the minimum approach is apt to be of sufficient magnitude to require the expenditure of considerable sums of money. Even on such operations there are some basic fundamentals that should be followed to evaluate the over-all problem. The entire area should be studied to locate the sources of heat generation. If the greatest amount of heat is coming through the roof from the sun load, consideration should be given to insulation of the roof deck, painting it with reflective paint, or perhaps spraying it with water to reduce the amount of heat transmitted to the room. If, on the other hand, most of the heat is generated by large amounts of electrical energy used throughout the area, little can be done to reduce this load at the source. In isolated cases some relief has been achieved by either locally ventilating the motors if they are large, or by adding small sections of duct work to air-cooled motors so that the heat is discharged above the heads of the employees. The use of man-cooling fans may lower the employees' effective temperature a little but does not remove heat from the space. Increasing the amount of air exhausted through the roof of the building is often disappointing, for replacement air flows in through open doors and windows and may follow along the ceiling and be exhausted with very little effect in the occupied zone. This is particularly true with the modern wide, flat type of building and experience has proved that surprisingly little relief is obtained from such installations.

Heat may be removed from the occupied space by introducing air at a lower temperature and then exhausting it after it has absorbed some of the heat in the area (see page 227). When the temperature of the air being introduced to the space is too high to give satisfactory relief it may be lowered by (1) evaporative cooling or (2) a chilled coil system.

1. Evaporative Cooling

In evaporative cooling the air is passed through sprays of water, or some porous material wetted with water. The condition of the air leaving the cooler depends on the efficiency of the unit, the wet- and dry-bulb temperatures of the entering air, and the temperature of the water. Although the evaporative cooler is usually thought of as adding a good deal of moisture to the air, this occurs only when the temperature of the spray water leaving the cooler is lower than the dry-bulb temperature and higher than the dew point of the entering air. Cooling also takes place at the same time. If the spray water leaving the cooler is at the dew-point temperature of the entering air, sensible cooling only results and if lower than the dew-point temperature of the entering air, both cooling and dehumidifying occur.[7]

Unfortunately, engineers have usually discussed evaporative cooling only in connection with comfort plotted at or near the 71° ET line, which has resulted in the belief that it should not be considered in many parts of the country. There are few places where it cannot be used, and even though true comfort may not be secured, at least an improvement is made and tolerable working conditions can be maintained. High air volumes and air movement must be incorporated in the design, however.[8]

[7] H. M. Hendrickson, *Heating and Ventilating*, **50**, 91 (July, 1953).

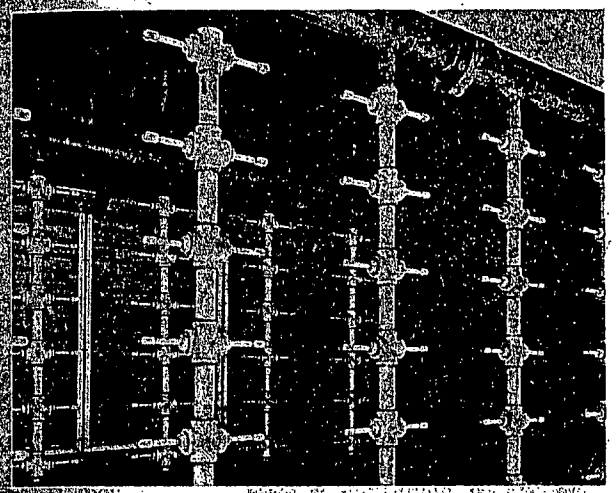


Fig. 6. Evaporative cooler showing two banks of nozzles and eliminators. (Courtesy American Blower Corp., Detroit, Mich.)

2. Chilled Coil System

In a chilled coil system air is passed over coils containing some medium whose temperature is sufficiently below that of the air to result in satisfactory cooling. These systems are usually of one of the following types:

Water-Cooled Coil. In this system, which is the simplest, water directly from the supply is circulated through the coil while air from the conditioned space is passed over the coil to remove heat and moisture. As a general rule water must leave the coil at not more than 52° F. and is wasted after leaving the coil unless used for process work.

Cooled Water System. When water is not available in sufficient quantities at satisfactory temperatures, it may be artificially cooled and recirculated. These systems are often used when the coolant must be piped long distances and a variety of loads must be overcome. Usually the heat is removed from the water by mechanical refrigeration, but in some intermittent operations, such as church cooling, it is removed by the melting of ice.

Refrigerated Coils. As the name implies, the coils are cooled by the

[8] Smith, *Heating, Piping, Air Conditioning*, **27**, 141 (August, 1955).