Generally, fans are selected either at the peak of the static efficiency or to the right of the peak depending on the requirements of the particular installation. Fans selected to the right of the peak will be smaller but will require more power, run at higher speeds and may have a higher sound rating. Where first cost is important and added horsepower and noise are not important, smaller fans may be used. Where efficient and quiet operations are most important, fans are selected at or near the peak of the static efficiency curve. Fans are not ordinarily selected to the left of the peak of the static efficiency curve as this results in larger, more costly fans, requiring more power and in some cases producing objectionable noise.

The curves in Figs. 1, 2, and 3 show operating characteristics for axial flow and two classes of centrifugal fans, namely, forward-curved multiple blade and backward-inclined blade design, for comparison purposes. These curves are not applicable for rigid comparison or actual selection, but are shown to indicate variations in operating characteristics.

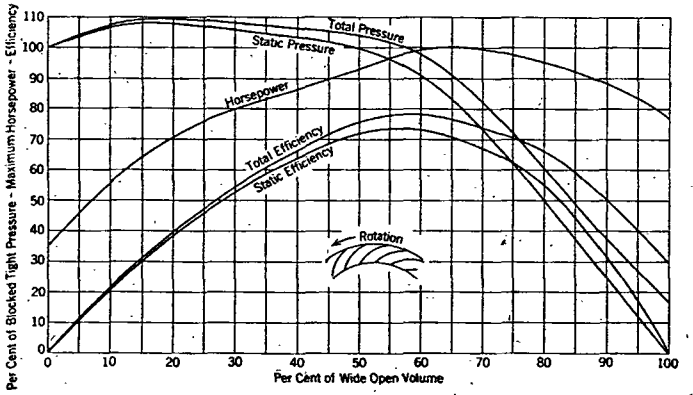


FIG. 3. OPERATING CHARACTERISTICS OF A FAN WITH BLADES CURVED BACKWARD

The curves in Fig. 1 of a *typical axial flow* fan show characteristics of non-overloading horsepower and high efficiency. These results are obtained by producing a more uniform pressure throughout the blade annulus, so that back flow does not occur except at high pressures. This avoidance in turbulence has a tendency to reduce noise. Fans of this type are operating against static pressures as high as 4 in. water. The capacity and efficiency of axial flow fans when operating above the low pressure range can be improved by the use of either inlet or outlet guide vanes or both. The effect of such vanes is to increase the level of the pressure volume curve, and properly designed vanes on the discharge side of the fan have the advantage of eliminating the rotational component of the air stream, thus restoring uniform axial flow. As high pressures usually require large hubs in proportion to the fan diameter, performance is improved by the use of round-nosed or conical forms mounted coaxially with the direct-connected fan (sometimes partly or wholly enclosing the motor) so as to make the changes in velocity to and from the fan blade annulus as uniform as space conditions permit. When axial 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, system characteristic curves A, B and C cross the fan characteristic curve at points X, Y and Z. The fan whose curve is shown, when