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High Temperature Water Heating System Supplies Dover Air Force Base Needs

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Water has long proved to be an excellent heat transfer fluid and the recent increased attention to high temperature water for heating and process reflects the development of system designs which make it possible to utilize the relatively high specific heats of water in and around 300 psig. Here is a description of a large scale high temperature installation at a U. S. Air Force Base.

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PLAINTIFF'S EXHIBIT

RS-263

THE U. S. Air Force Base, Dover, Del., employs a district heating system for the various buildings, warehouses and hangars on the base with a central heating plant serving as the heat source. High temperature water was selected as the most economical medium for distributing the heat.

In essence, high temperature water heating systems are a further development on a larger scale of principles used in countless heating systems for homes, schools and other small buildings. To effect economies on heat transfer apparatus and hot water distribution equipment higher temperatures and necessarily higher pressures are used. Higher pressures were used as early as the 1920's when pressures up to 235 psig (400 F equivalent) were adopted. Since very high temperatures, that is above 380 F, are not often required, except for process heating, the more practical and general range is from 350 F to 370 F. Temperatures above 400 F do not prove economical for district heating service.

High Temperature Water Boilers

The three hot water generators, Figs. 3, 4, selected for the Dover Air Force Base are C-E La Mont controlled circulation hot water boilers designed for 400 psig pressure but operated at 275 psig (415 F equivalent). The specified rated output is 50,000,000 Btu per hr, maximum continuous, when using No. 6 fuel oil of a calorific value of 18,500 Btu per lb, as fired. Each generator is of the watertube type with the boiler tube assembly divided into radiant and convection sections. Each tube circuit is $1\frac{1}{2}$-in. O.D. tubing with an orifice located at the inlet end for metering the water in accordance with the heat absorbing capacity of that tube.

Water from the distribution system enters the boilers through the inlet header at the bottom of the boiler in the rear, Fig. 4. The side wall tube platens and the front wall tubes have connecting headers so that the water parallels the gas flow, due to the single pass boiler design, with water leaving the boiler through the front top header and entering the expansion drum that serves more than one boiler. Water from the expansion drum enters the distribution system circulating pumps which discharge it into the system at 375 psig. Fig. 4 does not show the single separately installed expansion drum.

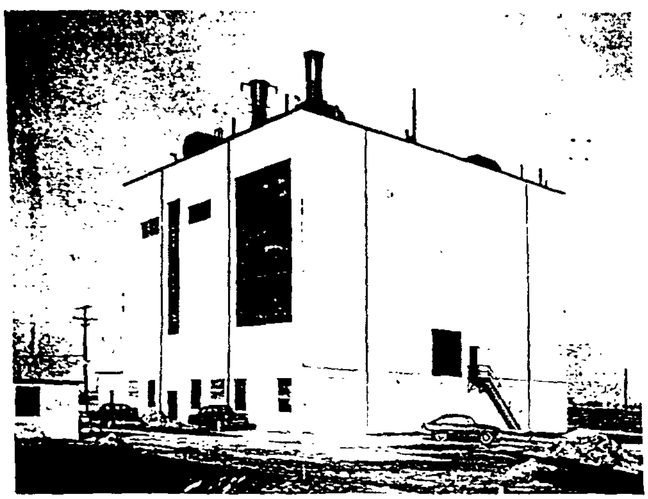

Fig. 1—Exterior view of the boiler plant at the Dover, Del., Air Force Base which can supply with three C-E La Mont controlled circulation boilers a heat load distributed in 98 buildings around the Base

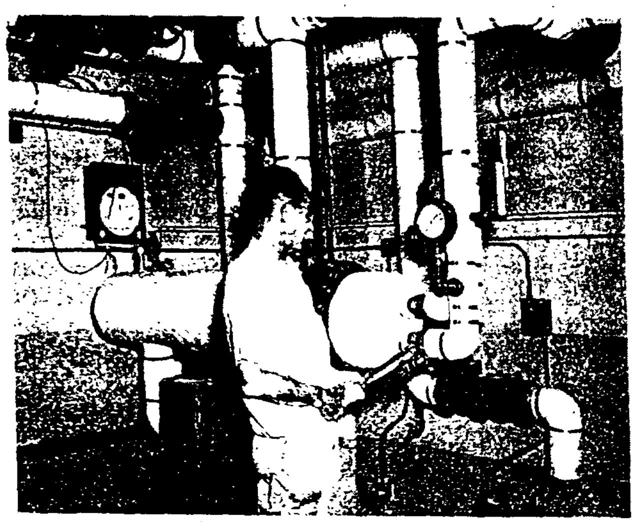

Fig. 2—Heat exchangers have been located in each of the 98 buildings for local building heating needs. Where steam is needed separate heat exchangers are provided. About $14\frac{1}{2}$ miles of interconnecting piping are employed

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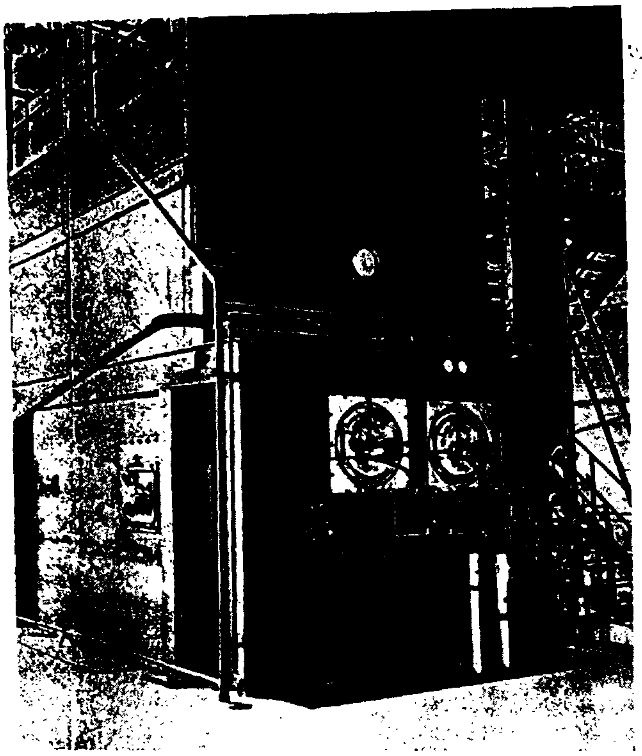


Fig. 3—Compact, fully enclosed design of the controlled circulation boilers, above, permits high degree of shop assembly as well as a conservative use of building space

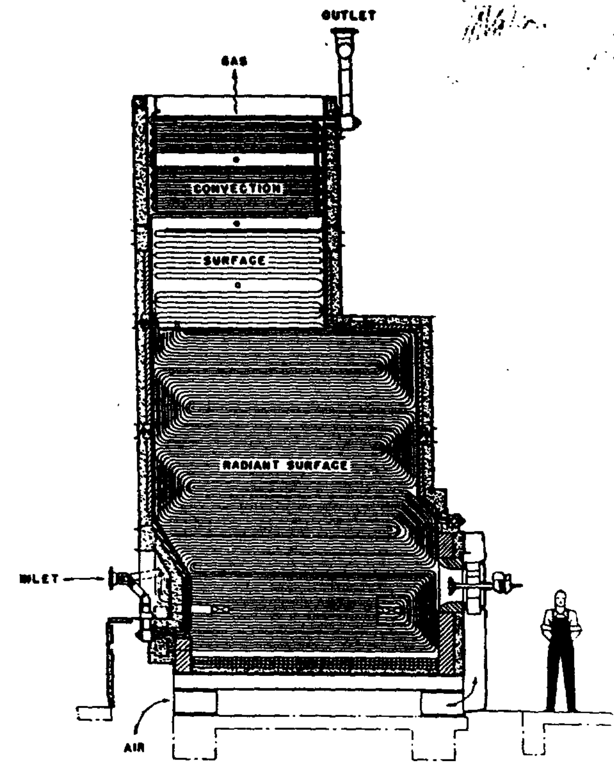


Fig. 4—Sectional view of the C-E La Mont controlled circulation boiler demonstrates its single pass design, freedom from baffles, absence of a boiler drum

Heating Load

At Dover Air Force Base there are 98 buildings requiring heat. Some of these buildings, such as the warehouses, are heated directly with high temperature water at the full pressure in the distribution system, whereas the living quarters, mess halls, and others are heated with low pressure, hot water. These individual heat loads, together with the steam requirements they impose, are listed below:

(*a*) High temperature water at 385 F is distributed directly to the unit heaters installed in the warehouses, hangars and shops.

(*b*) Low pressure hot water heats the living quarters through baseboard convectors, the mess halls by means of unit heaters, the medical buildings with fin tube radiators, the operational buildings also with fin tube radiators and unit heaters, and the special services buildings with fin tube radiators and unit heaters.

This low pressure hot water is produced through indirect heat exchangers, Fig. 2, located one to each utility room. Each of the 98 buildings has its own utility room. The high temperature (385 F) water from the main distribution system passes through the primary coils of the heat exchanger. The low pressure hot water is pumped from the secondary side to the local heating units. The medical and operational buildings will have air conditioning and will be connected into the low pressure heating lines serving the fin-tube type radiators.

Where steam is required, whether it be for cooking, sterilizers or other purposes, a separate high-temperature-water-to-steam heat exchanger has been installed in the building's utility room.

The steam requirements are as follows: Officers Mess Hall—30 psig, Refrigerator Storage—20 psig, Hospital—45 psig, Airmen's Mess Halls—30 psig, Boiler plant—6 psig, Maintenance Shops—30 psig, and the total steam flow amounts to 16,810 lb per hr.

If there were no heat exchangers, a separate boiler would be necessary in each building, requiring a licensed operator or boiler room attendant. Since heat exchangers are classified as unfired pressure vessels, they can be, and are, of course, left unattended except for periodic inspections and servicing visits. This is one of the greatest advantages of a district heating system. With high temperature water, there are other advantages such as the elimination of steam traps, no grading of supply and return lines, no condensate receivers or condensate pumps and a complete return of all unused heat to the central heating plant.

Distribution System

At the Dover Air Force Base, there are three main zones: Zone 1—19,890 ft of piping, Zone 2—35,350 ft of piping, Zone 3—20,850 ft of piping. The total length of these heating lines, excluding internal distribution within the 98 buildings, amounts to almost $14^1/_2$ miles. The main supply and return lines alone total 34,340 feet, the balance being external branches or sub-main circuits.

In steam distribution systems, the system pressure drop is the deciding factor and one which has a direct relation to the diameter of pipe used. With high temperature water, however, it is the design temperature drop which is the governing factor. In low pressure hot water systems for internal hot water space heating, it is usual to design the distribution piping for a temperature drop of 20 degrees F, but with high temperature water he design temperature drop may be as high as 200 de-rees F, although the most commonly used and more conomical design drop ranges from 150 degrees to 160 legrees F.

Another great advantage of high temperature water or heat distribution is its "thermal-flywheel" character-stic. This feature develops from the fact that the en-ire piping system, always maintained full of high tem-erature water, constitutes a vast reserve heat storage. This reserve effect represents approximately a 20 per ent cushion or safety factor in boiler capacity. As a esult boilers can and are designed for the average 24 our temperature rather than the peak load tempera-ure.

The reserve of heat in the entire system at the Dover ir Force Base may be better understood when you real-ze the total water in the complete system, including the hree operating boilers, is about 700,000 lbs. This is an mportant asset in an emergency and one of great value when changes or extensions are contemplated.

System Economies

Economies to be affected by using hot water instead f steam are as follows:

1. **No high pressure steam traps required,** resulting n substantial saving in first cost and a further saving by liminating steam losses likely in normal trap operation s well as attendant maintenance.
2. **Elimination of blowdown,** normally a three per ent operational loss.
3. **No pressure reducing valves needed,** producing a irst saving in valve cost, a second in maintenance and a hird in steam losses from improper regulation.
4. **No safety valve vent losses** such as exist with a team boiler.
5. **No condensate pumps, tanks, controls and vents equired,** avoiding their inherent steam losses.
6. **Elimination of expensive feedwater treatment ystem,** with its continuous chemical cost and main-enance. Water makeup for a high temperature water ystem is negligible and this can be handled with a small atch treatment storage system.
7. **No investment outlays for corrosion protection in ondensate return lines,** representing an essential con-ideration for a steam system but not for a high tempera-ure, water system.

Boiler Advantages

Following the decision to use high temperature water s the heat distributing medium instead of steam, it was lso decided to use boilers especially designed for high emperature water, Figs. 3, 4, rather than units designed o generate steam but modified for hot water. Pre-iously, the conventional watertube steam boiler with nultiple water passes had been adapted for high tem-erature water with mixed and not altogether satis-actory results.

The C-E La Mont controlled circulation boiler, Figs. , 4, especially designed for use in hot water systems rovides the following features:

1. *Controlled circulation* such that water is distributed to the various tubes in accordance with the heat ab-sorbing capacities of the tubes. With this arrangement, a minimum amount of water need be circulated through the boiler with a corresponding minimum pressure loss. With a small increase in head, the system circulation pumps can therefore provide for circulation through the boilers. The need for a separate boiler circulation pump is thereby eliminated thus affecting a saving in initial and operating costs.

2. *No drums* are required on individual boilers. A single expansion drum common to all boilers can be used. This results in a simplification of the control system and eliminates the necessity of providing balance pipes be-tween the various boilers in multi-boiler installations.

3. Special tube arrangement is provided so that:

(*a*) Boiler tubes are *ventable* to the outlet header (and thence to the expansion drum) under all operating con-ditions. Vapor binding will not occur. Even though a small amount of steam may be formed in the tubes under some operating conditions, it will remain entrained until it separates in the expansion drum.

(*b*) Boiler tubes are completely *drainable*, and there are no reverse vertical tube circuits.

(*c*) The boiler has a single pass design with no baffles, and tube arrangement gives *parallel flow of gas and water*. Low metal temperatures are avoided in zones of low gas temperature thus minimizing the possibilities of corrosion resulting from high sulfur fuels.

(*d*) *Maximum furnace water cooling* and the most effective utilization of heating surface occurs. This markedly lengthens refractory life.

(*e*) *Maximum cleanability* is obtained with *minimum fouling* in operation.

4. Miscellaneous advantages include:

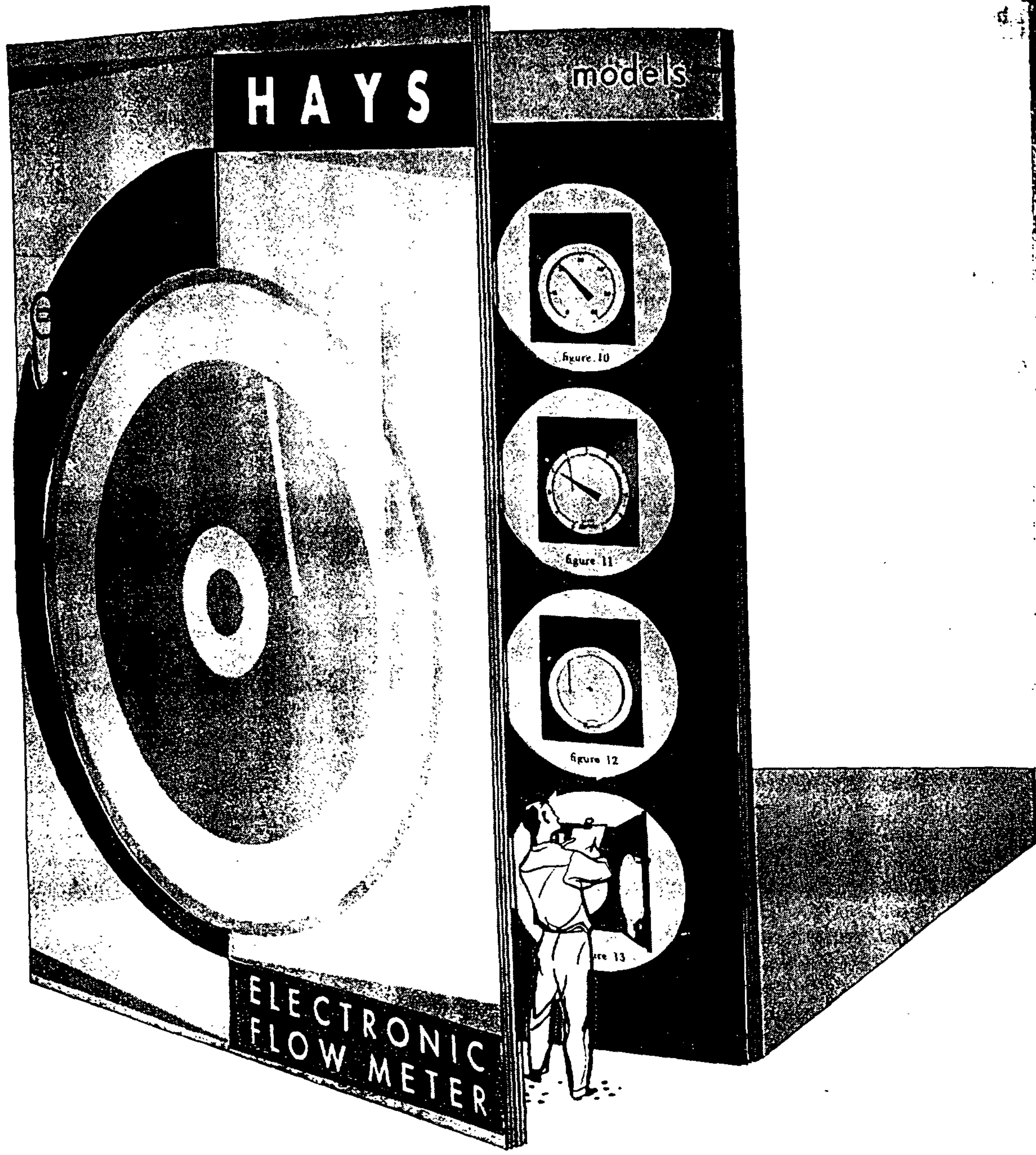
(*a*) Maximum degree of shop assembly thus greatly reducing field erection costs.

(*b*) Complete steel casing suitable for pressurized operation with oil or gas fuels thus eliminating the nec-essity of induced draft equipment.

c) Bottom-supported design thereby reducing struc-tural steel.

d) Adequate access panels for cleaning, inspection and maintenance of convection bank heating surface.

e) Minimum space required saving in building costs.



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