downstream leaves its record on each of these gauges, but it is obvious that the hydraulic slope is not the slope between the highest point reached at one gauge and the highest point reached at the succeeding gauge, since the crest of the flood was not at both of these points at the same time.

Wide errors may also be introduced into the estimate of flow by incorrect assumption of the value of the coefficient. It is only necessary to call attention to the fact that the values of n in Kutter's formula for the classes of sewers ordinarily gauged may range from 0.009 to 0.017 in order to realize that assumptions of this coefficient may be far from the truth. These two values, as it happens, have been found by velocity measurements at Pawtucket and Philadelphia to apply to the particular cases referred to; but it is evident that the assumption of such coefficients without experimental determination may introduce serious errors, possibly as much as 50 per cent. Obviously, this method of estimating flow can only be correctly employed when the coefficient is experimentally determined for the sewer under consideration. Either the coefficient of roughness n in Kutter's formula, or the coefficient C in the Hazen-Williams formula, may be determined and employed in the estimation of flow. It is not thought best to use the Chezy formula directly, since the coefficient in this formula would not be constant for varying depths in the sewer and the resulting changes in the hydraulic radius.

In the study of run-off at Pawtucket the following investigations were made in an endeavor to find the value for n in the Kutter formula for the sewer under investigation. The diameter of the sewer was too small to permit of the use of current meters when measuring storm flows. It is seldom that a depth greater than one foot is reached in this sewer, and most of the observations had to do with much lesser depths.

Because of these conditions, floats were tried between manholes 447 ft. apart. The surface slope of the discharge corresponded with the slope of the sewer, as nearly as it was practical to measure the depth of flow, and the slope of the sewer, .006, was therefore adopted for the value of s.

The floats used were pieces of wood three inches in diameter and two inches long, and the time taken for the passage of these between manholes was recorded by observers. About 170 observations were recorded, during storms occurring between February, 1905, and February, 1906, and from these data ninety-one velocities were figured for various depths of flow between 0.16 and 1.1 ft. These velocities have been plotted and a curve drawn which corresponds very closely to the curve of Kutter's formula when using a value for n of .0085.

As the velocity measured was the surface velocity, and therefore, for the shallow depths observed, was very nearly a maximum, it is fair to assume a somewhat lower figure for the average velocity. Mr. Fteley, in his measurements of the flow in the Sudbury River Conduit, found the average velocity there to be about 88 per cent. of the maximum velocity, and a velocity curve *cd*, representing 88 per cent. of the observed velocity has been drawn.

This curve lies between the curves of the Kutter formula drawn with values for n of .010 and .009, but very close to the former curve. It is identical with the velocity curve of the Hazen and Williams formula when giving a value of 150 to c in that formula, $V = cr^{0.63} s^{0.54} 0.001^{-0.04}$.

With respect to this latter formula, it may be said that c has a range of 145 to 152 when compared with the experiments of Darcy and Bazin in semi-circular conduits of 4.1 ft. diameter, with a surface of pure cement.

The following quotation is taken from W. G. Taylor's description of a new main intercepting sewer at Waterbury, Conn.: "Observations upon the sewage flow in the main carrier, at depths up to the springing line, have shown that the value of n in Kutter's formula when applied to the sewer flow is not greater than 0.010." The sewer for which these values were obtained was of reinforced concrete of horseshoe shape, 5 ft. 6 in. x 4 ft. 5 in. Great care was used in churning the deposited concrete, and the interior and exterior surfaces are reported as being "very smooth."

Types of Recording Gauges.—Leaving Venturi and current meters out of consideration, practically the only type of automatic gauge applicable to gauging storm water flows in sewers is a gauge of the water level recorder type. All of the gauges available for this purpose may be divided into two general classes—float gauges and pneumatic pressure gauges. Either class is equally applicable to keeping a continuous record of the head of water over a weir in case it is practicable to use a weir for accurate measurements of flow.

In order to secure proper registration with any type of gauge, it is practically essential to install the float or pressure chamber in a separate manhole connected with the sewer, rather than in the sewer itself. This adds materially to the cost of installing the gauge and keeping records of sewer flow, but it has not been found practicable to obtain trustworthy records by means of a gauge installed directly in the sewer itself.

In the float gauge a float contained within a pipe or other suitable guide is connected with a recording apparatus through the medium of a cord, chain, tape or by a solid rod or tube.

The report then presents descriptions of various recording gauges including the Hydro-Chronograph, Freiz's improved water stage register, Builders' iron water level register, pneumatic pressure and diaphragm gauges, and Sandborn's flow recorder.

Installation of Automatic Sewer Gauge.—A reliable automatic record of the depth of the storm flow in the sewer is of equal importance with the record of the rate of precipitation, but is even more difficult to obtain. So many difficulties beset the installation of an accessible recording device that it has been very hard to obtain the co-operation of municipal engineers in this work. In sewers less than four feet in diameter and in any sewer where the normal dry-weather flow is of very shallow depth, the installation of a recording device in the sewer itself is apt to produce such an obstruction to the flow as will set up artificial conditions, which make a record of the correct depth of flow impossible.

It is therefore much better to construct an auxiliary manhole, independent of the sewer, for the special purpose of installing the recording mechanism. In this manhole a float chamber can be constructed and connected with the main sewer by a small pipe, or pipes, and these need be the only connection with the sewer. Under such a construction it will be possible to visit and inspect the recording mechanism without the inconvenience attendant upon a descent into a regular manhole which is a part of the sewer itself. It will still have the disagreeable feature, however, of being below ground and accessible only through an opening in the street surface. A much better location for the recording device is at the edge of the curb and above the level of the sidewalk. This can be accomplished through a construction similar to a police