

of the necessity for providing for the extreme need which may be a long time coming, but which the experience of American cities has shown to be quite sure of coming some time.

Various engineers who have made a study of the subject have given us estimates of the number of 250-gallon fire streams, as governed by population, which may be required simultaneously for the entire city. Of course, population cannot be considered the only factor; for example, the southern city, as the trading center for a large surrounding territory, will have much higher values in its mercantile district than a city of the same population near a metropolis in the north; or in some cases, important manufacturing sections will demand increased protection. But on the whole, these estimates give us a very fair basis for comparison. For cities of 25,000 and 75,000 population, it is considered that about 3,500 and 6,000 gallons per minute, respectively, should be available in excess of maximum domestic consumption, as compared with 10,000 gallons per minute in a city of 200,000 population. Mr. John R. Freeman estimates that, as a general statement, two-thirds of the total number of streams should be capable of being "concentrated upon any one square in the compact valuable part of the city, or upon any one extremely large building of special hazard."

These quantities should be available for actual use in extinguishing fires. It has been noted at many large fires, and was particularly emphasized during the Baltimore conflagration, that mains are liable to be badly bled through broken service pipes in wrecked buildings, especially through the larger services to sprinkler systems and hydraulic motors. To allow for such losses, it is considered by National Board engineers that to provide for a conflagration in the valuable part of the city, distribution systems should be designed to furnish quantities from fifty to one hundred per cent. in excess of those named by Mr. Freeman, to be available within such distance of any point that the average distance to hydrants furnishing this supply will not exceed 350 feet.

While these quantities may seem excessive, it is interesting to note that in the congested value districts of most of the cities reported on by the National Board, such quantities have been found available in the immediate vicinity of the main feeders, and that they may easily be made available in other parts of these districts by replacing small mains or remedying other faults of the distribution system.

With a system supplied by direct pumpage, safe practice requires pumps of such number and capacity as to supply the maximum domestic consumption and the necessary fire flow, with any two units out of commission. If a distributing reservoir with capacity of four or five days' consumption is provided, this reserve pumping capacity may be reduced with safety.

The pumping station itself, in these days of concrete and steel construction, can be built practically fireproof at slight increase in cost over the type more often found, containing considerable combustible material. Most of the stations inspected, whether of municipal or private ownership, have been found very neatly kept, with machinery main-

tained in excellent condition. There is apt to be, however, a lack of adequate fire protection.

In preparing for a study of the distribution system, we find that seldom is there proper data arranged in such manner as to allow intelligent consideration of the system as a whole. A map should be prepared on such a scale that the mutual relations of all parts of the pipe scheme may be followed out, with large feeders emphasized by heavier lines, and all lack of connections indicated. In this way, faults hitherto unsuspected or not fully realized, are strongly brought out, and it is often a question of common sense rather than of profound engineering ability to discover points in the system where the insertion of mains is necessary to complete the gridiron of secondary feeders.

But this method of inspection will discover only the most strikingly evident faults. To determine whether the loss of head to various points is excessive, carefully located recording gauges are invaluable, or ordinary gauges read at hourly intervals may be used. The calculation of probable quantities available for fire protection is often intricate, and involves assumptions as to population and per capita domestic consumption in various districts, loss of head in hydrants, etc. Some method by which these quantities may be actually measured is much simpler and seems preferable; a method of testing the system originated by National Board engineers, and adopted by the water departments of several cities, has produced excellent results.

In making the tests, groups of hydrants are selected in such parts of the system as will bring out both the strong and weak points. The groups generally consist of six hydrants, though a less number is taken where hydrants are far apart, or in weak sections where the flow from three or four hydrants will develop the full capacity of the pipe system to furnish supply. The velocity of flow from hydrant outlets is measured by means of a Pitot tube with gauge attached, and from the velocity the discharge in gallons is calculated. All available outlets on each hydrant in the group are opened, except in cases where the velocity of flow is so low that it cannot be measured with the apparatus, when some outlets are closed to increase flows from the others.

In some distribution systems which at first sight seem well equipped with main arteries, a closer inspection shows that by reason of infrequent connections to these arteries in some sections through which they pass, large areas are supplied through considerable lengths of small pipe, and the value of the larger pipes is not fully realized. In other cases hydrants are found connected to the smaller of two available mains, or the loss of head in hydrants of poor type largely counteracts the head gained by installing large mains.

A careful study of relative pressures in various sections, and of discharges from the groups as a whole or from the individual hydrants, will usually reveal the faults of a system, whether the lack of main arteries or of secondary feeders to distribute the supply, small minor distributors, lack of gridironing or of connections at crossings, or poor type of hydrants.

(To be continued.)