L85
MHT

THE

LONDON, EDINBURGH, AND DUBLIN XI.

PHILOSOPHICAL MAGAZINE

AND

JOURNAL OF SCIENCE.

CONDUCTED BY

SIR ROBERT KANE, LL.D. F.R.S. M.R.I.A. F.C.S.

SIR WILLIAM THOMSON, KNT. LL.D. F.R.S. &c.

AND

WILLIAM FRANCIS, PH.D. F.L.S. F.R.A.S. F.C.S.

"Nec aranearum sane textus ideo melior quia ex se fila gignunt, nec noster vilior quia ex alienis libamus ut apes." JUST. LIPS. *Polit.* lib. i. cap. 1. Not.

VOL. XI.—FIFTH SERIES.

JANUARY—JUNE 1881.

LIBRARY OF CONGRESS,
SMITHSONIAN DEPOSIT.

LONDON:

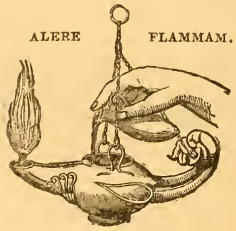
TAYLOR AND FRANCIS, RED LION COURT, FLEET STREET.

SOLD BY LONGMANS, GREEN, READER, AND DYER; KENT AND CO.; SIMPKIN, MARSHALL AND CO.; AND WHITTAKER AND CO.;—AND BY ADAM AND CHARLES BLACK, AND THOMAS CLARK, EDINBURGH; SMITH AND SON, GLASGOW;—HODGES, FOSTER, AND CO., DUBLIN;—PUTNAM, NEW YORK;—AND ASHER AND CO., BERLIN.

"Meditationis est perscrutari occulta; contemplationis est admirari perspicua . . . . . Admiratio generat quæstionem, quæstio investigationem, investigatio inventionem."—*Hugo de S. Victore.*

—"Cur spirent venti, cur terra dehiscat,
C. . mare turgescat, pelago cur tantus amaror,
Cur caput obscura Phœbus ferrugine condat,
Quid toties diros cogat flagrare cometas,
Quid pariat nubes, veniant cur fulmina cœlo,
Quo micet igne Iris, superos quis conciat orbes
Tam vario motu.

J. B. Pinelli ad Mazonium.



CONTENTS OF VOL. XI.

(FIFTH SERIES).

NUMBER LXV.—JANUARY 1881.

Page

MM. Lecher and Pernter on the Absorption of dark Heat-rays by Gases and Vapours. (Plate I.) 1

Messrs. Carnelley and O'Shea on a Relation between the Melting-points of the Elements and their Solid Binary Compounds and the Heats of Formation of the latter 28

Dr. O. J. Lodge on Action at a Distance 36

Mr. S. T. Preston on Action at a Distance 38

Mr. H. M'Coll on Implicational and Equational Logic 40

Messrs. Ayrton and Perry on Prof. Exner's Papers on Contact Electricity 43

Dr. J. H. Gladstone on the Specific Refraction and Dispersion of Isomeric Bodies 54

Messrs. Brauner and Watts on the Specific Volumes of Oxides 60

Dr. Brauner on the Atomic Weight of Beryllium 65

Proceedings of the Geological Society :—

Messrs. H. Keeping and E. B. Tawney on the Beds at Headon Hill and Colwell Bay in the Isle of Wight .. 72

Mr. J. A. Phillips on the Constitution and History of Grits and Sandstones 73

Note on Mr. Browne's Paper "On Action at a Distance," by Rev. A. J. C. Allen, B.A., Fellow and Assistant Tutor of Peterhouse, Cambridge 74

A Contribution to the Theory of so-called Electrical Expansion or Electrostriction, by Prof. L. Boltzmann, of Graz .. 75

On the Absorption of Solar Radiation by the Carbonic Acid of our Atmosphere, by Dr. Ernst Lecher 76

Spectral Reaction of Chlorine and Bromine, by M. Lecoq de Boisbaudran 77

On Radiophony, by M. E. Mercadier 78

NUMBER LXVI.—FEBRUARY.

Prof. G. Kirchhoff on the Measuring of Electrical Conductivities 81

Mr. C. S. Hastings's Theory of the Constitution of the Sun, founded upon Spectroscopic Observations, original and other 91

Page

Mr. G. F. Fitzgerald on Professor Osborne Reynolds's Paper "On certain Dimensional Properties of Matter in the Gaseous State" 103
Dr. P. Glan on a Spectrum-Telescope 110
Messrs. Nichols and Wheeler on the Coefficient of Expansion of Gas-Solutions. (Plate II.) 113
Dr. K. Domalip on Alternating Discharges *in vacuo* 121
Mr. W. R. Browne on Action at a Distance 129
Dr. A. Oberbeck on the Friction in Free Surfaces of Liquids .. 132
Notices respecting New Books:—
Dr. R. S. Ball's Elements of Astronomy 148
M. J. Petersen's Elementary Plane Geometry 149
Mr. R. M. Milburn's Mathematical Formulæ 149
Mr. R. Potts's Elementary Algebra, with brief notices of its History 150
Dr. T. Craig on the Motion of a Solid in a Fluid, and the Vibrations of Liquid Spheroids 150
Proceedings of the Geological Society:—
Mr. C. Callaway on the Archæan Geology of Anglesey; and on the Limestone of Durness and Assynt 151
Prof. T. G. Bonney on a Boulder of Horblende-Pikrite near Pen-y-Carnisiog, Anglesey 152
On the Motion of an Incompressible Viscous Fluid in the Vicinity of a Sphere, by Dr. A. Oberbeck 153
On the Measurement of the Electromotive Force of the Pile, by M. J.-B. Baille 153
A Study on Spectrophotometers, by M. A. Crova 155

NUMBER LXVII.—MARCH.

Dr. J. W. Draper on the Phosphorograph of a Solar Spectrum, and on the Lines in its Infra-red Region 157
Dr. C. R. A. Wright on the Determination of Chemical Affinity in terms of Electromotive Force.—Part III. 169
Lord Rayleigh on Copying Diffraction-gratings, and on some Phenomena connected therewith 196
Mr. J. B. Lawes on the Formation and Decomposition of Carbonic Acid 206
Lieut. L. Darwin on the Rate of the Decrease of the Light given off by a Phosphorescent Surface 209
Mr. J. Brown on the Theory of Voltaic Action 212
Lord Rayleigh on Images formed without Reflection or Refraction 214
Mr. S. T. Preston on Action at a Distance 218
Dr. O. J. Lodge on Action at a Distance 220

Page
On some Experiments Instituted to Supply all the Lines terminating at the Calcutta Telegraph-Office with Currents tapped from the Main Current produced by a Dynamo-electric Machine, by Louis Schwendler, Esq., M.I.C.E. &c. 221
Determination of the Colours corresponding to the Fundamental Sensations by means of Rotating Disks, by M. A. Rosenstiehl 222
On the Liberation of Electricity in Tourmaline by Pressure, by MM. Jacques and Pierre Curie 224
Confirmation of the Nebular Hypothesis, by Pliny Earle Chase, LL.D. 226
On the Choice of the Unit of Force in Absolute Electric Measurements, by M. Lippmann 226

NUMBER LXVIII.—APRIL.

Mr. J. J. Thomson on the Electric and Magnetic Effects produced by the Motion of Electrified Bodies 229
Prof. Challis's Theoretical Explanations of the Rectilinear Transmission and Spontaneous Diffusion of Sound and Light 249
Mr. H. A. Rowland on the new Theory of Magnetic Attractions, and the Magnetic Rotation of Polarized Light..... 254
Dr. C. R. A. Wright on the Determination of Chemical Affinity in terms of Electromotive Force.—Part IV. (Plate III.).. 261
Prof. H. Hennessy on the Figures of the Planets 283
Prof. S. P. Thompson on the Construction of the Photophone 286
Mr. R. T. Glazebrook on the Measurement of Small Resistances 291
Messrs. Roberts and Wrightson on the Determination of the Density of Fluid Bismuth by means of the Oncosimeter .. 295
Captain Abney on Lines in the Infra-red Region of the Solar Spectrum 300
Mr. S. Bidwell on the Effect of Temperature upon the Electrical Resistance of Selenium 302
Notices respecting New Books:—
Mr. B. Williamson's Elementary Treatise on the Integral Calculus, containing Applications to Plane Curves and Surfaces, with numerous examples 303
On Steady Motion in an Incompressible Viscous Fluid, by Thomas Craig 304
Determination of the Fundamental Colour-Sensations by the Study of the Distribution of the Complementary Colours in the Chromatic Circle. (Second Note.) By M. A. Rosenstiehl 305
On Tones produced by the Intermittent Irradiation of a Gas, by Prof. W. C. Röntgen 308
Researches on the Specific Magnetism of Ozone, by M. Henri Becquerel 311

NUMBER LXIX.—MAY.

Page
MM. Struve and Döllen on the Correction of Latitudes for Local Attraction 313
Prof. O. Reynolds on certain Dimensional Properties of Matter in the Gaseous State 335
Mr. C. V. Boys on an Integrating-Machine. (Plate VIII.).. 342
Dr. C. R. A. Wright on the Determination of Chemical Affinity in terms of Electromotive Force.—Part IV. 348
Mr. R. T. Glazebrook on a Method of Comparing the Electrical Capacities of two Condensers 370
Mr. E. H. Cook on a convenient Term expressing the Change from Radiant Heat and Light into Sound 377
Mr. W. R. Browne on Action at a Distance 379
Dr. G. J. Stoney on the Physical Units of Nature 381
Mr. S. T. Preston on the Importance of Experiments in relation to the Mechanical Theory of Gravitation 391
The Effect of Great Cold upon Magnetism, by John Trowbridge 393
On the Galvanic Conductivity of Heated Gases, by M. R. Blondlot 395
On an Acoustic Phenomenon noticed in a Crookes Tube, by Charles R. Cross 396

NUMBER LXX.—JUNE.

Mr. R. T. Glazebrook on the Molecular Vortex Theory of Electromagnetic Action 397
Messrs. Rowland and Nichols on the Electric Absorption of Crystals. (Plate IX.) 414
Mr. R. H. M. Bosanquet on the Beats of Consonances of the Form $h:1$. (Plates IV.–VII.) 420
Dr. A. Macfarlane's Analysis of Relationships 436
Mr. A. Tribe on an Electrochemical Method of Investigating the Field of Electrolytic Action 446
Messrs. Watson and Burbury on the Law of Force between Electric Currents 451
Messrs. Abney and Festing on the Transmission of Radiation of Low Refrangibility through Ebonite 466
Notices respecting New Books:—
Dr. E. Goldstein's Eine neue Form elektrischer Abstossung. (A New Kind of Electric Repulsion.) 469
Mr. E. B. Elliott on Williamson's Integral Calculus 473
Note by Mr. R. Shida on his Article (Phil. Mag. Dec. 1880), "On the Number of Electrostatic Units in the Electromagnetic Unit" 473
On the Principle of the Conservation of Electricity, by G. Lippmann 474
On a new Form of Galvanometer for Powerful Currents, by Professor C. F. Brackett, College of New Jersey 476

NUMBER LXXI.—SUPPLEMENT.

Pag
Mr. E. H. Cook on the Existence of the Luminiferous Æther 477
Mr. R. H. M. Bosanquet on the Beats of Consonances of the Form $h:1$ 492
Prof. Helmholtz on Stereoscopic Vision 507
Messrs. Gladstone and Tribe on Thermal Electrolysis 508
Prof. A. G. Bell upon the Production of Sound by Radiant Energy. (Plates X. & XI.) 510
Dr. O. J. Lodge on Action at a Distance, and the Conservation of Energy 529
Messrs. Wanklyn and Cooper on some new Apparatus for use in Gas-analysis 534
Notices respecting New Books :—
Miscellaneous Scientific Papers by the late W. J. Macquorn Rankine, C.E. 536
Proceedings of the Geological Society :—
Mr. T. V. Holmes on the Permian, Triassic, and Liassic Rocks of the Carlisle Basin 538
Dr. G. M. Dawson on the Superficial Geology of British Columbia and its adjacent regions 539
Mr. C. Parkinson on the Upper Greensands and Chloritic Marl of the Isle of Wight 540
Mr. C. Reid on the Flow of an Ice-sheet, and its Connexion with Glacial Phenomena 541
Mr. R. W. Coppinger on Soil-cap Motion 541
On the Internal Discharges of Electrical Condensers, by E. Villari 541
On the Secular Inequalities in Terrestrial Climates depending on the Perihelion Longitude and Eccentricity of the Earth's Orbit, by the Rev. Dr. Haughton 543

PLATES.

I. Illustrative of MM. Lecher and Pernter's Paper on the Absorption of dark Heat-rays by Gases and Vapours.

II. Illustrative of Messrs. Nichols and Wheeler's Paper on the Coefficient of Expansion of Gas-solutions.

III. Illustrative of Dr. C. R. A. Wright's Paper on the Determination of Chemical Affinity in terms of Electromotive Force.

IV.–VII. Illustrative of Mr. R. H. M. Bosanquet's Paper on the Beats of Consonances of the Form $h:1$.

VIII. Illustrative of Mr. C. V. Boys's Paper on an Integrating-Machine.

IX. Illustrative of Messrs. Rowland and Nichols's Paper on the Electric Absorption of Crystals.

X. & XI. Illustrative of Prof. A. G. Bell's Paper upon the Production of Sound by Radiant Energy.

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).