LETTERS TO THE EDITOR.

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Radio-activity and London Clay.

I VENTURE to think your readers may be interested in the following results.

The recent tube operations in London have brought to the surface specimens of the London Clay from different districts. Samples of this clay taken from such different points as Hyde Park Corner, Brompton Road, and Haverstock Hill have been tested in the physical laboratory of the South-western Polytechnic for the presence of a radio-active gas by Mr. H. Cottam, and he has been unable to detect with his apparatus any marked quantity of active gas from the clays.

With the same apparatus he has detected quite easily the radio-active gas from the water of a deep well, belonging to Messrs. Eastman, Latimer Road, W., which goes below the clay to the greensand. We have come to the conclusion that the London Clay forms a floor through which the radio-active gas does not penetrate; or it may be said that the radio-active substance only travels when the water with which it is associated can travel. This is an argument in support of Prof. J. J. Thomson's view, that the radio-active gas, which he found in deep well waters, arises from the splitting up of a trace of soluble radium salt which comes up with the water. S. SKINNER.

South-western Polytechnic, Chelsea.

Cecil's Gas Engine.

THE earliest practical gas engine appears to be unknown to the leading writers on internal combustion engines. I think that it may be a matter of interest to those who are antiquarians in their subject—as Maxwell used to say—to know that a working gas engine was shown in Cambridge in the year 1820. It was the invention of the Rev. W. Cecil, fellow of Magdalen College, Cambridge. A full account of his engine is given in vol. i., p. 217, of the *Proceedings* of the Philosophical Society of Cambridge (paper read November 27, 1820). The paper is long, and contains excellent matter; a new form of parallel motion is described, and what the author calls "ardent spirit" and turpentine, and vapour of oil, are suggested as possible substitutes for the gas employed by the inventor of the engine. F. J. JERVIS-SMITH.

Trinity College, Oxford, September 29.

The Iris and the Colour Sense.

MR. VINCENT NAPIER'S communication in your issue of September 1 on "Adaptive Colours of Eyes" moves me to record an observation which I have never seen formulated. It is that persons who exhibit a fondness, in dress, for striking colours, or display exceptional taste in colour combination, have eyes of a pronounced and positive colour. One naturally notices this chiefly in women, but I believe it holds good for men also. In the matter of harmonious costuming, perhaps it would not be too much to say that many women dress conformably to the tint of the iris.

New York, September 17. W. P. G.

Electrolytic Oxidation.

I NOTICE with interest that in your issue of September 22 (p. 511) a brief account is given of a memoir published by Paterno and Pannain in the *Gazzetta* on the electrolysis of alkaline aqueous solutions of potassium cyanide. The chief result of their work appears to be the production of potassium cyanate. In the summer of 1899 a friend and I were working in the same direction. From the commencement of our experiments, on both aqueous and semi-alcoholic solutions of potassium cyanide, we were struck by the almost entire absence of oxygen in the electrolytic gases. The aqueous solutions became strongly alkaline and ammoniacal. The semi-alcoholic solutions became strongly alkaline, but not ammoniacal. Acetamide was, however, detected in a distillate, the presence of which may explain the absence of free ammonia. The alcoholic solutions also yielded, on evaporation, white crystals, which proved to be potassium carbonate.

We therefore assumed, without direct proof, that oxygen had been absorbed by the potassium cyanide to form potassium cyanate. This assumption, which now receives confirmation, was based on the detection of its hydrolytic products, which we considered to have been formed according to the following equation:—

$$KCNO + 2H_2O = KHCO_3 + NH_3.$$

It is possible that continued electrolysis would have led to the production of potassium formate from the bicarbonate (*Berichte*, xxxvii., 2836), if this change had not, to some extent, already occurred.

We obtained evidence of the formation of more complex bodies, but have been unable, up to the present, to prosecute further experiments. HERBERT A. KITTLE.

Leatherhead, Surrey, September 26.

DEVELOPMENTS OF THREE-COLOUR PHOTOGRAPHIC PROCESSES.[1]

I.

IN reviewing the recent progress of the various processes, direct and indirect, of the reproduction of colours by photography, it is obvious that there is no very remarkable advancement to report. The ultimate aim of those who do fundamental work at this subject is to formulate a method that shall automatically reproduce the colours of the original, just as by means of a camera and lens the form of the original is automatically drawn in true perspective. The realisation of this desideratum does not seem at hand. There is no method of producing colour prints known that does not need so much control in the working of it or alteration of its results, that it would be incorrect to regard the final products as simple photographs. The skill and sometimes the taste of the operator, and the nature of the appliances that he makes use of, have an important effect upon the work. This fact may lead to the idea that photographic methods of colour reproduction are of little use. But by the aid of photography results may be obtained that were impossible before, either in their character or in the economy of their production. Photography in portraiture is not considered useless because the negative goes through the hands of the retoucher.

Of the direct methods of heliochromy, the interference method that was practically worked out by Lippmann remains nothing more than an interesting illustration of certain physical phenomena. The many restrictions that limit its applications and the difficulties that beset its practice are such that it can never be expected to develop into a practical process. After a dozen years or so, Lippmann photographs are still regarded as curiosities, and are interesting only as examples of the method. None appear to have been made for the sake of the subject. The restrictions as to size and the angle under which they must be viewed, the need for getting rid of reflections from the surface of the film, the slowness of their production, and, above all, the uncertainty of the colours produced and the fact that they change with any alteration in the condition of the film, render the process useful to the physicist rather than the photographer.

The only other method of direct colour photography that appears at all likely to develop into a practically

[1] "The Water-Colour Drawings of J. M. W. Turner, R.A., in the National Gallery." By T. A. Cook. Pp. vi+86 and 58 plates. (London: Cassell and Co., Ltd., 1904.) Price 3 guineas net.
"Three-Colour Photography." By A. F. von Hubl. Translated by H. O. Klein. Pp. 148. (London: A. W. Penrose, Ltd., 1904.)
"Photography in Colours." By R. C. Bayley. 2nd edition. Pp. 151. (London: Iliffe, Ltd., 1904.) Price 1s. net.

useful process, that is, a method in which the coloured image that falls upon the prepared surface produces on it its own colours at once, is that suggested about twenty-five years ago by Charles Cros. The receiving surface is coated with a red, a yellow, and a blue dye of suitable tint, each of which fades quickly when exposed to white light. As it is the light that is absorbed that causes the fading and not the reflected light, on exposure to light of any given colour the only dye or dyes that remain unbleached are those that reflect the same colour as the incident light: a red light, for example, causes the yellow and blue dyes to fade, but not the red, and this colour therefore remains in those parts upon which it impinges. The primary difficulty is to prevent further change in the resulting picture, for the very essence of the process consists in the fugitive nature of the dyes employed. This principle of work has recently engaged the attention of several investigators, but no satisfactory method has yet been arrived at.

All practical methods of colour photography, that is, methods that are practised for the sake of the results that they furnish, are indirect. The light from the coloured object does not produce colour at all. By dividing the light into three suitable parts or colours each may be photographed separately so as to give a record of the distribution of its own colour, and by the use of these records a compound print may be made with three suitable colours. Three colours are used for the same reasons that led to the theory that the normal eye can distinguish only three colours—the three colour sensations—all the vast variety of tints being due to the excitation of one or more of these simultaneously and in due proportions. Although it has been proved that three colours are sufficient, four, and even five, have occasionally been used to overcome the difficulties of the simpler method. But none of these methods must be confused with the procedure in chromolithography, in which a dozen or more colours may be used, their choice being chiefly, if not entirely, empirical.

If any two or all three of the colour sensations are excited to the same extent, the same colour effect will be produced whatever the character of the light that causes the excitation. Therefore, the fact that two colours are not distinguishable from each other by the naked eye is no proof that they are really the same; spectroscopic analysis of the two coloured lights may reveal a great difference between them. In reproducing colour by photography, therefore, it is not necessary (and not often possible) to reproduce the original colours; it is sufficient to produce a colour that the eye cannot distinguish from the original, that is, one that affects to the same extent each of the three sensations. It was by the application of this principle that Ives worked out the essential conditions for his chromoscope. It has been stated that Ives's actual apparatus does not illustrate this principle as completely as has been claimed, but whether this is so or not does not affect the principle itself nor the usefulness of it.

The conditions obtaining in Ives's chromoscope, and in the method of making coloured transparencies (or lantern slides) which Sanger-Shepherd has made a commercial success, are the two simplest illustrations of three-colour photography. In the first case the three lights are added, for each is transmitted to the eye independently of the others, while in the second case the colours are superposed and the light that passes is only that which is absorbed by neither of the three. In the first case the result is the sum of the transmitted lights, while in the second it is the sum of the absorptions that has to be considered. Practically speaking, though not quite actually, the colours used in the second case have to be complementary to those in the first case. The first thing to be done is to settle on the three fundamental colours. Ives and others have sought to follow the three-colour sensation spectrum curves founded on the Young-Helmholtz theory of colour, as drawn by Clerk-Maxwell and later by Sir William Abney. Colonel A. F. von Hübl, in his "Three-Colour Photography," just published in English (translated by Mr. H. O. Klein), arranges a diagram in which the normal spectrum forms a circle with purple between the violet and red, white being at the centre of the circle, and the remainder of the space being filled with whitish tints of the periphery colours. He says that an infinite number of systems of three theoretically correct fundamental colours may be selected by taking any three that are 120° distant from each other. But as blue is the darkest colour it must be one of the three fundamentals, and, of course, red and green follow. Hübl asserts that Ives's curves are entirely different from those which the theory of Helmholtz requires, and are based on Maxwell's colour-mixing experiments, in which three spectrum colours were assumed as fundamentals. Hübl, by means of a similar diagram, but with black (total absorption) at the centre, finds the three fundamental colours for superposition. "Three narrow-banded colours, situated in the colour circle at 120° from each other, form a suitable colour system for trichromatic printing, and a great number of such theoretically possible systems can be ascertained." But here again we are limited to one system. As "yellow cannot be produced by pigment mixtures . . . this colour must form one of the fundamental colours." "The yellow must be absolutely correct and must not be of a reddish tint," or any neutral pure yellow would be missing in the print. Both methods, therefore, in both cases give no choice for a perfect system, and the practical results as obtained by those who have worked them out on these rather different plans are very similar.

But it is not simply a matter of dividing the light into three suitable parts. The object of the division is to get a photographic record of each, and as no photographic plate yet made has a sensitiveness to various colours proportional to their brilliancy to the eye (or rather will give densities by exposure and development proportional to these brilliancies), the colour screens or filters that divide the light into the selected fundamental parts have to compensate for the deficiencies of the plates used. Now, this compensation can only be done by reducing the light that produces an excessive effect; it therefore always leads to the necessity for a lengthened exposure. Practically, a lengthened exposure means a more costly procedure, if only because, for the same capital outlay in apparatus and accommodation, less work can be done in a given time. But, even disregarding such considerations as these, ordinary plates are so little sensitive to red that it would be hardly possible to get a photograph on them of the red image, because the very protracted exposure would give the opportunity for all sorts of interfering circumstances to produce their characteristic errors. The sensitising of the plates to be used for the green and red elements becomes, therefore, an essential part of the procedure. About two years ago, Dr. Miethe, of Berlin, showed some results of three-colour work that attracted considerable attention, the superiority of which was partly due to the use of ethyl red, a cyanine derivative, instead of the cyanine invariably used until then. Plates treated with this sensitiser give with the prismatic spectrum an almost even density from nearly C to the violet, the deficient sensitiveness in the green that most sensitisers (including cyanine itself) give being hardly appreciable. Last year a still better sensitiser was introduced, namely, "orthochrome T," and a few months ago this was found to be surpassed by "pinachrome," both these being cyanine derivatives. Dr. E. König, who has investigated the comparative merits of these three sensitisers, states that if the sensitiveness conferred by ethyl red to red light is regarded as 100, "orthochrome T" gives a sensitiveness of 160 to 180, and "pinachrome" 450 to 500. But the density that the best of these sensitisers gives on development in the red and green of the spectrum is not proportional to the luminosity of these colours, therefore the exposure for these colours has to be longer than for the blue, but only about three times as long.

Theoretically perfect colour screens or filters are therefore useless, because a perfect plate, so far as the interpretation of colour is concerned, has not yet been produced. The colour screens and plates must be tested together, and for this purpose it is necessary to have recourse to the spectroscope, making photographs, of course, under the various conditions. But spectroscopic results are so liable to deceive observers who are not thoroughly accustomed to such work that less discriminative methods of testing are generally preferred. The colour sensitometric methods that Sir William Abney has done so much to perfect are often employed for this purpose. A series of small pieces of suitably coloured material are arranged in such a manner that when the plate is exposed through its screen and this sensitometer a definite and easily recognisable result will be obtained if the plate and screen are mutually correct. Or the colours may be arranged on a rotating disc concentrically with a grey produced by the mixture of definite proportions of black and white, so that the colour and the grey will give an equal density in a photograph of it taken in the camera through the screen on the plate. Colonel Hübl, in the volume above referred to, gives a colour chart that consists of small patches of nine pigments, with the results that should be obtained when this is photographed, using the given plate and each of the three colour screens in turn. To facilitate the use of the chart, an extra copy is provided in a pocket on the cover of the book. A grey scale of different shades, made on platinum printing paper, is exposed and developed with the colour chart, and the three prints should show this grey scale alike, when the differences due to the colour screens should be as shown in the three prints supplied.

CHAPMAN JONES.

(To be continued.)

REFLEXIONS IN WATER.[1]

THERE are few studies more fascinating than that of the reflexions formed naturally in the sea, and in rivers and lakes. In the first place, this study is naturally pursued in the open air; further, the effects observed are often of surprising beauty; and lastly, most, if not all, of the phenomena observed can be explained in accordance with a few simple principles, so that it is possible for almost anyone possessing a trained faculty of observation to add to our knowledge in this direction. In writing a book on reflexions in water, Sir Montagu Pollock has entered an almost untrodden region within the borders of both art and science; with the exception of some passages in the works of Mr. Ruskin, it would be difficult to refer to any other work dealing with the same subject. It is no small accomplishment to produce a book in which so many intricate effects are traced to their causes, using language

FIG. 1.—Old Harbour Side, Scarborough. From "Light and Water."

1 "Light and Water: a Study of Reflexion and Colour in River, Lake, and Sea." By Sir Montagu Pollock, Bart. Pp. xii+115; with 39 plates and 28 explanatory figures. (London: George Bell and Sons, 1903.) Price 10s. 6d. net.