pneumatic or electric, operate simultaneously so that when chilled water is fed to the coil, it is diverted to the chilled return line. When hot water is fed to the coil, it is diverted to the hot water return line.

Both of these dual-return four-pipe systems completely isolate the chilled water and hot water systems.

Units requiring hot water receive water from the hot water pump and heater. The maximum hot water supply temperature should be determined with the fan-coil unit fans operating on *low* speed. Steam control valve *V2* Fig. 48 should be controlled from a submaster thermostat sensing hot water supply temperature. The control point should be raised by a master outdoor thermostat as the outdoor temperature drops. Generally it is not necessary to make hot water available to the units until the outdoor ambient temperature drops below temperatures within the space. The maximum desirable perimeter space temperatures vary with the application. In hospitals or homes for the aged, it may be desirable to make it possible to heat rooms to 80 F, while in office buildings temperatures of 70 to 75 F are generally more desirable. Where an interior duct system is supplying ventilation air at about 60 F, it may be desirable to supply hot water to the perimeter units even when the outdoor ambient temperature is above the desired maximum inside space temperature to counteract excess cooling of shaded exposures.

Units requiring chilled water receive water from the chilled water pump through valves *V3* and *V1*, which are modulated to provide the chilled water supply temperature required for sensible cooling at the fan-coil unit. These two valves are thermostatically controlled to provide the proper mixture of return water and chilled water. The dehumidifier receives untempered chilled water as required for dehumidification.

Since control of perimeter space conditions is realized by modulating the flow of either hot or chilled water to the fan-coil conditioner, they are frequently supplied with 3-speed switches having *no off* position, to assure at least *low* speed air circulation and filtering at all times.

Dual-Supply with Single-Return Systems (Fig. 49), commonly referred to as three-pipe systems, provide the same flexibility to meet changing room loads as do the four-pipe systems, while permitting substantial first cost savings by using a common return system instead of two separate return systems. This also permits using one control valve instead of two for each fan-coil conditioner. Valves commonly used are pneumatic, self-contained, or electronic. They are all of the non-mixing type which select and modulate water from either the hot water supply or chilled water supply. Manual control valves should not be used with any dual-supply system regardless of type of water return used.

Operating costs of the three-pipe system are somewhat higher than those of a four-pipe system due to some mixing in the common return of water returning from the units operating on heating with water returning from units operating on cooling. This is minimized since the control valves are of the non-mixing type and since they are generally controlling in a modulated position. The result is that the return water from units on cooling and units on heating has gone through a sizeable temperature range before being discharged into the common return, and the return water temperature approaches room temperature in both cases.

Certain aspects of the dual-supply, single-return system appear to be covered by one or more patents and should be investigated before fixing final system design.

WIRING

The fan-coil conditioner fans are driven by fractional horsepower motors. These motors are generally of the shaded pole or capacitor type and are usually furnished with inherent overload protection. The operating wattage of even the largest sizes rarely exceeds 200 watts at the *high* speed setting. Running current rarely exceeds 2.5 amperes. The fans are commonly available for use with 115 volt, single-phase, 60-cycle circuits. Where overseas current requirements vary from this, the designer can either specify that the fan-coil units be furnished with special motors, which are generally more costly, or he can provide a converter, centrally located in the building, to convert to 115 volt, single-phase, 60-cycle circuits.

In planning the wiring circuit, local and national electrical codes must be followed. The wiring methods generally used are: (1) provision of a separate electrical circuit for the fan-coil conditioners, or (2) connection of the conditioners into the lighting circuit.

Separate electrical circuits, brought to a central panel board at the building air-conditioning operating station, enable the building operator to turn off all the unit fans from a central point during unoccupied hours. While this results in a higher first cost, it offers operating cost advantages in buildings such as office buildings and motels, that do not have 24 hr occupancy. During winter operation it is generally possible to obtain sufficient gravity heating to maintain unoccupied perimeter spaces at 60 F or more by elevating the night hot water temperature. When there is insufficient gravity heating capacity for the entire winter, the use of *separate electrical circuits* is advantageous in applying a single remote thermostat mounted in a well-exposed perimeter space to operate the unit fans if the 60 F set-back temperature cannot be maintained with gravity heating.

Connection of the fan-coil conditioners *into the lighting* circuit serving the space, results in a lower first cost and is entirely satisfactory where some or all of the perimeter spaces are occupied continuously, such as hospitals, apartments, and hotels. This method is especially well suited where air conditioning is being added to existing buildings, if existing wiring is not already fully loaded.

In usual practice, the wiring serving the fan-coil conditioners on a particular floor is brought to a panel board on that floor; the power being supplied from the lighting circuit. This permits using a grounded wiring circuit. If a disconnect plug is permitted by code between the baseboard wiring and the fan-coil conditioner switch, it should be of the grounded type. Where this approach is used in hotels or motels, the maids are frequently instructed to turn the fans *off* or to *low* when cleaning the room. The bellboys then set the desired speed when checking the guest into the room.

UNIT CONTROL

Frequently, new buildings are completed and the air conditioning is put in operation before the exact use of the space is known. This is particularly true in new office buildings where the spaces will be leased and then partitioned to suit the tenant. In such instances, adequate provision should be made to assure that control of the fan-coil conditioners serving these newly partitioned areas can be obtained if, and when, required.

Manual control by means of a 3-speed fan switch is standard on most makes of fan-coil conditioners. Manual water valves, available for use on single-supply systems, have not proved satisfactory since the occupant generally is unaware whether his unit is being supplied with chilled or hot water, and hence he does not know in which direction to turn the valve handle. Valves are available with a thermal sensing element which is built into the handle and senses whether the unit is receiving hot water or chilled water and indicates to the occupant which way he should turn the valve to get the desired result. These have, however, been found to confuse some occupants, necessitating special instructions by operating personnel.

Thermostatically operated controls are desirable and many types are available. When used with a single-supply system they should be applied with a change-over device.

Fan speed can be thermostatically controlled, using a wall thermostat which cycles the fan from any of three speeds, manually pre-set by the occupant, to the *off* position. Longer cycles and better control are obtained when the fan speed is set at the lowest speed setting. When fans are cycled to the *off* position, air movement and filtering are sacrificed; and so is ventilation unless separately supplied. Where the fan switch is manually set at *high* or *medium*, the occupant may experience annoying short cycling and become conscious of air motion and variation in sound levels.

Return-air thermostats are not recommended for this application because chilled water supplied to the fan-coil conditioner causes a downdraft when the fans are cycled to the *off* position. This chills the remote bulb which then is unable to sense a rise in room temperature.

Manual and automatic changeover devices are available. The automatic type which senses supply water temperature are recommended for apartment house application, in particular, where the building operator does not have access to the perimeter spaces.

Where the fan-coil conditioners are installed to handle the latent load, solenoid valves are frequently installed in the water line serving each unit and wired to shut off the flow of water when the fans are cycled to the *off* position. This eliminates chilling of the fan-coil conditioner chassis below the room dew point with consequent condensation of moisture when the fans are *off* for an extended period.

Water flow can be thermostatically controlled by using either return-air or wall thermostats. Water valves are available in the following types: (1) self-contained, (2) pneumatic, (3) electric, and (4) electronic. As mentioned earlier, some of these interrupt the flow of water, while others bypass the supply of water to the return line.

Water valves should not be used for control where wall aperture outdoor air intakes are used unless freezing of the coil is prevented whenever fans are operating and the water flow stops.

When used with a single water supply system, a changeover device must be employed. Changeover devices are not required with water control valves used with dual water supply systems.

Bypass dampers are available on some makes of conditioners. Control of room conditions is achieved by using either a return air thermostat or wall thermostat to modulate the bypass damper so as to bypass all, or part, of the air around the unit coil.

While the fan-coil conditioner with its controls is considerably more expensive when the cost of a damper assembly and damper motor is added, it overcomes the disadvantages due to thermostatic cycling the fan.

INSTALLATION

The construction of perimeter spaces varies greatly between buildings. Thus it is not always possible to utilize standard factory fan-coil conditioner enclosures. This is especially true in new building construction where the perimeter enclosures are more a part of the building than casings for the fan-coil conditioner, and the enclosures must be custom made.

Variation in sill heights and construction of the exterior wall and floor, frequently influence selection of the method of supporting vertical model fan-coil conditioners, and also determine whether wall apertures can be employed.

In some instances water piping serving the vertical models will run horizontally above the floor. In masonry buildings it can frequently be chased into the building wall behind the unit. In other instances it may prove more practicable to feed each unit with vertical piping take-off to each unit through the floor directly under the unit.

Horizontal models installed at the ceiling frequently present mounting, piping, and air distribution problems due to the construction and lay-out of the building.

Experience has indicated that, with all these variables, there is no substitute for a mock-up of a typical perimeter module in securing a successful fan-coil system installation. No matter how simple the application appears, it is wise for the designer to require, as a basic part of the specifications, that a mock-up be built. The mock-up is especially useful in assuring proper enclosures, piping, and control details before construction gets under way.

With regard to central station equipment it is not practicable to make mock-ups due to the cost involved. As with any central station system care must be exercised in locating the equipment and piping so that it can be moved into place and installed in a practical manner with assurance that sufficient space is provided for future maintenance.

OPERATION

Operation of the central system was previously described under controls.

The room fan-coil conditioners are equipped with either cleanable or throw-away filters which should be cleaned or replaced when dirty. Good filter maintenance not only improves sanitation and cleanliness within the space, but assures full air flow through the unit and hence full capacity. The frequency of cleaning will vary with the application. Units installed in apartments, hotels, and hospitals usually require more than normal filter service due to the presence of lint which is not present in office buildings.

The fan-coil conditioner motors are generally provided with oil cups which should be supplied with oil according to manufacturer's recommendations, to assure maximum motor life. Motor failures are uncommon, but when they occur it is generally possible, with most makes, to quickly replace the entire fan deck with little interruption within the conditioned space. The defective motor can then be replaced in the maintenance shop.

Two additional operating practices apply to particular system variations:

1. Where wall apertures are used for ventilation air, dampers should be closed during freezing weather if a constant flow of water through the coil is not assured to prevent coil freeze-up.
2. Where the fan-coil conditioner is applied to handle the entire latent load, the flow of chilled water to the fan-coil conditioner should be shut off by the valve whenever the unit fans in unoccupied spaces are to be turned *off* for more than 24 hr. An alternate solution, eliminating the need for shutting off the water, is to let the fans operate on *low* speed when rooms are unoccupied. Both of these precautions eliminate the possibility of the fan-coil conditioner chassis sweating and the consequent dripping of condensate on the floor.

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