with a thermal overload or inverse time limit overload device. This type of switch provides protection to the motor beyond that given by fuses. Fuses, when used, necessarily must be large enough to take care of the inrush current but this makes them inadequate for protecting the motor under operating conditions. The thermal overload device allows for this inrush and does not function until an overload has become persistent, the time element depending upon the percentage of overload beyond the rating of the element. This type of switch is available for manual operation and also is furnished in the magnetic type for remote operation by push button, or for operation by other types of pilots, such as pressure switches and thermostats.

On standard squirrel cage motors above 5 hp a starting compensator usually is employed to keep the inrush current within the limits specified by the local power companies. Compensators may be obtained in transformer types and primary resistor types, and usually are furnished for manual operation. They can be secured for remote control also, but necessarily are expensive. However, the new type of high reactance, self-starting motors usually may be thrown across the line up to 30 hp in size, and still have their inrush current within the limits of the rules of the *National Electric Light Association*. With this type of motor a magnetic contactor usually is used. This device may be operated from a remote point by push button, if desired. These magnetic contactors are furnished usually with thermal overload and no-voltage protection.

For remote operation of motors through magnetic starters, the operating buttons may be located in the engineer's or manager's office, and tell-tale indicating lamps may be wired up with the circuit to indicate whether or not the unit is in operation. This type of control is very desirable in large buildings where the engineer is to have complete charge of the ventilating system.

Remote or automatic control of the units may be effected also by 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 (which may be near the fan or at a remote point) and the motor is then automatically controlled at any given 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 heating system 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 heaters.

Internal combustion engines and line shafting often are used for fan

driving, requiring clutches or shift-belts with loose pulleys in order to secure proper starting and control.

Ability to adjust the speed of ventilating fans is desirable as a measure of economy and adaptability to varying loads, but where such adjustments are provided very definite speed and pressure indications should be supplied at the controller, since without them in most cases the operator would be compelled to guess at the output.

REFERENCES

Heating, Ventilating and Air Conditioning, by Harding and Willard, Revised Edition, 1932.

Fan Engineering, Buffalo Forge Company.

Theories and Practices of Centrifugal Ventilating Machines, by D. Murgue, translated by A. L. Stevenson.

Mechanical Engineers' Handbook, by Kent.

Mechanical Engineers' 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).

PROBLEMS IN PRACTICE

1 ● In a public building, what type of fan is suitable for:

a. A supply fan?

b. An exhaust fan?

a. The centrifugal housed fan is well suited for this work. The various types are the forward curved blade, the radial blade, the full backward curved blade, and the medium speed double curved blade with backward tip. When direct connected motors are to be used, the backward tip fans, on account of their speeds, are better adapted. This type has the added advantage of having a limiting horsepower characteristic which will prevent an overload on the motor. Where the belt drive is used, all of the above types are suitable.

b. For exhaust work all of the above types, as well as disc and propeller fans are suitable, although the latter are seldom used except where there is little or no duct work connected to the fan.

2 ● In selecting fans for quiet operation in public buildings:

a. Should the outlet velocity of the fan be limited?

b. Should the tip speed of the fan be limited?

a. Because all commercial fans operating at pressures suitable for this class of work would be considered noisy if the fan were to discharge directly into the room, and because the duct system on the fan discharge is depended upon to absorb a reasonable amount of fan noise, it is desirable to have a moderate run of duct work with some bends and elbows included as sound deadeners. Where this duct is of necessity very short, the outlet velocity must be kept down to the lower limits recommended in this chapter or else an efficient sound absorber must be used. The experience of the engineer must be his guide in determining the allowable outlet velocity in each individual case.

b. Tip speed should not ordinarily be limited, because different types of fan blades have entirely different allowable tip speeds for quiet operation. A fan having a backward blade at the tip can run at much higher tip speed than can a forward curved or a straight blade fan, with the same degree of quietness.