

Hydraulic Laboratories of the West, Their Technique and Equipments.

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IN the West hydraulic experiments have come to be recognised as the first essentials before a hydraulic construction of any magnitude is undertaken. Though the laws concerning hydraulic similitude are still in the making it is admitted on all hands that hydraulic model experiments conducted on proper lines can show up all the intricacies of movement inside the water medium which our present knowledge of mathematics and hydrodynamics cannot follow. It is therefore one of those cases that crop up very often in modern sciences where experiments come to the help of mathematics to establish a theory. This intimate interplay of theory and practice makes Hydraulics one of the most difficult of sciences. A number of careful experiments were conducted in the 19th century on various hydraulic problems. "Of these experimentalists perhaps Mariotte, Bernoulli and D'Alembert with Poiseuille, Darcy and Bazin in France, Rankine, Froude, Reynolds and James Thomson in England, Eytelwein, Weisbach and Hagen in Germany, Venturi in Italy with Francis and Hamilton Smith in America are most worthy of note.

"In spite, however, of all the work which has been so ably accomplished by these and other observers, Hydraulics cannot yet be classed as an exact science. The laws governing many of its phenomena are still imperfectly understood."¹ It had continued like this for some time till it was recognised that these laws had very serious limitations. Hydraulic structures based on Bligh's theory were found to be very unsafe², canals designed on Kennedy's theory very seldom ran smoothly.³ Hydraulics was at this stage when it was felt that something more than empirical laws was necessary if we wanted to control nature—a deeper insight into the workings of nature. A scientific and not only practical handling of the problems was felt imperative. It was felt that these problems must be tackled more

scientifically always with an eye to their practical applications. This new recognition has given rise to three distinct classes of Hydraulic Laboratories. The first are the purely scientific laboratories generally called Hydrodynamic Laboratories. These extend their fields of activities not only to Hydraulics but to Aeronautics and Meteorology as well. The second class are purely practical and are strictly confined to the practical solution of definite problems. The third class are a combination of the above two and have the most difficult and most useful career before them. I shall take a typical case from each of these classes and show their workings.

Of the first class the best that I have visited is that of Prof. L. Prandtl of the University of Göttingen. It is called Der Kaiser Wilhelm Institute für Stromungsforschung—the Research Institute for Fluid Movement. It has got four laboratories—one for hydrodynamical research, another for aerodynamics, third for turbine and the fourth for research by students. As I was concerned mostly with the first laboratory I shall describe briefly some of the experiments that were being carried on there at the time of my visit. The experiments that have made Prandtl's Laboratory famous throughout the scientific and engineering world are varied. I shall concentrate mainly on Turbulence that has direct bearings on Irrigation Problems. Prof. Prandtl's laws of turbulent flow⁴ in pipes have shown how even for high Reynolds' number the friction loss in pipes is dependent on this number. At present experiments are in progress that will show where this influence ceases. This fact that even in the turbulent region, unless the Reynolds' number is very high, friction loss due to turbulence depends on this number, is very important for model experiments and limits very seriously the dimensions of the model. It is well to point out here that the loss of energy due to turbulent friction is much more, sometimes even a thousand times more than that due to viscous friction. Prandtl's theoretical

¹ *Hydraulics and Its Application*, Prof. Gibson.

² E. McKenzie Taylor, *Curr. Sci.*, 1934, 2, 367.

³ G. Lacey, "Uniform flow in alluvial rivers and canals," *Proc. Inst. Civil Engineers*, Session 1933-34, 23.

⁴ "Neue Ergebnisse der Turbulenz-forschung," Prof. L. Prandtl. *Zeitschrift des Vereines Deutscher Ingenieure*, 1933.