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

TABLE 2. APPROXIMATE PRESSURE DROPS FOR LATTICE RETURN INTAKES
Inches Water Gage—Standard Air

Per Cent Free Area	Face Velocity, Fpm						
	400	500	600	700	800	900	1000
50	0.06	0.09	0.13	0.17	0.22	0.28	0.35
60	0.04	0.06	0.09	0.12	0.16	0.20	0.24
70	0.03	0.05	0.07	0.09	0.12	0.15	0.18
80	0.02	0.03	0.05	0.07	0.09	0.11	0.14

the exhaust wall area in square feet. Recommended return intake face velocitie 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 velocity be not in excess of 75 percent of the maximum permissible outlet velocity.

Outlet Location

The control of the room air motion for the maintenance of comfort conditions depends on the proper selection of the *supply* outlets. The location of the return or exhaust intakes does not critically affect air motion, unless room air velocities in the occupied zone adjacent to the intake exceed comfort limits. The locations of return or exhaust intakes are, however, important for obtaining the desired room temperature equalization.

Ceiling locations for exhaust outlets are recommended for bars, kitchens, lavatories, dining rooms, club rooms, etc., where warm air will rise to the ceiling level. In heating installations, location of the return grilles in the

ceiling or high on the wall will result in stratification of the conditioned air, and a high percentage of the heated air will be drawn into the return duct before it has served its purpose. (Refer also to considerations outlined previously in section *Outlet Location and Selection* in this chapter.)

Some circular ceiling outlets combine the supply and return openings in a single unit. The return duct is in the center with the supply pattern on the outside. This method gives best results for cooling applications. The application for heating is more critical and requires consideration of ceiling height, amount of outside wall area, and number of air changes required. In some cases, stratification of warm air may cause short circuiting. Where the wall losses are a small part of the total, little difficulty is encountered with stratification.

Floor locations of returns are used in heating installations for ceiling or side wall supply. When located so that air is drawn across exposed walls, the performance of the system may be somewhat improved. In general, floor locations tend to collect dirt and refuse.

Wall and door locations of exhaust outlets depending on their elevation, have the characteristics of either floor or ceiling returns. In large buildings

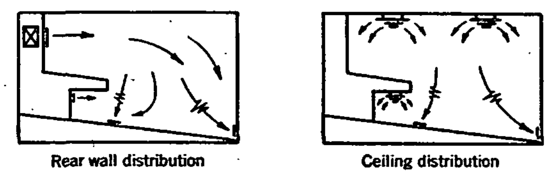

FIG. 8. AIR DISTRIBUTION METHODS FOR THEATERS, CHURCHES, AND AUDITORIUMS

with many small rooms, the return air may be brought through door grilles or door undercuts into the corridors, and then to a common return or exhaust. The pressure drop through door returns should not be excessive; otherwise the air distribution to the room may be seriously unbalanced with the opening or closing of the doors. Outward leakage through doors or windows cannot be counted upon for dependable results.

SPECIFIC APPLICATIONS

For *theaters and auditoriums* the air distribution methods used are the downward distribution system with ceiling diffusers, and the horizontal distribution system with ejector nozzles or wall diffusers. Fig. 8 shows both methods. Ceiling distribution is accomplished by ceiling outlets under main ceiling and balcony. It is indicated when main ceiling or balcony is cut up by architectural treatment or beams. The only critical points are under the balcony, and (occasionally) above the very rear of the balcony, where ceiling heights are low and where direct impingement of air is sometimes a hazard.

Wall or ejector distribution is particularly applicable for relatively long and narrow theaters. It is essential with this type of distribution that there be no interference with the movement of air throughout its entire path from the high velocity nozzles to the front of the theater. The ceiling should be smooth, without projecting beams or obstructing ornamentation. For large