RUN-OFF FROM SEWERED AREAS.

In May, 1907, the sanitary section of the Boston Society of Civil Engineers appointed a committee to investigate the above subject. The committee submitted a preliminary report early in 1908, designed particularly to describe the apparatus needed for the gauging of rainfall and run-off. This report offered many valuable suggestions for engineers contemplating the establishment of such apparatus. It has been followed by four progress reports bringing out the difficulties of maintaining gauging stations and of properly interpreting the results of gaugings. It has finally transpired that the committee has brought together all of the gaugings which it has been able to secure and has made such interpretation of the results as is practicable. This final report has been published in the June, 1914, Journal of the Society. It is divided into three main parts: methods of measuring precipitation; methods of measuring run-off, and results of measurements of rainfall and run-off, showing relation between precipitation and flow in sewers.

Methods of Measuring Precipitation.—The automatic or recording rain gauge is the only type which is of use in studies of this character, not only because it is essential that records be taken at the time storms occur, whether that be during the night or at other times when observers might not be on duty, but also and especially because it is the rate of rainfall, rather than total quantity, in which we are interested in studies of this kind. This point is so fully recognized that it is not necessary to do more than refer to it at this time.

A point not always recognized in connection with automatic rain gauges is the great importance of a good clock movement which can be closely and accurately regulated. In comparing the records of several rain gauges or the records of rain gauges with those of sewer gauges, the question of time is one of much importance. The correct time of starting a new gauge sheet and of removing the sheet from the gauge should always be distinctly marked upon the chart. With this information available, it may be possible to adjust the error so as to tell moderately closely the time of occurrence of a storm and the time occupied in travel of the storm.

With all commercial rain gauges on the market, the only method of estimating the time is by noting the position of the pen upon the chart. It is seldom possible to estimate the time closer than five minutes, and frequently it is difficult to estimate it closer than fifteen minutes. It is, therefore, a difficult matter to regulate the clock, or to compare the time indicated by two or more gauges. This would be greatly simplified if all gauges of this type were furnished with clock dials and hands, in addition to the ordinary regulator, so that it might be possible to adjust the clock to the correct time and to keep the clocks of several gauges properly synchronized. In large and important works the possibility of electrical operation of the clocks, thus insuring their keeping proper time and being absolutely synchronized, is worthy of consideration.

The report then enumerates and describes the construction and methods of operation of the principal types of automatic rain gauges, including the Fergusson, Draper, Freiz, Queen, Richard, Marvin, Fitzgerald and Hellman.

Measurement of Run-off.—A measurement of the actual volume of storm water run-off in sewers is not usually practicable. Weirs installed in the sewers themselves are objectionable on the score of the head required and also because they cause a retardation of velocity and retention of sediment; it is also difficult to arrange weirs which shall give satisfactory results under wide variations of flow, and frequently with high velocities of approach. Venturi meters are expensive if furnished with recorders, which are indispensible in studies of storm flow; they have an insufficient range for measuring the wide fluctuations which are likely to occur; and as they must usually be set in inverted siphons in order to register properly, their installation in sewers already built involves some difficulties. Current meters for continuously recording the flow of sewage are not ordinarily practicable on account of the foreign material in the sewage, which is likely to clog the meter, or otherwise derange it. As a result, gaugings, so-called, of storm-water flows in sewers, have almost invariably been made by recording the level of the sewage flowing and computing the quantity of flow, using Kutter's formula, usually with an assumed coefficient of roughness. In order to compute the flowing in the sewer from observations of this kind, it is necessary to know the cross-section of the flowing stream, the slope, and the coefficient of roughness. The former can be readily computed from the known or measured cross-section of the sewer, having given the elevation of the surface of the sewage, which is easily obtained from a record of the water level or flow gauge. In most observations of this character, the hydraulic slope has been assumed as parallel to the invert of the sewer, and a coefficient of roughness, n in Kutter's formula, has been assumed. In many cases these assumptions have probably been wide of the truth.

With regard to the hydraulic grade, the following comments by W. W. Horner, principal assistant engineer, Sewer Department, St. Louis, in a discussion of a paper by S. A. Greeley, in "Journal of the Western Society of Engineers" for September, 1913, are pertinent:

". . . It has been noted that there are marked differences between the grade of the sewer and the water surface grade. For example, in a 9-ft. sewer for one rain a depth of flow, at one point, of 4½ ft. was observed; 1,000 ft. downstream the depth was less than 4 ft. though several tributaries entered between, while 500 ft. farther downstream, the depth was over 5 ft. Similar variations have been noted in other rains. The sewer is uniform as to grade, size and condition. The most reasonable explanation of these differences is that the flow at the upper and lower gauges is distributed, in the case of the upper gauge, by a curve 200 ft. upstream, and of the lower by a 3-ft. lateral, discharging into the main sewer nearly at right angles, 100 ft. above the gauge. In both cases the velocities would be materially reduced from that computed by Kutter's formula. In another case, a sharp reverse curve and small local obstruction has been found to create a back pressure above of over 10 ft., although the sewer below was only slightly overcharged."

Other observers have had similar experiences. It is, therefore, evident that the use of the grade of the sewer as representing the hydraulic grade may result in serious errors in computing the actual flow in the sewer. It is obvious that correctly to compute this slope two or more water level indicators are necessary, and these must be exactly synchronized so that the true hydraulic slope corresponding to the depth at any time can be properly computed. The use of maximum flow gauges, indicating merely the maximum height reached by the flood wave at any point, for the purpose of determining the hydraulic slope, is not to be commended, although such gauges serve as a valuable check upon the readings of the automatic gauges. The crest of the flood wave progressing