CHAPTER 8

EVAPORATIVE COOLING

Section I. DESCRIPTION OF EQUIPMENT

8-1. Definition

Summer air conditioning requires air cooling and dehumidification besides air cleaning and circulation. Cooling and dehumidification are usually done simultaneously by the use of refrigeration. In this process air is cooled below its dew point by contact with a refrigerated coil or water spray, a portion of the humidity is condensed out, and the air is delivered to the conditioned space both drier and cooler than the condition to be maintained. Air may also be cooled independently by coils supplied with well water or some other medium which is cool enough to reduce the dry-bulb temperature of the air but not cool enough to reduce the air temperature to the dew point. Dehumidification can be achieved independently by the use of calcium chloride, silica gel, or other air drying materials. In climates which are sufficiently dry (average relative humidity 20 percent) but hot, it is usually possible to obtain a satisfactory reduction in dry-bulb temperature by the use of evaporative cooling. This chapter will be limited to the use of this type of air conditioning. For a discussion of other cooling and dehumidifying methods such as refrigeration, refer to chapter 9. When air is brought in contact with recirculated spray water, the water will in time come to the same temperature as the wet-bulb temperature of the entering air. The air in turn will pick up water and approach saturation without change in wet-bulb temperature (see psychrometric chart in app C). As there is no heat either added to or taken away from the system, the total heat in the air remains the same, but the dry-bulb temperature of the air is reduced in exchange for an increase in specific humidity. This is the principle of evaporative cooling (fig. 8-1).

8-2. Evaporative Coolers

Evaporative coolers are simple in construction, containing a fan and motor for circulating air and a pump for recirculating water and placing it in contact with the air by means of sprays or wet filter pads through which the air is drawn.

a. Drip Units. Drip units consist of water-evaporating filter pads; water-distributing troughs, piping and a recirculating pump; a motor-driven fan; and a water-collecting pan with water makeup float valve and drain. These parts are all mounted in a watertight cabinet (fig. 8-2). Self-contained units are manufactured in capacities up to about 10,000 c.f.m. air delivery. Larger units are delivered

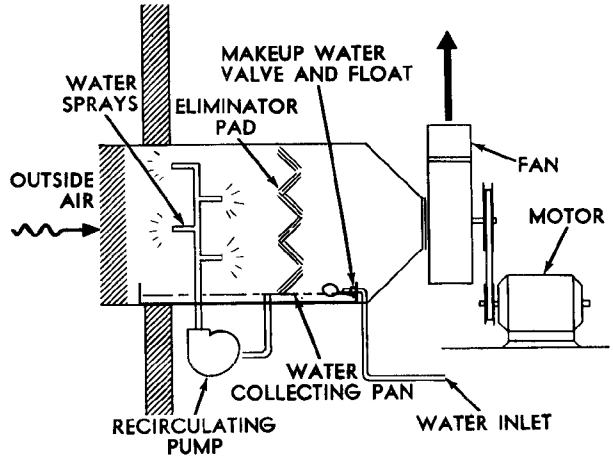


Figure 8-1. Schematic diagram of evaporative cooling system.

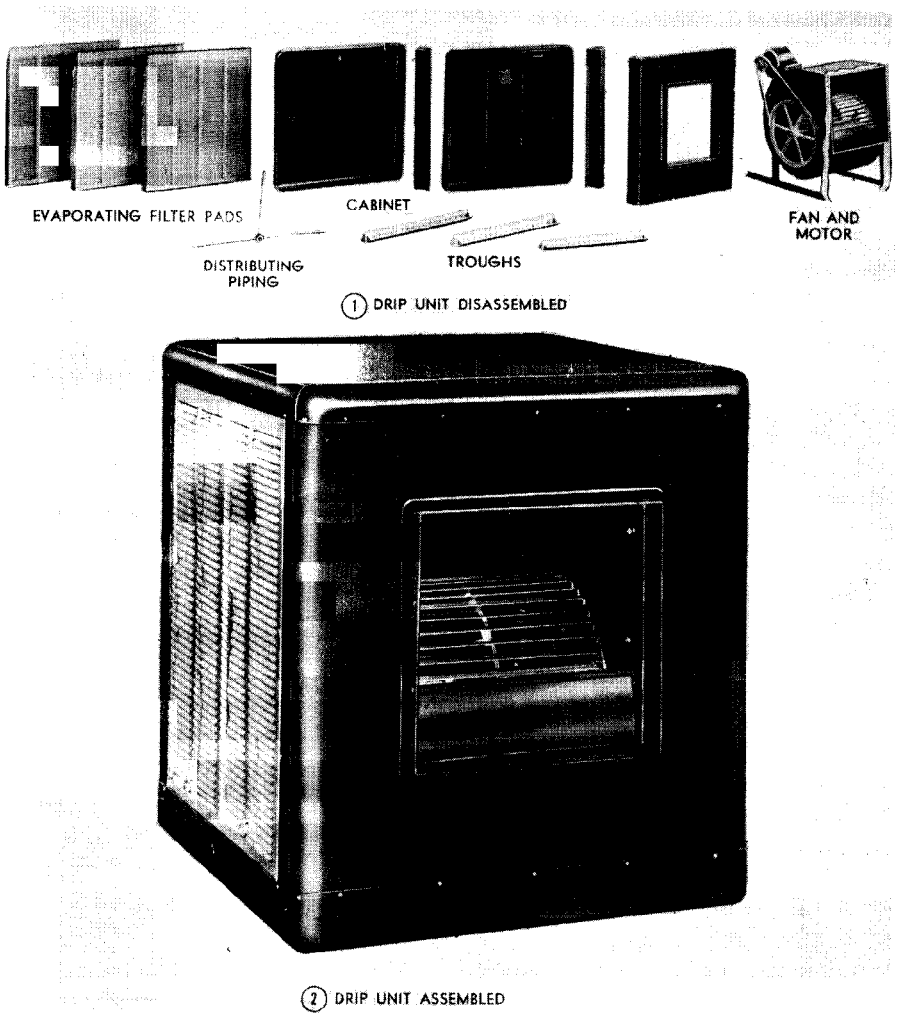
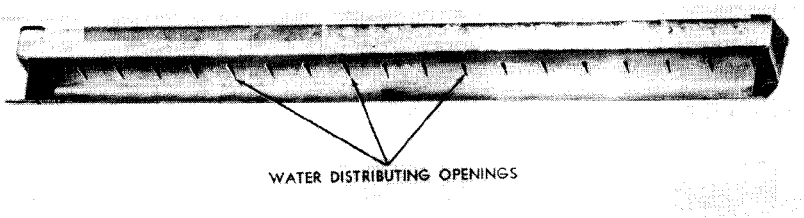
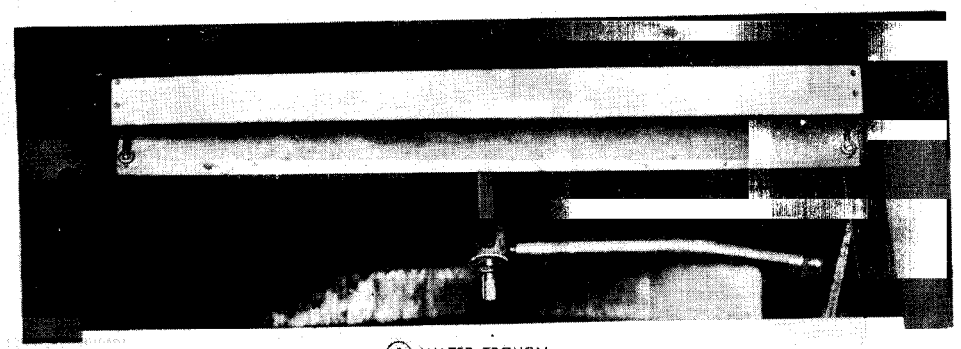


Figure 8-2. Drip-type evaporative cooling unit.

knocked down and assembled at the site. Pads of glass wool, aspen wood, or other fiber serve as evaporating surfaces for drip units. Air is drawn through these pads by the fan. Water is delivered by a recirculating pump to distributing troughs from which it drips on the top surfaces of the pads. Triangular openings in the trough govern the flow of water so that it drips evenly over the filter pads to saturate them throughout. A water-collecting pan forms the bottom of the unit. It contains an overflow pipe and float-actuated water makeup valve. Drip units of less than 2,000 c.f.m. capacity usually have propeller fans and are intended for direct discharge into the space to be cooled. Duct work should not be attached to them. Larger units are usually equipped with centrifugal-blower fans and can be connected to deliver air through a duct system. The rated external static pressure available for duct resistance should be checked before sizing the duct system. It is usually ¼-inch water gage.

b. Spray Units. Spray units are similar to drip units except that there are no drip troughs and the filter pads are preceded by a water spray chamber. Sprays in this chamber partially saturate the air by direct contact and in addition continuously wash down the inlet side of the filter pad. This method of wetting keeps the pads free of excess dust and other





(3) WATER TROUGH

Figure 8-2—Continued.

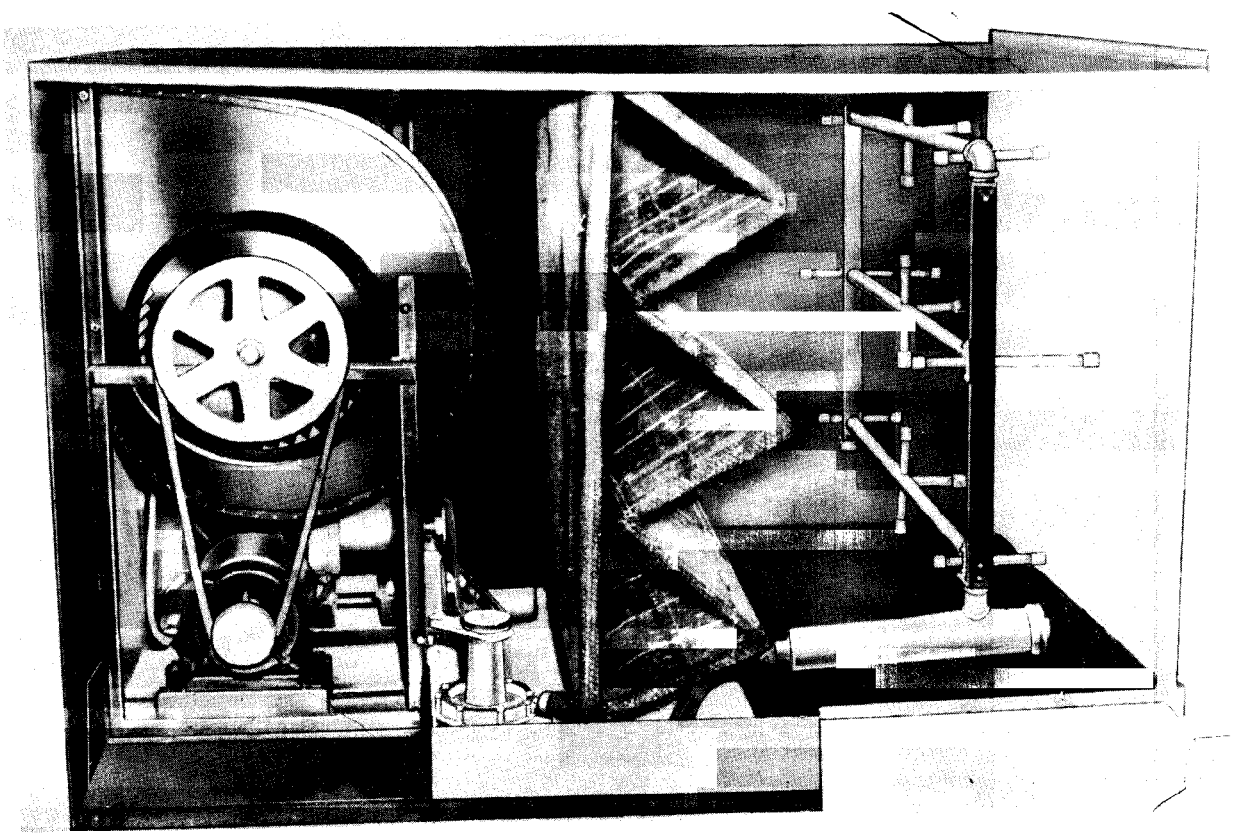


Figure 8-3. Spray-type evaporative cooling unit.

solids for a longer period of time than for drip units (fig. 8-3). The filter pads of spray units require added support and are usually made of glass wool fibers bound in metal frames and impregnated with a hygroscopic material. Pads are arranged in either a V-bank or a vertical bank. Spray units are equipped with blower fans rated for air delivery against ¼-inch water gage external static pressure resistance and are used for supplying air through duct systems. Because of the spray chamber they are larger and heavier.

8-3. Air Ducts

Air ducts used with evaporative cooling systems are usually of sheet metal and similar in construction to those required for warm air systems (para 5-6). The distribution of air for cooling service and the design of air duct systems are discussed in paragraphs 8-6 and 8-7. The fabrication of metal ducts is covered in chapters 10 and 11.

Section II. DESIGN OF SYSTEMS

8-4. Cooling Loads

Building cooling loads, similar to heating loads, can be determined from a calculation of the rate of heat flow through the walls and other surfaces surrounding the occupied space and an estimate of the effect of infiltration. In the summer, heat flows from outside the building to inside, and that portion of the load calculated as heat on the east side of the building may be much greater than the load on the west side of the building during the morning hours, whereas in the late afternoon the reverse is true. Unless the system is zoned to compensate

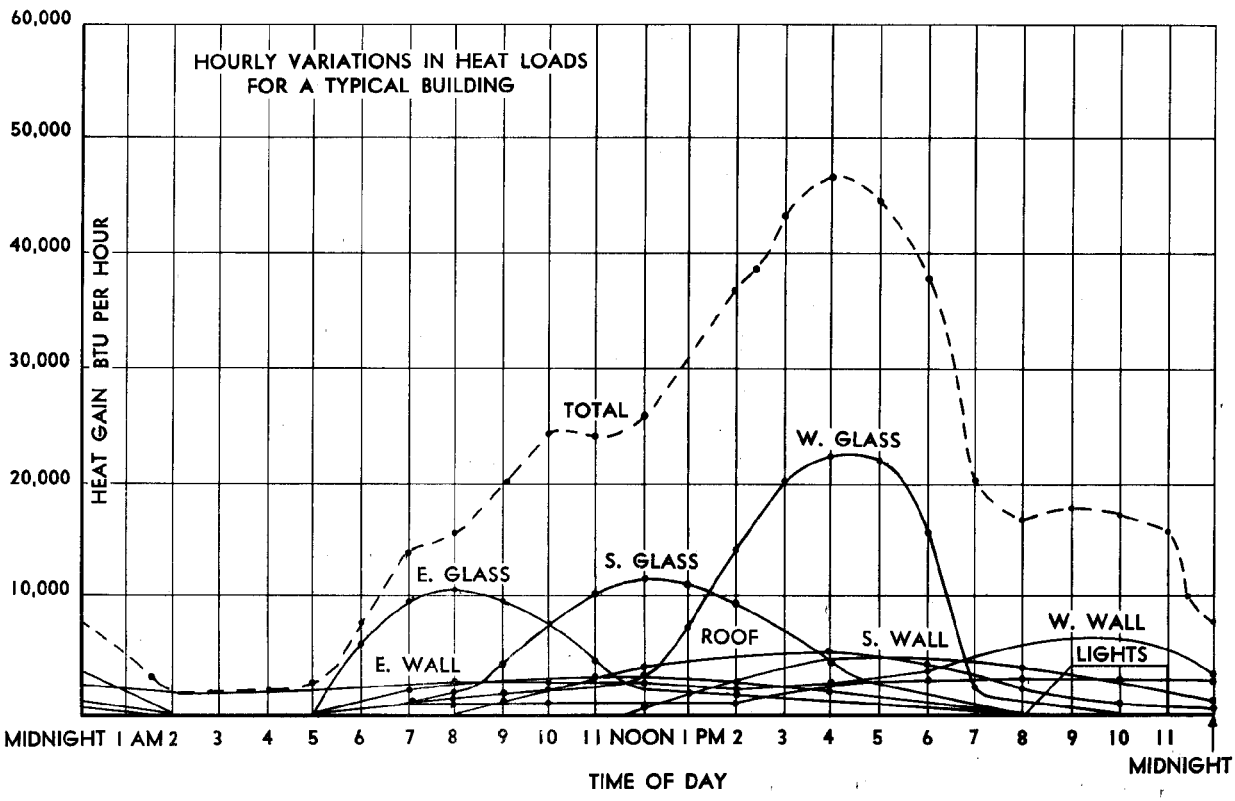


Figure 8-4. Hourly variations in heat loads on a typical building.

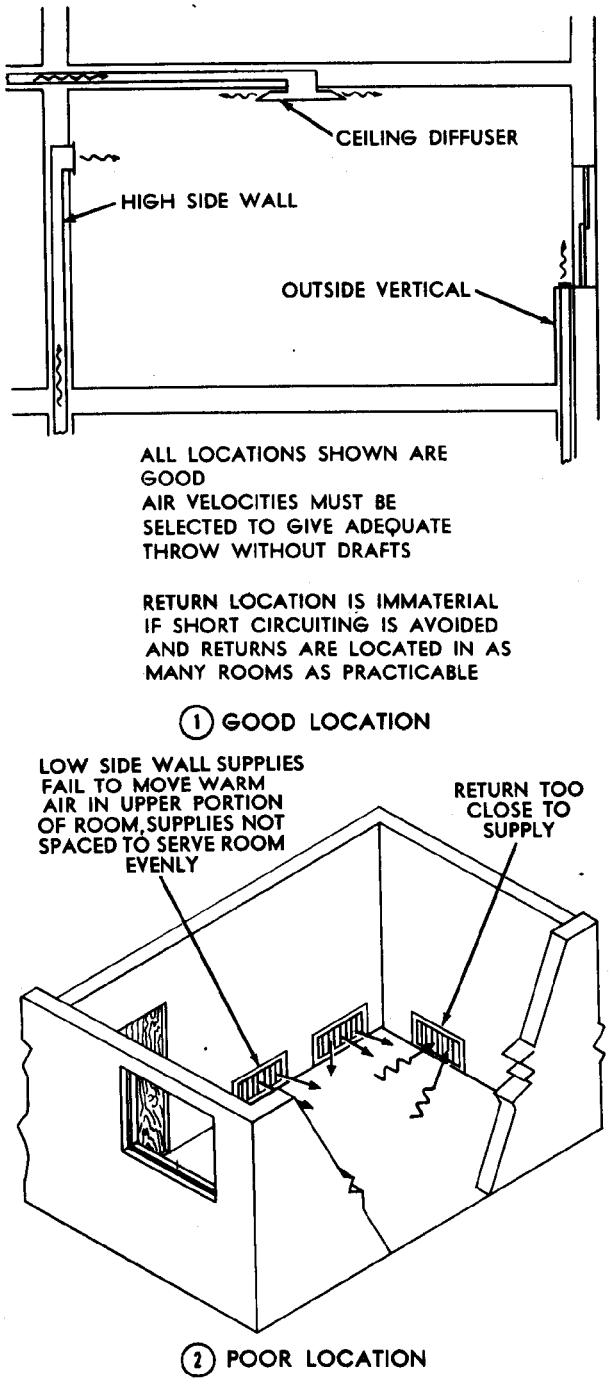


Figure 8-5. Supply grille location for cooling.

for these shifts, satisfactory control of internal temperatures may not be possible. Study of the nature and importance of summer heat gains points up several factors which should be considered in attempting to achieve summer comfort. Shade, man's first protection against the sun, is of particular importance. Building temperatures are reduced appreciably where buildings, particularly windows, are shaded. Awnings, which reflect the sun's rays before they enter the building, are more effective than shades inside of the window glass. Orientation of buildings and particularly windows may have a marked effect on heat gain. This varies with latitude, but in areas where air conditioning is usually desired, glass and wall areas on the east and west exposures receive much more direct radiation as the sun strikes low across the horizon than do walls and windows on the south (or north if in Southern Hemisphere), which only receive radiation at an oblique angle. Because outside air temperatures usually drop rapidly after sundown whereas inside air temperatures are kept up by heat absorbed in the structure and its contents, much effective cooling can be accomplished by ventilating the building with large quantities of outside air after sundown. Heat gained through roofs can be cut in half by keeping them wet with a water spray or, in the case of flat roofs, flooding them with water. See figure 8-4 for examples of hourly variations in heat loads on a typical building.

8-5. Selection of Equipment

Hospitals and other spaces requiring control of temperature and humidity under all outside conditions must use refrigeration equipment for summer air conditioning. However, evaporative coolers can be used for normal types of installations in arid regions. Evaporative coolers should be of sufficient size to supply a complete air change within the conditioned space at least once every 2 minutes. The required air delivery in c.f.m. is the volume of the space to be cooled divided by two. Where possible, the use of a few large units connected with duct work is preferable to the installation of many small units.

8-6. Air Distribution

As cold air is heavier than warm air and tends to drop in the conditioned space, air supply

outlets for cooling service are located above head level, either high on a side wall or in the ceiling. This is a reverse of the problem of distributing warm air as discussed in paragraph 5-8. Supply outlets (fig. 8-5) are so located and directed that the air output will not blow directly on occupants of the space, as air velocity increases the cooling effect and objectionable cold drafts may result. Size supply registers and diffusers to produce sufficient throw of air to cover the spaces to be cooled. Manufacturers' ratings give sizes of these outlets. The location of return grilles is relatively unimportant as long as short circuiting is avoided and returns are located in as many rooms as practicable. Where evaporative coolers are used, 100 percent fresh air will be employed and there will be no return duct system. Instead, each room to be conditioned should be provided with some type of exhaust opening. These may be windows or doors. The area of these openings should be adjustable to assist in the balancing of air distribution between the various rooms.

Section III. CONTROL

8-7. Air Duct Layout

The total air quantity delivered by an evaporative cooler may be divided among the spaces served in proportion to the volume of each space. This procedure may be modified somewhat to favor those spaces which have a higher than average heat gain due to unusual exposure or other cause. After the required rate of air delivery through each outlet has been determined the duct system can be sized as discussed in paragraph 5-10. Inasmuch as all air distributed by an evaporative cooler is taken from the outside, there will be no return duct system (fig. 8-6). Instead exhaust openings to the outside must be provided in each space to be cooled. These may be window openings, separate louvers, or other adjustable vents and are used to control air flow in the individual spaces. A minimum of 1 square foot of exhaust openings should be provided for each 500 c.f.m. of air delivered. In kitchens and mess halls or other crowded spaces, exhaust fans may be used to ensure adequate air movement through these spaces.

8-8. Automatic Temperature and Humidity Control

a. General. Evaporative coolers are seldom

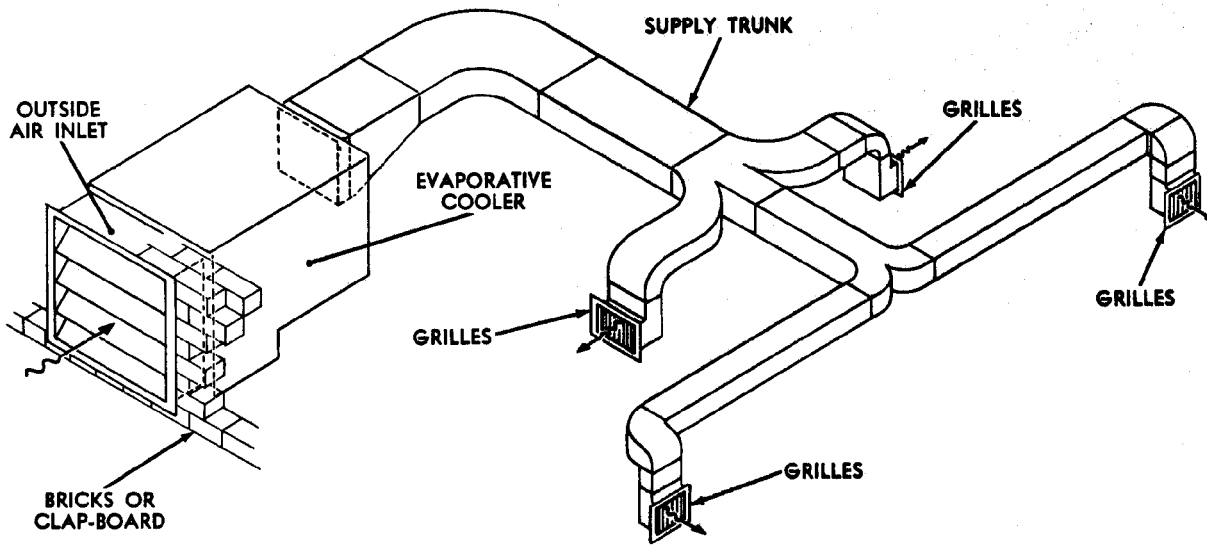
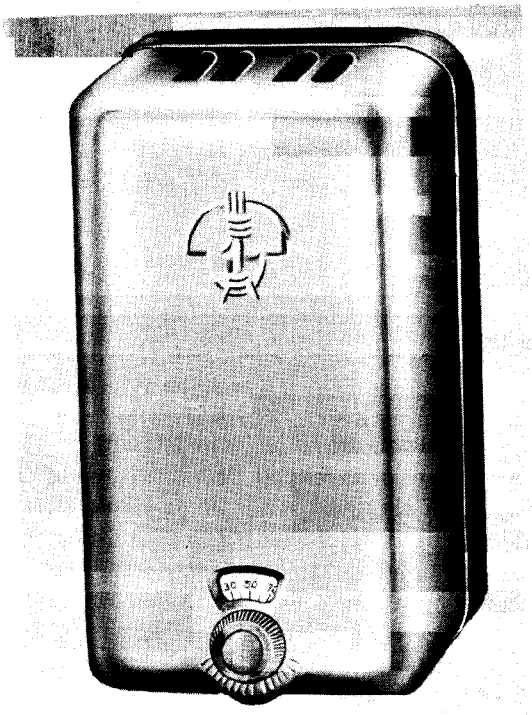


Figure 8-6. Evaporative cooler with duct system.

equipped with automatic coontrols. Control usually consists of a manual switch to start and stop the fan and a second manual switch to control the water recirculating pump. When necessary, water pump operation can be controlled by either a thermostat or a humidistat depending on whether it is more important to control the temperature or the relative humidity.

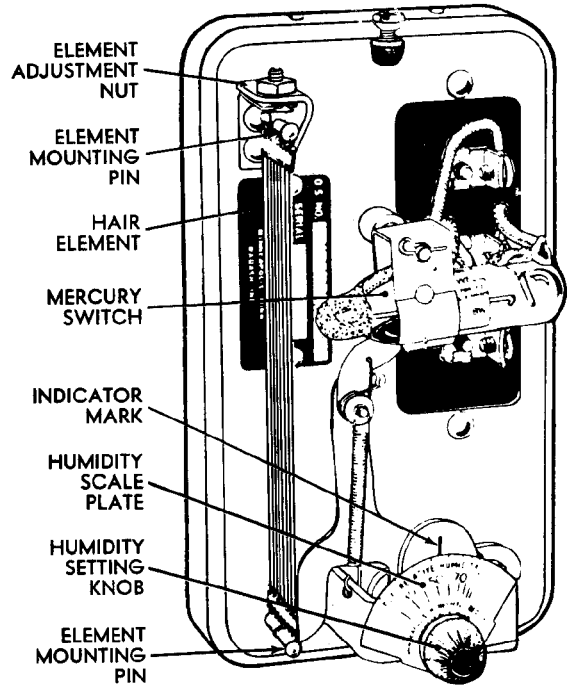
b. Thermostat. Thermostats used are similar to those discussed in paragraph 3–19 except that their action is reversed, the operating circuit being closed as the room temperature rises to the thermostat control point. Cooling thermostats are not equipped with heat-anticipating coils. Consideration should be given to the points discussed in paragraph 3–19*a*(3) in selecting a thermostat location. Care should be taken that the thermostat is not located in the path of direct sunlight.

c. Humidistat. Where a humidity control is important, pump operation can be controlled by a humidistat (fig. 8–7). These instruments are usually actuated by a hydroscopic material sensitive to change in relative humidity such as wood, fiber, or human hair. They are not very reliable unless calibrated regularly by means of a sling psychrometer. Humidity differences between rooms equalize more readily than temperature differences, and the location of the humidistat is not as critical as thermostat location. However, avoid locations subject to direct heat or local humidity influences.



(1) COVER IN PLACE

Figure 8–7. Humidistat.



(2) COVER REMOVED

Figure 8–7—Continued.

Section IV. INSTALLATION

8–9. Location and Placement of Equipment

Small evaporative cooling units with propeller fans may be installed in windows or in special openings made in outside walls of the spaces they serve. Large blower units are mounted on platforms resting on independent supports ad-

jacent to the building. Be sure that all units are accessible for servicing, and where units are mounted on platforms well above the ground, construct platforms large enough to provide walkways. Include a guard rail on all sides of the equipment where service is required. Where ladders are necessary to reach the platform they are an integral part of the platform construction. Large units which are to be connected with duct systems are located near the center of the area they serve so that the duct system may be as short and symmetrical as possible.

8-10. Air Ducts

The fabrication and erection of air ducts as used with evaporative cooling systems is discussed in chapters 10 and 11.

8-11. Water Piping

Water supply piping to the evaporative cooler is not less than ¾-inch diameter. A globe shutoff valve is installed ahead of the float valve assembly or solenoid valve to facilitate the cleaning or repair of these controls. It is well to install a water strainer between the globe shutoff valve and the water control valve to protect the valve seat from grit which would prevent it from closing tightly (fig. 8-8). A water faucet with hose connector is installed in the water supply line near the unit to permit washing down the interior of the unit whenever necessary. The waste-water drain line is not less than 1¼ inches in diameter to reduce frequent drain stoppages, and is piped to a sewage connection or street drainage system. If the vibrations caused by the fan or pump are transmitted through the water supply piping to an objectionable extent, this transmission can be reduced or eliminated by the use of flexible piping connections. These flexible connectors may be made of heavyweight rubber hose applied with clamps, or special flexible metal connectors.

8-12. Insulation

Ducts carrying cool air and running outside or through conditioned spaces are covered with insulating material to prevent undue heat gain. This fibrous insulation is made up of glass

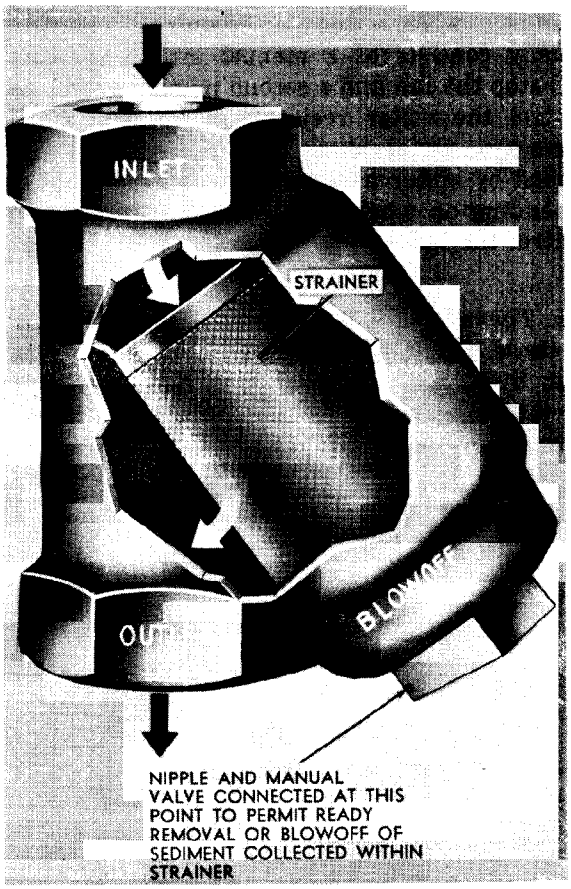


Figure 8-8. Water strainer.

wool, rock wool, shredded wood fiber, or similar material. Where the temperature of air surrounding the duct is 95°F. or more, the insulation should be at least 2 inches thick. For lower surrounding air temperature, 1-inch insulation can be used. Insulation can be applied to the ducts with a mastic or wrapped with wire or wire netting. Rigid insulation can be most easily applied by the use of spindles. These are first cemented to the duct and the insulation is pressed over them and secured by bending over the spindle ends (fig. 8-9). Insulation with special sound absorbing characteristics (fig. 8-10) may also be used as a duct lining to reduce sound transmission through the ducts. The quantity to be used will depend on the intensity and nature of the offending noise, the number of elbows in the ducts (which also help reduce sound transmission), and the per-

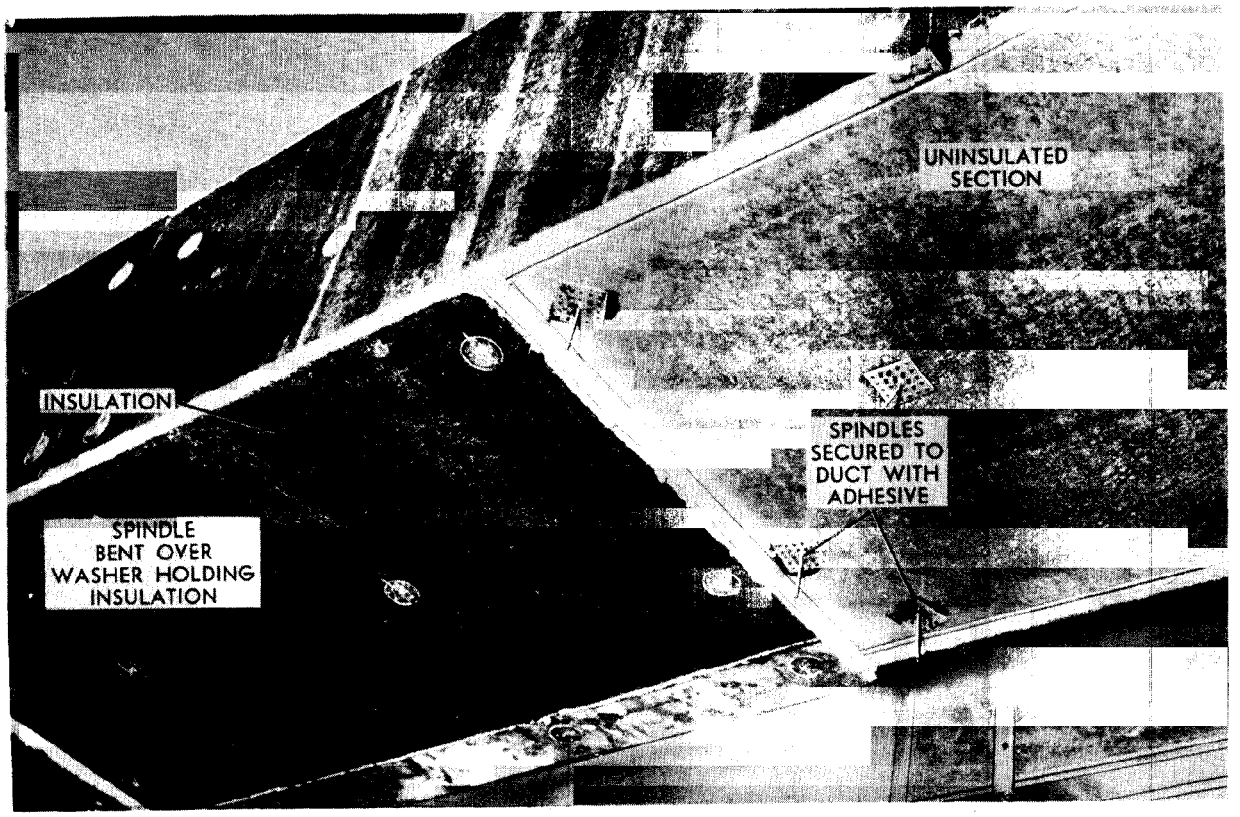


Figure 8-9. Use of spindles in appyling duct insulation.

missible sound level in the space being served. Since calculation of the quantity of insulation required is difficult it may be most easily determined by experimentation in individual cases.

8-13. Adjustments

Air delivery from cooling systems using air ducts must usually be balanced by means of dampers to obtain satisfactory temperature distribution to the spaces served. Air flow measuring instruments and thermometers for checking room temperatures can be used as discussed under warm air heating systems (para 5-16). The total air flow through evaporative coolers should also be measured and, if necessary, adjusted to approximate the design capacity of the system. If total air flow is less than rating, the cooling capacity of the unit will be reduced. If air flow is too high, water will be blown off the evaporating pads and carried into the fan compartment causing shorting of electrical circuits, motor burnouts, rust, and corrosion. Total air flow can be adjusted by changing fan speed by adjusting the variable-diameter motor pulley or changing the pulley size. Water distributors are adjusted to give complete coverage of evaporating pads. This may require the leveling of the troughs and weirs of drip systems or the cleaning of nozzles in spray systems. Where windows are used to exhaust air, they must be equipped with stops to prevent them from being raised to more than the allotted opening, usually 4 inches. Outside doors must be kept closed.

8-14. Maintenance

Evaporative coolers are subject to rapid deterioration from rusting unless they receive regular maintenance. All unit should be dismantled once each year and thoroughly overhauled, cleaned, and painted to prevent rust. Asphalt

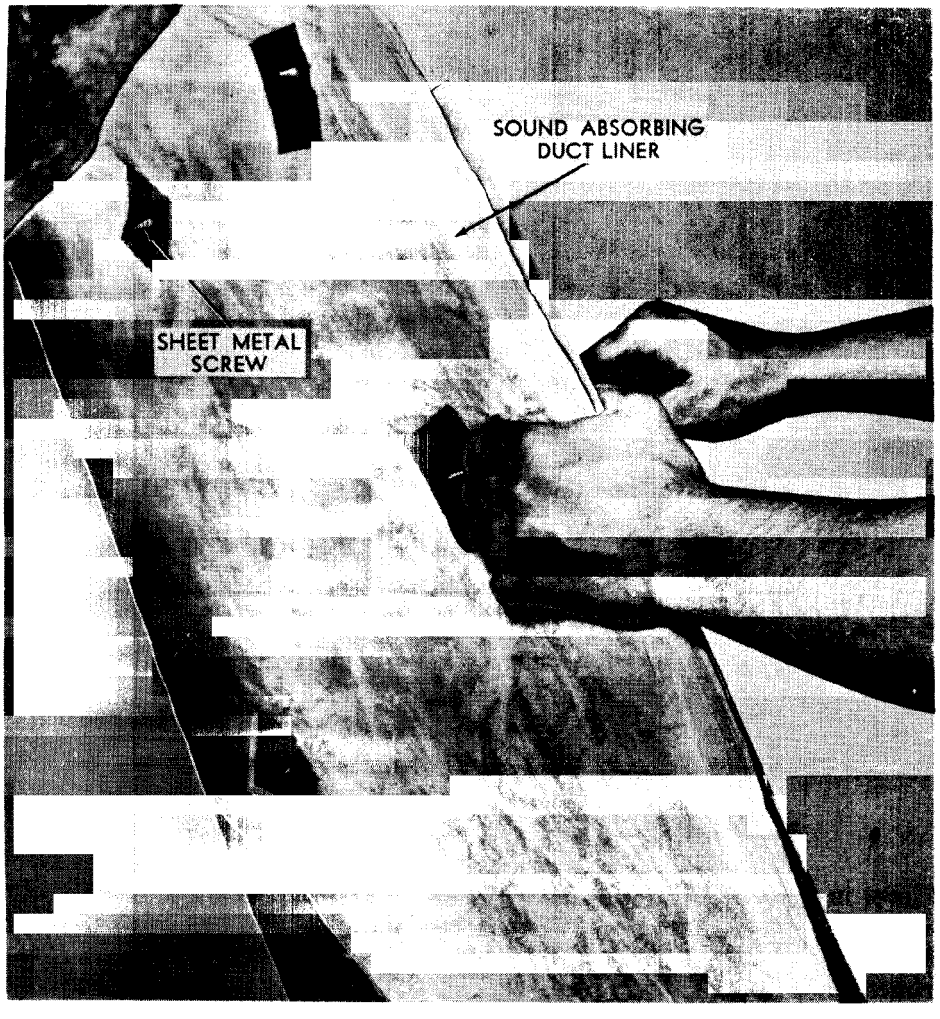


Figure 8-10. Installation of sound absorbing liner.

varnish (VA) should be used on metal surfaces. Water distributing pumps should be dismantled and inspected for excessive wear and worn parts replaced where necessary. Water control valves, both float-operated and solenoid should be inspected and cleaned yearly, and valve seats should be replaced where necessary. Fan, motor, and pump bearings must be inspected at least once each year and oiled or greased according to their individual requirements. To reduce accumulation of solids on water evaporating filter pads and to retard growth of algae, units are washed down regularly with a hose. All foreign material is washed into the water makeup tank, and the tank is drained and flushed. Filter pads must be washed as often as necessary and replaced when they cannot be adequately cleaned. Drip units must be washed once each week, but spray units may be left somewhat longer because of the cleaning eefect of the water sprays.