drop in temperature can be offset by passing some of the air around the conditioner instead of through it, while the total quantity of air in circulation remains unchanged. When used for this purpose, it is termed an *adjustable* or *automatic* by-pass. The second function is to maintain a lower effective temperature difference between the air supplied to the room and the room temperature than could be obtained if air at the apparatus dew-point were supplied, and when so used is called a *fixed by-pass*. As discussed previously, if return air from the conditioned space is passed around the conditioner and mixed with the conditioned air, the effect on the heat balance is the same as if the air were removed from the space and immediately reintroduced. This is not strictly true, due to the fact that when ducts pass through unconditioned spaces, there is a heat gain by this air, and an additional gain is imposed by the heat of compression of the circulating fan in moving the air against the resistance of the system. However, the heat gain, where the by-pass is used to lower the effective temperature difference, usually favors its use due to the fact that the increased volume and the resultant higher temperature of the mixture of conditioned air and room air may show a lower net duct heat gain with a smaller temperature increase per unit of volume of supply air. The advantages thus obtained may offset the increased fan power.

The adjustable or automatic by-pass can be made to serve the purpose of the fixed by-pass by providing a stop on the by-pass damper so that it cannot close completely. In some cases this stop is unnecessary since commercial dampers will permit an air quantity of 10 to 20 per cent of the conditioner capacity, depending on the resistance of the conditioner, to leak through even when fully closed.

Where a reduction in room sensible heat is not accompanied by a reduction in room latent heat, the by-pass is to be used with care. If the dew-point temperature of the air leaving the dehumidifier is controlled at a fixed value the reduced quantity passed through the conditioner may be sufficient to handle the sensible heat load but insufficient to handle the latent heat load, resulting in humidities that are too high. If the dew-point is not controlled, as when cold water is supplied at a constant temperature or where direct expansion cooling coils are used, the reduced loading on the conditioner brought about by the reduced air quantity will result in a lower dew-point temperature which often is entirely adequate. This condition should be investigated in each case.

The by-passing of outdoor air is to be avoided in general. While the sensible heat requirements of the space may be such that the by-passing of high temperature outdoor air will aid in controlling room temperature, high moisture content air introduced to the space may raise the humidity to an objectionable amount. If return ducts from which the by-pass air is taken run through unconditioned spaces and there is an inward leakage of outdoor or moist air, the effect, in a lesser degree, is that of by-passing outdoor air. Therefore the location of such return ducts and the points from which such air is taken are of importance. Exceptions to this are where the moisture content of the outdoor air is lower than that of the room, and where the sensible heat to latent ratio increases at partial loads.

The foregoing applies largely to summer air conditioning. In winter the by-pass usually is kept closed and room temperature control obtained by means of regulating the amount of heat supplied to the air. In some instances when the by-pass is located after the reheaters, the operation of the by-pass damper may be reversed and the by-pass still used as a means of control with the reheaters full on or operated in sequence with

the by-pass. In other cases the reheater may be located in the by-pass as described further.

The principle of the by-pass may be applied to items of equipment other than conditioners, such as humidifiers, dehydrators, heaters, etc., in much the same manner. Where a heater has a capacity such that the temperature rise of the air is higher than desired, a smaller heater may be used and a portion of the air by-passed around the heater. Throttling of the sprays in a humidifier is, in effect, a by-pass since it increases the portion of air passing through without being contacted.

Reheating

Reheating the supply air is necessary in winter where this air is used to offset heat losses. Tempering of the supply air (merely reheating to a lesser degree) is required where other means of heating, such as direct radiation or panel heating, are used to carry the main heating load. Supply air at the required apparatus dew-point would add to the load to be carried by the direct radiation and in addition may create a movement of cold air that while desirable in summer may be undesirable in winter. Modulation of the amount of steam supplied to the coils can be used to control temperature, or air can be by-passed around these heating or tempering coils.

Since reheating or tempering coils are required for winter and year 'round air conditioning, their use as a means of summer as well as winter temperature control is indicated. Where heat is available in summer, as the room sensible heat falls off, the low temperature of the supply air can be raised by means of these coils to maintain the desired room temperature while still providing adequate air at the proper dew-point.

Reheating presents an excellent method of accurate temperature control since the quantity of air passed through the conditioner is not changed as in the case of the by-pass, and since the distribution and circulation are not affected as when the volume of supply is reduced. However, reheating in summer has one disadvantage. It has the effect of maintaining a constant internal sensible heat load on the system. This means that when an effective temperature difference of 15 F is being maintained at the maximum room sensible heat load, this temperature difference must be reduced by means of heating to 7.5 F at half of the sensible heat load. The room sensible heat usually is about 35 to 45 per cent of the total cooling load and thus the penalty imposed on the refrigeration cycle is not extremely large. When the outdoor wet-bulb temperature is less than the desired room wet-bulb temperature, all outdoor air should be passed through the conditioner and under these circumstances reheating does not impose a load on the refrigeration cycle since the heated air is not returned to the conditioner. Further, where the volume of outdoor air introduced to the system, which for all practical purposes is wasted after its work has been done, is sufficiently large in relation to the amount of reheat used (that is, if the heat required does not exceed that necessary to raise the outdoor air only from dew-point to room temperature) the use of reheat does not impose a load on the refrigeration cycle. This, of course, assumes that there is no economic penalty involved in the use of heat itself.

One of the best applications of reheating for summer purposes is in combination with other means of temperature control for the purpose of levelling off accentuated demands for temperature control. As an example, the by-pass can be applied to a certain extent, or the volume of supply air throttled to a limited degree, or both of these used in sequence, and reheating can be used as the final step in temperature control.