cooled in an isolated room or building and then be circulated through the air conditioning equipment in perfect safety because it is used to cool the water or air, without any possibility of direct contact between the air and refrigerant.

When an indirect system of cooling is used, it will be found that the heat transfer rate of the water cooler is considerably higher as a general rule than that of a direct expansion cooler for the same requirements. With direct expansion interchangers, it is almost impossible to keep the entire system flooded with liquid, whereas with brine interchangers the cooling medium completely fills the space of the interchanger and perfect contact is insured.

Ice may be used for chilling water or air for conditioning work. Its application is limited because of the cost of ice, and the difficulty of handling it. The word "water cooling" is used advisedly in that the direct cooling of air by ice is, while not impossible, rather impractical. It might be said that ice coolers are economical for systems requiring a maximum of 20 tons per 24 hours where the load fluctuates considerably, and where ice is introduced only as it is required to cool water. The most general method of cooling water with ice is to spray the water over the surface of the ice, insuring as much contact as possible and approximating the same performance as the Baudelot type of cooler. Because of the large fluctuations in load in the air conditioning system, the higher cost of refrigerating effect when ice is used is offset by the fact that there are no motor and condenser inefficiencies under partial load. Also, because the cost of the mechanical refrigeration equipment for the small system is so much higher per unit of effect, the fixed charges are small enough to overbalance the extra cost of the ice.

Condensers

Condensers are usually either the double pipe type or the shell and tube type. Shell and tube condensers are almost identical with coolers. Double pipe condensers are arranged so that water passes through the inner of two concentric pipes, and refrigeration passes through the annular space in the outer pipe. Where possible, there should be counter flow of the refrigerant and the condensing water to maintain maximum temperature differences.

The amount and temperature of the condensing water determine the condensing temperature and pressure, and indirectly the power required for compression. It is, therefore, necessary to strike a balance so that the quantity of water insures economical compressor operation.

As part of the condenser, or attached to it, there must be storage space for liquid refrigerant. The installation of all equipment should be made accessible for inspection, repair, and cleaning. Both the coolers and condensers should have space for pulling tubes.

Because there is a decided tendency to conserve the water in city mains and most large cities are restricting the use of water, in order to use air conditioning systems and refrigeration equipment it is often necessary to install cooling towers. The cooling towers, unfortunately, produce the warmest condensing water at the time when the load on the system is greatest, so that the refrigeration equipment must be designed to meet

not only the maximum load at normal conditions, but also the maximum load at abnormal condensing water temperatures. If properly designed, this makes little difference in the efficiency of operation throughout the year except at those times when the condensing water temperature is highest. As this occurs only for 5 per cent of the entire cooling period it can be disregarded as a factor in establishing yearly operating costs.

The cooling tower has a certain advantage over the use of water from the city mains in that the temperature of the condensing water varies directly with the outdoor temperature and, as pointed out, the refrigeration load also varies with this temperature. Certain economies are possible when a cooling tower is used which cannot be achieved by the use of condensing water from city mains, even where the city water temperature is extremely low. Normally, the lowest city water temperature met during the summer months is from 65 to 70 F. This temperature range takes place for the entire cooling period, regardless of what the outdoor temperatures are. With the cooling tower, the temperature of the condensing water may rise to 80 or 85 F under maximum conditions, but under less than maximum conditions the temperature of the water off the cooling tower drops considerably, and it has been established that 50 per cent of the time the outdoor wet-bulb temperature varies from 60 to 70 F and the cooling tower water, therefore, for the same periods, varies from 65 to 75 F. When the outdoor wet-bulb temperature drops below 60 F, which occurs approximately 30 per cent of the time, the condensing water temperature is still lower. The cost of water used for condensing is negligible, as the only water required is that used to make up the loss by evaporation in the cooling tower itself. See also Chapter 11.

PROBLEMS IN PRACTICE

1 ● Discuss the difference in results obtained in cooling and dehumidifying in an air washer from those obtained in a surface cooling coil.

Air leaves a dehumidifying air washer in a saturated condition at a dew point temperature which can be easily maintained at a constant level by controlling the spray water temperature. This saturated air may then be reheated to proper delivery temperature by reheating coils or by mixing with bypassed air.

For a set air velocity and a set mean refrigerant temperature, a given cooling coil is capable of absorbing a definite amount of heat. Whether the air leaving the coil is saturated or not depends then on the entering dry- and wet-bulb temperatures. From practical operating standpoint, the easiest way to control the output of the cooling coil is by means of the dry-bulb temperature of the conditioned space. This means then that the final dew point will vary somewhat depending on entering air conditions.

Summarizing then, the air washers permit close control over both final dry-bulb and final dew point temperatures, while the surface coolers permit close control over the final dry-bulb only.

2 ● For condensing purposes, an air conditioning system uses city water which has an average 70 F supply temperature. The following table lists the number of hours per year during which definite wet-bulb temperatures and corresponding refrigeration rates pertain.