sinuous character of a river, with its deeps and shallows, could not be imitated under the necessarily limited conditions of the Berkeley Laboratory. There is no necessity to emphasize the points of difference, of which the experimenter was perfectly aware.

In the course of the experiments the apparatus was occasionally varied to meet particular requirements, or to increase the accuracy of measurement, but the greater part of the observations was made with a wooden trough 31½ ft. long, 2 ft. wide, but capable of variation, with vertical sides, 1 ft. 8 in. high at the head, diminishing in steps to 1 ft. at the end. Sheets of glass were let into the sides of the trough to facilitate observation, and a device consisting of a small aperture in a moving shutter that could be made to travel at the same rate as a selected particle was a useful adjunct, that enabled much information to be collected concerning the trajectory of a saltatory grain and the manner in which eddies and currents of water acted. The end of the trough was open, permitting the passage of a stream of water whose discharge could be controlled and measured. For experiments in "stream traction" the trough was mounted horizontally; sand grains of approximately uniform size were fed to the running water, and at first accumulated at the upper end of the trough, but were gradually shaped by the current into a characteristic deposit having a gentle forward slope. This deposit spread itself throughout the length of the trough, and finally was discharged at the outfall end. The object of the observation was to determine when accumulation ceased, or when the escape of the outfall equalled the amount fed at the upper end. The stable slope of the sand, automatically assumed under the conditions prevailing at the moment, was then evidently just sufficient to enable the particular discharges to transport sand of known quantity and kind. Keeping other conditions the same, it was possible to vary any one factor, as the size of the sand grain, or the rate at which the sand was fed, and from measurement of the resulting slope and depth, in connection with other known quantities, to determine the effect of the variation on the "capacity" of the stream, thus supplying data for studying the quantitative relations between load, slope, discharge, etc., from which the law of variation might be derived by discussion of the equations of conditions or their equivalents.

Confining attention to "stream traction," the experiments were so arranged that the observed quantity was a function of six variables; the degree of fineness of the débris, whose separate particles varied from approximately one hundredth of an inch to pebbles of half an inch or more in diameter; width of trough, which could be contracted from 2 ft. to 8 in.; the rate of discharge, determined by flow through an aperture of adjustable size under an adjustable head; slope of bed; depth of current; and, finally, capacity of stream. Under ordinary circumstances, equations of condition and a most probable solution would be obtained, but in this case there is no theory available. The form of the function that expresses variation is not known, and there is no certain way of deciding inadmissible errors of observation. An empirical curve had to be derived, and it was possible to obtain the numerical coefficients and exponents of several, founded on interpolation formulæ or on parabolic forms, that represented fairly well the short trace given by observations. To test the relative merit of these, they were extended by extrapolation, and those were rejected that indicated forms that failed to satisfy known criteria that must be fulfilled at critical points. Some gave a negative capacity, which might be interpreted to mean a capacity for traction up-stream, clearly erroneous. The process of elimination was carried as far as possible, but a wide choice was left, and, doubtless, the number could have been increased. The form selected has the advantage of simplicity. In the typical instance of the slope factor, the "capacity" is made to vary according to a power of the difference between the slope of the bed and the "competent" slope, or C is made to vary as $S - \sigma)^n$. S, the slope in per cent. of the stream-bed, is a simple matter; the "competency" as used here, is more technical. The "competent" slope is that which is just sufficient to initiate traction. Under particular conditions of the controlling factors, capacity may be zero; but if one factor be changed just sufficient to give a positive capacity, that factor in its new condition is said to be "competent." For example, a stream may have so gentle a slope that it possesses no capacity, but if coming to a steeper slope it is just able to move the débris, then the steeper slope is "competent," and is expressed by σ. We are inclined to regard the results here obtained, as far as they can be expressed by exponents, as having a very limited application. Great doubt will be entertained of the legitimacy of the plan of considering any one factor, especially when near its limit of "competency," apart from the other operating factors. But Mr. Gilbert was committed to a difficult inquiry, in which he had little help from the experience of former experimentalists, and the complexity of the problem could not have been appreciated at the outset. It is easy to suggest that it would have been well to have given a greater variation to the several conditions whose effects were being sought, in order to have a greater range of values with which to compare the empiric law, but doubtless the practical difficulties were very great. The observations were extremely involved; a great many appear to have been discarded, and owing to the form of the discussion, it is not easy to estimate the accuracy of the probable error attached to those that have been utilized.

Mr. Gilbert carried his inquiry to such a definite conclusion that it is possible to express the effect that variation of slope and discharge of a stream, the character or degree of fineness of the débris, and some other factors have upon the quantity of load carried in a straight stream, by means of an equation of simple form. In the case of slope we have seen that the observations can be represented by the equation $C = b_1\ (S - \sigma)^n$, where b_1 is the value of capacity when "competent" slope differs from that of bed slope by unity. In the same way, if Q be the discharge expressed in cubic feet per second, and κ is a constant relating to "competent" discharge, $C = b_2\ (Q - \kappa)^o$ and the influence of the fineness of débris, gives rise to similar expression $C = b_3$ $(F - \phi)^p$. Each of these equations expresses the law of variation of capacity when the other two conditions are unchanged, and in that sense they are independent, "but there is a mutual dependence of parameters which is of so complete a character that they are essentially simultaneous." For example, b_1, σ, and n are constant so long as Q and F are unvaried: they do not vary with variation of S. But when Q and F are altered, the values of b_1, σ, and n are modified. The extent, therefore, to which the exponents can vary is a matter of prime importance, and their values and range are shown in the following table:—