municating motion to the air after a very few vibrations. The case of a Leyden jar discharge is more like the case of a mass on a spring than the case of a pendulum, because in the cases of the Leyden jar there is nothing quite analogous to the way in which the earth pulls the pendulum: it is the elasticity of the ether that causes the electric currents in the Leyden jar discharge, just as it is the elasticity of the spring that causes the motion of the matter attached to it in the case of a mass vibrating on a spring. It is possible to push this analogy still further. Under what conditions would the spring vibrate most rapidly? When the spring was stiff and the mass small. What is meant by a spring being stiff? When a considerable force only bends it a little. This corresponds to a considerable electric force only electrifying the Leyden jar coatings a little, *i.e.* to the Leyden jar having a small capacity. We would consequently expect that the discharge of a Leyden jar with a small capacity would vibrate more rapidly than that of one with a large capacity, and this is the case. In order to make a Leyden jar of very small capacity we must have small conducting surfaces as far apart as possible, and two separate plates or knobs do very well. The second condition for rapid vibration was that the mass moved should be small. In the case of electric currents what keeps the current running after the plates have become discharged and recharges them again is the so-called self-induction of the current. It would be well to look upon it as magnetic energy stored up in the ether around the current, but whatever view is taken of it, it evidently corresponds to the mass moved, whose energy keeps it moving after the spring is unbent and rebends the spring again. Hence we may conclude that a small self-induction will favour rapidity of oscillation, and this is the case. To attain this we must make the distance the current has to run from plate to plate as short as possible. The smaller the plates and the shorter the connecting wire the more rapid the vibrations; in fact, the rapidity of vibration is directly proportional to the linear dimensions of the system, and for the most rapid vibrations two spherical knobs, one charged positively and the other negatively, and discharging directly from one to the other, have been used. Hertz in his original investigations used two plates about 40 cm. square, forming parts of the same plane, and separated by an interval of about 60 cm. Each plate was connected at the centre of the edge next the other plate with a wire about 30 cm. long, and terminating in a small brass knob. These knobs were within 2 or 3 mm. of one another, so that when one plate was charged positively and the other negatively they discharged to one another in a spark across this gap. An apparatus about this size would produce waves 10 or 12 metres long, and its rate of oscillation would be about 30 million per second. As the vibration actually produced by these oscillators seems to be very complex, the rate of oscillation can only be described as "about" so and so. In a subsequent investigation Hertz employed two elongated cylinders about 15 cm. long and about 3 cm. in diameter, terminated by knobs about 4 cm. in diameter, and discharging directly into one another. Such an oscillator produces waves from 60 to 70 cm. long, and, consequently, vibrations at the rate of between 400 and 500 million per second. Most other experimenters have used oscillators about the same dimensions as Hertz's larger apparatus, as the effects produced are more energetic; but many experiments, especially on refraction, require a smaller wave to be dealt with, unless all the apparatus used be on an enormous scale, such as could not be accommodated in any ordinary laboratory. When we are thus aiming at rapid rates of vibration, it must be recollected that we cannot at the same time expect many vibrations after each impulse. If we have a stiff spring with a small weight arranged so as to give a lot of its energy to the surrounding medium, we cannot expect to have very much energy to deal with, nor many vibrations, and, as a matter of fact, we find that this is the case. The total duration of a spark of even a large Leyden jar is very small. Lord Rayleigh has recently illustrated this very beautifully by his photographs of falling drops and breaking bubbles. We cannot reasonably expect each spark to have more than from 10 to 20 effective oscillations, so that, even in the case of the slower oscillator, the total duration of the spark is not above a millionth of a second. It is very remarkable that the incandescent air, heated to incandescence by the spark, should cool as rapidly as it does, but there is conclusive evidence that it remains incandescent after the spark proper has ceased, and consequently lasts incandescent longer than the millionth of a second. What is seen as the white core of the spark may not last longer than the electric discharge itself, and certainly does not do so in the case of the comparatively very slowly oscillating sparks that have been analyzed into their component vibrations by photographing them on a moving plate. The incandescent air remaining in the path of such discharge is probably the conducting path through which the oscillating current rushes backwards and forwards. Once the air gap has been broken through, the character of the air gap as an opponent of the passage of electricity is completely changed. Before the air gap breaks down, it requires a considerable initial difference of electric pressure to start a current. Once it has been broken down, the electric current oscillates backwards and forwards across the incandescent air gap until the whole difference of electric pressure has subsided, showing that the broken air gap has become a conductor in which even the feeblest electric pressure is able to produce an electric current. If this were not so, Leyden jars would not be discharged by a single spark. All this is quite in accordance with what we know of air that is, or even has lately been, incandescent: such air conducts under the feeblest electric force. All this is most essential to the success of our oscillator. Only for this valuable property of air, that it gives way suddenly, and thenceforward offers but a feeble opposition to the rapidly alternating discharge, it would have been almost impossible to start these rapid oscillations. If we wish to start a tuning-fork vibrating, we must give it a sharp blow: it will not do to press its prongs together and then let them go slowly: we must apply a force which is short-lived in comparison with the period of vibration of the fork. It is necessary, then, that the air gap must break down in a time short compared with the rate of oscillation of the discharge; and when this is required to be at the rate of 400 million per second, it is evident how very remarkably suddenly the air gap breaks down. From the experiments themselves it seems as if any even minute roughnesses, dust, &c., on the discharging surface, interfered with this rapidity of breakdown: it seems as if the points spluttered out electricity and gradually broke down the air gap, for the vibrations originated are very feeble unless the discharging surfaces are kept highly polished: gilt brass knobs act admirably if kept polished up every ten minutes or so. One of the greatest desiderata in these experiments is some method of making sure that all the sparks should have the same character, and be all good ones.

(*To be continued.*)

THE ROYAL SOCIETY SELECTED CANDIDATES.

THE following fifteen candidates were selected on Thursday last (April 30), by the Council of the Royal Society, to be recommended for election into the Society. The ballot will take place on June 4, at 4 p.m. We print with the name of each candidate the statement of his qualifications.

WILLIAM ANDERSON,

V.-P.Inst.M.E. M.I.C.E. Consulting Engineer, Royal Agricultural Society of England. Pupil of the late Sir William Fairbairn, F.R.S. Member of the firm of Messrs. Courtney and Stephens, Engineers, of Dublin, from 1855 to 1864. President, in 1863, of the Inst. of Civil Engineers of Ireland, to which Society he communicated important papers:—"On the Theory of Braced Girders;" "The Strength of Railway Bridges of Small Span, and the Cross-beams of Large Bridges;" and other subjects. Between 1872 and 1885, communicated many important papers to the Inst. of Civil Engineers, *e.g.*, "Experiments on Sugar Manufacture, in Upper Egypt, by the Sulphurous Acid Process;" "Experiments and Observations on the Emission of Heat by Hot-water Pipes;" and "Purification of Water on the Large Scale by Agitation with Iron" (being a process successfully elaborated by him, and applied at the Antwerp Waterworks, &c). Received the Telford Medal and the James Watt Gold Medal of the Inst. C.E. Author of a Lecture on "The Generation of Steam," being one of the "Heat Series" of Special Lectures delivered at the Inst. C.E.; of a Text-book on "The Conversion of Heat into Useful Work," being the substance of a course of Lectures delivered at the Society of Arts under the "Howard Trust"; of a paper on "New Applications of the Mechanical Properties of Cork," communicated as a Lecture to the Royal Institution; and of various papers communicated to the Inst. of Mechanical Engineers, the Royal Agricultural Society, &c. Distinguished for the ability with which he has applied his intimate knowledge of the science of heat, and other cognate sciences, to the practical requirements of the engineer.

FREDERICK ORPEN BOWER, D.Sc. (Camb.),

F.L.S., F.R.S.E. Regius Professor of Botany in the University of Glasgow. Distinguished for his researches in histological and morphological botany. Author (in conjunction with Prof. S. H. Vines, F.R.S.) of "A Course of Practical Instruction in Botany," and of the following papers, amongst others:—On the Development of the Conceptacle in Fucaceæ" (*Quart. Journ. Micros. Sci.*, 1879); "On the Germination of *Welwitschia*" (*ibid.*, 1880); "On the Further Development of *Welwitschia*" (*ibid.*, 1881); "On the Germination and Embryogeny of *Gnetum Gnemon*" (*Quart. Journ. Micros. Sci.*, 1882); "On the Structure of the Stem of *Rhynchopetalum montanum*" (Journ. Linn. Soc., 1883); "On the Comparative Morphology of the Leaf in Vascular Cryptogams and Gymnosperms" (Phil. Trans., 1884); "On the Apex of the Root of *Osmunda* and *Todea*" (*Quart. Journ. Micros. Sci.*, 1884); "On Apospory in Ferns" (Journ. Linn. Soc., 1884); "On the Development and Morphology of *Phylloglossum Drummondii*" (Phil. Trans., 1885); "On Apospory and Allied Phenomena" (Trans. Linn. Soc., 1887); "On the Limits of the Use of the Terms Phyllome and Caulome" (*Annals of Bot.*, 1887); "On the Modes of Climbing in the Genus *Calamus*" (*ibid.*); "On some Normal and Abnormal Developments of the Oophyte in Trichomanes" (*ibid.*); "*Humboldtia laurifolia* as a Myrmekophilous Plant" (Trans. Phil. Soc. Glasg.); "The Comparative Examination of the Meristems of Ferns as a Phylogenetic Study" (*Annals of Bot.*, 1889); "On the Morphology of the Leaf of Nepenthes" (*ibid.*); "On Antithetic as distinct from Homologous Alternation of Generations in Plants" (*ibid.*, 1890). Translator (in conjunction with Dr. D. H. Scott) of "Comparative Anatomy of the Phanerogams and Ferns," by Anton de Bary (Clarendon Press, 1884).

SIR JOHN CONROY, Bart., M.A.,

F.C.S. Lecturer on Physics and Chemistry, Keble College, Oxford. An assiduous Student of Experimental Science, and author of the following papers:—"On the Dioxides of Calcium and Strontium" (Journ. Chem. Soc., 1873); "On the Polarization of Light by Crystals of Iodine" (Proc. Roy. Soc., 1876); "Absorption-Spectra of Iodine" (Proc. Roy. Soc., 1876); "On the Light reflected by Potassium Permanganate" (*Phil. Mag.*, 1878); "The Distribution of Heat in the Visible Spectrum" (*Phil. Mag.*, 1879); "Experiments on Metallic Reflexion" (Proc. Roy. Soc., 1871, 1879, 1883).

DANIEL JOHN CUNNINGHAM, M.D. (Edin.),

M.D. (Dublin), F.R.C.S.I., F.R.S.E., F.Z.S., Professor of Anatomy, University of Dublin. Distinguished both as a teacher and original inquirer. Examiner in Anatomy in the Universities of London, Edinburgh, and Dublin. Member of Council, Royal Irish Academy. Vice-Pres. Zoological Society, Ireland. Vice-Pres. Anatomical Society of Great Britain and Ireland. Author of numerous anatomical memoirs in journals and publications of scientific societies. More especially may be mentioned—"Report on the Anatomy of the Marsupialia" (*Challenger* Report, Part 16); "The Lumbar Curve in Man and Apes," forming Cunningham Memoir, No. 2, published by the Royal Irish Academy, 1886; "The Spinal Nervous System of the Porpoise and Dolphin" (*Journ. Anat. Physiol.*, 1876). Author of a Text-book of Practical Anatomy.

GEORGE MERCER DAWSON, D.Sc.,

F.G.S., A.R.S.M., F.R.S.C. Assistant Director, Geological Survey of Canada. Much important and valuable work, more especially in geology and ethnology, as in the following summary statement. During his thirteen years of service on the Geol. Survey (Canada) has been chiefly engaged in working out the Geology of the North-West Territory and British Columbia. Placed in charge of the Yukon Expedition, 1887. Author of numerous papers, chiefly geological, but including geographical, ethnological, and other observations, published in the Quart. Journ. Geol. Soc., Trans. Roy. Soc. Canada, *Canadian Naturalist*, &c. These deal more especially with the superficial geology of the regions explored, but some describe Foraminifera and other microscopic organisms. Author of fifteen reports published by the Geological Survey of Canada, and joint author (with Dr. Selwyn) of a Descriptive Sketch of the Physical Geography and Geology of Canada, and (with Dr. W. F. Tolmie) of Comparative Vocabularies of the Indian Tribes of British Columbia.

EDWIN BAILEY ELLIOTT, M.A.,

Fellow of Queen's College, Oxford. Vice-President of the London Mathematical Society. Mathematical Lecturer of Queen's and Corpus Christi Colleges. Distinguished as a Mathematician and original investigator in various branches of mathematical research. Author of the following papers:—"Generalization of Prevost and Lhuilier's Theorem in Chances" (*Ed. Times*, vol. xxxv.); "On Normals to Envelopes" (*Mess. of Math.*, vol. ix. p. 85); "On Multiple Definite Integrals" (Lond. Math. Soc. Proc., vol. viii., pp. 35, 146); "Kinematics on a Sphere" (*ibid.*, vol. xii., p. 47); "Multiple Frullanian Integrals" (*ibid.*, vol. xv., p. 12; Small Motions of Systems with One Degree of Freedom" (*Mess. of Math.*, vol. xv., p. 38); "The Linear Partial Differential Equations satisfied by Pure Ternary Reciprocants" (Lond. Math. Soc. Proc., vol. xviii., p. 142); "On the Interchange of the Variables in certain Linear Differential Operators" (Abstract, Roy. Soc. Proc., vol. xlvi., p. 358 [ordered to be printed in the Phil. Trans.]); and eighteen other papers printed in the London Mathematical Society's Proceedings and elsewhere between the years 1875 and 1890.

PERCY FARADAY FRANKLAND, B.Sc.,

A.R.S.M., Ph.D. Professor of Chemistry. Formerly Senior Demonstrator in the Chemical Laboratory of the Normal Schools of Science, South Kensington. Author of upwards of twenty original papers in the Phil. Trans. and Proc. Roy. Soc., in the Journals of the Chem. Soc., the Soc. of Chem. Industry, &c. Known for his researches on Bacteriology and on the Chemical Aspects of Fermentation.

PERCY C. GILCHRIST,

A.R.S.M. Metallurgist. Distinguished as a Metallurgist, especially in connection with the manufacture of iron and steel. In association with the late Mr. S. G. Thomas he greatly advanced metallurgical practice by the introduction of a process which enables iron to be dephosphorized on a large scale. The process, which is known as the "Basic" process, possesses more than national importance, and its value has been universally recognized. It has further been shown that the slag, which is a product of the Basic process, contains phosphorus in a form which can be readily assimilated by vegetation. One result of his metallurgical work has thus been to substantially benefit agriculture, as more than half a million tons of basic slag are now used annually as a fertilizer. He is the author of numerous papers published in the Journal of the Iron and Steel Institute and elsewhere.

WILLIAM DOBINSON HALLIBURTON, M.D., B.Sc.,

Assistant Professor of Physiology in University College, London. Has during the past four years devoted his entire time to research work in, and teaching of Physiology, especially the chemical side of that science. Has published the following, among other communications:—"On the Proteids of Serum" (Proc. Roy. Soc., and *Journ. of Physiol.*, 1884); "On the Chemical Composition of Invertebrate Cartilage" (Proc. Roy. Soc., 1885, and *Quart. Journ. Micros. Sci.*); "On the Blood of Crustacea" (*Journ. of Physiol.*, 1885, and in a Report to the Scottish Fisheries Board); "On Hæmoglobin and Methæmoglobin Crystals" (*Brit. Med. Journ.*, 1886, and Proc. Physiol. Soc.); "On the Blood-proteids of Lower Vertebrates" (*Journ. of Physiol.*, 1886); "On the Coagulation of Myosin" (Prelim. Communication to Physiol. Soc., 1887).

OLIVER HEAVISIDE,

Learned in the science of electro-magnetism, having applied higher mathematics with power and success to the developments of Maxwell's theory of electro-magnetic wave propagation, and having extended our knowledge of facts and principles in several directions and into great detail. He is the author of the following papers among many others:—"On Electro-magnetic Induction and its Propagation" (48 parts, 1885–87, in the *Electrician*); "The Induction of Currents in Cores" (15 parts, 1884–85); "Some Electrostatic and Magnetic Problems" (5 parts, 1883); "Current Energy" (19 parts, 1883–84); "On the Electro-magnetic Effects due to the Motion of Electrification through a Dielectric" (*Phil. Mag.*, 1889); "The General Solution of Maxwell's Equations" (*Phil. Mag.*); "On Electro-magnetic Waves" (6 parts, *Phil. Mag.*, 1888); "On Resistance and Conductance Operators" (*Phil. Mag.*, 1887); "On the Self-induction of Wires" (7 parts, *Phil. Mag.*, 1886–87); "On the Electro-magnetic Wave Surface" (*Phil. Mag.*, 1885); "On the Electro-magnetic Effect of a Moving Charge"; "The Deflection of an Electro-magnetic Wave by Motion of the Medium"; "On the Working of Cells with Condensers" (*Phil. Mag.*, 1874); "On the Extra Current" (1876); "On the Speed of Signalling through Heterogeneous Telegraph Circuits" (*ibid.*, 1877); "On the Effect of Faults on the Speed of Working Cables"; "On Electro-magnets" (Journ. Soc. Tel. Eng.); "On Induction between Parallel Wires" (*ibid*).

JOHN EDWARD MARR, M.A. (Cantab.),

F.G.S. Fellow and Lecturer of St. John's College, Cambridge, and University-Lecturer in Geology. First Class Nat. Sci. Tripos, 1878; Sedgwick Prizeman, 1883; Examiner for the Nat. Sci. Tripos, 1886–87. Secretary of the Geological Society, 1888. Author of the following:—"Fossiliferous Cambrian Slates near Carnarvon" (Quart. Journ. Geol. Soc., 1876); "On Phosphatized Carbonate of Lime at Cave Ha" (*Geol. Mag.*, 1876); "On some well-defined Life-zones in the lower part of the Silurian of the Lake District" (Quart. Journ. Geol. Soc., 1878); "On the Cambrian and Silurian Rocks of the Dee Valley" (*ibid.*, 1880); "On the Pre-Devonian Rocks of Bohemia" (*ibid.*, 1880); "On some Sections of the Lower Palæozoic Rocks of the Craven District" (Proc. Yorks. Geol. Soc., 1882, and Brit. Assoc., 1881); "The Classification of the Cambrian and Silurian Rocks" (*Geol. Mag.*, 1881); "On the Cambrian and Silurian Rocks of Scandinavia" (Quart. Journ. Geol. Soc., 1882); "Origin of the Archæan Rocks" (*Geol. Mag.*, 1883); "The Classification of the Cambrian and Silurian Rocks" (Sedgwick Prize Essay, 8vo, Cambridge, 1883); "The Earth History of the Remote Past compared with that of Recent Times" (8vo, Cambridge, 1886); "The Lower Palæozoic Rocks near Settle" (*Geol. Mag.*, 1887); "The Work of Ice Sheets" (*ibid.*); "Glacial Deposits of Sudbury" (*ibid.*); "On some Effects of Pressure on the Devonian Sedimentary Rocks of North Devon" (*ibid.*, 1888); "The Lower Palæozoic Rocks of the Fichtelgebirge" (*ibid.* 1889); "The Metamorphism of the Skiddaw Slates" (Brit. Assoc., 1889). Joint-papers:—"The Lower Palæozoic Rocks of the Neighbourhood of Haverfordwest" (Quart. Journ. Geol. Soc., 1885); "The Stockdale Shales" (*ibid.*, 1888).

LUDWIG MOND,

F.I.C. President of the Society of Chemical Industry, V.-P. Chem. Soc. Distinguished technical chemist and inventor. Has made important additions to chemical industrial processes and products, especially with reference to the alkali industry, having improved the mode of manufacture of carbonate of soda, caustic soda, hydrochloric acid, chlorine, ammoniacal products, and gas generating furnaces, &c. In 1863 he developed what is known as the "Mond Process of Sulphur Recovery from Alkali Waste," and has since that date devoted himself to the introduction and development of the ammonia soda process of alkali manufacture into England. Author of various papers in Rept. Brit. Assoc., Journ. Soc. Chem. Ind.

WILLIAM NAPIER SHAW, M.A.,

Fellow of Emmanual College, Cambridge. Was nominated by Lord Rayleigh as one of the Demonstrators of Physics in the Cavendish Laboratory at Cambridge. He held that position from 1880 to 1887, and he has since continued his connection with the Laboratory as University Lecturer in Physics. His knowledge of the manner in which the teaching of Physics is conducted in the great German Universities (acquired at Berlin under Helmholtz) enabled him to bear an important part in the organization of the laboratory. A considerable part of the success of the Cambridge School of Physics is due to his exertions, backed by his knowledge of Physics. Author of numerous books and papers, of which the following are especially worthy of notice:—"Practical Physics" (jointly with Mr. Glazebrook), Longmans, 1885; "Practical Work in the Cavendish Laboratory," University Press, 1886; "Faraday's Law of Electrolysis with reference to Silver and Copper," Rept. Brit. Assoc., 1886; "Electrolysis" and "Pyrometer," "Encyc. Brit."; "On Vaporimeters," &c., Rept. to the Meteorol. Council, 1884; "On Hygrometric Methods, Part I.," Rept. to the Meteorol. Council, printed in Phil. Trans.

SILVANUS PHILLIPS THOMPSON, D.Sc. (Lond.),

Principal and Professor of Physics in the City and Guilds of London Technical College, Finsbury; formerly Professor of Experimental Physics in University College, Bristol. Author of many papers published in the Proceedings, &c., Royal Society, Physical Society, Institution of Electrical Engineers, Society of Arts, and British Association, including the following:—"The Theory of the Magnetic Balance" (Proc. Roy. Soc., 1884); "Electro-deposition of Alloys" (*ibid.*, 1887); "Subjective Interference of Sound" (*Phil. Mag.*, 1887); "Opacity of Tourmaline Crystals" (*ibid.*, 1881); "The Meaning of the Constant in Bernouilli's Law of the Lifting Power of Magnets" (*Phil. Mag.*, 1888); "Development of the Mercurial Air Pump" (Journ. Soc. Arts, 1887); "The Influence Machine from 1788 to 1888" (Journ. Soc. Telegr. Engin., 1888). Author of a treatise on "Dynamo-Electric Machinery" (3rd edit., 1888), and of an elementary text-book of Electricity and Magnetism (43rd thousand, 1889), which has gone through many English and several foreign editions. Originator of improvements in polarizing prisms, in the method of adjusting resistance coils, and in sundry electrical apparatus. Member of Council of the Physical Society, and of the Institution of Electrical Engineers. Distinguished for his acquaintance with the science of electricity, more particularly in its experimental and technical aspects.

THOMAS HENRY TIZARD, Staff-Commander, R.N., H.M.S. *Triton*,

F.R.G.S. Distinguished as a Hydrographical Surveyor and Marine Meteorologist. Has been employed for 25 years in the Naval Surveying Service. In China, Mediterranean, and Red Seas, 1862–72. Senior Assistant-Surveyor in the *Challenger* Expedition, 1872–76. Prepared the reports on the sea temperatures, and on the meteorological observations obtained under his own superintendence during the voyage (*Challenger* Report, vol. ii.); Joint Author of vol. i. *Challenger* Report, contributing the hydrographical portion of the Narrative of the Voyage. Has since served for nine years in charge of surveys on the coasts of the United Kingdom; now employed in command of H.M.S. *Triton*. Has contributed a paper to the Royal Society on the exploration of the Faeroe Channel (Proc. Roy. Soc., vol. xxxv. pp. 202–26; and on the meteorology of Japan, to the Meteorological Council (Official Publication, No. 28).