type, since this application requires a wide range of satisfactory and quiet operation against relatively high pressures. They can readily be connected to apparatus of large cross-section on the inlet side, and to relatively small ducts on the outlet side.

Comparative sizes have been standardized among manufacturers,[2] and most rating tables cover a range of 700 to 500,000 cfm, and static pressures from ¼ to 15 in. of water.

Central system exhaust fans are predominately centrifugal, but the space conservation of the axial is being increasingly utilized. Tubeaxial and vaneaxial fan sizes are not yet standardized, but several manufacturers list capacities from 2000 to 100,000 cfm, and static pressures up to 3 in. of water.

Exhaust fans are found in all types. *Wall fans* are predominantly of the propeller type, since they operate against little or no resistance. They are listed in capacities from 1000 to 75,000 cfm. They are sometimes incorporated in factory-built pent houses or roof caps, or are provided with matching automatic louvers. *Hood exhaust fans* (Chapter 45) involving ductwork, are predominantly centrifugal, especially if handling hot, corrosive or erosive fumes, where it is best to keep the bearings and drive remote from the air stream. Otherwise, axial fans are applicable, and where little or no ductwork is involved, propeller fans are suitable. *Spray booth exhaust fans* (Chapter 45) are frequently centrifugal, especially if built into self-contained booths. Tubeaxial fans lend themselves particularly well to this application where ease of cleaning and of suspension in a section of ductwork are advantageous. For such application built-in clean-out doors are desirable. *Material handling fans* (Chapter 45) are always straight radial (or modified) blade centrifugal type. They are of heavier construction, and have fewer blades and greater clearances than ventilating fans. Many characteristics are compromised to provide wear resistance and ease of maintenance. They are commonly listed in capacities from 600 to 60,000 cfm, and static pressures up to 15 in. water.

Mine fan applications[11] vary greatly and require fans ranging from small portable units for local ventilation, to immense slow speed centrifugal fans, often steam engine driven, for general or emergency ventilation. Vaneaxial fans are well suited to mine ventilation. For underground location, their compactness saves on cost of excavations, and above ground, their ready reversibility is valuable in emergencies, even if reversal causes a reduction in capacity.

Marine fans (Chapter 47) are of both centrifugal and vaneaxial types. The latter are particularly well adapted to both combatant and non-combatant ships, where compactness and light weight are invaluable.

Unitary systems, i.e., unit heaters, unit ventilators, unit humidifiers, unit air conditioners, unit air coolers and unit evaporative condensers are equipped with centrifugal or propeller fans, the latter usually being limited to the relatively small suspended type where no ductwork is involved. Fans for units having considerable internal or possible external resistance, are mostly of the forward-curved blade, or so-called mixed flow centrifugal type. The latter is really a centrifugal type with axial inlets, having a pressure curve resembling a backward-curved blade centrifugal fan. Both of these types have the high capacities (in relation to displacement) requisite for a compact unit. Ratings are frequently given for these units as separate fans, as well as in conjunction with the various internal resistances.

In multiple units on a common shaft they are listed up to 40,000 cfm capacities.

Cooling tower fans (Chapter 34) are predominantly of the propeller type, but axial types are also used for packed towers, and occasionally a centrifugal fan is used to supply forced draft.

Circulating fans are invariably of propeller or disk type, and are made in a vast variety of blade shapes and arrangements. They are designed for pleasing appearance, as well as utility.

General purpose fans are centrifugal fans of conventional design, built for service in the lower capacity ranges. They are built with the fan wheel mounted on the motor shaft, or connected to a self-contained belt driven arrangement. They are listed in capacities from 100 to 20,000 cfm, and static pressures up to 1½ in. water.

Kitchen fans for domestic use are small propeller fans arranged for window or wall mounting, and with various useful fixtures. Their capacities range from 300 to 800 cfm.

Attic fans are used during the warm seasons to draw large volumes of outside air through a house or other building whenever the inside temperature exceeds the outside, and thereby utilize the cooling effect of the relatively cool evening or night air. Research by the A.S.H.V.E.[12] indicates that a two to three-minute air change per hour is desirable in the North; in the South, a one-minute change is recommended to provide the additional cooling effect of air motion.

Fans may be centrally located in an attic or other unused space, or in a hallway, and arranged to draw proportionately from several rooms; or local window units may be installed in a single room. Central units draw from the living quarters and discharge into the attic, whence the air escapes through windows or grilles; or the air may be drawn through grilles into the attic with the fan discharging directly outdoors. Discharge openings on the lee side are preferred.

Attic fans are invariably propeller type, and should be selected for low velocities to minimize the noise. Noise is more of a problem on local units, but care should be taken to prevent transmission of noise or vibration on all installations, since they operate during sleeping hours. Central units are available in sizes from 3,000 to 30,000 cfm, and window units up to 8,000 cfm.

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