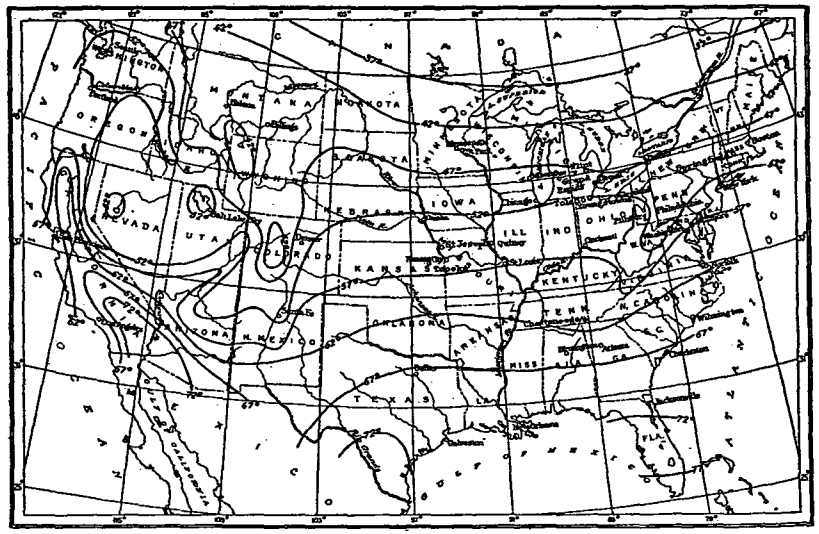


Fig. 4 .... Approximate Well Water Temperatures at Depths of 30 to 60 Ft[1]

and water is required, multi-stage washers are used. These washers are equivalent to a number of washers in series, and the water has to be pumped from one stage to the other in a direction counter to the air flow.

The most common air washer arrangement for cooling and dehumidifying air has two spray banks and is eight to nine feet long. If the air washer has ability to cool and dehumidify the entering air to a wet-bulb temperature equal to the leaving water temperature, it is convenient to assign to such a washer a performance factor of 1.0. The actual performance factor of any washer is the actual enthalpy change divided by the enthalpy change in a washer of 1.0 performance factor.

Calculation of the required performance factor, $F_P$, for any washer application involving cooling and dehumidifying can be made from Equation 2:

$$F_P = (h_1 - h_2)/(h_1 - h_3) \qquad (2)$$

*where*

$h_1$ = Enthalpy at entering air wet-bulb temperature, Btu per pound.

$h_2$ = Enthalpy at leaving air wet-bulb temperature at actual condition, Btu per pound.

$h_3$ = Enthalpy at wet-bulb temperature leaving a washer with $F_P = 1.0$, Btu per pound.

Knowing the performance factor of a particular air washer, the actual conditions of operation can be graphically determined as shown in Fig. 5. Points 1 and 2 are plotted on the saturation curve representing total heat at the entering and leaving air wet-bulb temperatures, $t_1'$ and $t_2'$. Point 5 represents the condition at which leaving air wet-bulb and leaving water temperatures would be the same. This point is determined by solving Equation 2 for the unknown quantity, $h_3$.

$$h_3 = h_1 - \frac{(h_1 - h_2)}{F_P}$$

A diagonal line is drawn through Point 5 with a negative

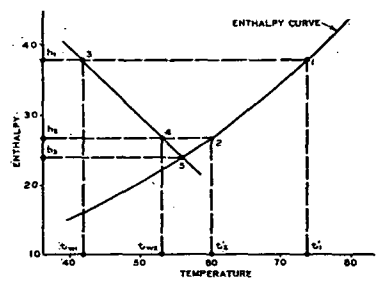



Fig. 5 .... Graphical Solution of Conditions Produced by an Air Washer



slope equal to the water-to-air weight ratio. Points 3 and 4, at which this diagonal line intersects horizontal lines through points 1 and 2, show the required entering and leaving water temperatures $t_{w1}$ and $t_{w2}$. A check of the solution can be made from the fundamental heat balance equation,

Heat absorbed by the water = heat removed from the air.

The graphical method as described can be used to arrive quickly at solutions of air-washer cooling and dehumidifying problems where there are a number of unknown factors, including quantity of water to be used and the entering and leaving water temperatures. It can be adapted to problems of heating and humidifying as well as to water cooling (indoor washer-cooling tower) and multi-stage applications.

The actual performance factor of a particular washer must, however, be obtained from the manufacturer's data and depends on the many factors listed previously.

### Control of Air Washers

Chapter 43 discusses methods of controlling air washers to meet system or space requirements.

## EVAPORATIVE AIR COOLING

Evaporative air cooling is undoubtedly the oldest method used in man's attempt to produce comfort in hot climates. In pre-biblical times,[2, 3, 4] wetted grass mats and porous jars utilized the evaporative process to cool air or water. The early settlers of Southwestern United States found the Indians using these same devices. In the 1930's a rush of inventions appeared which mechanized evaporative cooling and various devices were developed and manufactured to utilize evaporation directly in the air stream or indirectly to cool the air in a heat exchange process.

Evaporative air cooling equipment may be placed in two general classes, direct and indirect. The first of these uses primary wet surfaces which evaporate water directly into the fresh air supplied to the space being cooled. This may be done with a series of sprays as in an air washer or by use of an extended wetted surface material such as aspen wood excelsior, glass fibers, metal wire, or expanded paper. As these devices are relatively simple and economical, they represent the vast majority of equipment in use today.

The second class of evaporative air cooling is termed indirect. The indirect cooler uses the evaporative principle to cool air or water in a device similar to a cooling tower. The resultant cool air or water is then used by means of a secondary heat exchanger to cool the air in the occupied space. The simplest form of this consists of a cooling tower, a circulating pump, and a chilled water coil. The pump circulates the chilled water from the cooling tower sump through the blast coil in the building ventilating system. More complex arrangements of this principle have been used. By applying recirculating, regenerating principles, temperatures below the initial wet-bulb may be produced.[5, 6] The complexity and cost of these devices has made them relatively obsolete with the advent of economical refrigeration equipment.

### Types of Primary Wet-Surface Evaporative Cooling Equipment

Currently, the drip or desert-type coolers (see Fig. 6) constitute the largest percentage of evaporative coolers. These devices use evaporative pads, usually made of aspen wood fibers, and a water circulating pump to lift the sump water

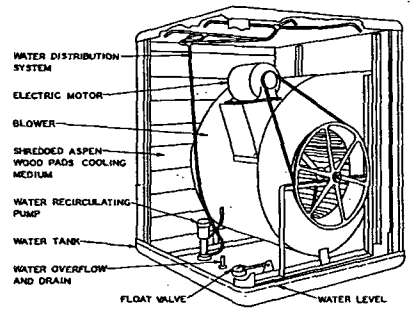



Fig. 6 .... Typical Drip-Type Evaporative Cooler

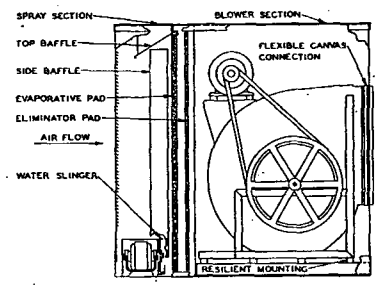



Fig. 7 .... Typical Spray-Type Evaporative Cooler

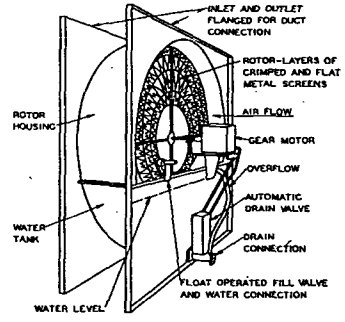



Fig. 8 .... Typical Rotary-Type Evaporative Cooler