containing potassium chlorate for which safety is claimed. It is really quite incomprehensible how people with the slightest knowledge of chemistry can propose mixtures containing potassium chlorate and organic substances, and in many cases even sulphur as well.

By drawing the attention of chemists to the amount of nonsense palmed off on the Patent Office, this little book will serve a good turn; but it is also of practical value, as extracts from the specifications are given in many cases which may save much seeking.

Some advice at the end of the book is useful, especially to those interested in explosives in a professional way, but who are not sufficiently chemists to be able to deduce it for themselves. Possibly it is the fault of the specifications, and not the author, that benzene is written in several ways, benzole, benzine, &c.

On p. 68 there is an equation to represent the products of gun-cotton when detonated, to which perhaps some exception may be taken, but after all but slightly, for there is still much ignorance on the matter. It is

It is very doubtful indeed whether any of these nitrates can be burnt under any conditions without yielding a considerable quantity of oxides of nitrogen as end products; probably NO in the first instance, which takes up oxygen from the air, and is undoubtedly the greatest drawback in the use of gun-cotton, glycerol nitrate, and similar substances.

Some advice is given about nitro-glycerine on p. 39. "Any indication of acid fumes or tinge of green should be followed by their prompt destruction with suitable precautions." It would have been well here to give some precautions even at the risk of repetition, for it is not safe to play with nitro-glycerine when in this state. The author might have added that an addition of aniline at this stage renders the destructive operations much safer.

Under the heading of smokeless and "noiseless" gun-powder, little more could be said at the present time than the author has ventured upon. We do not quite believe that a "noiseless" explosive will be so easily found as a smokeless one. Such a substance belongs almost to the category of explosives that act in "one direction only," or have no recoil.

We think the book will be useful in several ways. Blank pages are inserted for further additions to our stock of explosives, safe and unsafe, as they are published.

W. R. H.

Gaseous Fuel. By B. H. Thwaite. (London: Whittaker and Co., 1889.)

THIS little book of forty-six pages contains the substance of a popular lecture delivered by the author, under the auspices of the Manchester and Salford Noxious Vapours Abatement Association. It gives an account of the principles which underlie the economical consumption of fuel in general, and of the various forms of "gaseous fuel" in particular, and more especially of those forms in which the lecturer is professionally interested. The book, of course, makes no pretensions to deal with the subject exhaustively: its main object, apparently, is to direct attention to the advantages of smokeless fuel as compared with coal as ordinarily burnt. The author is occasionally to be found tripping in his chemistry and physics, and there are, now and then, a few awkward turns of expression. Thus, we read that fire-damp "is a light carburetted hydrogen, one of the gaseous paraffines or methane, its principal formula being chiefly CH_4 !" (p. 15). The inventor of the well-known laboratory burner is styled "Baron Bunsen." On p. 34 we read: "The principle of the development of motive power by the instantaneous combustion of gaseous fuel rests in the laws of Charles Gay Lussac and Boyle—*ergo*, that the pressure exerted by a gas varies directly as its volume."

The author seems to imply that the idea of using the fire-damp at Hebburn Colliery, near Newcastle, originated in a suggestion made by him some two years ago in *Engineering*. In reality, the idea is due to the younger Buddle. Indeed, as a matter of fact, blowers which have been encountered in the process of working have been frequently utilized either for heating or illuminating purposes; notable examples are at Llwynypia and at Pandy, in the Rhondda Valley.

A Treatise on Spherical Trigonometry, and its Application to Geodesy and Astronomy. With Numerous Examples. By Dr. J. Casey, F.R.S. (London: Longmans, 1889.)

THIS is a sequel to the large "Plane Trigonometry" by the same writer, and is naturally drawn up on the same plan. Its size is handy, and yet it contains a very large amount of matter. Much of this the author claims to be original, and a great deal, as in the case of the "Plane Trigonometry," has been collected from the foreign mathematical journals. The first three chapters cover familiar ground, with here and there a new feature inserted. Chapter iv, entitled "Various Applications," gives properties of transversals, of isotomic and isogonal conjugates, of the Lemoine and symmedian points, and of some other lines with which recent plane geometry has made us familiar—more especially our author's own "Sequel to Euclid." Chapter v. discusses the spherical excess, and in chapter vi. we have a full account of small circles on the sphere. The subject of inversions is discussed in chapter vii., and in chapter viii. we have full details of the polyhedra. The last chapter gives an account of numerous applications of the subject, as to geodesy and astronomy. It would be almost impossible, we should say, to light upon a theorem elsewhere which is not contained here. More than 500 exercises afford scope for practice. As in the case of the "Plane Trigonometry," the author's great indebtedness to Prof. Neuberg, of Liège, is suitably acknowledged, for it is through this gentleman's courtesy the book is brought so thoroughly into touch with Continental sources of information.

LETTERS TO THE EDITOR.

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Coronæ round a Light produced by a Peculiar Structure in the Eye.

FOR some years past I have been aware that a bright light on a dark background appeared to be surrounded by faint coloured rings, and that these rings were due to something in the eye itself. But I gave them little attention, for I imagined they were formed in the same way as the coronæ seen when the sun or moon is covered by a thin cloud; opaque particles in the cornea, or little elevations or depressions of its surface, playing the part of the drops of water in the cloud. This is the view taken in Verdet's great work on the wave-theory of light. "Les cercles irisés, qu'à la suite de certaines inflammations de la conjonctive on aperçoit autour des corps lumineux, se rattachent à la même cause que les couronnes; ces apparences sont dues à l'existence de granulations très-petites et sensiblement égales dans la portion de la conjonctive qui se trouve en avant de la cornée transparente" (Verdet, "Leçons d'Optique Physique," § 79). I have lately discovered, however, that the phenomenon in my own case must be due to quite a different cause.

A leading characteristic of the diffraction phenomena produced by a number of equal obstacles, *irregularly spaced*, is the bright disk surrounding the light, which is for the most part nearly white. Near the light it is bluish, while the outer border passes through yellow to red. To the red succeeds purple, blue, green,

yellow, red, &c., the colours resembling those of Newton's rings. The central disk is far the brightest part, and there is no real break in the colours, though the first purple is a good deal darker than its neighbours. The easiest way to see these colours is to sprinkle a slip of glass with Lycopodium seed and look through it at a bright point of light. The above description applies equally well whether the obstacles are spherical or cylindrical. The latter form is nearly approached in Nature by the fine needles of ice of which many clouds must be largely composed. With other forms of obstacle the colours would be more or less blurred, but in any case the bright central disk would survive.

When recently engaged in investigating such phenomena, I noticed that the rings formed in my eye were of an utterly different character. There are two narrow rings, apparently in contact—the inner green, the outer red; the apparent breadth of each being about $20'$, and the radius of the intermediate circle about $2^\circ 30'$. Within the green ring is a broad dark space, and then comes the ordinary colourless haze surrounding the light. The rings are not quite continuous, and certain short arcs are much brighter than the rest. But the arrangement of these arcs seems quite irregular, and is different in the two eyes. With this exception the two eyes behave alike. The green and red, though faint, are of good quality, not unlike a very faint prismatic spectrum. They are rather capricious in their appearance, requiring a dark background and a moderately bright light. A small arc light some thirty yards from my window generally shows them well, though they vary a good deal in brightness, and at times I cannot see them at all.

The question was, how the colours were produced. After pondering the matter for some time, and rejecting one explanation after another, the true solution suddenly flashed upon me. The colours are the first spectrum of a diffraction grating, and the ring form is due to the bars of the grating lying in different directions in different parts of the eye. The idea was readily put to the test. Cutting a small hole, one-tenth of an inch square, in a piece of paper, I held it in front of the eye. When the aperture was in the centre, the coloured rings vanished; when it was drawn to one side to the very edge of the pupil, two bright spots appeared on the circle, one above, the other below the light. The rest of the circle was invisible. As the aperture was moved round the outside of the pupil, the two bright spots revolved round the circle, preserving their angular distance of 90° from the aperture. This shows that the bars of the grating radiate from the centre of the pupil and are only found near its edge. From the dimensions of the rings we may deduce that the lines are spaced at the rate of about 75 to the millimetre, or 1900 to the inch. Since the coloured ring is not uniformly bright, the grating must be imperfectly developed behind some parts of the outer edge of the pupil. But trial with the diaphragm left no doubt that the structure was present to some extent all round. I then compared the coloured rings with the spectra seen on looking at a light through an ordinary diffraction grating of 3000 lines to the inch. The appearance was very similar, though in the latter case of course the red and green were much brighter, and were accompanied by a comparatively faint violet band. The breadth of the red and green bands relatively to their distance from the light agreed very well with the measurements given above.

Another evening I prepared some diaphragms with annular apertures of which three, A, B, C, had the inner and outer diameters respectively 10.7 and 8.6 mm., 9.9 and 7.6 mm., 8.1 and 6.1 mm. In A the central stop was large enough to hide the light and of course extinguish the rings too. With B when held centrally the rings were very plain—indeed yellow could be made out between the green and red—while the light was distorted and enlarged by both spherical and chromatic aberration. With C the rings were visible but not distinct. I found too that with B I could see the rings round the naked flame of a bright paraffin lamp only two or three feet away, for the pupil enlarged till it cleared the stop. But with C, I had to move two or three yards away before the rings appeared. These experiments show the diffracting structure to exist in a ring, whose diameter lies between 8.1 mm. and 7.6 mm., and that it does not extend far inside the lower limit. Further, the diameter of the pupil when the rings are visible may be decidedly less than 8.6 mm. The structure is not on the inner edge of the iris, but it may lie either in the cornea or in the crystalline lens. The latter is known to be built up of closely-packed radial fibres from 0.0056 mm. to 0.0112 mm. in breadth (Helmholtz, "Physiologische Optik," § 5).

It seems probable that some modification of these near the edge of the lens form the diffracting layer. I have since found that at a distance of a hundred yards from the electric light the pupil can be made to clear the central stop of A. There is then seen a narrow circle of light, too faint to show colour. I was not able to get a good enough measure of its diameter to decide whether it was smaller than before.

I can hardly fancy this curious structure in the eye to be a rare peculiarity. One of my friends saw the green ring well defined round the electric light one evening, and with practically the same radius as I. He was not sure about the red. Inside the green he described the colour as very dark purple, almost black. Probably this was a contrast effect, but possibly it was the violet of the spectrum. In Sir John Herschel's "Meteorology" I find the following passage. After speaking of coronæ round the sun, he says: "Occasionally the cornea of the eye itself becomes filmy by the diffusion over it of minute particles, which (such at least is our personal experience) exhibit round a candle two or three beautiful coronas, the second of $17' 57''$ in diameter, of vivid colours and most perfect definition." This description makes me feel suspicious that the rings were of the same class as mine. It suggests separate spectra such as are produced by a diffraction grating. Further, the accuracy of the measurement implies a tolerably narrow ring, whereas in ordinary coronæ, if the second green had a diameter $18'$, the second blue and second red would have diameters $15'$ and $23'$ respectively. His dimensions do not agree with mine, but imply bars or lines at distances of about 0.007 mm. Fibres of this breadth are found in the crystalline lens. JAMES C. McCONNEL.

Davos, Switzerland.

Use or Abuse of Empirical Formulæ, and of Differentiation, by Chemists.

As I believe that I am one of the "ingenious and clear-sighted" chemists who, Prof. Lodge suggests, may be "run away with by a smattering of quasi-mathematics and an overpressing of empirical formulæ," I hasten to assure him that he is quite wrong in his surmises.

With every word of Prof. Lodge's remarks on the proper method of examining curves I heartily agree; with his strictures on the abuse of formulæ I more than agree: I should advise chemists not even to use them.

The method of examining the continuity of any curve by plotting out the experiments themselves, and then differentiating the curves representing them, is the method which I have applied in nearly every case, and applied it, I believe, for the first time to questions of a chemical nature. The only difference between my *modus operandi* and that which Prof. Lodge suggests is that, instead of differentiating the curves by a mechanical integrator, I take readings from them at definite intervals, and find the differences between these readings arithmetically.

I do not consider, however, that this is the safest method of examining results. The method which was introduced to the notice of chemists by Mendeleeff, which was used subsequently by Crompton, and on which I have placed my chief reliance, consists of differentiating the experimental numbers themselves, and not the curves which may be drawn to represent them. If

s_1 and s_2 be the densities of p_1 and p_2 per cent. solutions, $\frac{dp}{ds}$ at a percentage $\frac{p_1 + p_2}{2}$ is given by $\frac{s_1 - s_2}{p_1 - p_2}$.

Each of these two methods has its own special advantages, but the balance is generally strongly in favour of the last one. It does not necessitate the drawing of the original curve, which drawing may often be considerably modified by the "taste" of the drawer; it will sometimes bring about the recognition of breaks which might be overlooked in the original curve, for though the differential curve can show no breaks which do not exist in the original curve, it may often, as a consequence of its very nature, show breaks clearly, which would be recognized only with difficulty in the original curve; and, lastly, the proper depiction of the original curve is often a practical impossibility, as, for instance, with the densities of sulphuric acid solutions, where the scale which would have to be adopted to give the experimental error a fairly visible magnitude would involve dealing with a curve some 3000 inches long.

Prof. Lodge could, no doubt, have told us more than he has done of the difficulties and dangers of differentiation in any form, and, perhaps, the extensive practical experience which I