jointly by the AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS and the *National Association of Fan Manufacturers* are generally plotted to show total and static pressure, mechanical and static efficiency, and horsepower in relation to air delivery as a basis. Results may also be plotted against per cent of wide open volume or discharge. Examples of fan performance curves are shown in Figs. 1, 2 and 3.

In the selection of all but very small fans, power consumption is usually a major consideration. It must be borne in mind that the horsepower at peak efficiency alone may be misleading, as actual operation is apt to occur at some point on the pressure-volume curve varying considerably from that specified, due to inaccuracies of the estimated system resistance or to fluctuating resistance caused by damper or louver adjustments. To cope

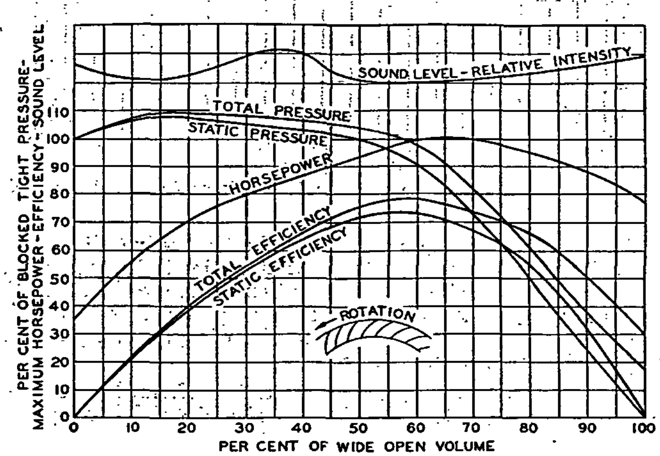

FIG. 3. OPERATING CHARACTERISTICS OF A FAN WITH BLADES CURVED BACKWARD

with such variations a fan should be selected having a high efficiency over a wide range, that is, a *flat* or broad efficiency curve is more desirable than a sharp or narrow curve which, though reaching a high peak, falls off rapidly to either side of a narrow range. When the point of operation varies only within narrow limits and both volume and pressure requirements are accurately known in advance, the designer can select a fan operating at maximum efficiency, irrespective of performance over the entire range.

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.

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 by employing slots in the duct to permit a belt drive from motor to 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.

Between the extremes of the forward and backward curved blade type centrifugal fans there exists a number of modified designs differing in