reduced the energy requirement to 90 per cent in long radius elbows and to 74 per cent in short radius turns. In expanding heads splitters reduced the energy requirement to 58 per cent.

Side Outlets in Horizontal Air Ducts

When air is supplied to a room from side outlets in horizontal ducts it is necessary to use directive devices within the duct at each outlet in order to obtain a uniform velocity of delivered air and to obtain a direction of flow perpendicular to the face of the outlet. In tests[6] conducted with 3 in. x 10 in., 4 in. x 9 in., and 6 in. x 6 in. outlets in a 6 in. x 20 in. horizontal duct at duct velocities of 200 to 1400 fpm (in the 6 in. x 20 in. section) it was found that multiple curved deflectors produced the best flow characteristics. Vertical guide strips in the outlet were not so effective as curved deflectors. A single scoop type deflector at the outlet did not improve the flow pattern obtained from a plain outlet and was therefore not found to be desirable.

Ceiling Outlets on Horizontal Ducts

Ceiling outlets are usually installed below horizontal supply ducts so that the supply air has to make a 90 deg turn before entering the outlet it-

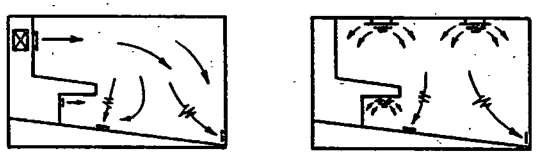

Fig. 8. Air Distribution Methods for Theaters, Churches, and Auditoriums

self. The shorter the connection between bottom of duct and outlet, the greater is the need for directive devices to obtain uniformity of flow. Generally speaking, conditions and remedy in such cases strongly resemble those for side outlets in horizontal air ducts. Ceiling ducts often have a rectangular cross section while the connections to the ceiling outlets are circular. It will then be quite difficult to install turning vanes successfully, particularly if the ducts are shallow and the connection areas are comparatively large. This will be the case, when more than one outlet is installed on one duct run and restrictions of duct area must be avoided. In such cases good results have been obtained by using a series of vertical guide strips, installed at right angles to the direction of air approach in the outlet connection where it leaves the horizontal air duct.

Volume Control

Various methods are used to regulate volume of supply and return (exhaust) air. Some of these accomplish only minor changes in volume; most of them however permit a range of adjustment from maximum air supply to complete shut-off.

When selecting type and location of such dampers, the following points must be considered, especially when the volume control feature is to be ocated near the air outlet itself: (1) deflection of air stream by the damper,

need and feasibility of directional control; (2) increase of noise level due to irregular and localized high air velocities caused by damper operation.

The following types of volume control are most frequently encountered:

1. *Slide Damper*. A single plate which can be pushed across the duct. Since its operation changes the free area of air passage in a one sided manner it should not be located near any air outlet and is practicable only where no intermediate setting between full open and closed is required.

2. *Hit-and-miss Damper*. Two slotted plates or discs, closely adjacent; by moving one of the two plates the respective slots may be opened or closed. This type of volume control may be installed close to an air outlet and it is easy to operate, but its main disadvantage is that even in the open position the air passage area is blocked by at least 50 per cent. This requires oversizing of the air outlet in order to avoid excessive increase of noise level.

3. *Splitter Damper*. A single blade sheet metal plate hinged at one edge, usually located at the branch connection of a duct or outlet. It is easy to operate but often causes irregular air flow in the duct. When used in connection with, and near an outlet additional directional control is required.

4. *Butterfly Damper*. A single blade sheet metal plate hinged in the middle, usually located in a straight duct run. It is easier to handle than a splitter damper, since only half the motion is necessary to change its setting. However, if located too close to an air outlet, it is objectionable because its operation frequently results in a condition whereby two high velocity jets are created along the sides of the duct or the air spills immediately downward into the occupied zone (see C Fig. 7).

5. *Louver Dampers*. Numerous designs have been developed incorporating a series of splitter or butterfly dampers across the duct or air outlet. Their main advantage consists in retaining greater uniformity of air flow and in requiring less depth for installation. Some designs provide for louver blades moving in opposite directions, and while decreasing free air passage area, retain a constant air flow direction along the axis of the duct air outlet connection (see A and B in Fig. 7).

RETURN AND EXHAUST INTAKES

The *selection of return and exhaust intakes* depends on: (1) velocity in occupied zone near intake, (2) permissible pressure drop through intake, and (3) noise.

1. *Velocity*. The effect of air flow through return intakes upon air movement in the room is slight. Air handled by the intake is drawn from all directions, the velocity dropping off rapidly as distance from intake increases. The only locality where drafts may prove objectionable is adjacent to the intake. To prevent excessive air motion in this area due to the return intake, it is advisable to compute the total air motion toward the exhaust opening as outlined in Equation 14 where A is the exhaust wall area in square feet. Recommended return intake face velocities are given in Table 1.

2. *Permissible Pressure Drop*. The permissible pressure drop will depend on the choice of the designer. Table 2 gives pressure drop through plain lattice intakes as a function of free area and face velocity.

Proper pressure drop allowance should be made for control or directive devices.

3. *Noise*. The problem of *noise* generated by return intakes is the same as that for supply outlets. In computing resultant room noise levels from the operation of an air conditioning system, the return intake must be included as a part of the total grille area. The major difference between the supply outlets and return intakes is the frequent installation of the latter at ear level. When so located, it is recommended that the return intake