be selected to meet the peak load. Thus at normal loads the equipment is oversized. Their principal advantages are low installation costs and simplicity, and for these reasons they are frequently used in small self-contained units.

2. *Water cooled condensers* are commonly used with compressors of one horsepower or larger in size, and they are found almost exclusively on large installations. They usually prove to be the most economical choice if an adequate water supply and means for its disposal are available. Although water cooled condensers may be of many designs, the shell and coil and the shell and tube are most commonly found in present day practice.

The amount and temperature of the condensing water determine the condensing temperature and pressure, and indirectly the power required for compression. It is

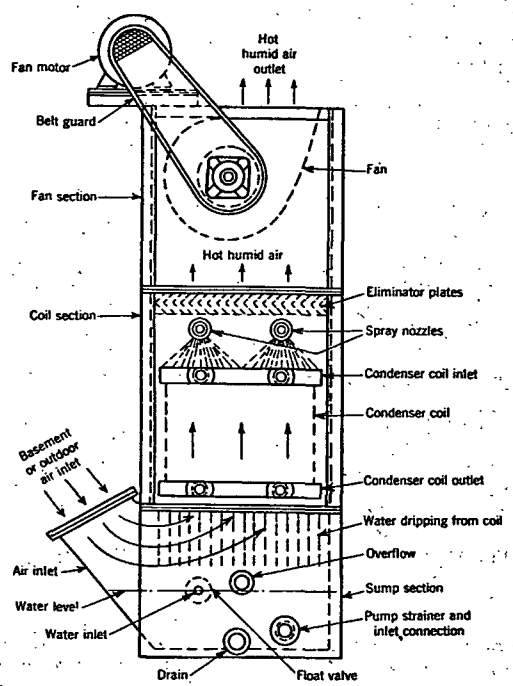


FIG. 12. SCHEMATIC VIEW OF AN EVAPORATIVE CONDENSER

therefore necessary to determine a balance so that the quantity of water insures economical compressor operation.

Because there is a decided tendency to conserve the water in city mains and because most large cities are restricting the use of water for air conditioning and refrigeration equipment, it is often necessary to install cooling towers or evaporative condensers. 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 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. For further information on cooling towers, reference may be made to Chapter 37.

3. *Evaporative condensers* were developed to alleviate the over-burdened water supply and drainage facilities of communities where many small air conditioning systems using water cooled condensers were applied. The adaptation of cooling



towers to small installations is not practicable. The evaporative condenser combines the functions of the two by using a minimum amount of water on a finned surface, cooling it to approximately the wet-bulb temperature of the surrounding atmosphere.

The end view of a typical evaporative condenser is shown in Fig. 12. The fan draws the air over a finned tube condenser which is kept wet by a water spray. The discharge refrigerant gas from the compressor enters the top of the condenser coil and the liquid refrigerant is drained from the bottom of the coil into a liquid receiver and then circulates through the remaining portion of the system in the usual way.

The water is circulated through the spray nozzles and the level is maintained in the sump by means of a float valve. The eliminator plates are placed in the path of the water-air mixture so as to remove the entrained water. The air leaving the unit is almost completely saturated, so that care must be taken in locating discharge ducts to prevent condensation.

Evaporative condensers are available in sizes up to 100 tons or more. These units use only a small portion of the water required for a water cooled condenser. The water is vaporized by the heat of the refrigerant so that each pound of water used extracts approximately 1000 Btu from the refrigerant, whereas under standard rating conditions where the water temperature rise is 20 F, each pound of water extracts only 20 Btu from the refrigerant. Including the water lost by entrainment in the discharge air, by overflow and stand-by evaporation, the water used is about 3 to 5 per cent of the amount that would be required for a water cooled condenser.

The evaporative condenser requires more maintenance, occupies greater space (must be located where air is available), and has a higher first cost than the water cooled condenser, but where the use of water is restricted or expensive, the evaporative condenser has become widely accepted. Compared with a water cooled condenser and cooling tower, which combination uses about the same quantity of water, the evaporative condenser has the advantage of lower cost and smaller space requirements.

## Evaporators and Coolers

Refrigeration evaporators must be designed for efficient removal of heat from the medium being cooled as well as effective boiling of the refrigerant and a minimum drop of pressure through the coil. There are two general types of evaporators, dry and flooded. In the dry evaporator the refrigerant enters in the liquid state, and the design provides for complete evaporation with the vapors leaving slightly superheated. In flooded evaporators not all of the refrigerant is evaporated, the liquid-vapor mixture leaving the evaporator flows into a surge drum from which the vapors are drawn into the compressor suction line, and the liquid is recirculated through the evaporator.

The types of coolers used in connection with air conditioning work fall into three general groups: (1) direct water coolers, (2) direct air coolers, and (3) brine coolers for circulation of the brine in a closed system and thus cooling indirectly either water or air.

1. *Water coolers.* One method of the direct cooling of water is to install direct expansion coils in the spray chamber so that the water sprayed into the air comes in direct contact with the cooling coils. Another common and efficient method of cooling spray water is to use a Baudelot type of heat absorber where the water flows over direct expansion coils at a rate sufficiently high to give efficient heat transfer from water to refrigerant.

Another type of spray water cooler is the shell and tube heat exchanger in which the refrigerant is expanded into a shell enclosing the tubes through which the water flows. The velocity of the water in the tubes affects the rate of heat transfer, and as the refrigerant is in the shell completely surrounding the tubes at all times, good contact and a high rate of heat transfer are insured. The disadvantage of such a system is that with the falling off of load on the compressor the suction temperature or the temperature in the evaporator drops and there is a possibility of freezing the water in the tubes, which, of course, might split the tubes and allow the refrigerant to escape into the water passage. This danger can be eliminated by automatic safety devices.

Another system of cooling spray water is to submerge coils in the spray collecting tank, or in a separate tank used for storage. The heat transmission through the walls