THE 'BALL AND NOZZLE' PHENOMENON.

THE interest which has been recently shown in the phenomena of the 'ball and nozzle' must be the excuse for the present publication of some experiments which were made and described about eighteen years ago, while a sophomore at college. At that time I was of course ignorant of Bernoulli's well known theoretical conclusion that in such cases the pressure is always least where the velocity is greatest. The experiments with the water surface could be so modified as to be shown in a projection lantern. I have preferred to print the text and figures without alteration.

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IT is an apparently inexplicable fact that if we take two cards as A B and C D, Fig. 1, and through the middle of the lower C D, bring a tube G, as shown in Fig. 1, A B being held about one-fourth of an inch from C D by four tacks, or some such means, that if a current of air is set in motion through G, no matter how slight, or how strong, A B, instead of being immediately blown up and carried away upon the current, retains its position and is even drawn down closer to C D and held there by a force directly in proportion to the velocity of the current in G. Even a quick, strong puff can not remove it, and, in fact, we can in no way remove A B from over C D by blowing through the tube G.

The explanation of this fact seems to consist of two parts: First, why A B is not blown off as soon as a current starts in G and before any eddies, or whirlpools could be formed between A B and C D. Second, what currents are formed between A B and C D, and what action of theirs holds A B over C D. The first of these two actions is that of the first instant, the second is that of the subsequent time until the current in G ceases. During the first instant we have the current from G pressing upon a small circle of A B directly over the mouth of G. This surface is represented as included between E and F, Fig. 1. Hence all the force tending to raise the card is applied to the surface E F and by the very compressible and yielding column of air from G. The resisting forces which tend to hold the card down are its weight and inertia applied over its whole surface, and add to these two the fact that, in order to raise A B suddenly by pressure over E F, we must either lift all the air above A B along with it, thus rarefying the air between A B and C D, or we must compel the air just above A B to rush around it; even if the air G should fill the space left under A B as it is lifted up, still we should have to overcome the weight and inertia of a large quantity of air. Thus upon comparing the conflicting forces at work upon the card A B we find only the slight force of the current upon E F tending to raise A B resisted by the weight and inertia of A B and also the weight or inertia, or both, of a large quantity of air; and it would seem quite reasonable that the latter should prevail. The brevity of the time and the delicacy of the forces make experimenting very difficult.

In experimenting to confirm the theory of this first action, the lifting force applied at E F remained constant, and the resisting forces were lessened by reducing the size of the card, since by so doing its weight and inertia were lessened, and also the amount of air set in motion. Making A B smaller and smaller, a size is finally reached when A B would be lifted off by the first puff, but if held a second or two until the currents are all started it stays on of itself, *i. e.*, the lifting force at E F is now able to overcome the above mentioned resisting forces; this inferior limit to the size of A B is shown in Fig. 2. If we pass below this limit, as Fig. 3, A B will be

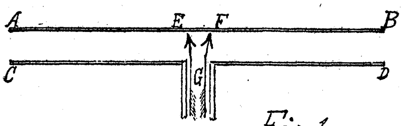

Fig. 1.

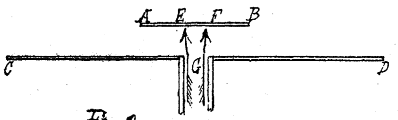

Fig. 2.

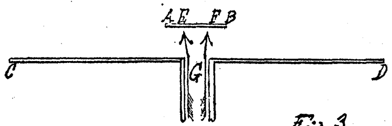

Fig. 3.

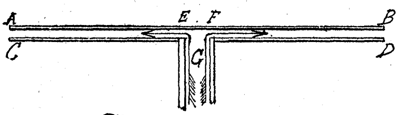

Fig. 4.

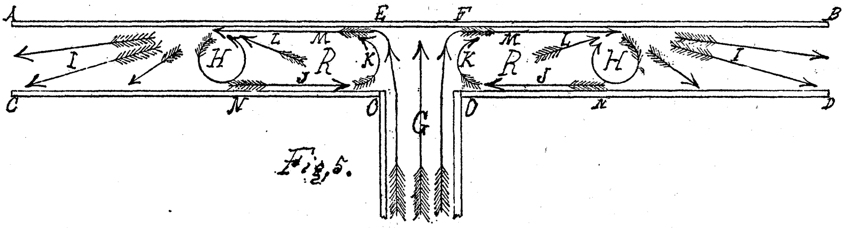

Fig. 5.

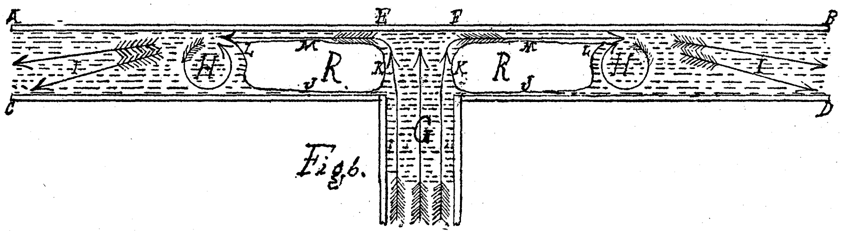

Fig. 6.

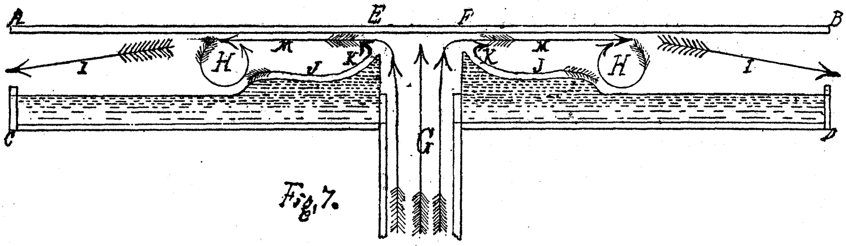

Fig. 7.

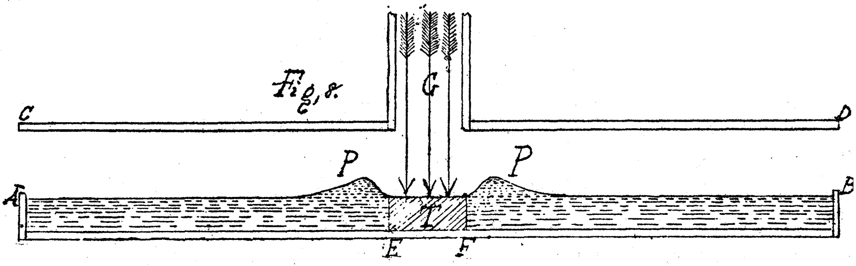

Fig. 8.

blown off every time. The size of A B, Figs. 2 and 3, varies as the square of the radius of G, and as the distance of A B from C D.

This seems a sufficient confirmation of the theory of the action of the first instant of time.

The subsequent action can be explained as follows: Fig. 5. The current from G, rising strikes A B on E F and spreads out in a direction M, passing on along M at some point H, the current M forms a whirlpool H and spreads, taking most or all of the air beyond H slowly along with it, out from between A B and C D. The currents G and M gradually attract and draw with themselves a part of the dead air in R and form a current K. The tendency of a current is to draw into, and along with itself, the adjoining dead fluid through which it flows. M and H thus drawing the air from R start a current L, which gradually draws out air from R, thus causing a slight vacuum directly over O N, and the pressure of the atmosphere on O N tends to press the two cards together to fill the space R. C D cannot rise, being fast to the tube, so A B is bent down until the space between F and O is just sufficient for the air from G to pass out through, *i. e.*, when A B and C D are separated by a distance equal to one-half the radius of G. This is shown in Fig. 4. The instant this limit is reached the action of Fig. 5 is replaced by that of Fig. 4, and the card by its own elasticity and the pressure over G rises and the action of Fig. 5 is restored. Thus in almost all cases the card vibrates rapidly. The experiments to confirm this theory were made almost entirely with water, since the results and actions would be the same and it was more convenient. The apparatus used consisted of a piece of thin board with four upright wires near the corners, upon which slid a second board; this was so arranged in order that the distance from A B to C D could be varied at pleasure. Instead of introducing the tube G through the middle of the board C D, it was placed in the middle of one of its sides, and over this edge was placed a plate of glass. This arrangement was to obtain a view of the currents in a section through the center of G and perpendicular to A B and C D. Placing this apparatus in a tub of water, with the plate of glass parallel and near to the surface, and pouring muddy or colored water through G, the currents take the directions represented by the arrows in Fig. 5. To further test the action of the currents M and H in drawing the water from R, a bubble of air was introduced in front of G before the current started, and on starting the current in G the bubble separated and each half assumed the shape shown in Fig. 6, R R, and the air was rapidly drawn out in little bubbles at L, and driven out in a direction I. To confirm the theory that the force which holds the cards together is applied at O N of the bottom card, and in order to find where the currents increased and where they diminished the pressure of the atmosphere, a surface of water was substituted for the lower card, and, again obtaining a sectional view with the plate of glass, it was found that the surface of the water assumed a shape whose section is shown in Fig. 7; thus proving very conclusively that the pressure of the atmosphere upon the surface of the water was diminished to some little extent by the currents M and H, and that here we have the whole cause of the apparently strange action of the card. On substituting a surface of water for the upper card A B, a section shown in Fig. 8 was obtained; thus showing that the only effect of the currents upon A B is the pressure at E F. These four experiments, Fig. 5, with colored water and Figs. 6, 7 and 8, seem to sufficiently establish the above theory of the cause of the card being drawn down after the first instant. The theories of the action at the beginning and during the continuance of the current from G being established, and as the whole action is comprehended in these two periods of time, this apparently inexplicable fact would seem to be explained.

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*THE PRESENT PROBLEMS OF ORGANIC EVOLUTION.**

AT the outset of a conference on the subject of evolution, it is necessary that we understand what we mean by the term. Evolution is creation by energy which is intrinsic in matter, and is not creation by energy exclusively without the evolving matter. Those who explain creation by interference from an external creative power are not therefore evolutionists. This view of creation is opposed to the natural tendency to account for phenomena not otherwise explainable, by an appeal to a supernatural cause. If we desire to know the truth, however, in this or any other matter, it is necessary to divest ourselves of prepossessions and preferences, and rely exclusively on the evidence. But the result of this method in the case of organic evolution is to demonstrate, in my opinion, that the elements of mind have had an important place in the process and have materially influenced the results.

The evidence for organic evolution, it is well known, is derived from three sources: First, the spontaneous variations from uniformity of structure, frequently observed in plants and animals; second, the regular succession of forms displayed in the history of life, taught by the science of paleontology; third, the recapitulation of the same succession, more or less completely, in the embryonic histories of organic beings. As time passes on, the evidence of the origin of species and the groups into which they fall by modification during descent from preëxistent forms becomes more and more perfect.

The problems presented by the preceding facts for solution may be embraced under two heads: (1) how are the variations or changes in individuals produced? and (2) when produced, are they inherited and so accumulated, or not?

The question as to the cause of variation is difficult of solution. The attempt to solve it must be preceded by a knowledge of what the lines of variation which constitute evolution have been. These are presented by the study of the life of past geologic ages. From this source we learn that there has been a successive improvement in the mechanisms of organic beings. Since the mechanisms are constructed of always plastic, and for a time growing, material, it looks probable that they have been produced by the movements of the organism itself. This suspicion is made a certainty when we learn that new mechanisms are readily constructed by organic beings, to take the place of their normal ones which have been injured or lost. The annals of surgery and of orthopedic hospitals are full of such cases, and the lower animals are still more capable of producing new structures to take the place of old ones than is man. I do not mean by this the reproduction of lost parts, as in the case of the crab and its pincer; but I mean the construction of a new joint or segment in a new place, which is obviously moulded by the mechanical action of the parts.

The movements of animals have led their progressive evolution, and a great many structures have been modified in consequence in ways which are indirect, and whose characters do not always betray their real efficient cause without full investigation. *Per contra*, the absence of motion has resulted in degeneracy and retrogressive evolution. This is amply demonstrated by the results of parasitism. Parasites are always degenerate. This is the

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