X. *Various Experiments on the Force of Electrical Explosions.* *By* Joseph Priestley, *LL. D. F. R. S.*

Read March 2, 1769. MAKING the explosion of a battery pass over the surface of a green cabbage-leaf, I observed that it left a track near $\frac{1}{4}$th of an inch in breadth, exceedingly well defined, and distinguishable by a difference of colour from the rest of the leaf. Along this path, also, the firmness of texture in the leaf was entirely destroyed, that part becoming quite flexible, like a piece of cloth. Presently after, it turned yellow, grew withered, and became perfectly brittle.

Willing to try the effect of this explosion passing along the surface of other substances, I laid a piece of common window-glass on the path, pressed by a weight of six ounces; but it was shattered to pieces, and totally dispersed, together with the leaf on which it lay. Placing the black side of a piece of cork-wood upon it, pressed by a weight of half a pound, the leaf was not rent, but the cork was furrowed all the way, a trench being made in it about half an inch in breadth, and a quarter of an inch in depth. Laying the smooth cut surface of the piece of cork, it was furrowed all the way, as if it had been cut with a file, but not near so deep as before. Many of the small pieces, which had been rubbed off in the explosion,

ploſion, remained in the furrow. Alſo the ſubſtance of the cork ſeemed to be ſhattered, and it was eaſily rubbed off, a little way into it.

I made this exploſion on the ſurface of ſome red wine, in a ſmall diſh, and kept a part of the ſame quantity expoſed in a ſimilar manner; but I could perceive no difference between them after ſeveral days.

The track of an electrical exploſion on the ſurface of the cabbage-leaf, being ſo well defined, ſuggeſted an experiment to aſcertain whether there was any ſenſible momentum in the electric fluid, when it is ruſhing with violence from one ſide of a battery to the other. For this purpoſe I made the exploſion paſs over the leaves when they were cut in right and acute angles; ſo that the ſhorteſt path, from the inſide to the outſide of the battery, was to turn cloſe at the angle; and obſerved that it was not diverted from its courſe, in the leaſt degree, by the rapidity of its own motion, but that it had turned exactly at the angle, and kept as cloſe to the oppoſite ſide, as if the motion had begun at the angle. The electric matter had, however, been evidently attracted by the veins of the cabbage-leaf, having purſued them a little way, at leaſt having ſenſibly affected them, wherever it met with them in its paſſage.

This experiment ſuggeſted another, intended to determine whether the force of an exploſion was at all diminiſhed by being diverted from a right-lined courſe, and made to turn in a great number of angles. To do this, I firſt found, by a great number of trials, what length of a ſmall iron wire I was able to melt with a battery of about twenty ſquare feet, in the middle

middle of a circuit of about three yards of braſs wire, conſiderably thicker than the iron, and ſtretched in two right lines, ſuſpended on ſilken ſtrings. The length of the iron wire, melted in theſe circumſtances, was about three inches. I then took the ſame braſs wire, and fixing pins into a board of baked wood, twiſted it about them, making it turn in a very great number of acute angles, and I put three inches of the ſame iron wire in the middle of this crooked circuit, that I had done in the ſtraight one; ſo that the electric matter in the exploſion was obliged to make a great number of turns at acute angles, before it could come to the iron wire; but I always found that the ſame length of iron wire was melted in theſe circumſtances as in the other, and not the leaſt difference was perceived in the force.

But though the form of the wire through which an exploſion paſſed, made no difference in its force, I found a very remarkable difference occaſioned by the length of the circuit in wires of the ſame thickneſs; and which, I own, ſurprized me very much.

In order to aſcertain the practicability of firing mines by electrical exploſions, I took twenty two yards of ſmall braſs wire (but ſo thick, however, that I could not have melted the leaſt part of it by the force of any battery I have ever conſtructed), and extending it along a dry boarded floor, with a ſmall piece of iron wire, and a cartridge of gunpowder about it, in the place that was moſt remote from the battery, I found that, upon the diſcharge, the wire was not melted, nor the gunpowder exploded; alſo the report was very faint. In other circumſtances, a charge of the ſame battery was able to melt more than

nine inches of this iron wire; and this ſame cartridge was eaſily fired near the battery, connected with ſhorter pieces of the ſame braſs wire; ſo that the diminution of force muſt have been owing to the length of the circuit.

In the place of this ſmall braſs wire, I ſubſtituted an iron wire one fifth of an inch thick, when about half an inch of the ſmall iron wire was exploded; ſo that the force was not leſſened ſo much in a circuit of the thick iron wire, as it had been in one of the ſmall braſs wires. In order to judge how much of the force might be loſt by nearer circuits, conſiſting of leſs perfect conductors, I joined the middle of the circuit made by the iron wire with water, in which both the wires were immerſed. The effect was, that the ſmall iron wire was only made red-hot, but not exploded as before.

Being ſenſible how much depended upon avoiding leſſer circuits, whereby part of the fire of an exploſion might return to the battery, without reaching the extremity of the circuit, where I intended the whole of its force to be exerted, in the remaining experiments, I inſulated half the circuit of iron wire. There was no occaſion for inſulating the whole circuit; for if there was but one paſſage to, or from the middle of it, there could be but one from, or to it. In this method it was eaſy to aſcertain what loſs of force was occaſioned by the length of the circuit, as every other circumſtance was carefully excluded; and it preſently appeared to be very conſiderable; for tho' I could melt nine inches of the ſmall iron wire at the diſtance of fifteen yards from the battery; when I tried twenty yards, I found that I was juſt able to make

fix

ſix inches of it red-hot. The battery in theſe experiments was in the houſe, and the wires of which the circuit conſiſted were conveyed by ſilken ſtrings into a garden adjoining to the houſe.

Mentioning this loſs of force occaſioned by the length of the circuit in electrical exploſions to Dr. Franklin, he told me that the ſame obſervations had occurred to him, and that he had alſo been diſappointed in an attempt to fire gunpowder at a diſtance from his battery.

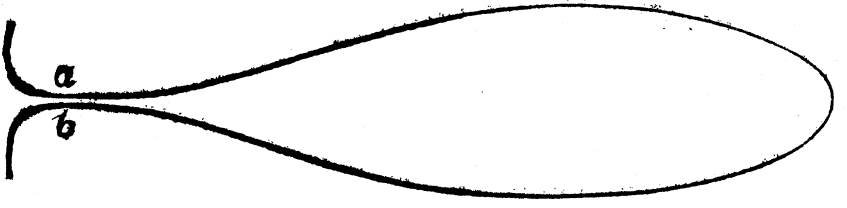
Struck with this appearance, I endeavoured to aſcertain the quantity of this obſtruction, by trying what other courſes the electric fire would chuſe preferably to a long metallic circuit. In the firſt place, taking about a yard of the ſmall braſs wire, mentioned above, I diſpoſed it in the manner deſcribed below, connecting one of the ends with the outſide of the battery, and the other with the inſide. In the firſt place, I brought the parts *a* and *b* (near the two extremities) into contact, and, upon the diſcharge, found there had been a fuſion in that place, and that a great part of the fire had taken the ſhorter circuit, though it had been obliged to quit the wire in one place, and enter it again in another. Afterwards I removed the parts *a* and *b* to a ſmall diſtance from one another, and, upon the exploſion, obſerved a ſtrong ſpark paſs between them. Removing them to greater and greater diſtances, I found the exploſion to paſs above one third of an inch in the air, rather than make the circuit of the continued wire. Uſing a longer and ſmaller iron wire, the paſſage through the air exceeded half an inch. I then took four or five yards of iron wire one tenth of an inch thick, when

the paſſage through the air was ſtill half an inch; and taking three yards and a half of wire that was one fifth of an inch thick, the ſpark in the air was half an inch, and ſometimes near three quarters of an inch. Making uſe of only half the length of this wire, the paſſage through the air was only half that diſtance, or $\frac{1}{4}$th of an inch. When I kept the place of near contact about the middle of this wire, and made the exploſion at the extremities of the whole wire, I was obliged to bring them about as near again, *i. e.* to little more than one eighth of an inch, before the paſſage would be through the air; ſo that the force of the whole exploſion muſt have been greatly weakened by its paſſing through ſo much of the wire. Laſtly, I took a pair of kitchen tongs, the legs of which were two feet, and the ſmalleſt part of them above half an inch in diameter; when the circuit was made about one ſixth of an inch in the air (for at that diſtance from one another the ends of the tongs had been fixed) rather than through four feet of that thick iron.

Notwithſtanding this evident paſſage of the electric matter through the air, at the ſame time that a metallic circuit was provided for it; it was certain that the whole of the charge did not paſs in the air: for when I extended $\frac{1}{3}$d of an inch of ſmall iron wire between *a* and *b*, it was only made red-hot by the diſcharge; whereas above two inches of it would have been exploded, if there had been no other metallic circuit at all.

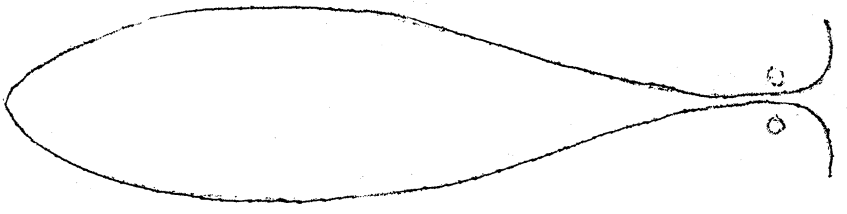
As the electric fire meets with ſo much obſtruction in paſſing through a circuit of iron of this thickneſs, I make no doubt but that it is conſiderably obſtructed in

in paſſing through metallic circuits of any thickneſs whatever; and that it would prefer a very ſhort paſſage thro' the air, if they were made even of no great length. In this method the different degrees of conducting power in different metals may be tried, uſing metallic circuits of the ſame length and thickneſs, and obſerving the difference of the paſſage through the air in each. N. B. A common jar anſwers as well, in theſe experiments, as a large battery. It is evident, from many experiments, that the whole fire of an exploſion does not paſs in the ſhorteſt and beſt circuit; but that, if inferior circuits be open, part will paſs in them at the ſame time. Of this I made the following ſatisfactory trial. I took an iron chain, and laid it upon a table, in contact with a charged jar; ſo that the parts of it made two circuits for the diſcharge, which I could vary at pleaſure; and I obſerved that, when one of the circuits was but half an inch, and the other more than half a yard; yet, if the charge was high, it always went in them both, there being conſiderable flaſhes between the links of the remoteſt part of the chain. If the charge was weak, it paſſed in the ſhorteſt circuit only.



It is evident, that when the wires of a battery are not in cloſe contact, there muſt be ſome loſs of force

in the diſcharge; but this never appeared to me to be very conſiderable. In order to aſcertain it by experiment, I firſt found, by repeated trials, what length of a piece of iron wire I was able to melt with a battery conſiſting of twenty jars, with the wires and connecting rods quite looſe, and a chain to join the rods belonging to each row of jars, which is the manner in which I have generally conſtructed them. In theſe circumſtances, I found the battery was able to melt ſomething more than two inches and a half of the wire. I then ſoddered the wires of each jar to the rod which connected them, and alſo ſoddered another rod to all theſe, inſtead of the chain which I had uſed; ſo that I avoided near a hundred ſparks in the diſcharge, at each of which there muſt have been ſome loſs of force; but I did not find, after many trials, that the ſtrength of the battery had been thereby ſenſibly diminiſhed: for I could not melt three inches of the ſame piece of wire in theſe circumſtances. It was only made red-hot, which is equivalent to the melting and exploding of little more than two inches and a half.



XI. *Abſtract*