$$t_y = \frac{H + 0.24\ M_d}{0.24\ M_o} \qquad (9)$$

This case illustrates the arrangement of apparatus when the heating of several rooms is required with individual control of temperature for each room. The arrangement of apparatus, including tempering coil, air washer or humidifier, retempering coil and reheater coil, will be the same as has been outlined in Case 4.

The air leaving the reheater and the air by-passed around the reheater, although having different dry bulb temperatures, will have the same dewpoint temperature as the air t in the room or building to which the air is delivered and with relative humidity as specified; if no relative humidity is specified it can be assumed as 35 per cent. If no room temperature is specified it should be assumed as 70 deg. The relative weights of air passed through the reheater and by-passed around the reheater shall be ascertained by the following method:

X = Parts of reheated air in mixture
$(1 - X)$ = Parts of tempered air in mixture
t_y = Mean dry-bulb temperature of the mixture entering room or building
t_x = Loss of temperature in the duct system
t_1 = Mean dry bulb temperature of the air entering reheater and by-pass
t_2 = Mean temperature of the air leaving the reheater

$$(X)\ (t_2 + 460) + (1 - x)\ (t_1 + 460) = (t_m + 460) \qquad (10)$$

t_m = Mean tempearture of air entering the duct system = $(t_y + t_x)$.
SOLVE: for X. Then $M_h = X$

M_h is the weight of air in pounds per hour to be passed through the reheater. The temperature t_y will ordinarily be different for each room of the building. The *total weight* of air passed through the reheater will be the sum of the requirements for all the rooms.

Case 7—Indirect system for warming the air drawn in from the outside for ventilating purposes only. (When an indirect system is employed to warm the air drawn into the system from the outside for ventilating purposes only, the heat loss is provided for by direct radiation or by some other means).

The weight of air to be circulated per hour is M_o as may be determined from the specified ventilation requirement $M_h = M = M_o$. The temperature of the air delivered to the room t_y shall be assumed 5 deg. higher than room temperature t specified.

a. If no air-conditioning apparatus is to be employed the arrangement is similar to *Case 2* where $t_1 = t_o$ and $t_y = t + 5$.

b. If air-conditioning apparatus is to be employed the arrangement is similar to *Case 4; $M_h = M = M_o$.*

Loss of Temperature in Duct Systems (t_x):

a. When the indirect heater and duct system, are located in the enclosure to which the air is to be delivered, it may be assumed that there is no loss of temperature between the indirect heater and the point or points of discharge into the enclosure. $t_x = 0$.

b. For gravity indirect heating, a loss in air temperature of 5 deg. for the first floor, 8 deg. for the second floor and 10 deg. for the third floor between the indirect radiator and room register can be assumed.

c. For ducts run underground an allowance must be made based on the estimated heat loss of the duct, assuming an average temperature of the ground of 55 deg. fahr.

d. For ducts run in outside walls to the second floor and above, a loss of not less than 10 deg. shall be used in the calculations.

When the heating and ventilation requirements have been found the size of the heater and fan are calculated for a given friction, temperature range, pressure loss in ducts, etc. Pressure losses build up rapidly as velocities are increased and generally vary approximately as the square of the velocity. The allowable pressure loss through the heater should in

general not exceed 50 per cent of the total static pressure of the system. In public building practice allowable pressure loss through tempering coils and reheaters should be under ½ in. of water and when an air washer is used the friction through the tempering coil and reheater should not exceed 40 per cent of the total resistance as a rule.

Factory work permits greater friction allowance for the heaters where duct runs are comparatively short and the resistance of the heater is a large part of the entire pressure loss in the system.

The fan can be selected when the following facts are known:

1. Quantity of air required in cubic foot per minute.
2. Static pressure of system (ducts, heaters, air washers, filter, entrance connections, etc).

The kind of fan will depend upon the service required, disc and propeller fans being used generally where no resistance is built up. In ventilation work centrifugal fans are largely used and these come under two classifications—those with straight radial blades and those with curved blades. Each type of fan has its special applications and there is a definite relation between its pressure characteristics, power requirements and the service rendered. Where noise is not objectionable, fan efficiency is the governing factor. In places where quiet operation is essential proportionate outlet velocities should be chosen (see Chapter XIX).

The quantity, velocity and pressure of air delivered by the fan should be determined by the A. S. H. V. E. Standard Code for Testing Centrifugal and Disc Fans (See TRANSACTIONS, 1923, Vol. 29, p. 407.

It is well to remember that good practice requires that:

1. The mechanical efficiency of a centrifugal should exceed 55 per cent.
2. Air velocity passing thru the fan outlet should not cause excessive noise.
3. The fan should operate silently and not transmit noise to ducts.
4. The use of variable speed motors is advisable to meet changes in frictional resistance, power economy when ventilation demands vary while constant speed motors are less expensive when ventilation requirements remain uniform.

A fan installation rightly designed and operated will be quiet and efficient but every precaution should be taken to prevent vibration or sound passage to the rooms. The method of fan drive is important, the insulation of motor, and fan foundations with felt, cork and other approved materials of adequate thickness properly waterproofed.

UNIT SYSTEMS*

Unit systems consist of an individual unit incorporating all the apparatus necessary for providing, directing and controlling the necessary volume of air heated to the proper temperature for the purpose. Two types are in common use, one for public building work and the other for factory and

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