formed in the tubing after they were drained (on the cooling water side) and not in use. It was determined that a small amount of moisture remaining in the tubes, when combined with air, caused a corrosion of the stainless steel tubes on the cooling water side. Thus, it is recommended that when not in use, heat exchangers should not be drained of the cooling water.

There are two basic types of WFI distillation units—the vapor-compression still and the multiple-effect still.

Vapor-Compression Distillation

The vapor-compression still is primarily designed for the production of large volumes of high-purity distillate with low consumption of energy and water. The feed water is heated from an external source in the evaporator to boiling. The vapor produced in the tubes is separated from the entrained distilland in the separator and conveyed to a compressor that compresses the vapor and raises its temperature to approximately 107°C. It then flows to the steam chest where it condenses on the outer surfaces of the tubes containing the distilland; the vapor is thus condensed and drawn off as a distillate, while giving up its heat to bring the distilland in the tubes to the boiling point. Vapor-compression stills are available in capacities from 50 to 2800 gal/hr. They have lost favor in Europe and many other parts of the world, but are still quite popular in the United States.

Multiple-Effect Stills

The multiple-effect still (Fig. 15-2) also is designed to conserve energy and water usage. In principle, it is simply a series of single-effect stills or columns running at differing pressures where phase changes of water take place. A series of up to seven effects may be used, with the first effect operated at the highest pressure and the last effect at atmospheric pressure. Steam from an external source is used in the first effect to generate steam under pressure from feed water; it is used as the power source to drive the second effect. The steam used to drive the second effect condenses as it gives up its heat of vaporization and forms a distillate. This process continues until the last effect, when the steam is at atmospheric pressure, and must be condensed in a heat exchanger.

The capacity of a multiple-effect still can be increased by adding effects. The quantity of the distillate also will be affected by the inlet steam pressure; thus, a 600-gal/hr unit designed to operate at 115 psig steam pressure could be run at approximately 55 psig and would deliver about 400 gal/hr. These stills have no moving parts and operate quietly. They are available in capacities from about 50 to 7000 gal/hr.

Reverse Osmosis (RO)

The principle of osmosis was covered in Chapters 2 and 6. *Osmosis* involves the flow of a solvent through a semipermeable membrane (permeable to the solvent, but impermeable to solutes in the solvent) into a solution of higher solute concentration. Solution flows until concentrations on either side of the membrane are equal. Such concentrations can be measured by osmostic

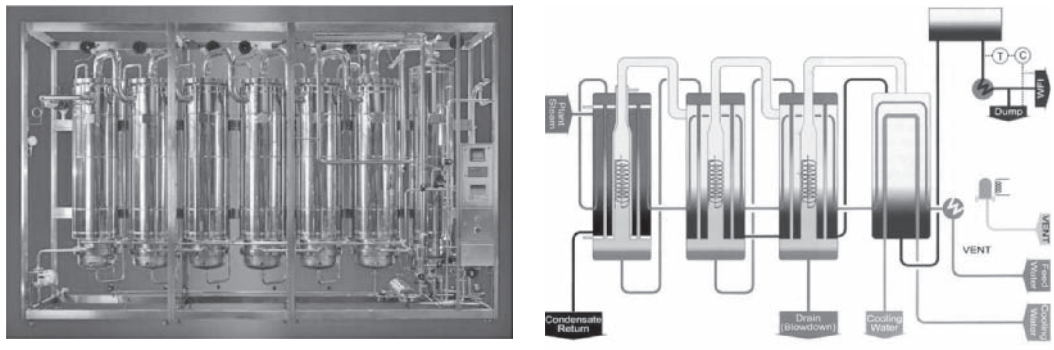

Figure 15-2 Multiple-effect still. *Source:* Courtesy of Getinge Water Systems.