pneumatic or hydraulic apparatus, or by thermostats or by pressure devices which are provided with electric contacts for starting or stopping the units upon reaching certain conditions.

Variable speed slip ring motors and direct current motors may also be arranged for remote speed control by means of pre-set automatic regulators, where the operating speed of the motor is set by a dial-switch or regulator (which may be near the fan or at a remote point) and the motor is then automatically controlled at this speed merely by operating the remote control push button for starting or stopping the equipment.

Arrangements may 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 quiet in operation, 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.

It is seldom necessary to reduce the speed of ventilating fans more than 50 per cent from the maximum fan speed, but for economical operation on large systems there should be a number of operating speeds between maximum speed and 50 per cent below maximum speed.

REFERENCES

Heating, Ventilating and Air Conditioning, by Harding and Willard, Revised Edition, 1932.
Fan Engineering.
Theories and Practices of Centrifugal Ventilating Machines, by D. Murgue, translated by A. L. Stevenson.
Mechanical Engineer's Handbook, by Kent.
Mechanical Engineer's Handbook, by Lionel S. Marks.
Constructive Mechanism and the Centrifugal Fan, by George D. Beals.
Coal Miners Pocket Book.
The Fan, by Charles H. Innes.
Mine Ventilation, by J. J. Walsh (A.S.H.V.E. TRANSACTIONS, Vol. 23, 1917).
Fan Blower Design, by H. F. Hagen (A.S.H.V.E. TRANSACTIONS, Vol. 28, 1922).
The Centrifugal Fan, by Frank L. Busey.
Section X, A.S.H.V.E. Code of Minimum Requirements for the Heating and Ventilation of Buildings (Edition of 1929).

Chapter 18

SOUND CONTROL

Measurement of Noise, Noise in Buildings, Absorption of Sound, Coefficients of Absorption, Insulation of Air-Borne Sound, Location and Insulation of Equipment Room, Insulation of Machinery and Solid-Borne Vibration, Control of Noise Transmission Through Ducts, Air Currents, Effect of Humidity upon Acoustics

THE part which ventilating and air conditioning plays in the acoustics of buildings becomes apparent from a consideration of the requirements for good hearing in any architectural interior. These requirements are:

1. The room should be free from noise, whether of inside or outside origin.
2. The useful sound, whether speech or music, should be sufficiently loud (with reference to any residual noise) to be heard easily and distinctly.
3. The useful sound should be distributed uniformly in all parts of the room, and the sound reaching the listeners should be free from long-delayed reflections which produce interference or echoes.
4. The room should be free from pronounced resonant tones which may result from either volume or panel resonance.
5. The room should contain sound-absorptive materials in such amounts, and of such qualities, as will provide a proper balance between the persistence and cessation of the articulated components of sound, that is, the reverberation in the room should be long enough to sustain harmony and impart tonal blending to music, and at the same time it must be short enough to prevent the overlapping and confusing of the separate sounds of speech.

Obviously, the first of these requirements is the one which imposes restrictions on the installation of ventilating equipment—the equipment noises must be unobjectionable in occupied rooms—although the fifth requirement is not entirely independent of the humidity and temperature of the air.

LOUDNESS

Loudness is the sensation of sound intensity. When we say one sound is louder than another we imply a difference in intensity level. Two identical whistles when sounded together do not make a sound twice as loud as one. It may take ten to make a sound 20 per cent louder than one. It has been found that loudness bears a logarithmic relationship to intensity of sound. On this basis a scale of loudness has been built and a unit, the decibel (db), has been established. This scale is illustrated in Fig. 1 which shows the loudness of some typical noises. The formula for relating loudness and intensity is:

$$L_1 - L_2 \text{ (db)} = 10 \log_{10} \frac{I_1}{I_2} \qquad (1)$$

where

L = Loudness in db. I = Intensity.