One type of room instrument consists of a blackened copper sphere of 6 or 8 in. in diameter, in which a cylindrical sump contains a volatile liquid. A small electric heating coil creates in the sphere a vapor pressure which remains constant as long as the total heat loss from the sphere is at the desired rate. If the Operative Temperature becomes too high for comfort, a greater vapor pressure results from the smaller heat loss from the sphere. This acts on a diaphragm and reduces the supply of heat to the room. With too low an Operative Temperature the reverse action occurs. A similar instrument which has an electric heating element for warming the air inside the sphere and the thermostat operated switch is also used for controlling room conditions.

In addition to a thermostatically controlled device for modulating the temperature of the circulating water, it is advantageous to insert in each coil a locked flow control or adjustable resistance to give uniform conditions throughout all rooms. Owing to unforeseen difficulties with varying frictional losses in pipes, emission factor, and exposures, it is an advantage to be able to regulate permanently the flow through each circuit by means of a key operated valve as indicated in Fig. 4.

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# CHAPTER 32

# Fans

*Classification, Performance, Fan Efficiency, Characteristic Curves, System Characteristics, Selection of Fans, Fan Designations, Control, Motive Power*

IN heating, ventilating, and air conditioning practice, fans and blowers are used to produce air flow. All fans or blowers are classified according to the direction of air flow through the fan with relation to the axis of rotation and are either of the (1) *axial flow* or *propeller* type, in which the flow is parallel to the axis, or (2) *radial flow* or *centrifugal* type, in which the flow is at right angles to the axis.

*Axial flow fans* are made in various designs and sizes. The form and number of blades may vary for impellers of the same or different diameters. The blades may be of uniform thickness and made of cast or sheet metal, and either flat or cambered or of screw form; or they may vary in thickness, in the latter case usually being designed to conform to so-called *airfoil* sections of known characteristics, similar to those which have been developed for airplane propellers. Likewise, blade angle, or the angular relation of the blades to the plane of rotation, varies over a wide range. For operation against comparatively high pressures, it is customary to resort to enlarged hubs in proportion to fan diameter (large hub ratio) and correspondingly short blade length. The term *disc fan* has sometimes been loosely applied to such large hub fans, though it has long been generally used in connection with any propeller fan of comparatively short axial length whose blades are relatively flat; in other words, for fan wheels which occupy a space which is more or less disc-shaped. Single stage air foil axial flow fans can operate at pressures up to 4 in. at a quite low noise level and, at considerably higher pressures, they are comparable in regard to noise to the centrifugal fan type.

*Radial flow* or *centrifugal fans* used in heating, ventilating, and air conditioning practice, are in general of two types; one with forward-sloped blades, and the other with backward-sloped blades. Many modifications may be made in the proportions, the curvature, and the slope or angularity of the blades. The slope or angularity of the blades determines the operating characteristics of a fan; a forward-curved or sloped blade is found in a fan having low speed operating characteristics, while a backward-curved or sloped blade is found in a fan having higher speed operating characteristics.

A wide variety of heating, ventilating, and air conditioning systems creates a wide variety in the demands that have to be met by the fan or blower. The requirement may be to move small or large quantities of air against little or no resistance, or to move small or large quantities of air against higher resistance. Between the two limits innumerable specific requirements must be met. Although fans of any class in either of the two general types can in general be made to perform the same duty, mechanical difficulties, space and noise limitations, efficiency and power limitations usually determine the selection.

## FAN PERFORMANCE

Fans of all types follow certain laws of performance which are useful in predicting the effect upon performance of changes in the conditions of operation, the duty required of the installation, or the size of the equip-