the starting device and means for adjusting speed are usually incorporated in one controller.

Alternating current motors, 5 hp. and smaller, may usually be thrown directly on the line, unless local regulations may prevent.

Remote speed indicating controllers are available for operating fan motors. Speeds are changed by push-button stations, and small electric lamps indicate at what speed the fan is running. This type of control is very desirable in large buildings where the engineer is to have complete charge of the ventilating system. The push-button station may be located in the engineer's office, giving him complete control of the motor and indicating to him at what speed the various fans are running, or these push-button controls may be located in the spaces being ventilated, either with or without duplicate pilot lights in the engineer's office. Remote control may also be effected by pneumatic or by hydraulic apparatus.

Fan speeds generally are constant unless changes in the weather require corresponding variations. There is available a dial switch controller which can be pre-set manually for any speed desired and which after having been so pre-set will operate to control the motor indefinitely, in connection with the push-button. The dial switch may be located either at the remote station or near the fan.

Arrangements can be made for remote control of fan motors, or for automatic control by influence of temperature. Remote control may be by pneumatic or by hydraulic manipulation as well as by electrical means.

In many large ventilating systems which have heating plants in connection, steam engines are used to operate fans. A medium-speed steam engine, exhausting at low pressure into the radiators which heat the building or which warm the air, is a very economical source of power, is nearly noiseless, and has a wide range of speed variation. The steam-economy of such an engine usually is of little importance, since the engine serves as an auxiliary to the pressure-reducing valve interposed in such cases between the boiler and the radiators.

Internal combustion engines and line shafting are often used for fan driving, requiring clutches or shift-belts with loose pulleys in order to secure proper starting and control.

Control of Noise from Fan Motive Power

Experience seems to indicate that noise is largely eliminated by isolation of foundations. The best practice is to bolt the fan and motor rigidly to substantial foundations of concrete or wood, to give inertia and solidity, and to float this foundation above a yielding, inert non-resonant buffer of cork or dry sand, with arrangements to prevent any side motion by interposing similar side-buffers.

It is sometimes necessary to sound-insulate the walls of the machinery room. The best practice for this purpose is cork, felt or other sound absorbing material against the walls, faced with sheet metal, the metal being isolated from direct contact with the building structure, or it is better still to use some porous and non-resonant material instead of the sheet metal.

All duct connections to fans should be made with canvas or other non-sound transmitting materials.

CHAPTER XXVIII

AIR DUCT DESIGN AND CONSTRUCTION

Air Velocities, Properties of Air, Pressure Losses, Proportioning Ducts, Construction Data.

THE successful operation of a mechanical or plenum heating installation, an exhaust system or a dust collecting plant is largely dependent upon the correct design of the duct system. Materials, proportions, friction, location and innumerable other items are factors in the correct operation of a duct system.

In the design of ducts and flues for gravity or mechanical circulation of air, losses due to friction are the basis for figuring and these losses must be kept within the available pressure difference. This pressure difference in mechanical ventilation is that derived from the fan, while in gravity ventilation it is the aspirating effect due to the temperature and height of the column of heated air.

When attempting the design of a duct system the general rules to remember are:

1. The air should be conveyed as directly as possible at reasonable velocities to obtain the result desired with greatest economy of power, material, and space.
2. Sharp elbows and bends are to be avoided.
3. All ducts or flues shall have sides as nearly equal in size as possible. (In no case shall the ratio between long and short sides be greater than 10 to 1.)

The piping systems for various operations must be of different design as the principal consideration for industrial work is for heating while in public buildings the air required for ventilation greatly exceeds the volume needed for heating. For instance, the ducts for a school, theatre or other public building, where freedom from noise and elimination of drafts is essential and where branch ducts serve individual rooms, present more difficult problems in design than are involved in proportioning ducts intended for heating a factory, where a main duct of decreasing dimensions extends lengthwise of the building and gives a uniform distribution of air. For public buildings air velocities must, therefore, be kept low between 900 and 1200 ft. per minute while in industrial buildings they can range from 1500 to 2000 ft. per minute or even more with no other disadvantage than expensive operation.

Material for this Chapter especially prepared for THE GUIDE by A. A. Criqui.