fault. In a large school where complaint was made that the ventilation, formerly excellent, recently had become defective, it was found that the cold air intake and the exhaust openings were functioning and that the thermostats were operating. They were operating the housed supply fan in the wrong direction! When such a fan is operated backward the amount of air delivered may be about half of that normally delivered, and as the power demand is proportional to the work done, the electric motor functions satisfactorily. In this case, a careless workman in reconnecting the motor had transposed two of the leads and no one had noticed, in the dark fan chamber, the fact that the rapidly-turning wheels were going in the wrong direction.

In another case of deficient air delivery, the motor pulley was ordered correctly as 8 in. in diameter and the shipping list of the manufacturer and all of the records showed an 8-in. pulley, but unfortunately when the manufacturer sent out the motor he placed a 6-in. diameter pulley on it. Naturally the fan which this motor was propelling failed to deliver as much air as was expected and several days' delay and a long railroad trip were expended before the difficulty could be diagnosed.

Occasionally a thermostat in a school classroom is connected by mistake so as to control the air supply damper of some other classroom. Such a cross connection is often a long time in being discovered and corrected and may lead to very interesting temperature-complications. Thus the trouble shooter learns to doubt everything he reads or hears and to be suspicious even of what he sees and of what he feels.

HUMIDIFICATION FOR RESIDENCES

With most methods of heating, the problem of humidity control in residences is a difficult one, particularly in cold weather. Not infrequently the relative humidity is lowered to 20 per cent or less as a direct result of artificial heating. As much as 24 gal of water per day may be evaporated in an average home to maintain a relative humidity of 40 or 50 per cent. Pans of water on the radiators may help to supply moisture but the amount thus evaporated usually is not sufficient. Mechanical humidifiers of the cabinet or console type are effective. The unit conditioners described in Chapter 37 may also be used for residence humidification.

Humidifying devices which may be installed inside the duct work of existing warm-air heating systems are available. Fans may be incorporated to increase the air movement and evaporation. A modified type of central station equipment which in general consists of a fan furnace system with attached air washer and blower, and a system of distributing ducts, is available. (See discussion of fan furnace systems in Chapter 31).

The principles underlying humidity requirements and limitations for residences are summarized in University of Illinois Bulletin No. 48[1], as follows:

1. Optimum comfort is the most tangible criterion for determining the air conditions within a residence.

[1]See Humidification for Residences, by A. P. Kratz (University of Illinois, Bulletin No. 48).

2. An effective temperature of 65 deg[2] represents the optimum comfort for the majority of people. Under the conditions in the average residence a dry-bulb temperature of 69.5 F with relative humidity of 40 per cent is the most practical for the attainment of 65-deg effective temperature.

3. Evaporation requirements to maintain a relative humidity of 40 per cent in zero weather depend on the amount of air inleakage to the average residence, and vary from practically nothing to 24 gal of water per 24 hours.

4. Relative humidity of 40 per cent indoors cannot be maintained in rigorous climates without excessive condensation on the windows unless tight fitting storm sash or the equivalent are installed.

5. The problems of humidity requirements and limitations cannot be separated from considerations of good building construction, and the latter should receive serious attention in the installation of humidifying apparatus.

The following conclusions were drawn from the experimental results reported in the aforementioned bulletin:

1. None of the types of warm air furnace water pans tested proved adequate to evaporate sufficient water to maintain 40 per cent relative humidity in the Research Residence except only in moderately cold weather.

2. The water pans used in radiator shields tested did not prove adequate to maintain 40 per cent relative humidity in a residence similar to the Research Residence when the outdoor temperature approximates zero degrees Fahrenheit.

PANEL HEATING SYSTEM[3]

If a room is warmed by applying heat directly to the walls and/or ceiling, it is possible to render the room comfortable with an expenditure of less heat than if heat is supplied by warming the air. It is also found that the room is rendered equally comfortable if warmed by this method, when the room temperature is 5 deg or more below what is required when the room is warmed by convection.

The panel system, which has been in use in England for many years, is based on this principle. This system consists of coils of pipe through which water flows imbedded usually in the ceiling, although in some cases the pipes are embedded in the walls. The pipes which are ordinarily of ½ in. or ¾ in. diameter, are run parallel to each other on 4 to 6 in. centers and are embedded in the concrete in the underside of the ceiling of the room to be heated. The surface of the concrete is then plastered.

Heat is conducted from the pipes to the plaster face and is then emitted in radiant form. The surface temperature of the plaster is considerably lower than that of the water flowing through the pipes and is affected by their diameter and spacing. At 4 in. to 6 in. pipe centers, the temperature varies little over the whole of the panel.

SOUND LEVEL[4]

By the use of noise measuring instruments, sounds may be analyzed into various frequency bands within the range of audibility, and frequently the period of vibration enables noises to be analyzed and traced

[2]66 deg is recommended by the A.S.H.V.E. Committee on Research.

[3]See Panel Warming, by L. J. Fowler (A.S.H.V.E. TRANSACTIONS, Vol. 36, 1930).

[4]For additional information on this subject see Noise Reduction in Ventilating Units, by Warren Ewald, (*Heating, Piping and Air Conditioning*, November, 1930); Noise and Ventilation, by G. T. Stanton, (*Heating, Piping and Air Conditioning*, December, 1930); Some Studies on the Absorption of Noise in Ventilating Ducts, by G. L. Larson and R. F. Norris, (*Heating, Piping and Air Conditioning*, January, 1931).