Received February 9, 1769.

IX. *Experiments on the lateral Force of Electrical Exploſions.* *By* Joſeph Prieſtley, *L L. D. F. R. S.*

Read February 23, 1769.

BEING informed, in accounts of damages done by lightning, of perſons and things being removed to conſiderable diſtances, without receiving any hurt, I was excited to try whether I could produce ſimilar effects by electricity. All the other known effects of lightning had been frequently imitated by the application of this power; but I do not know that this effect has ever been ſo much as taken notice of by any electrician. The experiments I preſently found to be very eaſy; and I think it not difficult to aſcertain the cauſe of this ſtriking effect, and the manner in which it is produced.

If pieces of cork, wood, powder of any kind, or any light bodies whatever, be placed near the exploſion of a jar, or battery, they will not fail to be moved out of their places, at the inſtant of the diſcharge. If the exploſion of a large battery be made to paſs over the ſurface of animal or vegetable ſubſtances, in the manner deſcribed in the printed account of my experiments, and large corks be ſtrewed along, or near the path intended for it, it is ſurprizing

to obſerve with what violence they will be driven about the room; and this diſperſion is in all directions from the center of the exploſion; and it makes no difference whether the rods, between which it is made, be ſharp-pointed or otherwiſe.

The effect of this lateral force is very remarkable in attempts to fire gunpowder in electrical exploſions. If the gunpowder be confined ever ſo cloſe in quills or cartridges, and they be held faſt in viſes, yet, when the exploſion is made in the center of them, it will ſometimes happen, even when a wire has been melted in the midſt of the powder, and the fragments have been ſeen red-hot for ſome time in different parts of the room, that the powder has not been fired, or only a few grains of it, the reſt being diſperſed with great violence, part of it flying againſt the faces of perſons who aſſiſted in making the experiments. This circumſtance, together with the charcoal being a conducter of electricity, makes it ſo extremely difficult to fire gunpowder by electrical exploſions; and it is evidently owing to this lateral force, that parts of the melted wire fly ſo many ways, and to ſo great a diſtance from the place of exploſion.

This lateral force is exerted not only in the neighbourhood of an exploſion, when it is made between pieces of metal in the open air, but alſo when it is tranſmitted through wires that are not thick enough to conduct it perfectly; and the ſmaller the wire, and the more complete the ſuſion, the greater is the diſperſion of light bodies placed near it. At one time, when the wire was not melted, but turned blue by the exploſion (in which caſe it generally aſſumes a duſky red, which laſts but for a moment), there

there was a ſmall diſperſion from every part of the wire, but by no means ſo great as it would have been if it had been melted, or only heated to a greater degree.

By a conſiderable number of trials I found, that a greater force of exploſion would move light bodies at a greater diſtance; but the ſmaller the bodies were, the leſs was this difference; ſo that I ſuppoſed, that if they had no weight at all, they would, probably, be moved at the ſame diſtance by the exploſion from any quantity of coated ſurface, charged equally high; but there was a great difference in the weights removed by different forces at the ſame diſtance. Placing the ſame piece of cork at the ſame diſtance from the place of exploſion, I found that the diſcharge of one jar removed it $\frac{1}{4}$th of an inch, two jars $1\frac{1}{4}$th, three $1\frac{3}{4}$ths, and four about two inches; ſo that I do not wonder at very heavy bodies being moved from their places, and to conſiderable diſtances, by ſtrong flaſhes of lightning.

That the immediate cauſe of this diſperſion of bodies in the neighbourhood of electrical exploſions is not their being ſuddenly charged with a quantity of electric matter, and therefore flying from others that are equally charged with it, is, I think, evident from the following experiments and obſervations. I never obſerved the leaſt ſenſible attraction of theſe light bodies to the braſs rods, through which the exploſion paſſed, or to the electric matter paſſing between them, previous to this repulſion, though I uſed ſeveral methods which could not have failed to ſhew it, if there had been any ſuch thing. Sometimes I ſuſpended them in fine ſilken ſtrings, and obſerved

that they had contracted no electricity after they had been agitated in the manner deſcribed above. Sometimes I dipped them in turpentine, and obſerved that no part of it was found ſticking either to the braſs rods themſelves, or to any part of the table betwixt them and the place where the light bodies had been laid. I even found that the exploſion of a battery made ever ſo near to a braſs rod did not ſo much as diſturb the equilibrium of the electric fluid in the body itſelf: for when I had inſulated the rod, and hung a pair of pith balls on the end oppoſite to that near which the exploſion paſſed, I found that the balls were not in the leaſt moved at the time of exploſion, which they would have been, if part of the electric fluid, natural to the body, had been driven, though but for a moment, towards the oppoſite end. I alſo obſerved, that the effect was the ſame, when the exploſion was made to paſs through one of the knobs of the inſulated rod. This lateral force was evident through thin ſubſtances of various kinds interpoſed between the exploſion and the bodies removed by it, as paper, tin-foil, and even glaſs; for when ſome grains of gunpowder were put into a thin phial, cloſe ſtopped, and held near the exploſion of a battery, they were thrown into manifeſt agitation.

I therefore think it moſt probable, that this lateral force is produced by the expulſion of the air from the place where the exploſion is made. For the electric matter makes a *vacuum* of air in its paſſage; and this air, being diſplaced ſuddenly, gives a concuſſion to all the bodies that happen to be near it. Hence the removal of the light bodies, and the agitation commu-

communicated to the thin ſubſtances, and to the air, and the light bodies placed beyond them.

The only objection to this hypotheſis is, that this lateral force is not ſo much leſs *in vacuo* as might be expected, when the air is ſuppoſed to receive the concuſſion firſt, and to communicate it to other bodies; but it muſt be conſidered, that the moſt perfect *vacuum* we can make with a pump is not free from air. I have tried to make this experiment in a Torricellian *vacuum*, but could not ſucceed at that time. Beſides, as the electric matter, of which an exploſion conſiſts, muſt take a wider path *in vacuo*, if not equally fill the whole ſpace, it may affect a body in its paſſage, without the intervention of any air. In condenſed air, this lateral force was not, as far as I could perceive, much increaſed.

Willing to feel what kind of an impulſe it was that acted upon bodies, when they were driven away by this lateral force of electricity; I held my finger near the path of an exploſion of the battery, paſſing over the ſurface of a green leaf, when I felt a ſtroke, as of ſomething puſhing againſt my finger. Several corks, placed in the ſame ſituation, were driven to a conſiderable diſtance by the ſame exploſion.

Recollecting that this power, which I now call the lateral force of electrical exploſions, muſt be the ſame with that which gives the concuſſion to water, mentioned in my experiments to imitate an earthquake, and to vegetable and animal ſubſtances, over the ſurface of which it paſſes; and being determined to make a more ſatisfactory trial of it than I had ventured to do before, I laid a green leaf upon the palm of my hand, intending to make the exploſion paſs over the leaf;

leaf; but the leaf was burſt, and torn to pieces, and the exploſion, paſſing over my hand, gave it a violent jar, the effect of which remained, in a kind of tingling, for ſome time.

Laſtly, in order to judge the moſt perfectly of this force, I laid a chain communicating with the outſide of the battery upon my bare arm, above the wriſt, and bringing the diſcharging rod near the fleſh, within about two inches and a half of the chain, I made the exploſion paſs over that quantity of the ſurface of the ſkin. Had I taken a greater diſtance, I was aware that the exploſion would have entered the fleſh; which, I was ſenſible, would have given a painful convulſion to the muſcles through which it paſſed. In this caſe the ſenſible effect was very different from that, being the ſame external concuſſion as before; and I have ſometimes thought, that the ſenſation is not diſagreeable. However, the hairs upon the ſkin were ſinged, and curled up along the whole path of the exploſion, and for the ſpace of about half an inch on each ſide of it: alſo the *papillæ pyramidales* of the ſkin were raiſed, as when a perſon is ſhivering with cold. This was alſo the caſe in every part of the arm which the chain touched, and even that part of it which was not in the circuit. Both the path of the exploſion, and the place on which the chain had lain, had a redneſs which remained till the next day. Sometimes the fleſh has contracted a blackneſs by this experiment, which has remained for a few hours.

X. *Various*