ments, such as dust-collecting systems in woodworking shops, explosion-proof exhaust systems in wood-finishing rooms, and underfloor exhaust gas conveying systems in automobile shops. Locker rooms and toilets may be used in connection with outdoor sports activities during the summer.

Gymnasiums require lower temperatures and adequate ventilation without drafts. Ventilating and heating systems should take into account the ability to divide the gymnasium in half by means of folding partition, if provided. High school gymnasiums are often furnished with collapsible bleachers, indicating a greater occupancy and higher levels at which drafts should be avoided. Combination gymnasium-auditoriums (*general purpose* rooms) and gymnasium-cafeterias (*eating space*) should be treated so as to meet the requirements of each use. Football uniform drying rooms present a special problem of drying and odor control.

Listening rooms (for listening to records), an adjunct to the library, are usually interior rooms and, because of sound transmission, must be sound-proofed as well as ventilated. Visual-aid rooms should receive careful attention in ventilating or air conditioning because of the necessity for excluding light during use.

Panel heating is frequently used in kindergarten floors, since so much of the activity in these rooms takes place on the floor.

The room used by the board of education for its meetings is often air conditioned even in the northern part of the country, and even when it is the only space so treated. This is necessary because the board works during all months of the year. This room should be ventilated as recommended elsewhere for *smoking* conditions.

Governmental Regulations

Almost every state or territory, and in some cases counties, cities, and towns as well, as its own set of regulations governing the heating and ventilating of school buildings. Unfortunately, most of these regulations have not been coordinated through any one central source, and consequently they vary tremendously. Each designer of heating and ventilating installations for schools should completely familiarize himself with the regulations of the locality in which the building is to be built and satisfy these regulations.

The regulations usually specify the minimum requirements. The designer can refer to Chapter 6, Table 1, for recommended air changes, to Chapter 11 for other ventilation requirements, and to Chapter 13, Table 3 and page 278 for recommended air changes for various types of occupancy.

Fire Safety Regulations

Many states have fire safety regulations which limit the routing and arrangement of ducts and vary the requirements of fire dampers. Most of these regulations are based upon the *National Board of Fire Underwriters'* Pamphlet No. 90 which covers the regulations for the installation of air conditioning, warm air heating, air cooling, and ventilating systems. All installations should be made in accordance with these requirements.

Economic Considerations

School building program budgets are often extremely marginal, especially if a succession of increases in building costs have occurred since the appropriation was voted. Under such circumstances, the board of education, its architect, and its engineers, in order to get the school built, are not

infrequently forced to adopt courses of action that are obviously not the most desirable or the most economical over the life of the building. Needless to say, the design of the mechanical systems should be consistent with the budget. However, the board is entitled to know precisely what penalty it will be paying for each departure from the optimum design.

SYSTEMS IN COMMON USE

There are several different methods of complying with the foregoing requirements. All methods are not acceptable in all states, but all methods have been used in one form or another in this country.

Open Window Ventilation

The term *open window ventilator* usually means that there is no mechanical or gravity ventilating equipment. Air movement is caused by opening one or more windows at the top and raising some windows at the bottom. Where classrooms have windows only on one side this is not very effective and cannot be recommended for any part of the country. When the classroom has windows on two sides, particularly when they are at different levels, satisfactory conditions can be maintained if the teacher acts as the thermostat. In climates where heating is required for a large percentage of the time, open window ventilation should not be used.

Gravity Exhaust Ventilation

This is the next step in producing satisfactory conditions. Exhaust grilles are placed in the ceiling or wall away from the windows, and are connected to exhaust ducts or plenum spaces connected to roof ventilators. Due to the differential pressure, air is exhausted through these ventilators. It is, of course, necessary to open the windows in order to replace the exhausted air and the heating system must be designed to heat the air as it enters the windows. Satisfactory air changes can be obtained by this method, but it usually results in objectionable drafts. This type of system is reasonably satisfactory in mild climates but cannot be recommended where the design temperature is lower than 10 F.

Mechanical Exhaust Systems

A reasonably satisfactory arrangement for any mild climate can consist of a mechanical exhaust system where motor driven exhaust fans are connected to the exhaust grilles as previously described. With this arrangement, the fans can be operated on a schedule depending upon the outside temperature. When windows are closed the replacement air is drawn from the corridor or is greatly reduced.

This method usually consists of providing direct radiation along the window wall of a space to be heated and ventilated, and providing some means of positively exhausting air from the space to obtain ventilation. To make up the exhausted air, the windows are usually opened. To minimize drafts from open windows they are constructed with inside hoppers or baffles at the bottom to cause the incoming air to deflect upward and avoid blowing directly on the room occupants at desk level. To provide sufficient heat for tempering the incoming air, the radiation is designed for the total of the normal transmission plus the amount needed to offset the chilling effect of the entering air. The air quantity calculated to require such tempering is assumed to be the same amount as the amount exhausted. The amount of air exhausted from each space is established in each state code. The control of these systems is usually all manual or a combination