may be considered as the *observed* loss due to the enlargement, providing H_f, the loss due to friction, be considered as known and equal to the loss for straight pipe with undisturbed flow.

H_f cannot otherwise be separated from H_e for the reason that the conditions of which H_e is a result are modifying the flow in such a way as to affect the frictional coefficient, H_f. It seems better then, to charge up to the left-hand member of the equation the term H_f, assigning to it the usual values for frictional loss in straight pipe at the various observed velocities, thus leaving the right-hand member of the equation, H_e, as the total result of the effects due to the enlargement, and of finally comparing this result with the theoretical loss expressed in Borda's formula.

to obey this law perhaps on account of conditions which might be considered as producing a water-cone of gradual instead of sudden enlargement.

The writer prefers the latter theory as a possible explanation rather than the former, for it is difficult to imagine any reduction in frictional resistance less than that for straight pipe in the region of these greatly disturbed conditions.

The position of Piezometer 5, 6 feet below the enlargement, was selected as the down-stream point for observation, and Piezometer A as the up-stream point (see Fig. 1) in order that all the losses due to the disturbance might be included. The velocity curves of distribution as shown by the Pitot tube observations indicate that

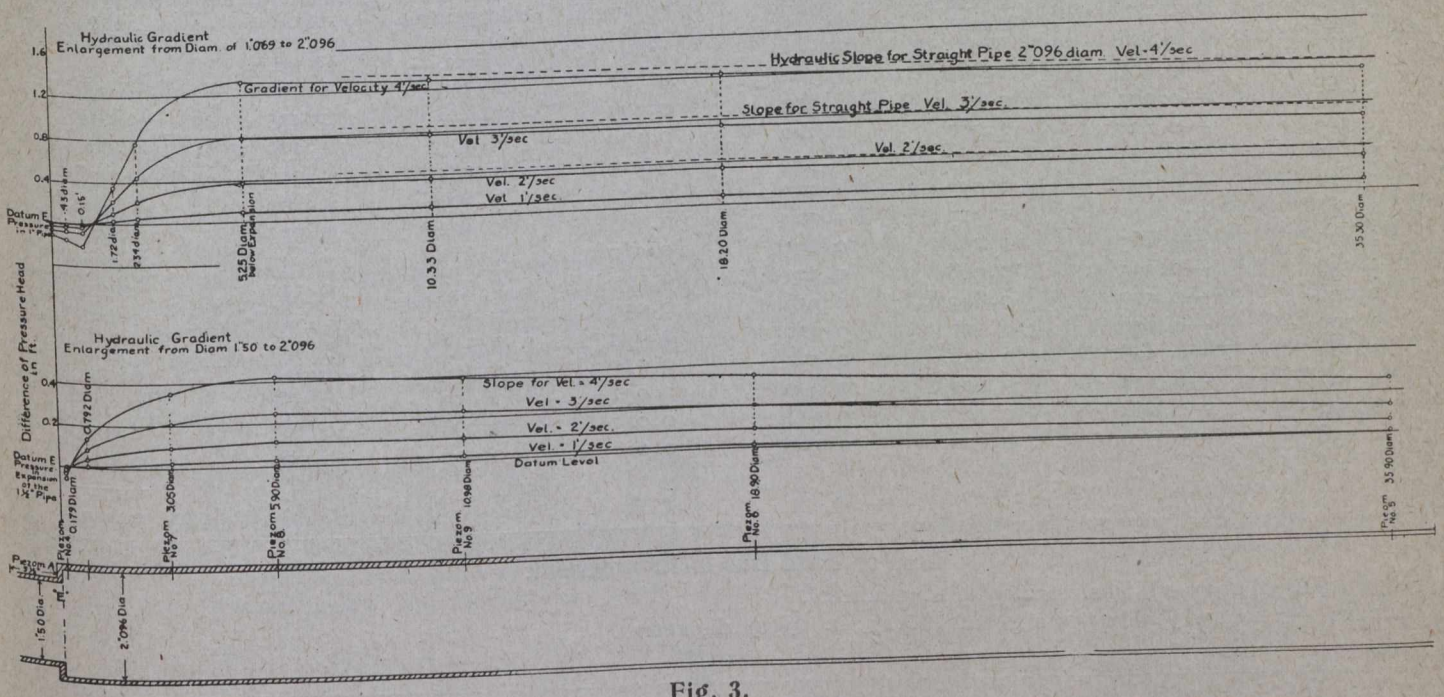

Fig. 3.

If the first member of the equation, $h_1 - h_2 + \frac{V_1^2 - V_2^2}{2g} - H_f = H_e$, be considered as the indicated loss of head between any two points, then the expression may be written $h_1 - h_2 + \frac{V_1^2 - V_2^2}{2g} - H_f = K \cdot \left(\frac{A_2}{A_1} - 1\right)\frac{^2V_2^2}{2g}$, where K is a coefficient to be applied to Borda's formula.

The accompanying tables have been prepared in which the last column of ratios gives the value of K. The tables show a slightly less loss of head thus indirectly observed than the computed theoretical loss due to enlargement as expressed by Borda's formula. This discrepancy may be due to one or two causes or perhaps a part due to each. Either the frictional loss expressed in the term H_f is less than occurs in the case of straight pipe with undisturbed flow, due perhaps to the high central velocity of the jet as it enters the larger pipe and continues in this condition for some distance before spreading out and obtaining its full pressure and frictional effect on the wall of the pipe, or else the loss in the impact of the particles in the expanding jet due to the enlargement of the pipe-section does not follow exactly the law for sudden enlargement as expressed in Borda's formula, $\left(\frac{A_2}{A_1} - 1\right)\frac{^2V^2}{2g}$ failing most of the disturbance has been eliminated in this distance.

A correction might be applied for the effects due to the piezometers themselves in the battery just below the enlargement. That there is a slight excess loss of head due to the battery was found by Messrs. Utz and Ellis in their experiments upon the Effects of Contraction in which they used the same battery of piezometers. However, this slight loss of head, if applied as a correction, does not relieve the conditions above, but rather augments the discrepancy. The excess loss due to the presence of the piezometers is very small, and was obtained by placing the battery of piezometers, No. 5 to No. 7, in a line of straight pipe of the same diameter as that of the battery, thus eliminating all other disturbances than those due to the piezometers themselves. The distance from piezometer No. 7 to No. 5 is 5·75 feet. The formula for the total loss of head in this section as determined by Messrs. Utz and Ellis was $h = 0.268\ V^{1.75}$ in feet per 100. The excess loss of head due to the battery length then is found to be .001, .005, .016, and .026 feet for the respective velocities of 1, 2, 3 and 4 feet per second. Applying these corrections to the column in the tables, H_e, the loss due to the enlargement is further decreased and the coefficient K in the last column consequently decreased. This affects the coefficient K due to the enlargement to such a small amount, however, that it is thought better to leave the