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

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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 surprising

VOL. LIX.

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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 vices, 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 conductor 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 fusion, 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),
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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
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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.