1838 of Sabine's tables and chart of lines of equal total intensity, in the seventh report of the British Association, which inspired him to complete the laborious task. He also used the inclination (dip) chart by the German, Horner, and the declination chart of Barlow. Gauss then tested his formula by calculating fields at new points, and also the positions of the terrestrial magnetic poles. These last he predicted, in 1838, to be near $73^{\circ} 35' \text{ N.}$, $95^{\circ} 39' \text{ W.}$, and $72^{\circ} 35' \text{ S.}$, $152^{\circ} 30' \text{ E.}$, respectively, long before Amundsen (1903-6) found the North Pole to be at 71° N. , 96° W. , and the Discovery expedition (1902-4) found the South Pole at $72^{\circ} 50' \text{ S.}$, $156^{\circ} 20' \text{ E.}$ Thus Gauss laid a firm foundation for the theory of terrestrial magnetism on which Schuster, Gunn and others have built. Using the better observations of 1885, Neumayer recalculated the twenty-four constants. Schmidt (1889) found that 1 per cent of the field was due to external sources. Later still, in 1923, Bauer found that 3 per cent was due to a potential arising from external sources, 94 per cent to a potential arising from internal sources, and 3 per cent, of non-potential origin, to electric currents in the atmosphere, but this last result is disputed by some authorities. Chapman has shown that about 72 per cent of the diurnal variation is due to external, and 28 per cent to internal sources. The quality of Gauss's work is indicated by the following comment by Clerk Maxwell: "Gauss, as a member of the German Magnetic Union, brought his powerful intellect to bear on the theory of magnetism, and on the methods of observing it, and he not only greatly added to our knowledge of the theory of attractions, but reconstructed the whole of magnetic science as regards the instruments used, the methods of observation, and the calculation of the results, so that his memoirs on Terrestrial Magnetism may be taken as models of physical research by all those who are engaged in the measurement of the forces in nature".

Maxwell's reference to attractions probably relates to Gauss's memoir, "Allgemeine Lehrsätze in Beziehung auf die im verkehrten Verhältnisse des Quadrats der Entfernung wirkenden Anziehungs- und Abstossungs-kräfte" (1840). These theorems relate to gravitation, electrostatics and magnetism. Among them we find that celebrated theorem, Gauss's theorem *par excellence*, showing that the total normal outward flux of force over a closed surface is 4π times the electric charge or magnetic pole-strength enclosed, or $4\pi G$ times the mass enclosed.

Much of Gauss's work in pure mathematics has contributed, since his time, to advances in electricity and magnetism. For example, in order to calculate the magnetic field of a two-dimensional pole-piece the cross-section of which is a curvilinear triangle, and the sides of which are circular arcs, one must first use Gauss's concept of a conformal transformation to change the edge of the triangle into the real axis of another plane. This is done by the aid of Gauss's hypergeometric equation, which is solved by Gauss's methods.

Turning to optics, we find another manifestation of Gauss's power in the memoir "Dioptrische Untersuchungen" (1840). Here the concept of principal points was introduced, a concept which reduced the laborious mathematics of thick lenses and sets of coaxial lenses almost to the easy algebra of single thin lenses. Gauss's ideas were extended in 1845 by Listing, who discovered nodal points. Along with

this may be mentioned, as a bagatelle of genius, Gauss's optical invention called a heliotrope (1821), based on the law of reflexion of light by plane mirrors, and useful in geodetic work for sending signals of sunlight to distant points.

Like Newton, Gauss wrote a "Principia", not a bound book, but a memoir called "Principia generalia Theoriae Figurae Fluidorum". To Gauss this was just a trifle, but it alone would have made the name of a lesser man. The principle of virtual work and the calculus of variations were applied to a liquid standing in a capillary tube. The differential equation of the free surface and Young's equation relating to angles of contact were deduced in an elegant manner, free from a defect which vitiated Laplace's treatment of the same topic.

Gauss never rushed into publication. As the years passed, he became more and more averse to it or indifferent to priority. Von Waltershausen tells us that in 1831 Gauss suddenly took up crystallography, quickly mastered it in a few weeks and as suddenly relinquished it. His unpublished note-book shows that he had largely forestalled the later work of Miller.

There is no space to relate all Gauss's personal peculiarities, his virtues and failings, his literary style, his veto on the taking of notes of his lectures by his students, his adverse opinion on Abel's first great paper, and so forth. We trust that enough evidence has been adduced to show that, in both theoretical and experimental physics, Gauss was as great a master as in mathematics and astronomy, and that, as Johnson said of Goldsmith, he touched nothing which he did not adorn.

¹ von Waltershausen, W. Sartorius, "Gauss zum Gedächtniss" (Leipzig, 1856).

² Tucker, R., *Nature*, 15, 533 (April 19, 1877).

³ Prasad, G., "Some Great Mathematicians of the Nineteenth Century", 3 vols. (Benares, 1933); see vol. 1, pp. 1-67.

⁴ Bell, E. T., "Men of Mathematics", pp. 250-305 (London, 1937).

⁵ *Proc. Roy. Soc.*, 7, 589 (1856).

OBITUARIES

Prof. G. V. Anrep, F.R.S.

PROF. GLEB VASILIEVITCH ANREP, who died in Cairo on January 9, was one of the outstanding physiologists of his generation. He was born in St. Petersburg in 1891, the son of Basil Anrep, professor of pharmacology in the Military Medical Academy, who discovered the local anæsthetic action of cocaine, and who was of Swedish extraction. Gleb Anrep studied at the Military Medical Academy, where he came under the compelling influence of I. P. Pavlov, commencing research work on the conditioned reflexes while still a student. He was not yet qualified when 'Ivan Petrovitch' sent him in the vacation of 1912 to visit Starling, in order to demonstrate to him the effect of vagus stimulation on the secretion of pancreatic juice, and to acquire the method of preparing pancreatic secretin. He already spoke tolerable English, and soon became fluent during that and two similar visits in the next two years, when he worked under Starling at University College, London. The third visit was curtailed by the outbreak of war in 1914, when he returned to Russia, completed his qualifications, and joined the Army, in which he served until 1917 as a medical officer. He then returned to Petrograd, studied at the Institute of Experimental Medicine, and took his M.D. Being opposed to the Revolutionary Government, he joined the anti-

Bolshevik forces of General Denekin in 1918, remaining with them until their defeat, after which, with the help of Starling, he came to England, and worked as a lecturer at University College until 1926, taking a D.Sc. He became naturalized in 1925, and was made a Fellow of University College in 1928.

In 1926 he moved to Cambridge, as lecturer in physiology, was awarded an M.A., and in 1928 was elected a Fellow of the Royal Society.

In 1931 he accepted the chair of physiology at the Fuad I University, Cairo, in succession to Prof. W. H. Wilson, and remained there until a short time before his death.

Anrep was an outstanding experimental physiologist of the classical type, imbibing his inspiration, through Pavlov and Starling, largely from the German school of Ludwig and his contemporaries. His first loyalty was to 'Ivan Petrovitch', whom he revered and imitated largely, and to the land of his birth, the exile from which he greatly deplored. His second loyalty was to Starling, and to England, to both of which he owed so much. Perhaps a third was to Egypt, the deserts of which he explored with characteristic intrepidity and enthusiasm, having acquired a good knowledge of Arabic, and always having had a taste for adventure.

His physiological work fell into two main categories: in Russia, on the conditioned reflexes; and in England and Egypt, on circulatory problems. His first paper in the *Journal of Physiology*, in 1912, showed that the rise of blood pressure which followed when the splanchnic nerve was stimulated was in part due to the release of adrenaline. He was made a member of the Physiological Society in 1913, and contributed many papers to that and other journals, on such subjects as the coronary circulation, pancreatic and salivary secretion, the pulmonary circulation, cardiac reflexes, tissue histamine, and the peripheral circulation.

All his work was technically first-class; he had a terrifying capacity for work, was a quick and skilful, but rather temperamental, operator, and had a great knowledge of the literature of his subject.

As a person, Anrep was engaging, buoyant, dynamic, with quick enthusiasms and Slav introspectiveness; and, on occasion, as when an experiment failed, he was capable of acute self-deprecation. He had great gifts as a raconteur and as a lecturer of an unusual type. He was a keen collector of apparatus and of postage stamps.

He had one son by his first wife, Olga; by subsequent marriages no issue. C. LOVATT EVANS

Mr. A. S. Ramsey

ARTHUR STANLEY RAMSEY, senior Fellow of Magdalene College, Cambridge, died at Cambridge on December 31.

He was born at Hackney in 1867, the eldest son of the Rev. Averell Ramsey, a well-known Congregational minister. He was educated at Batley Grammar School and Magdalene College, Cambridge, where he graduated fifth wrangler in 1889. After seven years as mathematics master at Fettes College, he returned to Magdalene in 1897 as Fellow and lecturer in mathematics, and held the latter post until his retirement from active teaching in 1934. When the office of University lecturer was instituted in 1926, Ramsey was one of the first to be appointed, and he continued in office until his retirement under the age limit in 1932.

Ramsey would have been the first to disclaim originality in his contributions to mathematics. His great gift was as a teacher, particularly of applied mathematics, and he had an especial understanding of the needs of the average student. He soon realized that there was a great lack of systematic text-books adapted to the course of study, and he set himself with indefatigable industry to fill this gap. In the course of years a truly remarkable series of text-books flowed from his pen. His published works are: "Modern Plane Geometry" (Richardson and Ramsey); "Hydromechanics" (Besant and Ramsey); "Hydrodynamics"; "Elementary Geometrical Optics"; "Dynamics"; "Statics"; "Hydrostatics"; "Electricity and Magnetism"; and "Introduction to Newtonian Attraction". All these books are marked by clear thinking, orderly presentation and a wealth of illustrative examples, and most of them, despite great developments in mathematical theory and method, have maintained a steady and deserved popularity. His lectures were equally clear and systematic, and, in private teaching, there were few questions to which he would not at once produce the answer from among his carefully filed manuscript notes.

In addition to his mathematical work, Ramsey took a very active part in college and university administration. He was successively bursar, tutor and president (that is, vice-master) of Magdalene, and he was a member of the Financial Board of the University of Cambridge for more than twenty years. He had a special interest in religious matters and particularly in the affairs of the Congregational Churches. He was for many years a member of the Council of the Congregational Union of England and Wales, and gave very valuable help to Cheshunt College, Cambridge, as a governor and for nine years as chairman of the governors.

Ramsey was a man of uncompromising integrity, and he was possessed by a tremendous sense of duty. Though he could be formidable indeed in his condemnation of the culpably second-rate, kindness was never far absent, and in his later years it was his dominant characteristic. In his retirement he could be relied upon to delight his listeners with a seemingly inexhaustible fund of reminiscence, told with inimitable humour. He made a lasting impact upon the life of his College, and both there and elsewhere he will long be remembered as a teacher and as a wise friend. His private life was clouded by two great tragedies, stoically endured. His wife, whom he had married in 1902, lost her life in a motor-car accident in 1927, and three years later came the lamentably early death of his elder son, the brilliant F. P. Ramsey, Fellow of King's and author of "Foundations of Mathematics". He is survived by his younger son, A. M. Ramsey, Bishop of Durham, and by two daughters. D. W. BABBAGE

Mr. Edwin Grey

ONE of the last links with the Rothamsted of Lawes and Gilbert's time was broken when Edwin Grey died on January 30 at the age of ninety-five. Young Ted Grey went to the Rothamsted Laboratories in 1872 when he was thirteen years old, and with other boys was trained to carry out the botanical analysis of the hays from the Park Grass plots. He was soon marked out as a careful and reliable worker, and as time went on he took part in the classical experiments on soil fertility and animal feeding of