XXXII. *An Account of a Treatiſe, preſented to the* Royal Society, *intituled*, "Letters "concerning Electricity; in which the "lateſt Diſcoveries upon this Subject, and "the Conſequences which may be de- "duced from them, are examined; by "the Abbé *Nollet*, Member of the Royal "Academy of Sciences of *Paris*, Fellow "of the Royal Society, of the Inſtitute of "*Bologna*, &c." *extracted and tranſlated from the* French, *by Mr.* William Watſon, *F. R. S.*

Read May 17, 1753. THE work before us contains 262 pages in 12mo, excluſive of the preface, and four copper plates, repreſenting ſeventeen figures.

This treatiſe is the production of a great maſter upon the ſubject of electricity: he has already publiſhed two volumes expreſsly thereupon, beſides ſeveral memoirs among the works of the Royal Academy of Sciences at Paris. For ſeveral years he has done me the honour of being my correſpondent, and I have communicated ſeveral valuable papers from him to the Royal Society.

The diſcoveries made in the ſummer of the year 1752 will make it memorable in the hiſtory of electricity. Theſe have opened a new field to philoſo-

phers, and have given them room to hope, that what they have learned before in their muſeums, they may apply, with more propriety than they hitherto could have done, in illuſtrating the nature and effects of thunder; a phænomenon hitherto almoſt inacceſſible to their inquiries.

But to make the moſt certain advantage of theſe new diſcoveries, we ſhould confine ourſelves to facts; and if we do draw conſequences from them, they ſhould be immediate and neceſſary ones; for, whenever our diſcoveries ſeem to promiſe to be uſeful and important, we are apt to hope and expect great ſucceſs from them: we muſt therefore be careful to reſtrain our imagination, or we ſhall fall into error.

Theſe conſiderations have induced our author to examine with care, what may truly be concluded from the experiments propoſed by Mr. Franklin of Philadelphia, and ſince carried into execution in France, and elſewhere, in relation to the electricity of the clouds during a ſtorm; by weighing every circumſtance, and comparing the greatneſs of the effects, which have been had in view, with the more than apparent inſufficiency of the means, which have been employed to produce them. He thinks, he ſees clearly, that the conſidering the electriſation of pointed bodies as a proof of leſſening the matter of thunder, is abuſing a real diſcovery to flatter ourſelves with a vain hope; and it is chiefly to diſſipate this error, if it yet ſubſiſts, that determined our author to print, in the work before us, ſome reflexions, which he had made at firſt only for himſelf, and a few perſons, to whom he was deſirous of communicating his opinion.

Mr.

Mr. Franklin's treatiſe upon electricity contains a great many very curious experiments; but the deductions from them being different from thoſe, which the Abbé Nollet has given upon the ſame ſubjects, it might be imagined, if he were ſilent upon this head, that he had given up his former opinions. The honour, which the Royal Academy of Sciences has done them, in publiſhing them in their Memoirs, and the kind reception, which the public has given them, has obliged him to re-examine theſe opinions, and to undertake their defence; more eſpecially as he ſees, that he has powerful reaſons to ſupport them. This has alſo been a motive for the preſent publication, which our author is deſirous ſhould be conſidered, leſs as a criticiſm upon Mr. Franklin's doctrine, than as a defence of his own.

In ſome parts of theſe letters, our author mentions an electricity, which is very often, and perhaps always, in our atmoſphere, when there is no appearance of thunder. He ſpeaks of this, as if he only ſuſpected it, and, in a manner, as if it wanted confirmation. He was then unacquainted with ſome deciſive experiments made upon this ſubject by Dr. le Monnier*, at St. Germain-en-laye, and which have been juſt publiſhed. He now conſiders, as a thing certain, that electricity is a very common meteor, which may manifeſt itſelf, when the weather is moſt ſerene;

* In a memoir read to the Royal Academy of Sciences at Paris, Nov. 15, 1752.

ſerene; and that thunder is, ſtrictly ſpeaking, only one of its modifications, which renders it more ſenſible to us.

The Abbé Nollet's treatiſe contains nine letters; ſix of which are addreſſed to Mr. Franklin, one to Mademoiſelle Ardinghelli, who, when only ſixteen years old, tranſlated Dr. Hales's treatiſe of Hæmaſtatics into Italian, and added thereto ſome very ingenious remarks; one to Mr. Jallabert of Geneva, and one to Mr. Boze of Wittemberg: To theſe are added ſome experiments in electricity, made in ſupport of opinions, laid down in this work, in the preſence of Meſſieurs Bouguer, de Montigny, de Courtivron, d'Alembert, and le Roi, who were appointed by the Royal Academy of Sciences for that purpoſe.

In the firſt letter our author gives his correſpondent Mademoiſelle Ardinghelli an account of the diſcoveries in electricity in the year 1752; among which he takes particular notice of the experiment made on May 10, at Marly-la-ville, in conſequence of Mr. Franklin's hypotheſis; wherein pointed non-electrics, ſupported by electrics *per ſe*, gave manifeſt ſigns of electricity during a thunder-ſtorm. This experiment, in the letters to Mr. Collinſon, Mr. Franklin had propoſed, but, as far as may be judged, had not then carried into execution. The experiment of Marly-la-ville was ſoon after verified by Dr. le Monnier at St. Germain-en-laye, who found further, firſt, that the like effects were produced, whether the iron rods were pointed, or not; and that it was indifferent, whether their poſition was horizontal, or not. Secondly, that thunder electriſed not only iron, but alſo wood,

wood, living bodies, and other electriſable ſubſtances. Thirdly, that it was not abſolutely neceſſary to place theſe bodies at the tops of buildings; and that it was ſufficient for them to be placed about four feet from the ground in an open ſituation, and at ſome diſtance from large buildings. Fourthly, that bodies electriſed in this manner produced the like phænomena with thoſe electriſed by glaſs after the uſual manner. It was afterwards diſcovered, that electriſable bodies, thus diſpoſed in open air, were ſometimes electriſed under thick clouds, but without thunder, lightning, or even without rain or hail.

The Abbé Nollet recommends, that theſe experiments ſhould be made with circumſpection, as he has been informed by letters from Florence and Bologna, that thoſe, who have made them there, have had their curioſity more than ſatisfied by the violent ſhocks, which they have ſuſtained, in drawing off the ſparks from an iron bar electriſed by thunder. One of theſe in particular ſays, that once, as he was endeavouring to faſten a ſmall chain, with a copper ball at one of its extremities, to a great chain, which communicated with the bar at the top of the building, in order to draw off the electrical ſparks by means of the oſcillations of this ball, there came a flaſh of lightning, which he did not ſee, but which affected the chain with a noiſe like wild-fire. At that inſtant, the electricity communicated itſelf to the chain of the copper-ball, and gave the obſerver ſo violent a commotion, that the ball fell out of his hands, and he was ſtruck backwards four or five paces. He never had been ſo much ſhocked by the experiment of Leyden.

From

From the experiment at Marly-la-ville, and thoſe which have been made ſince, have been drawn two conſequences; one, that the matter of thunder, and that of electricity, are one and the ſame: the other, that, by the means of pointed iron rods, one might, without its doing any harm, draw off all the fulminating matter from a ſtormy cloud. But our author has ſhewn, that bodies being pointed are not abſolutely neceſſary; and is deſirous, we ſhould not too haſtily believe, that miſchiefs ariſing from thunder may be averted by the apparatus propoſed. He thinks the means vaſtly too ſmall for the greatneſs of the cauſe.

Our author's firſt letter to Mr. Franklin is an introduction to the five ſubſequent ones.

The ſecond letter treats of the nature of the electric matter. In this its analogy with fire is conſidered and proved; and our author takes notice, that Mr. Franklin, he imagines, who has certainly made ſome important diſcoveries into the properties of electricity, cannot but be diſſatisfied with the editors of his work, for publiſhing, "that he exhibited to "our conſideration an inviſible ſubtil matter, diſſe-"minated throughout all nature, *&c.* which had hi-"therto eſcaped our obſervations." The latter part of which aſſertion is not ſtrictly true; as the conſidering the matter of fire, and that of electricity, to be one and the ſame, is a fundamental principle of what both the Abbé Nollet and myſelf formerly publiſhed upon this ſubject.

The third letter to Mr. Franklin contains ſeveral proofs, that glaſs is not impermeable to the electric matter.

matter. Some of the experiments of our author upon this ſubject I heretofore did myſelf the honour to lay before you; and they are in my opinion fully concluſive.

The fourth letter to Mr. Franklin relates to ſeveveral phænomèna of the experiment of Leyden. In this letter it is examined, whether the effects of this experiment proceed from the glaſs phial, or from the non-electrics contained therein; and experiments are produced to prove, that the power of giving a ſhock in an electriſed phial of water, proceeds from the water in the phial, and not from the phial itſelf, as Mr. Franklin imagines. In this letter likewiſe is an examination of Mr. Franklin's opinion, that, in the charged phial, as much fire as is received by one of its ſurfaces is loſt by the other.

The fifth letter to Mr. Franklin is in relation to the power of pointed non-electric bodies drawing off and throwing off electrical fire, at a much greater diſtance than obtuſe bodies do of the ſame kind. Our author thinks, that Mr. Franklin has attributed more power to pointed bodies, than, upon experiment he finds to be true.

The ſixth letter to Mr. Franklin is upon the analogy of thunder with electricity. This is a fact at preſent ſo well eſtabliſhed, as to admit of no doubt. But our author cannot agree with Mr. Franklin in his opinion, "that thunder is at preſent in the power of "men, and that we are able to diſſipate it at our "pleaſure: that an iron rod (ſuch a one as Mr. "Franklin has directed, and ſuch a one as has been "made uſe of) is ſufficient to diſcharge of all its fire

"a

" a ſtormy cloud againſt which it is directed." For his part he confeſſes, that he cannot believe it; firſt, becauſe he ſees too great a diſproportion between the effect and the cauſe: ſecondly, becauſe the principle, which is given us to ſupport this opinion, is not ſufficiently eſtabliſhed. He can hardly think, that the fulminating matter, contained in a cloud, capable of covering a great city, can be drawn off in a few minutes by a pointed bar, as thick as your finger. If even a number of theſe placed upon the tops of eminencies were only neceſſary to prevent the effects of thunder, would not the vanes and croſſes at the tops of our ſteeples have been ſufficient to procure us this advantage? Theſe buildings however, in all times, have not been exempted from the miſchiefs of thunder. He deſpairs of our weak efforts ever being able to diſarm the heavens.

Our author here gives us the repreſentation and deſcription of his apparatus for electriſing during the thunder: it differs in nothing eſſential from thoſe, which we uſed laſt year.

In this letter are likewiſe conſider'd the validity of Mr. Franklin's hypotheſis of electric and non-electric clouds; the former ariſing from the ſea, the latter from the land; their operation, upon their approaching one near the other; the difference, according to Mr. Franklin, between electrical and common fire; and ſeveral other parts of Mr. Franklin's doctrine.

The eighth letter is addreſſed to our worthy brother Profeſſor Jallabert of Geneva; and, among other curious particulars, inſerts part of a letter, which our author had received from Mr. Jallabert, giving an

account of an experiment, which Mr. Jallabert had ſome time ſince made at the water-works at Geneva. An account of this experiment was communicated by myſelf to the Society; and it has near relation to the experiment, which we made here in electriſing the river Thames ſix years ago. Mr. Jallabert conſults the Abbé Nollet in relation to the ſolution of the phænomena of this experiment; and the Abbé does me the honour now to give the ſame ſolution thereto, which I firſt gave to a ſimilar experiment of Dr. le Monnier's, and laid before the Society in January * 1746, and ſince applied upon other occaſions in illuſtrating the electrical circuit.

The ninth letter is addreſſed to Mr. Boſe, profeſſor of mathematics and philoſophy at Wittemberg; and is in anſwer to one of Mr. Boſe, in which this gentleman expreſſes himſelf ſurpriſed, that ſo many ages have paſſed, without it having been diſcovered, that thunder electriſes bodies; ſince it depends upon an experiment ſo ſimple, and which it is hardly poſſible to fail in, when you deſire to repeat it under proper circumſtances.

Upon this our author obſerves, that people in general only ſee the facts, and are ignorant of, or do not conſider, the means, by which philoſophers arrive at them; nor perceive the circumſtances, without which theſe phænomena could never have been made known to us; and that Mr. Boſe will ceaſe to be ſurpriſed, as he is ſo well verſed in theſe phænomena, when he reflects upon what our author offers.

To

* See *Phil. Tranſ.* Vol. XLIV. p. 388.

To make the experiment in queſtion, it is neceſſary that bodies ſhould be ſupported by glaſs, ſilk, or reſin, without touching any thing elſe communicating with what we now call non-electrics; without which, the ſigns of electricity, which are ſought for, cannot manifeſt themſelves.

To this experiment, therefore, a previous knowlege is required, of inſulating bodies to be electriſed; but where is the man who was acquainted with this fact thirty years ago? Before that period, it was not even gueſſed at by any one.

Since Mr. Gray diſcovered, that bodies muſt be inſulated, to communicate to them a perceptible electric virtue, to what purpoſe could we ſet up iron bars under a ſtormy cloud? This thought could not have happened, but to thoſe who had taken notice of the analogy between lightning and electricity, and upon whom this idea had made a ſtrong impreſſion. And no one could think ſeriouſly upon this analogy, but ſince the diſcovery of the experiment of Leyden, that is, ſince the year 1746. Before that time the electriſation of bodies by thunder could not have been perceived, but by an accident very difficult to meet, on account of the conditions requiſite.

Nevertheleſs it may be urged, that bodies, being really electriſed, have ſhewn themſelves in all ages *, as

* I formerly took notice, that the electrical attraction had been obſerved ſo early, as to be mentioned by Theophraſtus (ſee *Phil. Tranſ.* Vol. XLIV. p. 732); ſo its luminous appearance, though only conſidered as a meteor, is mentioned by Plutarch, in the life of Lyſander. Pliny, in the ſecond book of his natural hiſtory, chap.

as hiſtorians both ancient and modern have made formal mention thereof. But to this it may be replied, that it was not enough to know the fact, unleſs people were enough acquainted with it to take it for what it really was; that is, the electric virtue: for without that, obſervations of this kind could have very little weight with

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37, calls theſe appearances ſtars; and tells us, not only that they ſettled upon the maſts, and other parts of ſhips, but alſo upon mens heads: 'Exſiſtunt (ſays that hiſtorian) ſtellæ et in mari terriſque. 'Vidi nocturnis militum vigiliis inhærere pilis pro vallo fulgorem 'effigie ea: et antennis navigantium, aliiſque navium partibus, 'ceu vocali quodam ſono inſiſtunt, ut volucres ſedem ex ſede mu-'tantes: . . . . geminæ autem ſalutares, et proſperi curſus 'prænunciæ; quarum adventu, fugari diram illam ac minacem, 'appellatamque Helenam, ferunt. Et ob id Polluci et Caſtori id 'numen aſſignant, eoſque in mari deos invocant. Hominum quo-'que capiti veſpertinis horis, magno præſagio circumfulgent." But (adds he) all theſe things are 'incerta ratione, et in naturæ 'majeſtate abdita.'

Seneca, in his Natural Queſtions, chap. 1. takes notice of the ſame phænomenon. 'Gylippo (ſays he) Syracuſas petenti viſa eſt 'ſtella ſuper ipſam lancem conſtitiſſe. In Romanorum caſtris viſa 'ſunt ardere pila, ignibus ſcilicet in illa delapſis.'

Cæſar *de Bello Africano*, cap. 6. *edit. Amſtel.* 1686. We here find them attending a very violent ſtorm. 'Per id tempus fere 'Cæſaris exercitui res accidit incredibilis auditu; nempe Virgili-'arum ſigno confecto, circiter vigilia ſecunda noctis, nimbus cum 'ſaxea grandine ſubito eſt exortus ingens. . . . Eadem nocte 'V legionis pilorum cacumina ſua ſponte arſerunt.'

Livy, chap. 22. mentions two ſimilar facts: 'In Sicilia militi-'bus aliquot ſpicula, in Sardinia in muro circumeunti vigilias 'equiti, ſcipionem, quem in manu tenuerat, arſiſſe, et litora cre-'bris ignibus fulſiſſe.'

Theſe appearances are called by both French and Spaniards inhabiting the coaſts of the mediterranean, St. Helme or St. Telme's

with any perſon engaged in the inquiry. At preſent, indeed, when we know, from the experiment of Marly-la-ville, that a ſtormy cloud is a great electric maſs, the action of which extends itſelf ſenſibly even to bodies, which are upon the ſurface of the earth, we muſt agree, by reflecting on them, that the lights, which have been ſeen upon the croſſes placed on the tops of ſeveral ſteeples, thoſe, which the Roman ſoldiers ſaid they had obſerved at the end of their pikes, and thoſe lambent flames, which appear upon the maſts of ſhips, which mariners call St. Helmo's fire, are ſo many electrical phænomena. But until the moment that this experiment was made, which open'd our eyes with regard to the poſſibility and nature of theſe marvellous effects, theſe appearances were regarded either as popular illuſions, or falſe prodigies, or even as luminous vapours, which might be ranged in the claſs of *phoſphori*. Moreover, as theſe were ſeen but ſeldom, if ever we had been tempted to attribute them to the influence of ſtormy clouds, we might have been diſſuaded therefrom, by conſidering the little agreement there is, between the rarity of

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fires; by the Italians, the fires of St. Peter and St. Nicholas, and are frequently taken notice of by the writers of voyages.

If ſome late accounts from France are to be depended upon, we are informed, that at Plauzet it has been obſerved for time immemorial; and M. Binon, the curé of the place, bears his teſtimony of the truth, that, for twenty-ſeven years, which he has reſided there in that capacity, in great ſtorms, accompanied with black clouds, and frequent lightnings, the three pointed extremities of the croſs of the ſteeple of that place appear ſurrounded with a body of flame; and that, when this phænomenon has been ſeen, the ſtorm was no longer to be dreaded, and calm weather returned ſoon after.

of theſe effects, and the frequency of the cauſes, which might produce them.

We ſee, therefore, how important it is to deſcribe exactly the phænomena we obſerve: otherwiſe, how long may it be, before we can deduce any real inſtruction from thoſe, which we have been informed of in a negligent and ſuperficial manner? We have heard all our lives of St. Helmo's fire, of thoſe which the antients call Caſtor and Pollux, and of the comazants of our mariners. But, from what we have had related to us, and from what we have read, who could have been prevailed upon to range them with electrical phænomena? We have heard them repreſented, as thin lambent ſhining lights, a kind of phoſphoreal vapour: but there is a paſſage in the memoirs of the Count de Forbin, quoted by our author, wherein mention is made of St. Helmo's fire; which if any one, well verſed in the phænomena of electricity, had carefully attended to and conſidered a few years ago, he might have prognoſticated ſucceſs to Mr. Franklin, when he propoſed his experiment upon thunder. "In the night (ſays the author of "thoſe memoirs) on a ſudden it became exceed-"ingly dark, and thunder'd and lightened moſt dread-"fully. As we were threatened with the ſhip's "being torn to pieces, I ordered the ſails to be taken "in: We ſaw, upon different parts of the ſhip, above "thirty St. Helmo's fires: Among the reſt, there was "one upon the top of the vane of the main-maſt, "which was more than a foot and half in height. "I ordered one of the ſailors to take it down: When "this man was on the top, he heard this fire; its "noiſe reſembled that of fired wet gunpowder: I

"ordered

" ordered him to lower the vane, and come down;
" but ſcarce had he taken it from its place, but
" the fire left it, and fixed itſelf upon the top of
" the mainmaſt, from which it was impoſſible to
" remove it; and continued there a conſiderable time,
" until it went out by little and little, *&c.*"

If all the authors, who have taken notice of St. Helmo's fire, had ſpoken of it as this juſt quoted, philoſophers might have reproached themſelves for its having been ſo long before they had a juſt idea thereof, and for their not having ſhewn the principle upon which it depended. But how few hiſtorians are there, who could have related this fact with circumſtances ſo proper to put us in a right train, as thoſe juſt mentioned?

" And here I cannot but obſerve, as I am con-
" vinced, that the matter of thunder and that of
" of electricity are one and the ſame, how vaſt an
" idea muſt the attending to the before-mentioned
" paſſage excite in the mind of perſons, accuſtomed
" to the phænomena of electricity? How immenſe
" a quantity of it muſt they conceive to have been at
" that time in the atmoſphere ſurrounding the ſhip,
" and within the verge of its action, to furniſh more
" than thirty St. Helmo's fires; the ſame, in fact,
" which we ſee at the ends of our conductors in
" electriſing, one of which was more than a foot and
" half in height? At this time, and under theſe cir-
" cumſtances, the maſts, yards, and every part of
" the ſhip, I conſider as conductors of electricity,
" between the, at this time electriſed, atmoſphere,
" and the ſea: and tho', being of a vegetable nature,
" and, if dry, even of the worſt kind for this pur-
" poſe,

" poſe, they conducted electricity much leſs perfectly " than metal under the like circumſtances would " have done, I doubt not, but that they were greatly " inſtrumental in averting the danger, with which " the ſhip was threatened.

" Upon theſe conſiderations, I do not ſcruple to " recommend, as Mr. Franklin has done, communi- " cations of metal between the ſpindles and iron- " work at the tops of the maſts of ſhips, and the ſea; " or, which will anſwer the ſame purpoſe, the bilge " water in the well. This can be liable to little " objection, as the doing it is neither difficult, nor " expenſive; an iron wire, of the thickneſs of a gooſe- " quill, conducting electricity more readily than any " piece of timber, however large; and theſe maſts " do it ſo much the worſe, as they are of a reſinous " nature.

" From attending to theſe phænomena, we every " day ſee more and more the perfect analogy (to " compare great things with ſmall) between the " highly electriſed glaſs jar, in the experiment of " Leyden, and a cloud replete with the matter of " thunder. But more of this poſſibly upon ſome " future occaſion.

" Though the number and continuance of the St. " Helmo's fires, in the paſſage before-mentioned, " probably tended greatly to preſerve the ſhip from " the deſtruction, with which it was then threatened, " yet the cauſe may be too great, and come on too " faſt, to be leſſened enough by theſe means to avert " the miſchief. Thus in the account, publiſhed in " the * *Philoſophical Tranſactions*, from Captain John " Waddel,

* Vol. XLVI. p. 111.

" Waddel, his ſhip was almoſt beaten to pieces by " the thunder and lightning: although, as he expreſſes " himſelf, there were ſundry large comazants over " head, ſome of which ſettled on the ſpindles on " the topmaſt-heads, and burnt like very large " torches. When this account was written, theſe " phænomena were only conſidered as the preſages " or attendants of a ſtorm, and no ſort of inference " propoſed from them."

But to return to our author: His work cloſes with a ſeries of experiments, intended to demonſtrate the validity of the concluſions exhibited therein. Theſe merit the particular attention of thoſe converſant in theſe matters; but I muſt refer you here to the work itſelf, and only obſerve, that ſome of the experiments are made *in vacuo*, and are of the ſame kind with thoſe which I communicated to the Royal Society in February 1752; and which have been ſince publiſhed in the *Philoſophical Tranſactions* *.

Upon the whole, I think the treatiſe before us a very valuable one, as it gives us the ſtill riper thoughts of an able writer upon a difficult, and, till very lately, an almoſt unknown, ſubject; of one, who, beſides his inquiries into this part of philoſophy, has a great compaſs in the knowlege of nature, and is therefore well qualified to inveſtigate her phænomena.

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* Vol. XLVII. p. 363, et ſeq.