The power required for such fans is proportional to the volume of the air moved, and to the pressure overcome. Centrifugal fans with radial or forward-curved blades require power proportional to the volume at constant speed and have a power increase as the cube of the speed. If the resistance is increased the air volume is reduced, and the power at constant speed is reduced. If the resistance is reduced the air volume is increased at constant speed, and the power demand will be increased.

Centrifugal fans with backward-curved blades and those with compound curves while following the same general laws as the fans with the forward-curved blades, have been developed to the extent that they have a self-limiting power demand at a certain peripheral velocity even though the resistance at that speed may be decreased.

It is no easy matter to predetermine the exact resistance to be encountered by a fan, or having determined this resistance, to insure that no changes in construction or operation shall ensue which may increase air resistance, thus requiring more fan speed and power to deliver the required volume, or which may reduce air resistance, thus causing delivery of more air and a consequent increase of power even at constant speed.

It is recommended therefore for centrifugal type fans that the rated power to be supplied shall exceed the rated fan power by a liberal margin, depending on the type of blade, of from 10 per cent minimum, to about 25 per cent maximum.

Justification for liberal power provision exists also in the possibility of varying demand due to changes in ventilation requirements, intensity of occupation, weather conditions, etc.

Speed Control

Some method of volume control of fans usually is desirable. This may be done by varying the peripheral velocity, or by interposing resistance, as by throttling-dampers. Both methods, since they reduce the volume of air, reduce the power required. In many installations adjustments of volume are desirable during varying hours of the day. In others an increased supply of air in summer over that needed for winter, is demanded. There is room for judgment in deciding whether speed-control or damper-control shall be used for specific cases. Where noise is a factor, it may be exceedingly desirable to reduce the speed at times, while on the other hand a centrifugal fan which has its normal speed reduced as much as 50 per cent without change in resistance will move so small a volume of air that operating the fan will be hardly worth while.

Electric Motors

Electric power is the almost universal solution for fan operation, and each type of motor and current has its advantages and disadvantages.

Direct connected electric motors are usually very efficient for fan driving because there is no slippage due to belts, and no wear or noise due to chains or gears.

Unless the fan speeds are high enough to permit comparatively high rotative speeds, however, direct connected motors must be unduly large and heavy and will be costly. If anything goes wrong with a direct

connected motor there may be a considerable delay in replacing or repairing it, and changes in speed are not always made easily with full efficiency. On the other hand, the non-direct-connected motors have transmission subject to wear and slippage, and chains and gears may be noisy. With the latter type, however, changes in speed-ratio are easily made, and in case of a break-down a standard stock-motor may be substituted quickly.

Improved operating characteristics are obtained in the higher speed belted motors than in the slower speed direct connected motors. Efficiencies and power factors of alternating current higher speed motors are greatly improved over those of the slower speed motors. Quietness of operation in induction motors is more easily obtained in the higher speed machines. Magnetic noise is the chief offender because it is carried, and sometimes is amplified, by the steel work of a building. It is possible, however, to obtain motors especially designed for quiet operation, which will practically be free from objectionable noises. Even though these quiet operating motors shall be used the motor and fan still should be insulated from the foundation and the duct system should be broken and a suitable connection made by canvas or some non-metallic substance.

KINDS OF ELECTRICAL CURRENT

Direct current motors are extremely satisfactory for fan drive. Various kinds of speed-control can be obtained by the use of hand, semi-automatic or full automatic controllers.

Single phase, constant speed motors are satisfactory and available in sizes 10 hp. and smaller. Single phase adjustable speed motors (repulsion motors) in small sizes are available, but are satisfactory only when the load is always present. The repulsion single phase motor has an inherent characteristic of being subject to change of speed with a change in load. It should not, therefore, be used in driving centrifugal housed fans where there is any restriction in the fan line, such as a damper. Shutting off the air intake or air outlet from a centrifugal housed fan relieves the motor of the load and, with a repulsion single phase motor, the speed attained because of this light load would be objectionable from a noise standpoint and might do some damage to the fan wheel itself. With a propeller type of fan, the repulsion motor is quite satisfactory because if the air outlet is closed, load on the motor is still maintained.

Single phase motors require special starting devices, which are noisy and troublesome as compared with electric motors for direct current or polyphase current.

Polyphase motors are generally satisfactory for driving fans, though they are not adapted to exceedingly low speeds. It is seldom necessary to reduce the speed of a ventilating fan more than 50 per cent from the maximum fan speed and this feature is obtainable with alternating current motors by the use of hand, semi-automatic or full automatic controllers.

CONTROLLERS FOR ELECTRIC MOTORS

Very small direct current motors may be started by throwing them directly on the line through a suitable starting switch. The larger sizes require some type of starting device. When speed adjustment is desired,