Experiments and observations made with a view to point out the errors of the present received theory of electricity and which tend in their progress to establish a new system, on principles more ...

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Chapter VI. The Franklinian theory [...].

CHAPTER VI.

The Franklinian theory, of charging, and dischარging, the Leyden phial, examined by experiments; with remarks to shew the deficiency of the system in explaining the cause of action of this wonderful jar.

IN addition to what I have already offered, chapter III. p. 15. it will still be necessary to examine attentively the theory of charging, and discharging, of glass.

1. [1] The Leyden phial, which took its name from the shock being first received by Mr. Muschenbroek, professor of philosophy at Leyden, in the year 1746, must be impervious to the electric fluid, in order to produce a charge.

2. The charging of an insulating body, such as glass, is effected, we are told, p. 12. by raising at once, and in equal degrees, two contrary electricities on the two surfaces of the phial. While the inside of the jar, connected by the wire to the conductor, is charging positively, it at the same time repels an equal quantity of the electric fluid from the outside of the jar, which is driven to the earth by means of a conductor, which forms a communication with the outside of the jar [2]. Thus, while one side becomes exhausted, the other is redundant, or, in other words, one side is electrified positively, and the other negatively.

3. In order to effect a discharge, a communication must be

[1] Beccaria's treatise, &c. p. 69.

[2] Becket's essay, p. 39.

introduced

introduced between the two ſurfaces of the phial, that the exceſs condenſed on the inſide, may paſs to the oppoſite ſurface, and reſtore the equilibrium. This is called the diſcharging.

This is the ſubſtance of the theory of charging and diſcharging of electrics. Thoſe who are deſirous of ſeeing a more particular explanation, may conſult Dr. Franklin's Letters, Prieſtley's Hiſtory of Electricity, and Beccaria's Treatiſe, who has wrote many quarto pages to explain and eſtabliſh his propoſitions.

Several ingenious experiments have likewiſe been invented to ſupport this doctrine of charging and diſcharging of glaſs, which are equally wonderful, curious, and entertaining, and ſo plauſible that they appear to carry demonſtration with them.

In order to give this theory a fair trial, I ſhall firſt tranſcribe ſome of the moſt curious, and, as I think, convincing experiments in favour of the hypotheſis; and, after making ſome objections to the concluſions drawn from them, I intend to contraſt them with experiments which appear to confute the whole ſyſtem.

Experiment I.

[3] Take two bottles, equally charged through their hooks, one in each hand; bring their hooks near to each other; no ſpark nor ſhock will follow, becauſe each hook is diſpoſed to give fire; and neither to receive it.

If a perſon takes one jar by the wire, and the other by the coating, and brings the wire of the one to the coating of the other, there will be immediately an exploſion, and a ſhock, and he will be ſenſible of it by the charge paſſing through him.

[3] Franklin's letters, p. 22. Becket's eſſay, p. 42.

This experiment may be varied, by charging one of the phials on the outſide, and the other by the wire, and if the diſcharging-rod be applied to the outſide of each of them, a diſcharge will immediately enſue.

Experiments with the inſulated rubber.

It may be neceſſary to remark here [4], for the ſake of the unexperienced reader, that, according to the preſent hypothetical doctrine of charging and diſcharging, all electrical exploſions depend on the balance of the fluid being diſturbed; and that there could be no electric appearances, unleſs ſome bodies were poſitively, and others negatively electrified. To ſhew this more fully, let there be two conductors, ſee figures 5, 5. plate I. of the ſame kind and dimenſions, and let that connected with the inſulated rubber be called the negative, and the other, placed near the cylinder of the electrical machine, the poſitive conductor.

[5] EXPERIMENT II.

Place the two conductors, the one to the cuſhion, the other to the cylinder, in a parallel direction, and about an inch aſunder. Turn the machine, and ſtrong ſparks will iſſue from the poſitive to the negative conductor.

EXPERIMENT III.

Remove the two conductors a little farther apart; fix a jar to the poſitive conductor, and let the bottom reſt on the negative

[4] Becket's Eſſay, p. 121. [5] Idem, p. 122.

 conductor.

conductor. Though the phial in this case has no communication with the ground, it will charge and discharge, the same as in the common experiment.

An explanation of the foregoing experiments, according to the present theory of charging and discharging of glass.

The second experiment, we are informed, depends upon the circulation of the electric fluid, from the negative conductor to the rubber, from the rubber to the cylinder, and from thence to the positive conductor, which gives the negative conductor the fire it has received from it, and the balance is restored.

The third experiment is explained from the same principle.

It is supposed, that while the electric fluid is condensing in the phial connected by the wire of the positive conductor, its outside is diminishing its natural quantity of the electric fluid, which goes to the negative conductor, and from thence to the cylinder, as before. As soon as a communication is formed between the inside and outside of the jar, an explosion ensues, and the equilibrium is restored.

It will be needless to multiply experiments, to shew the nature of charging and discharging, according to the present system, as they all depend (we are told) upon this principle, *viz.* Every thing connected to the conductor, which is fixed to the back of the insulated rubber, is deprived of its natural quantity of the electric fluid, and such bodies as are fixed to the positive conductor, placed near the cylinder of the electrical machine, have an additional quantity condensed on their surfaces.

Remarks on the foregoing experiments, and the conclusions drawn from them.

The firſt experiment is mentioned by Dr. Franklin [6], and it has ſince been tranſcribed by ſeveral writers in this branch of natural philoſophy, to prove the truth of the preſent theory; but for want of varying it a little, they have ſtumbled at the threſhold, and have not hit on the principle upon which the phials or jars act.

EXPERIMENT I. *varied.* See p. 41; *or* EXPERIMENT IV.

Take the two jars, and charge them by their knobs, at the poſitive conductor. While they are ſtanding with their knobs in contact with the conductor, and at ſome diſtance from each other, form a communication between the outſide of one of the jars, and the inſide of both of them, (for, the conductor connecting the two jars together by their knobs, their internal ſurfaces become as one) and there will be a ſpark, a ſhock, and a diſcharge of both the jars, notwithſtanding the outſide coatings are at a conſiderable diſtance from each other.

If the charging of glaſs depends upon repelling as much of the electric fluid from one ſide, as is condenſed upon the other, and the diſcharging upon reſtoring the equilibrium, then the external ſurface of one jar could not contain the electric fluid condenſed upon the internal ſurfaces of two jars. Beſides, how is the equilibrium reſtored to that jar which has no communication with the inſide? The jars are both apparently in the ſame ſtate after the diſcharge is made, as they were before they were charged.

[6] Franklin's Letters, p. 22.

EXPE-

EXPERIMENT III. *varied.* See p. 42; *or* EXPERIMENT V.

Inftead of fixing the knob of a jar to the plus conductor, and its coating to the negative conductor, as in experiment III. p. 42; fix a jar to each conductor, fee figures 5, 5. plate I. When the apparatus is ready, turn the cylinder of the machine; and if the theory be true, while you condenfe the electric fluid in the jar at the pofitive conductor, you exhauft the jar at the negative conductor of the natural quantity of the electric fluid inherent in it. Though one of the jars be faid to be pofitively electrified, and the other negatively, they will not difcharge each other, nor give a fpark, if you only form a communication between the two knobs. If the circulation of the electric fluid be from the negative conductor to the rubber, and from thence to the jar of the pofitive conductor; the jar pofitively charged will be full, and ready to throw out, the jar negatively charged, empty[7], and extremely hungry; yet the one will not receive, though the other ftands ready to give, unlefs you connect the outfide coating of each jar with fome conducting fubftance; and then there will be a fpark, a fhock, and a difcharge. I believe, by this experiment, there is another myftery in the difcharging of the Leyden phial, than the reftoring the equilibrium; but I do not by any means confider this as conclufive, for I have perhaps fome incontrovertible facts to produce.

[7] Franklin's Letters, p. 25.

Experiment VI.

With two jars, one at the poſitive conductor, the other ſtanding at a diſtance upon the inſulated table.

Fix the wire rod, fig. 11. plate I. to the end of the negative conductor. Take two coated jars, and put a thin tin hoop round each of them, with a ſmall link, to which you may hook a braſs chain, of three feet in length, to form a communication between the outſide coatings of the jars. Place one of the jars at the poſitive conductor, and the other upon the inſulated table, at any diſtance at pleaſure; but not in contact with either of the conductors. When the apparatus is prepared, let a perſon ſtanding upon a ſtool with glaſs legs, charge the jar at the poſitive conductor, and when charged, form a communication with the diſcharging bow, from the outſide of the jar upon the table to the inſide of the jar at the conductor, and there will be a diſcharge. There is not any thing in the diſcharge of the jar, but what may be accounted for from the preſent theory; for, in fact, it is no more than a common diſcharge from inſide to out: but there muſt be electrical effluvia condenſed on the outſide of the jar ſtanding upon the table, or there would be no diſcharge.

If the jar at the poſitive conductor be inſulated, and the knob placed a little diſtance from the conductor, for the electric fluid to ſtrike it with a ſpark; if the wire or chain which forms the communication between the jars be alſo inſulated, and the room darkened, you may ſee the electric fluid as it paſſes from one jar to the other, which is a proof it muſt be condenſed denfed upon the jar ftanding in contact with the chain, at a diftance from the conductor, upon the table.

The queftion then is, How the electric effluvia, according to the prefent theory, can be condenfed upon the outfide furface of this jar, as it cannot repel any from the infide, becaufe the knob has not any communication with a conducting body to lead it off?

EXPERIMENT VII.

Or the laft Experiment varied.

Let the apparatus remain as directed in the preceding experiment. Charge the jar as before, at the pofitive conductor. Form a communication with the difcharging bow between the two knobs of the jars: there will be a fpark and a fhock; but in this inftance the jar at the pofitive conductor is not more than half difcharged.

2. The jars being now both equally charged, they may be difcharged by forming a communication between the outfide and infide of each of them; for both of them will give a fpark and a fhock.

Remarks on the preceding Experiments.

While the jar is charging at the conductor with pofitive electricity, the electric fluid inherent in the outfide furface of the glafs, muft be paffing off (fee p. 40.) along the chain to the outfide coating of the jar upon the table, and it will receive more than its natural quantity of electric effluvia. Upon forming a communication between the knobs of the two jars, when

when charged, as before, the jar ſtanding at a diſtance upon the table receives half the electric fluid from the jar at the conductor; and half the electric effluvia repelled from the outſide ſurface of the jar, while charging, returns, according to the theory, to reſtore the equilibrium. If only half returns by this operation, the outſide of the jar, at a diſtance from the negative conductor, upon the table, will have, in proportion with the chain, the remaining half; inſtead of which it ought to have been deprived of half of its own natural quantity of electric effluvia inherent in its ſubſtance, for it has received half a charge. I believe it will be a difficult taſk to prove the outſide of this jar, in this caſe, in a negative ſtate; but I will purſue the examination of this theory a little farther.

EXPERIMENT VIII.

With ſeveral jars placed along the chain, to ſhew there is a myſtery in the Leyden phial, which has not yet been pointed out.

Take away the metal rod, fig. 11. from the negative conductor, and place a coated jar at each conductor, with a chain fixed to the hoops before deſcribed, to form a communication between the outſide coatings of the jars. Place two more coated jars, with wires and knobs, at equal diſtances, upon the inſulated table, but let their outſide coatings be in contact with the chain.

When the apparatus is fixed, let a perſon ſtanding upon a ſtool with glaſs legs, charge the jars. Take the diſcharging-bow, begin either at the poſitive or the negative conductor, and form a communication between the wire of the jar ſtand-

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ing at the conductor, and the wire of the fecond jar; there will be a fpark, and if a perfon makes the trial he will receive a fhock. Repeat the experiment between the third and fourth jar, there will be a fpark and a fhock as before. I have fometimes paffed the fpark back again from the fecond to the third jar, before the electricity of the jars has been difperfed.

Remarks.

In the foregoing, and, in fhort, in all the experiments on the charging and difcharging of glafs, if the caufe of action depends on the internal and external furfaces being contrarily electrified, there appears to me an infuperable difficulty to explain, by the prefent theory, how a combination of jars act, when their knobs are not connected with each other, as in the laft experiment. If glafs be impervious to the electric fluid, and the two knobs of the middle jars be detached from any conducting fubftance, how can their internal furfaces fuffer any diminution or change? or how can their external furfaces, by the prefent hypothefis, receive any addition of the electric effluvia, either on their furfaces, or in their pores? If there be no alteration of the electric fluid in the fubftance of the jars ftanding in contact with the chain, during the charging the jars at the conductors, they would not receive, as they do, a fpark, and half the charge, from the jars at the conductors.

This may eafily be proved. Take away the chain, and let the perfon who turns the machine get off from the ftool with glafs legs, and ftand upon the floor: the infulated table will now have a communication with the earth. Let the jar at the poſitive conductor be charged, and take it in your hand, and bring the knob to one of the knobs of the middle jars. It will not, in this caſe, receive a ſpark; yet I know of no reaſon, according to the preſent theory, why it ſhould not. While a jar at the poſitive conductor is charging, ſtanding upon a table which has a communication with the floor, it can part with the electric fluid from its outſide ſurface; and why ſhould not an uncharged jar do the ſame, and receive a ſpark from a charged jar, when their knobs be in contact? It cannot be becauſe the charged jar cannot be ſupplied with the electric fluid to reſtore the equilibrium; for there are many inſtances, we are told, in which an electric will receive a ſpark from a perſon ſtanding on the floor [8].

Notwithſtanding all Dr. Franklin has ſaid, in his obſervations on the acting of the charged and the uncharged jar, and likewiſe Pere Beccaria, with his ſeries of jars, I am led by the foregoing experiments and remarks to believe, there is a myſtery in the charging and diſcharging of the Leyden phial, which the hypotheſis of poſitive and negative electricity can never explain.

It may be neceſſary to examine, under this head, into the reaſon why a jar ſuſpended from the conductor, without any communication with the floor, will not, in ſome caſes, receive a charge, as this has been conſidered as a convincing proof in favour of the preſent ſyſtem.

It is well known to thoſe who are acquainted with pneumatical experiments, that condenſed air acts with a prodigious force.

[9] Let a quantity of air be thruſt into a tight forcing ſyringe,

[8] Franklin's letters, p. 23. Beccaria's Treatiſe, p. 99.

[9] Clare's motion of fluids, p. 48.

ftopped at the end; the refiftance againft the pifton is fuch, that if the materials do not give way, no power whatever will bring that pifton down.

[10] If a fluid confifts of particles repelling one another, with a force reciprocal to the diftances of their refpective centers, fuch fluid will have a fpring reciprocal to the fpace in which it fhall be compreffed.

This appears in fome inftances to be applicable to the electric fluid. We know, from a variety of experiments, that the component particles of the electric effluvia endeavour to expand and recede from one another, with a force fo great, that no power which can be applied will fo condenfe, or drive them within the fphere of each other's attraction, and prevent or overcome their elafticity.

Have we not reafon to believe, by the charging and difcharging of electrics, that the electric fluid is as elaftic as air, and its particles as ftrongly repulfive of each other? They pafs through the denfeft metals, and with inconceivable velocity efcape from the furfaces of fuch coated electrics as are formed to retain them within their pores. It muft be this repulfive power inherent in thefe primoriginal particles of matter, the electric fluid, which prevents the charging of a jar fufpended from the prime conductor, and without a communication with the floor. It has been already proved, that the electric fluid paffes through glafs; but the circumambient air, when dry, will not lead away the electric fluid from the jar, to caufe a fucceffion of the electric effluvia from the cylinder of the machine. The electric fluid being ftopped within and about the furface of the jar, by an at-

[10] Newton's Principia.

tractive power, immediately becomes repulfive, and counteracts the effluvia at the knob of the jar, and in this inftance will prevent a charge from taking place.

Experiment IX.

To prove the repulfive power of the electric fluid at the knob of the jar.

Take a large brafs rod, and fcrew a middling-fize metal knob at each end of it. See plate II. fig. 5. Let it be nicely balanced with a central point, and fixed upon a perpendicular pivot on the top of a glafs ftand. Let the ball A, of this balanced rod be placed at the middle of the prime conductor, juft to touch, but not to confine it from moving. Place the jar *c*, upon a ftool with glafs legs, under the other knob *b*, and let the knobs touch as in the figure. Turn the cylinder, and as foon as the jar has received three or four fparks, the knob of the balanced conductor will be repelled, and driven to fome diftance from the jar. This fhews the particles of the electric effluvia become repulfive within the jar, and counteract the particles of the fluid in the rod, fo as to prevent a charge, when there is no conducting fubftance to pafs them away from the jar. Fix a chain to the jar, and form a communication with the floor, the jar will then receive feveral fparks, and there will be a confiderable charge of the electric fluid condenfed within the jar, before the knob of the balanced conductor will be repelled from the knob of the jar.

Experiment

EXPERIMENT X.

Fill a ſeaſoned jar with hot water, ſtop it cloſe, and let it be air tight: place the jar upon the ſtool under the end of the balanced conductor, as in the laſt experiment. If the cylinder of the machine be turned, the knob of the balanced conductor will be repelled with conſiderable force; which ſhews that the particles of the electric effluvia are not only repulſive of each other, but that the particles of air repel them, when conſiderably rarefied, and confined in a cloſe glaſs veſſel. This appears to be the real reaſon why a jar will not charge when there is no conducting body to lead the electric effluvia from the glaſs.

CHAP-