Etylwein also had brought out his forumla for ascertaining the size of pipes, which was:

$$D = 1.2 \times \sqrt[10]{\frac{A^4 \times q^4}{S^2}}$$

q = Volume of discharge per second per hectare in cubic metres.

A and S were the same as above.

By combining the two formulæ, Bürkli-Ziegler obtained the value of "q" corresponding to the rainfall assumed by Hawksley. Thus:

$$D = 0.32 \times \sqrt[10]{\frac{A^3}{S}} \text{ equal } 1.2 \times \sqrt[10]{\frac{A^4 \times q^4}{S^2}}$$

$$q = 0.037 \times \sqrt[4]{\frac{S}{A}}$$

Reducing this to litres per second per hectare he got

$$q = 37 \times \sqrt[4]{\frac{S}{A}}$$

The ratio between the discharge and the quantity of rain fallen, which was sought for by Bürkli-Ziegler, was found thus:

$$\frac{\text{Volume of discharge}}{\text{Rainfall}} = \frac{Di}{Rn} = \frac{37}{70} \times \sqrt[4]{\frac{S}{A}}, \text{ say } 0.5 \times \sqrt[4]{\frac{S}{A}}$$

$$Di = 0.5\ Rn \times \sqrt[4]{\frac{S}{A}}$$

This is the classic formula deduced by Burkli-Ziegler. Considering 0.5 as the factor of impermeability denoted by "p" it then takes the form in which it has been so extensively published in America, etc.,

$$Di = P \times Rn \times \sqrt[4]{\frac{S}{A}}$$

Of the foregoing formulæ, the last (Lloyd-Davies) is the most advanced, but is does not satisfy all the conditions, as will be shown later on. With regard to the others, it can be stated that they are inadequate and no longer up-to-date.

These formulæ (excepting Lloyd-Davies') are unsatisfactory inasmuch as it is assumed that the discharge is constant, regardless of the shape and configuration of the drainage area, and the velocity of the flow in the sewers.

Lloyd-Davies' formula is an advance on the others, for it takes into consideration the above mentioned factors, which are ignored by the others, but which, nevertheless, are important, as they actually influence the discharge of the storm water. But he and Mr. Wallington Butt, who have read interesting papers on this subject, assumed that the entire area must be contributory to the flow in the sewers, before the maximum discharge is attained. This assumption, however, must be controverted, as it does not suit all conditions.

The principal factors which influence the discharge of storm water are:

1. Rainfall intensity.
2. Impermeability of the surface of the drainage area.
3. Retardation, which depends on the shape, extent, and configuration of the drainage area and also on the velocity of flow in the sewers.

1. Rainfall Intensity.—The annual rainfall in different parts of any country varies considerably. The mean annual precipitation over a long period, in parts of Prairie Provinces, for instance, is about 18 inches, but in other parts it is much less. In the semi-arid parts of the United States it is under 10 inches, whilst in the Canadian Rockies it must be many times as much. On Table Mountain, Capetown, the average yearly rainfall over a certain area is nearly 70 inches, but in the city, which is only four miles distant, it is 30 inches. In the Berg River Hoek watershed, which is about 50 miles inland from Capetown, the mean annual precipitation is about 120 inches, whilst in the valley, less than ten miles away, it is only 36 inches.

The mean rainfall in Germany is about 26½ inches, although near Berlin it is 24 inches and near Basel 33½ inches.

The rain, moreover, does not fall in convenient, uniform showers, but often in erratic torrential downpours, with very great intensity, during more or less short periods.

In New England, a rate of 3.6 inches an hour, continuing for 5 minutes may be expected every year or so, a rate of 2 inches continuing for 20 minutes; 1½ inches for 30 minutes, and 1 inch in one hour (Folwell).

(To be continued).

LOCATING A RAILWAY LINE.

By J. A. Macdonald.*

When surveys are to be conducted in a country which is timbered and little known, it is, in the long run, a great saving of time and money if it is practicable to have the engineer who is to have charge of the survey, accompanied by a good assistant, and say, half a dozen or more men, go over the country as best he can, running rough compass lines, using a micrometer, pacing or estimating for distances, taking barometrical altitudes, and generally becoming acquainted with the nature of the country and principal difficulties he may expect to have to overcome. Having gone over the whole of the section allotted to him, and thoroughly explored the country for several miles on either side of his rough compass line, he will have naturally formed some idea of the best route to be followed and save the cost of a large party running instrumental lines that may prove, after weeks of hard labor, utterly impracticable through running into some unforeseen obstacle. The engineer in charge of work of this character should be one who has had considerable experience in a timbered country, able to find his way anywhere, and not afraid of being lost. He should be able to establish his latitude and approximate longitude by observation though, owing to the difficulty in carrying a reliable chronometer, the latter is seldom to be relied upon. On reaching his point of departure his aneroid barometers, of which he should have at least two, or better four, having all been previously compared and rated, he will assume a datum for elevation for his work, and all altitudes should be reduced to that datum. By arranging the movements of his party he can provide that one barometer will always be stationary, and if a half-hourly record of its readings is carefully kept all altitudes taken by the party in the field can be reduced to one datum, the party having kept record of the time at which the observations were made. As is well known, such barometrical altitudes cannot be explicitly relied upon, but with care and good barometers it is surprising what close approximation to the true altitudes can be obtained. My experience has been that the aneroid barometers best suited for rough work are those about two and a half inches in diameter, divided to read five feet. The range of such barometers does not generally exceed two thousand eight hundred feet, but are much less

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