come by placing a certain amount of heating surface just below them and so counteracting the falling currents of cool air before they reach the floor. In the case of a skylight three or four lines of 1-inch pipe around the inside perimeter will usually be found sufficient for this purpose. While direct radiation may give satisfactory results so far as the warming of a building is concerned, it does not provide fresh air for ventilation. In stores where the cubic contents of the rooms are large compared with the average number of occupants, very satisfactory results are often obtained by the inleakage of fresh air around windows and through the opening of doors, but in modern city stores of large size artificial ventilation should always be provided by means of fans. The heating may be done independently of the ventilation by means of direct radiation, or they may be combined in the form of hot-blast heating. The latter arrangement may generally be made the most satisfactory, especially if supplemented by a certain amount of direct surface or secondary indirects placed at the most exposed locations upon the lower floors.

When the air is delivered to the whole building at the same temperature the upper floors are very likely to become overheated, while the lower ones are only comfortable. This is sometimes overcome by reducing or cutting off entirely the warm air supply to the upper part of the building, depending upon the warm air rising from below. This arrangement may be made to work very well if the elevator shafts and stairways are large and open, and the full air supply for the whole building is delivered through the registers on the lower floors.

In designing a system of this kind, provision should be made for supplying the required amount of air to each floor, and all regulation as to the requirements of the different floors be made by the closing of registers or dampers.

A better way is to provide supplementary radiation for the lower floors and then supply air to the buildings at the temperature required for the upper storeys and depend upon the supplementary heaters to make up the deficiency on the lower storeys. When this is done the supplementary heaters should be arranged for automatic temperature regulation. The temperature of the general air supply of the building can usually be regulated with sufficient accuracy by the engineer after a little experience, although automatic means may be employed if desired.

In proportioning the heating surface for protection against exposed glass and walls the ratio may be made about one square foot of heating surface for each four or five feet of glass, and the same amount for each ten or twelve feet of wall surface of average thickness and good construction.

When hot blast heating is used, the air supply may be based on a change of the entire contents of the building once in every twelve minutes for the average city store, although in special departments where the space is large in proportion to the number of occupants it may be better to base the air volume on the number of occupants rather than the cubic contents, giving in this case about thirty cubic feet per minute per person for the average number occupying the room.

Table 1 gives the size and approximate speed of fans of different diameters to furnish given quantities of fresh air under the usual conditions to be overcome in this class of work. The last column in the table gives the approximate horse-power of motor necessary for driving the fan at the given speed.

The size of the main heater may be computed either from the air volume and the required rise in temperature of the air or it may be based upon the cubic contents of the building.

Table 2 gives the number of rows of pipe required under different temperature conditions, and also the corresponding efficiency in heat units per square foot of heating surface per hour. The square feet of heating surface required in any given case may be found by the equation,

When the size of the heater is based on the cubic contents of the building there should be provided one linear foot of 1-inch pipe for approximately each 75 cubic feet of space to be warmed. The arrangement of the ducts, flues and other parts of the system will depend largely upon circumstances in each case. The fan and heater are located either in the basement or sub-basement, as conditions may require. Unless an air filter or washer is used the supply should be taken from an elevation of at least one or two stones to avoid carrying in surface dirt. Oftentimes a higher elevation of inlet is a disadvantage, as it is more liable to catch the soot from surrounding chimneys. In locating the fresh air inlet the premises should be carefully examined in order to avoid so far as possible objectionable surroundings. The air shaft or downtake and its connection may be of brick, concrete or galvanized iron, as most convenient. The first two are more durable, but iron is lighter and less expensive to construct. The size of this airway should be such that the velocity of air through it will not exceed about 1,000 feet per minute.

The distributing ducts may be of the same material as the intake. If carried underground, as is often the case, they should be of brick or concrete, but when run at the basement ceiling galvanized iron is the best material. Velocities here may be 1,000 to 1,200 feet in the main ducts, 800 to 1,000 in the branches, and 600 to 700 in the uptakes. Higher velocities may be employed in the uptakes if the inlet registers are backed with perforated metal or wire gauze to reduce the velocity into the rooms, which should not exceed 300 feet per minute unless special diffusers are provided in front of the registers, in which case velocities as high as 400 to 450 feet may be allowed.

Uptakes and registers should be located with reference to throwing the warm air toward cold walls and other exposed points, and should be sufficient in number to give a pretty even distribution of the air.

Discharge ventilation is not usually required in buildings of this kind, as the plenum effect of the fan is generally strong enough to produce sufficient outward leakage to care for this.