of the room. The physical appearance of air outlets has been highly influenced by modern interior design, and to meet the demands of architects and engineers, outlets to be installed flush with the ceiling and outlets with built-in lighting as well as square and linear-type outlets have been developed in the past years. Linear-type outlets and perforated ceilings or panels have the advantage of unobtrusive appearance.

Procedure for Outlet Location and Selection

In determining outlet location and selecting the type of outlets, it is customary to proceed as follows:

1. Study the plan of the building and note the amount of air to be supplied to each room. (For computation of the *required air quantity* for heating and cooling refer to the formulas given in Chapters 12, Heating Load and 13, Cooling Load. The amount of outside air introduced into the room must be checked against the ventilation requirements of state or local codes).

2. Select number of outlets for each room, considering air quantity required and distance available for throw or as radius of diffusion. The same factors, as well as distance from floor level available as mounting height, structural characteristics of the space and consideration of appearance, will determine the type of outlet used.

3. Arrange location of outlets in the room. Generally, the outlets must be evenly spaced to distribute the air uniformly throughout the room. More air, however, must be supplied and directed towards areas with exceptional heat gain or loss. An important point to consider is the combination of proper outlet location and efficient duct design (see Chapter 31). Consult manufacturers' tables for recommended location and spacing of outlets.

Refer to Chapter 29 for a discussion of zoning and zone control.

4. Select size of outlets according to air quantities handled, permissible throat or discharge velocities, or effective throw, taking into consideration other factors, such as permissible noise level, etc. In order to determine whether the selection made will satisfy the requirements of the job, type, size and location of the outlet must be checked against manufacturers' ratings. The most important questions to be considered are:

a. Will drafts be created because of divergence between rated throw (radius of diffusion) and distance between outlet and nearest obstacle of air stream (wall, beam, column, etc.)?

b. Will drafts be created because of excessive cooling temperature differential or too low mounting height of the outlet?

c. Will drafts be created because of too low velocity energy of the air stream, causing excessive downward air flow in cooling installations?

d. Will the air pass through the outlet at too high a velocity and thereby cause an excessive increase in noise level?

Balancing the System

In designing a system, the engineer aims to size ducts and outlets in such a manner that the supply of air is properly distributed. He may, however, feel it necessary to oversize certain trunks, branches or outlets to allow flexibility or to permit future redistribution, so that the system as designed may not be self-balancing. Even if ducts are designed for self-balancing and outlets are properly selected, all air systems must be balanced, that is, the amount of air through supply ducts, supply outlets, outside air intakes, exhausts, return outlets and ducts must be properly adjusted so that the air quantities correspond closely with the design quantities. Balancing, therefore, is part of the field test procedure to which each air conditioning system should be subjected in order to determine whether the capacity and performance of the equipment correspond with the design.

For balancing, air systems may be equipped with dampers in supply, return, and outside air ducts, splitter dampers, or dampers in outlets. In selecting the desired type of damper or balancing method, the following points should be kept in mind.

1. Unfavorable effect on air stream and noise level should be avoided. This will often rule out blank-offs or dampers in outlets, unless such dampers are of special design.

2. It should be possible to alter outlet volume without altering the direction of discharged air, and to measure the amount of air handled without difficulty. Blanking off part of the area of supply outlets makes this difficult.

Generally speaking, it is most satisfactory to install dampers at some distance back of outlets so as to avoid disturbing the air flow. Dampers in both supply and return ducts form the most flexible means of controlling supply of air to the room and static pressure within the room. (Refer to section Directional and Volume Control for discussion of various air distribution control devices.)

Instruments for balancing include instruments for measuring air quantities, static pressure, temperature and humidity. Commonly used instruments are the rotating vane anemometer, deflecting vane anemometer, thermal anemometer, smoke gun, clamp type ammeter-voltmeter, sling psychrometer and thermometers. Pressure, humidity and temperature recorders are sometimes useful. The Pitot tube and a manometer may be used on higher velocities, but only with the technique prescribed for its use by the manufacturer for the tube used. (See Air Flow Measurement in Chapter 52.)

The following balancing procedure is recommended for air systems:

1. Open all duct and outlet dampers.

2. Measure fan capacity. This can most often be done with a rotating vane anemometer inside the fan inlet plenum. For exhaust fans the discharge outlet will often serve.

3. Measure fan motor input.

4. Determine approximate flow at each outlet.

5. Adjust outlets or branches so that outlet deviation (from design quantity) is approximately the same (percentagewise) as fan capacity deviation (from total design quantity).

6. Recheck fan capacity.

7. Adjust fan speed or main trunk damper to make fan capacity equal to design. (The fan laws apply when changing speeds; quantity varies directly with speed,—power input as the cube of speed). Use power input readings to check possibility of overloading the motor.

The procedure outlined may be shortened depending on the type of installation. For instance, where many outlets serve one room, exact balancing of each outlet may not be required, so long as drafts, noise and temperature differences are checked. Experience and judgment are valuable in determining how carefully or thoroughly a system must be tested and adjusted.

DIRECTIONAL AND VOLUME CONTROL

Duct Approaches to Outlets

The importance of the manner in which the air stream is introduced into the outlet cannot be overestimated. To obtain correct air distribution, the velocity of the air stream must be as uniform as possible over the entire connection to the duct, and perpendicular to the outlet face. No air outlet can compensate for improper duct approach.

A wall grille installed at the end of a horizontal duct and a ceiling outlet at the end of a vertical duct receive the air perpendicularly and at (for practical purposes) uniform velocity over the entire duct cross-section, provided the system is carefully designed. However, very few outlets are installed in this manner. Most side wall outlets are installed either at the end of vertical ducts or in the side of horizontal ducts, and most ceiling