arranged in the middle of the 18th century several astronomical expeditions to different regions of the State (among them two expeditions to Siberia) for observations of the transit of Venus across the solar disk on 1761 July 6.

When in 1764 the Russian Admiralty, adopting Lomonosov's project, decided to equip an expedition in search of a seaway from the northern shore of Europe across the Arctic Ocean to the eastern shore of Asia, Lomonosov took upon himself the duty of supplying the ships with the most modern astronavigation instruments; some of them were of his own construction.

On 1765 April 15 Lomonosov died, at the age of 54; the activity of this great astronomer of that time ceased.

This is a brief enumeration of those of Lomonosov's works which enriched the astronomical science of that time. When one takes into account that besides astronomy he made significant contributions to many other branches of science, it will become clear why his contemporaries treated him with such respect, and why people living in our time continue to do so.

THE DUNSINK OBSERVATORY

By N. P. J. O'Hora
Royal Greenwich Observatory

Francis Andrews, a Provost of Trinity College, Dublin, in the latter half of the 18th century, was determined to have the study of astronomy promoted in the University. He accordingly made provision in his will for the establishment of an astronomical observatory and for the foundation of a Chair in Astronomy at Trinity College. Following his death in 1774 the will was disputed by his family with the result that his bequests towards the promotion of astronomy were considerably diminished. Because of this the greater part of the burden of maintaining the observatory was undertaken by the Board of Trinity College. A further result of the prolonged litigation that followed the family's opposition was a delay in building and Andrews had been dead for more than twelve years before the observatory was completed.

The building was supervised by the Rev. Henry Ussher, a Trinity scholar who was appointed Andrews Professor of Astronomy at Trinity College in 1783. In choosing a suitable site Ussher selected the summit of a hill at Dunsink, 300 ft. above sea-level and about 4 miles from Dublin. The site commands a magnificent view, the surrounding horizon is broken only to the south where the Wicklow Mountains, 15 miles distant, rise 2° or 3° above the level of the observatory. Throughout its history results of observations made at Dunsink have been communicated to the Royal Irish Academy (R.I.A.) and by a curious coincidence the first paper in the *Transactions* of this Society is a description by Ussher of his plan of the proposed observatory.

The main buildings of the observatory are preserved today almost as Ussher designed them. The largest is a two-storey rectangular structure about 75 ft. by 50 ft. with a central dome rising more than 20 ft. above the façade. On the west side of this building is the old meridian observatory in which the first astronomical instruments of the observatory were housed. The transit and meridian circles were designed by Ussher and Ramsden and made by the latter. In the design of the transit Ussher prevailed upon Ramsden to break with the traditional practice of having the micrometer wires illuminated by light reflected through the objective. In the Ramsden transit supplied to Dunsink the illumination was admitted through a lens system in a hollowed pivot and reflected down the tube by a plane mirror fixed inside the cube of the instrument.

Ussher died in 1790 and was succeeded by Dr. John Brinkley whose appointment was supported by Maskelyne, the fifth Astronomer Royal. Before going to Ireland Brinkley had spent two years at Greenwich as an assistant to Maskelyne and he had distinguished himself at Cambridge where he was Senior Wrangler in 1788. Shortly after his arrival in Ireland he took Holy Orders and in 1791 he was honoured by being appointed to the newly created post of Astronomer Royal for Ireland—a position which subsequently was automatically attained by appointment to the Andrews Chair in Trinity College.

For some years, while awaiting the construction of the meridian circle ordered for the observatory, Brinkley devoted himself to mathematical studies. Eventually, twenty-three years after it was commissioned, the Ramsden circle was erected in the meridian observatory. The circle was 8 ft. in diameter and graduated in divisions of 5′. With this instrument Brinkley achieved excellent results over the next fifteen years. In the formation of the R.A.S. catalogue of stars compiled in the 1820s the adopted constants of aberration and lunar nutation were those deduced by Brinkley from his own observations. Between 1808 and 1810 he made a series of observations of several of the brighter stars with the aim of measuring parallax in some of them. A few years earlier some Italian astronomers claimed to have discovered the existence of parallax but their measures of it seemed much too large and were not accepted by British astronomers. Brinkley's results, based on observations of zenith distances of stars at different seasons of the year, seemed to indicate that four of the brightest stars possessed parallaxes as great as a few seconds of arc—much smaller values than those discovered in Italy for other stars. Pond, Maskelyne's successor at Greenwich, relying on the evidence of the Greenwich observations, discounted Brinkley's results. In the light of later work it is known that Pond's objections were well founded although the anomalous results obtained by Brinkley have never been satisfactorily explained. Regardless of the results he obtained, his investigation of stellar parallaxes was considered so valuable that the Royal Society awarded him the Copley Medal for his paper on the subject. In his ecclesiastical career also Dr. Brinkley achieved distinction and in 1826 he succeeded Berkeley as Bishop of Cloyne.

Several distinguished astronomers, among them G. B. Airy, applied for the vacated position at Dunsink. The Governors of Trinity College having interviewed all the applicants, passed them over to appoint to the post a twenty-one year old undergraduate of the College, William Rowan Hamilton. Three years earlier when Hamilton, then a schoolboy, had presented a

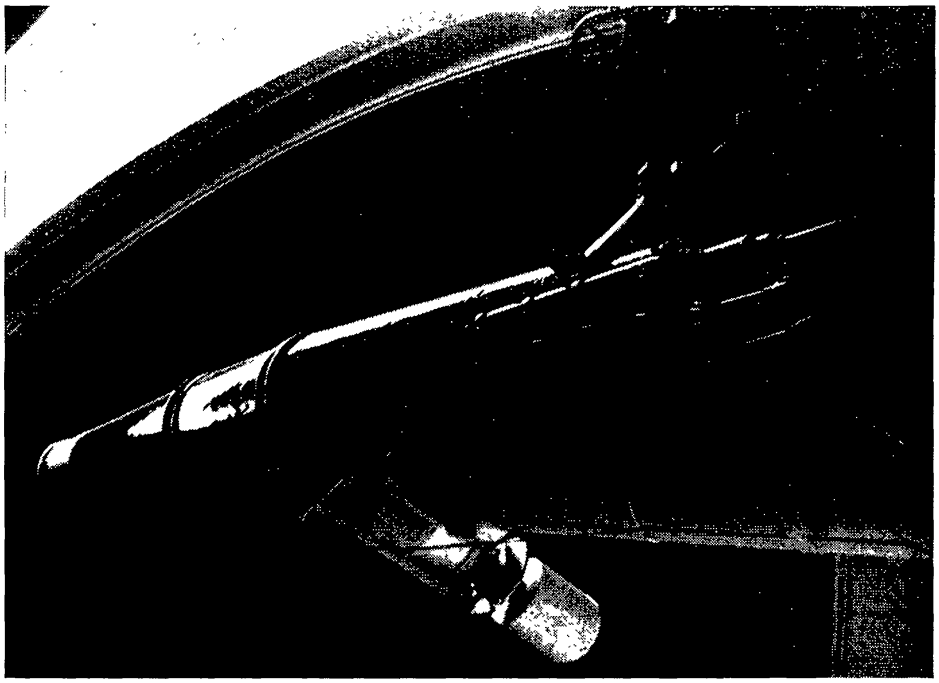

PLATE XV

The 12-inch South Refractor at Dunsink Observatory.

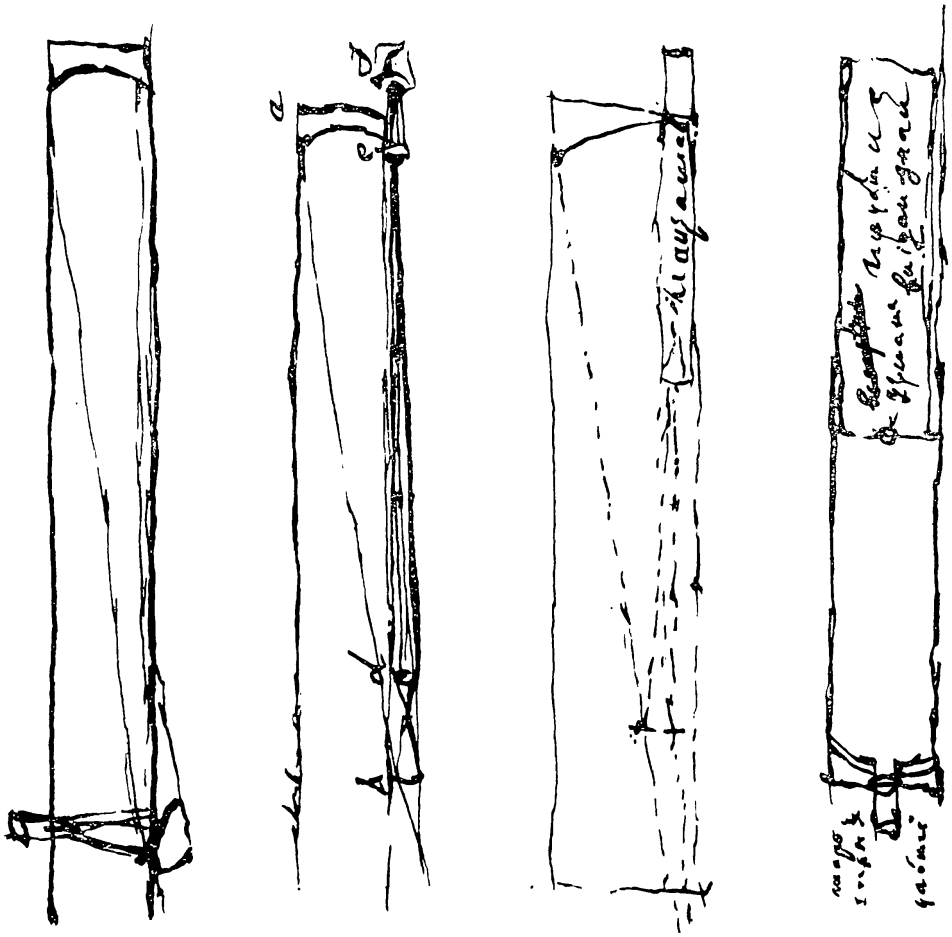

PLATE XIV

Drawings by M. V. Lomonosov of the new types of reflector proposed by him.

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memoir on optical systems of rays to the R.I.A., Dr. Brinkley was moved to remark "This young man, I do not say *will* be but *is* the first mathematician of his age"—a judgement later supported by history. Despite his youth Hamilton's appointment to Dunsink caused little surprise; his reputation for extraordinary genius was already well established in the United Kingdom and a few years later when the existence of conical refraction, predicted in his theory of rays, was verified by laboratory experiment his fame extended to the whole of the scientific world. The discoveries of Hamilton's youth in optics and mechanics have in recent years proved invaluable in the development of microwave technology. His whole life was devoted to the study of mathematics; he had spent eighteen years at Dunsink before he made his first major discovery in Quaternions. Knighted at the age of thirty, elected President of the R.I.A. at thirty-two, chosen as first foreign member of the National Academy of Sciences of the U.S.A., in his lifetime he collected the highest awards of the scientific world. However, his enthusiasm for mathematical research limited his astronomical activities and, although he continued to attend to his professional duties, towards the end of his life he tended to pay less attention to the affairs of the observatory.

At Dunsink Hamilton was followed by Franz Friedrich Brünnow, a German astronomer of the generation following that of Gauss, Bessel and W. Struve. He was trained by Encke in Berlin Observatory and is said to have participated in the observations that resulted in the discovery of Neptune. After three years as chief assistant of Berlin Observatory he became, at the age of 33, Director of the Observatory of the University of Michigan in the U.S.A. Brünnow was an eminent astronomer; his *Textbook of Spherical Astronomy* was translated into several languages and his investigation of the division errors of the meridian circle of the Michigan Observatory was considered the most advanced work of that nature ever performed. Shortly after the outbreak of the American Civil War he returned to Germany whence he went to Ireland in 1865.

Commencing with Brünnow's arrival the observatory entered the most productive period of its existence. Within a year of his appointment he was supervising the erection of a dome for the observatory's first equatorial telescope. This telescope (the South Equatorial), incorporating an excellent 12-inch lens manufactured by Cauchoix and presented to the observatory by Sir James South, together with a mounting by Grubb, is still used at Dunsink. It was first brought into use in 1868 when, furnished with a filar micrometer, it was employed in measurements of stellar parallaxes and observations of binary stars. The method of comparisons of relative parallaxes by means of the position micrometer as developed by W. Struve was used in Dunsink for several years by Brünnow and his successor.

In 1873 Brünnow installed a Pistor and Martin transit circle to replace the Ramsden meridian instruments which had become obsolete. The new instrument was almost identical with that previously supplied to the U.S. Naval Observatory and described in the Washington Observations of 1865. In addition to modernising the observatory and re-organising its administration Brünnow commenced the regular publication of routine observations. After nine years as director he retired in 1874 because of failing health and eye-sight.

Robert Stawell Ball was appointed fourth Astronomer Royal for Ireland in succession to Brünnow. The son of a noted naturalist, Ball belonged to a

PLATE XVI
View of Dunsink Observatory from the East.

PLATE XVII
South Dome of Dunsink Observatory.

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distinguished and popular Dublin family. After graduating from Trinity College he spent two years as assistant astronomer at Birr Castle Observatory and later, at the age of twenty-seven, he became Professor of Mathematics in the Royal College of Science. He was thirty-four years of age when he went to Dunsink, where he became one of the best known astronomers of his time. He was a prolific writer and a popular lecturer—it has been claimed that more than a million people heard him lecture while to this day his books are readily available in second-hand book shops throughout Britain and Ireland. Notwithstanding his heavy commitments in literary and educational pursuits he was a keen observer and he continued the work of modernising the observatory and extending its activities. He completed the restoration of the meridian observatory with the installation of a Dent sidereal clock and a Grubb barrel chronograph. For the time-service he obtained a mean solar clock by Booth of Dublin—this was the first Dunsink standard from which time signals were telegraphed to the offices of the Dublin Port and Docks Board where they were used for the control of a time ball.

The transit circle was maintained in continuous service for the determination of the positions of stars and for time observations. Between the years 1880 and 1905 a considerable amount of the meridian work carried out at Dunsink was undertaken at the request of other observatories, particularly the Royal Observatory at the Cape of Good Hope. Co-operating in investigations conducted by Sir David Gill at the Cape, several programmes of observations of reference stars, of major and minor planets and of star clusters were conducted in this period. In one such programme in the years 1900–1903 20,000 meridian observations were made of 2,800 zodiacal stars—an enormous effort for an observatory the total staff of which never exceeded four in number. For his own observations Ball utilised the South Equatorial for parallax and binary star work. In 1886 he was knighted and he left Dunsink in 1892 to become Lowndean Professor of Astronomy at Cambridge. He was succeeded at Dunsink by Arthur Alcock Rambaut.

Rambaut was born in Waterford of a clergyman's family and educated at the Royal School Armagh and at Trinity College. In 1882 when Dreyer became Director of Armagh Observatory, he was succeeded as chief assistant at Dunsink by Rambaut who was made responsible for meridian astronomy in the observatory. During his tenure of the directorship transit observations remained his chief interest but he was active in other fields as well. In 1889 the observatory was presented with a 15-inch mirror by Dr. Isaac Roberts for its first reflector telescope and for some years Rambaut was concerned with experiments in mounting and using the mirror for astronomical photography. In the well-established Dunsink tradition the new telescope was first used in parallax observations and the R.I.A. provided the observatory with a Troughton & Simms plate-measuring machine for use in this work. Rambaut collaborated with W. E. Wilson, who maintained a private observatory at Daramona in Co. Westmeath, in several astronomical researches. Apart from its scientific value, their bolometric measurement in 1892 of the solar constant used in evaluating the temperature of the photosphere is of historic interest in view of the modern development of Dunsink as a solar observatory.

In 1897 Rambaut went to Oxford as Radcliffe Observer, a position he held until his death in 1923. With the appointment of his successor, Charles Jasper Joly, each of the four provinces of Ireland had provided at least one

Director of Dunsink Observatory. Like his predecessor Joly was a clergyman's son: he was born at Athlone and educated at Galway Grammar School, at Trinity College and later at the Helmholtz Laboratories in Berlin. In his work Joly's greatest contributions were to mathematics, particularly Quaternions, on which he wrote several research papers. He was a great admirer of Hamilton, whose later works he endeavoured to interpret and publicise; at the time of his death he was President of the International Society for the Development of Quaternions. His interests in scientific and cultural life in Ireland were very varied; he was Secretary of the R.I.A., Trustee of the National Library and a member of the Royal Dublin Society. In 1900 together with Rambaut he led a successful solar eclipse expedition to Plasencia in Spain under the joint auspices of the R.I.A. and the Royal Dublin Society. Joly was the last Irishman to hold the office of Astronomer Royal for Ireland; he died in 1906 at the early age of forty-one.

Edmund Taylor Whittaker, a thirty-two year old Englishman of a Lancashire family, obtained the Dunsink appointment in succession to Joly. Whittaker was educated at Manchester Grammar School and at Cambridge where he had a brilliant academic career. At the age of twenty-eight he became Secretary of the R.A.S. and three years later he was elected F.R.S. He only remained in Ireland a few years, leaving Dublin in 1912 to become Professor of Mathematics in Edinburgh University. In this position he became one of the greatest British mathematicians of this century, and he was subsequently knighted. His only contributions to observational astronomy were two papers on the variable stars RW Cassiopeiae and SS Cygni communicated to the R.A.S. from Dunsink in 1910. He is nevertheless familiar to British astronomers of every rank as the joint author (with Robinson) of the *Calculus of Observations*, the first comprehensive English textbook of numerical analysis. His greatest work, the *History of the Theories of Aether and Electricity*, was published from Dunsink in 1910.

Before Whittaker left Dunsink the practice of meridian astronomy in the observatory had virtually ceased but the transit instrument continued in use for time determination. Visual parallax observations for which the South Equatorial had proved so valuable had given way to superior photographic methods not practicable with the Dunsink telescopes. By the application of an ingenious technique devised by Whittaker for the 15-inch reflector the telescope proved capable of providing extremely accurate comparisons of stellar magnitudes and observations of variable stars represented for many years the the main work of the observatory.

The eighth and last Astronomer Royal for Ireland was Henry Crozier Plummer who is perhaps more widely remembered for a distinction which came later in his life—the Presidency of the R.A.S. (1939–1941). The son of a Chief Assistant of Oxford University Observatory, Plummer had become a prominent astronomer even before he obtained the Dunsink appointment. In the ten years of his directorship he published in addition to his observational papers a large number of research papers of great interest. The observational papers were mainly concerned with photometric measurements (with the 15-inch reflector) of short-period variable stars. From his investigations of these stars he concluded that the periodic changes in their radial velocities could be accounted for by pulsations in the atmospheres of the stars; this explanation was supported by Shapley and it later led to the development of the pulsation theory of cepheid variables. The research

papers produced by Plummer at Dunsink covered a wide variety of topics and they were characterised by the power and simplicity of the formulae developed in them—this is particularly evident in his papers on the distribution and counting of stars in globular clusters. While in Dublin he also wrote a textbook of dynamical astronomy.

Plummer was not satisfied with the equipment of the observatory and he made repeated requests for new instruments, comparable with those in use elsewhere and required by the demands of contemporary astronomy. The generosity of Trinity College was, however, limited by its resources and the University was unable to bear the ever-increasing expense of maintaining a modern astronomical observatory. In providing funds for the observatory for one hundred and thirty-five years Trinity College had made a unique contribution to astronomy in Ireland and for this, as for so many services in other fields of national endeavour, Ireland is deeply indebted to the University of Dublin.

In 1921 Plummer was appointed Professor of Mathematics at the Military College of Science, Woolwich, and after his departure from Dublin the position he had occupied in Ireland remained vacant. The observatory, deprived of a director, was compelled to curtail its activities and although it continued to function until 1936 the only observations made there were for time determination. The Observatory of Trinity College was finally closed down in 1936 on the death of Mr. Charles Martin, an assistant who had managed its affairs from 1921.

In 1946 Prime Minister De Valera, desirous of the scientific advancement of the nation and mindful perhaps of his own youthful aspirations as a student of astrophysics under Whittaker, authorised the purchase of the observatory estate from Trinity College and its restoration as a national observatory. It was decided that the reconstituted observatory should form a department of the Dublin Institute for Advanced Studies and that its director should be the Senior Professor of Astronomy in the Institute. The restoration was entrusted to the new director Professor H. A. Brück, the present Astronomer Royal for Scotland. Originally a German astronomer, Professor Brück came to Britain in the 1930s and at the time of his Irish appointment he was John Couch Adams Astronomer and Assistant Director of the Observatories at Cambridge.

Under Professor Brück solar spectroscopy and stellar photometry became the primary fields of work. A new solar installation consisting of a 16-inch coelostat, a Cassegrain reflector and a 7-metre concave grating spectrograph, was set up for the study of the intensities of Fraunhofer lines in the ultra-violet region of the solar spectrum. Results of this work are now embodied in the *Utrecht Photometric Catalogue of Fraunhofer Lines*. Other solar work included studies of temperatures in prominences from line-widths and attempts to measure interferometrically the widths of chromospheric lines at a total solar eclipse. In close collaboration with Dr. D. A. Jackson the observatory sent a successful solar eclipse expedition to Khartoum in 1952; a second expedition to Öland in 1954 was spoiled by cloud. In preparation for its contribution towards the I.G.Y. programme the observatory was furnished with a spectrohelioscope and radio receivers fitted with recorders for the registration of S.E.A.s.

Stellar work at Dunsink during this period included photoelectric measurements of magnitudes and early recordings of stellar scintillation. The

15-inch reflector was later modified and fitted with a 28-inch mirror. It is now designed for the photoelectric measurement of stellar magnitudes with the aid of dekatron pulse counters and a number of experiments in the investigation of pulse-counting techniques in photometry have been carried out at Dunsink by Dr. M. J. Smyth, Chief Assistant of the observatory for several years. The South Equatorial was also overhauled and is used by the public on open nights and by members of the Irish Astronomical Society.

The installation of new instruments and the provision of laboratories and an engineering workshop together with the restoration of office and dwelling accommodation embodied a large amount of constructional work. The first stage of the work was completed within two years and by summer 1950 Dunsink had become re-established as an astronomical centre. In September of that year the observatory was visited by large numbers of British astronomers visiting Ireland to attend an R.A.S. meeting held in Dublin at the invitation of the R.I.A. Five years later the observatory was open to hundreds of astronomers convened in Dublin for the Ninth General Assembly of the I.A.U. For many of the conference delegates the most enduring memory of their Dunsink visit is the cordial and generous welcome extended to them by the Director and his wife and by the observatory staff.

In 1957 Professor Brück was appointed Astronomer Royal for Scotland and he was succeeded at Dunsink by Professor M. A. Ellison, the present Director of the Observatory. Like so many of his predecessors in this office, Professor Ellison is a graduate of Trinity College. His appointment to Dunsink secured for the Ellison family the distinction of having produced directors for the two important Irish observatories; his father, Canon W. F. A. Ellison, was director of Armagh Observatory from 1918 to 1936. Professor Ellison is a well-known solar physicist and he is familiar to readers as a frequent contributor to and a former Editor of this magazine.

The work of the observatory is now chiefly directed towards the study of solar activity and solar-terrestrial relations. Once again the observatory is co-operating with the Royal Observatory at the Cape of Good Hope, where a Lyot $H\alpha$ Heliograph was established in 1958 by the British National Committee for the I.G.Y., as an important link in the chain of solar patrol stations. The films of the chromosphere and prominences taken daily with this instrument during the past three years have been despatched weekly to Dunsink for analysis. The two Irish observatories, Armagh and Dunsink, share in the support and facilities provided by the Boyden Observatory at Bloemfontein in co-operation with Harvard Observatory, Belgium, West Germany and Sweden.

I am grateful to Professor M. A. Ellison for his stimulating suggestions and to him and Professor H. A. Brück for their helpful comments. The photographs were taken by Ian Elliot of Dunsink Observatory.