REMARKS ON THE THEORY OF THE PITOT TUBE

DESPITE the great number of valuable papers and results of tests published during the past few years on the subject of the Pitot tube, hydraulic engineers have not as yet come to any definite agreement as to whether $h = \frac{v^2}{2g}$ or $h = \frac{v^2}{g}$ is the correct formula underlying its action. The following extracts from a paper read by N. W. Akimoff at the recent convention of the American Waterworks Association in Philadelphia, may be of assistance in clearing up a number of points serving as a foundation for argument. Mr. Akimoff is inclined to believe that the contention inherent in the controversies as to whether $\frac{v^2}{g}$ or $\frac{v^2}{2g}$ is correct, is mostly based upon the fact that entirely different premises are at the bottom of such discussions.

The formula $h = \frac{v^2}{g}$ is the same as $v = 0.7\sqrt{2gh}$ and it is not very difficult to build rods that will yield this result or even slightly less, instead of $v = c\sqrt{2gh}$, where c varies from 0.84 down to 0.75, as is the case in some of the rods now on the market.

It is often "assumed" that c really ought to be unity and, therefore, that smaller values of c are caused by the "suction," due to the "trailing orifice," bent back (Fig. 5, c) in the direction of the flow. It so happens, however, that out of all means available for decreasing the

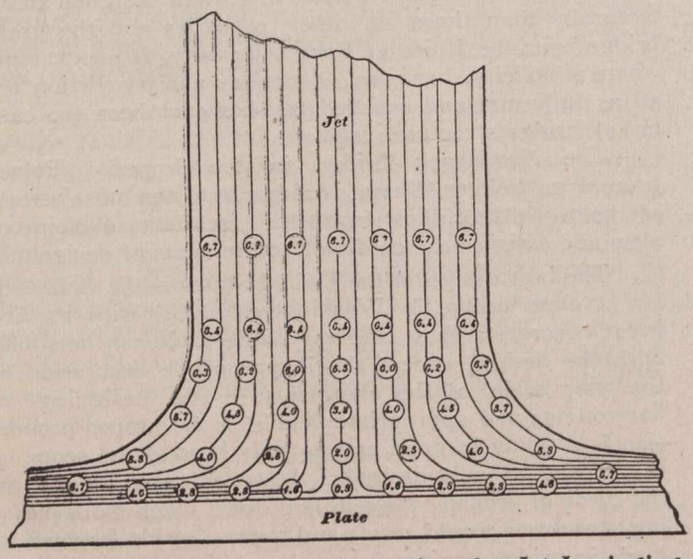

Fig. 1.—Stream Lines and Velocities of a Jet Impinging on a Plate.

value of c, the "trailing orifice" seems to be the least effective; experiments made both in this country and abroad show that the lowest c that can be secured with the trailing orifice is 0.84 and often as high as 0.92, whereas, as said before, other means enable us to bring c down to 0.75 and even to 0.70. Greater "reliability" is claimed by the advocates of the "trailing orifice," however, which point it is not our intention to consider in this paper; our object being to present a few considerations relative to the formula itself of the Pitot tube, and not at all either to endorse or to condemn any particular existing article now on the market.

We shall first take up the impulse tube itself; the "static" tube will be considered later. The writer will assume that everyone is familiar with the article on "The Pitot Tube; Its Formula," by Mr. W. M. White, published in the Journal of the Association of Engineering Societies, August, 1901. This article, which in our time will perhaps be found somewhat unconvincing, and, possibly a trifle obsolete, contains at least one valuable feature, which will be of advantage in our discussion. In

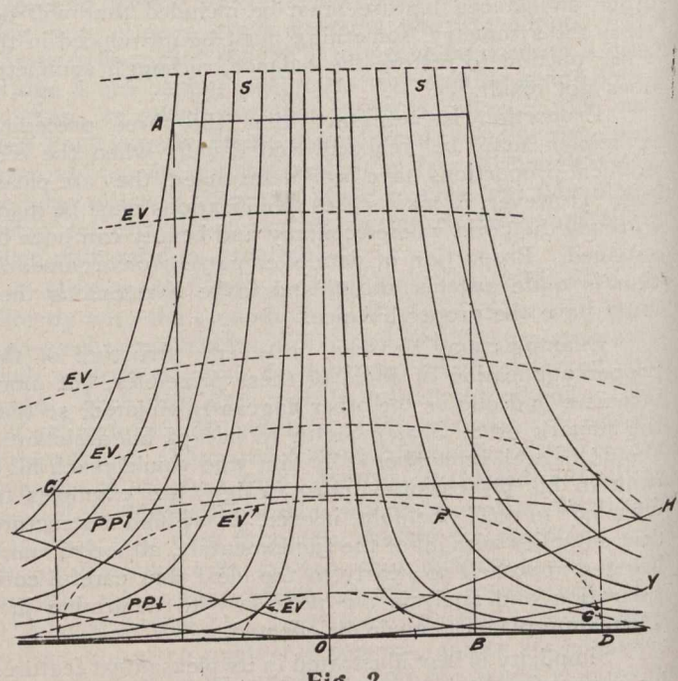

Fig. 2.

order to substantiate his opinion that in an impact tube, whose impinging surface is one of revolution, the coefficient c, of conversion of velocity head into static head is exactly unity, Mr. White has made many tests, the results of one of which are given in a chart (Fig. 1), taken from his paper.

A stream of water was directed against a round plate; individual velocities of separate filaments were measured and the results, in feet per second, are marked on the chart.

At the present time it would not be necessary to take all this trouble, the effects of the stream, directed both against a long, narrow strip (dam) and against a round plate, have been carefully analyzed with the following most interesting results (Fig. 2, for round plate only).

1. The stream lines S are curves of third degree, possessing this most curious property: that all cylinders, inscribed in the surface generated by each stream line are equal, so that, for instance, the volume of A-B is the same as that of C-D. The stream lines began to diverge at a considerable distance from the plate. Of course, the size of the plate proper does not in the least affect the general shape of the curves.

2. The curves of equal velocity EV are ellipses, located as shown and having O as centre. Since, in general, these lines intersect the stream lines at two points, such as F and G, it is clear, that somewhere between F and G there must be a point of minimum velocity, where the corresponding ellipse is tangent to the stream line. The locus of such points of minimum velocity will be a straight line, OH, the angle of which with the base will be about 20°.