There is only one general rule for the design of pipe systems that is applicable in all cases. It is this: *When the heating system is functioning at a uniform rate, that is when, in a given time, the radiators dissipate exactly the same quantity of heat that is delivered to the water in the heater, and when, consequently, the water in the system is circulating with a uniform velocity*, the friction head in every circuit leading from the heater to a radiator and back again must be exactly equal to the pressure head for that particular radiator, *i.e.*, to the pressure head which tends to make the water flow from the heater to that radiator and back again, along the circuit referred to previously.

Before applying this general rule to the design of a piping system, it is necessary to assume:

1. The maximum temperature of the water leaving the heater when the outside temperature is the minimum for which the system is to be designed.
2. The drop in the temperature of the water while it is flowing through the radiator.
3. Whether the circulation of the water in the system is to be effected by gravity or by circulating pumps.
4. The arrangement of the piping connecting the heater with the several radiators.

These four preliminary steps will be discussed in the order named.

MAXIMUM WATER TEMPERATURE

For some time it has been customary to select 180 deg. as the maximum temperature of the water leaving the heater. With this maximum temperature and a temperature drop of 20 deg. through the radiator, the average water temperature in the radiator will be 170 deg. If the temperature of the room is to be 70 deg., the temperature difference, water to air, will be 100 deg. The corresponding value of k for a 38-in., 3-col. radiator is 1.34 and the heat dissipated by the radiator per square foot per hour is 134 B.t.u. A steam radiator of similar size and design and supplied with low-pressure steam will dissipate about 210 B.t.u. per square foot an hour. Under these conditions, a hot-water heating system would require about 210 sq. ft. of radiation for every 134 sq. ft. required by the steam heating system. The first cost of the hot-water system would, consequently, be considerably higher than that of the corresponding steam system. This higher first cost of a hot-water system is frequently the cause of the installation of a steam system.

If, on the other hand, 220 deg. is selected as the temperature of the water leaving the heater, the average temperature of the water in the radiator will be about 210 deg., practically the same as that in low-pressure steam radiation, and the total radiation required for the hot-water system will be about the same as that required for the corresponding steam system. The cost of the pipe system for hot water is probably a little higher than the cost of the pipe system for steam, but the cost of valves and traps for a steam system is higher than the cost of the valves for a hot-water system, so that, finally, the cost of a hot-water heating system will not be higher, and is frequently lower, than the cost of a corresponding steam heating system, if the maximum temperature of the water is selected sufficiently high.

The selection of 220 deg. as the maximum water temperature is entirely proper because the minimum outside temperature for which the

heating system is designed and for which the heat losses are calculated, occurs only a few times in any one year and perhaps never in some years. Consequently, it is very seldom and in some years never necessary to heat the water to the assumed maximum temperature.

If 220 deg. is selected as the maximum temperature, it is necessary to provide sufficient pressure of the water in all radiators and in the entire pipe system so that the water will not boil at that temperature. This can be accomplished easily in all closed systems and also in all open systems. In the latter case, it is only necessary to place the expansion tank at a sufficient altitude above the highest point of the heating system. For example, if the expansion tank is located 10 ft. above the highest point in the system and if the expansion tank riser is filled with 200 deg.

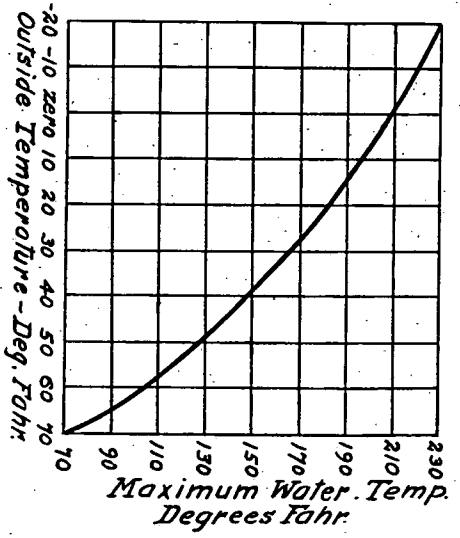

FIG. 3. AN ILLUSTRATION OF THE VARIATION, WITH THE OUTSIDE TEMPERATURE, OF THE REQUIRED MAXIMUM WATER TEMPERATURE IN THE HEATING SYSTEM

water when the flow risers carry 220 deg. water, the pressure at the highest point of the heating system will be about 4.2 lb. per sq. in. The corresponding boiling point is about 226 deg. and there would be no danger of boiling the water in the heating system at 220 deg.

In such cases the expansion tank riser should be connected to the return main. Precautions must always be taken to prevent freezing of the water in the expansion tank or in the expansion tank riser.

Having assumed the maximum temperature of the water for the minimum outside temperature, the required maximum temperature of the water for any other outside temperature may be found as follows:

If 220 deg. is selected as the maximum temperature of the water when the minimum outside temperature is -10 deg., if the inside temperature is to be 70 deg. and the temperature drop through the radiator is to be 20 deg., if R represents the total radiation in square feet, and if