(5.) The phenomenon of a change of refrangibility proves to be extremely common, especially in the case of organic substances such as those ordinarily met with, in which it is almost always manifested to a greater or less degree.

(6.) It affords peculiar facilities for the study of the invisible rays of the spectrum more refrangible than the violet, and of the absorbing action of media with respect to them.

(7.) It furnishes a new chemical test, of a remarkably searching character, which seems likely to prove of great value in the separation of organic compounds. The test is specially remarkable for this, that it leads to the independent recognition of one or more sensitive substances in a mixture of various compounds, and shows to a great extent, before such substances have been isolated, in what menstrua they are soluble, and with what agents they enter into combination. Unfortunately, these observations for the most part require sunlight.

(8.) The phenomena of internal dispersion oppose fresh difficulties to the supposition of a difference of nature in luminous, chemical, and phosphorogenic rays, but are perfectly conformable to the supposition that the production of light, of chemical changes, and of phosphoric excitement, are merely different effects of the same cause. The phosphorogenic rays of an electric spark, which, as is already known, are intercepted by glass, appear to be nothing more than invisible rays of excessively high refrangibility, which there is no reason for supposing to be of a different nature from rays of light.

NOTES ADDED DURING PRINTING.

Note A. Art. 23.

SHORTLY after the preceding paper was forwarded to the Royal Society, I found M. EDMOND BECQUEREL's map of the fixed lines of the chemical spectrum, which is published in the 40th volume of the 'Bibliothèque Universelle de Genève' (July and August 1842). I had seen in MOIGNO's 'Repertoire d'Optique Moderne,' that the map had been presented to the French Academy, and naturally felt anxious to obtain it; but not finding any further notice of it either in that work or in the 'Comptes Rendus,' I supposed that it had not yet been published. The principal lines in this map I recognized at a glance. M. BECQUEREL's broad band I is my *l*; his group of four lines M with the preceding band forms my group *m*; his group of four lines N forms the first four of my group *n*; his line O is my *n*. It is only in the last group that there can be any doubt as to the identification; but I feel almost certain that M. BECQUEREL's P is my *o*, and the next two lines, the last in his map, are the two between *o* and *p*. It is difficult at first to believe that the strong line *p* should have been left out, while the two faint lines between *o* and *p* are represented, but the difficulty is, I think, removed by considering the feeble photographic action in that part of the spectrum. M. BECQUEREL expressly states that lines were seen beyond the last he has represented, though they were hardly distinct; and on comparing together his map, Mr. KINGSLEY'S photographs, and my own map, I think hardly any doubt can remain as to the identification.

I take this opportunity of referring to another very interesting paper of M. BECQUEREL'S, entitled 'Des effets produits sur les corps par les rayons solaires,' which is published in the Annales de Chimie, tom. ix. (1843) p. 257, with which I was not acquainted till lately, or I should have referred to it before. This paper contains, among other things, an investigation of the effects of transparent and coloured screens on the luminous, chemical, and phosphorogenic rays, in which it is shown, that, notwithstanding the great difference in the action of a given screen on the three classes of rays, when we study the effect of the incident rays as a whole, its action is the very same when we confine our attention to rays of any one refrangibility. Among the media employed by M. BECQUEREL, are some whose absorbing effect I have mentioned in the present paper, as having been determined by methods depending upon the change of refrangibility. In such cases my own results, as might have been anticipated, are in perfect harmony with those of M. BECQUEREL. With respect to the results at which I have arrived regarding the nature of the phosphorogenic rays of an electric spark, which are mentioned towards the end of the paper, I have been in a good measure anticipated by M. BECQUEREL. Yet I do not think that even he was aware that so much of the effect of the spark was due to rays of such high refrangibility.

Note B. Art. 105.

I have since succeeded, by a particular arrangement, in seeing so far into the "lavender" rays as to make out the groups of fixed lines *m, n, p* by means of light received directly into the eye, and even to perceive light beyond that.

As to the colour of these rays when they are well isolated, I think the corolla of the lavender gives as good an idea of it as could be expected from the circumstances. They seem to me to want the luminousness of the blue and the ruddiness of the violet. No doubt much error and uncertainty has hitherto existed both as to the colour and as to the illuminating power of these rays, because the gray prolongation of a spectrum formed on paper by projection has been mistaken for the lavender rays.

Note C. Art. 154.

On adding common phosphoric acid to a solution of nitrate of uranium no effect seemed to be produced, but on examining the vessel some days afterwards, a precipitate was found to have fallen. This precipitate proved to be sensitive in a very high degree.

Note D. Art. 158.

I have since observed in a mineral solution a system of absorption bands so remarkable, and so closely resembling in many respects those found in the salts of peroxide of uranium, though they occur in a totally different part of the spectrum, that I think no apology is needed for mentioning the circumstance. The medium referred to is a solution of permanganate of potassa, in fact, red solution of mineral chameleon. In order to see the bands, it is essential to employ a dilute solution, or else to view it in small thickness, since otherwise the whole of the region in which the bands occur is absorbed. The bands are five in number, and are equidistant, or at least very nearly so. The first is situated at about three-fifths of a band-interval above D; the last coincides with F, or, if anything, falls a little short of it. The second and third are the most intense of the set. I have carefully examined the solution for change of refrangibility, and have not found the least trace. Ferrate of potassa shows nothing remarkable.

By means of the bands just mentioned, the colour of permanganate of potassa may be instantly and infallibly distinguished from that of certain other red solutions of manganese, the colour of which some chemists have been disposed to attribute to permanganic acid (see a paper by Mr. PEARSALL 'On red Solutions of Manganese,' Journal of the Royal Institution, New Series, No. IV. p. 49).

Note E. Art. 171.

If we suppose the angle of incidence *exactly* equal to 45°, assume $\frac{4}{3}$ for the refractive index of the fluid, and apply FRESNEL's formulæ to calculate the ratio of the intensity of light reflected at the exterior surface of a bubble, and polarized in a plane perpendicular to the plane of incidence, to that of light similarly reflected and polarized in that plane, we find 0·228 to 1, a ratio which certainly differs much from one of equality. But in order to render the two intensities equal, it is sufficient to increase the angle of incidence by only 3° 35′; and in fact, as a matter of convenience, the position of the observer was usually such that the deviation of the light was somewhat greater than 90°, and therefore the angle of incidence somewhat greater than 45°.

Note F. Art. 191.

I have since received a slab of glass of the kind here recommended, which has been executed for me by Mr. DARKER of Lambeth, and which answers its purpose admirably, the medium being eminently sensitive. Besides its general use as a screen, this slab, from its size and form, has enabled me to trace further than I had hitherto done (Arts. 75, 76) the connexion between certain fluctuations of transparency which the medium exhibits and corresponding fluctuations of sensibility.

Note G. Art. 192.

Paper washed with a mere infusion of the bark of the horse-chestnut is quickly discoloured; but a piece washed with a solution which had been purified by chemical means remained white, and proved exceedingly sensitive.

Note H. Art. 204.

I have since ordered a complete train of quartz, of which a considerable portion, comprising among other things two very fine prisms, has been already executed for me by Mr. DARKER. With these I have seen the fixed lines to a distance beyond H more than double that of p; so that the length of the spectrum, reckoned from H, was more than double the length of the part previously known from photographic impressions. The light was reflected by the metallic speculum of a SILBERMANN's heliostat, which I have received from M. DUBOSCQ-SOLEIL. With the glass train the group p was faint, but with the quartz train there was abundance of light to see not only the group p, but the fixed lines as far as Hp1, or thereabouts. From the group n to about the middle of the new region, the lines are less bold and striking than in the region of the groups H, l, m, n, but the latter part of the new region contains many lines remarkable both for their strength and for their arrangement. I hope to make a careful drawing of these lines as shown by the complete train with a summer's sun.

I have some reasons for believing that the photographic action of these highly refrangible rays is feeble, perhaps almost absolutely null. In the second of the papers referred to in Note A. (p. 300), M. BECQUEREL describes an experiment in which a prism of quartz was employed to form a spectrum; and yet the impressed spectrum formed by rays which had traversed the quartz alone was hardly longer than that formed by rays which, in addition to the quartz, had traversed a screen of pure flint-glass a centimetre in thickness. It is possible, I am inclined to think probable, that glass made with *perfectly* pure materials would be transparent like quartz, but all the specimens I have examined were decidedly defective in transparency. Besides, M. BECQUEREL, who may be allowed to be the best judge of his own experiments, considered the result just mentioned as a proof that the impressed spectrum formed by rays which had traversed quartz only did not extend, except a very trifling distance, beyond that formed by his train of glass; and yet his map, formed by means of the latter, does not take in the line p.

However, among the multitude of preparations capable of being acted on by light, it is probable that there may be some which are acted on mainly by rays of unusually high refrangibility, and which, on that very account, would not be suitable for the ordinary purposes of photography. With these it is possible that the new region of the solar spectrum might be taken photographically.

Note I. Art. 213.

I have since examined the salt, or product, whatever it may be, in the dry state, and under more favourable circumstances, and have found it sensitive, though not by any means in a high degree. It exhibits also the absorption bands which seem to run through the salts of peroxide of uranium.

In connexion with the insensibility of a solution of nitrate of uranium in ether, it seems interesting to mention a fact which I have since observed, namely, that the sensibility of a solution of nitrate of uranium in water is destroyed by the addition of a little alcohol.

Note J. Art. 217.

On repeating this experiment on a subsequent occasion, I could not satisfactorily make out the difference of character of a strong and of a weak spark from the prime conductor, perhaps because the machine was in less vigorous action; but the difference between the effects of a mere spark and of the discharge from a Leyden jar was plainly evident. I would here warn the reader, that in order to perform the experiment in such a manner as to obtain a striking and perfectly decisive result, it is essential to employ an excessively weak solution. The reason of this is evident.

A severe thunder-storm which visited Cambridge on the evening of July 16, 1852, afforded me a good opportunity of observing the effect of lightning on a solution of quinine, and other sensitive media. From the copiousness of the dispersed light, it was evident that the proportion of the active, and therefore highly refrangible rays to the visible rays was very far greater in the radiation from lightning than in daylight. A difference of character was observed between the effects of a weak distant flash, and of a bright flash nearly overhead, similar to that which has been described with reference to the effects of a spark from a machine, and of the discharge from a Leyden jar. In artificial discharges, the stronger the spark the more the rays of excessively high refrangibility seem to abound, in proportion to the whole radiation. Now a flash of lightning is a discharge incomparably stronger than that of a Leyden jar. It might have been expected, therefore, that the radiation from lightning would be found to abound in invisible rays of excessively high refrangibility. Yet I could not make out in a satisfactory manner the absorption of the rays by glass, even by common window-glass. I do not wish to speak positively regarding the result of this observation, for of course observations with lightning are more difficult than those made with a machine which is under the control of the observer. Yet it did seem as if the spark from a Leyden jar was richer than lightning in rays of so high a refrangibility as to be stopped by glass. If this be really true, it must be attributed to one of two things, either the non-production of the rays in the first instance, in the case of lightning, or their absorption by the air or clouds in their passage from the place of the discharge. If they were not produced, that may be attributed to the rarity of the air at the height of the discharge, that is, at the height of the thunder-cloud. No doubt the metallic points of the discharger belonging to the electrical apparatus may have had an influence on the nature of the spark; but I am inclined to think that this influence, so far as it went, would have acted in the wrong direction, that is, would have tended to produce rays of lower, at the expense of those of higher refrangibility.

Note K. Art. 220.

My attention has recently been called to a paper by M. Brücke (Poggendorff's Annalen, B. v. (1845) S. 593), in which he describes some experiments which show that the different parts of the eye, and especially the crystalline lens, are far from transparent with respect to the rays of high refrangibility. The eyes employed were those of oxen and some other animals; and the inquiry was carried on by means of the effect which light that had passed through the part of the eye to be examined produced on a film of tincture of guaiacum that had been dried in the dark. Of course the phenomena described in the present paper afford peculiar facilities for such an inquiry, and I had frequently thought of entering upon it, but have not yet made any observations. Independently of the facility of the observations, and the advantage of being able to examine readily light of each degree of refrangibility in particular, the results obtained by means of sensitive media seem to be more trustworthy on this account, that it would be possible to employ fresh eyes. The experiments of M. Brücke necessarily occupied a considerable time, and it may be doubted whether the eye, especially after dissection, might not have changed in the interval, and whether the results so obtained are applicable to the eye as it exists in the living animal.

INDEX TO THE PRECEDING PAPER.

N.B. The figures refer to the articles, the letters to the notes.