REPORT

OF THE

ASTRONOMER ROYAL

TO THE

BOARD OF VISITORS

OF THE

ROYAL OBSERVATORY, GREENWICH

Read at the Annual Visitation of the Royal Observatory, 1940 June 1.

THE BOARD OF VISITORS

		To serve until June 30th.
The President of the Royal Society	Sir William Bragg.	
The President of the Royal Astronomical Society	Prof. H. C. Plummer.	
Nominated as Fellows of the Royal Society	Sir George Simpson.	1940
	Dr. E. V. Appleton.	1941
	Prof. G. P. Thomson.	1942
	Prof. R. H. Fowler.	1943
	Dr. C. G. Darwin.	1944
	Prof. T. R. Merton.	1945
Nominated as Fellows of the Royal Astronomical Society	Dr. Wilfred Hall.	1940
	Rev. T. E. R. Phillips.	1941
	J. Evershed Esq.	1942
	Prof. E. A. Milne.	1943
	Dr. R. Stoneley.	1944
	Prof. W. M. Smart.	1945
Savilian Professor of Astronomy at Oxford	Prof. H. H. Plaskett.	
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Secretary	W. E. Llewellyn Esq.	

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Read at the Annual Visitation of the Royal Observatory, 1940 June 1.

The Report here presented refers to the period from 1939 May 1 to 1940 April 30 and exhibits the state of the Observatory on the last-named day.

I. INSTRUMENTS AND APPARATUS.

Reversible Transit Circle. The observations for providing the foundations of a system of right ascensions have been continued.

Under blackout conditions the observing has been more difficult, but progress has been satisfactory. During the current year 3,564 transits have been observed as follows:-

Clock stars	.. ..	1,811 observations
Zenith stars	.. ..	474 "
Azimuth stars	.. ..	1,246 "
Miscellaneous	.. ..	33 "

In addition 1,306 collimations and 1,313 levels were obtained. Since the programme began, late in 1937, a total of 7,897 transits have been observed. Concurrently with these transits special observations of collimation and level are being continued.

The clock errors derived from observations with this instrument are now being used for the determination of time, in addition, of course, to the usual observations by the Small Transit. There is a small irregular but apparently systematic difference between the two instruments as measured over a period of 20 months. More data will be required before it can be decided if this is a regular seasonal variation. The observations of clock error by the Reversible Transit Circle show slightly less scatter then those made on the Small Transit, and agree better with foreign radio time signals. This is a very satisfactory result, in view of the fact that large instruments are not usually considered as accurate as the small reversible ones.

The level error of the instrument has proved to be subject to rapid diurnal variations due to changes of temperature and direction of wind. To reduce these fluctuations as much as possible it was decided to protect the metal of the piers from direct contact with the incoming air. The experiment is being carried out by utilizing the sun screens already in use. These were modified to give better protection to the north faces of the piers and their inner surfaces have been lined with felt. The superstructure comprising the exposed metal surfaces of the microscope mountings was also jacketed with felt. Large diurnal changes of temperature are necessary to provide a real test. These occur mainly in the spring, but as observations under the conditions described only started last November, more data are required before it can be decided to what extent the changes of level due to changes of temperature have been reduced.

A new jewel (diamond) forming an end bearing surface to the R.A. micrometer screw was inserted on August 31. The surface of the bearing previously in use was found to be breaking up and a small portion had flaked off. The results for horizontal flexure since the instrument was erected give very satisfactory accordance.

Observations made by three observers are as follows:-

	Clamp E		Clamp W	
Uncorrected	+"·16	10 observations.	+"·17	12 observations.
Corrected	+"·28	" "	+"·29	" "

In the corrected results account has been taken of the movement of the zenith distance frame.

Observations for the errors of the divisions of the fixed circle, other than those of the quarter degrees, are nearing completion. Using the six ordinary microscopes six arcs of 120° have been obtained, three in the E. and W. positions respectively. The bulk of this work has been carried out by Messrs. Cullen, Acton and Barton, with occasional assistance from the other transit observers. An idea as to the labour involved in the determination of the division errors is given by the approximate total number of individual microscope readings made, namely 180,000. All the astronomical observations have been made by the same staff.

Small Transit Instrument. A small transit instrument made by Messrs. Cooke, Troughton and Simms Ltd. has been purchased from the Crown Agents for the Colonies. This instrument was constructed for time determinations at Singapore but was not used as it was found that time to a sufficient degree of accuracy could be obtained by recording time signals from various countries. The instrument is of more modern design than the small transit instruments hitherto used as the Observatory, which were constructed for use by expeditions to observe the Transit of Venus in 1874. After thorough overhaul in the workshop and the fitting of a new contact wheel to the impersonal micrometer, to change from a 'make' to a 'break' circuit, the telescope was mounted in the Altazimuth dome. A personal equation machine is under construction in the workshop and will be fitted to the south collimator. An artificial star will be travelled along in either direction by a geared reversible motor; a gear box is provided to enable the star to be moved at a rate corresponding to the speed of an equatorial star, or to one-half or one-quarter of that speed. The north collimator will be used to provide a check on the stability in azimuth of the telescope. It is hoped that observations with two small transit instruments on the same night, in conjunction with observations with the Reversible Transit Circle, will give some information about fluctuating errors of instrumental origin.

Yapp 36-inch Reflector. Because of the trouble with the declination control mentioned in last year's Report, the use of an electric motor for fine setting and guiding in declination has been abandoned. A manual control working directly on the slow-motion screw was fitted on August 8 and works satisfactorily. Four hand-operated wheels spaced approximately equally around the telescope lattice tube allow the observer to operate the control from the guiding eyepiece at all positions of the telescope.

Microphotometer. The Casella microphotometer was delivered on May 24 and mounted in the laboratory by the end of the month. After a number of minor adjustments had been made, the screw errors were determined by obtaining low- and high-magnification traces from a test-plate ruled at millimetre intervals and standardised on a long-screw measuring machine. By this test, the errors, which have an extreme range of $\pm 10\mu$, seem to be at least three times as large as those in the screw of the Oxford instrument of similar design. It is, however, possible that part of the trouble is apparent, and is really due to unequal spacing of the cams operating the time-mark contact-maker. Special tests on this point suggest that some such effect is operating; certainly time-marks are not in fact printed on the record at equal fractions of a screw revolution. Tests of the inertia of the thermocouple and galvanometer give satisfactory results. Further investigation of the errors of the instrument will be undertaken when its use is resumed. Records of a few of the ultra-violet spectra obtained with the slit spectrograph on the Yapp reflector had been obtained when the outbreak of war held up the work.

Total Eclipse of the Sun, 1940 October 1. An expedition had been planned to observe this eclipse at Calvinia, C.P., South Africa. The programme of observations was to consist of two parts. The Einstein displacement of stars near the limb of the Sun was to be re-measured. A specially designed portable equatorial mounting, the cost of which was defrayed from funds provided by the Royal Society and the Joint Permanent Eclipse Committee, was constructed for these observations. The two outer portions of the tube of the 13-inch astrographic telescope, carrying the objective and breech-end respectively, were to be fitted to the central section of this mounting. The mounting was designed so that the telescope could be moved rapidly and with certainty from the eclipse field to a pre-selected neighbouring comparison field. The comparison field was selected to have a sufficient number of stars of suitable brightness in those regions of the plate in which the stars of the eclipse field would be shown. The effects of optical distor-

tions would be the same for the two sets of stars, and the scale derived from the comparison field could therefore be directly applied to the eclipse field, for the determination of the Einstein displacement. It was found that the stars of the eclipse field were well shown with an exposure of 15 seconds, with the objective stopped down to 7 inches.

A three-prism spectrograph with 6-foot collimator and camera with repeating back was constructed in the Observatory workshop for the spectroscopic observations. Most of this work was done at the cost of the Joint Permanent Eclipse Committee and the repeating back of the camera will remain the property of the Committee. It was intended at the eclipse to set the slit tangential to the limb of the Moon and to guide on the Moon's advancing limb through second and third contacts. 15 eclipse exposures, together with 2 or 3 calibration exposures, could be made on a single 10 x 15-inch plate; the entire operation of the plate-holder and shutter, including the rapid shifting of the plate between exposures, was accomplished by turning a single crank at uniform speed. One plate was to have been exposed at second contact, and another at third.

On the outbreak of war, it became necessary to cancel the plans for an expedition from the Royal Observatory, but arrangements were made for a part of the equipment, together with some of the equpiment that was to have been used by other expeditions from this country, to be sent to South Africa for use by a combined expedition from the Royal Observatory, Cape of Good Hope, and the Union Observatory, Johannesburg. The portable field equatorial was received from Sir Howard Grubb, Parsons and Co. in December. The instrument was erected in the workshop and tested; some minor alterations were made, including the casting and fitting of counterpoise weights for the arc. The release governor, received later, was tested for rate. The instrument was then dismantled and packed, and was shipped, along with spectrographic equipment from the Solar Physics Observatory, Cambridge, to South Africa in March.

II. BUILDINGS, GROUNDS, MOVABLE PROPERTY AND LIBRARY.

The section of the track rail of the 28-inch dome, which was fractured early in 1939, has been successfully repaired by electrical welding. This is a temporary expedient and further trouble is to be expected unless both the track and the dome wheels are renewed. The proposals that were under consideration for the removal of the Observatory to a new site made it inadvisable to incur this heavy expense. Meanwhile, as the telescope is not at present in use, the question whether more extensive repairs should be undertaken has remained in abeyance.

The new 4-inch water main leading from the Main Avenue to the Christie Enclosure has been completed.

The Altazimuth Instrument has been dismantled and stored. A brick pier has been erected in the dome to take the Cooke Small Transit Instrument.

The windows of the ground floor of the South-East Dome and of the Lower Chronometer Store have been bricked up. A concrete housing for the new time desk and terminal frame was erected on the site of the cold greenhouse; a new greenhouse has been erected adjoining this room.

The ceiling of the Central Store, which was found to be in a dangerous condition, has been taken down and is being replaced by plaster board.

New fireplaces have been fitted in the West Wing of the Main Building and in the Low Computing Room.

A new wash basin has been fitted in the workmen's lavatory; and a new wash basin has been fitted in the lavatory outside the Lower Computing Room.

A concrete cable trench for new time circuits has been laid through the Time Department, the Airy Transit Circle house and the passage.

Dark blinds have been fitted to the windows throughout the Observatory.

At Abinger, a wooden housing for the small transit instrument has been erected. Special care was taken in the design of this building to secure adequate ventilation and to aviod stratification of the air. A portion of the old battery room has been divided off by insulated plaster board for use as a clock room and thermostatically controlled electric heating has been installed. The former engine room has been divided off by glazed partitions and a block flooring has been laid.

A considerable amount of time has been spent on Passive Defence Work. The 28-inch and 26-inch object glasses have been dismounted and removed to a place of safety. Steps have been taken to protect the Flamsteed manuscripts and other valuable books and records. Suitable refuges for the staff have been prepared.

The following painting was done during the year:-

> Internal redecoration of the South, East and West Wings, South Lobby, Workshop, Workmen's Lavatory and First Aid Room in the Main Building; the Altazimuth Dome and walls; the Upper Computing Room and the Lower Chronometer Store. In Flamsteed House, five bedrooms and bathroom. At Abinger, the house of the Assistant-in-Charge was redecorated internally and externally on change of occupancy, and the water tower was repainted.

The following instruments in regular use are on loan from other institutions:-

The Cookson floating zenith telescope, from the Cambridge Observatory, for a fifth period of seven years from July, 1939.

A 13-foot spectrohelioscope, complete with coelostat, but withoug grating, from the Mount Wilson Observatory.

A 7-inch prism of 40° angle, from the Joint Permanent Eclipse Committee.

A 16-inch coelostat and spectroscope slit from the Royal Astronomical Society.

A position micrometer for measuring solar photographs, from the Solar Physics Observatory, Cambridge.

A Schuster–Smith coil magnetometer for measurement of horizontal intensity, from the National Physical Laboratory.

A coil magnetometer, designed by the late Dr. D. W. Dye, F.R.S., for measurement of vertical intensity, from the National Physical Laboratory.

Three potentiometers, with standard cells and resistances for measuring current supplied to the coil magnetometers, from the National Physical Laboratory.

A Smith portable coil magnetometer, with potentiometer, for measurement of horizontal intensity, from the Ordnance Survey Department.

Several other smaller instruments are also on loan to the Royal Observatory.

The following instrument, borrowed for observation of the Solar Eclipse of 1932, August 31, is stored at the Royal Observatory:–

A 6–inch lens of 45–feet focus, from J. H. Worthington, Esq.

The following instruments have been lent by the Royal Observatory:–

To the Royal Observatory, Cape of Good Hope –

Transit A : Altazimuth B : Object glass of photoheliograph No.1 : Clocks, Dent 1916 and Dent 2013.

To the Solar Physics Observatory, Cambridge –

Photoheliograph object glass No.5.
9–inch speculum concave mirror with stand and guiding microscope.

To the Imperial College of Science and Technology –

6–inch Equatorial, Simms No.2 : Altazimuth A.

To the Meteorological Office –

A dip inductor for use at Lerwick Observatory, Shetland Islands.

To the Science Museum –

A number of astronomical instruments of historical interest.

To the National Maritime Museum –

Harrison's Time Machines Nos. 1, 2, 3 and 4, and the copy of No.4 by Larcum Kendall.

To the Mine Design Department, H.M. Dockyard, Portsmouth –

Small Transit instrument with stand and striding level; Theodolite, complete with striding level.

The annual examination of the Observatory Library has been made. Seventeen books are missing and cannot be traced as present. Of these, fourteen were reported missing last year, one of which has been missing for a number of years and has now been written off.

The Binding Department of H.M. Stationery Office at the British Museum have kindly consented to renovate, and rebind where necessary, about 190 valuable and rare books belonging to the Observatory Library. 100 have been completed and returned, and the remainder are still in their hands. The condition and value of these volumes has been greatly enhanced by this expert treatment, and a suitable glass-fronted mahogany bookcase has been acquired for the purpose of housing these books when normal conditions return.

III. ASTRONOMICAL OBSERVATIONS.

Transit Circle. The sun, Moon and planets have been regularly observed together with accompanying clock and azimuth stars. The preparation of the star catalogue based on the observations from 1931–1938 has again been held up.

During the year 1,744 transit observations and 1,793 observations of zenith distance were obtained. These include the following:–

89 observations of the Sun.

75 " " " Moon.

Major Planets		Minor Planets	
Mercury ..	5 observations.	Ceres ..	6 observations.
Venus ..	18 "	Pallas ..	1 "
Mars ..	39 "	Vesta ..	7 "
Jupiter ..	23 "		
Saturn ..	20 "		
Uranus ..	12 "		
Neptune ..	9 "		

The observations of the Sun, Moon and planets for the year 1937 are now ready for the printer but the printing of the *Greenwich Observations* has been postponed.

The observations of the Sun in recent years show a small decrease in the correction to the right ascension given by Newcomb's Tables. The mean corrections to the Tables, indicated by the observations during recent years, are as follows:-

Year	Correction	Year	Correction
1923	+0^{s}·106	1931	+0^{s}·117
1924	+ ·113	1932	+ ·087
1925	+ ·114	1933	+ ·101
1926	+ ·118	1934	+ ·097
1927	+ ·113	1935	+ ·107
1928	+ ·114	1936	+ ·102
1929	+ ·109	1937	+ ·094
1930	+ ·116	1938	+ ·102
		1939	+ ·106

An amount +0^{s}·050 of these corrections is accounted for by the correction of -0^{s}·050 known to be required to the position of the equinox adopted by Newcomb. The remaining portions are attributable to defects in Newcomb's theory, to the effect of variations in the rate of rotation of the Earth and to errors of observation.

The observations of the Moon continue to show a decrease in the correction to the longitude given by Brown's Tables, which were introduced into the *Nautical Almanac* in 1923.

	Longitude		Latitude		No. of observations	
Year	Limb	Mösting A	Limb	Mösting A	Limb	Mösting A
	"	"	"	"		
1923	+6·99	+7·47	-0·36	-0·43	101	60
1924	+7·21	+7·14	-0·62	-0·39	87	54
1925	+6·61	+6·71	-0·67	-0·55	90	52
1926	+6·40	+6·55	-0·48	-0·72	93	66
1927	+6·20	+6·24	-0·50	-0·71	80	43
1928	+5·51	+5·88	-0·73	-0·46	97	60
1929	+5·20	+5·89	-0·58	-0·60	108	67
1930	+5·08	+5·40	-0·73	-0·63	82	47
1931	+4·76	+4·87	-0·82	-0·71	69	46
1932	+4·61	+4·56	-0·81	-0·77	85	57

Year	Longitude Limb	Longitude Mösting A	Latitude Limb	Latitude Mösting A	No. of observations Limb	No. of observations Mösting A
	"	"	"	"		
1933	+4·21	+4·10	-0·56	-0·60	96	61
1934	+3·98	+3·33	-0·49	-0·46	103	64
1935	+3·15	+3·26	-0·71	-0·48	97	61
1936	+2·77	+2·75	-0·76	-0·56	78	46
1937	+2·40	+2·24	-0·85	-0·89	86	55
1938	+2·3	+1·8	-	-	93	48
1939	+1·7	+1·8	-	-	76	34

The corrections in longitude for 1938 and 1939 are approximate and based on the mean values O − C in right ascension.

The above values are referred to Newcomb's equinox and to an adopted colatitude of 38°31′ 21″·70.

Cookson Zenith Telescope. During the year 244 plates were taken for latitude variation, and 2 for the determination of scale. The measurement of the plates is proceeding.

28-inch Refractor. In the early part of the year, observations were restricted, as, in consequence of the fracture of the dome rail, the dome could not be moved. The dome was placed in the position that allowed the best selection of stars to be observed without moving it. The object glass was dismounted for safety on September 1. Up to that date, the following observations were secured.

1	Observation	of 1 pair	with separation	> 2″·0
23	Observations	of 8 pairs	with separation	2″·0 − 1″·0
23	"	" 9 "	" "	1″·0 − 0″·5
31	"	" 8 "	" "	< 0″·5

Thompson Equatorial. With the 26-inch refractor, 402 plates suitable for parallax measurement and 14 for the determination of proper-motions were obtained up to September 2, when the object glass was dismounted. The measurement of the 45 completed series of parallax plates has been continued, 1,361 plates being measured and parallaxes completed. The *Monthly Notices* for November contained the results for 42 stars, one being a provisional value from 8 photographs of a star suspected of having a large parallax.

Yapp 36-inch Reflector. The completion of the programme of colour temperature determinations, commenced in 1926, was announced in the Report for last year. A volume containing the

detailed results for 250 stars, together with a full discussion of the results, was prepared and sent to the printer. The printing of this volume has been deferred until after the war, A list of the final relative spectrophotometric gradients for all stars in the programme was published in the *Monthly Notices* for January, so that the results are available for use by other observatories. A paper on the relationship between stellar gradients and colour indices, embodying some of the results of the dicussion of the material, was published in the same number of the *Monthly Notices*.

The observing programme with the slit-spectrograph has been continued. 49 ultra-violet spectra of 35 F- to M-type giants have been obtained. Some of these stars are spectroscopic binaries, which may possibly have high-temperature companions; the others are non-binaries, which are photographed as comparison stars. Microphotometric traces of the first few spectra have not revealed the presence of any early-type companions. At the time the programme was started, no reliable detailed information had been published on the spectra of stars of early-type in the region 3400_A to 3900_A, so that thirteen spectra of twelve stars of types Oe5 to A5 were also secured.

Observations of Eros.

(a) Photographic observations:-

Final places from photographic observations have been received during the year from the following observatories and a comparison has been made with the Tabular Position.

Allegheny	165	positions	on 33	nights
Bergedorf (1)	24	"	" 4	"
(2)	98	"	" 14	"
(3)	43	"	" 4	"
(4)	48	"	" 4	"
Catania	271	"	" 63	"
Cordoba	277	"	" 52	"
Dearborn	1,966	"	" 45	"
La Plata	277	"	" 17	"
Lick	68	"	" 12	"
McCormick	62	"	" 18	"
Tacubaya	18	"	" 14	"
Tokyo	274	"	" 37	"
Van Vleck	227	"	" 24	"
Washington	47	"	" 16	"

Observations have yet to be received from Hyderabad, San Fernando and Lembang.

(b) Visual observations:-

The Tabular Place has been computed and compared with the observations obtained at the following observatories:

Arcetri	32	positions	on	15	nights
Berlin (Babelsberg)	398	"	"	46	"
Besançon	15	"	"	11	"
Heidelberg	19	"	"	19	"
La Plata	48	"	"	21	"
Padua	126	"	"	30	"
Poulkovo	35	"	"	11	"
Trieste	45	"	"	26	"
Washington	55	"	"	26	"

The above, together with the observations obtained at the Union Observatory, Johannesburg, which were reported last year, complete the list of micrometric observations so far received.

The discussion of the material already to hand is in progress. It is clear that the final value of the solar parallax will be nearer 8"·79 than 8"·80. The path of Eros at the opposition of 1931 was such that the solar parallax can be derived both from observations in right ascension, by comparing observations obtained at the same observatory when Eros was at easterly or westerly hour angles, or from observations in declination by comparing observations on the same night at a northern and southern observatory. Both right ascension and declination observations indicate an appreciable reduction of the value of 8"·80, adopted in the Nautical Almanac and other national ephemerides.

The discussion at the Bergedorf Observatory of the observations of Eros made there led to the conclusions that there existed rapid variations in the position of the centroid of brightness of Eros with respect to the centroid of mass, with periods of approximately 12·5 minutes and 79·5 minutes; that Eros was a multiple system, consisting of at least three bodies, and that it was therefore an unsuitable object for the accurate determination of the solar parallax. These conclusions have been investigated using the extensive material available from many observatories and have been found to be incorrect. A small variation in position in declination of the centroid of brightness with respect to the centroid of mass, with period of 2h 38m – the interval between successive minima of brightness of Eros – and amplitude of a few hundredths of a second of arc has been established; no effect in position in right ascension with this period could be detected. This small effect can be neglected in the determination of the solar parallax from the observed declinations of Eros. The results of these investigations are being published in the *Monthly Notices*.

Observations of Jupiter's Eighth Satellite. In response to a request received from Mr. Herbert Grosch (Ann Arbor Observatory) seven plates taken during the opposition of 1917–18 have been measured and reduced and the results will be communicated in due course.

Photoheliograph. Photographs of the Sun were obtained on 273 days. The number of photographs selected for preservation is 534, including 24 with double images of the Sun for the determination of the zeros of position angle. The zeros of position angle have also been determined regularly by visual observations.

H.M. Astronomer at the Cape has reported that the Sun was photographed there on 344 days in the year 1939 and on 60 days in the first two months of 1940. The Director of the Kodaikanal Observatory has reported that plates were taken there on 329 days in the year 1939 and 89 days during the first three months of 1940.

Photographs in duplicate have been received from the Royal Observatory, Cape of Good Hope, to 1939 May 18, and the single series to June 21. With the inclusion of 5 or 6 plates from Kodaikanal, the series for 1939 will be complete.

The measurement of the combined series has been made from 1938 April 29 to 1939 January 4. The reductions of positions and areas of spot groups and their principal components have been completed from 1938 January 1 to 1938 December 12. The copy for press of the *Greenwich Photoheliographic Results* for 1937 has been completed, and the usual summary of mean daily areas and heliographic latitudes has been communicated to the Royal Astronomical Society.

The downward trend of the present 11-year cycle after a very high maximum seems now established, although the Sun has shown considerable activity throughout the year. There have been during the last twelve months about 27 groups of spots whose maximum area each exceeded 500 millionths of the Sun's hemisphere. Groups notable for their size were those with central meridian passage on the following dates: September 1·0 (2,800 millionths), September 10.5 (2,300 millionths), September 28·0 (2,000 millionths), October 26·0 (1,900 millionths) and January 5·5 (2,500 millionths).

The computed times of central meridian passage of groups with an area of 500 millionths or greater have been supplied to the Superintendent, Radio Research Station, Slough, and to the Controller (Engineering), British Broadcasting Corporation, as soon as possible after the first appearance of each group. Advance notification has also been given to the Engineer-in-Chief, General Post Office, to the Post Office Engineering Radio Station and to the Superintendent, Eskdalemuir Observatory, of the occurrence of spots having an area of 1,000 millionths or greater (or of smaller spots showing unusual activity spectroscopically).

Eight groups of area equal to or greater than 1,000 millionths were reported during the year. In three cases a magnetic storm occurred within two days preceding and four days following the time of central meridian passage of the respective sunspot. (The big spot with central meridian passage on March 26 was associated with two "great" storms within this range.) Of the 19 spot groups with maximum area between 500 and 1,000 millionths of the Sun's hemisphere, 8 were associated with one or more magnetic storms within the same range with respect to the central meridian. On the other hand, of a total of 23 magnetic storms (including 7 "great" storms), 7 were not apparently associated with any large sunspot or other unusual activity observed at Greenwich.

Daily sunspot numbers, based on Wolf's method of counting, have been supplied quarterly to Professor Brunner at Zurich for incorporation in the *Bulletin for Character Figures of Solar Phenomena*, published under the auspices of the International Astronomical Union.

Spectrohelioscope. Observations were made with the spectrohelioscope on 162 days; on 44 days, observations were limited to a few minutes owing to cloud. The observations comprise (a) a search for bright Hα eruptions, (b) radial velocity measures of dark Hα flocculi, special attention being given to those associated with sunspots, (c) photometric measures chiefly of bright eruptions seen in Hα.

(a) The number of bright eruptions observed during the year was 63, as compared with 89 in the preceding twelve months. Quarterly lists of all eruptions observed are sent to Slough and also to M. d'Azambuja, at Meudon, for inclusion in the Zurich *Bulletin*.

(b) 169 measures of radial velocity were made, of which 141 relate to dark markings associated with sunspots. The largest component of radial velocity recorded during the year was -200 km/sec on May 9, belonging to an absorption marking associated with a sunspot. On six other occasions, radial velocities between 90 and 170 km/sec were recorded.

(c) Attention was chiefly given to the use of a simple direct wedge photometer, decribed in last year's Report, in measuring the peak intensities of bright eruptions. Five of the 63 eruptions observed had a peak intensity exceeding that of the continuous spectrum from an adjacent part of the disk. Four of these major eruptions synchronized with marked fade-outs on long distance short-wave transmission.

A preliminary analysis of bright eruptions in relation to sunspots and magnetic storms has been made during the year, and the results have been published in *The Observatory* for December, 1939.

The Engineer-in-Chief, Cable and Wireless Limited, has arranged for definite fade-outs (ionospheric irruptions) to be notified to Greenwich while in progress. This information will be very useful in the study of bright eruptions and associated ionospheric disturbances.

The two pyrex mirrors of the coelostat of the spectrohelioscope were re-aluminized in January.

IV. TIME SERVICE.

Determinations of time have been made throughout the year by a rota of observers with the small transit instrument B. Observations were secured on 121 nights. The application of relative personality corrections determined on the basis of the observational results has been continued. The new Cooke level referred to in the previous report has been in use throughout the year. A number of observations secured with the reversible transit instrument have also been employed as an additional check. In accordance with the recommendations of the International Astronomical Union, star places based on the FK3 catalogue have been employed for the reduction of time

observations since January 1. The universal adoption for time determinations of the same fundamental system of star places will make the times determined at different observatories more directly comparable than hitherto.

The principle of employing a mean clock has been continued, and by the courtesy of the Astronomer Royal for Scotland, and the Director of the National Physical Laboratory, it has been made possible to continue the use of clocks Shortt Nos.4 and 13 in the mean. The following table shows the composition of the mean clock at different dates throughout the year:-

May 1 to July 31	..	Shortt Nos. 3, 4,11,13,16,40.
Aug.1 to Jan. 7	..	" " 4,11,13,16,40,49.
Jan.8 to Jan. 31	..	" " 3, 4,11,13,16,40.
Feb.1 to Apr. 30	..	" " 4,11,13,16,40,49.

Shortt 49, after having been overhauled and cleaned, was put into the mean on August 1. Shortt 3 was fitted with a new impulse wheel and bracket on August 3 and the weight tray was turned down to compensate for the additional weight of the new bracket. Shortt 49 was found stopped on January 7, and was cleaned and restarted. Shortt 3 was opened on February 1 for cleaning the contacts, and was again opened on April 24 for resealing.

The main battery employed for all the time circuits has given rise to some concern for the past few years, and pending the installation of a new alkaline battery, a number of cells were replated and put back in circuit on November 29. Some units of the alkaline battery were hurriedly put into use for a short time, but the discrepancy in the voltage per cell combined with the inadvisability of placing alkaline and acid batteries in close proximity, rendered it necessary for the Electrical Engineering Department, Chatham Dockyard, to supply a new reserve battery. The new alkaline battery still awaits installation, and none of the auxiliary equipment is yet to hand.

The chronograph and sidereal time circuits of the Observatory were operated by Shortt 3 until July 31, since which date they have been controlled by Shortt 11. Shortt 16 has been used throughout the year to control the mean time circuits. The quartz crystal controlled oscillator clock is running satisfactorily, but with rather a large rate. It is not proposed to stop it for readjustment. The phonic motor has proved to be the most troublesome part of the equipment and it is apparent that the clock is not giving as good a performance as it should. At the completion of the present run it may be necessary to have a fresh crystal cut, and advantage will be taken of the opportunity to employ a fundamental frequency of 100 kilocycles per mean solar second, instead of per mean sidereal second as at present.

The service of rhythmic time signals at 10h and 18h, radiated by the Post Office long wave GBR transmitter on a frequency of 16 kilocycles per second, had been maintained except for the period January 31, 18 hours, to February 19, 10 hours, when the transmitter was not available. From February 15 the signals were transmitted simultaneously from the stations GBV (78 kc/s), GIA (19·640 mc/s) and GIM (12·975 mc/s) at 10 hours and from GBV, GIM, and GIH (10·650 mc/s) at 18 hours. The signals from GBV were discontinued from the end of March, and the short wave signals from April 11. Advantage has been taken of the opportunity thus afforded to request reports on the reception of the short wave signals, as this is the first occasion on which Greenwich time signals have been transmitted on the short wave band. The B.B.C. six dots time

signals and the hourly signals to the Post Office for controlling the Talking Clock have been transmitted regularly. As in previous years, the signals have been sent out from Dent 2012 controlled by the mean time standard. The reserve signal transmitting clock, Dent 2016, is on loan to the emergency time station pending the installation of Dent 2009, which is undergoing modification. When Dent 2009 is competed, Dent 2016 will resume its duties as reserve at Greenwich.

The rhythmic time signals from Paris (FLE), Bordeaux (FYL) and Nauen (DFY) have been recorded regularly. From June 1 the American long wave transmitter NSS (17·6 kc/s) recommenced radiating the Washington time signals. The resumption of these signals, which had been discontinued since June 1934, was made possible through the co-operation of the U.S. Navy Department, in response to a request from the Committee on Cosmic Terrestrial Relationships of the American Geophysical Union, in order that regular intercomparison of time signals between the Royal Observatory, Greenwich, and the U.S. Naval Observatory, Washington, should be made on low frequency waves, which are less subject to ionospheric disturbances than waves of high frequency.

The American transmissions were recorded from the first day of their inception, and apart from occasional bad records, regular comparisons have been made.

The 0h or 23h signals from Washington (NAA) were recorded by means of the R.M.E. short wave receiver until May 25, when the receiver was transferred to the emergency station. Since the new Skyrider SX 17 short wave receiver became available on February 19, the American 14h or 15h signals have been recorded.

Until February, the FLE time signals were recorded on the equipment previously employed. The Marconi receiver was used for GBR throughout the year, and for FYL, DFY and NSS until February. The special long wave receiver designed at the National Physical Laboratory and constructed by Messrs. Haynes Radio has been used since February for the signals from GBV, FYL, DFY, NSS, and FLE, for GBR since the cessation of transmissions from GBV. Two Hallicrafter Super Skyrider Special SX 17 receivers have been on loan from Messrs. Webb's Radio since February, and a new National HRO is on order and should arrive shortly. The wireless recording apparatus was removed from the wireless room in September to a better protected position, and is now assembled in a very temporary manner. Despite the make-shift aerial system, the performance of the Skyrider sets has been good, and little difficulty is experienced in obtaining excellent records from stations as far apart as Moscow, Rio de Janeiro and Arlington. It is planned to install the receiving and recording apparatus as soon as possible in a room below the old wireless room, and to erect efficient aerial systems designed to minimise interference from the clock circuits of the Time Department. The cathode-ray oscillograph apparatus for the determination of recorder lag has not been in use since September, but it is proposed to install it in an improved form when the removal of the wireless apparatus is made. The need for additional chronographs has become acute; a modified design is being drawn up in consultation with the Foreman of the Observatory and the chronographs will be constructed in the workshop.

The corrections to the transmitted times of the rhythmic signals for adjustment to the final time determinations, together with the corrections obtained for the foreign time signals recorded at Greenwich were published and distributed monthly by the Hydrographer of the Navy in *Notices to Mariners*, until March, 1939. Subsequently they have been circulated direct from Greenwich.

The following table gives the monthly means of the differences from Greenwich shown by the principal foreign time signals, and is computed by differencing the corrections to the signals as determined at Greenwich and at the observatory of origin.

1939	Paris 9½ hr. Rhythmic	Nauen 12 hr. Rhythmic	Bordeaux 20 hr. Rhythmic
	s	s	s
January	-0·008	-0·001	-0·006
February	- ·004	+ ·018	- ·008
March	+ ·010	+ ·028	+ ·009
April	- ·005	+ ·008	- ·007
May	- ·007	- ·033	- ·008
June	+ ·016		+ ·011
July	+ ·035		+ ·030
August	+ ·028		+ ·029
September	+ ·017		+ ·012
October	+ ·063		+ ·068
November	+ ·093		+ ·091
December	+ ·033		+ ·031
Mean	+ ·022	+ ·003	+ ·022
Number of comparisons	324	128	340

The sign + means late on Greenwich. The reference point for all comparisons is the commencement of the signals. The times of the Nauen signals have been referred to the Eichelberger system of star places. The reception time of the signals has been corrected for time lag in recording apparatus at Greenwich, but it is not known what corrections are applied at foreign stations.

Further investigation of thermionic relays has led to the design of suitable units which have been tested experimentally. The complete installation of these units has been held up by pressure of other work, and by the delay in the carrying out of the rewiring scheme. A new room has been constructed for the central control desk, but only a part of the equipment is so far to hand. In order to cause minimum interruption of the Time Service, it is proposed to wire up all the new system to the new control desk and new main battery before removing any of the existing wiring. It may, however, be necessary to run for a short time from the reserve station.

Despite some additions to staff coupled with continued temporary loans from other departments, the staffing question is still not satisfactory. The splitting up of the Department caused by the establishment of a reserve time station and the transference of the chronometer and watch work, has not made for economy of operation.

The setting-up of a duplicate time service is now almost completed. The equipment includes a small transit instrument in a newly-erected observing hut, two new free pendulum clocks - Shortt 66 (Sidereal) and Shortt 67 (Mean Time), a rhythmic signal transmitter and a time signal transmitting clock on loan from Greenwich. Mr. H. R. Fry has kindly loaned his free pendulum clock, Shortt 61, a chronograph, a wireless receiver, and a calculating machine. A short wave wireless receiver is on loan from Greenwich. Thermionic relays are being employed, and special lines have been installed to connect the emergency station with the Post Office, GBR transmitter, and the B.B.C. This station will shortly be capable of taking over the Time Service duties from Greenwich. The clocks Shortt 61, 66, and 67 will be incorporated in the Greenwich mean clock.

The performance of the Westminster Clock during the year is shown by the following table giving the errors of the clock signals:-

Error of Signal	Number of Days
Not greater than $0^s \cdot 2$	46
$0^s \cdot 2$ to $0^s \cdot 5$	58
$0^s \cdot 5$ to 1^s	58
Greater than 1^s	44

The clock is not corrected by any signals from the Observatory.

The Time Ball was raised and dropped correctly throughout the year except on October 24 when it was raised half way and lowered by hand; on January 17, owing to snow on mast, and on March 25, when it was raised and dropped at 14h. It was dropped in accordance with custom at 11h on November 11.

V. CHRONOMETERS.

As mentioned in the previous report, arrangements were made for the decentralisation of the stock of instruments normally held at the Royal Observatory. With the co-operation and active assistance of the Director and Deputy Director of the Museum and Art Gallery, Bristol, some premises belonging to the Museum were made available, and were in use until September. It was then decided to move the entire chronometer and watch testing and repair work to premises in the same town. Suitable accommodation was selected on the 30th August, and as soon as approval had been obtained, the work required to make it ready for occupation was put in hand. The transfer of staff and instruments was carried out between September 7th and 12th. This entailed the removal of some 1,400 instruments together with all the records relating to them, office furniture, stationery and other requirements, the complete equipment of the watch repair shop, and the necessary materials required for the packing and despatch of instruments on service, Normal rating was recommenced by September 30th. In the meantime issues on service were made from reserve stocks, the winding and rating of which had been continued without interruption. The accommodation is arranged to provide offices, rating rooms, watch repair shops, insulated chambers for high temperature tests, packing and storage rooms, space for a refrigerator (now on order), A.R.P. shelter for staff, and living rooms for a caretaker.

During the past year the watch repair shop has continued to prove its value by the consistently good results obtained from the watches returned after repair.

In spite of the increased number of receipts and issues dealt with during the past year, the ledgering and other records of the chronometer and watches have been kept right up to date. Considerable simplification of the methods of keeping the records has been effected, and good progress has also been made towards completing the ledgering, which, at the time of the introduction of the card index system, was much in arrears.

VI. NAUTICAL ALMANAC OFFICE.

During the year the work of the Office has been mainly devoted to the routine calculation and proof-reading involved in the preparation and publication of the regular publications of the

Office, which are now five in number – the *Nautical Almanac*, the *Abridged Nautical Almanac*, the *Air Almanac*, the *Astronomical Navigation Tables* and, for the first year, the *Apparent Places of Fundamental Stars*. In all, the Office, is now responsible for the calculation and publication of approximately 3,500 large octavo pages of figures annually; this is undoubtedly the highest output the Office has ever attained, and there is probably no other institution of similar size that approaches this figure.

The organisation developed in the previous year and outlined in last year's report continues to function satisfactorily, although minor changes have been made from time to time to meet special contingencies. According to a preconsidered policy, individual members of the staff have been interchanged between sections as opportunity offers, with three objects in view:– the avoidance, as far as possible, of the monotony that must be associated with routine computation; the training of the junior staff in the computational methods used in all sections; and the eventual choice of the individuals who are most suited to permanent retention in one section or another. So far this interchange has not functioned formally between the astronomical and navigational sides of the Office, between which there is still a strong dividing line; during the year however there have been many times when pressure of work has made it necessary to overstep this line. On the whole, the organisation has shown itself sufficiently flexible to meet the exceptional conditions that have occurred, though in the second half of the year it has only been carried on in the face of considerable difficulties, and with frequent temporary modifications.

In general, the routine work of the Office has been carried through almost according to schedule, though certain delays have been unavoidable.

In August, the Office moved from the Royal Naval College, in which it had occupied rooms since 1922, to Devonport House, a block of office buildings on the north side of Greenwich Park. Subsequent events, shortly afterwards, necessitated a second move.

The Nautical Almanac. The *Nautical Almanac* for 1941 was published on February 28, as compared with the corresponding date March 10 in the case of the 1940 edition. The Almanac was, however, passed for press early in December, nearly two months ahead of 1940.

For the first time for many years, the *Nautical Almanac* for 1941 contains fewer than 800 pages, and there is little doubt that the reduction in size will be appreciated by many users. This reduction is consequent upon the agreement between the ephemeris offices to restrict the number of apparent places of stars, in view of the publication of one volume containing the apparent places of the 1535 stars in the *Dritter Fundamentalkatalog des Berliner Astronomischen Jahrbuchs* (FK3). Apparent places are now given in the Almanac for 208 stars only, these being chosen on account of their brightness and distribution in the sky to meet the requirements of navigators and surveyors; the mean places are referred to the FK3, and the apparent right ascension and declination restricted to $0^{s}\cdot01$ and $0''\cdot1$ respectively. Other changes include the restoration of the heliocentric ephemeris of Mercury to its logical place immediately preceding the geocentric ephemerides of the planets, and the tabulation for all planets of the natural value of the true radius vector, instead of the logarithmic value, previously given for all planets except Mercury.

The first part of the *Nautical Almanac*, containing the ephemerides of the Sun, Moon and planets, is set in type in advance of the remainder; that for 1944 is now complete and has been circulated to the other ephemeris offices in accordance with the arrangements for the interchange of computations to avoid duplication.

A complete series of independent checks on all the ephemerides published in the *Nautical Almanac* is in course of preparation. Checks have always been applied to the work, but they have never before been systematised in the manner now envisaged.

Occultations and Eclipses. The occultation programme for 1942 has been continued without major change, but it has not this year been possible to complete the whole of the predictions and reduction elements before the end of April; the reduction elements are complete, but predictions for 7 stations are still outstanding. A start has lately been made on the examination with the occultation machine of the stars in the 1943 programme. During the year predictions for 35 stations for 1941 and for 11 stations for 1942 have been forwarded to the observatories and periodicals concerned.

For 1942, elements of occultations for 1,772 stars not fainter than magnitude 6·5 were received from the Office of the American Ephemeris, and elements for 809 stars between magnitudes 6·6 and 7·5 were computed in the Nautical Almanac Office from material supplied by Washington. These 2,581 stars were examined by the occultation machine and preliminary times recorded for 1,372 stars, which were retained for subsequent computation. During the latter process 144 stars were rejected as the resulting occultations would not be visible under the adopted conditions. Prediction and reduction elements for 1,222 stars and prediction elements for 6 planets will therefore be published in the *Nautical Almanac* for 1942. Although the prediction programme is not yet completed, it is possible to say, with considerable accuracy, that the total number of predictions made for the 58 stations will be 4,830, involving 8,690 separate computations; these figures compare with 4,816 predictions and 8,563 computations in 1941. Further, 284 extra computations have been done for additional stations to ensure the inclusion in the prediction elements of all stars observable under suitable conditions anywhere on the Earth.

It is unfortunate that, while there is no urgency for the completion and publication of the predictions of occultations and still less for the reduction elements, it is necessary to complete practically all the programme before the correct selection of prediction elements can be made; if the situation warrants it, some modification of the present programme will be made in future years. The question whether the vast amount of work expended on the occultation programme is repaid sufficiently by the increased observation of occultations is under consideration; it is probable that the number of stations will be drastically reduced, as the result of a survey, now in progress, of the numbers of observations from various stations.

No special eclipse calculations have been originated during the year; if the demand is sufficient, data for the eclipse of 1941 September 21, similar to that published for the eclipse of 1940 October 1, will be computed and published as supplement.

Abridged Nautical Almanac and Air Almanac. The *Abridged Nautical Almanac* for 1941 was published on March 12, although the printing was completed by the middle of January. After careful consideration it has been decided that, at present, the time is not suitable for a change over to the direct tabulation of the Greenwich hour angle in this Almanac, though a practical form has been devised.

A separate Supplement, extending the times of sunrise, sunset, twilight (civil and nautical), moonrise and moonset from north latitude 60° to 72°, for the last quarter of 1939, was published early in October; a similar supplement for 1940, but extending to 73°, was issued early in January. Work is now well advanced on the data for 1941 and 1942; those for 1941 will also be

published as a supplement, to appear in August or September, while those for 1942 will be incorporated in the Almanac for that year. The extension of this information to more northern latitudes has long been overdue, and it will form a permanent addition to the Almanac in future.

As in former years, the tables of sunrise, sunset, moonrise and moonset (for latitudes 0° to 60°) for 1940 were reprinted, with other associated data, for separate sale.

The Air Almanac has now become established in the new form introduced in January, 1939; it has been possible to adhere strictly to a rigid schedule of 12 weeks for the computation, proof-reading and printing of each quarterly issue of approximately 200 pages, with the result that the dates of publication have shown a progressive (but by no means uniform) advance. Five volumes have been published during the year as follows:-

1939 Third	Quarter	May 23
1939 Fourth	"	July 12
1940 First	"	October 23
1940 Second	"	January 17
1940 Third	"	April 10

The fourth quarter of 1940 is in the hands of the binders, and the first quarter of 1941 is in proof.

It is gratifying to record that reprinted editions were necessary for the first few volumes, and that a larger printing has since been justified. Among the many favourable reactions to the Almanac, none is more pleasing than the arrangement by which the Almanac is photographically reproduced for sale in the U.S.A.

The Astronomical Navigation Tables, which are being prepared for the Air Ministry, are being extended to cover all latitudes from S.69° to N.69° in fourteen volumes. Four of these volumes, covering latitudes 40° to 59°, have now been issued, three more have been printed but not yet issued, while five others are in various stages of production. The work of preparation is up to schedule, and copy for the final volume should be completed early in 1941. By careful organisation, it has been possible to reduce the time necessary to produce each volume to a little less than 12 weeks.

Apparent Places of Fundamental Stars. As was reported last year, negotiations in connection with the contract for printing the volume of apparent places of stars for 1941 were in progress, and the contract was finally placed on May 8; by this date the whole of the material for the volume was in hand, and the first section of the copy was sent to the printers on May 20. Considerable delay was caused owing to difficulty in obtaining the necessary types, and later, owing to the fact that some of the copy, made by pasting up printed and manuscript strips side by side, had considerable disadvantages for the compositor. These matters were settled in due course, and the first section of proofs was received on August 5, and returned for printing on September 13. The final section of proofs has now been passed for press. As the volume is being printed from

movable type, the actual printed sheets are being read and the first 352 pages have already been received in this form, and are now under examination. It is hoped that the volume may be published during May.

The introduction to the volume, which gives all necessary details of the tabulation, has been translated into French, German and Spanish, and it is hoped that the four versions will render the volume acceptable to users in most countries.

About two-thirds of the material for the volume for 1942 has been received, and copy is being prepared. Minor typographical changes are proposed, and the implications of these proposals are now being discussed with the printers and with H.M. Stationery Office.

It has been found that the work of collation and preparation of copy has been very considerable, and much in excess of that anticipated; for the first year, the proof-reading has also been particularly onerous, but this will be considerably eased in future years. Without immediate access to the actual computations, complete checking by proof-reading is impossible, but every effort has been made, both by independent and other checks, to overcome this difficulty and to place the volume on the same footing as other Office publications, in which the reading of the proofs is designed to check both the computation and copy, as well as the compositor.

Other Publications. The lengthy interval between passing a volume for press and publication, which has often been indicated in these reports, was evident in the case of both the *Seven Figure Trigonometrical Tables for every Second of Time* and the second volume of *Planetary Co-ordinates for the Equinox of 1950·0,* which were not published until September, six months after being passed for press.

The 8-figure table of trigonometrical functions for every second of arc, which was produced in collaboration with Professor Peters, was, by agreement, published in Germany last summer. No arrangements for publishing the similar 7-figure table in this country have yet been found possible.

Proof Reading. The proportion of the work of the Office devoted to preparation of copy and reading of proofs continues to be large, and has in fact considerably increased since last year. There is an easily attained limit to the proportion of time a computer can spend on intensive proof-reading of figures, and the present commitments of the Office represent well over 75 per cent of the gross possible available time, leaving little margin for illness or other eventualities. The instructions for proof-reading the various pages, referred to in last year's report, are now almost complete, though revision of the material tabulated and the increase in experience of proof-readers make it desirable from time to time to modify these instructions. It is unlikely therefore that they can ever be regarded as final. In the past year there have been separate readings of about 10,000 pages of proofs; this figure includes duplicate reading of approximately three-quarters of the first proofs, and also the reading of stereo proofs or printed sheets. The number of separate pages involved is about 4,350.

Other Work. The increase in repayment work for the supply of astronomical information to commerical firms continues, and has been intensified by the demand, in the latter half of the year, for blackout times for the B.B.C., as well as for a number of police authorities and newspapers.

Machines. The present equipment of the Office consists of Brunsviga, Marchant, Mercedes, Monroe and Muldivo calculating machines and of Burroughs and National accounting machines, which have been applied to sceintific computing, while the Hollerith tabulating, sorting and multiplying equipment is used as occasion demands. No additions have been made during the year.

VII. MAGNETIC OBSERVATIONS.

Regular magnetic observations have been made at Abinger throughout the year.

The variations of declination and of horizontal and vertical intensity have been recorded photographically.

Absolute observations of declination, of horizontal intensity with the Schuster–Smith coil magnetometer, and of vertical intensity with the Dye coil magnetometer are made every week-day. The measurements both of the horizontal and vertical components of magnetic intensity are dependent upon electrical standards, but observations of horizontal intensity with a unifilar magnetometer and of inclination with an inductor have been taken frequently, for purposes of comparison.

The Observatory is indebted to the National Physical Laboratory for periodical re-measurement of the electrical constants of the potentiometers, which are essential accessories to the coil magnetometers.

The La Cour magnetographs installed in 1937 and 1938, continue to give great satisfaction. The steadiness of their observed base-line values is evidence of the excellence of their design and construction. An improvement in the method of placing time-marks on the records made at ordinary speed was effected in January. In addition to the points registered at five-minute (latterly at ten-minute) intervals, narrow dark lines are photographically printed at the same instants across the whole width of the sheet. This method is a return to that in use with the former installation and is of great assistance in the measurement of mean hourly values.

In view of the steadiness of the base-line of the La Cour magnetograms, continuous recording with the Watson quartz-fibre vertical intensity variometer was abandoned, from January 1, as unnecessary duplication.

The disused recording mechanism will shortly be incorporated in a magnetograph of low sensitivity capable of recording fully any variations of declination and horizontal intensity that could occur at Abinger.

As regards the reduction of observations, the mean hourly ordinates of all the traces have been read off to date. The reduction of absolute observations is complete to 1939 December 31, and with provisional constants to the present time.

The tabulation of results for 1939 is almost complete, and awaits only the receipt of the final list of International "quiet" and "disturbed" days.

	Decl. W.	Horizontal Intensity	Vertical Intensity	Inclination
1936 ..	11° 20′·0	0·18524	0·43007	66° 41′·8
1937 ..	11° 10′·4	0·18522	0·43031	66° 42′·7
1938 ..	11° 1′·4	0·18522	0·43050	66° 43′·2
1939 ..	10° 51′·9	0·18528	0·43074	66° 43′·5

The weekly report of mean hourly values of declination has been sent regularly to several offices for publication or information – a service maintained in conjunction with Eskdalemuir Observatory.

During the past twelve months there have been 23 magnetic disturbances reaching the dimensions of a "storm," and, in addition, seven disturbances classified as "great storm." (A range of 30′ in declination or 150γ in horizontal intensity is considered the lower limit for a "storm"; 60′ or 300γ for a "great storm.")

The disturbance which took place on March 24 (Easter Sunday) ranks among the most severe disturbances of the past 90 years. There was a range of more than 1000γ in the vertical component of the earth's magnetic field at Abinger.

One instrument has been examined during the year for the determination and certification of constants, namely the Marine Earth-inductor constructed for use in R.R.S. Research. Test observations have also been made with the combined magnetometer and inductor supplied by the Precise Instrument Co. of New York for use on R.R.S. Research shore expeditions.

The disturbance of the earth's magnetic field at Abinger by artificial fields due to electric traction is continuous throughout the working hours and ceases only during the interval 1h to 5h civil time. In amount it usually varies from 5γ to 10γ. It depends not only on the number and weight of the trains but also on meteorological conditions. Prolonged rain increases the disturbance to a marked degree, and during the snowfalls in January the effect was specially severe.

VIII. METEOROLOGICAL OBSERVATIONS.

Routine meteorological observations began on 1840 November 9, and the Meteorological Department has thus how entered the hundredth year of its existence.

The registration of atmospheric pressure, temperature of the air and of evaporation, the direction, pressure and velocity of the wind, the amount of rainfall, of sunshine and of cloudiness at night has been maintained continuously. Estimates of visibility have been made by eye at definite hours. Regular records for measurement of the amount of solid matter polluting the air have been continued, using an Owens automatic filter. The gaseous pollution of the air by sulphur dioxide has also been measured daily.

The tabulation of meteorological results for 1939 is complete and the copy for press is well advanced.

The following details of the weather refer to the period of twelve months ending 1940 April 30.

The mean temperature was 49°·1 which is 0°·4 lower than the average of 75 years 1841–1915. The highest temperature in the shade was 85°·2, registered on June 7. Temperatures exceeding 80° were recorded on 6 days. The lowest temperature was 12°·4, on January 20. Temperatures of freezing point or below were recorded on 66 days of which 27 were in January. The month of November was remarkable for a mean temperature 5°·3 above the 75 years' average and the month of January for a mean temperature 7°·8 below the average.

The standard thermometers have been enclosed in a Stevenson screen since 1938 January 1.

The mean daily horizontal movement of the air was 278 miles, which is 7 miles below the average for 50 years 1867–1916. The greatest daily movement was 621 miles, recorded on November 26; the least daily movement was 120 miles, on March 7. The greatest motion on one hour, 34 miles, was recorded on November 26 and the greatest pressure reached, 17·0 lbs. to the square foot, was recorded on November 19.

The duration of *bright* sunshine recorded was 1291·3 hours, or 28·7 per cent of the possible total. There were 82 entirely sunless days, 65 being in the four months November to February. No day in July or September was entirely sunless. There were 33 entirely cloudless nights in the period, that is, nights on which a complete unbroken trace was obtained by the night-sky camera. The number of nights on which no trace of δ Ursæ Minoris appeared on the plates was 87, while on a further 33 nights the record was not more than 10 per cent of the whole time of exposure.

The total rainfall during the period was 30·23 inches, that is 5·99 inches greater than the average for 75 years 1841–1915. There were 176 days in which rainfall amounting to 0·005 inch or more was recorded.

The wettest month was October with 6·155 inches; the driest month December with 1·180 inches. The total rainfall in October and November together was 10·29 inches and was greater that had ever been recorded at the Observatory in a corresponding period of the year.

The mean amount of solid matter in suspension in the air during the period May to September was 0·52 milligrams per cubic metre; and from October to April the mean amount was 0·84 milligrams. These figures are substantially the same as for the previous year. The worst day was December 22 when the mean amount was 3·20 milligrams per cubic metre.

With regard to gaseous pollution the average amount over the whole period May 1939 to April 1940 was found to be 0·048 parts of sulphur dioxide per million parts of air, which is a slight increase on the average for the previous period of twelve months. On the worst day (ending at noon October 21) the amount was 0·255 parts per million. Conditions were uniformly bad throughout December. No measurement was possible on many days in January and February on account of frozen apparatus.

IX. PRINTING AND DISTRIBUTION OF GREENWICH PUBLICATIONS.

1. The volume of *Greenwich Observations* and its separate parts for 1936 have been published.

2. MS. for the Volumes for 1937 and 1938 are being prepared.

3. A volume containing the Latitude Variation Results for 1927 to 1936 and a Discussion of the Observations from 1911 to 1936 has been published.

4. MS. for a Volume of Observations of Colour Temperatures of Stars, 1926-1939 is complete.

A revised distribution list, operative during the present emergency, has been prepared. Distribution of 1 and 3 above is being made accordingly.

By arrangement with H.M. Stationery Office, printing of the volumes 2 and 4 above is deferred until after the cessation of hostilities.

X. PERSONAL ESTABLISHMENT:-

The staff of the Royal Observatory at the present time is constituted as follows:-

(a) Observatory Staff.

Chief Assistants	– R. d'E. Atkinson, M.A., Ph.D., H. R. Hulme, M.A., Ph.D.
Assistants	– A. Hunter, Ph.D., P. J. Melotte, H. M. Smith, B.Sc., W. M. Withcell, B.Sc.
Junior Assistants (Higher Grade)	– H. W. Acton, E. A. Chamberlain, R. T. Cullen, F. Jeffries, H. W. Newton, G. W. Rickett.
Junior Assistants	– H. H. J. Barton, K. C. Blackwell, H. F. Finch, B.Sc., C. C. Harris, T. W. W. Hodgson, Miss C. M. Lark, P. S. Laurie, B. R. Leaton, E. G. Martin, P. L. Rickerby, J. Rudd, A. Shortland, L. S. T. Symms, R. H. Tucker, G. F. Wells.
Clerical Assistants	– Miss J. Auckland, Miss L. Ching, Miss G. M. Cumberledge, Miss R. A. Foster, Miss G. I. Gennery, Miss E. B. Gray, Miss V. M. Hall, Miss F. E. A. Jeffries, Miss O. M. Judd, Miss D. A. Nunn, Miss J. E. Payne, Miss J. K. Penwill, Miss D. F. G. Poole, Miss R. C. Stepto.

(b) Principal Watch Adjuster – Vacancy.

Assistant Watch Adjuster – H. Warden.

Secretary and Cashier – H. G. Barker.

Clerical Officer – N. J. Miller.

Temporary Clerk – D. Oliver.

Established Typists – Miss M. Brickman,
Miss M. F. Cackett.

(b) Nautical Almanac Office Staff.

Chief Assistant as Superintendent – D. H. Sadler, M.A.

Assistants – Miss F. M. McBain, M.A.,
H. W. P. Richards, B.Sc.,

Temporary Assistant – W. E. Candler, B.A.

Junior Assistants (Higher Grade) – A. J. Daniels, S. G. Daniels,
W. A. Scott, B.Sc.

Junior Assistants – A. E. Carter, W. G. Grimwood,
G. A. Harding, Miss M. R. Rodgers,
Miss M. C. Scadeng, E. Smith,
Miss W. D. White.

Clerical Assistants – Miss E. N. Histed, Miss V. H. Hitches,
Miss D. J. Ifield, Miss G. E. Jackson,
Miss J. Mounteney, Miss J. E. Pullen,
Miss M. B. Simm, Miss R. E. West.

Clerical Officer – Miss H. A. Howard.

Shorthand–Typist – Miss V. M. Hooper.

Several piece–workers are also employed.

The present arrangement of the Observatory staff under the general superintendence of the Chief Assistants is as follows:–

Transit Circle, Right Ascensions – Mr. Acton, Miss Hall, Miss Judd.

Transit Circle, Declinations – Mr. Symms, Miss Gennery,
Miss Payne.

Transit Circle, Ledgering and Miscellaneous Reductions – Mr. Cullen, Mr. Blackwell,
Mr. Hodgson, Mr. Oliver,
Miss Nunn, Miss Poole.

Cookson Zenith Telescope	– Mr. Acton, Mr. Symms.
Time Department	– Mr. Smith, Mr. Rickett, Mr. Finch, Mr. Harris, Mr. Shortland, Mr. Rudd, Mr. Tucker, Miss Lark, Miss Gray, Miss Ching.
Thompson and Yapp Equatorials	– Dr. Hunter, Mr. Martin, Miss Auckland, Miss Cumberledge.
28-inch Equatorial	– Mr. Symms.
Astrographic Department	– Mr. Melotte, Mr. Jeffries, Miss Jeffries.
Photoheliograph and Spectro-helioscope	– Mr. Newton, Mr. Barton, Mr. Laurie, Miss Penwill,
Magnetic and Meteorological Department	– Mr. Witchell, Mr. Chamberlain, Mr. Wells, Mr. Rickerby, Mr. Leaton, Miss Foster, Miss Stepto.
Watch and Chronometer Repairs	– Mr. Warden.
Secretariat and Library	– Mr. Barker, Mr. Miller, Miss Brickman, Miss Cackett.

Dr. R. d'E Atkinson and Dr. H. R. Hulme, Chief Assistants, have been loaned for special work in another Department of the Admiralty.

Mr. W. Stevens, Junior Assistant, Higher Grade, acting as Assistant-in-Charge of the Magnetic Observatory at Abinger, retired on 17th July after 44 years service on the Royal Observatory staff. Mr. Stevens was appointed Assistant-in-Charge at Abinger when the magnetic observations were transferred from Greenwich to Abinger in 1923, in consequence of the electrification of the surburban railway lines in the vicinity of the Observatory. The high standard of the results obtained at Abinger has been due in no small measure to the zeal and skill with which Mr. Stevens performed his duties. His place has been filled by the promotion of Mr. E. A. Chamberlain.

Mr. R. Kunzler, Principal Watch Adjuster, died on March 4. He will be greatly missed on account of his varied experience of both English and Swiss watchmaking. He had done much adjusting for the Greenwich trials, in which he held the record for high performance and had supplied nearly 250 chronometer watches for Admiralty service, in addition to many deck watches. Mr. Kunzler was in charge of the watch repair shop from its inception in November, 1937; his services have proved of great value in organising this new department.

Mr. G. W. Rickett, Junior Assistant, Lower Grade, has been appointed to the Higher Grade in an acting capacity whilst in charge of H.M. Chronometer Depot at Bristol.

Mr. F. E. Potter, Junior Assistant, Lower Grade, has been temporarily loaned from the Hydrographic Department of the Admiralty for duty at Bristol.

The staff of workmen employed at the Observatory consists of a Foreman of Observatory, two Joiners, a mechanic, two watch repairers and an improver in the watch repairing department, a gate porter, three messengers, all of whom perform in turn the duty of night watchman, a gardener, four labourers and two charwomen. There is also a caretaker-mechanic at Abinger, a messenger at the Nautical Almanac Office, a caretaker and a messenger at the Bristol Chronometer Depot.

Captain A. G. Kirk, United States Naval Attaché, visited the Observatory on April 5.

Mr. H. G. Scott Barrett, whose services have been lent to the Observatory by the Radcliffe Trustees, is still rendering valuable help in the reduction of the Eros photographs.

The Astronomer Royal had intended to be present at the meeting of the International Union for Geodesy and Geophysics held in Washington in September, but the international situation necessitated the cancellation of the visit. Mr. Newton attended the meeting of the British Association in Dundee to take part in a discussion on Solar and Terrestrial Relationships; the outbreak of war caused the meeting to curtailed, involving the cancellation of this discussion.

In last year's Report, reference was made to the deterioration of the conditions for astronomical observations at Greenwich and for the urgent need for the Observatory to be removed to a site where the conditions are favourable. At the same time the increasing magnetic disturbance at Abinger caused by the development of electric traction required the removal of the magnetic observations to a site remote from railways, if high precision in the observations is to be attained and if the Observatory is to be secure for the future against further developments in railway electrification. A number of possible sites, both for the astronomical and for the magnetic observations, were examined during the year. The further consideration of the plans for the removal to new sites of the astronomical and magnetic observations has necessarily had to be deferred until after the conclusion of the war.

The further improvement in accuracy of the time service provided by the Observatory has been under consideration. For purposes where high precision is needed, corrections to the time signals are published at approximately monthly intervals, after the errors of the mean clock have been satisfactorily determined from a large number of observations. The great developments in recent years in precision frequency standards and in their use have created a need, which is extending rapidly, for time signals of such precision that an interval of 24 hours can be measured to an accuracy of one thousandth of a second, without the application of corrections published after a considerable interval. This precision is not attainable with pendulum clocks, which are less accurate than the precision frequency standards themselves. The installation of a battery of quartz crystal oscillator clocks of the highest precision is required, in order that the frequency stability of modern frequency standards may be satisfactorily controlled. Conferences on this subject have been held with the Radio Section of the General Post Office and the Research Department of the British Broadcasting Corporation. The help and collaboration of these bodies and also of the National Physical Laboratory are greatly appreciated and should go far towards enabling a satisfactory scheme to be drawn up.

H. SPENCER JONES.

Royal Observatory, Greenwich.

1940 May 4.