true resistance to air flow. Such tables charge both the inlet and outlet velocity of the fan, to the fan performance, and may be used directly where the static pressure of the system as calculated represents only the actual resistance to flow of the air.

The efficiency based upon static pressure is known as the static efficiency and may be expressed as follows:

$$\text{Static efficiency}^1 = \frac{\text{cfm} \times \text{static pressure in inches of water}}{6356 \times \text{Horsepower input}} \qquad (2)$$

Different fans may develop the same capacity against the same static pressure and with the same power input, and therefore operate at the same static efficiency, while maintaining different outlet velocities. Where a high outlet velocity is desirable or can be utilized effectively, the static

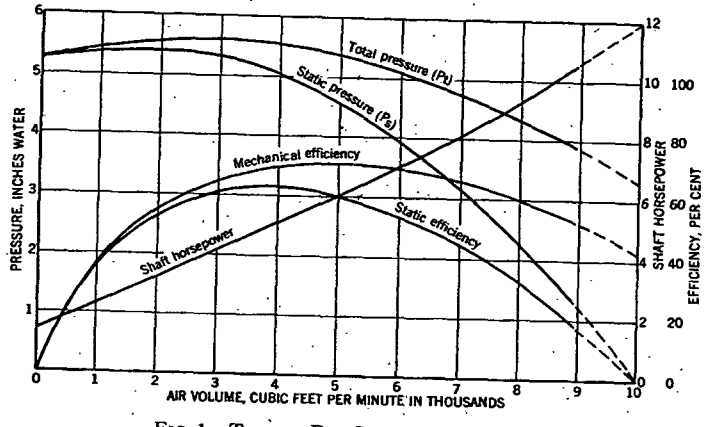


FIG. 1. TYPICAL FAN PERFORMANCE CURVE

efficiency fails to be a satisfactory measurement of the performance. In many applications of propeller fans, air is circulated without encountering resistance and no static pressure is developed. The static efficiency is zero and its calculation is meaningless. Because of such situations where the static efficiency fails to indicate the true performance, many engineers prefer to base the calculation of efficiency upon the total pressure. This efficiency is variously known as the total, or mechanical efficiency, and may be expressed as follows:

$$\text{Mechanical or Total efficiency}^1 = \frac{\text{cfm} \times \text{total pressure in inches of water}}{6356 \times \text{Horsepower input}} \qquad (3)$$

CHARACTERISTIC CURVES

In the operation of a fan at a fixed speed the static and total efficiencies vary with any change in the resistance which is imposed. With different designs the peak of efficiency occurs when the fans deliver different percentages of their wide-open capacity. Variations in efficiency accompany

variations in pressures and power consumption which are characteristic of the individual designs and which are influenced particularly by the shape and angularity of the blades. Such variations in pressure, power, and efficiency are shown by characteristic curves.

Characteristic curves of fans are determined by tests performed in accordance with the Standard Test Code for Centrifugal and Axial Fans[2] prepared jointly by the AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS and the *National Association of Fan Manufacturers*. The results of tests are plotted in different ways: the abscissae may be the ratio of delivery, assuming full open discharge as 100 per cent, and the ordinates may be static pressure, total pressure, horsepower and efficiency. A typical fan performance curve is shown in Fig. 1.

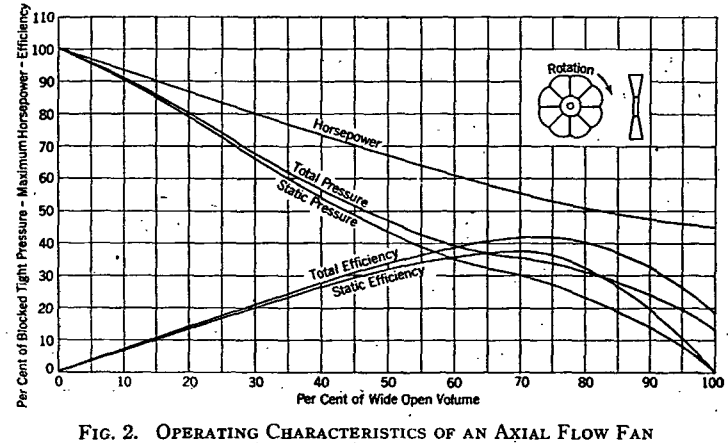


FIG. 2. OPERATING CHARACTERISTICS OF AN AXIAL FLOW FAN WITH BLADES OF UNIFORM THICKNESS

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 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

[1] A.S.H.V.E. TRANSACTIONS, Vol. 29, 1923, p. 407. Amended in A.S.H.V.E. TRANSACTIONS, Vol. 37 1931, p. 363. Third Edition of 1938.