# The Equitable Building

## Heat Pump System

**A National Historic Mechanical Engineering Landmark**

Dedicated May 8, 1980
in Portland, Oregon

A Century of Service
1880*1980

# Dedication Ceremony

National Historic Mechanical Engineering Landmark
The Equitable Building
Portland, Oregon
1:00 p.m., May 8, 1980

# Program

**Welcome**
Harry Reeder, Vice President, Region VIII

**Introduction**
Paul E. Oliver, Chairman, Oregon Section

**Major's Address**
Mayor Connie McCready

**ASME Landmark Program**
Prof. J. J. Ermenc, Chairman, National History
& Heritage Committee

**History of Equitable Building**
J. Donald Kroeker

**Presentation of Plaque**
Dr. Charles E. Jones, President-elect, ASME

**Acceptance of Plaque**
President of Far West Federal Savings, Guy Jacques

**Closing Remarks**
Paul E. Oliver

# Introduction

The use of heat pumps for the heating and cooling of the Equitable Building, initiated in 1948, was a pioneering achievement in the Western hemisphere. The theoretical conception of the heat pump was described in a neglected book, published in 1824, and written by a young French army officer, Sadi Carnot. Its practical application on a large scale is attributable to designers J. Donald Kroeker and Ray C. Chewning; building engineer, Charles E. Graham, and architect Pietro Belluschi.

In 1948 if one were to predict the site of the first commercial heat pump installation in the US, Portland, Oregon would probably not even be on the list. Located in the north end of the Willamette Valley, the confluence of the Willamette River and the Columbia River, Portland enjoys a moderate climate. Winter average temperature is approximately 38°, while the summer average is 64°F. In 1948 the standard for building design because of the moderate temperatures in the summertime, did not require air conditioning in the Willamette Valley.

The time that Equitable Savings & Loan decided to build a new headquarters building in Portland, the chairman of the board was Ralph H. Cake, a Portland native born in 1891. During the war there had been a moratorium on the construction of commercial buildings. In 1946 the partial relaxation on commercial building was granted under a permit system, and a federal office was created to review the applications and grant permits. Anticipating this procedure, Mr. Cake went to Washington, D.C. carrying plans for the new building. After a conference with the Administrator, assured approval was given, resulting in the first permit for construction of a large commercial building in a nation following World War II.

This building was to be unique in the following ways: It was the first architectural style of a building that was to become standard for the next several decades. The building design by Pietro Belluschi, a nationally prominent Portland architect, was the first to use the natural colored aluminum sheathing, cast in anodized aluminum spandrels and heat absorbing double plate, green-tinted windows. The use of aluminum in a Portland building was a natural, because of the production of aluminum in the northwest which was a result of the low-cost available hydro-electric power.

A building of this type with no opening windows required an air conditioning system capable of providing an environment of comfort through summer and winter conditions. Ralph Cake had insisted on air conditioning in his buildings and heard about the heat pump used in England. Being a man of innovation he pressed for the use of the heat pump in this building. The office of J. Donald Kroeker was selected as the engineering form to design the heating, ventilating and air conditioning system incorporating the first heat pump installation in the western hemisphere. Site clearance began in May 1946, and the building grand opening was held in January 1948.

# A Heat Pump in an Office Building

SUMMARY–A description of the largest heat pump installation in the U.S. Year around air conditioning is effected by automatic switch-over from heating and cooling as required. Special features include heat recovery from ventilation exhaust air and heating of incoming ventilation air with waste cooling water resulting in a reduction of normal heat requirements by one third.

Water at two different temperatures is supplied by wells of different depths. No provision is made for auxiliary heating. Circulated air is the heating or cooling medium arranged to permit change of partitions without effect on distribution of air.

Comprised of 12 rental office stories, basement, and two penthouse levels, the building rises 200 ft above the street; is 200 x 100 ft at the street level and 62 x 200 ft at the third floor and above; has a floor space of 212,000 sq ft, and a volume of 2,275,000 cu ft; is the first all-aluminum-clad building in the country; and incorporates some unusual architectural features, such as fixed, double glazed, column-to-column windows flush with the building faces throughout, neither horizontal nor vertical exterior reveals, and utmost flexibility of repartitioning without affecting electrical and mechanical factors.

## Heat Pump–Water to Water

The typical room air circuit occurs on 13 levels. The heat source is well water pumped from two warm wells, roughly 150 ft deep, one of 64½°F at 195 gpm, the other 62½°F at 450 gpm, and is disposed to a 57°F well 510 ft deep. Four condensing units of the hermetically-sealed, diffusion-centrifugal, constant-speed type, two of 200 rated ton capacity using Freon 11 and two of 70 ton rated capacity using Freon 113, are the basic heat pumps. In addition to circulating pumps in separate heating and cooling circuits shown, **settling tank** pumps are used to introduce well water from a settling or storage tank into the heating or cooling circuits as discussed in the following paragraphs.

The heating or warm water circuit is a closed system when heating is the greater, during which time a thermostat in the return, through a step controller, determines the number and selection of condensing units to be operated. The evaporator, or cooling circuit, receives well water through settling tank pumps in a quantity determined by thermostat T1 in the chilled water return, operating valve W1. The chilled water is circulated to cooling coils in the fan units and then, after recovering heat from exhaust air and in turn heating ventilation air, is wasted to the casing of the cool well.

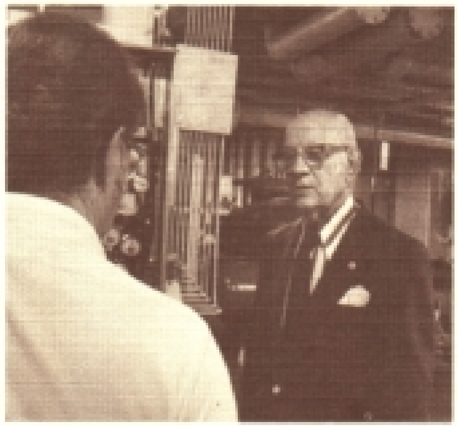
## No Auxiliary Heat Provided

Another unusual feature of the heat pump installation is that it has no provision for auxiliary heat, which to date has been incorporated in other applications larger than residential. The capacity required for cooling was so far in excess of that necessary for heating, since one-third of the load at heating design temperature was provided by waste chilled water that no auxiliary source was seen justified.

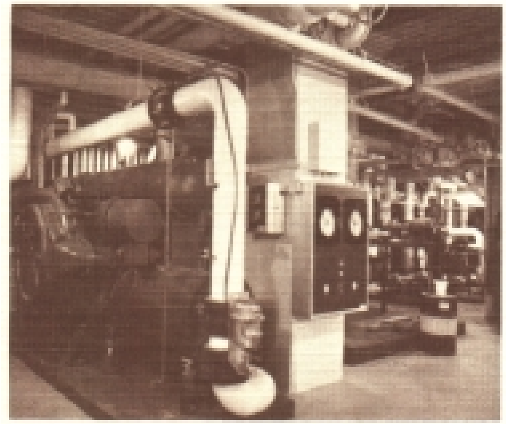
## Costs

Decision to accomplish heating by means of the heat pump was reached after considering first and operating costs, both showing economical feasibility.

Use of the district steam available in heating coils would have made temperature control by air mixing from plenum chambers less accurate and would have required greater cooling capacity to offset



Donald Kroeker, (right), the engineer for the original heat pump system in the Common wealth Building, acted as the consulting engineer for the new installation. Much of the building's original system was utilized in the change-over.



This heat pump, a part of the new installation, has the capacity to run 300 tons of refrigeration. It is one of two heat pumps which heat and cool the Commonwealth Building. When both pumps are running, the system can handle 700 tons of refrigeration.

damper leakage. The same was seen true, though to a lesser degree, in use of district steam to heat water for circulation through the coils in the fan units. The saving in first cost by either system was seen as being within one percent of that of the installation as made. Cost of the installation complete was $0.29 per cu ft, or roughly $1,250.00 per rated ton.

While average operating costs cannot be accurately predicted, and were expected to vary widely with seasons, reasonably reliable comparisons were made. On the basis of a coefficient of performance for heating of 3.5, a 7-mill per kilowatt hour power rate, and a weighted value of waste chilled water utilization, a cost of $0.46 per million Btu for heating was estimated. The applicable rate indicated for district steam during design was 22 percent higher. Steam rates have increased since that time.

## Heating is Largely By-Product

During all normal heating weather a supply of by-product heat is available from cooling. Had steam been used for heating, this by-product would have been wasted. The heat pump made its utilization possible. Further, since air conditioning was a requirement, this cooling load was present in any case. Actually there was no heating period and no cooling season as such. It was difficult to discard the age-honored concept that there must be these two separate seasons and that for comfort below 65°F outside must be charged to heating. Yet, in this instance, this clearly was not the case. In computing its estimate, the power company was therefore requested to charge to heating only the heating load in excess of the by-product from cooling. Further, on the same basis, the company was requested to charge to heating only the portion of the maximum heating demand for any month which exceeded the maximum cooling demand for that month.

Another factor apparent on preliminary analysis was that the estimated building demand normally occurs at 4:30 p.m. and that, except at design heating conditions which do not recur each year, the morning pick-up load does not impose the maximum demand, making it necessary to investigate only the 4:30 p.m. conditions.

## Heating COP for Representative Year Computed

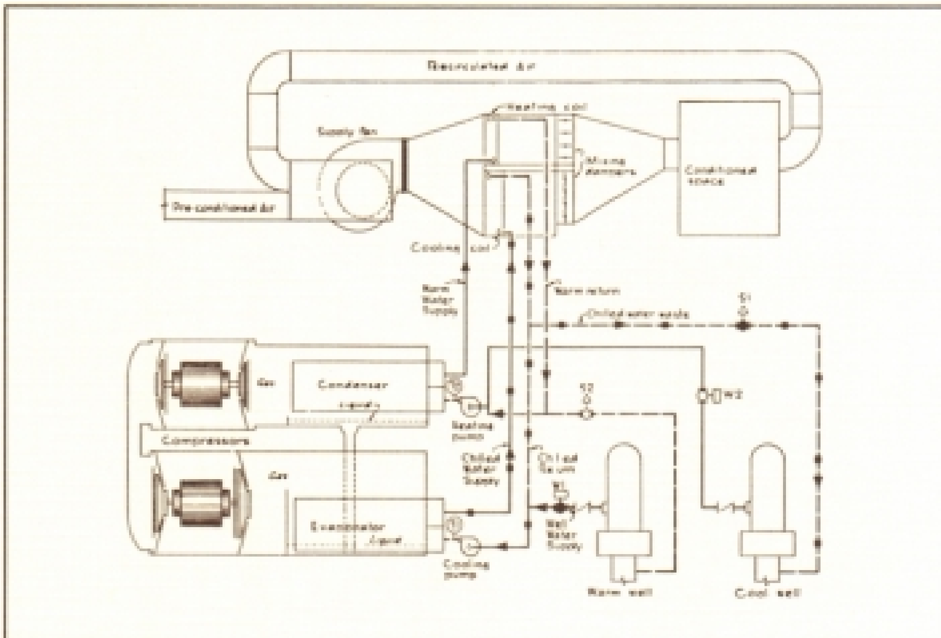
The normal building demand for lights and power, chiefly for elevators, was estimated at 468 kw, the monthly consumption at 113,000 kwhr. The constant fan load was estimated at 67 kw and 23,692 kwhr. All power consumption in excess of 100,000 kwhr. is billed at 3.15 mills, all demand in excess of 10 kw at $1.00 per kilowatt.

The heating load for 1940 integrated under normal heating curves, plus heating accomplished with chilled waste water was computed at 5.01 billion Btu, the power consumption chargeable to heating at 99,000 kwhr or 340 million Btu. Related to each other these figures result in the fantastic **job COP** for heating of 14.8. Including auxiliaries chargeable to heating, this **job COP** for heating drops to 7.8.

Auxiliaries include deep well pumps, settling tank pumps, and warm water circulating pumps. Inclusion of the latter in auxiliaries chargeable to heating is questionable, inasmuch as had steam been used for heating, a hot water generator would have been provided to furnish warm water for circulation to coils.

In general, in any complex heating and cooling system, a coefficient of performance is meaningless without detailed specification of division of load between heating and cooling as herein attempted.

In this application, if it had been contemplated to use steam for heating with the heat pump adapted independently for cooling, the internal cooling, or the minimum cooling requirement, would have been accomplished with outside air reheated as required at temperatures below 60°F, and a COP materially lower would have been shown.




Basic Heat Pump Scheme. Heating Cycle.

Outside air was not used for the internal or minimum cooling, inasmuch as to do so would have required equipment arrangement on each floor, encroaching on rentable floor space and would have necessitated additional complexity in automatic control.

## Actual Performance

The above performance data were based on design computations in 1947. Subsequently, actual conditions and performance were established in 1952-53 from recordings of power input to the heat pumps and numerous auxiliaries, such as pumps. The major change found was an increase in "Actual Cooling Load" over that predicted on the basis of design analyses.

Over its 30 years of operation, some changes have been necessary, such as replacing all water chillers, but the performance is excellent. In 1953, the comparative costs of normal sources of energy would have been for use of distric steam, 6.38 times that used by the heat pump system, and 4.44 for the use of oil to accomplish the heating and cooling required.

As with any modern technological system, change is inevitable over time. Since the original installation, all the heat chillers have been replaced. The building and the capacity expanded. The building has also been expanded by the addition of approximately 30,000 sq. ft. An additional floor and expansions floor 4, 5, and 6. The original design the well water was circulated through the chillers and to the heating coils of the various floor air circulation systems. Subsequent scaling and corrosion damage to those chillers coils on each floor led to the installation of heat exchangers so that there was a closed system of treated water circulated through the coils and to minimize any scaling and corrosion damage. This also reduced the effectiveness of the system somewhat because of the heat exchanger efficiency.

Today, the Equitable Building heat pump provides an economical method of heating and cooling and would comply with the standards of the new federal building Energy Performance Standards being studied and promulgated today.

# Acknowledgements


The Oregon Section of The American Society of Mechanical Engineers gratefully acknowledges the efforts of all who cooperated on the landmark dedication of the Equitable Building, Portland, Oregon.

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The Equitable Building heat pump system is the 44th Landmark to be dedicated since the program was begun in 1973. For information on other Landmarks, contact ASME, 345 E. 47th Street, New York, N.Y. 10017.