or contactors, which should break all of the power lines. All heaters having fan circulation should have the heat circuit interlocked with the motor circuit so that the fan will be running when the heat is on. A thermal fuse or trip should be located in the heat chamber to throw off the heat in case any interruption of air flow should occur; otherwise undue temperature rise would result. In all large heaters the heating elements should be arranged in groups and control provided to vary the heat input to correspond approximately to the heat demand. If this is not done, and all the heat is kept available, the thermostat will continue throwing it on and off at short intervals. Except for central fan systems, the heat stages can be operated by manual switches, but automatic modulation of the heat load is usually preferred.

CALCULATING CAPACITIES

The methods of calculating heat losses outlined in Chapters 6, 7, and 8 may be used for electric heating exactly as for fuel heating. The total heat requirements in Btu per hour may then be converted into the electrical rating of an equivalent heating system by using the equation:

$$\frac{\text{Total Btu per hour}}{3415} = \text{kw rating of required electric heating} \qquad (1)$$

POWER PROBLEMS

The first point to determine is the cost of the power which is available for electric heating. Unlike fuels, there is no uniform cost for electric power because of the unequal cost of distribution to large and small users. The fact that electricity cannot be economically stored, but must be used as fast as it is generated, makes it impossible to operate power plants at uniform loads; hence, even the time of use may affect the cost of power. As distribution is a big item in power costs, the best places to use power for heating are large industrial plants which have heavy service lines.

Homes are almost universally supplied with lighting current of 115 volts, which cannot be used economically for any but the smallest heaters. Usually the service lines will not permit more than plug-in devices. The underwriters permit heaters of 1250 watts to be used from approved base board receptacles. Where homes have 230 volt service for cooking and water heating, and rates are favorable, larger heaters can be installed. For industrial purposes, heaters should be designed to use polyphase power, which is usually supplied at 230, 460 or 575 volts. All polyphase heaters should be balanced between phases.

ELECTRIC HEATING DATA

Electric heater capacity is rated in kilowatts (kw). Electric power is measured in kilowatt-hours (kwh). Cost of operation = kw rating × hours used × cost per kwh.

One boiler horsepower (bhp) = 33,471.9 Btu per hour
One kilowatt-hour (kwh) = 3,415 Btu per hour

$$\text{One boiler horsepower} = \frac{33{,}471.9}{3{,}415} = 9.80 \text{ kwh}$$

One boiler horsepower will evaporate 34.5 lb water per hour *from and at* 212 F.

$$\text{One kilowatt-hour} = \frac{34.5}{9.80} = 3.52 \text{ lb of water per hour at 212 F}$$

Additional conversion factors are given in Chapter 42.

Chapter 39

WATER SUPPLY PIPING

Maximum Possible Flow, Maximum Probable Flow, Average Probable Flow, Factor of Usage, Kind of Pipe Used, Sizing of Risers, Sizing of Mains, Sizing of Systems, Hot Water Supply, Hot Water Storage

IN the design and layout of domestic water supply systems, the engineer is confronted with the necessity of combining the somewhat empirical rules and formulae in use with the more or less exact hydraulic principles involved. Unlike heating and ventilating layouts, there are practically no definite data for estimating the quantity of water likely to be consumed or the probable rate of water flow at any particular moment.

Metered results in one building often show two or three times the metered amount in another building of the same size and with the same type of tenants. In hotels, one riser will often have an almost constant flow that may never be reached by another at peak load. In office buildings, the women's toilets show a far greater daily consumption than those of the men, yet at no time will they approach the hourly consumption of the men's toilet during the first hour of the day. This condition has led to a multiplicity of rules of practice which vary as much as the data used. All must of necessity be based on an assumed rate of consumption and on an assumed probability of simultaneous use, and while the formulae employed may have been derived on sound technical bases the assumptions are often in error.

To arrive at a safe standard, the approximate rate of flow of each fixture to be supplied must be known and the probable number of fixtures in use at any one time must be assumed. Obviously, the maximum number of fixtures assumed to be in use must be taken at the peak of demand and the lines must be made adequate to supply such a peak regardless of the riser or branch on which the demand may occur. This means that all water piping under the usual conditions will be over-sized.

In tall buildings it is customary to divide the water supply systems, both hot and cold, into sections of 10 to 20 stories. Such *zoning* or *sectionalizing* is for the purpose of avoiding excessive pressures on the fixtures in the lower stories of each system. This limits the consideration of water pipe sizes to horizontal mains and to risers not exceeding 20 stories in height or about 200 ft[1].

[1]It is impractical to attempt to size piping so as to produce the proper pressure on fixtures at different levels by employing friction, owing to the fact that this friction will be built up to the amount desired only in times of maximum demand and at all other times the friction will be only a fraction of the maximum friction so that the fixtures by this method are subjected to a varying pressure on the water supply line. A much more practical method is to throttle the flow at the fixture, or to use flow regulators, so that the quantity of water delivered will approximate the fixture demands and so that this is accomplished without splashing or noise.