favorably with a direct connected layout. This type of drive is also very quiet in operation, being similar to a conventional belt drive in this respect.

Alternating current motor designs are such that improved operating characteristics are obtained with the higher motor speeds. Efficiencies and power factors are improved over those in effect with slower speed motors, thus showing a considerable saving in power consumption, where some effective speed reducing transmission device to the fan, is installed.

Quietness of operation is more readily obtained with moderately high speed induction motors than with low speed motors, as any slight magnetic unbalance is not as easily heard. Magnetic unbalancing at times causes noises whose repetition and wave length is such as to cause vibrations and harmonics. Amplifications of the noises in other parts of a building remote from the motor equipment are sometimes found, due to such noises being carried by the steel work, ducts, or piping in the building. There is considerable evidence that these sounds are more easily controlled with higher motor speeds than with lower motor speeds.

Motors which are practically quiet in operation and free from magnetic disturbing noises can be obtained and should always be specified for quietness of operation when used for fan installations in buildings where quietness is a factor.

Even though quiet operating motors may be secured, the fan and motor foundations should be insulated from the building structure and the duct system should have a suitable connection made by canvas or other non-metallic substance so as to prevent direct metallic contact between the fan and the building.

In the construction of fan and motor foundations where the machinery is mounted on the floor or upon a concrete platform, it is a usual practice to install a layer of cork on top of which is laid or floated the base which carries the apparatus. It is essential that the bolts or lag screws which fasten the machines to this foundation shall not extend through to the floor. It is wise to fasten curbs to the floor, these presenting insulated surfaces to the machinery foundation and so preventing it from traveling.

Kinds of Electric Motors

Direct current electric motors are extremely satisfactory for fan drives on account of quietness in operation and flexibility in the selection of speeds. Regulation in speed below as well as above the normal operating range may readily be secured by means of either manual or automatic controllers.

Single phase constant speed motors are satisfactory and available. Single phase adjustable speed motors (repulsion type) in small sizes are available, but are satisfactory only when the load is constant. 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 intake or discharge lines, such as a damper. Shutting off the air intake or air outlet from a centrifugal housed fan relieves the motor of most 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 disc or propeller type of fan, the repulsion motor is quite satisfactory because if the air outlet is closed, the load on the motor is still maintained.

Single phase motors require special starting devices which are often noisy and troublesome as compared with the more simple devices available for use with direct current or polyphase motors.

A single phase motor known as the condensor type, has been developed recently which is very quiet in operation, requiring no starting devices in the motor. The motor is similar to a polyphase motor, being without brushes or starting devices. A condenser in series with one of its windings is used to secure the starting torque. This type of motor has a low starting torque well adapted to direct-connected fans, and can be secured in high speeds as well as in low speeds.

Polyphase motors generally are satisfactory for driving fans and are made for constant speed, known as squirrel cage type and for variable speed, known as slip ring type. Both types are available for quiet operation, making them suitable for direct connection for moderately slow speeds. They are not as adaptable to exceedingly slow speeds as are direct current motors on account of low power factor and low efficiency at these speeds.

For slow speed fans, a belt drive of some efficient type is desirable so as to permit use of the higer speed polyphase motor, the design of which has a high efficiency and a more satisfactory power factor.

A new polyphase motor known as the high reactance, self-starting squirrel cage type has become quite popular for fan applications.

It does not require any cumbersome manually-operated starting compensator in sizes up to 30 hp. It may be thrown directly across the line in starting. These motors are designed to give about 100 per cent starting torque, which makes them very suitable for fans; and the instantaneous current demand does not exceed the limits set by the *National Electric Light Association.*

By the use of a magnetic contactor, this type of motor may be installed for remote control and the cost with the controller is less than that of the standard squirrel cage motor with a manually-operated compensator.

There are available also *variable speed polyphase slip ring* type induction motors, suitable for reduction in speed from the normal operating speed to 50 per cent below normal.

It is seldom necessary to reduce the speed of a ventilating fan more than 50 per cent from the maximum fan speed.

Control 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 rheostat. When speed adjustment is desired, the controller for adjusting the speeds of the motor usually functions also as a starting device.

Alternating current motors of 5 hp. and under, usually may be thrown directly on the line. It is good practice to use a starting switch equipped with a thermal overload or inverse time limit overload device. This type