Address of the President, Sir Ernest Rutherford, O.M., at the Anniversary Meeting, November 30, 1927.

At this Anniversary Meeting we are naturally conscious of the losses suffered by our Society during the year. These include thirteen of our Fellows and three Foreign Members. We have also to record the loss of one of our Fellows under Statute 12, Edward Cecil Guinness, Earl of Iveagh, elected 1906.

Sir William Augustus Tilden passed away on December 11, 1926, in his 85th year. He was appointed Professor of Chemistry and Metallurgy in the Mason College, Birmingham, in 1880, and in 1894 became Professor of Chemistry in the Royal College of Science; he retained this latter position until his retirement in 1909. Much of Tilden’s early work was concerned with the terpenes, and he was the first to show that the hydrocarbon, isoprene, undergoes polymerisation with formation of caoutchouc. His Bakerian Lecture in 1900 dealt with the relation between atomic weight and specific heat, and he was awarded the Davy Medal in 1908. A man of many accomplishments and a courtly gentleman, he gained the affection and esteem of all with whom he came in contact.

J. J. Lister made his mark in the science of Zoology by his important discoveries on the life-history and morphology of the Foraminifera and by his contributions to our knowledge of Myctozoa. During his travels in the Pacific Ocean he made many valuable additions to our knowledge in several branches of the science and enriched our collections of the organisms that construct coral reefs. His father and grandfather were Fellows of the Royal Society, and his uncle, Lord Lister, was formerly our President.

Sir George Greenhill, for more than 30 years professor at the Royal Artillery College, Woolwich, was a mathematician of distinction and one of the foremost authorities on the science of ballistics. He especially excelled in the application of dynamics to the practical problems of everyday life, where his interests ranged from aeroplanes and ships to spinning-tops.

Arthur William Crossley was taken from us at the early age of 58 years. He was successively Lecturer in Chemistry in the Medical School of St. Thomas’ Hospital, and Professor of Chemistry to the Pharmaceutical Society and to
King's College, London; as an accomplished organic chemist he contributed much to our knowledge of the hydro-aromatic compounds. On the outbreak of war, Crossley threw himself whole-heartedly into the national effort and became the first Secretary to the Advisory Committee of the Trench Warfare Department; he was given the rank of lieutenant-colonel, R.E., and undertook the organisation of the newly founded Experimental Station at Porton, a task which he performed with conspicuous success. After the war he became the first Director of the Shirley Institute, Manchester, the home of the research association dealing with the cotton industry. The results of Crossley's marked ability as an initiator of organised scientific effort will long remain as a memorial to a brilliant leader.

Ernest Henry Starling, who died at the relatively early age of 63 years, was the first of the Royal Society's Research Professors, being appointed first Foulerton Professor in 1922. For more than 30 years Starling has been recognised as an outstanding figure in Physiology, and the investigations which he carried out with energy and enthusiasm have effected a clarification of knowledge and a new orientation of ideas concerning a succession of the most important functions of the body. His earliest studies, made like so many later ones in co-operation with his great friend and scientific partner, the late Sir William Bayliss, were directed to analysis of the action of the mammalian heart.

Though his activities were for many years diverted to other problems, his interest in the heart and the factors regulating its function remained with him always, and became again effective in his later years in a series of masterly researches. These he carried out, with a succession of able colleagues and pupils, on the mammalian heart, isolated by a method of his own devising, from the vessels of the major circulation, and performing its function under conditions which allowed the rate at which the blood entered the heart, and the resistance encountered in its ejection, to be artificially controlled—the well-known "heart-lung preparation."

In the intervening years he had completed and published, largely with Bayliss, a series of researches in which the physical laws governing filtration, diffusion and osmosis through membranes were applied to explain the formation and absorption of lymph. There followed further co-operative investigations with Bayliss on the movements of the intestinal walls, their co-ordination by the local nervous plexuses and their general control by the central nervous system, and then—most famous, probably, of all their joint researches—their work on the stimulation of pancreatic secretion following the discharge
Anniversary Address by Sir Ernest Rutherford.

of the stomach contents into the small intestine. This led to the discovery of "secretin" and the formation of general conceptions of the control of bodily functions by chemical messengers or "hormones," embodied in Bayliss and Starling's joint Croonian Lecture before this Society.

During the war and the years immediately following it, Starling gave his whole energies to the service of the State, as director of investigations on defence against chemical warfare, as chemical adviser to the army at Salonica, and later as chairman of the Royal Society's Food Committee, Scientific Adviser to the Ministry of Food and British Scientific Delegate to the Interallied Food Commission.

When his thoughts and activities were at last free to return to their own natural channels, he began a large and exacting series of investigations in which he combined some of his earlier methods to study the formation of urine under conditions artificially controlled and varied. These researches with many which grew from them, he continued to prosecute during his tenure of the Foulerton Professorship. He enjoyed the assistance and collaboration of a succession of able colleagues and of visiting workers from many countries, eager to learn his methods and to imbibe his ideas. It might have been hoped that the new conditions of freedom from the responsibilities of administration and formal teaching would have enabled him to conserve his physical powers; but Starling's restless energy and burning enthusiasm forbade all thought of relaxation, till at length a physique, weakened by illness, broke under the strain.

By Starling's death the Royal Society has lost not only a great investigator who has rendered one of its Chairs illustrious by his brilliant record of research as Foulerton Professor, but a Fellow who has been generous of efficient service to the Society on its Council and its Committees, who has been proud of its traditions and jealous for its fame and prosperity. He was awarded a Royal Medal in 1913. In and beyond this Society he was a stalwart champion of the claims of research and of the interests of his scientific colleagues. Physiology, above all, was the central interest and enthusiasm of his life. In its faithful and single-minded pursuit he had always one end in view; this, to quote from his own beautiful Harveian Oration was "to attain to a comprehension of the 'wisdom of the body and the understanding of the heart,' and thereby to the mastery of disease and pain, which will enable us to relieve the burden of mankind."

By the death of Gösta Mittag-Leffler, mathematical science lost one of its outstanding figures, one who played a notable part in the great development of
the Theory of Functions which occurred in the latter half of the last century. Even more memorable, perhaps, than his additions to the growth of knowledge, was his foundation of the *Acta Mathematica* in 1882, a journal which he conducted with loving care for over 40 years to the inestimable benefit of mathematical science. He will be long remembered for his critical studies in the history of mathematics, for his activities at international gatherings, and for his outstanding personality.

**Henry Richardson Procter**, who died in his 80th year, was head of the Procter International Research Laboratory of the University of Leeds. His laboratory, as its name implies, was built by subscriptions from all over the world, to further by fundamental scientific research the advance of leather technology, and to commemorate Prof. Procter's unique services in the leather industry.

Prof. W. Burnside was Professor of Mathematics at the Royal Naval College for over 30 years. Of much originality and power as a mathematician and distinguished as a teacher, his contributions to mathematical knowledge covered a wide variety of subjects, his earlier papers dealing mainly with hydrodynamics and waves, a large number of later papers with the Theory of Functions, and his more mature work with the Theory of Groups, a subject with which his name will always be associated. His book *The Theory of Groups*, first published in 1897 and again in 1909, is a standard exposition of the subject, much of it the result of his own researches.

**Sir Arthur Shipley** was in his early years a well-known contributor to the scientific journals on Parasitology, but when appointed to the Mastership of a Cambridge College and involved in the administrative duties of the University, he devoted his great organising powers to the wider dissemination of scientific truths and to the application of biological knowledge to the solution of problems in Agriculture and Fisheries.

As a scientific adviser to several Government Departments, as Chairman of the Marine Biological Association, and in many other activities, he rendered most valuable assistance to the promotion of Science and the welfare of the community.

The death of Prof. A. Livesidge, in his 80th year, removes one of the pioneers of scientific education in one of our great Dominions. At one time Demonstrator of Chemistry in Cambridge, he was elected in 1873 to the Chair of Chemistry in the University of Sydney, and held this post for 35 years. He was active in promoting scientific and technical education in Australia and was largely responsible for founding the Australasian Association for the Advancement of
Science, which has been of signal service in bringing together the widely scattered scientific workers. An ardent collector of minerals and meteorites, his scientific contributions were mainly connected with experimental mineralogy. On his retirement he resided in England, where he had a wide circle of friends.

William Einthoven, for 42 years Professor of Physiology in the University of Leyden, Nobel Laureate in Medicine, was elected a Foreign Member of the Society in 1926. His long scientific career was devoted to the invention and perfecting of physical apparatus of the greatest delicacy and precision for the record and analysis of processes occurring in the living body or having a physiological interest. His string galvanometer, originally devised for recording the fleeting electrical changes which accompany the different stages of the beat of the heart, and now in world-wide use in hospitals as well as physiological laboratories, has also found application in a wide range of purely physical investigations.

The scientific world deplores the loss at the age of 67 of Svante Arrhenius, Foreign Member and Davy Medallist of our Society and Nobel Laureate. Shortly after his graduation he published, in 1889, a famous paper in which he advanced the theory of ionic dissociation to explain the properties of electrolytes. This theory, and the modifications of it proposed from time to time, have stimulated an enormous amount of research in all lands, and indeed Arrhenius may justly be regarded as one of the founders of modern Physical Chemistry. A man of wide scientific interest and almost encyclopaedic knowledge, he made valuable contributions in many branches of science. As Director of the Nobel Institute in Stockholm he guided an active school of research, not only in problems of physical chemistry but in the application of physico-chemical ideas to physiological and biological problems, particularly to serum-therapy. Nor must we omit an excursion into the realm of cosmical physics, where he brought his wide knowledge to bear in interesting speculations on many subjects, such as the cause of variations of the earth's climate, the origin of our solar system and the dissemination of life throughout the universe. A man of forceful personality, of courageous and original mind, his early death will be mourned by a wide circle of friends throughout the scientific world.

Henry Martyn Taylor was known to many generations of mathematicians as Tutor and Lecturer of Trinity College, Cambridge. Failing eyesight restricted his activities in middle age, and after his sight was completely lost he devoted himself with energy to the preparation and publication of embossed books for the blind. Courageous in adversity, he continued to take an active part in public affairs and was Mayor of Cambridge and for many years a Magistrate.
In these notices I should like to include the name of A. A. Lawson, at one time Lecturer in the University of Glasgow and later Professor of Botany in the University of Sydney, who was a Selected Candidate for our Fellowship, but died before the date of formal election. His tenure of the professorship in Sydney was marked by the erection of a new Botanical Institute, which was opened in 1926 shortly before his death. A botanist of distinction and a worker in many lands, he made contributions to our knowledge in cytology and the morphology of the gymnosperms, and developed in Sydney an active school of research.

Turning to other matters, I would like to say a few words on some events in the past year of special interest to the welfare of our Society. In 1925, Messrs. Brunner, Mond & Co. gave a grant of £500 for three years towards the publication fund. In substitution for this grant, Sir Alfred Mond, on behalf of Imperial Chemical Industries, Ltd., has this year given a grant of £1,000 a year, until further notice, to help meet the deficit in the publication funds. This is a very welcome gift to the Society in a direction where help is much needed. Not only has the cost of printing greatly increased since the war, but there has been a notable increase in the number of papers published by the Society. This is specially marked in the 'A Proceedings,' where, in place of one or two volumes per year before the War, three or four volumes now appear, the separate numbers being issued with promptness and regularity.

On the Biological side, where the process of differentiation into separate subjects has probably gone further, the healthy and progressive activities of the specialist societies, which the Royal Society regards with pride as its children, has prevented so large an expansion in our published Proceedings. The expansion on this side of the Society's activities is more clearly shown in the 'Philosophical Transactions,' where the Society is able to do the important service to science of issuing large and elaborately illustrated monographs, the publication of which would be beyond the scope or the resources of the specialist organisations.

Anyone who reads our 'Proceedings' cannot fail to be impressed in general by the great variety and importance of the papers appearing in them. In some respects our Society is now the most important medium of publication of papers in Experimental and Theoretical Physics and Physical Chemistry in this country. This development of the Society's activity owes much to the energy and devoted work of the Physical Secretary, Dr. Jeans. This growth has in many ways thrown a heavy burden on some of the Fellows of our Society, for it is to be remembered that in general each paper has to be reported on favour-
Anniversary Address by Sir Ernest Rutherford.

ably by one or two referees before it is accepted for publication. This difficult work of adjudication has been undertaken uncomplainingly by our Fellows, and we are grateful to them for invaluable help in this important matter.

While the growth of the 'A Proceedings' and their punctual publication has led to a marked increase in the sales, there still remains a deficit, which is in part met from the residue of the Government Grant but mainly by special grants in aid from the Messel and Mond Bequest Funds. In no way can our Society be more helpful to the progress of science than by prompt publication of records of important original work, and it would be a great advantage if our Society could have at its disposal ample funds specially allocated for this important purpose.

During the last few years, your officers have given much thought to methods of improving the attendance of Fellows at the ordinary meetings. While special lectures and discussions, and many of the ordinary meetings, are in general well attended, there are occasions when important and interesting papers are read before a very small audience. Quite apart from the painful impression left on the presiding officers, the sparse attendance has inevitably a discouraging effect on the reader of the paper, particularly, as is often the case, if he has come from a distance and spent much time and trouble in order to present the subject matter of his paper in an interesting way. With a view to improvement, the Secretaries in recent years have endeavoured to choose a group of related papers of special interest for reading and discussion at a particular meeting. While this to some extent has been successful in its purpose, no one who has the interests of the Society at heart can feel entirely satisfied with the present state of affairs.

It is only by the co-operation and goodwill of our Fellows that we can hope to remedy this defect in our meetings. If only a small fraction of our Fellows who have a special knowledge of the subject matter of the group of papers to be read at a particular meeting, made a point of attending, we could be sure of an interesting meeting and discussion, profitable alike to all concerned. I would, therefore, urge on our members the duty of attending as far as possible the meetings of our Society, even though it may involve some sacrifice of their time and energy, and even of their inclinations.

In the early days of our Society it was customary for members and their friends to perform experiments of special interest before the Fellows, quite apart from any question of publication of the results. We know from the history of our Society the importance attached to such demonstrations and their value in disseminating information in various branches of science. This custom
gradually fell into abeyance, probably as a result of the ever-increasing specialisation of the sciences, and apart from the Soirées, it is only on special occasions in recent years that experimental demonstrations have been made at our meetings.

It has occurred to some of our members that it would be a definite advantage to the Society if the old custom were revived, and the members encouraged to show experiments of special interest and novelty during tea-time, before the beginning of the ordinary meeting. There can be no doubt that such demonstrations would add greatly to the interest of the meetings and might indirectly help to increase the attendance during the reading of papers.

In order to give this suggestion a fair trial, portable demonstration tables have been placed in the tea-room with connections for water, gas, and electric current. In every branch of science, and particularly in the biological sciences, there must be many simple experiments and preparations which can readily be shown in such an extemporised laboratory—demonstrations that would prove of interest not only to the specialist but to the Society in general. I trust that our Fellows will not only avail themselves of these facilities but also encourage their scientific friends to do so.

In the short time at my disposal, I would like to make a few remarks on the results of investigations carried out in recent years to produce intense magnetic fields and high voltages for general scientific purposes. In the past our laboratories have had to be content with the comparatively weak magnetic fields provided by the ordinary electro-magnets and the voltages supplied by simple electrostatic machines and induction coils. In order to push further our investigations in many directions, much stronger magnetic fields and higher voltages are required in the laboratory. Scientific men thus naturally follow with great interest advances in these directions, whether undertaken for purely scientific or for technical uses.

By means of modern electrostatic machines, it is not difficult to produce weak direct currents at potentials from 200,000 to 300,000 volts, while a large well-insulated induction coil can give momentary voltages of a similar magnitude. The wide use of X-rays for diagnostic and therapeutic purposes has led to a marked improvement in apparatus for exciting intense X-rays. The requirement of very penetrating X-rays for deep therapy in our hospitals has led to the construction of comparatively light transformers, which will supply the requisite small currents at voltages between 300,000 and 500,000.

One of the simplest ways of producing very high voltages is by the Tesla
transformer, in which the oscillatory discharge of a Leyden Jar is passed through the primary of an air transformer. In this way it is not difficult to produce voltages in the secondary of the order of a million volts, and I understand as much as five million volts have been obtained in the Carnegie Institute at Washington. The striking effects produced by these rapidly oscillating discharges from a Tesla coil, and the immunity with which long sparks may be taken through the body, are well known to all. The rapid frequency of the oscillations and the comparatively small energy given to the secondary of a Tesla coil has, however, restricted its use for general technical purposes as a source of high voltages, although it is now finding an application for the testing of insulating materials.

In order to transmit electrical power economically over long distances, there is a continuous tendency to raise the voltage in the transmission lines. This increase of the operating voltage has led to the need of very high voltages to test the insulating properties of these lines and their transformers and the effect of electric surges in them. In the course of the last few years a number of high-voltage plants have been installed for testing purposes in various countries, which give from one to two million volts. These voltages may be obtained either by a very large well-insulated power transformer or more generally by a cascade method employing several transformers in which the secondary current of one transformer passes through the primary of a second, and so on, the cores of the successive transformers being mounted on insulating pedestals. This cascade method is very advantageous for the purpose, since it allows a great reduction in weight and dimensions of the transformers. Such a high-tension plant in full operation is a striking sight, giving a torrent of sparks several yards in length and resembling a rapid succession of lightning flashes on a small scale. Actually the highest voltage so far obtained by these methods is very small compared with the voltage in a normal lightning flash from a cloud to the earth, where the difference of potential may be as high as a thousand million volts.

There appears to be no obvious limit to the voltages obtainable by the cascade arrangement of transformers, except that of expense and the size of the building required to install them. I am informed that the General Electric Company, of Schenectady, have a working plant giving 2,800,000 volts (max.) and hope soon to have ready a plant to give 6 million volts.

While no doubt the development of such high voltages serves a useful technical purpose, from the purely scientific point of view interest is mainly centred on the application of these high potentials to vacuum tubes in order to
obtain a copious supply of high-speed electrons and high-speed atoms. So far we have not yet succeeded in approaching, much less surpassing, the success of the radioactive elements, in providing us with high-speed $\alpha$-particles and swift electrons. The $\alpha$-particle from radium C is liberated with an energy of $7.6$ million electron volts, i.e., it has the energy acquired by an electron in a vacuum which has fallen through this difference of potential. The swiftest $\beta$-rays from radium have an energy of about $3$ million electron volts, while a voltage of more than $2$ million would be required to produce X-rays of the penetrating power of the $\gamma$-rays.

The application of high voltages to vacuum tubes presents serious technical problems, but a vigorous attack on this side of the question has been recently undertaken by Dr. Coolidge, whom we are glad to welcome as one of our Medallists to-day. In 1894, Lenard made the discovery that high-speed cathode rays generated in a discharge tube could be transmitted into the open air through a very thin window, and made many important observations on the laws of absorption of these swift particles. The voltage used to accelerate the electrons in these experiments seldom exceeded $80,000$ volts and the rays were stopped in passing through a few inches of air. Taking advantage of the great improvements in vacuum technique and the ease of supply of electrons from a glowing filament, Dr. Coolidge has constructed an electron tube which will stand $300,000$ volts, the rays passing into the air through a thin plate of chrome-nickel-iron alloy about $0.0005$ inch thick.

It has not so far been found practicable to apply much more than $300,000$ volts to a single tube, on account of the danger of a flash over, due possibly to the pulling-out of electrons from the cathode by the intense electric field. For the application of still higher voltages, a number of tubes are arranged in series and communicating with one another, the fall of potential in each being about $300,000$ volts. In these preliminary experiments, a large induction coil has been used to generate the voltage. So far experiments have been made with three tubes in series and $900,000$ volts, giving a supply of electrons corresponding to one or two milliamperes through the thin window in the last tube. This gives an intense beam of high-velocity electrons, which spreads out into a hemisphere, due to the scattering of the electrons in passing through the metal window and the surrounding air, extending to a distance of about two metres from the window. Marked luminous effects are produced in the air itself and in phosphorescent bodies placed in the path of the rays. I am informed by Dr. Coolidge that further experiments are in progress and it is hoped to extend the system for still higher voltages.
Anniversary Address by Sir Ernest Rutherford.

While the energy acquired by the individual electrons in falling through 900,000 volts is smaller than that possessed by the swifter $\beta$-particles expelled from radium, the number emitted from the electron tube is very much greater; for example, the number of electrons per second corresponding to a current of 2 milliamperes is equivalent to the number of $\beta$-rays emitted per second from about 150,000 grammes of radium in equilibrium.

While important progress has been made in artificially producing streams of swift electrons, there is still much work to be done before we can hope to produce streams of atoms and electrons of a much higher individual energy than the $\alpha$ or $\beta$-particle spontaneously liberated from radioactive bodies. As we have seen, the $\alpha$-particle from radium C is initially expelled with an energy of about 8 million electron volts. So far the $\alpha$-particle has the greatest individual energy of any particle known to science, and for this reason it has been invaluable in exploring the inner structure of the atom and giving us important data on the magnitude of the deflecting field in the neighbourhood of atomic nuclei and of the dimensions of the nuclei. In case of some of the lighter atoms, the $\alpha$-particle has sufficient energy to penetrate deeply into the nucleus and to cause its disintegration manifested by the liberation of swift protons.

It would be of great scientific interest if it were possible in laboratory experiments to have a supply of electrons and atoms of matter in general, of which the individual energy of motion is greater even than that of the $\alpha$-particle. This would open up an extraordinarily interesting field of investigation which could not fail to give us information of great value, not only on the constitution and stability of atomic nuclei but in many other directions.

It has long been my ambition to have available for study a copious supply of atoms and electrons which have an individual energy far transcending that of the $\alpha$ and $\beta$-particles from radioactive bodies. I am hopeful that I may yet have my wish fulfilled, but it is obvious that many experimental difficulties will have to be surmounted before this can be realised, even on a laboratory scale.

We shall now consider briefly the present situation with regard to the production of intense magnetic fields. Electro-magnets are ordinarily employed for this purpose and the magnetic fields obtainable are in the main limited by the magnetic saturation of the iron. By the use of large electro-magnets and conical pole pieces, the magnetic induction can be concentrated to some extent. For example, in the large Weiss electro-magnet, a field of 80,000 gauss can be obtained over a volume corresponding to about a pin's head, and a field of about 50,000 gauss through a volume of about 20 cubic mm. In general,
Anniversary Address by Sir Ernest Rutherford.

however, most experiments have been restricted to fields less than 35,000 gauss.

In order to push this method of obtaining magnetic fields to the practical limit, Prof. Cotton, of Paris, has designed and has under construction a very large electro-magnet. The cross-section of the iron will be of the order of one square metre, and about 500 kilowatts will be required to excite it. Such a large electro-magnet will not give a much stronger maximum field than existing ones, but will produce a field of given intensity through a larger volume. No doubt this electro-magnet will prove very useful in experiments where steady fields of high intensity are required through a reasonable volume.

In order to provide magnetic fields of the order of half a million gauss, the use of the electro-magnet must be abandoned. Some years ago, Dr. Kapitza suggested that intense momentary magnetic fields could be obtained by sending a very strong current through a coil for such a short interval that the heating effect in the coil is restricted to a permissible value. It is well known that momentary currents of great intensity can be produced by the discharge of a large high-voltage condenser through a coil. Experiments of this kind have been made by Dr. Wall, in which the duration of the discharge was of the order of one-thousandth of a second. It is estimated that in this way a field of about 200,000 gauss may be reached.

In his experiments to obtain intense magnetic fields, Dr. Kapitza at first employed a special form of accumulator to send a very strong current through a coil for about one-hundredth of a second, the current if necessary being sharply broken after this interval. In this way it was shown to be practicable to carry out experiments on the Zeeman effect, and in bending \( \alpha \)-particles in magnetic fields considerably stronger than those obtainable with ordinary methods. In subsequent experiments, a generator of special design was installed, which gives a very large current, of the order of 70,000 amps. at 2000 volts when short-circuited. A heavy current from the generator is passed for about one-hundredth of a second through a coil and then sharply broken by means of a specially designed automatic break. By this means very strong momentary currents can be produced.

The main difficulty in these experiments has been to construct a coil strong enough to withstand the enormous disrupting forces which arise when a large current is passed through the coil. By special attention to the design, a coil has been constructed which gives a field of 320,000 gauss over a volume of about 3 c.cm. without any signs of fracture. Measurements have been regularly carried out in fields of this magnitude. It is anticipated that the present design
of coil will give about 500,000 gauss before bursting, and that still higher fields can be obtained in coils specially constructed for the purpose. An account of these experiments has recently been published in the Society’s Proceedings.

As the current only lasts about one-hundredth of a second, oscillograph methods have to be employed to determine the strength of the current and magnetic field. There seems to be no inherent difficulty in conducting magnetic experiments in these momentary fields, for the shortness of the time available is in many cases compensated for by the magnitude of the effects which arise in such intense fields.

The investigations, which have been carried out in the Cavendish Laboratory, Cambridge, have been made possible by the generous support of the Department of Scientific and Industrial Research, which has defrayed the cost of the apparatus and experiments.

The application of these new methods of producing intense fields opens up a wide region of research, where all magnetic properties can be examined in fields 10 to 20 times stronger than those hitherto available. Such researches cannot fail to yield results of great interest and importance and to advance our knowledge of magnetic phenomena.

While the application of external magnetic fields of the order of one-million gauss will no doubt markedly perturb the orbits of electrons in the outer structure of the atom, it is not to be anticipated that it will seriously affect the stability of atomic nuclei. General evidence indicates that the magnetic fields within the nucleus are much too great for such a relatively weak external field to cause a disruption of the nucleus. In this direction, the bombardment by high-speed particles is likely to be far more effective than the strongest magnetic field we can hope to generate.

The advance of science depends to a large extent on the development of new technical methods and their application to scientific problems. The recent work to which I have referred, on the development of methods of producing high voltages and intense magnetic fields, is not only of great interest to scientific men in itself but promises to provide us with more powerful methods of attack on a number of fundamental problems.

The Copley Medal is awarded to Sir Charles Scott Sherrington, O.M., my immediate predecessor in this Presidential Chair.

Sherrington early chose as the special field of his investigations the physiology of the central nervous system. To this, during some thirty years, he has steadily devoted his great skill in experiment, bringing the immense complexities of
its function within the range of objective analysis, and revealing fundamental plan and orderly sequence in the reflex actions by which it controls the activities of the body, and continuously adjusts them to the environment. The results of this work have been embodied in a series of some two hundred original memoirs, presenting a continuous record of progressive investigation. The earlier stages have been brought under review and treated synthetically by Sherrington in his now famous Silliman Lectures on "The Integrative Action of the Nervous System." In these he deals with the occurrence and significance of the muscular rigidity which appears when the higher brain is removed, with the co-ordination of muscular movements by reciprocal excitation and inhibition of antagonistic muscles, with the rhythmical, phasic activity which the conflict produces in the centres concerned with certain movements, and with the appearance of a purposeful character which the integrating action impresses on many forms of reflex response.

During more recent years our own Proceedings have borne steady witness to the progress made in the finer analysis of the functions of the central nervous system by Sherrington himself and by pupils using the methods which he has created, and building on the foundations which he has laid.

The influence of Sherrington’s investigations has spread far beyond the limits of his own laboratory and has inaugurated a new era in neurological investigation throughout the world. In this connection we may fittingly pay a tribute to the memory of one of the most eminent among those who have drawn inspiration from Sherrington’s work and from personal contact with himself. Rudolph Magnus, of Utrecht, whose early death in this year the whole world of science deplores, found there the impulse to his own original and far-reaching investigations, the results of which he embodied in the Croonian Lecture to this Society two years ago, on "Animal Posture." In every civilised country, in the neurological clinic as well as in the laboratory of physiology and of experimental psychology, the influence of Sherrington’s work is felt, giving the clue to the understanding of many of the motor symptoms of nervous disorder, and holding out promise that even the higher functions of the central nervous system will not remain permanently beyond the reach of man’s experimental enquiry.

A Royal Medal is awarded to Prof. John Cunningham McLennan.

For more than thirty years Dr. J. C. McLennan has been an energetic and enthusiastic experimenter, having published over one hundred papers in the principal scientific publications of England and America. These are
mainly concerned with radio-activity, gaseous conduction of electricity, the spectra of the elements, and the liquefaction of gases. In all these subjects he has made substantial and much-used contributions to quantitative knowledge, generally of high accuracy.

Among his works of outstanding merit may be mentioned the measurements he has made with his pupils on the fine structure of spectral lines, which are of much importance to modern theories of the mechanism of the atom. Recently he has had a sensational success in tracing to its source the elusive auroral line λ 5577, an extremely difficult task which had baffled the skill of many previous investigators. This is important not only in itself but on account of the information it yields as to the structure of the upper atmosphere.

Apart from his own researches, he has built up a most efficient School of Physics in Toronto, and is largely responsible for the present strong position of physical science in Canada. He has devoted much energy to the establishment of a cryogenic laboratory in Toronto, a heavy task which he has carried out with much success.

During the war, he was in charge of important scientific work for the Admiralty; he developed with great energy the supply of helium from the natural sources in Canada and the States, and rendered material assistance in connection with anti-submarine warfare, especially in mining operations on a large scale and of novel character.

A Royal Medal is awarded to Sir Thomas Lewis.

From 1911 onwards to the present day, Sir Thomas Lewis has taken a leading part in the remarkable growth of our knowledge of the mammalian heart-beat, which has been one of the conspicuous scientific achievements of the period in question. Until he began his work, nothing was known for certain of the relations of the specialised structures known to anatomists with the origin and propagation of the beat of the heart. Lewis's researches enabled him to locate the point of origin of the beat, and to plot out the course of the wave of excitation over the ventricles and auricles of mammals. By extending these observations to the hearts of representative vertebrates, he was able to compare the modes of spread of the wave with the special forms of the electrocardiogram, and thus to appreciate clearly the meanings of the several deflections. Further extension to diseased hearts led to the interpretation of the abnormalities of the electrocardiographic record.

In 1911 Lewis was able to show that, as Cushny had previously suggested, certain cardiac irregularities are due to fibrillation of the auricles; and his
later clinical and experimental work on auricular fibrillation and flutter suggest that the irregularities are due to the formation of an endless circulating wave of contraction in the auricles.

In this special field of physiology and pathology, of such great importance to medicine, Lewis's researches have replaced a mass of scattered, suggestive observations by a coherent and established theory. His book on this subject, which is necessarily based, to a large extent, upon his own observations, is recognised as authoritative throughout the world.

Quite recently Lewis has published another book which embodies the results of investigations of the peripheral circulation, upon which he has been engaged during the past twelve years. The response to other kinds of stimulus closely resembles that invoked by injection of histamine into a puncture, and Lewis produces strong evidence that even the response to pressure is due to the liberation in the tissue of a chemical compound, which, if not actually histamine, resembles that substance very closely in its physiological effects.

In these investigations, which may be taken as models for the application of exact methods to human physiology and pathology, Lewis shows the same qualities of accurate experimentation and exact reasoning which are so conspicuous in his work upon the heart's action.

The Davy Medal is awarded to Prof. Arthur Amos Noyes.

Prof. Noyes was the torch-bearer of the modern theories of solution to the West, and under his guidance there grew up in the Massachusetts Institute of Technology a school of research in physical chemistry which held the leading place in America. His researches have been chiefly concerned with the properties of solutions, in particular of electrolytic solutions. Soon after the inception of the electrolytic dissociation theory of Arrhenius, it was recognised that all was not well with the strong electrolytes. Whilst qualitatively their properties were accounted for by the theory, there yet existed marked quantitative discrepancies. Accurate measurement of the properties of such solutions was the first requisite for the attack on the problem, and to this task Noyes applied himself. His investigation of the conductance of aqueous solutions up to temperatures as high as 300° forms a classical example of exact physico-chemical measurement executed under conditions of great experimental difficulty.

His work on the influence exerted by one salt on the solubility of another, on transport numbers and the mobilities of the ions, on the ionisation of pure water at different temperatures, is all directed to the same end. Noyes showed
the importance of the classification of the strong electrolytes according to their valency type, and over twenty years ago attempted to take into account the electrostatic forces between the ions. He thus foreshadowed the modern theory now so widely developed by Noyes himself amongst other workers.

Outside this field Noyes made many additions to our knowledge of solutions; for example, the mass-action theory of acid indicators, velocities of reactions of different orders, and reaction-velocity in heterogeneous systems. Noyes has exercised a great influence on physical chemistry, not only by the value of his experimental work, but by his careful analysis of the fundamental concepts of the science, and by his clear and logical presentation of their nature and their inter-relations.

The Buchanan Medal is awarded to Dr. Major Greenwood.

Dr. Greenwood, Professor of Epidemiology and Vital Statistics, University of London (London School of Hygiene), is specially distinguished for the statistical study of medical subjects, having applied the statistical method to the elucidation of many problems of physiology, pathology, hygiene and epidemiology. He has been pre-eminent in encouraging and developing the use of modern statistical methods by medical laboratory investigators and in securing the adequate planning and execution of field investigations. He is almost unique in the possession of both the medical knowledge and mathematical ability which are essential in these researches. Dr. Greenwood is the author (with Prof. E. L. Collis) of a book on 'The Health of the Industrial Worker,' and of numerous biometric studies dealing with the causation, prevention and treatment of disease.

The Hughes Medal is awarded to William David Coolidge, a distinguished member of the scientific staff of the General Electric Company of America.

Science is under a great debt to Dr. Coolidge for the invention and production of a new type of X-ray tube, called by his name, of great flexibility and power, which has proved of great service not only in Medical Radiology but in numerous scientific researches. In the last few years he has applied his unrivalled technical knowledge to the generation of high-velocity cathode rays, which can be passed into the air through a thin window as in Lenard's pioneer experiments thirty years ago. Such researches are of great importance to science as they promise to provide us with new methods of obtaining a copious supply of swift electrons and high-speed atoms of matter for experimental investigations.