PROBLEMS INVOLVING AIR VOLUME AND HEAT REQUIREMENTS[1]

The following cases arise in practice:

1. The heating of the building is done entirely by means of a fan steam system, all of the air being drawn from the outside.

2. Similar to (1), except that all of the air is recirculated.

3. A portion of the air is recirculated, and the remainder is drawn in from the outside.

4. Air at the same temperature to be delivered to all the rooms. A constant relative humidity is maintained in the building and all of the air circulated is drawn from outside the building. (Not applicable to the heating of various rooms where individual control of each room is desired).

5. Arrangement similar to (4), except that a portion of the air is recirculated.

6. Arrangement of apparatus where individual control of the temperature for each room is required in conjunction with air washer equipment to maintain a constant relative humidity in the rooms. The air washer is provided with a water heater for the spray water, capable of fully saturating the air. It is impossible to maintain the same room temperature throughout the building with a uniform temperature of the air entering the rooms owing to the fact that the weight of air to be delivered to each room is determined and fixed by the ventilating requirements.

In analyzing these six cases, the following symbols will be used:

H = heat loss of the room or building, Btu per hour.
H_1 = heat to be supplied to the heater, Btu per hour.
H_2 = heat supplied tempering coil, Btu per hour.
H_3 = heat supplied air washer, Btu per hour.
M = weight of air to be introduced into the room or building, pounds per hour.
M_r = weight of recirculated air, pounds per hour.
M_o = weight of air drawn in from outside, pounds per hour.
t_o = mean temperature of outside air, degrees Fahrenheit.
t = mean air temperature to be maintained in the room or building, degrees Fahrenheit.
t_1 = mean temperature of the air entering the heater.
t_2 = mean temperature of the air leaving the heater.
t_z = assumed temperature loss in the duct system.
t_y = temperature of the air leaving the duct outlets.
0.24 = specific heat of air at constant pressure.

$$t_y + t_z = t_2 \text{ or } t_y = t_2 - t_z$$

Case 1. (Fig. 3) All of the air circulated to be drawn from outside the building, in which case $(t_1 - t_o)$.

$$M = \frac{H}{0.24\,(t_y - t)} \qquad (1)$$

$$H_1 = 0.24\,(t_2 - t_1)M \qquad (2)$$

Example. The heat loss H for a certain factory building is 700,000 Btu per hour. The mean inside temperature t to be maintained is 65 F. The assumed outside air temperature t_o is 0 deg; $t_z = 0$ and $t_y = t_2$ and is assumed to be 140 F. Required, M and H_1.

$$M = \frac{700{,}000}{0.24\,(140 - 65)} = 38{,}889 \text{ lb per hour}$$

$$H_1 = 0.24\,(140 - 0)\,38{,}889 = 1{,}305{,}000 \text{ Btu per hour}$$

[1] See *Mechanical Equipment of Buildings*, by Harding and Willard, Vol. I, second edition, 1929.

Case 2. (Fig. 4) All of the air is to be recirculated, in which case $t_1 = t$.

Using the data from the preceding example, $M = 38{,}889$ and from Formula 2

$$H_1 = 0.24\,(140 - 65) \times 38{,}889 = 700{,}000 \text{ Btu per hour}$$

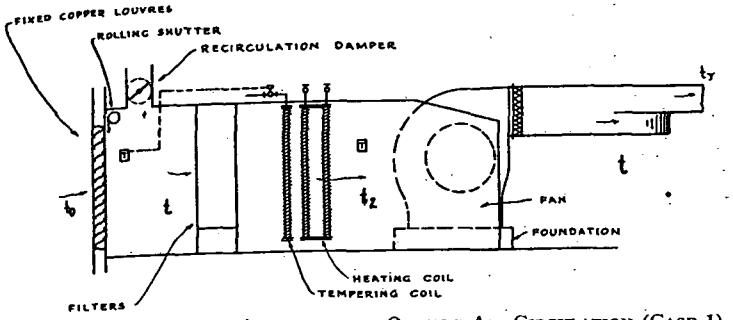

FIG. 3. HEATER AND FAN ARRANGED FOR OUTSIDE AIR CIRCULATION (CASE 1)

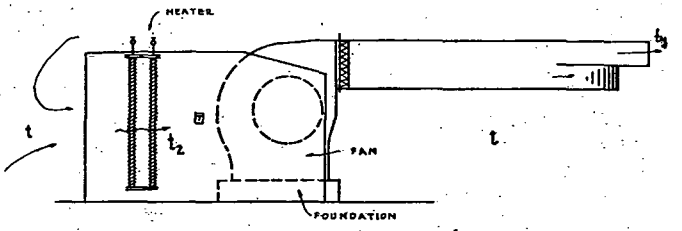

FIG. 4. ARRANGEMENT FOR RECIRCULATION (CASE 2)

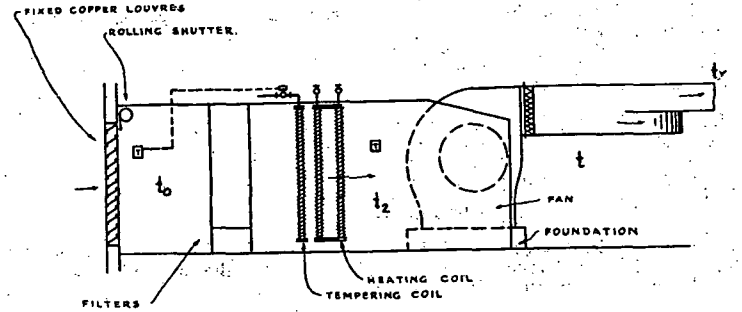

FIG. 5. COMBINATION OF RECIRCULATED AND OUTSIDE AIR (CASE 3)

This example illustrates the saving in fuel consumption by the recirculation of the air. The heat to be supplied the apparatus is the same as that required for a direct system of heating and is equal to the heat loss of the building ($H_1 = H$).