separation and identification of the last missing rare-earth element, promethium. Seaborg and his colleagues have applied here the same technique which was, however, made more difficult by the small quantities of material and, in the case of element 98, by the short life of the new nuclide. A further complication was the presence of the mother substances, of many million times stronger activity than the new nuclide, from which these new elements had to be cleanly separated before their own activities could be observed.

While on one hand the great chemical similarity between the new elements and those preceding them made their separation laborious, on the other hand it enabled the research workers to foresee the exact places where the elements 97 and 98 ought to appear in a carefully regulated fractionation process, and the success has fully justified their expectation. It is certainly unnecessary to emphasize that years of experience and the skill of a large and highly trained research team under steady leadership were necessary to perform the many operations, from the bombardment of invisible quantities of synthetic americium and curium up to the chemical isolation and radioactive characterization of the two short-lived new elements.

The strict regularity shown by the elements 93–98 when subjected in the trivalent state to fractional adsorption and elution is an experimental confirmation of Bohr's theoretical prediction mentioned above, that the elements following uranium should be very similar to each other; in any representation of the periodic system we must, therefore, avoid allotting to these elements places which would imply that they are higher homologues of rhenium and the elements of the platinum group. Seaborg and those who follow him like to break off the last row of the periodic table at actinium and to write the elements 89–96 (and now to 98) as the group of 'actinides' under the group of 'lanthanides' 57–72. They can point out in favour of this arrangement that in this way probable similarities in the electronic structure of the respective members of the two groups are clearly indicated. However, these similarities, even if present, do not manifest themselves in the chemical behaviour of the first members, and those chemists who want to show above all in the periodic system a grouping according to chemical relationships, hold that the discovery of the transuranium elements does not justify the neglect of the old-established and obvious correspondence between thorium and hafnium, protactinium and tantalum, and uranium and tungsten. They prefer to leave the periodic system up to uranium unchanged, and to put a group of transuranic elements, or 'uranides' as they are sometimes called, at the end of the table.

In the accompanying presentation of the periodic system the close similarity of these elements is indicated by the absence of dividing lines, just as in the group of the lanthanides which, for reasons of economy of space, are written outside the framework of the table and not within period VI, to avoid the interruption of the other periods by too much white paper. In this table are included the symbols of the elements technetium, promethium, astatine, francium, neptunium, plutonium, americium and curium, which last September were officially sanctioned by the International Union of Chemistry. The new symbols 'Bk' and 'Cf' for elements 97 and 98 are also inserted, since there is little doubt that the proposals of their discoverers to name them "berkelium" and "cali-

fornium", after Berkeley and the University of California, where this excellent work has been carried out, will be accepted.

¹ See, for example, the survey in *Nature*, **159**, 8 (1947).

² Thompson, S. G., Ghiorso, A., and Seaborg, G. T., *Phys. Rev.*, **77**, 838 (1950).

³ Office of Public Information, University of California, Release March 17, 1950. *Phys. Rev.* (in the press).

OLIVER HEAVISIDE (1850–1925)

By ENG.-CAPT. EDGAR C. SMITH, O.B.E., R.N.

ON May 13 the centenary occurs of the birth of Oliver Heaviside, the British mathematical physicist whose name is familiar to millions by the term 'Heaviside layer'. Heaviside, in an atmosphere of scepticism, unravelled one of the secrets of long-distance telephony, and his work in various branches of electrical science is appreciated by those most capable of judging its importance. Of the man himself, few biographical details have been recorded, for much of his life was passed in seclusion in Devonshire, and he took no part in the proceedings of the societies of which he was a member. Though it is stated he was born in London on May 13, 1850, little has been published of his parents and his education. He was apparently largely self-taught, and for some years had a post with the Great Northern Telegraph Company at Newcastle upon Tyne. At the age of twenty-four, however, increasing deafness made him retire from business life, and he settled in Torquay, which was his home until his death on February 4, 1925, at the age of seventy-four. He was buried in Paignton Churchyard. An obituary appreciation by the late Dr. Alexander Russell was published in *Nature* of February 14, 1925.

Among the correspondents of his later years were Sir Oliver Lodge, Prof. John Perry, Dr. G. F. C. Searle and the distinguished American electrician, Mr. B. A. Behrend. Writing in the *Electrical World* of February 21, 1925, Sir Oliver Lodge said: "Probably no one in his time had an equal grasp of the present and future outcome of Maxwell's theory. He expressed the generation of electric waves in his own style; he treated of the motion of electric charges at different velocities, including those which equalled or even hypothetically surpassed the velocity of light. Everything relating to electrical induction and the energy of electric currents, and the forces and fluxes of energy in the electromagnetic field, the self-induction of wires and the generation of waves was elaborately worked out . . .". Many of the terms in use to-day were coined by him.

Heaviside's papers were published in the *Philosophical Magazine*, the *Philosophical Transactions* and the *Electrician*. His papers were reprinted in his "Electrical Papers" (1892), published by Macmillan and Co., Ltd., and in three volumes on "Electromagnetic Theory", published in 1893, 1899 and 1912, and reprinted in 1922. A full review of his work was given by Dr. W. E. Sumpner in the twenty-third Kelvin Lecture delivered to the Institution of Electrical Engineers on April 21, 1932.

Though recognition came to Heaviside late in life, he had been elected a fellow of the Royal Society in 1891, and was afterwards elected a fellow of the Institution of Electrical Engineers and an honorary member of the American Academy of Arts and Sciences and of the American Institute of Electrical Engineers. In his tribute to Heaviside, Behrend

wrote: "The war had brought on rapidly rising prices peculiarly hard to bear by the older people. It had dissipated to the four winds domestic servants of any kind. . . . Delicate and sensitive, Heaviside suffered, at first inconvenience, later real want. . . . He lived on alone. He saw reared on his work and genius an industrial and economic edifice of enormous proportions, and he had no share in the rewards and little in the fame. . . ."

When he was seventy-one, the Institution of Electrical Engineers held its jubilee. On the proposal of Sir Oliver Lodge, a special message was sent to Heaviside, and a little later he received the first Faraday Medal founded to mark the occasion of the jubilee of the Institution; this was personally conveyed to Heaviside by the president, the late Mr. J. S. Highfield.

SUBMARINE GRAVITY SURVEY

A BRITISH EXPEDITION IN THE EASTERN MEDITERRANEAN

THE figure of the earth is so nearly an ellipsoid of revolution that people are apt to think that the distance between two places can be calculated exactly, once their latitudes and longitudes are known. This is not so. The actual shape of the mean sea-level surface depends on the distribution of matter within the earth and is appreciably distorted in the vicinity of large masses. A good example is found on Cyprus. It is known from triangulation that Limmasol and Kalokhorio, which lie on the northern and southern shores of the island, are 57 km. apart. Yet the distance between them, as calculated from astronomical observations, is 1.8 km. greater, a difference of approximately 3 per cent. This discrepancy at once suggests that there is an abnormal concentration of high-density material between them. A gravity survey has confirmed this, for large positive anomalies are found almost everywhere on the island. At Agros, which is approximately half-way between Limasol and Kalokhorio, the free air anomaly is + 282 milligals, and after allowing for the attraction of topography, the Bouguer anomaly is found to be + 174 milligals. It is estimated, however, that even these large positive anomalies would only account for about half the observed difference in the deflexions of the vertical: presumably the rest is due to mass deficiencies below the sea farther to the north or south.

The example just given is abnormal, but it is a striking reminder that the fundamental problem of geodesy, the determination of the shape of the earth, is still far from solved. It has been shown by Stokes that the shape of the geoid can be calculated if gravity is known all over the earth. Unfortunately, this method can only be applied very approximately at present, owing to scarcity of data, especially over the oceans. At sea, except in shallow water, the only practical method of measuring gravity with sufficient accuracy is to make observations in a submerged submarine. Such experiments demand close collaboration between naval and scientific personnel. In Great Britain, the Defence Services Research Facilities Committee of the Royal Society provides the necessary liaison. Since the War, two expeditions have been made in the vicinity of the British Isles.

The results of the first, made in 1946, have recently been published, and technical details of the second are also available. A third expedition is now planned in the Eastern Mediterranean and is due to sail from Malta in the middle of May. The necessary funds are being provided by a special grant from the Royal Society, and the Royal Navy is giving wholehearted co-operation. The technical arrangements have been made by the Department of Geodesy and Geophysics in the University of Cambridge, with the generous assistance of the Danish Geodetic Institutes.

The Western Mediterranean has already been studied by the French and Italians, and so, when the British results are known, a fairly complete general picture of the gravitational field of the whole Mediterranean Basin will be available. Quite apart from the geodetic importance of these observations, it should be possible to draw some most interesting geological conclusions. The Mediterranean is generally supposed to be that portion of the Tethys Sea remaining after the great earth movements, which formed the Alps and other folded mountains in southern Europe and Asia Minor, had subsided. But even now the crust of the earth is not quiescent, for volcanic eruptions and earthquakes are still experienced. A study of the gravitational field may well throw light on the cause of these phenomena. Particular points will also be examined. Comparative surveys around Pantelleria and Malta may show whether or not the latter is of volcanic origin. The structural relationship between the islands of Crete and Cyprus and the Taurus Mountains on the Turkish mainland should be plainly revealed if the large anomalies mentioned earlier are found to extend out to sea. Measurements over the Nile Delta and among the Dodecanese Islands will show how nearly these regions are in isostatic equilibrium. In addition, it is hoped to connect up the results of earlier surveys by making special observations, both at sea and in harbours, and to carry out an extensive programme of echo sounding.

The survey itself will last about twelve weeks, during which about a hundred and twenty gravity determinations will be made; but it will be several months before all the records are finally measured and the results known. More accurate estimates of relative deflexions of the vertical can then be made and tentative geological conclusions drawn. These may require revision as further data become available; but the actual gravity measurements and soundings will be of permanent value. Geophysical methods are rapidly becoming of great assistance to geologists, and in areas such as the Eastern Mediterranean, where sediments obscure the underlying rocks, they may well prove of major importance. The results of the proposed British submarine gravity survey will therefore be awaited with great interest.

B. C. BROWNE

OBITUARIES

Prof. J. A. Crowther

By the death, on March 25, of James Arnold Crowther, we have lost another of the remaining living links with the Cavendish Laboratory of J. J. Thomson's time. It was in those days—which now seem both so recent and so distant—that Crowther, after a brilliant undergraduate career (1903–6) at Cambridge, made his first indelible mark on physics history with his important investigations into the