demands of each case will dictate which type of control is most desirable. Where noise is a factor, lowering the fan speed if possible is preferred as a control means, because of the resulting reduction in sound level.

MOTIVE POWER

Heating, ventilating and air conditioning fans are usually driven by electric motors, although other prime movers may be used. The small sizes of fans, and especially those operating in the higher speed range, are equipped with direct-connected motors. For larger size fans and those operating at lower speed V-belt drives are generally used.

In selecting the size of motor for operating a fan, it is advisable to select at least the standard size next larger than the fan requirements. Direct-connected motors do not require so great a safety factor as belted units. Justification for liberal power provision exists only in systems where it is possible that larger volumes of air may be required at intervals and made available by use of by-pass dampers, thus greatly reducing the system resistance. If such a system includes a fan with forward-curved blades, it would be necessary that the motor be sized for the maximum volume and duty. If such a system includes fans with backward-curved blades, the volume peak would not make it necessary to provide additional motor power. In selecting fans for such a system, sound ratings should be given careful consideration.

Where a system is constant, and has no provision for volume change that would materially reduce the resistance, and when the resistance calculations are reasonably accurate, there is no necessity for too liberal a motor allowance, even where fans with forward-curved blades are used, if the fan has been properly selected. Fig. 4 shows that the system resistance varies as the square of the volume and the fan static pressure varies approximately inversely as the volume, thus greatly offsetting the trend toward both increase in air delivery and motor load. Reference to Fig. 4 indicates that there is no justification for allowing large spare motor capacity, and it is generally more economical to operate motors well loaded.

ATTIC FANS

Attic fans are used during the warm months of the year to draw large volumes of outside air through a house and offer a means of using the comparative coolness of outside evening and night air to lower the inside temperature.

Because the low static pressures involved are usually less than $\frac{1}{8}$ in. of water, disc or propeller fans are generally used instead of the blower types. The fans should have quiet operating characteristics, and they should be capable of giving 20 to 30 room air changes per hour in northern areas. In the South usual specification requires one air change per minute which provides appreciable air movement in addition to lowering the inside air temperatures[4].

Types

Open attic fans are units in which the fan is installed in a gable or dormer of the attic and one or more grilles are provided in the floor of the attic, permitting air to flow from the hall below. Outdoor air, which enters the house through open windows, is drawn into the attic through the grilles, and is discharged outside by the fan. An attic stairway may be used in place of the grilles. It is essential that the roof and the attic walls be free from air leaks.

Boxed-in fans are units in which the fan is installed within the attic in a box or housing directly over a central ceiling grille, or in a bulkhead enclosing an attic stair. The fan may be connected by a duct system to the grilles in individual rooms. Outdoor air entering through the windows of the rooms below is discharged into the attic space and escapes to the outside through louvers, dormer windows, or screened openings.

Another version of the attic fan is the *window fan* for use when attic application is not feasible or no attic is available. Supplied with a perforated or expanded metal enclosure and mounted in either the upper or lower window section, this fan is easy to install or transfer.

The locations of the fan, the outlet openings, and grilles should be selected after consideration of the room and attic arrangements in order to give uniform air distribution in the individual rooms served. If the outlet for the air is not on the side away from the direction of the prevailing wind as in the case of the boxed-in fan, openings should be provided on all sides. Kitchens should be separately ventilated because of the fire hazard, and to prevent the spread of cooking odors.

The window fan may be located in a hall or an unused bedroom. Noise of operation is more of a problem with the window fan than with the attic type, although care should be taken to locate either type of fan so that occupants are not disturbed.

These fans range in capacity from 3,000 to 30,000 cfm. The window type usually does not exceed 8000 cfm, while the most generally used attic type ranges from 8000 to 16,000 cfm. Power consumption is under 50 watts an hour per 1000 cfm of rated output for the 8000 cfm fan and larger, while the watts input for smaller fans is greater than this figure. Improved results can be secured with the window fan by closing off parts of the house where ventilation is not desired.

REFERENCES

[1] See Standard Test Code for Centrifugal and Axial Fans, 3rd Edition, 1938, Bulletin No. 103, *National Association of Fan Manufacturers*.

[2] Recommendations adopted by the *National Association of Fan Manufacturers*.

[3] Supplement No. B to Form X-12, *National Association of Fan Manufacturers*.

[4] Comfort Cooling with Attic Ventilating Fans, by G. B. Helmrich and G. H. Tuttle (A.S.H.V.E. TRANSACTIONS, Vol. 40, 1934, p. 155). A.S.H.V.E. RESEARCH REPORT No. 979—Study of Summer Cooling in the Research Residence for the Summer of 1933, by A. P. Kratz and S. Konzo (A.S.H.V.E. TRANSACTIONS, Vol. 40, 1934, p. 167). A.S.H.V.E. RESEARCH REPORT No 1198—The Effect of Attic Fan Operation on the Cooling of a Structure, by W. A. Hinton and A. F. Poor (A.S.H.V.E. TRANSACTIONS, Vol. 48, 1942, p. 145). The Installation and Use of Attic Fans, by W. H. Badgett (Agricultural and Mechanical College of Texas, *Bulletin* No. 52, 1940).

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