radiating surface giving a higher rate of heat emission, special care must be given to the selection of the boiler.

The matter of levels also effects the design and proportions of the heating mains. In many greenhouse ranges the walk levels are not more than 2 ft. 6 in., or 3 ft., above the top of the boiler and where all of the radiating

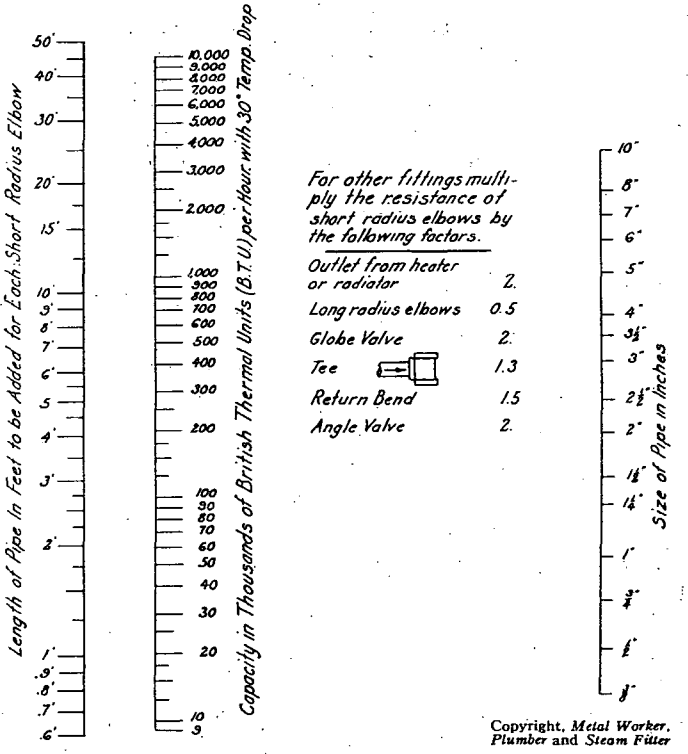

FIG. 40. CHART FOR FINDING FRICTION LOSS THROUGH FITTINGS

surface is made up of pipe coils on a level not higher than 1 ft. 6 in. above the floor, especially if there are short benches requiring short coils under them, special care is necessary to avoid short circuiting, or interference with the flow through low temperature drops in the short coils.

The temperatures required in houses are given in Table 75.

ESTIMATING HEATING REQUIREMENTS

Heating requirements, i.e., the amounts of radiation for greenhouses, are not obtained by scientific calculation or intricate formulae; at least, they are not so obtained by greenhouse specialists. In this calculation only the exposed glass surfaces and other exposed surfaces reduced to the equivalent of glass surfaces are considered. The loss of heat by conduction through the glass is, of course, by far the greatest loss, but there is another considerable loss which it is very difficult, if not absolutely impossible to calculate, that is, the loss by air leakage between the lights of glass at the laps. These two make up practically all of the losses. The only other losses are those through open doors and through vents. The latter are generally intentional, and used to reduce the greenhouse to the required temperature; but a change of air is necessary for plant growth, so the vents are not opened except for reducing the inside temperature.

Modern greenhouses are glazed almost exclusively with double-thick glass in lights 16 in. wide and 24 in. long. The glazing bars, or ribs, are then usually 16½ in. center to center. The *lap* of the glass is ⅜ in. by eye measurement. Sometimes 24 x 24 in. glass is used, but not often, and with this size, the bow, or spring, of the glass when the wind blows is greater, and the heat loss through the laps may accordingly be greater as a consequence.

The cubic contents in ratio to the surrounding glass surface, the size and the shape are, of course, more or less factors, but as previously stated, only the glass and glass equivalent enter into the calculation for the quantities of radiating surface. The engineer may modify somewhat the quantities so obtained because of the ratio of the contents to the enclosing glass, or the size or shape of the structure, or because of its geographical position or its elevation, or because the greenhouse is in a particularly exposed position. The calculation is merely that of dividing the glass and the equivalent surface by the proper divisor.

WATER TEMPERATURE

The average temperature of the water in a gravity hot-water heating system is assumed to be about 150 deg. fahr., and the average coefficient of transmission of the radiating surface is assumed to be 2, and as previously stated, only the glass and other exposed surfaces reduced to the equivalent of glass are considered in the calculation. The factors, or divisors, for glass surfaces are derived from the following formula:

$$R = \frac{(T - t) \times G}{(150 - G) \times 2}$$

where

T = temperature desired, fahr.;
t = temperature out of doors (0 deg. fahr.);
150 = temperature of water in radiating surface, fahr.:
G = glass and glass equivalent surface;
2 = coefficient of transmission;
R = radiating surface.