element of a unit humidifier is an atomizer or evaporator. To this may be added a fan, a heater, outlet vanes or diffusers, and a housing to enclose the various parts.

Unit humidifiers fall into four general classifications, depending on the method of causing evaporation. These are as follows: (1) *Nozzle Type*, (2) *Rotary Type*, (3) *Cascade Type*, and (4) *Heater Type*.

In the *nozzle* type of humidifier water is sprayed into the air and evaporation is effected by adiabatic exchange of energy. Units of this type in simplest form, spray a fine mist of water directly into the air in a space. They are used to a great extent in the textile industry.

The *rotary* type of humidifier generates and distributes by mechanical separation using rotating discs. In all other respects, this type of humidifier is similar to the nozzle type. It has the advantage over the nozzle type of being less likely to become clogged.

In the *cascade* type the humidification takes place by water falling in sheets over a series of baffles or trays. This type is usually furnished with a fan, air heater, and air filter, all enclosed in a housing.

In the *heater* type of humidifier the water is heated either to the boiling point or to a temperature at which the water vapor readily passes into the air stream. In the simplest form the heating element using steam, hot water, gas, oil, or electricity is placed in a pan or vessel of water, and the vapor passes from the surface of the water to the stream of air.

A modification of this type of humidifier is the combination of spray nozzle and heater type in which the water is sprayed over a hot surface and evaporated. It has the disadvantage of accumulating scale on the surfaces of the vessel or heating surface.

Unit humidifiers are usually controlled by a two-position room humidistat operating a controlled device which functions to start and stop the humidifying action. This may be a valve on the water supply to the humidifier. The fan, if used, normally is also turned off by the humidistat. The controlled device operates the source of heat in the heater type of humidifier. See Chapter 43 for a general discussion of humidity controls.

AIR WASHERS

Spray-Type Washers

A spray-type air washer consists essentially of a chamber or casing containing a spray nozzle system, a tank for collecting the spray water as it falls, and an eliminator section at the discharge end for removal of entrained drops of water from the air. A pump recirculates water at a rate greatly in excess of the evaporation rate. Intimate contact between the spray water and the flowing air causes heat transfer between the air and the water, resulting in either humidification or dehumidification, depending upon the method of operation and the relative temperatures of air and spray water.

To prevent backlash of spray ahead of the washer chamber, and to provide more uniform air distribution, perforated inlet plates, horizontal louvers or vertical eliminator baffles may be provided in the washer inlet. Inlet diffusion plates may be required when the air and water spray are in the same direction because eddy currents may be present. Eliminator baffles are used where one or more of the water sprays opposes the air flow and is sufficiently close to the entering end that water might come out. At the outlet end of the washer, suitable eliminator plates are placed and may or may not be provided with flooding devices. These plates or blades, for the removal of entrained moisture, may cause four to six directional air changes and present as many as four effective hooked edges for trapping the water. Blades usually have bends at 30 deg to the direction of air flow. Sharper bends add substantially to the resistance without improving the elimination materially. Vertical type baffles may be provided with flooding devices where the air contains large quantities of particulate matter or lint, as in cotton mills, to prevent build-up on the baffle blades.

Table 1 . . . . Classification of Apparatus Used for Humidification and Evaporative Air Cooling

Designation	Humidification: Indirect	Humidification: Direct	Evaporative Air Cooling: Primary Wet Surfaces	Evaporative Air Cooling: Dry Surface or Secondary Cool Surface	Evaporative Air Cooling: Two Stage
Residential	1. Evaporating pans with "wick action" water transport. 2. Externally heated evaporator pans (electric or steam heat). 3. Porous, extended surface pad types.	1. Atomizers or sprays.	1. Drip type, usually nonmetal pads. 2. Slinger type, usually metal pads. 3. Rotary type, usually metal screens.	1. Blast coils cooled by cooling tower water.	
Commercial or Industrial	1. Air washers, spray and fill types.	1. Pneumatic atomization. 2. Pressure atomization. 3. Centrifugal atomization. 4. Steam jets.	1. Drip type, usually non-metal pads. 2. Slinger type, usually metal pads. 3. Spray or washer type. 4. Rotary type, usually metal screens.	1. Blast coils cooled by cooling tower water.	1. Secondary cool surface cooling followed by primary wet surface or spray cooling.

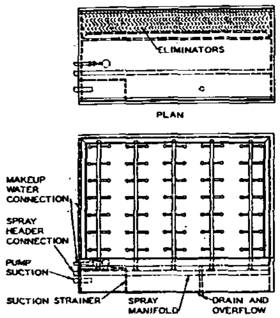

Fig. 1 . . . . Typical Single-Bank Air Washer

Figs. 1 and 2 show the essential construction features of conventional spray-type air washers. Intimate contact between the air and water is secured (1) by breaking the water into fine drops, (2) by passing the air over the surfaces continuously wetted by water, or (3) by a combination of the two.

Essential requirements in the air washer operation are: uniform distribution of the air across the spray chamber, air velocities of from 400 to 700 fpm in the washer chamber, an adequate amount of spray water broken up into fine droplets at pressures of from 15 to 30 psig, good spray distribution across the air stream, sufficient length of travel through the spray and wetted surfaces, and the elimination of free moisture from the outlet air.

Expected performance, physical size, length, number of sprays, etc., vary greatly depending on the functions of the installation. In general, the width and height of an air washer will depend on the space available. Washers of nearly equal height and width are desirable from an air flow and economic standpoint, although these proportions are not necessary. The length of washers varies considerably. A space of approximately 2½ to 4½ ft between spray banks is used, and the first and last banks of sprays are located about 1 to 1½ ft from the entering or leaving end of the washer. In addition, air washers may be furnished with heating or cooling coils within the washer chamber. These coils may affect the overall length of the washer.

Spray water requirements for spray-type air washers used for washing or evaporative cooling vary from 4 gpm with a single bank to 10 gpm for double banks per 1000 cfm. Pumping heads will usually be in the range from 55 to 80 ft of water depending on spray pressure, height of apparatus, pressure losses in pipe and strainers, etc.

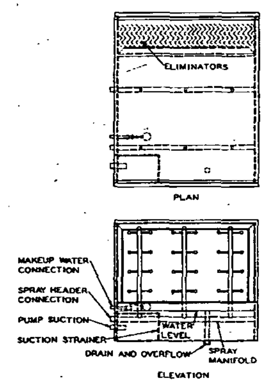

Fig. 2 . . . . Typical Two-Bank Air Washer

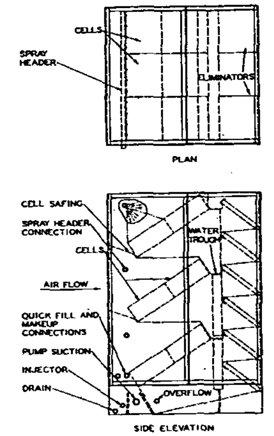

Fig. 3 . . . . Typical Fill-Type Air Washer

The resistance to air flow through an air washer varies with the type and number of baffles, eliminators, and wetted surfaces; number of spray banks and their direction; air velocity; size and type of other resistances such as cooling and heating coils; and other factors such as air density. Resistance may be as low as ¼ in. or high as 1 in. water column. It is therefore necessary that the manufacturer be consulted with regard to the resistance of any particular washer design combination.

Fill-Type Washers

Other air washer types achieve contact between air and water by passing the air through cells packed with glass fibers or sheets of specially designed media. See Fig. 3. These washers have the cells arranged in tiers over which water is distributed at low pressure. The cells are followed by conven-