flow fans are installed in ducts, provisions may be made to install the driving motor outside the duct by employing slots in the duct to permit a belt drive from the motor to the fan sheave, or by extending the shaft for a direct-connected motor placed outside of a Y fitting or elbow in the duct system.

The *forward-curved multiblade* fan and the *backward-curved* type are used extensively in heating, ventilating, and air conditioning work. The forward-curved type has a low peripheral speed and a large capacity. (See Fig. 2). The point of maximum efficiency for this fan occurs near the point of maximum pressure. The static pressure drops consistently from the point of maximum efficiency to full open operation. The power curve rises continuously from low to peak capacity and, if reasonable care is exercised in calculating resistance, a moderate reserve in power in the motor selection will prevent overloading.

The *backward-sloped type* includes the full backward-curved blade and the double-curved blade having a forward-curved heel and a backward-curved tip. This type has steep pressure curves, non-overloading power characteristics, and relatively high speed (see Fig. 3). This fan operates at a peripheral speed approximately 175 to 200 per cent of that of the forward-curved multiblade fan for like performance. Pressure curves for this type begin to drop at very low capacity, with the most rapid drop beginning at about 60 per cent of wide open volume. The steep portions of the pressure curves tend to produce nearly constant capacity under changing pressures. Where wide fluctuations in demand occur, especially where the regulation is obtained by damper control and particularly through by-passes, this type of fan is desirable to prevent overloading of motor. The maximum power requirement occurs at about the maximum efficiency. Consequently a motor selected to carry the load at this point will be of sufficient capacity to drive the fan over its full range of capacities at a given speed. The high speed of this type makes it adaptable for direct connected electric motor drives. The dimensional bulk is usually greater than that of the forward-curved multiblade type.

Between the extremes of the forward and backward curved blade type centrifugal fans there exists a number of modified designs differing in angularity and in the shape of the blades. Characteristic curves of these types show varying degrees of similarity to the curves in Figs. 2 and 3.

SYSTEM CHARACTERISTICS

Any ventilating system consisting of duct work, heaters, air washers, filters, etc., has a system characteristic which is individual to that system and is independent of any fan which may be applied to the system. This characteristic may be expressed in curve form in exactly the same manner that fan characteristics may be shown. Typical system characteristic curves are shown as A, B and C in Fig. 4. These curves are drawn to follow the simple parabolic law in which the static pressure or resistance to flow of air varies as the square of the volume flowing through the system. Heating and ventilating systems follow this law very closely and no serious error is introduced by its use.

When a constant speed fan curve for a given size fan is super-imposed upon a system characteristic curve, the relation between the two is at once apparent. The only point common to the two curves is the point at the intersection of the system characteristic curve and the fan characteristic curve, and it is at this point that the combination will operate. In

Fig. 4, curves A, B and C cross the fan characteristic curve at points X, Y and Z. This means that when the fan whose curve is shown is applied to system A, 10,000 cfm will flow through the system. If it is applied to system B, 13,000 cfm will flow, and applied to system C, 16,400 cfm will flow through that system.

The curves in Fig. 4 also illustrate the effect of errors which may be determined by calculating the resistance of a ventilating system. For instance, a given system requires 13,000 cfm and the resistance to flow of the system has been computed as 1.25 in. static pressure. Such a

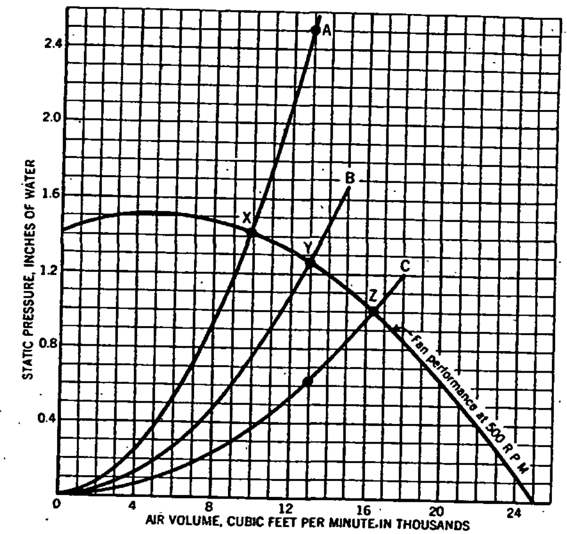

Fig. 4. Parabolic System Characteristic Curves

system may be represented by curve B in Fig. 4. Assume that 100 per cent error has been made and the resistance calculated should have been 2.5 in. instead of 1.25 in. Then the system would be as shown in curve A. This new system curve crosses the fan curve at 10,000 cfm. Such an error would result in the flow of air being decreased from a design volume of 13,000 cfm to 10,000 cfm. In case the resistance to flow had been over estimated and instead of 1.25 in. being required, the resistance actually should have been 0.625 in., this would correspond to a system curve as shown at C and on this curve the fan would deliver 16,400 cfm to the system instead of the design volume of 13,000 cfm.

In this example extreme errors have been selected to emphasize the effect the square function of the system characteristic has in maintaining the fan performance within comparatively narrow limits. In the first example a system estimated at half what it should have been, resulted in a drop of 23 per cent in volume; and in the second example, a system estimated at twice what it should have been resulted in an increase of 26 per cent in volume.

In some instances fans may be applied to variable flow systems. In such cases the limiting systems may be plotted and the effect on fan performance examined. For instance, a system might vary between