selection. Fans selected to the right of the peak will be smaller but will require more power, run at higher speeds and 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 operation 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 shown in Figs. 2, 3, 4 and 5 show operating characteristics for various types including the backwardly inclined blade design for comparison purposes. These curves are not applicable for rigid comparison or actual selection and are shown to indicate the variations in operating characteristics.

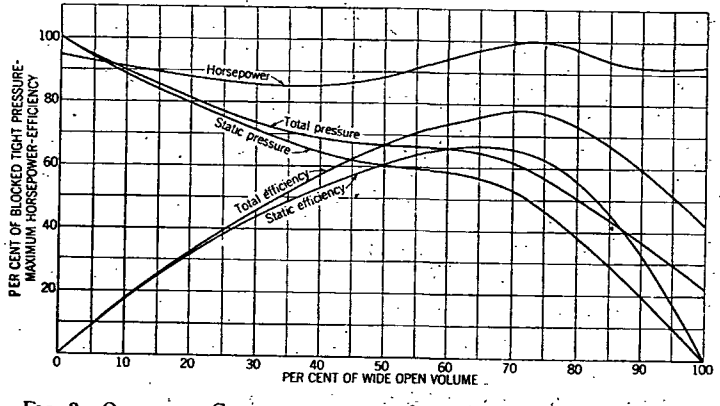

FIG. 3. OPERATING CHARACTERISTICS OF AXIAL FLOW AIRFOIL TYPE FAN

Axial flow fans having blades of *uniform thickness* at any given radius are characterized by rapid rise in power consumed as the resistance increases, as illustrated in Fig. 2. When operating against high resistance, this type of blade permits some of the air to pass back between the blades near the hub, where blade speed is much lower than near the tip or periphery. Obviously, a fan of such characteristics should only be used against low resistance.

The curves in Fig. 3 show the characteristics of typical *axial flow fans* with *airfoil* design. This type of fan shows characteristics of non-overloading horsepower and high efficiency at relatively high static pressure, as contrasted with a fan blade of uniform thickness. These results are obtained by more uniform pressure throughout the blade annulus, so that back flow does not occur until high pressures are reached. This reduction in turbulence also has a tendency to reduce noise. Fans of this type are now available, operating against static pressures up to 3 and 4 in. water, single stage and 6 to 8 in. water, double stage. The capacity and efficiency of axial fans can be improved, particularly when operating against considerable pressure, by the use of either inlet or outlet guide

vanes or both. Generally, 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 quickly 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 space conditions permit. When axial flow fans are installed in ducts, provisions may also 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.

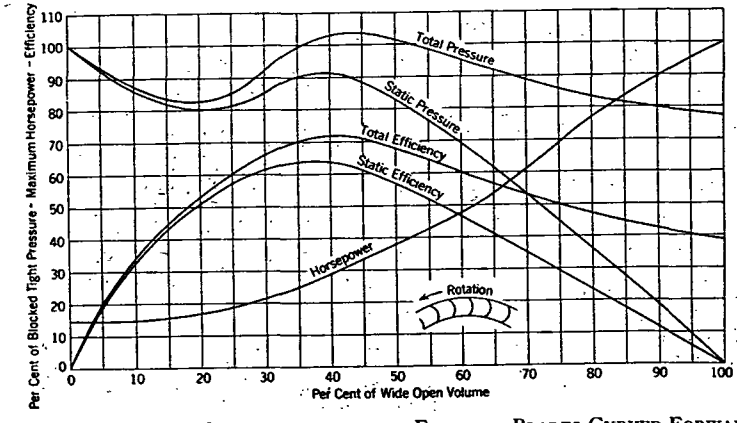

FIG. 4. OPERATING CHARACTERISTICS OF A FAN WITH BLADES CURVED FORWARD

The *straight blade* (*paddle-wheel*) or partially backward curved blade type of fan is seldom used for ventilation. Its use is largely confined to such applications as conveyors for material, or for gases containing foreign material, fumes and vapors. The open construction and the few large flat blades of these wheels render them resistant to corrosion and tend to prevent material from collecting on the blades. This type of fan has a good efficiency, but the power steadily increases as the static pressure falls off, which requires that the motor be selected with a moderate reserve in power to take care of possible error in calculation of duct resistance.

The *forward curve* multiblade fan and the backward curve types are used extensively in heating and ventilating work. The forward curve type has a low peripheral speed and a large capacity, and is quiet in operation. (See Fig. 4.) The point of maximum efficiency for this fan occurs near the point of maximum static pressure. The static pressure drops consistently from the point of maximum efficiency to full open operation. The power curve rises continually 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.