Admiralty, and during his period of office Douglas, a true naval officer and a man of science, was no exception to the rule. He was elected a Fellow of the Society on 1919 April 11, and took an active interest not only in the astronomical and geophysical activities of the Society, but also in the more social side. He will be missed by many astronomers for his bluff good humour and genial companionship.

(Many of the facts of the above notice are taken from *The Times* obituary notice.)

JOHN WILLIAM DURRAD died on 1939 December 29 while in his eighty-sixth year. He was born in Leicester on 1854 October 25, and lived in that city the whole of his life, following the occupation of a leather merchant. At an early age he became interested in astronomy, which became for him a lifelong hobby. Before he was twenty-one he had already studied and taken a great interest in astronomy, and in that year (1875) he discovered several new crevasses on the Moon near Gassendi. Some finished drawings that he made about this time were used by Goodacre in his book on the surface formations of the Moon. For many years he was connected with the astronomical section of the Leicester Literary and Philosophical Society, and the small observatory in the garden of his home was a centre for all interested in astronomy. He had many interests other than astronomy: he was a water-colour artist of no mean standing, and exhibited up to the year of his death; he was a keen lover of music, and played the 'cello in the Leicester Orchestral Union for over twenty years. His interest in music was shared by his wife, Elizabeth Hodgkins, who was herself an accomplished pianist; they were both well known in local musical circles. He is survived by two sons and one daughter.

He was elected a Fellow of the Society on 1876 March 10, and was one of the oldest as well as one of the longest serving Fellows.

FRANK WATSON DYSON. The death of Sir Frank Dyson has removed from our midst one who has played an outstanding part in the progress of astronomy. His official position brought him into contact with most astronomers not only in England but from all countries of the world, while his simple and engaging personality endeared him to all. The loss to our Society is a heavy one. He was a Fellow for forty-five years, and for a total of thirty-seven years he served on the Council, holding office as President, Vice-President, Secretary and Treasurer. As he attended the meetings regularly he was well known to many Fellows, by whom his death will be felt as a personal loss.

Frank Watson Dyson, son of the Rev. Watson Dyson, a Baptist minister, was born at Ashby, in Lincolnshire, on 1868 January 8. His early life, however, was spent in Yorkshire, and he attended Bradford Grammar School. In due course he was elected to an entrance scholarship at Trinity College, Cambridge, where his successes were many. In 1888 he was awarded the Sheepshanks Exhibition in Astronomy. The following year he was placed second in the list of the Mathematical Tripos (the senior being our Fellow

Sir G. T. Walker). Thereafter he commenced research work in problems of gravitational attraction, and in 1891 he was awarded a Smith's Prize and elected a Fellow of his College. In 1892 he became the second Isaac Newton Student, the first being R. A. Sampson, who succeeded him as Astronomer Royal for Scotland.

His first paper, published in the *Quarterly Journal of Mathematics*, dealt with the "Motion of a Satellite Round a Spheroidal Planet." Later he published in the *Philosophical Transactions* a paper "On the Potential of an Anchor Ring." This work done at Cambridge indicated his interests.

In 1894 H. H. Turner, Chief Assistant at the Royal Observatory, Greenwich, was elected Savilian Professor of Astronomy at Oxford, and Dyson was appointed to the vacant post at Greenwich.

The appointment of a young man who had hitherto had no practical experience of astronomical observations to an important post at a great observatory may not appear a natural one, and at times such appointments have given rise to considerable criticism, but it must be admitted that such appointments at Greenwich have generally been justified by the results. It was particularly so in the case of Dyson. From the time of his appointment, throughout his period as Astronomer Royal for Scotland (1906–10) and finally as Astronomer Royal at Greenwich (1910–33) he devoted himself continuously to the advancement of practical astronomy. He was well aware of the necessity of having the original observations made with every possible care, for on them the accuracy of the final results must depend. Therefore while he as Astronomer Royal followed the plan of appointing chief assistants direct from Cambridge, he was always anxious to have men of a practical turn of mind, and he stressed on them the importance of personally taking part in routine observations. He often expressed the view that it was the duty of an observatory to get observations, and up to the time of his retirement he assisted in this way, often playing the humble rôle of recording observations made with the transit circle or making exposures with the Cookson floating telescope for latitude variation when such observations were badly wanted.

When Dyson went to Greenwich in 1894 work on the Astrographic Catalogue had already commenced, and the methods for measuring plates and reducing them had been developed, a work in which his predecessor Turner had played an important part. It does not seem to have been fully realised at some observatories when the photographic part of the work was commenced that it was essential to obtain accurate places of the reference stars. This, however, was not the case at Greenwich, and although the zone allotted to it, from the Pole to declination $+64°$, had been pretty well observed in the past, a new series of observations was carried out for the determination of the places of the reference stars. Dyson seems to have paid particular attention to the derivation of the plate constants. Preliminary values were calculated from star places already available. He found that when the usual six constants (three in each co-ordinate) were calculated from old star places the theoretical relations between them were not nearly so closely satisfied as when modern Greenwich observations were used. This indicated that the

geometrical conditions were more closely satisfied at the telescope than shown by the constants based on poor places of the reference stars. It was possible to assume a standard scale for all plates and one orientation for both co-ordinates, thus reducing the number of independent constants for each plate from six to three and greatly increasing the accuracy of their determination.

The work in connection with the Astrographic Catalogue was not the most important work done by Dyson as Chief Assistant at Greenwich (1894–1905). His attention was attracted to the motions of the stars, not only in connection with the astrographic reference stars, but also in the preparation for publication of the Greenwich Catalogue for 1890. This included the re-observation of many circumpolar stars which had been observed by Stephen Groombridge at Blackheath some eighty years earlier. In the report of the Astronomer Royal (Sir William Christie) for 1899 we read: "It is proposed now to undertake the determination of the proper motions of all the Groombridge stars; but before doing this it is advisable that Groombridge's observations should be re-examined in view of the large systematic errors in R.A." A year later he wrote: "A new reduction of Groombridge's observations has been undertaken and is steadily progressing." The work was pushed ahead rapidly and published in 1905 under the joint names of Dyson and W. G. Thackeray. There can be no doubt that Dyson played the leading part in this extensive work, although it was an official production of the Royal Observatory, Greenwich. The observations, some 27,000 in number, were completely re-reduced from the original records, the work involving such details as determination of division errors, wire intervals and the daily instrumental errors. The ledgers were published in detail and combined to a catalogue of 4239 stars for the epoch 1810. This is on the system of Newcomb's Fundamental Catalogue. In combination with the latest Greenwich observations, proper motions for all the Groombridge stars were derived and comparisons were given with the Radcliffe Catalogue for 1845 and the various catalogues of the Astronomische Gesellschaft.

These proper motions constituted a most important contribution to our knowledge in so far as they more than doubled the number of well-determined motions and extended them to fainter stars. Hitherto accurate motions had been derived only from the bright stars observed by Bradley. The Groombridge stars have a mean magnitude of 7·0, while a considerable number of them are between magnitudes 8 and 9. Dyson and Thackeray discussed the motions they had determined with reference to magnitude, spectral type and size of proper motion. A correction to the constant of precession was derived. Many results now well known, but only just coming to light at that time, were confirmed: such results as the dependence of the solar apex on the magnitude of the stars considered, and the connection between the average size of the proper motion, the spectral type and the distance from the Milky Way. The fact that the latter would influence the derived position of the solar apex was noted.

From 1906 to 1910 Dyson was Astronomer Royal for Scotland and Professor of Astronomy at Edinburgh. The work of Edinburgh Observatory

was extended to include the observation of double stars near the Pole (unobservable at Greenwich with the 28-inch equatorial) and the measurement of astrographic plates taken at Perth, in Western Australia. Dyson continued his interest in proper motions and published papers on stars of large proper motion. In particular he showed that star streaming, which had been announced by Kapteyn in 1904 and was not readily accepted by some astronomers, was confirmed by stars of large proper motion. For these stars the results could not be seriously influenced by errors of observation, as might be the case in stars of small proper motion. He also discussed the systematic motion of the stars as indicated by the cross proper motion of the Bradley stars.

In 1910 Dyson was appointed Astronomer Royal in succession to Sir William Christie, and from then till his retirement in 1933 a description of his work is largely a description of the work of the Royal Observatory at Greenwich. It is not possible in a notice of this nature to go into all the work accomplished at Greenwich during that time, and Dyson himself would have been the last man to claim the work as his own. He, indeed, was always foremost in attributing the success of the institution to the ability and industry of the staff. He gave direction to much of the work, but at the same time readily listened to the proposals or suggestions of others. The General Index to the *Monthly Notices* for the years 1911–31 gives references to only fourteen papers by Dyson himself and seventeen in collaboration with members of the staff. Fellows who attended the meetings of the Society during these twenty years will be surprised that these numbers are so small. The explanation is that he did not claim personal credit for work done at the observatory. During the same period there were many papers communicated to the Society by members of the Greenwich staff and many others, simply communicated by the Astronomer Royal.

In 1910 the time was ripe for an extension of the work of the Royal Observatory in new directions. In the U.S.A. Schlesinger had shown how accurately stellar parallaxes could be determined by photographic methods, and Pickering had established standard magnitudes for a sequence of stars in the neighbourhood of the North Pole. Within a very short time of Dyson's return to Greenwich parallax observations were commenced. In photographic photometry several programmes were put into operation—standardisation of magnitudes in the Astrographic Catalogue and the Franklin-Adams Charts, and the determination of magnitudes in the northern Kapteyn areas. The work involved as well as the overcoming of technical difficulties was naturally done by other hands than his, but Dyson played the part of an effective Director of the observatory with his knowledge and encouragement. In 1911 the Cookson Floating Telescope was lent to Greenwich—a loan which has been renewed at intervals as required—and observations for the determination of latitude variation have been regularly carried on since then. This enabled work with the reflex zenith tube to be discontinued.

Dyson's principal contributions to astronomy were connected with the reduction and discussion of meridian observations. We have already noted his work at Greenwich as Chief Assistant, and after he returned as Astronomer

Royal he spent much of the time free from administrative duties in the preparation of the results for publication. He was specially interested in the motions of the stars, and paid particular attention to the systematic differences between the various catalogues. The programmes of observation with the Transit Circle were carefully chosen, and included the Backlund-Hough Stars (1915–21), followed by the brighter stars between $+32°$ and $+64°$ and finally stars between the Equator and $+24°$. The first of these showed how important to him were the regular observations of the fundamental stars, while the others completed at Greenwich the observation during the present century of all the stars down to magnitude 7·5 (or fainter) north of the Equator. This enabled the proper motions of all these stars to be determined, and the date of the preface to the second Greenwich Catalogue for 1925 shows that he was engaged in this work till the day of his retirement. Dyson realised that the Transit Circle at Greenwich which had been in use since 1851 was not up to the highest modern standard, and he long thought of a new one. But the difficulties of the post-war period held him back from pressing this need. When finally he approached the Admiralty and obtained sanction for a new instrument his tenure of office had not long to run. But he had the satisfaction of seeing the work of construction well in hand and the new building in course of erection.

We have already noted how Dyson found the work of the Astrographic Catalogue started when he first went to Greenwich. When he returned he found both the Catalogue and the Charts published. Many observatories have found this more than sufficient to tax their strength, and consequently they have not so far been able to reap a harvest comparable with the labour expended. Greenwich has been able to follow up the publication of the rectangular co-ordinates of the stars with more interesting work. By 1913 the spherical co-ordinates of the brightest stars had been published together with a comparison of the positions with those derived from meridian observations. Dyson's interest in proper motions directed the work into new channels, and first of all proper motions were determined for all the brighter stars, using photographs of later epoch where early meridian observations were lacking, and finally all the stars of the Astrographic Catalogue were measured for proper motion on photographs taken at an interval of about thirty years. The derived motions were naturally discussed with reference to spectral type, etc.

Dyson was keenly interested in total eclipses of the Sun. As Chief Assistant he observed the eclipses of 1900 in Portugal, 1901 in Sumatra and 1905 in Tunis. He was fortunate in having good weather at these eclipses, and his observations contributed to the determination of the wave-length of the coronal lines as well as the identification of elements in the chromosphere. He witnessed the eclipses of 1912 in Paris, 1927 in Giggleswick and 1932 in U.S.A., again under good conditions. But as Astronomer Royal and as a member of the Joint Permanent Eclipse Committee he did splendid work in arranging for expeditions to be sent from England, and especially from Greenwich, to observe the various total eclipses between 1911 and 1932. His greatest success was that of 1919. In a short paper to the *Monthly*

Notices published in 1917 he drew attention to the opportunity of testing the deflection of star-light in the Sun's gravitational field. Photographs taken with the astrographic telescope at the eclipse of 1905 showed three or four stars, and proved that that telescope was suitable for testing the predicted displacement. By far the best field of stars along the whole length of the ecliptic lies in the region which the Sun passes through on May 29, and by great good fortune a total eclipse with six minutes' totality in regions where clear skies were probable was due to take place on that very day in 1919. Such a favourable eclipse will not occur on the average more frequently than once in a thousand years.

"In 1918, in the darkest days of the war, two expeditions were planned, one by Greenwich Observatory and one by Cambridge, to observe, if the state of civilisation should permit when the time came, the eclipse of May 1919 with a view to a crucial test of Einstein's generalised relativity. The Armistice was signed in November 1918; the expeditions went and returned, bringing back news which changed, and that irrevocably, the astronomer's conception of the nature of gravitation and the ordinary man's conception of the nature of the universe in which he lives. If the credit of this achievement is to be divided between Sir Frank Dyson and Professor Eddington I frankly do not know in what proportion the division should be made. To my mind, however, it is not so much an occasion for sharing out credit as for attributing the whole credit to each, for if either had failed to play his part, either from want of vision, of enthusiasm, or of capacity for seizing the right moment, I doubt if the expeditions would have gone at all, and the great credit of first determining observationally what sort of things space and time really are would probably have gone elsewhere." *

Astronomers have observed the Einstein displacement at subsequent eclipses but always under conditions of the greatest difficulty on account of the faintness of the stars, so that even with improved technique the small outstanding residuals will not be easily accounted for. Dyson continued his interest in eclipses, and after his retirement carried out the plan he had formed many years earlier of writing a book on eclipses. (In the parts dealing with modern theories of spectra he was assisted by Dr. Woolley.)

During Dyson's tenure of the office of Astronomer Royal technical advances in various directions led to considerable changes at Greenwich. This was particularly the case in the time service, a rather important work for a national observatory. In 1912 the first wireless time signals were received from Eiffel Tower. Wireless time signals made possible a much closer comparison of time determinations made at different observatories than had previously been possible and unexpectedly large differences were found. Although considerable improvement has been made in the actual time determinations, the greatest advances have been in the means of time keeping and time distribution. The standard clock had been in use for nearly half a century. It was undoubtedly a very fine piece of workmanship, but it was not compensated for temperature and pressure changes with anything like modern accuracy. Fortunately Mr. W. H. Shortt had designed a

* Sir James Jeans, *M.N.*, **85**, 677, 1925.

new type of clock known as a free pendulum clock. In 1925 the first Shortt clock was brought into use, and its value being at once realised clocks of this type were procured for maintaining both sidereal and mean time. For distribution of time to the public the system of sending out six pips was inaugurated, and for scientific purposes powerful rhythmic signals were sent out twice daily from Rugby. Dyson took a keen interest in clock making, and became President of the British Horological Institute, which awarded him its Gold Medal in 1928.

The magnetic work of the observatory underwent various changes. A new magnetograph house with improved recording instruments was erected in the Magnetic Enclosure before the war. The approaching electrification of the local railways necessitated the removal of all the magnetic work from Greenwich, and a new Magnetic Observatory was erected at Abinger in 1924.

As a consequence of his official position Dyson was called upon to assist in the work of many committees and this took up much of his time. After the war the whole scheme of international co-operation had to be rebuilt. He took his full share in this work, going to Brussels in 1919 for the meeting at which the International Research Council (now the International Council of Scientific Unions) was formed. The International Astronomical Union soon brought astronomers into closer international co-operation than they had ever been before. Dyson attended all the meetings of the Union from 1922 to 1935, taking an active part in the work of the various commissions as well as of the executive committee. His work for the Union as well as for astronomy in general was fittingly recognised by his election as president for the years 1928–32.

He undertook a considerable amount of work in connection with committees of the University of London and educational institutions generally. For a number of years he was the only astronomer amongst the Trustees of the Radcliffe Observatory, and he had a good deal of responsibility in connection with the removal of the observatory from Oxford to Pretoria. Locally he was called on to serve on many charitable organisations, and he was ever willing to serve in any good cause. During the war he raised considerable sums of money for the Red Cross by garden parties at the Royal Observatory, a means of raising money which was afterwards continued on behalf of local hospitals.

There is no doubt that Dyson enhanced the prestige of the Royal Observatory in the eyes of the public both in the neighbourhood of the observatory and in the country at large. A quite unexpected recognition of his services came a few years before he was due to retire. It was intimated to him that Mr. William Johnston Yapp, a gentleman previously unknown to him, wished to commemorate his work in some signal manner—by a gift of a large instrument to the observatory. Dyson was at the time thinking more of the needs of the observatory in the form of a new transit circle and in the general advancement of astronomy (not necessarily at the Royal Observatory) than in some permanent memorial to his own work. But the donor made it plain that the gift must be in recognition of Dyson's work

and must take the form of a large instrument for the Royal Observatory. After careful consideration it was decided that a 36-inch reflecting telescope was the largest which could be efficiently used in a climate such as that at Greenwich, and for its construction and housing Mr. Yapp offered the £15,000 estimated to cover the cost. The gift was gratefully accepted by the Lords Commissioners of the Admiralty and plans were speedily prepared. The inaugural ceremony took place on Visitation Day, 1934, when the new telescope was formally accepted by the First Lord of the Admiralty in the presence of both Dyson and the donor.

Dyson received many honours in recognition of his scientific work. He was awarded a Royal Medal of the Royal Society in 1921, the Bruce Medal of the Astronomical Society of the Pacific in 1922 and the Gold Medal of our Society in 1925. He received honorary degrees from many universities, including those of Cambridge, Oxford and Edinburgh, and several colonial universities. He was created a Knight Bachelor in 1915 and a K.B.E. in 1926.

Those who knew him best will not claim that he was a great administrator if by that is meant a man skilled in the ways of diplomacy. He never exaggerated his case or presumed on the ignorance of others. When he had to ask for money for any project he never asked for more than what he himself was convinced was necessary. He was transparently honest. The result was that he probably sometimes got his way where a more forceful man might have failed. He was a most successful head of an institution, carrying on scientific work where complete confidence between all the members of the staff is essential. He did not presume to be an authority on instruments, but he recognised mechanical ability in others and its great importance for successful work in an observatory. He was as willing to co-operate with those below him as above him in status or knowledge. To all members of the staff he gave free scope. He tried to interest all in the work they were doing and by his own enthusiasm imparted enthusiasm to others. It was by these methods that so much was accomplished while he held office at Greenwich.

Dyson married Caroline Bisset Best, daughter of Dr. Palemon Best, in 1894. The marriage was a most happy one. They had a family of two sons and six daughters who, with a number of grandchildren, all survive. With the care of a large family Lady Dyson had a very busy life and for long was unable to accompany her husband abroad on expeditions or to attend conferences. But towards the end, as the family grew up, she was able to travel with him. At all times she was heart and soul in his work, and as all astronomers were his friends so were they hers. Large is the number of those who will recall the friendly, natural welcome which they received in the family circle at Flamsteed House. Lady Dyson predeceased her husband by a few years, and he never really recovered from the loss of her companionship.

Till the last few years of his life Dyson enjoyed good health. After he retired he carried on active work both on scientific committees and in connection with charitable organisations. He made trips to South Africa in