interior of the building, as in some office buildings, a separate system or zone for the conditioning of the interior portions may be required. In these cases the interior system handles the relatively small and steady loads, due to such items as lights and people; while the exterior system must cope with the relatively large and variable loads imposed by sunshine and temperature difference through walls and glass. Descriptions of the three common unitary-central systems follow.

Induction Convectors—High-Pressure Type

Induction convectors, Fig. 3, employ nozzles that produce a high-velocity air jet without objectionable noise. The term,

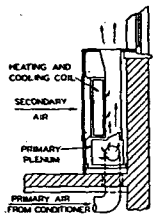

Fig. 3 .... Induction Unit (High-Pressure Type)

high pressure, is to some extent inaccurate, since the air pressure at the nozzles is still less than the total resistance pressure of a conventional central system. The high-velocity jets of primary air induce a flow of air from the room through coils located in the secondary-air stream and supplied with chilled water in summer and with hot water in winter. The chilled water removes a large portion of the sensible heat in summer and the hot water supplies the sensible heat loss in winter. The primary air is delivered at a sufficiently low dew point to compensate for the latent heat gain in summer. In winter the primary air is supplied at a sufficiently high dew point to take care of latent heat losses. Control of temperature is obtained by throttling the water quantity supplied to the secondary coil. The required flow of primary air is greatly reduced due to the fact that a portion of the sensible heat load is carried by the secondary air stream. Since the primary quantity is small, very high velocities can be maintained in the supply ducts without requiring fan power in excess of that for a conventional system. Therefore, the supply ducts or pipes can be very small and can be run in chases, or furred in at columns along with the water pipes. The primary air is treated in the usual manner to reach the required dew point and a surface or spray dehumidifier or a dehydrator may be used. The primary-air quantity is sufficient for ventilation purposes and frequently consists entirely of outdoor air.

Fig. 4 shows the general arrangement and control of the system. The operation of the controls is as follows:

When supply fan circuit is energized, solenoid air valve or relay E-1 opens minimum outdoor-air damper M-1 and allows T-2 to control the maximum outdoor-air damper M-2 and return-air damper M-3. When the fan system does not have a return-air connection, a time delay relay often is used to assure at least partial outdoor-air damper opening before the fan actually starts running. This is done to prevent the intake duct from collapsing.

The final temperatures in the spaces are controlled by individual valves, either automatic or manual, which throttle the flow of secondary water to the unit coils. Where automatic valves are used, the thermostats are of the heating-cooling type so that a rise in room temperature opens the valve when cold water is circulated and closes the valve when hot water is being supplied. Thermostat T1 controls the preheater steam valve V1 to maintain a temperature of about 45 F leaving the preheater. Thermostat T2 controls the maximum outdoor-air and return-air dampers so that the air entering the dehumidifier is maintained at 50 F whenever outdoor air conditions permit.

During the heating cycle, thermostat T3 and valve V2 are inoperative so that cool primary air is supplied to the units but at the same time thermostat T6 operates valve V4 so that the secondary water is heated. Thus the combination of cool primary air and hot secondary water can provide heating or cooling as required. The primary pump and water cooler are inoperative.

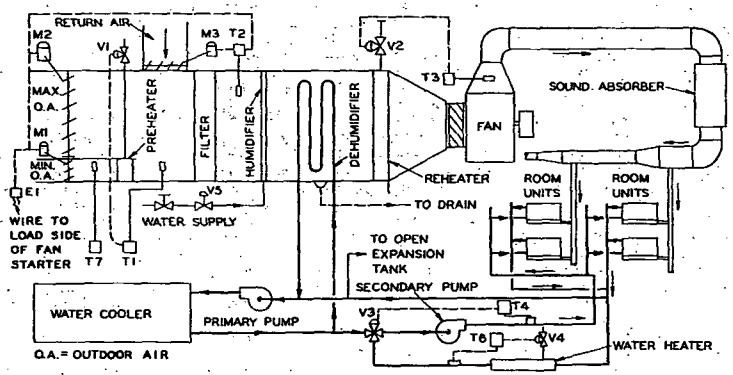

Fig. 4 .... General Arrangement of Induction Unit System

When the outdoor air is no longer suitable to provide sufficient cooling through the primary air system (typically about 50 F) the system is changed from heating to cooling operation. The primary pump is started and supplies chilled water to the dehumidifier. Thermostat T4 controls mixing valve V3 so as to maintain the secondary water at temperatures in the range of 50 to 55 F. At outdoor temperatures below 80 F thermostat T3 regulates reheater valve V2 so that warm primary air is supplied at the same time that cold secondary water is fed to the units. The changeover from heating to cooling is usually manual and the exact time is not too important because both heating and cooling are available in either case. During the cooling cycle, thermostat T7 acting through thermostat T3 readjusts the primary-air temperature downward as the outdoor-air temperature increases from the changeover point to about 80 F so that above this temperature the primary air is at the apparatus dew point.

In some buildings the primary-air system and water circuits are zoned according to exposure, but because both heating and cooling are available at the units whenever either is needed, such zoning is not always used.

All-Air High-Velocity Systems

All-air high-velocity systems are air-conditioning systems in which the duct velocities and static pressures are such that special control and acoustic equipment is required for proper introduction of the conditioned air into the space to be served.

All-air high-velocity duct systems are of either single-duct or dual-duct types.

The *single-duct system* is usually zone controlled. The single supply temperature is established for each zone and therefore variations in individual rooms must be compensated by throttling the air supply volume. Throttling is limited to the lowest air quantity required for ventilation and for satisfactory air distribution which depends to a large degree on the performance of the type of air outlet used.

Dual-duct systems deliver the entire air supply to cold- and warm-air supply ducts, from which it is distributed into air-mixing valves or acoustic terminal devices. (A mixing valve is a mechanical device that serves to proportion air from a cold-air duct and a warm-air duct into a common outlet, or duct. An acoustic terminal device is an air distribution unit consisting of an air valve, acoustical attenuation chamber, and an air outlet.)

The proportion of cold air and warm air delivered to the air-mixing valves or acoustic terminal device is thermostatically controlled. This control, together with controls for maintaining fixed volumetric delivery, results in a constant volume of air supply at a temperature that satisfies the load.

Mixing valves may be used to deliver large quantities of mixed or blended air at high velocity to a single-duct system equipped with acoustic terminal devices supplying the needs of an entire zone or area. The air coming from the mixing valve may also be reduced in pressure (either in the mixing valve itself or by means of an additional valve or damper) so that it can be distributed by a conventional low-velocity duct system. In this case, noise attenuation is accomplished by a length of lined duct, or by a separate noise attenuator installed after the mixing valve.

For greater flexibility, acoustic terminal devices which usually are equipped with one air outlet only, may discharge into a low-velocity rigid or flexible duct equipped with several air outlets.

Refer to Chapter 21 on Air Duct Design for a discussion of the design of high-velocity ducting.

The general arrangement of a typical dual-duct system is shown in Fig. 5. In some arrangements, two supply-air fans are used with one fan supplying the cold-air duct and the other the hot-air duct. The warm-air fan handles only recirculated air so that operating economy is slightly improved.

The maximum outdoor-air damper and the preheater are controlled as in Fig. 1 so that when the temperature of the outdoor air is favorable it is used increasingly instead of return air.

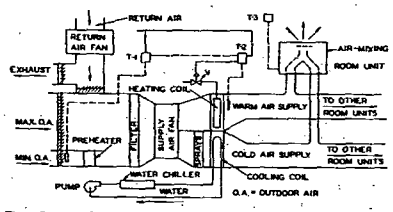

Fig 5:.... Schematic Arrangement or Dual-Duct System

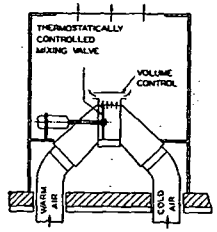

Fig. 6 .... Room Air-Mixing Unit for Dual-Duct System

The warm-air supply-duct temperature is controlled by a thermostat, T2, Fig. 5, in the air leaving the heating coil. Thermostat T2 is reset by thermostat T1 in accordance with variations in outdoor-air temperature. Whenever outdoor-air temperature is not low enough to accomplish the required cooling, the cold-air supply-duct temperature is regulated by the cooling coil. The final temperature in the conditioned areas is controlled by the individual air-mixing units.

Air-mixing room units under control of the room thermostat draw warm and cold air from the ducts in accordance with the room requirements, affording individual room control without zoning. Fig. 6 shows schematically one type of room unit designed for dual-duct systems. The warm and cold air pass through the three-way mixing damper which delivers air at the temperature required by the room. Some units are placed under windows, while others are mounted in the ceilings from which air may be delivered to the room through ceiling, wall, or window outlets. Some units are also provided with volume regulators to maintain a steady flow condition.

This system is best suited for multi-room or multi-zone installations, and may be of either high- or low-velocity and