IMPROVEMENTS

IN

ELECTRICITY.

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BODY PHYSICIAN TO THEIR IMPERIAL MAJESTIES.

Who was nominated by the Preſident and Council to proſecute Diſcoveries in Natural Hiſtory, purſuant to the Will of the late HENRY BAKER, Eſq. F. R. S.

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IMPROVEMENTS IN ELECTRICITY.

BEING appointed to deliver the annual diſſertation on ſome philoſophical ſubject, inſtituted by our worthy brother the late Mr. HENRY BAKER, I will endeavour to explain ſome contrivances in electricity which I invented a good while ago, one of which has been much employed, and has undergone ſeveral material improvements ſince I firſt thought of it.

IT is now about fifteen years ago ſince I began to make uſe of flat glaſſes inſtead of globes or cylinders, to excite electricity. Finding that a greater quantity of electricity could be excited upon a flat piece of glaſs, when rubbed on both ſurfaces, than when it was only expoſed to friction on one ſide; I thought it would be an advantage to ſubſtitute a round plate, or disk, of glaſs, to a globe

or cylinder. I alſo thought another material advantage might be derived from a plate of glaſs, as the form of it admits of placing cuſhions or rubbers upon different parts of it, and taking the electricity, excited by theſe rubbers, from the interſtices between them, which cannot conveniently be done when a globe or cylinder is uſed. The only inconvenience which I at firſt conceived would enſue from it was, that the center upon which the plate was to be fixed and whirled round, would always be too near the rubbers (unleſs theſe were very ſhort, or the plate of a conſiderable ſize) and that theſe would throw the electricity, collected on the ſurface of the glaſs, upon that very center. In order to obviate this difficulty, I propoſed to make the center likewiſe of glaſs, or ſome other non-conducting ſubſtance, as, for inſtance, baked wood.

I began firſt by making uſe of one of thoſe glaſs ſtands, which they call a waiter, and which has a glaſs ſupport fixed at right angles to its center. I whirled the waiter round as well as I could, rubbing it ſometimes on one ſide, ſometimes on both. In this imperfect ſtate I ſhewed it to Dr. FRANKLIN, who approved much of the ſcheme, and adviſed me to purſue it. Soon after, I ſhewed it to ſeveral of my acquaintance, and in a ſhort time I found ſuch machines ready made at Mr. RAMSDEN's and ſome

other mathematical inſtrument-maker. Since that time great uſe has been made of theſe electrical plate machines throughout Europe, as they were thought by many to be more powerful in a little compaſs than thoſe with globes and cylinders.

In my travels through different countries, I now and then met with conſiderable improvements made in them. Abbé FONTANA had contrived one for the cabinet of the great Duke of Tuſcany, which conſiſted of two plates, eighteen inches diameter, fixed to the ſame center, and each rubbed on both ſides on two oppoſite places. The electrical fire excited on theſe joint plates, when forced upon a conductor divided in two branches to receive it, was very powerful; ſo much ſo, that the conductor, being unable to contain the whole, threw it back upon the braſs center; from which it paſſed to the hand of the operator, and gave him a very diſagreeable ſhock.

Mr. CUTHBERTSON, an ingenious mathematical inſtrument-maker at Amſterdam, contrived an apparatus with a double plate, by which all the electrical fire collected by the eight cuſhions was forced upon the conductor, ſo that none of it could be thrown back upon the center, though made of braſs. His contrivance conſiſted in placing between the glaſs plates a ſtrong glaſs ring, about two inches in diameter, ſo that the braſs

center paſſed through the middle of it. This ring was ſtuck to the plates with ſealing wax or ſome other non-conducting cement; and the ſpace between the center and the ring was carefully filled with the ſame non-conducting ſubſtance. The conductor had two branches, each of which was placed between the two glaſſes, reaching very near to the glaſs ring. By this method all, or almoſt all, the electricity excited by the eight cuſhions, was forced to paſs upon the conductor, there being no way to reach the braſs center, between which and the conductor all communication was cut off by the above mentioned glaſs ring being filled up with a non-conducting cement. The power of ſuch a machine, notwithſtanding that the plates were not above fifteen inches diameter, was very aſtoniſhing. I ſaw one made in London with this improvement (the glaſs plates being eighteen inches diameter) by which a coated jar of two quarts was fully charged in leſs than five ſeconds.

Mr. C. CUYPERS, an ingenious electrician at Delft, has not a little contributed to the improvement of theſe machines, by making them leſs liable to be affected by damp weather. This gentleman, conſidering that all glaſſes are not equally fit for electricity, and that J. H. WARTZ, and after him Profeſſor MUSSCHENBROEK, were of opinion, that glaſs, in the compoſition of which there enters

a great deal of alkaline ſalt, is very apt to attract moiſture from the air, and therefore leſs proper for electricity (which defect they thought might be corrected by expoſing it to a violent and continued heat), took a proper advantage of this knowledge in the improvement of the machines with flat glaſſes. He found, that glaſſes, which have been many years expoſed to the warm air of a room, very old looking glaſſes for inſtance, become by this means much harder, ſo as better to reſiſt the force of a file; and are then much better for electrical machines: and that ſuch glaſſes become ſtill incomparably better, if they are expoſed to a conſiderable degree of heat during ſome months: the heat forcing out of the glaſs (at leaſt out of its ſurface) the alkaline ſalt, not vitrified, which is to be found upon it, and may be known by the taſte.

In December 1777 I ſaw one of theſe double-plated machines at Mr. CUYPER's houſe, and found it do admirably well, though the weather was at the time very damp, and the machine kept in a room in which there never was any fire made, and though the cuſhions had no amalgama upon them: they were made of yellow Turkiſh leather, ſtuffed with fine ſhavings of cork, rammed in them; and had been preſſed to give them an equal ſmooth ſurface.

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The ſame gentleman found glaſſes, prepared in the above mentioned way, far ſuperior in ſtrength to a cake of roſin uſed in the electrophorus. He publiſhed his method in a pamphlet, intitled, *Expoſé d'une Methode, par la quelle on rend les Diſques de Verre deſtinés à des Machines Electriques capables d'exciter l'Electricité dans une Air humide, ſuivi d'une Maniere de faire de très bons couſſins pour frotter les Verres des Machines electriques, et de la Deſcription d'un Electrophore perpetuel plus parfait que ceux dont on s'eſt ſervi juſq' ici.* A la Haye, 1778.

Thoſe who make uſe of plate machines ſhould carefully avoid putting the apparatus near the fire, for the purpoſe of drying or warming it; becauſe the ſudden expanſion of the glaſs by the heat cannot ſo quickly propagate itſelf through its whole extent; for the center being commonly ſqueezed between two flat ſhives of braſs, with a piece of leather between the metal and the glaſs, does not acquire a ſimilar degree of heat at the ſame time as the reſt, and cannot ſo eaſily expand; and therefore the plate is in great danger of breaking. If, in conſequence of ſuch a blunder, a flaw ſhould happen, its progreſs might be ſtopped by drilling a round hole at the extremity of the flaw. Theſe flat glaſſes may very ſafely be rubbed with a dry warm cloth.

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As the quantity of electricity excited upon glaſs is nearly in the proportion of the ſurface expoſed to friction; and as glaſſes of a great ſize are very precious, and liable to accidents, I conceived, that inſtead of a disk of flat glaſs one might ſubſtitute one of paſte-board, thoroughly imbibed with copal or amber varniſh.

To try how this would anſwer, about ſeven years ago I ordered three paſte-board disks to be made, of four feet in diameter, the diſtance of ſix inches from the center being the fitteſt to give the whole a proper ſupport in whirling it round. When theſe disks were thoroughly dried and heated, I poured upon them a varniſh made of amber diſſolved in linſeed oil. After they had taken in as much of the varniſh as they could imbibe, I covered them with a thick coat of the ſame varniſh, and dried them by the heat of a German ſtove.

When the varniſh was very hard, I found, that even a ſlight friction with a cat's skin or hare's skin excited a ſtrong electricity upon them.

I then made a frame to place them in, and to whirl them round; which frame was ſo contrived, that it could contain about twelve ſuch disks, whirling all round on the ſame center. It conſiſted of two ſquare pillars of wood, about five feet high, and three inches broad; joined together at top and bottom by a tranſverſe piece

of

of wood. In the middle of the two pillars was a hole, about an inch and an half diameter, fitted to receive a wooden axis, which could be placed in, and taken out, at pleaſure. Upon this axis were to be ſtuck the paſte-board disks; and a flat board, three inches broad, covered on both ſides with flannel, and over this with a hare's skin, was to be placed between each paſte-board. The two ſquare pillars were alſo to be wrapped up firſt with flannel, and over that with hares skin.

The flat boards, to be placed between the paſte-board disks, had each a notch in the center, to give room for the axis to turn round freely. Theſe flat boards could be brought as near one another as was required by two wooden male ſcrews, placed at the upper and lower end of the frame, which reached from one ſquare pillar to the other; which ſcrews were to receive a notch cut out at the upper and under end of each flat board, in order to keep them ſteady in their vertical ſituation. A female ſcrew, turning upon theſe horizontal male ſcrews, was placed between each of the flat boards at their upper and under extremities, and ſerved to bring each of the disks as near in contact with the hares skins as was required to receive a proper friction.

The three paſte-boards were fixed in the frame, and whirled round. The electricity excited was ſo ſtrong that

that I took ſparks between one and two feet long from the front ſurface of the firſt disk by approaching my knuckle to it. I then applied a tin conductor to it, about ſix feet long and ſix inches diameter, divided into two branches, the extremities of which were furniſhed with a thick ſilver lace fringe inſtead of points. The ſparks from this conductor were about four or five inches long, appeared to be very thick, were very brilliant, and ſo ſtrong, that I did not chuſe to receive many of them; nor did thoſe who came to ſee the machine care to receive more than one. As theſe ſparks ſucceeded one another at ſhort intervals, I think they would have been much longer if every thing had been adapted for that purpoſe; as I ſaw afterwards done at Mr. NAIRNE's, who contrived to obtain ſparks of twenty inches long and upwards from a large glaſs cylinder.

I conſidered this paſte-board machine rather as a rough ſketch of an apparatus, by which I conceived the hope of obtaining an electrical power of almoſt any degree required, than as a compleat machine. My intention was to find out a contrivance by which a very great quantity of electrical fire might be collected without great expence and without much danger of breaking the apparatus, which two articles cannot be avoided when you make uſe of uncommon ſize glaſs cylinders or disks.

I ſaw, two years ago, at the Duke of CHAULNES at Paris, an apparatus which had a plate glaſs five feet diameter. This alone coſt him eight hundred French livres.

As I had not adapted the tin conductor to receive the electricity from the three disks, but only from the front disk, I cannot tell whether the force of electricity would have been proportionably ſtronger if I had made ſome metallic communication between each of the disks.

I found, that the apparatus, as it was conſtructed, could not eaſily have admitted more than three ſuch large disks; for the twelve ſurfaces expoſed to friction being each a foot and an half long, and above three inches broad, made ſo much reſiſtance to the working of the machine, that it required a ſtrong arm to work it.

Being ſatisfied with having found that by this, or a contrivance of the ſame kind, a much greater power could be excited than by the common glaſs apparatuſes; I did not chuſe to put myſelf to more trouble or expence to increaſe the ſtrength of its frame, or the number of disks.

I muſt obſerve, that ſuch a machine may be kept in good order in a heated room; but that it will ſoon loſe its force in countries where it is not the cuſtom to heat rooms as the Germans do. My paſte-board disks kept

very good during all the time I left them in a room conſtantly warmed, which was about two months; but, when they were placed in a cold room, they ſoon loſt their power, having probably attracted moiſture from the air. I cannot be ſure that the varniſh I got made for the purpoſe was of the beſt kind: I have reaſon to ſuſpect the contrary, and therefore I ſhould think that much better might be obtained in London.

Such paſte-boards might be poſſibly preſerved from attracting moiſture, by keeping them ſhut up in a box made on purpoſe, lined within with tinfoil. The moiſture might alſo be expelled again by placing them a good while in a heated room, or upon a baker's oven.

It ſeems, beſides, not improbable, that a kind of paſte-board might be made by ſticking together the lamina of paper (firſt thoroughly dried) with a good oil varniſh inſtead of common paſte, as this laſt never can be deprived of its watery particles without loſing its coheſive quality. A good kind of paſte-board might likewiſe be contrived by ſticking together ſilk cloth inſtead of paper.

I contrived a plated machine, the disk of which was made of baked wood and boiled in linſeed oil; but it did not anſwer near ſo well as the paſte-board disks.

I found the paſte-board disks not much leſs ſuſceptible of electricity before I had varniſhed them than they were afterwards; but they loſt their force again in a few minutes, and did not recover it till they were dried and heated again.

It is well known, that writing and brown packing paper, when warmed, may acquire a conſiderable electrical power by being rubbed with hares skin, a piece of wood, ivory, nay even (as I found by experience) with a metallic body.

As it ſeems to be a general law of nature, that all reſinous bodies, excited either with a poſitive or a negative electricity, are more tenacious of keeping it, or ſeem to part with it, as it were, with more reluctance than glaſs (as I have demonſtrated in a paper, read laſt year before the Royal Society); it is adviſeable, that the conductor of ſuch a paper machine be not furniſhed with metallic points, which being neceſſarily kept at a diſtance will not take away all the electricity; but that ſome flexible, conducting ſubſtance, as ſilver or braſs lace fringes, communicating with the conductor, be in cloſe contact with the excited ſurface.

As woollen cloth or Mancheſter cotton velvet, and ſuch like ſubſtances, excite a good deal of electricity upon dried paper and reſinous ſubſtances, and do not wear out

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ſo ſoon as hares skin, it might, perhaps, be found better to ſubſtitute them for hares skin.

I have alſo excited a very conſiderable electrical force on ſtrong ſilk velvet, tied upon the circumference of two wooden disks, two feet in diameter, and diſtant about three feet from one another, fixed upon a wooden axis. The velvet was ſupported by a ſtrong ſilk cloth tied under it, in order to give it more ſtrength and ſteadineſs. This machine had the appearance of a drum, and was whirled round, as is uſually done with glaſs cylinders. The rubber was a cuſhion covered with hares skin.

As ſilk cloth, and more particularly oiled ſilk, very eaſily receives a ſtrong electricity, I make no doubt but a good uſe might be made of them, by expoſing a great ſurface of them (which may be as large as one pleaſes) to friction. I have attempted more than one method of conſtructing ſuch a machine; but as I tried it only in ſmall, I have not purſued the object far enough, and therefore, I think, I have no right to throw out hints unſupported by experience.