using the space during nights or on weekends. The central system and main control cables are adequate to serve all the tenant space but exterior space is only controlled if tenants desire.

F. Boiler standby heat, if required, is injected into the system from a boiler recirculation loop connected to the four main loops. If heat is required in a main loop a three way valve extracts cold water from that loop and replaces it with warm water. Boilers are seldom required. The cost of operating backup boilers was $500 for December, 1989, which was the coldest December on record in Louisville.

Economics:

Table 1

	Demand		Total KW		Total $	
	GH	GHE	GH	GHE	GH	GHE
1991 Apr						
May	1884	1092	907,546	571,680	42,751	26,167
June	2196	1175	1,118,536	565,440	59,257	30,396
July	2378	1242	1,325,889	676,800	67,357	34,374
Aug	2573	1380	1,426,339	686,400	72,093	36.004
Sept	2407	1282	1,232,804	608,640	65,437	33,,043
Oct.	2305	1183	1,045,052	589,920	49,739	26,955
Nov	1913	1053	913,040	555,360	42,615	25,730
Dec	1847	1075	822,237	519,840	48,321	23,635
1992 Jan	1596	1002	796,460	512,640	36,070	22,857
Feb	1758	980	791,746	498,720	38,409	16,344
Mar	1750	924	828,839	48,960	38,908	21,548
Apr	1641	955	751,315	457,440	35,761	21,263
Total			11,959797 KW	6,369,480 KW	$591, 018	$318,316

Table 1 is recorded demand, KW usage and power costs for the Galt House (GH) and for the Galt House East (GHE) during a year when occupancy was basically equal in the two hotels.

The Galt House East's energy cost is approximately 53% of the adjacent Galt House, when subjected to the same rented room/meeting room occupancy. The adjacent Galt House has heat pumps in the fust three floors, which include meeting and public space. The remainder is served by electric heat from air units and package air conditioning units with electric heat. An energy management system and better insulation in the Galt House East contribute to the total savings but the all-heat-pump, geothermal system contributes the major portion of the savings.

Pump capacity and pipe sizing was determined with a .75 diversity factor against connected load, due to use of water regulating valves, which proved to be rather high. A .65 diversity would have been more accurate. The office building pump and pipe sizing was based on maximum calculated load plus 20%.

This created very significant savings in mechanical construction cost and, due to reduced pump size electrical cost was also reduced.

Due to water regulating valves and variable frequency drives on the Galt House East circulating pumps the pumps quite normally are operating at 25% to 30% of full load current. With 200 hp running at 70% less than full load, savings are: 200 HP x 70% x .746 KW/HP x $.065/KW x 8760 hours/year = $59,468.00/year. The office buildings are not filled but similar savings are expected on that system.

A four foot tall, fifteen horsepower 700 gpm pump provides a HVAC system with 3,500,000 btu per hour of heating or cooling which equals a 300 ton chiller/cooling tower combination and a 4,000,000 btu per hour input boiler. The well pump and a heat exchanger pump will cost approximately $ 1.50 per hour to operate vs. $ 15.00 to $20.00 for the more conventional system.

Maintenance has been very favorable as to cost and personnel requirements. A heat pump package does not require the skill and experience required by a centrifugal system with four pipe controls, VAV or other systems common in large complexes.

In addition to saving approximately $25,000.00 per month in energy cost the geothermal heat pump has been very reliable due to each space having its own system. The system also has reduced capital requirements during construction since the major portion of the equipment need not be purchased until needed. *Also,* we did not have to furnish a 4,000 ton cooling tower or provide space and support for it.

I have priced a central system for this complex to calculate cost saving and I estimate that our cost has been $500.00 less per ton than a central system for total saving of $2,350,000.

The above adds up to lower initial cost, lower operating cost, and a very friendly system to the owner, occupants, and to maintenance personnel.

Environmental Advantage:

Due to the considerable reduction in power, emissions from the Louisville Gas and Electric Company generation stations will be reduced.
The following table is emission predictions from Louisville Gas and Electric.

Table 2

Emissions per 1,000,000 KW	
Co_2	340,000 pounds
So_2	8,000 pounds
HO_x	6,000 pounds
Particulate	1,000 pounds

Savings on just the Galt House East per Table 1 with approximate 5.5 million KW saved will be:

Table 3

Emission/Million KW x 5.5 MMKW saved = pounds/year emission reduction	
Co_2	1,870,000 pounds
So_2	44,000 pounds
NO_x	33,000 pounds
Particulate	5,500 pounds

Chemical emissions from cooling tower bleed and boiler blowdown also are eliminated by the geothermal heat pump system.

Conclusion:

When an adequate supply of ground water is available, a Geothermal Heating and Air conditioning system is vastly superior to other systems commonly used in complexes like Galt House East/Waterfront Building or individually in apartments, hotels, or office buildings.

Technology of our system is quite simple since it merely follows a law of physics that says, "heat flows down hill". All ductwork, piping, pumps, fans, controls, etc. are common to other more conventional systems.!

Many power companies in the United States are helping promote geothermal heating and air conditioning due to reduced power demand which will help delay construction of new plants.

Interest in geothermal heating and air conditioning is increasing rapidly and, due to it's advantages, will eventually be a major factor in the HVAC industry.