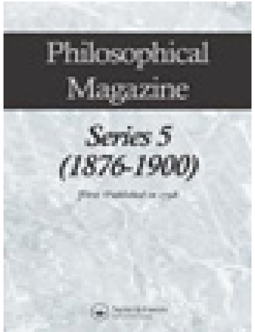

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On tones produced by the intermittent irradiation of a gas

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out in the rough result of experiment thus disappear. The results obtained agree exactly with those recorded in my first Note. Maxwell*, who has studied the solar spectrum with the greatest care from the physiological point of view, has assigned slightly different positions to the colours which correspond to the fundamental sensations, as the following table shows:—

MAXWELL.

Place in the chromatic circle.	Place in the solar spectrum.
Third red	$\frac{1}{3}$ from C towards D.
Green	$\frac{1}{4}$ „ E „ F.
Fifth blue	$\frac{1}{2}$ „ F „ G.

ROSENSTIEHL.

Place in the chromatic circle.	Place in the solar spectrum.
Orange	$\frac{3}{4}$ from C towards D.
Third yellow-green	$\frac{3}{4}$ „ D „ E.
Third blue	$\frac{1}{3}$ „ F „ G.

As rotating disks permit us to experiment with greater precision, I believe these last data to be very near the truth†.

In brief, taking as a basis the equidistance of the colours which constitute each of the three sections of the chromatic circle, I arrive, by two analytical experimental methods, and without making any hypothesis, at proving that there exist three colours (the exact position of which I have determined) which possess relatively to our eye special properties. I have rigorously defined these properties, which coincide with those accorded by physiologists to the fundamental sensations. Thus the law of the mixture of colours, established *à priori* by Newton, developed by Young, Helmholtz, and Maxwell, is verified in its principles and specified in its consequences.—*Comptes Rendus de l'Académie des Sciences*, t. xcii. pp. 357–360 (Feb. 14, 1881).

ON TONES PRODUCED BY THE INTERMITTENT IRRADIATION OF A GAS. BY W. C. RÖNTGEN.

In my lectures on experimental physics I have for some time employed the following apparatus to render visible, in a simple way, the different capabilities of absorbing heat-rays possessed by the gases.

A glass tube about 4 centims. in diameter and 40 centims. in length, placed horizontally, is closed at both ends with plates of

* Proceedings of the Royal Society of London, vol. x. p. 404 (1860).

† Maxwell, moreover, operated upon only sixteen colours of the spectrum, which he mixed three by three.

rock salt. In the middle between the two plates the tube is perforated in two diametrically opposite places. The upper opening communicates with a small glass tube that can be closed by a cock; the lower with a somewhat longer glass tube, descending vertically, which during the experiment dips in a vessel containing a coloured fluid. The fluid stands some centims. higher in the tube than in the vessel.

In front of one of the rock-salt plates, in a line with the glass tube, is a source of heat, say the gas-flame of an argand burner; between the flame and the tube a diaphragm about 4 centims. wide and a double screen of sheet metal are placed: the latter can be quickly drawn back and pushed forward.

Now the experiment is made in the following manner:—The height of the liquid in the manometer having been observed while the screen shut out the heat-radiation, the screen is quickly withdrawn; by the absorption of rays which now takes place on the part of the gas enclosed in the apparatus the gas is heated, in consequence of which the manometer shows a sudden increase of pressure, which, after some time, reaches a maximum. The increase, especially that which takes place at the first moment, is very different with different gases—comparatively slight with air, while it is considerable in the case of the strongly absorbing illuminating-gas and ammonia.

If the screen be then again pushed between the flame and the glass tube, the pressure diminishes, in correspondence with the cooling of the gas—at first quickly, afterwards slowly.

The phenomenon is, on the whole, tolerably complicated, because, besides the absorption-capacity, the specific heat also, as well as the ability of the gas to equalize more or less rapidly any differences of temperature that may be present, play a part; yet it is very suitable for a demonstration-experiment.

Now, after obtaining from M. Breguet's paper in the *Journal de Physique* for November 1880 a knowledge of some details of Mr. Graham Bell's experiments with the so-called photophone, the question arose in my mind whether the gas enclosed in the glass tube in the above-described experiment could not by intermittent irradiation be caused to emit sounds. The above-mentioned sudden rise and fall of the pressure at the moments when the irradiation commences and ceases respectively permitted a favourable answer to the question to appear possible; and experiment has, in fact, confirmed my supposition in a very satisfactory manner.

As the source of heat, I used Drummond's lime-light. By two lenses the rays were concentrated upon a notched disk of pasteboard, which could be rapidly rotated about a horizontal axis by means of a cord. In order to deaden as much as possible the noise arising from the rotation of the disk, it rotated between two larger fixed disks, which were provided with a notch corresponding to each of the openings in the rotating disk and closed by a thin plate of glass.

Behind these notches the absorption-apparatus was either fixed or held free in the hand; in this experiment it had a length of 12 centims.; the manometer was replaced by a short glass tube of 1 centim. diameter, over which was pushed a wide caoutchouc tube that led to the ear of the observer and was inserted in it as deeply as possible.

The rays penetrated into the absorption-apparatus every time an opening in the rotating disk came in front of the rock-salt plate; the interruption of this was effected by the unnotched parts of the disk.

At the commencement the apparatus was filled with air; on rotating the disk I could not perceive any tone, perhaps because, on account of the rotation &c., too many extraneous noises were still present. The affair, however, took quite another shape when illuminating-gas was substituted for air; the tone could be heard with extraordinary distinctness, and might almost be compared to the whistling of a not too strong wind. Its height varied with the velocity of the rotation; and the tone vanished only when the rotation became very rapid. The strength of the tone varied perceptibly with the time during which the cube was exposed; but the tones ceased directly if the rays were intercepted by an impervious body (as the hand, a small wooden board, or a hardgum plate) held before the disk.

With ammonia gas I likewise obtained distinct tones; while dry hydrogen and oxygen behaved like atmospheric air.

The explanation of these experiments is not far to seek; it has already been intimated above. We have not to do with any new property of the rays; the heating and expansion produced by absorption, and the subsequent cooling and contraction of the absorbing body, are the causes of the phenomena. That the gas really played the chief part in my experiments, and not the glass, upon which likewise the rays fell, follows even from this—that only the strongly absorbent gases emit audible tones; and I found direct proof of it by so directing the rays, in some experiments, by means of a third lens and a diaphragm, that they passed merely through the rock salt and the gas, without anywhere coming into contact with the glass wall of the tube: the effect was substantially the same as with the simple irradiation.

A solution of alum placed in the path of the rays caused an instantaneous cessation of the tone; on the contrary, scarcely a weakening could be observed when the rays had passed through a layer 10 centims. in thickness of solution of iodine (in sulphide of carbon). Consequently it is the less-refrangible rays which are most operative, at least upon illuminating-gas and ammonia.

I purpose investigating the behaviour of aqueous vapour, in the hope of furnishing in this way a contribution to the decision of the question whether it to any considerable extent absorbs heat-rays or not.—*Separate impression from the* XX. *Ber. der Oberh. Gesellsch. f. Natur- u. Heilkunde.*

Giessen, Dec. 8, 1880.

RESEARCHES ON THE SPECIFIC MAGNETISM OF OZONE. BY M. HENRI BECQUEREL.

In the course of my researches on the magnetic rotatory powers of the gases*, oxygen presented some remarkable anomalies, which have induced me to resume the study of the magnetic properties of that gas, discovered by my father†, and to evaluate the specific magnetism of ozone.

For that purpose I fixed above the large electromagnet of the Museum a torsion balance enclosed in a vertical test-tube of glass, in which a vacuum can be produced and into which various gases can be introduced. The torsion-thread employed was a very fine gold wire 32 centims. in length, sustaining a small glass bar consisting of a tube filled with air, and closed at both ends. A microscope was directed towards a mark traced upon the bar, and permitted the latter to be at any time brought back to a fixed position, at about 45° from the line of the poles of the electromagnet.

When this was magnetized, the small bar was attracted; and by a suitable torsion of the gold wire the attraction was balanced, so as to restore the bar to its initial position. We know that in these circumstances, in virtue of a principle analogous to the principle of Archimedes, the attraction measured is the difference between the action exerted upon the bar and that exerted upon an equal volume of the ambiant gas. On measuring the attraction *in vacuo* we have the effect produced on the bar alone; and the difference between the torsion thus obtained and that which is observed in different gases measures the action exerted by the magnet upon the gas. It was moreover verified repeatedly, by determining the periods of the oscillations of the small bar under the influence only of the torsion of the thread, that the elasticity of the latter had not changed during the experiments.

The ozonized oxygen was prepared by passing pure and dry oxygen through an effluvia-apparatus like that prepared by M. Berthelot; and the gas was collected over sulphuric acid under a glass bell furnished with a glass cock. Thence it passed, through pipes entirely of glass, into the test-tube, in which a vacuum had been previously made.

Notwithstanding these precautions, perhaps by reason of the presence of traces of organic matters (grease, resin), the ozone in the test-tube was rapidly decomposed, and it was not possible to

* *Annales de Chimie et de Physique,* série 5, t. xxi. p. 289 (1880).
† Ibid. sér. 3, t. xxviii. p. 323 (1850).