Such a curve is shown in Fig. 1, the ordinates are the costs in dollars per lineal foot of drains whose capacities in cubic feet per second on a grade of 1 ft. in 1,000 ft. are the respective abscissae. The costs were calculated from a series of concrete sewer sections using the prices of material and labor in the vicinity of New York city and naturally would not hold for dissimilar sewer sections or even similar sections in other localities. From such a curve the cost of carrying the water on any grade can be obtained by simply converting the given discharge to the corresponding discharge on the grade to which the prices on the curb refer. For instance the cost of carrying 1,000 cu. ft. per second on a grade of 4 ft. in 1,000 ft. would be equivalent to the cost shown on the diagram for carrying

$$1000 \times \frac{\sqrt{1}}{\sqrt{4}} \text{ or } 500 \text{ cu. ft. per second.}$$

The value of such a cost curve is that it renders possible the determination of the cost of a large drain whose capacity steps up as it lengthens without necessarily establishing the lengths and diameters of its sections and calculating the cost of each separately. It is evident that such a drain is approximately funnel shape, but, instead of a gradual and constant transition from a small to a large diameter the

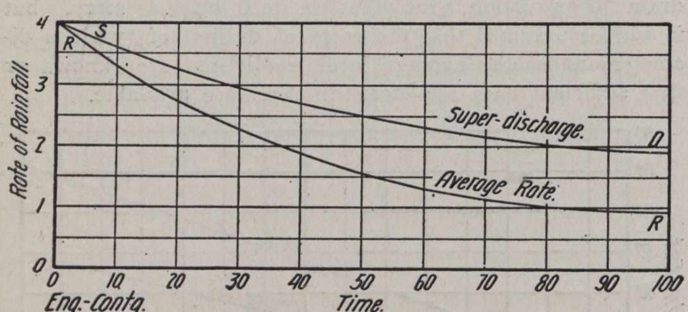

Fig. 2—Curve of Super-Discharge for Cost Calculation.

changes of size are abrupt. Therefore the cost of such a drain would be approximately the same as a theoretical funnel shaped one of the same average diameter.

For example: If the capacity of a drain 3,000 ft. long with an average grade of one in one thousand increases uniformly to 200 cu. ft. per second at the outlet the average cost per ft. will be the average of the ordinates on the cost curve up to 200 cu. ft. per second. This can be found from the lower curve on the diagram, for it is drawn to represent at every point the average value of the preceding ordinates on the cost curve. The cost shown at 200 cu. ft. per second on this curve is $16 and therefore the total cost will be 3,000 times $16, or $48,000. One point to be noted in this connection is that the curve of average costs as drawn, represents the average cost from the smallest capacity shown. Clearly if the capacity of the sewer at its beginning is larger than this, the curve cannot be used directly, but must be employed to determine the average of the ordinates on the original cost curve between the capacity of the drain at its beginning and ending. If the average grade of the drain had been other than one in one thousand, the discharge of 200 cu. ft. per second would have to be converted to an equivalent discharge on the grade of one in one thousand as has been before described.

This method is suitable then, when the capacity of the drain is uniformly increased. This is practically the case when the territory drained is approximately proportional to the length of the sewer and the runoff proportional to the area, which latter assumption has been shown to be the best for designing drainage systems of limited capacity, but, it will not give good results when the runoff from small areas is considered to be proportionately higher than the runoff from large areas because then the capacity of the drain at its upper end is much greater in proportion to its length than it is at the outlet.

The cost of such a drain can be estimated by taking for the determining discharge not the actual discharge, but a super-discharge obtained by multiplying the total area drained by a rate of runoff which is the average of all the average runoff rates that would be used to determine runoff by the Rational Method. For instance, if RR in Fig. 2 represents the rainfall curve of average rates such as the Rational Method employs, a curve SD can be drawn so that it will represent at every point the average value of the preceding average rainfall rates. The curve SD can then be used to determine the super-discharge for cost calculation in the same manner that the rainfall curve of average rates is used to determine the actual discharge.

The accuracy of the costs arrived at depends upon how closely the area approximates the tacitly assumed conditions that the area drained is proportional to the length of the sewer at all points and that the time of concentration is proportional to the area. Although these conditions are never exactly fulfilled the approximation is near enough for all practical purposes, and it is surprising how closely the results will agree with the cost as determined by fixing the sizes of the drain and summing up the cost of the separate sizes. If the area is so shaped that the sewer palpably does not drain equal proportions with equal lengths it may be split up into sections where this condition will be more nearly true and closer final results achieved by considering each section separately.

It is now evident that the cost of any system of drains may be obtained without actual design. The first step is to lay out the lines the sewers are to follow. The small laterals will of course be pipe sewers and as their size is usually governed not so much by the amount of water to be carried as other considerations, their capacity will remain uniform throughout and their cost may be easily arrived at. The drainage area of each trunk sewer should now be determined together with the length of the sewer and the available amount of hydraulic grade. The time length of each drainage area may then be approximated and the super-discharge of actual discharge obtained for fixing the cost as has been described. The cost of each trunk sewer may then be determined and the entire cost of the system arrived at by addition.

In order to find the cost of a system of greater or smaller capacity it is not necessary to go through the whole process again, but it may easily be obtained in the following manner. If the total cost of the trunks is divided by their total length the result will be their average cost per foot, then by referring to the average cost curve the corresponding capacity can be obtained and used as an index to establish the cost of a larger or small system. If, for instance, the average cost of the trunk sewers is found to be $20 per ft. the corresponding capacity is 300 cu. ft. per sec. by the average cost curve in Fig. 1 and by doubling this capacity and finding the corresponding cost we will have $29, the average cost per foot of a system of twice the original capacity.

The method is likewise of great assistance in fixing the most economical run of the sewers as the cost of following many different routes with the trunks may be compared with but a slight expenditure of time; though naturally a number of important elements, such as depth of cut, character of soils, etc., would have to be allowed for separately.