nearest the boiler as at *C*, in Fig. 37, with a slightly lower drop at *B* and the lowest at *D*. Then the water would have a gradually falling temperature throughout the main circuit, from the boiler back to the boiler. These conditions would favor a steady circulation at any boiler temperature without interference or retarding of the return flow from any of the various radiators.

Therefore, if the radiators at *C* were 90 sq. ft. and connected with ¾ in. pipe, the temperature drop might be greater than 40 deg., but the result would be better than if 1 in. were used and resistances introduced to equalize the drop to 40 deg.

PIPE SIZES FOR FORCED CIRCULATION

A basic rule to be followed in computing pipe sizes for systems of hot-water heating using forced circulation is that the pressure drop at each radiator, due to friction in the mains, risers and branches, must be uniform throughout.

Selection of pipe sizes from charts or tables stating the maximum duty performed does not afford a close enough distribution of the load on the system to insure perfect operation. The pump in a forced circulation system delivers a fixed volume of water and a gain for one radiator must be a loss for another.

A convenient means of determining the pressure drop due to friction is found in two charts which originally appeared in the May 28, 1920, issue of the *Metal Worker, Plumber & Steam Fitter*, and are reproduced herewith. Fig. 39 gives the friction pressure drop in straight lines of pipe and is based upon the formulae of A. V. Serginsky. These formulae take into consideration the greatly decreased viscosity of liquids at increased temperatures as found by the experiments of Biel and give much smaller pipe sizes for this class of work than those obtained by the formulae of Weisbach. The chart shown in Fig. 40 gives the length of pipe for which the resistance is equivalent to that of a given fitting of the same size.

The chart is read by laying a straight-edge across the given pipe size and the given capacity, and reading the result for short-radius elbows. The equivalent length of pipe for other fittings may be found by multiplying by the constants given.

An average pressure drop per foot for the mains, due to friction, must first be obtained by dividing the pressure against which the pump will deliver the necessary quantity of water by the actual piping distance to and from the farthest radiator, plus the allowance for fittings. Using this figure for the loss-in-pressure factor on the chart, preliminary pipe sizes may be obtained. To make the sizes of the branches more nearly equal throughout the system, the size of the main near the pump should be less than that read on the chart, and the size of the main at the far end greater than that given.

The total friction drop for the circuit should now be checked and such corrections made as may be necessary.

To obtain the pipe sizes for the branches compute the friction drop for the supply and return main from the pump to each supply and return

branch. The working pressure of the pump less the sum of the friction loss in the supply and return mains to any pair of branch lines will give the pressure loss due to friction, that may be used in those branches. From the charts the size of each branch may be computed in the same way as the sizes of the mains were obtained.

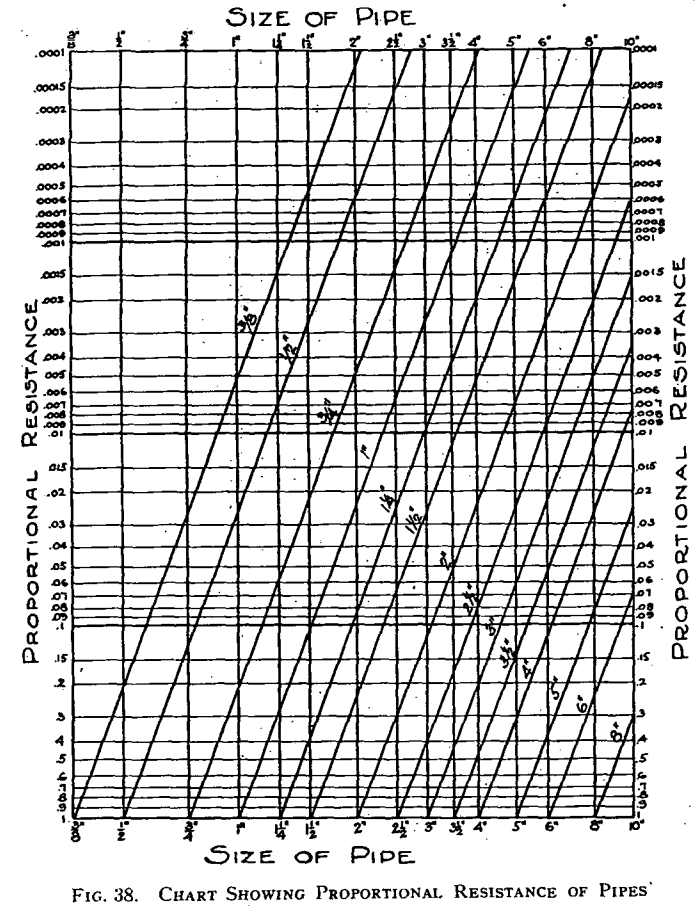

FIG. 38. CHART SHOWING PROPORTIONAL RESISTANCE OF PIPES

As much of the pressure drop as possible should be confined to the branches so that they will be as small as possible. At the same time it must be borne in mind that if this is carried too far the size of the branches near the pump may be smaller than is desirable in practice.