present carried on by educational bodies other than that Board." Examinations are held in India and in several of the colonies as well as at home. The report shows that Bombay sent up this year thirty-eight candidates in cotton manufacture and dyeing, against eighteen last year. Earnest efforts are being made to provide technical instruction for operatives engaged in cotton mills in or near Bombay, and, with the further development of the cotton industry, the number of candidates from India who present themselves for the institute's examination is likely to increase. The work of the department also includes the direction of instruction and the conduct of examinations in technology and manual training. The instruction in manual training is intended exclusively for those who are preparing to become teachers in elementary or secondary schools. The difficulty of arranging for the special instruction in the methods of teaching, of which artisan students stand in need, has for some time engaged the serious attention of the institute, and, with a view of indicating the kind of lessons which it was thought desirable that County Councils might provide, a letter, enclosing a suggested scheme of instruction, was addressed in November last to the organising secretaries, and secretaries of local committees having manual training classes under their charge.

SCIENTIFIC SERIAL.

Bulletin of the American Mathematical Society, October.—Prof. F. N. Cole gives an account of the proceedings at the seventh summer meeting of the Society, which was held in June last at Columbia University, New York City. The occasion was one of the most successful in the Society's history, having been attended by upwards of fifty members. Abstracts are given of many of the papers read. These papers will subsequently appear either in the *Bulletin* or in the *Transactions*. In connection with this gathering, the final session was devoted to an organised discussion of the following question:—What course in mathematics shall be offered to the student who desires to devote one-half, one-third or one-fourth of his undergraduate time to preparation for graduate work in mathematics? An abstract of papers read by Profs. Moore, Harkness, Osgood, Morley and Young is given by Prof. W. H. Maltbie. The discussion suggests many points of interest. Prof. (Miss) C. A. Scott furnishes an interesting article on a memoir by Riccardo de Paolis. This mathematician about twenty years since published a series of memoirs dealing with the (2, 1) transformation of the plane (cf. *Atti d r. Accad. dei Lincei*, vol. i. (1877) pp. 511–544; vol. ii. (1878) pp. 31–50; and pp. 851–878). An exhaustive treatment is given, and Miss Scott ends thus: "the intrinsic interest of de Paolis' work is surely excuse enough for devoting some little space to it" in the *Bulletin*. References are freely made to the writings of other geometers on cognate lines. The "Notes" are full of the "Courses in Mathematics" for the winter semester at most, if not all, of the German Universities. Other details of interest to mathematicians fill up the remainder of the number, together with a long list of recent publications.

SOCIETIES AND ACADEMIES.

LONDON.

Royal Society, June 21.—"Energy of Röntgen and Becquerel Rays and the Energy required to produce an Ion in Gases," by E. Rutherford, M.A., B.Sc., Macdonald Professor of Physics, and R. K. McClung, B.A., Demonstrator in Physics, McGill University, Montreal. Communicated by Prof. J. J. Thomson, F.R.S.

The primary object of the investigations described in the paper was the determination of the energy required to produce a gaseous ion when X rays pass through a gas, and to deduce from the result the amount of energy radiated out into the gas by uranium, thorium and the other radio-active substances.

In order to determine this "ionic energy" it has been necessary to accurately measure the heating effect of X rays and the absorption of Röntgen radiation in passing through a gas.

The method adopted to determine the ionic energy was briefly as follows:—

The maximum current between two electrodes produced by the ionisation of a known volume of the gas by the rays was determined.

In order to ionise the gas energy has to be absorbed, and the intensity of the radiation falls off more rapidly than the law of inverse squares. Assuming that the energy of the radiation absorbed in the gas is expended in the production of ions, then, knowing the coefficient of absorption of the rays in the gas, the total current produced by the complete absorption of the whole radiation given out by the bulb into the gas can be deduced.

Let i = maximum current produced by the total ionisation of the gas by the rays,
n = total number of ions produced per sec.,
ϵ = charge on an ion.
Then $i = n\epsilon$.
Let H = heating effect per sec. due to the rays when absorbed in a metal,
E = total energy of the rays in ergs,
Then E = JH, where J = Joule's equivalent.
If W = average energy required to produce an ion, then

$$nW = E = JH,$$
$$\therefore W = \frac{JH}{n} = \frac{JH\epsilon}{i}.$$

The values of H and i are experimentally determined, and, assuming the value of ϵ, namely, $6\cdot5 \times 10^{-10}$ electrostatic units, determined by J. J. Thomson, the value of W is found in absolute measure.

Heating Effect of the Rays.

An automatic focus tube was employed, excited by a large induction coil with a special form of Wehnelt interrupter giving 57 breaks per second. The bulb gave out intense rays of a very penetrating character.

The heating effect was measured by determining the variation of resistance in a specially constructed platinum bolometer when the rays fell upon it. The heating effect was standardised by observing the change of resistance caused by the passage of a known current through the bolometer. Special precautions were taken to screen off all heating effects except that due to the X-rays employed.

About ·55 of the incident rays were absorbed in the platinum bolometer. The energy dissipated in exciting secondary radiation at the surface of the platinum was neglected in comparison with the total energy absorbed.

The rate of supply of heat to the bolometer surface (area 92·2 square cms.) at a distance of 26 cms. from the source of the rays was about

0·00014 gramme-calorie per sec.

The total energy of the rays given out from the front surface of the platinum antikathode (omitting absorption of rays in glass of bulb, air, and screens, &c.) was

0·011 gramme-calorie per sec.

Absorption of X-Rays in Gases.

A null method was employed, as the absorption of the rays in air at atmospheric pressure was small. The rays passed through two long brass tubes with aluminium ends, and the current produced by the rays, after passing through one tube, was balanced against the current due to the other. On exhausting one tube the electrometer balance was disturbed. From measurements of the deflection per second from the balance and the deflection per second due to the rays after passing through one tube, the absorption can be calculated. The mean value of the coefficient of absorption of the rays in air at atmospheric pressure was found to be

0·000279,

or the rays would pass through 24·7 metres before absorption reduced the intensity of the radiation to one-half.

The absorption was found to be proportional to the pressure from a half atmosphere to three atmospheres.

The coefficient of absorption in carbonic acid gas was found to be 1·59 times the absorption in air.

Energy required to produce an Ion.

The current produced when a given volume of the gas was ionised by X rays was determined by means of an electrometer. In order to get rid of the secondary radiations set up when X rays strike on a conductor, the rays passed between two charged parallel plates without striking them. A guard-ring method was employed to ensure uniformity of the electric field.

The value of the ionic energy was deduced from the determination of the current, heating effect and absorption of the

rays. The mean value of the energy required to produce an ion in air at atmospheric pressure and temperature was found to be

$$1\cdot90 \times 10^{-10} \text{ ergs.}$$

This value is much greater than the energy required to produce hydrogen and oxygen ions in the decomposition of water.

The ionic energy of air was found to be approximately the same from pressures of one-half to three atmospheres.

The method of determining the ionic energy for other gases is described, and the evidence that the "ionic energy" is the same for all gases is discussed.

Emission of Energy from Radio-active Substances.

The velocity of the ions produced by Röntgen and uranium radiation in air has been shown to be the same. The ions are thus probably the same, and it is a reasonable assumption that the same energy is required in both cases to produce them. On this assumption the energy radiated by the radio-active substances can be determined.

The radio-active material was spread over a known area and the maximum current produced between the parallel plates determined. The number of ions produced, and consequently the energy to produce them, can be calculated.

For a thick layer of uranium oxide (3·6 grammes spread over a surface of 38 cm.) the energy radiated into the gas for 1 sq. cm.) of the surface is

$$10^{-11} \text{ calories per second.}$$

This amount of energy would suffice to raise 1 c.c. of water 1° C. in 3000 years, assuming no loss of heat by radiation. From observations on the current due to a very thin layer of uranium oxide it is shown that the energy radiated into the gas is not less than 0·032 calorie per year for every gramme of the substance.

The energy radiated from thorium and radium is also considered, and the presence of the rays from radium deflected by a magnet is taken into account.

In the case of radium, which is 100,000 times more radio-active than uranium, the emission of energy per gramme of the substance is not less than 3000 calories per year.

Distance between the Charges of the Ions in a Molecule.

On the assumption that the energy absorbed in producing an ion is due to the work done in separating the ions against the forces of their electrical attraction, it can be shown that the mean distance between the charges of the ions in the molecule is

$$1\cdot1 \times 10^{-9} \text{ cm.}$$

This is only 1/30 of the probable diameter of the atom. This result is in accordance with the view recently advanced by J. J. Thomson, that ionisation is produced by the removal of a negative ion from the molecule, and that the negative ion is only a small fraction of the mass of an atom.

Minimum Potential required to produce a Spark.

If the production of ions is necessary before a spark can pass, it can readily be deduced from the value of ionic energy that a spark cannot pass for a potential difference less than 175 volts. Experiments have shown that the minimum value is over 300 volts The theoretical value is of the same order, but from the complexity of the phenomena a very close agreement could not be expected.

Efficiency of a Fluorescent Screen.

Photometric comparisons were made of the light from a fluorescent screen, excited by the X-rays, with the standard Hefner-Alteneck amyl lamp. The energy of the visible radiation from the amyl lamp has been determined in absolute measure by Tumlirz (*Wied. Annal.*, vol. 38, p. 640), and the energy of the rays was measured by the method explained earlier in the paper. From these results the efficiency of the transformation of X-rays into visible light (compared with the amyl lamp) was found to be

4·4 per cent.

A method of determining the intensity of X-rays in absolute measure by photometric observations is explained.

Entomological Society, October 17.—Mr. G. H. Verrall, President, in the chair.—Mr. A. H. Jones exhibited a series of *Pararge maera*, a light form resembling *P. megaera* from the Basses Alpes and the Cévennes; a dark form approaching *P. hiera* from Cortina; and an intermediate form from the Italian Lakes; also a variety of *Lycaena corydon*, female, in which the under wing showed a decided blue coloration, taken at Lago di Loppio near Riva. Dr. Chapman suggested that the union between the three named species of *Pararge* was very near, if the species were not indeed identical.—Mr. A. J. Scollick exhibited a specimen of *Cethosia cyane*, a species inhabiting North-West India, which had been taken this year on the wing near Norwich. It was suggested by Mr. Distant that this was a case of accidental importation, probably in the pupal condition.—Mr. H. Rowland-Brown exhibited specimens of *Erebia glacialis*, taken this year on the Stelvio pass, showing transitional forms to the var. *Alecto*. He said that the typical form and the variety were not found flying together, but on opposite sides of the valley. Dr. Chapman observed that the darker specimens approached to the form of *E. melas* found in the neighbourhood of Cortina-di-Ampezzo. Specimens of *E. glacialis* also exhibited from Saas Fée and Evolena showed marked inferiority in size and brilliancy of colour.—Mr. W. L. Distant exhibited a piece of Hawkesbury sandstone from Australia, showing the borings of Termites, and in connection with the same communicated a note from the *Proceedings* of the Linnean Society of New South Wales (Pt. iii. 1899, p. 418), as follows:—"Mr. D. G. Stead exhibited specimens of Hawkesbury sandstone (1) From the sea-shore between tide marks showing the tunnelling of Marine Isopods (*Sphaeroma*) with the living animals *in situ*; and (2) from the hill-tops overlooking Port Jackson, offering examples of the borings which so often attract notice and the production of which has been attributed to Hymenoptera, and also to the Termites. Since last meeting Mr. Stead reported that he had investigated the matter and that, after breaking up a quantity of stone, he had come upon Termites, of a species at present undetermined, actually at work, specimens of which he exhibited.—Mr. M. Burr exhibited a male and female specimen of *Anisolabis colossea*, Dohrn., from New South Wales—the largest known earwig in the world.

PARIS.

Academy of Sciences, October 29.—M. Maurice Lévy in the chair.—On a method of Riemann and on linear partial differential equations, by M. R. Liouville.—The application of the interference method to the measurement of wave-lengths in the solar spectrum, by MM. A. Perot and Ch. Fabry. The method described permits of the direct comparison of the wave-length of a given dark line in the solar spectrum with a known cadmium ray, a single experiment requiring only the measurement of the diameters of two rings.—On the ammoniacal arsenates of nickel, by M. O. Ducru. Nickel forms three ammoniacal arsenates corresponding to those previously described for cobalt.—On the selenides of cobalt, by M. Fonzes-Diacon. Cobalt combines with selenium giving according to the conditions of the experiment $CoSe_2$, Co_3Se_3, Co_3Se_4, and CoSe. At a high temperature all these selenides are reduced by hydrogen to Co_2Se, which, after prolonged contact with the gas, loses all its selenium.—Modification of the chemical properties of some simple bodies by the addition of very small proportions of foreign substances, by M. Gustave LeBon. Magnesium and aluminium amalgams behave differently, from either of their constituents taken singly, towards water and air.—Cellulose, precipitated cellulose and hydrocellulose, by M. Leo Vignon. The reducing properties, velocity of saccharification, and heats of combustion of cellulose that had been submitted to different modes of treatment were determined. Solutions of strong alkali produced apparently a polymerisation, and similar effects were caused by dilute acids, but none of these celluloses possessed any reducing properties, and thus were sharply differentiated from the oxycelluloses.—On two ketones containing the acetylene grouping, acetyl-œnanthylidene and benzoyl-œnanthylidene. Transformation into β-diketones by hydration, by MM. Ch. Moureu and R. Delange. Amylacetylene $CH_3.(CH_2)_4—C\equiv CH$ is converted into its sodium derivative, and this, suspended in ether and treated with the acid chloride, gives the corresponding ketone. With strong sulphuric acid these ketones are hydrolysed, giving the β-diketones $C_5H_{11}.CO.CH_2.CO.CH_3$ and $C_3H_{11}.CO.CH_2.CO.C_6H_5$.—Transformation of α-amido-acids into phenylhydantoins, by M. A. Mouneyrat. A description of the preparation and

properties of γ-phenylhydantoin, phenyl-methyl-hydantoin, phenyl-ethyl-hydantoin, phenyl-isobutyl-hydantoin, and phenyl-benzyl-hydantoin.—On the regeneration of a confined volume of air by means of sodium peroxide, by M. George F. Joubert.—On the gaseous exchanges between plants and the atmosphere, by M. Th. Schlœsing, junr. An extension of previous work on the same subject to plants growing in soils containing ammonia salts as the only available source of nitrogen, and free from the nitrifying organism.—A case of rapid transformation of wood into a substance resembling a combustible fossil, by M. G. Arth.—On the examination of contaminated waters for cystine, by M. M. Molinié. The author has repeated the experiments of M. Causse on this subject, and finds that the reagent proposed as a test for cystine gives a permanent orange coloration, not removable by sulphurous acid, even in distilled water. Further examination of the reaction showed that the tint is produced only when the test solution has an acid reaction. The test would thus appear not to be a characteristic one for cystine.—On a new sporozoa from the larvæ of Diptera, by M. Louis Léger.—Precocity and sexual periodicity in man, by M. Gustave Loisel. An attempt to explain the phenomenon of sexual periodicity by the periods in the evolution of spermatogenesis in man and the higher vertebrates.

NEW SOUTH WALES.

Royal Society, August 8.—The President, Prof. Liversidge, F.R.S., in the chair.—The President announced that the third science lecture of the Royal Society of New South Wales' series for 1900, viz. a Study of the Mechanics of the Human Frame-work, by Prof. T. P. Anderson Stuart, would be given in the Royal Society's House on August 22.—The following papers were read: Notes on rack railways, by C. O. Burge.—On the damage done to the Seal Rocks lighthouse by lightning on July 10, by C. W. Darley. The author said that the lighthouse tower was fitted with a solid copper lightning conductor extending half round, and was attached at the top to the copper roof of the lantern. The electricity evidently entered the vane on top of the lantern dome, the end being bent and fused, and thence passed down the lightning rod. A portion of the current was communicated to the electric bell wires on the middle floor. These wires led to the principal and assistant light-keepers' quarters, and were laid underground in a 1-inch iron pipe for a distance of 300 feet. The current had tried to make earth at three places, for the pipe was burst and the earth above blown away.

DIARY OF SOCIETIES.

THURSDAY, NOVEMBER 8.

MATHEMATICAL SOCIETY, at 5.30.—Annual General Meeting.—On the Transmission of Force through a Solid: Lord Kelvin, G.C.V.O.—In a Simple Group of an Odd Composite Order every System of Conjugate Operators or Sub-groups includes more than Fifty: Dr. G. A. Miller.—Prime Functions on a Riemann Surface: Prof. A. C. Dixon. (i) Further Note on Isosceleans; (ii) On Two In-triangles which are similar to the Pedal Triangle: R. Tucker.—(i) A General Congruence Theorem relating to the Bernoullian Function; (ii) On the Residues of Bernoullian Functions for a Prime Modulus, including as Special Cases the Residues of the Eulerian Numbers and the I-numbers: Dr. Glaisher, F.R.S.—On Green's Function for a Circular Disc: H. S. Carslaw.—On the Real Points of Inflexion of a Curve: A. B. Basset, F.R.S.—On Quantitative Substitutional Analysis: A. Young.—On a Class of Plane Curves: J. H. Grace.—On Group Characteristics, and on some Properties of Groups of Odd Order: Prof. Burnside, F.R.S.—(i) Conformal Space Transformations; (ii) Dynamical and other applications of Algebra of Bilinear Forms: T. J. I. Bromwich.

INSTITUTION OF ELECTRICAL ENGINEERS, at 8.—Inaugural Address: Prof. J. Perry, F.R.S.

FRIDAY, NOVEMBER 9.

ROYAL ASTRONOMICAL SOCIETY, at 8.—Observations of Nebulæ made at the Chamberlin Observatory, University Park, Colorado: Prof. H. A. Howe.—On the Appearance of Saturn's Crape Ring in 1900: E. M. Antoniadi.—Observations of Jupiter and his Satellites made at Mr. Crossley's Observatory, Bermerside, Halifax, 1899–1900: J. Gledhill.—Photographic Measures of the Ring Nebula in Lyra and of the Neighbouring Faint Stars: F. P. Leavenworth.—(1) Ephemeris for Physical Observations of the Moon for 1901; (2) Note on the Moon's Eclipse Diameter: A. C. D. Crommelin.—The Occultation of Saturn, 1900 September 3: Rev. S. J. Johnson.—Variable Stars in Star Clusters: A. W. Bickerton.—On the Disappearance from Photographic Films of Star Images, and their Recovery by a Chemical Process: Isaac Roberts.—Note on the Total Eclipse of the Sun, 1900 May 28, observed at Algiers: Rev. C. D. P. Davies.—Micrometric Measures of the Diameter of Neptune and Satellite made with the 28-inch Refractor: Royal Observatory, Greenwich.—*Probable Papers:* Stationary Meteor Radiants: an Alternative Explanation: H. H. Turner.—Photographic Observations of the Planet Eros: a Close Approach to a Small Star: F. A. Bellamy.—On the Variable Velocity of α Persei: H. F. Newall.—On the System of ζ Herculis as deduced from Micrometric Measures and Meridian Observations: T. Lewis.—Kinematograph Photographs of the Total Solar Eclipse of 1900 May 28: Nevil Maskelyne.

PHYSICAL SOCIETY, at 5.—Electromotive Force and Osmotic Pressure: Dr. R. A. Lehfeldt.—On Astigmatic Lenses: R. J. Sowter.—(*a*) On a Phase-turning Apparatus for use with Electrostatic Voltmeters; (*b*) On a Method of Measuring Power in Alternate-Current Circuits; (*c*) Note on obtaining Alternating Currents and Voltages in the same Phase for Fictitious Loads: A. Campbell.—On the Refraction of Sound by Wind: Dr. E. H. Barton.

MALACOLOGICAL SOCIETY, at 8.—Morphological and Descriptive Notes on the Genus *Cryptoplax*: H. A. Pilsbry.—Notes on a Remarkable Nudibranch from N.W. America: Sir Charles Eliot.—On the Anatomy of some Agnathous Molluscs from New Zealand: R. Murdoch.—Fate of the Type Specimen of *Voluta Roadknightae*, McCoy: W. Baldwin Spencer.

MONDAY, NOVEMBER 12.

ROYAL GEOGRAPHICAL SOCIETY, at 8.30.—Introductory Address: The President.—Expedition through Somaliland and between Lake Rudolf and the Nile: Dr. A. Donaldson Smith.

TUESDAY, NOVEMBER 13.

INSTITUTION OF CIVIL ENGINEERS, at 8.—The Metropolitan Terminus of the Great Central Railway: George A. Hobson and E. Wragge.

MINERALOGICAL SOCIETY, at 8.—Anniversary Meeting.—An Improved Form of Three-Circle Goniometer: G. F. H. Smith.—A Simple Proof of the Rationality of the Anharmonic Ratio of Four Faces of a Zone: Harold Hilton.—Sulpharsenites of Lead from the Binnenthal. Part II. Rathite: R. H. Solly.

THURSDAY, NOVEMBER 15.

ROYAL SOCIETY, at 4.30.—The following Papers will *probably* be read: Further Note on the Spectrum of Silicium: Sir Norman Lockyer, F.R.S.—On Solar Changes of Temperature and Variations in Rainfall in the Region Surrounding the Indian Ocean: Sir Norman Lockyer, F.R.S., and Dr. W. J. S. Lockyer.—Argon and its Companions: Prof. W. Ramsay, F.R.S.—Data for the Problem of Evolution in Man. VI. A First Study of the Correlation of the Human Skull: Dr. Alice Lee and Prof. K. Pearson, F.R.S.—Mathematical Contributions to the Theory of Evolution. IX. On the Principle of Homotyposis and its Relation to Heredity, to the Variability of the Individual and to that of the Race. Part I. Homotyposis in the Vegetable Kingdom: Prof. K. Pearson, F.R.S.—On Retinal "Blaze" Currents: Dr. Waller, F.R.S.

LINNEAN SOCIETY, at 8.—Contributions to the Comparative Anatomy of the Cycadaceæ: W. C. Worsdell.—On a New Parasitic Copepod: Miss Alice L. Embleton.

CHEMICAL SOCIETY, at 8.—The Bases contained in Scottish Shale Oil: F. C. Garrett and Dr. J. A. Smythe.

FRIDAY, NOVEMBER 16.

INSTITUTION OF MECHANICAL ENGINEERS, at 8.—Capacity of Railway Waggons as affecting Cost of Transport: D. Twinberrow.

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