clined backward away from direction of rotation. They are also characterized as slow speed, moderate speed and high speed types, respectively, although the actual speed range of each may be wide and overlapping. The highest speed type may operate as high as 200 percent of the speed of the lowest speed type, to deliver the same volume of air and the same pressure. The differentiating curvature is always the tip of the blade, since the inlet edge, if inclined, is always curved forward to minimize the shock loss at entrance. Straight radial blades are most frequently found in pressure fans and material handling fans.

Centrifugal fans produce pressure from two independent sources: (1) from the centrifugal force created by rotating the enclosed air column, and (2) from the kinetic energy imparted to the air by virtue of its velocity

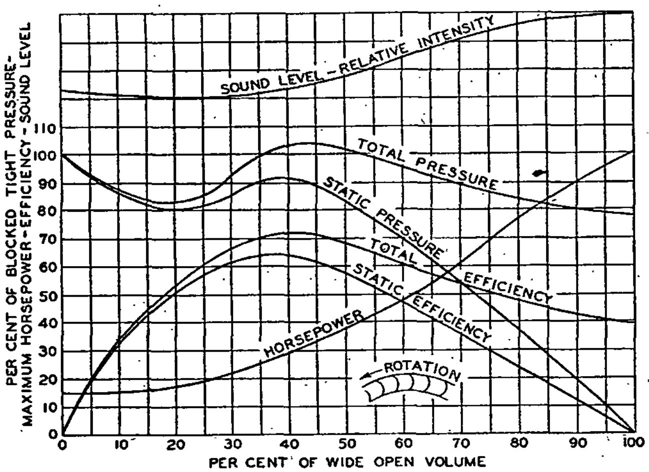

Fig. 2. Percentage Performance Curves of a Forward-Curved Blade Centrifugal Fan

leaving the impeller. This velocity in turn is a combination of rotative velocity of the impeller and air speed relative to the impeller. When the blades tip forward, these two velocities are cumulative, and when backward, oppositional. Thus a fan with forward-curved blades depends less on centrifugal force for its pressure, and more on velocity pressure conversion in the scroll, with the result that it may run at relatively low speed. Conversely, a fan having backward-curved blades builds up more of its pressure by centrifugal force (a more efficient form of energy transfer) and less by velocity conversion and, therefore, must run at a higher speed. Likewise, a fan having forward-curved blades will produce the greatest capacity of any type of the same size when operating against no resistance.

Since the energy imparted to the air depends on the velocities,[7] and since the velocities are cumulative with a fan having forward-curved blades, the theoretical energy per pound of air rises rapidly with an increase of air delivery. With the velocities oppositional in the fan having backward-curved blades, the energy per pound of air may decrease, and in a fan

having straight blades it is roughly constant. Thus the shape of the horsepower curve definitely identifies the blade angle.

Performance curves of a typical *forward-curved* blade centrifugal fan are shown in Fig. 2. The pressure rises from free delivery toward no delivery, with a characteristic drop at low capacities, because a large share of the pressure is being generated by conversion of velocity, which is small at low capacity. The maximum efficiency occurs at approximately maximum pressure. The horsepower curve reflects the increase in energy by rising rapidly from no delivery to free delivery. The sound is a minimum at maximum efficiency, and rises toward free delivery as the velocities increase.

Performance curves of a typical *backward-curved* blade centrifugal fan are shown in Fig. 3. The pressure is constantly rising from free delivery

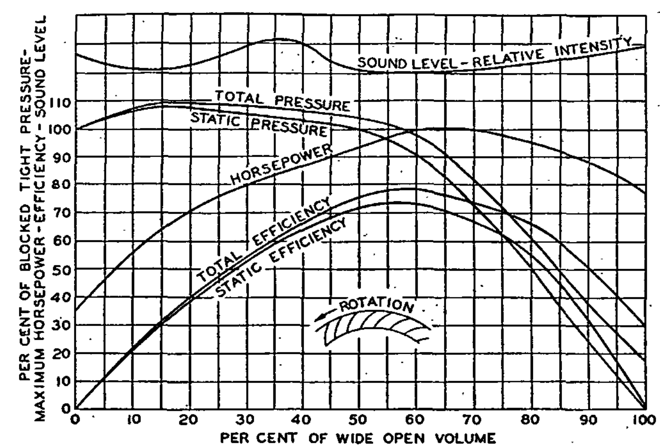

Fig. 3. Percentage Performance Curves of a Backward-Curved Blade Centrifugal Fan

nearly to point of no delivery. The horsepower reflects the energy-velocity relationship by rising to a maximum value as the capacity increases, and then decreasing with further increase in capacity to give a self-limiting horsepower characteristic. The maximum horsepower coincides approximately with the maximum efficiency. The sound is again a minimum near maximum efficiency, but is little or no higher at free delivery than at low capacities.

Between the extremes of forward and full-backward-curved blades, there exists a number of intermediate designs which show varying degrees of similarity to the curves in Figs. 2 and 3. A common variation is a fan having modified backward, single or double-curved blades and equipped with fixed inlet vanes. Such vanes applied to a partially backward-curved impeller give the steep, constantly rising pressure characteristic, and the self-limiting horsepower feature of the full-backward-curve. They also