

XI. *Observations and Experiments on the Light of Bodies in a State of Combustion.* By the Rev. Mr. Morgan; communicated by the Rev. Richard Price, LL.D. F.R.S.

Read January 27, 1785.

THE discussion which I now wish to lay before the Royal Society is nothing more than a series of facts, and of conclusions which seem to flow from those facts, and from an attention to the following data.

I. That light is a body, and like all other bodies subject to the laws of attraction.

II. That light is an heterogeneous body, and that the same attractive power operates with different degrees of force on its different parts.

III. That the light which escapes from combustibles when decomposed by heat, or by any other means, was, previous to its escape, a component part of those substances.

It is an obvious conclusion from these data, that when the attractive force, by which the several rays of light are attached to a body, is weakened, some of those rays will escape

escape sooner than others. Those which are united with the least degree of power will escape first, and those which adhere to it most strongly will (if I may be allowed the expression) be the last to quit their basis. We may here have recourse to a familiar fact, which is analogous to this, and will illustrate it. If a mixture, consisting of equal parts of water, of spirits of wine, and of other more fixed bodies, be placed over a fire; the first influence of that heat, to which all the ingredients are alike exposed, will carry off the spirits of wine only. The next will carry off the spirits of wine blended with particles of water. A still greater degree of heat will blend with the vapour which escapes a part of the more fixed bodies, till at length what evaporates will be a mixture of all the ingredients which were at first exposed to the fire. In like manner, when the surface of a combustible is in a state of decomposition, those parts which are the least fixed, or which are united to it with the least force, will be separated first. Amongst these the indigo rays of light will make the earliest appearance. By increasing the heat we shall mix the violet with the indigo. By increasing it still more we shall add the blue and the green to the mixture, till at length we reach that intensity of heat which will cause all the rays to escape at the same instant, and make the flame of a combustible perfectly white. It is not my present design to shew why the most refrangible rays are the first which escape from a burning body, but to enumerate the several facts which seem to shew, that such a general law takes place in combustion; and that the various colours of bodies in this state are uniformly regulated by that decrease of attractive force now described.

By examining the flame of a common candle we may observe, that its lowest extremities, or the part in which the black colour of the wick terminates, discharges the least heat; and that, as the vertex of the flame is approached, a successive order of parts is passed through, in which the lowest is continually adding to the heat of what is just above it, till we come to the top of the flame, near which all the heat is collected into a focus. At the lowest extremity, however, where the heat is inconsiderable, a blue colour may be always observed; and from this appearance, amongst others, it may, I think, be safely concluded, that the blue rays are some of those which escape from combustibles in an early period of their decomposition; and that if the decomposition could be examined in a period still more early, the colour of their flame would be violet. By an *a priori* deduction of this kind, I was led to watch the appearances of a candle more attentively; whence I found that to the external boundary of a common candle is annexed a filament of light, which, if proper care be taken to prevent the escape of too much smoke, will appear most beautifully coloured with the violet and indigo rays. To the preceding instance of a common candle many facts may be added, which speak a similar language. If sulphur or æther is burned, or any of those combustibles whose vapour is kindled in a small degree of heat, a blue flame will appear, which, if examined by the prism, will be found to consist of the violet, the indigo, the blue, and sometimes a small quantity of the green rays. The best mode, however, of shewing the escape of some rays by that degree of heat which will not separate others till increased, is the following. Give a piece of brown paper a spherical form, by pressing it upon

upon any hard globular substance. Gradually bring the paper, thus formed, to that distance from the candle at which it will begin to take fire. In this case a beautiful blue flame may be seen, hanging as it were by the paper till a hole is made in it, when the flame, owing to the increased action of the air upon all parts of it, becomes white, though the edges still continue of a blue or violet colour. As a confirmation of what I have concluded from the preceding facts, it may be observed, that the very flame which, when exposed to a certain degree of heat, emitted the most refrangible rays only, will, if exposed to a greater degree of heat, emit such as are less refrangible. The flames of sulphur, spirits of wine, &c. when suddenly exposed to the heat of a reverberatory, change their blue appearance for that which is perfectly white. But to gain a more striking diversity of this fact, I adopted Mr. MELVILL's mode of examining bodies whilst on fire. I darkened my room, and placed between my eye and the combustible a sheet of pasteboard, in the center of which I made a small perforation. As the light of the burning body escaped through this perforation, I examined it with a prism, and observed the following appearances. When the spirits of wine were set on fire, all the rays appeared in the perforation; but the violet, the blue, and the green, in the greatest abundance. When the combustion of the spirits was checked by throwing some sal ammoniac into the mixture, the red rays disappeared; but when, by the long continuance of the flame, the sal ammoniac was rendered so hot as to increase, rather than diminish the combustion, the red rays again appeared at the perforation. If the screen was managed so that the different parts of the flame might be examined separately, I always observed that

the colours varied according to the degree of heat. At the base of the flame, or where the heat was least, the indigo, the violet, and a very small tinge of the blue and green appeared. As I approached the vertex of the flame, the rays which escaped became more and more numerous till I reached the top, when all the rays appeared in the prism. It should be attended to, that when the red rays first made their appearance, their quantity was small, and gradually increased as the eye in its examination approached that part where the heat was greatest. Mr. MELVILL, when he made some of the preceding experiments, observed, that the yellow rays frequently escaped in the greatest abundance; but this singularity proceeded from some circumstances which escaped his attention. In consequence of mixing acids or salts with the burning spirits, a very dense fume of unignited particles arises, and before the rays of the burning body arrive at the perforation where the prism catches them, they must pass through a medium which will absorb a great part of the indigo and the violet. On the other hand, owing to the imperfection of the decomposition, very few of the red rays are separated from their basis, and consequently the yellow and the orange rays are those alone which pass through the unburnt smoke of the flame.

I would now proceed with observing, that, besides the increase or decrease of heat, there are other modes of retarding or accelerating the combustion of bodies, by which also may be examined some of the preceding illustrations.

1. A candle burns most rapidly and brilliantly in dephlogisticated air.

2. The

2. The blue colour of a sulphureous flame in pure air is changed into a dazzling white.

3. The flame of inflammable air, when mixed with nitrous air, is green. It is white strongly tinged with the indigo and violet when mixed with common air; but when mixed with dephlogisticated air, or surrounded by it, the brilliancy of its flame is most singularly beautiful.

If the preceding facts prove that light, as an heterogeneous body, is gradually decomposed during combustion; if they prove, likewise, that the indigo rays escape with the least heat, and the red with the greatest; I think we may rationally account for several singularities in the colours of different flames. If a piece of paper, impregnated with a solution of copper in the nitrous acid, be set on fire, the bottom and sides of the flame are always tinged with green. Now this flame is evidently in that weak state of decomposition, in which the most refrangible rays escape in the greatest abundance; but of these rays the green escape most plentifully through the unignited vapour and that portion of the atmosphere which separates the eye from the flame. The peculiarity which I have now endeavoured to account for may be observed in the greatest perfection in brass founderies. The heat in this instance, though very strong, is scarcely adequate to the decomposition of the metallic vapour which escapes from the melted brass. A very singular flame therefore appears to the eye; for while its edges are green, its body is such as to give the objects around a very pallid or ghastly appearance, which is the consequence of its wanting that portion of red rays which is necessary to make a perfect white.

The most singular phænomenon attending a burning body is, perhaps, the red appearance it assumes in its last stage of combustion. The preceding facts and observations may, I think, help us to explain it.

1. After a body has continued to burn for some time, its external surface is to be regarded as having lost a great portion, if not the whole of those rays which the first application of heat was able to separate. But these rays were the indigo, the violet, the blue, and perhaps the green. Nothing, therefore, will remain to be separated, but the yellow, the orange, and the red. Consequently, the combustion of the body, in its last state of decomposition, can assume no other than a reddish appearance. But

2. Let us consider the external surface of the combustible as annexed to an inner surface, which may be partly, but not so perfectly decomposed as itself: for the violence of the heat will be found to lessen in its effects the nearer it approaches to the center of the substance which is exposed to it. Hence we are to consider the parts which are just covered by the external surface as having lost less of their component light than the external surface itself. Or the former may retain the green rays when the latter has lost both indigo, violet, blue, and green.

3. Those parts which are nearer the center of the body than either of the preceding must, as they are further from the greatest violence of the heat, have lost proportionably fewer of their rays. Or while the more external parts may have lost all but the red, these may have lost only the indigo and violet.

4. The most central parts may be unaffected by the heat; and whenever the fire does reach these parts, they will immediately discharge their indigo rays, and be decomposed in the
gradual

gradual manner which I have already described. A piece of rotten wood, whilst burning, will exemplify and confirm the preceding illustration. When influenced by the external air only, if examined through a prism, no rays will be found to escape but the orange and the red. By blowing upon the burning wood with a pair of bellows, the combustion, being increased, will affect those internal parts of the body which were not acted upon before. These parts, therefore, will begin to lose their light, and a prism will shew the green, the blue, the violet, and indigo, all appearing in succession. Appearances similar to the preceding may be observed in a common kitchen fire. When it is faintest, its colour is most red, the other rays having been emitted, and the combustion at a stand; but by blowing upon it in this state, its brightness will be increased, and more and more of the rays which are yielded by the internal parts of the body will come to the eye, till at length, by continuing to blow, the combustion will be made so complete as to yield all the rays, or to make it appear perfectly white.

Many are the varieties discoverable in the flames and in the appearances of fixed burning bodies to which the preceding observations may be applied; but, to avoid unnecessary amplification I will take notice only of what appears to me an imperfection in Sir ISAAC NEWTON's definition of flame. He conjectures, that it may be a vapour heated red-hot. I think I should rather say, that flame is an instance of combustion whose colour will be determined by the degree of decomposition which takes place. If it be very imperfect, the most refrangible rays only will appear. If it be very perfect, all the rays will appear, and its flame will be brilliant in proportion

proportion to this perfection. There are flames, however, which consist of burning particles, whose rays have partly escaped before they ascended in the form of vapour. Such would be the flame of a red-hot coal, if exposed to such a heat as would gradually disperse it into vapour. When the fire is very low under the furnace of an iron foundry, at the upper orifice of the chimney a red flame of this kind may be seen, which is different from the flame that appears immediately after fresh coals have been thrown upon the fire; for, in consequence of adding such a supply to the burning fuel, a vast column of smoke ascends, and forms a medium so thick as to absorb most of the rays excepting the *red*.

Experiments on electric light.

If we would wish to procure any degree of certainty in any hypothesis which we may form concerning electrical light, perhaps the following general deductions may be of some service to us.

1. There is no fluid or solid body in its passage through which the electric fluid may not be made luminous. In water, spirits, oil, animal fluids of all kinds, the discharge of a Leyden phial of almost any size will appear very splendid, provided we take care to place them in the circuit, so that the fluid may not pass through too great a quantity of them. My general method is to place the fluid, on which I mean to make the experiment, in a tube three-quarters of an inch in diameter, and four inches long. I stop up the orifices of the tube with two corks, through which I push two pointed wires, so that the points may approach within one-eighth of an inch to each other.

other. The fluid in passing through the interval which separates the wires is always luminous, if a force be used sufficiently strong. I should observe, that the glass tube, if not very thick, always breaks when this experiment succeeds. To make the passage of the fluid luminous in the acids, they must be placed in capillary tubes, and two wires introduced, as in the preceding experiment, whose points shall be very near each other. It is a well known fact, that the discharge of a small Leyden phial in passing over a strip of gold, silver, or Dutch metal leaf, will appear very luminous. By conveying the contents of a jar, measuring two gallons, over a strip of gold leaf one-eighth of an inch in diameter, and a yard long, I have frequently given the whole a dazzling brightness. I cannot say, that a much greater length might not have been made very splendid, nor can I determine to what length the force of a battery might be made luminous in this manner. We may give this experiment a curious diversity, by laying the gold or silver leaf on a piece of glass, and then placing the glass in water; for the whole gold leaf will appear most brilliantly luminous in the water by exposing it, thus circumstanced, to the explosion of a battery.

2. The difficulty of making any quantity of the electrical fluid luminous in any body increases as the conducting power of that body increases.

EXP. I. In order to make the contents of a jar luminous in boiling water, a much higher charge is necessary than would be sufficient to make it luminous in cold water, which is universally allowed to be the worst conductor.

EXP. II. I have various reasons for believing the acids to be very good conductors. If therefore into a tube, filled with water, and circumstanced as I have already described, a few drops

drops of either of the mineral acids are poured, it will be almost impossible to make the fluid luminous in its passage through the tube.

EXP. III. If a string*, whose diameter is one-eighth of an inch and whose length is six or eight inches, is moistened with water, the contents of a jar will pass through it luminously, but no such appearance can be produced by any charge of the same jar, provided the same string be moistened with one of the mineral acids. To the preceding instance we may add the various instances of metals which will conduct the electrical fluid without any appearance of light, in circumstances the same with those in which the same force would have appeared luminous in passing through other bodies whose conducting power is less. But I proceed to observe,

III. That the ease with which the electrical fluid is rendered luminous in any particular body is increased by increasing the rarity of the body. The appearance of a spark or of the discharge of a Leyden phial, in rarefied air is well known. But we need not rest the truth of the preceding observation on the several varieties of this fact; similar phænomena attend the rarefaction of æther, of spirits of wine, and of water.

EXP. IV. Into the orifice of a tube, 48 inches long, and two-thirds of an inch in diameter, I cemented an iron ball, so as to bear the weight which pressed upon it when I filled the tube with quicksilver, leaving only an interval at the open end, which contained a few drops of water. Having inverted the tube, and plunged the open end of it into a basin of mercury, the mercury in the tube stood nearly half an inch lower than it

* The thickness and diameter of the string should be regulated by the force we employ.

did in a barometer at the same instant, owing to the vapour which was formed by the water. But through this rarefied water the electrical spark passed as luminously as it does through air equally rarefied.

EXP. V. If, instead of water, a few drops of spirits of wine are placed on the surface of the mercury, phenomena similar to those of the preceding experiment will be discovered, with this difference only, that as the vapour in this case is more dense, the electrical spark in its passage through it is not quite so luminous as it is in the vapour of water.

EXP. VI. Good æther substituted in the room of the spirits of wine will press the mercury down so low as the height of 16 or 17 inches. The electrical fluid in passing through this vapour (unless the force be very great indeed) is scarcely luminous. But if the pressure on the surface of the mercury in the basin be gradually lessened by the aid of an air-pump, the vapour will become more and more rare, and the electric spark in passing through it more and more luminous.

EXP. VII. I could not discover that any vapour escaped from the mineral acids when exposed *in vacuo*. To give them, therefore, greater rarity or tenuity, I found different methods necessary. With a fine camel-hair pencil, dipped in the vitriolic, the nitrous, or the marine acid, I drew upon a piece of glass a line about one-eighth of an inch broad. In some instances I extended this line to the length of 27 inches, and found that the contents of an electric battery, consisting of 10 pint phials coated, would pass over the whole length of this line with the greatest brilliancy. If by widening the line, or by laying on a drop of the acid, its quantity was increased in any particular part, the charge, in passing through that part, never appeared luminous. Water, spirits of wine, circum-

franced similarly to the acids in the preceding experiment, were attended with similar, but not equal effects, because, in consequence of the inferiority of their conducting power, it was necessary to make the line through which the charge passed considerably shorter.

4. The brilliancy or splendor of the electric fluid in its passage through any body is always increased by lessening the dimensions of that body. I would explain my meaning by saying, that a spark, or the discharge of a battery which we might suppose equal to a sphere one quarter of an inch in diameter, would appear much more brilliant if the same quantity of fluid is compressed into a sphere one-eighth of an inch in diameter. This observation is the obvious consequence of many known facts. If the machine be large enough to afford a spark whose length is nine or ten inches, this spark may be seen sometimes forming itself into a brush, in which state it occupies more room, but appears very faintly luminous. At other times the same spark may be seen dividing itself into a variety of ramifications which shoot into the surrounding air. In this case, likewise, the fluid is diffused over a large surface, and in proportion to the extent of that surface, so is the faintness of the appearance. A spark, which in the open air cannot exceed one quarter of an inch in diameter, will appear to fill the whole of an exhausted receiver four inches wide and eight inches long. But in the former case it is brilliant, and in the latter it grows fainter and fainter as the size of the receiver increases. To prove the observation, which I think may be justified by the preceding facts, I made the following experiments.

EXP. VIII. To an insulated ball, four inches in diameter, I fixed a silver thread, about four yards long. This thread, at the end which was remotest from the ball, was fixed to another

insulated substance. I brought the ball within the striking distance of my conductor, and the spark in passing from the conductor to the ball appeared very brilliant; but the whole length of the silver thread appeared faintly luminous at the same instant. In other words, when the spark was confined within the dimensions of a sphere one-eighth of an inch in diameter, it was bright; but, when diffused over the surface of air which received it from the thread, its light became so faint as to be seen only in a dark room. If I lessened the surface of air which received the spark by shortening the thread, I never failed to increase the brightness of the appearance.

EXP. IX. To prove that the faintness of the electric light *in vacuo* depends on the enlarged dimensions of the space through which it is diffused, we have nothing more to do than to introduce two pointed wires into the vacuum, so that the fluid may pass from the point of the one to the point of the other, when the distance between them is not more than the one-tenth of an inch. In this case we shall find a brilliancy as great as in the open air.

EXP. X. Into a Torricellian vacuum, 36 inches in length, I conveyed as much air as would have filled two inches only of the exhausted tube, if it were inverted in water. This quantity of air afforded resistance enough to condense the fluid as it passed through the tube into a spark 38 inches in length. The brilliancy of the spark in condensed air, in water, and in all substances through which it passes with difficulty, depends on principles similar to those which account for the preceding facts. I would now proceed to shew,

5. That in the appearances of electricity, as well as in those of burning bodies, there are cases in which all the rays of light do not escape; and that the most refrangible rays are those

which escape first or most easily. The electrical brush is always of a purple or bluish hue. If you convey a spark through a Torricellian vacuum, made * *without* boiling the mercury in the tube, the brush will display the indigo rays. The spark, however, may be divided and weakened even in the open air, so as to yield the most refrangible rays only.

EXP. XI. To an insulated metallic ball, four inches in diameter, I fixed a wire a foot and a half long. This wire terminated in four ramifications, each of which was fixed to a metallic ball half an inch in diameter, and placed at an equal distance from a metallic plate, which communicated by metallic conductors with the ground. A powerful spark, after falling on the large ball at one extremity of the wire, was divided in its passage from the four small balls to the metallic plate. When I examined this division of the fluid in a dark room, I discovered some little ramifications which yielded the indigo rays only: indeed, at the edges of all weak sparks the same purple appearance may be discovered. We may likewise observe, that the nearer we approach the center of the spark, the greater is the brilliancy of its colour. But I would now wish to shew

6. That the influence of different media on electrical light is analogous to their influence on solar light, and will help us to account for some very singular appearances.

EXP. XII. Let a pointed wire, having a metallic ball fixed to one of its extremities, be forced obliquely into a piece of wood, so as to make a small angle with the surface of the wood, and to make

* If the Torricellian vacuum is made with mercury perfectly purged of air, it becomes a perfect non-conductor. This, I believe, will be proved decisively by some experiments which I hope will be soon communicated to the Royal Society.

the point lie about one-eighth of an inch below the surface. Let another pointed wire, which communicates with the ground, be forced in the same manner into the same wood, so that its point likewise may lie about one-eighth of an inch below the surface, and about two inches distant from the point of the first wire. Let the wood be insulated, and a strong spark which strikes on the metallic ball will force its passage through the interval of wood which lies between the points, and appear as red as blood. To prove that this appearance depends on the wood's absorption of all the rays but the red, I would observe, that the greater the depth of the points is below the surface, the less mixed are the red rays. I have been able sometimes, by increasing or diminishing the depth of the points, to give the spark the following succession of colours. When they were deepest below the surface, the red only came to the eye through a prism. When they were raised a little nearer the surface, the red and orange appeared. When nearer still, the yellow; and so on till, by making the spark pass through the wood very near its surface, all the rays were at length able to reach the eye. If the points be only one-eighth of an inch below the surface of soft deal wood, the red, the orange, and the yellow rays will appear as the spark passes through it. But when the points are at an equal depth in a harder piece of wood (such as box) the yellow, and perhaps the orange, will disappear. As a farther proof that the phænomena I am describing are owing to the interposition of the wood, as a medium which absorbs some of the rays and suffers others to escape, it may be observed, that when the spark strikes very brilliantly on one side of the piece of deal, on the other side it will appear very red. In like manner a red appearance may be given to a spark which strikes
brilliantly

brilliantly over the inside of a tube, merely by spreading some pitch very thinly over the outside of the same tube.

EXP. XIII. I would now give another fact, whose singularities depend very much on the influence of the medium through which the electrical light is made to pass. If into a Torricellian vacuum, of any length, a few drops of æther are conveyed, and both ends of the vacuum are stopped up with metallic conductors, so that a spark may pass through it, the spark in its passage will assume the following appearances. When the eye is placed close to the tube, the spark will appear perfectly white. If the eye is removed to the distance of two yards, it will appear green; but at the distance of six or seven yards, the colour of the spark will be reddish. These changes evidently depend on the quantity of medium through which the light passes; and the red light more particularly, which we see at the greatest distance from the tube, is accounted for on the same principle as the red light of a distant candle or a beclouded sun.

EXP. XIV. Dr. PRIESTLEY long ago observed the red appearance of the spark when passing through inflammable air. But this appearance is very much diversified by the quantity of medium, through which you look at the spark. When at a very considerable distance, the red comes to the eye unmixed; but, if the eye is placed close to the tube, the spark appears white and brilliant. In confirmation, however, of some of my conclusions, I would observe, that by increasing the quantity of fluid which is conveyed through any portion of inflammable air, or by condensing that air, the spark may be entirely deprived of its red appearance, and made perfectly brilliant. I have only to add, that all weak explosions and
sparks,

sparks, when viewed at a distance, bear a reddish hue. Such are the explosions which have passed through water, spirits of wine, or any bad conductor, when confined in a tube whose diameter is not more than an inch. The reason of these appearances seems to be, that the weaker the spark or explosion is, the less is the light which escapes; and the more visible the effect of any medium which has a power to absorb some of that light.

The preceding observations concerning electrical light were the result of my attempts to arrange, under general heads, the principal singularities attending it. They may, perhaps, assist others in determining how far they may have led my mind astray in giving birth to a theory which I would now briefly describe in a few queries.

I. If we consider all bodies as compounds, whose constituent parts are kept together by attracting one another with different forces, can we avoid concluding, that the operations of that attractive force are regulated, not only by the quality, but the quantity likewise of those component parts? If an union of a certain number of one kind of particles, with a certain number of a second and third kind of particles, forms a particular body, must not the bond which keeps that body together be weakened or strengthened by increasing or diminishing any one of the different kinds of particles which enter into its constitution?

II. When, to the natural share of the electric fluid already existing in the body, a fresh quantity of the same fluid is added, must not some of the component parts of that body escape; or must not that attractive force which kept all together be so far weakened as to let loose some constituent parts,

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parts, and amongst these the particles of light in particular?

III. Must not this separation of parts be great in proportion to the quantity of extraneous particles which are added to the body? Or (agreeable to the 4th observation) must not the spark be more splendid and brilliant, the more the electrical fluid is concentrated in any given space?

IV. In the diminution or alteration of that attractive force on which depends the constitution of bodies, may there not be a gradation which, in the present case, as well as in that of burning bodies, will cause the escape of some rays sooner than others?

Observations on phosphoric light.

It is obvious, from Mr. B. WILSON's experiments, that there are many curious diversities in the appearances of phosphori. Some shells, prepared agreeably to his directions, after exposure to the sun or to the flash of a battery, emit a purple, others a green, and others a reddish light. If with Mr. WILSON we suppose, that these shells are in a state of slow combustion, may we not conclude, that some are just beginning to burn, and therefore, agreeably to what I have observed on combustible bodies, emitting the most refrangible rays; whilst others are in a more advanced state of combustion, and therefore emitting the least refrangible. If this conclusion be right, the shells which are emitting the purple, or the green, must still retain the yellow, the orange, and the red, which will also make their appearance as soon as the combustion is sufficiently increased.

EXP.

EXP. xv. Place a shell whilst emitting its green rays on a warm shovel, and the appearance of the shell will be soon changed into that of a yellow mixed with red. To Mr. WILSON's theory, however, of slow combustion the following objections may be opposed.

1°. If phosphoric shells owe their light to this cause, we must consider the word combustion when applied to them as implying in its signification all those circumstances which are the usual attendants of a body whilst on fire. Amongst other necessary consequences in such a case, the increase of heat must increase the decomposition of the combustible; whereas we discover an effect the very opposite to this in the appearance of a phosphoric body, which never fails to lose its light entirely in a certain degree of heat, without losing the power of becoming phosphoric again when it has been sufficiently cooled. Besides, when a phosphoric shell has been made very hot, and while it has continued so, I have conveyed the most brilliant discharge of a battery over it without effect. In other words, heat, or the very cause which promotes combustion in all other instances, in this particular case puts an end to it. Mr. WILSON, in his Treatise on Phosphori, has described an experiment similar to the preceding. But the result he mentions is different from that here mentioned. However, from a regard to his authority, I have so frequently repeated my trials that I cannot justly suspect myself of any inaccuracy. 2°. When bodies are wasted by combustion, they can never be made to re-assume the appearances which they previously displayed. No power can give to ashes the phænomena of a burning coal. But phosphoric bodies are very different in this respect; for a shell may be made to lose all its light by exposure to heat, and again

may be made as luminous as ever by exposure to the sun. But 3°. It is observable, that some bodies, which are most beautifully phosphoric, or which, according to Mr. WILSON's theory, are in the best state of slow combustion; it is observable, I say, that the same bodies are the most obstinate in resisting the fire. The diamond, which to be decomposed requires the force of a most powerful furnace, is, according to this theory, wasting away, owing to a separation of parts which is promoted by the weakest influence of the sun's rays.—Without determining whether the preceding objections be valid, let us now see the consequence of admitting the common hypothesis, that the detention of those rays which fall upon phosphori is owing to some force which prevents their immediate reflection, but is not adequate to their entire absorption. This force, whatever it be, cannot well be supposed to operate with equal power on all the rays. And if this be not the case, I think we cannot avoid concluding, that phosphoric shells will assume different colours, owing to the earlier and later escape of the different rays of light. This conclusion is justified by an experiment which I have already appealed to. When the force is such as to admit of the escape of the purple, the blue, and the green, we have only to lessen that force by warming the body, and the yellow, the orange, and red escape. It is proved by BECCARIA's extensive experience on this subject, that there is scarcely any body which is not phosphoric, or which may not be made so by heat. But as the phosphoric force is most powerful when the purple rays only escape, so we are to conclude, that it is weakest when it is able to retain the red rays only. This conclusion is agreeable to several facts. Chalk, oyster-shells, together with those phosphoric bodies whose goodness

has been very much impaired by long keeping; when finely powdered and placed within the circuit of an electrical battery, will exhibit by their scattered particles a shower of light; but these particles will appear reddish, or their phosphoric power will be sufficient only to detain the yellow, orange, and red rays. When spirits of wine are in a similar manner brought within the circuit of a battery, a similar effect may be discovered; its particles diverge in several directions, displaying a most beautiful golden appearance. The metallic calces are, of all bodies, those which are rendered phosphoric with the greatest difficulty. But even these may be scattered into a shower of red luminous particles by the electric stroke.

Norwich, Oct. 7, 1784.

POSTSCRIPT by the Rev. Dr. PRICE.

BY the *phosphoric* force mentioned in the last paragraph of this paper, Mr. MORGAN appears to mean, not the force with which a phosphoric body *emits*, but the force with which it *absorbs* and *retains* light. This last force is proportioned to the degree of attraction between the phosphoric body and light; and therefore must (as Mr. MORGAN observes) be *weakest* when it emits so freely the light it has imbibed as not to retain those rays which adhere to it most strongly. According to Mr. MORGAN's theory, these rays are those which

are least refrangible. The observations and experiments in this paper seem to render this theory probable. It is, however, an objection to it, that the less refrangibility of rays seems to imply a less force of attraction between them and the substances which refract them; but it should be considered, that, possibly, the force of cohesion, which unites the rays of light to bodies, may be a different power from that which refracts them.

