REPORT

OF THE

ASTRONOMER ROYAL

TO THE

BOARD OF VISITORS

OF THE

ROYAL OBSERVATORY, GREENWICH.

Read at the Annual Visitation of the Royal Observatory, 1935 *June* 1.

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The Report here presented refers to the period from 1934 May 11 to 1935 April 30, and exhibits the state of the Observatory on the last-named day.

I.—New Instruments :—

The construction by Messrs. Cooke, Troughton and Simms, Ltd., of the new reversible transit circle has been completed, and the instrument is undergoing final tests. Some modifications to the counterpoise system were found to be necessary and are now being made. The construction of the two glass circles of 28 inches diameter and the etching of the divisions spaced at intervals of 5 minutes of arc have been carried out successfully. Each circle is supported on a spigot formed by 12 gunmetal arms, which are in turn attached to a cast-iron bracket fixed to the central casting. The coefficients of expansion of samples of the cast iron, gunmetal and glass were determined at the National Physical Laboratory, and the dimensions of the supporting gunmetal arms have been chosen so that the difference of expansion between the cast iron and the glass is compensated. The rotation of the circle is prevented by a single stop pin. The weight of each glass disc is approximately 16 lbs. Flexure in the plane of the disc is minimised by a system of twelve counterpoises bearing on the outer edge of the circle. Each counterpoise consists of a lever

arm weighted at one end, and carrying at the other end a self-aligning arm; leather pads at the two ends of this arm bear on the edge of the circle. Only the lower six counterpoises are in operation in any position of the circle. The weight on each arm is adjusted so that the maximum pressure of each counterpoise is the same, and so that the total weight relieved is slightly less than the weight of the circle. Each circle is protected by a cover disc, so that only the graduated annulus is exposed.

A contract has been placed with Messrs. Adam Hilger, Ltd., for the construction of a slit spectrograph which will be mounted on the Yapp 36-inch reflecting telescope. This spectrograph will have two prism systems, viz., one prism and three prisms. The optical parts will be constructed of ultra-violet glass giving good transmission down to λ 3500. The design includes provision for half-aperture shutters across the collimator for the purposes of the Hartmann focal test. A further pair of half-aperture shutters will provide an accurate means of checking photometric scales. The instrument will be fitted with a Cambridge automatic temperature regulator.

II.—Buildings and Grounds, Movable Property, and Library :—

The boundary fence on the east side of the Observatory, abutting on to the Main Avenue in Greenwich Park, has been renewed.

The air intake for the hot air heating system in the Main Building being in the stokehole, fumes and dirt from the stokehole were drawn through with the air and ejected into the rooms in the building. To obviate this, a new intake has been built, so that air from outside the building is drawn into the heating chamber. The opportunity was taken, whilst this work was in progress, to overhaul the system and to clean all flues and ducts. The alterations have greatly improved the conditions for the staff working in this building.

The pathway from the 28-inch dome to the Main Building has been re-laid with tar macadam.

The external painting with aluminium paint of the domes housing the following instruments has been completed: 28-inch refractor, altazimuth, Sheepshanks telescope, astrographic refractor, small transit instrument, and the 4-inch photo-heliograph. All the painted domes have now been re-painted with aluminium paint. The results are pleasing, and the appearance of the Observatory has been improved.

The interior re-decoration of the lower portion of the altazimuth building and the distempering of the walls of the building housing the 36-inch reflector have been

completed. The floor of the basement of the latter building, which is being used for spectroscopic solar observations, has been covered with cork carpet.

A hut for housing the 16-inch coelostat has been built in the workshop and erected in the Christie Enclosure adjacent to the 36-inch reflector building, in connection with the solar observations.

The wiring of the new clock room, housing the two mean-time free pendulums, has been completed, and the necessary wires for connecting the two free pendulums with their respective slave clocks in the Rugby Signal Room have been run. An additional length of cable was laid across the Courtyard for carrying the current for heating the clock cellar.

An additional telephone line from the Observatory to the local telephone exchange has been installed, to reduce the frequent delay in both outgoing and incoming calls.

The following instruments which are in regular use have been lent to the Royal Observatory :—

The Cookson floating zenith telescope, from the Cambridge Observatory, for a fourth period of seven years from July, 1932.

A 13-foot spectrohelioscope, complete with coelostat, but without grating, from the Mount Wilson Observatory.

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

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

A 4-inch concave grating from the Joint Permanent Eclipse Committee.

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. W. D. 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 instruments, borrowed for observation of the Solar Eclipse of 1932 August 31, are stored at the Royal Observatory :—

Two 16-inch coelostats, one 12-inch coelostat and a 15-inch concave mirror, from the Joint Permanent Eclipse Committee.

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 University Observatory, Oxford—

Clock Arnold No. 2.

To the Solar Physics Observatory, Cambridge—

Photoheliograph object glass No. 5.

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 Hydrographic Department of the Admiralty—

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

A large double-barrelled chronograph, with Grubb automatic rate control, formerly in use at the Radcliffe Observatory, Oxford, has been presented to the Observatory by the Radcliffe Trustees. The adaptation of this chronograph to record Morse signals from the Rugby wireless station, together with signals from the standard clock, is under consideration. Such records would enable the absolute value of gravity of any place to be determined by comparing the swings of a gravity pendulum with the same series of Morse signals, being essentially the method employed differentially by Dr. Bullard, of Cambridge University.

The annual examination of the Library has been made. Nine books are reported missing and cannot be accounted for at present. Of these, seven were reported missing last year, and two books, which have been missing for a number of years, are now assumed lost and have been written off. Three books which were missing last year have since been returned.

III.—Astronomical Observations :—

Transit Circle.—The Sun, Moon, planets, and fundamental stars have been regularly observed, and good progress has been made with the programme commenced in 1931.

During the period covered by this Report, 9,576 transit observations and 9,221 observations of zenith distance were obtained. These include the following :—

Sun ..	.. 130 observations.	Jupiter	.. 8 observations.
Moon	.. 94 ,,	Saturn	.. 26 ,,
Mercury	.. 2 ,,	Uranus	.. 7 ,,
Venus	.. 43 ,,	Neptune	.. 6 ,,
Mars	.. 5 ,,	Vesta	.. 1 ,,

The observations of the Sun, Moon and planets are published yearly in the *Greenwich Observations*. A copy of these results for the year 1934 is being prepared for the printer.

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.

Year.	Longitude.		Latitude.		No. of observations.	
	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
1933 ..	+ 4·21	+ 4·10	− 0·56	− 0·60	96	61
1934 ..	+ 3·98	+ 3·33	− 0·49	− 0·46	103	64

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

Ledgering of the observations, made since 1931 January 1 in the zone + 0° to + 24° declination, has begun.

Nova Herculis 1934 was observed on the meridian six times above pole and twice below pole between December 13 and February 14. The position for 1935·0 from the observations above pole is R.A. $18^h\ 5^m\ 39^s{\cdot}85$: Dec. $+\ 45°\ 50'\ 54''{\cdot}2$ (Epoch 1934·99).

The stars observed with the Cookson zenith telescope for the determination of latitude variation are on the observing list with the transit circle. 136 stars on the new programme with the Cookson telescope have been added to the observing list.

The printing of the Second Greenwich Catalogue of Stars for 1925 was completed, and the catalogue has been published. The catalogue contains the positions of 2,111 fundamental stars and of 10,584 stars in the zone of declination $+\ 32°{\cdot}0$ to $+\ 64°{\cdot}0$, based on observations during the years 1922 to 1930.

Cookson Zenith Telescope.—During the year, 243 plates were taken for latitude variation, and 4 for determination of scale. The results for 1934 were published in the *Monthly Notices* for 1935, March.

The construction of a new brick building to house the instrument, adjacent to the south collimator house of the reversible transit circle in the Christie Enclosure, has been approved. The building will be erected this year.

The programme of observations with the Cookson telescope at Greenwich was planned for the determination of the constant of aberration as well as of the latitude variation. In the winter months, observations are made both evening and morning in order to obtain large aberration factors. This programme has been continued from 1911 to date. When the instrument is moved to its new position in the Christie Enclosure, the present programme of observations will be terminated and a new programme, planned for the determination of latitude variation only, will be commenced. 24 groups, generally comprising 5 or 6 pairs of stars and each extending over about one hour in right ascension have been selected. Three groups, centred round midnight, will be observed throughout the year. The stars of the new programme which are not on the present observing programme, or which have not recently been observed with the transit circle, have been added to the observing programme.

28-*inch Equatorial.*—During the year, 106 observations of 87 double stars were made. These consist of:—

12	double	stars,	with	separation	$< 0''{\cdot}5$.
35	,,	,,	,,	,,	$0''{\cdot}5$ to $1''{\cdot}0$.
38	,,	,,	,,	,,	$1''{\cdot}0$ to $2''{\cdot}0$.
2	,,	,,	,,	,,	$> 2''{\cdot}0$.

Thompson 26-inch Refractor.—The work on stellar parallax has been continued During the year 1,019 plates suitable for measurement were obtained, 1,016 plates were measured, and the parallaxes of 35 stars were determined.

The cramped conditions of the telescope in its dome and their detrimental effect on the work was referred to in the last Report. A contract for the re-mounting of the telescope has been placed with Messrs. Sir Howard Grubb, Parsons, and Co., and the work will be carried out during the summer months.

"Observations of Stellar Parallax," Vol. 2, containing the parallaxes of 250 stars, has been published.

Yapp 36-inch Reflector.—This instrument, in conjunction with the slitless spectrograph, is being devoted at present to the colour temperature work hitherto carried on with the 30-inch reflector. Attention is being concentrated on stars of types O, B and A, and their colour temperatures are being determined by comparison with the Greenwich standard stars. In the period under review 296 comparisons of 97 stars with standard stars were secured. These include 17 plates of δ Cephei, which is being observed systematically for the purpose of determining the changes in colour temperature of this star through its cycle. About half the plates have been measured and reduced.

In addition, a series of 42 plates has been exposed on Nova Herculis. All these have been calibrated for photometry and, whenever possible, a comparison star was photographed at approximately the same altitude as the nova. These plates will provide material for studies of the general behaviour of the spectral lines and of the distribution of energy throughout the spectrum.

The plates used are Ilford Hydrogen Alpha plates. The region of good sensitivity of these plates extends to beyond λ 6800, and on account of their high speed a well-exposed spectrum of a star of magnitude 3·0 is now obtained with an exposure time of one minute.

Observations of Eros.—The measurement of the plates taken in connection with the 1930–31 opposition is proceeding. The following series of plates have now been measured :—

(*a*) The Greenwich series of 113 plates taken with the 13-inch astrographic telescope for the purpose of obtaining positions of secondary comparison stars required for the reduction of photographs of Eros obtained with long-focus instruments.

(*b*) The Cape series of 114 plates taken with the 13-inch astrographic telescope for the same purpose.

(*c*) The Greenwich series of 160 plates exposed on Eros with the 26-inch refractor.

(*d*) The Greenwich series of 204 plates exposed on Eros with the 13-inch astrographic refractor.

(*e*) The Radcliffe series of 52 plates exposed on Eros with the 24-inch refractor.

(*f*) The Melbourne series of 41 plates exposed on Eros with the 13-inch astrographic telescope.

The following series of plates have been received and are at present being measured :—

(*g*) The Cape series of 478 plates exposed on Eros with the Victoria 24-inch telescope.

(*h*) The Yale series of 60 plates exposed on Eros with the 26-inch refractor at the Johannesburg Station, and

(*j*) The Johannesburg series of 176 plates exposed on Eros with the 10-inch Cooke telescope of the Union Observatory.

Of the above, 32 plates of series (*b*),
81 ,, ,, (*d*),
41 ,, ,, (*f*),
139 ,, ,, (*g*),
were measured in the period covered by this Report. All plates have been measured in right ascension and declination.

The reductions are in hand. Plate constants for series (*a*) and (*b*) have been computed and adopted and revised places for the primary reference stars deduced. The conversion of the measured co-ordinates of the secondary comparison stars to right ascension and declination is proceeding.

For series (*d*) and (*f*), stars from Dr. Kopff's list are being used as reference stars, and the standard co-ordinates of these have been computed.

For series (*g*) and (*h*), using the Bergedorf places of the secondary comparison stars selected by Dr. Schorr as far as these are available, standard co-ordinates have been computed.

In addition, plates have been received from the Harvard station at Bloemfontein and from Sydney Observatory, and will be dealt with later.

Astrographic Equatorial.—Photographic determinations of the magnitude of Nova Herculis (1934) were obtained on sixteen nights. Three plates were exposed on the field of a suspected nova (Morgenroth) in Canes Minor on November 23 and

December 5. On the latter date, a star of about magnitude 13·5 was identified near the place indicated.

Two plates were exposed on object Lause, which was reported from Copenhagen on 1935 March 24, and subsequently identified as the cluster h375.

The telescope has been fitted with a new controlling pendulum, manufactured by the Synchronome Company.

Photoheliograph.—Photographs of the Sun were obtained on 263 days with either the Dallmeyer 4-inch photoheliograph or the Thompson 9-inch. The number of photographs selected for preservation is 525, including 38 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 351 days in the year 1934 and on 89 days in the first three months of 1935. The Director of the Kodaikanal Observatory has reported that plates were taken there on 323 days in the year 1934 and on 85 days during the first three months of 1935.

Photographs, in duplicate, have been received from the Royal Observatory Cape of Good Hope, to 1934 October 22, and the single series to 1934 November 12. Five photographs have been sent from the Kodaikanal Observatory to complete the series for 1934.

The measurement of the combined series has been made from 1933 November 12 to 1934 October 24; the Greenwich plates have been measured to 1935 April 18 The reductions of positions and areas of spot groups and their principal components have been completed from 1933 November 12 to 1934 October 5, and the reductions of the Greenwich plates carried to 1935 March 31.

During the period covered by this Report, the sunspot activity has definitely increased, though somewhat irregularly, from the solar minimum during the latter half of 1933; the Sun's rising activity is more consistently shown by phenomena observed with the spectrohelioscope. Two groups of spots of appreciable area (about 800 millionths of the Sun's hemisphere) were visible on May 13–26, in latitude 30° S., and on February 5–11, in latitude 16° S.

Daily spot-numbers, both for the whole disc and for a central zone of the Sun, based on Wolf's method of counting, have been supplied quarterly to Zurich for incorporation in the *Bulletin for Character Figures of Solar Phenomena*, published under the auspices of the International Astronomical Union.

Photographic prints of solar negatives from 1933 October 1 to 1934 September 30 have been supplied to the Director, Solar Physics Observatory, Cambridge. A duplicate set of negatives for the year 1933 has been sent to the Science Museum, South Kensington.

The photographic reproduction of the series of solar negatives obtained at Greenwich from 1874 to 1903 has been completed. The number of prints made during the year is 2,541, covering the period 1892 September to 1903 December. The complete series of about 5,000 prints is safely stored in two steel presses.

At the termination of another 11-year cycle, the Sun's rotation period has been determined from the Greenwich measures of long-lived sunspots during the epoch 1924–33, and the results published in the *Monthly Notices*. The derived value of the sidereal angular daily motion expressed in the usual form, $a - b \sin^2 \phi$, is $14^\circ{\cdot}37 - 3^\circ{\cdot}00 \sin^2 \phi$, in good accordance with the values derived for the four preceding cycles to be found published in the *Greenwich Results* for 1924.

Spectrohelioscope.—The Sun's disc was examined in Hα light with the spectrohelioscope on 179 days ; on about 22 days, observations were limited to a few minutes owing to cloud. A special watch was kept for bright eruptions of Hα on the disc ; four of minor extent were recorded near sunspots on May 17 and 24, November 11 and March 1 ; the occurrence of these was reported to Meudon. 157 observations were made of radial velocities of dark flocculi associated with sunspots ; 23 of these flocculi were connected with the large spot group visible from May 13 to 26, and the maximum velocity recorded was + 80 km./sec. on May 17, one of the largest velocities measured during the year. In addition to these measures, 601 were made on other dark and bright flocculi and prominences observed in Hα, the majority of these yielding small or inappreciable radial motions.

In July, a photometer with a comparison lamp source was mounted on the spectrohelioscope, and a number of preliminary measures were made during August to October of the light intensity of bright Hα flocculi compared with that of the adjacent background in a wave-length about 4 A from the centre of Hα. Intensity measures of prominences visible in Hα and in Hβ were also commenced. These observations, which were of necessity suspended during the adverse winter conditions, have been resumed. In addition, some comparative measures were made directly with a calibrated wedge of the light intensity of flocculi and prominences relative to the adjacent portion of the disc at the same wave-length, normally in the middle of Hα.

The Intensities of the Fraunhofer Lines.—As was mentioned in the last Report, some preliminary work was undertaken in the summer of 1934, using a temporary set-up of apparatus in the south gallery of the altazimuth building. Sunlight was fed into this gallery by a coelostat mounted on an improvised support. It was decided to transfer these experiments to permanent quarters in the basement of the 36-inch reflector dome. The coelostat and secondary mirror have been mounted on brick pillars standing on a concrete base. These instruments are protected from the elements by a light hut, constructed in the workshop, which can be run away on rails, admitting sunlight to the coelostat. The beam enters the basement through a window. The solar spectrum is formed by a 4-inch concave grating spectrograph, and is made to fall on a second slit. The short length of spectrum which passes through the second slit is then further dispersed by a single prism mounted in the Littrow form, which separates out the true spectrum from scattered light which has fallen on the second slit. It is intended to make measurements by photography, with the thermocouple purchased last year, and with the eye, using the method of an auxiliary lamp, as used at present in the spectrohelioscope observations.

Investigation of the Performance of a Grating.—An investigation was made of the amount of light scattered into the centre of an artificial absorption line by the 4-inch concave grating spectrograph. Light from a " Pointolite " lamp was dispersed by a large prism and the spectrum was brought to a focus, at which the dispersion was 60 A/mm. in the yellow. The light was then reflected back to the original prism, which re-combined the rays to form a white image, unless an obstruction had been made at the spectrum focus. A thin wire placed at the focus produced an artificial absorption line in the light, which was otherwise white. When this light was examined with the grating spectrograph the artificial absorption line was seen, but had a non-zero central intensity. The false central intensity of a narrow line was 5 per cent. of the intensity of the continuous spectrum. On examining the image of a bright region of the spectrum about 5 A in width, it was seen that the false light was concentrated for the most part into definite maxima or ghosts. The principal pair of ghosts have an intensity of 1 per cent. of the main line and are situated at a distance of 26 A from either side of it. The scattered light was seen to come from groups of defective rulings on the grating. According to Allen (1903), the bad rulings are sets of rulings spaced a little too closely or a little too far apart.

IV.—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 now dependent upon electrical standards, but observations of horizontal intensity with a unfilar 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.

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 1934 December 31, and with provisional constants to the present time.

The tabulation of results for 1934 is almost complete, and awaits only the receipt of the final list of International " quiet " and " disturbed " days.

The mean values of the magnetic elements at Abinger for the year 1934 are given below. The values for the years 1931, 1932 and 1933 are given for comparison.

	Decl. W.	Hor. Intensity.	Vert. Intensity.	Inclination. †
1931.. ..	12° 13′·7	0·18544	0·42923	66° 38′·1
1932.. ..	12° 2′·6	0·18536	0·42940	66° 39′·1
1933.. ..	11° 51′·7	0·18532	0·42942	66° 39′·4
1934.. ..	11° 41′·1	0·18533	0·42955	66° 39′·7

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.

A coil-magnetometer of the Dye pattern for measurement of vertical intensity and a coil-magnetometer of the Smith portable type for measurement of horizontal intensity have been tested. The constant of the coil was determined for each instrument.

Seven portable magnetic variometers for measuring changes of the vertical component of the earth's field have been examined for the determination and certification of their constants.

V.—Meteorological Observations.

The registration of atmospheric pressure, temperature of the air and of evaporation, the direction, pressure and velocity of the wind, the amount of rainfall, sunshine

† These values are deduced from observations with the coil magnetometers, and are not derived from actual observation of the angle of inclination.

and cloudiness at night, has been maintained continuously. Estimates of visibility have been made by eye at definite hours.

The measurement, by a continuously recording photographic apparatus, of the air-earth current discharged at a metallic point was commenced on 1935 January 1. The point is mounted in the Christie Enclosure, on a pole, 30 feet from ground level, and is earthed through two galvanometers placed in series in the circuit. The sensitivity of one galvanometer is approximately twenty times that of the other. The more sensitive of the two simultaneously-recorded traces is capable of showing a current of 10^{-8} ampère.

Regular observations for the measurement of the amount of solid matter suspended in the air were commenced on 1934 July 1. A known quantity of air, drawn from outside the recording house, is sucked through a small tube ending in a diaphragm of white fibrous paper which retains the solid impurity. By means of an Owens automatic filter the operation is performed three or four times each hour throughout the day. The spots of discoloration left on the paper are subsequently matched with one of a series of standard shades representing known degrees of pollution.

A preliminary tabulation of the results from the records has been made, and the following data are abstracted as of interest.

Month.	Mean weight of suspended impurity per 100 cubic metres of air.	Average period of maximum pollution.	Average period of minimum pollution.	Number of "Z" days.*
1934.	Milligrammes.			
July	71	5h to 8h	17h	3
August	78	5h to 9h	16h to 19h	4
September with October 1–6...	86	6h to 8h	12h to 15h	9
October 7–31	117	8h to 10h	2h to 5h	16
November	178	9h to 11h	3h to 6h	28
December	101	17h to 20h	3h to 6h	11
1935.				
January	146	17h to 20h	1h to 6h	25
February	103	17h to 21h	1h to 6h	12
March	113	19h to 22h	2h to 6h	23
April 1–13	94	19h to 21h	3h to 5h	3
April 14–30	76	7h to 9h	0h to 3h	3

* A "Z" day is defined by the Advisory Committee on Atmospheric Pollution as a day on which, at some period, the quantity of suspended matter reached 1·28 milligrammes per cubic metre (corresponding to shade number 4 of the Standard series).

Mean hourly values for the " Winter " period
(October 7 to April 13)
expressed as milligrammes per 100 cubic metres of air.

Hour.	Ordinary Days.			" Z " Days.*		
	Weekdays (45).	Saturdays (12).	Sundays (13).	Weekdays (86).	Saturdays (15).	Sundays (14).
1	68	80	71	121	96	96
2	65	77	69	113	90	93
3	65	80	67	113	83	82
4	64	80	67	110	81	78
5	65	75	67	110	85	78
6	66	72	67	111	90	82
7	74	75	69	125	100	94
8	92	80	71	151	115	103
9	103	93	91	174	132	128
10	103	96	101	182	145	144
11	102	96	104	173	139	153
12	99	91	108	165	136	153
13	91	83	104	147	124	144
14	84	83	99	148	128	153
15	86	83	99	148	126	153
16	92	85	101	154	124	162
17	99	91	99	167	134	201
18	108	99	103	183	139	206
19	109	96	103	191	143	192
20	117	96	108	196	160	178
21	113	96	106	190	160	190
22	102	91	99	176	160	173
23	91	91	84	157	145	148
24	82	85	84	133	119	128

The maximum pollution occurred on November 21, the *average* quantity of suspended impurity on that day being 336 milligrammes per 100 cubic metres—a quantity which may be expressed alternatively as one ounce in a cube of approximately 22 yards edge.

Compared with the figures recently published for the previous year at other stations, it would appear that the pollution at Greenwich is fully as great as at any London station, and is not, on the average, surpassed at any reporting station in

* See footnote on preceding page.

Britain, although in Central Glasgow the pollution is worse at the worst times of the day.

The gaseous pollution of the atmosphere by sulphur dioxide has been measured daily from 1935 January 1. Air is continuously drawn through a weak solution of hydrogen peroxide by means of a suction pump, the volume being given by an ordinary gas meter. The sulphur dioxide is converted to sulphuric acid during its passage through the hydrogen peroxide, and remains in solution. The quantity of acid is estimated by titration with alkali, the corresponding volume of sulphur dioxide being subsequently derived by formula.

The tabulation of meteorological results for 1934 is complete, and the copy for press is in the printer's hands.

The following details of the weather refer to the period of twelve months ended 1935 April 30 :—

The mean temperature was 51°·9, which is 2°·4 higher than the average of the 75 years 1841–1915. The highest temperature in the shade was 90°·6 registered on June 17. Temperatures exceeding 80° were recorded on 22 days, of which 13 were in July. The lowest temperature was 25°·4 on January 29. Temperatures of freezing point or below were recorded on 25 days. It is an exceptional circumstance that no day in December has to be included in this number. There is only one previous instance, namely, in 1862. The mean temperature in December was 7°·1 above the average. The mean daily horizontal movement of the air was 285 miles, which is just equal to the average for 50 years 1867–1916. The greatest daily movement was 743 miles, recorded on February 16; the least daily movement was 104 miles on November 29. The greatest motion in one hour, 35 miles, was recorded on February 16. The greatest pressure reached was 21·0 lbs. to the square foot, also on February 16. The duration of bright sunshine recorded was 1,399·0 hours, or 31·3 per cent. of the possible total. There were 79 entirely sunless days, of which 50 occurred in the winter months November to January. There were 39 entirely cloudless nights—that is, nights on which an unbroken trace of Polaris was obtained by the Night Sky Camera. The total rainfall was 20·41 inches—that is, 3·83 inches less than the average for 75 years 1841–1915, and measurable rain fell on 159 days. The wettest month was December with 4·55 inches. The driest month was May with 0·40 inch. Estimated by the average for 75 years, the accumulated deficiency of rainfall in the two years since May 1, 1933, is 11·1 inches.

VI.—Time Service.

A generous offer to present to the Observatory a free pendulum installation has been made by Mr. H. R. Fry, F.R.A.S., and has been accepted by the Admiralty. The two sidereal free-pendulum clocks which the Observatory at present possesses are required for routine purposes. One is used as the standard clock; the second is kept available for adoption as standard whenever it may be required. The new clock will not be required for routine work, but will be available for experimental purposes, though it will also serve to improve the accuracy of the time distributed from the Observatory. The need for a third sidereal clock of this nature has often been felt. The new installation will include an improved slave clock, and a special time indicating and distributing clock, in an air-tight case, which will be synchronised by the free pendulum within narrower limits than in the ordinary installations; time will also be taken directly off the free pendulum by a photo-electric method. The specification for the new clock has been prepared.

Determinations of time have been made by a rota of observers with the reversible transit D fitted with an impersonal micrometer. On April 11 Transit B was used, whilst the pivots of Transit D were re-ground.

Observations were secured on 106 nights, the transits being registered on a syphon recording tape chronograph operated by a thermionic valve relay. The determinations of time have been corrected for the relative personal equations of the three observers, but no determination has been made of the absolute personal equation of the mean observer. A personal-equation machine, designed for this purpose, is under construction in the workshop.

The free pendulum clock Shortt No. 11, used as sidereal standard throughout 1934, was dismounted for overhaul early in January after a continuous run of $8\frac{1}{2}$ years. High insulation coils were fitted in all circuits, and during the period of overhaul the opportunity was taken to grind the surfaces of the case, the glass bell jar and bottom plate. The clock was re-assembled in February, and is now being rated as reserve standard. The free pendulum clock Shortt No. 3 has been used as sidereal standard since January 1.

A second mean time free pendulum clock was ordered from the Synchronome Company and was delivered in November. This clock (Shortt No. 49) was mounted in the cellar under Flamsteed House adjacent to that containing the sidereal standard clocks. After adjustment it was brought into use on February 14. It controls the mean time clocks used for Post Office and broadcast signals, and also the rhythmic signal transmitter.

The clock Shortt No. 16, which until February 14 had controlled the mean time services, was then dismounted for overhaul. The free pendulum was remounted in the same cellar as No. 49, the slave clock and other accessories being left in the Clock Room under the Shuckburgh Dome. Clock No. 16 was fitted with high insulation coils similar to the sidereal clocks, and the free pendulum case surfaces were ground flat while the clock was under repair. The clock was re-assembled and re-started early in April, and is now under adjustment.

The service of rhythmic time signals at 10^h and 18^h transmitted through the Post Office wireless station at Rugby, and also the daily time signals to the General Post Office and the British Broadcasting Corporation, have been transmitted regularly.

The corrections to the transmitted times of the rhythmic signals for adjustment to the final time determinations are published and distributed periodically by the Hydrographer of the Navy in "*Notices to Mariners.*"

The Time Ball was released prematurely on December 29. It was raised again and dropped correctly at 14^h.

The performance of the time balls at the Admiralty Signal stations and also the Westminster Clock is shown by the following table of the errors of the return signals.

Error of Return Signal.	Portsmouth.	Devonport.	Westminster.
Not greater than $0^s{\cdot}2$...	255	261	80
$0^s{\cdot}3$ to $0^s{\cdot}5$	1	2	68
$0^s{\cdot}6$ to $1^s{\cdot}0$	1	0	83
Greater than $1^s{\cdot}0$	0	0	19

The Westminster Clock was under repair from May 1 till July 3.

The clocks at the Admiralty stations are corrected daily by the 10^h signal, but the Westminster Clock is not so corrected.

Radio time signals are received regularly from the Eiffel Tower, Nauen and Bordeaux. The long wave signals from Annapolis were received, when possible, until the discontinuance of these signals at the end of June. The signals are registered automatically, and the corrections found for the Nauen and Bordeaux signals, together with the corrections to the Rugby signals, are published monthly in the Admiralty *Notices to Mariners.*

A cathode ray oscillograph apparatus embodying mains unit for operation of tube, square wave oscillator for time scale, and recording camera of cinema type, was used during November for determining time-lags in the recording of radio time signals. Modification in the recording circuit and various causes have interrupted the use of this instrument, but regular comparisons between the syphon recorder and the oscillograph are now in progress.

The following table gives the monthly means of the differences from Greenwich shown by the various time signals, using the final clock errors derived from observations made with the small reversible transit instrument D at Greenwich, and the corrections for final time determinations published by Paris, Hamburg and Washington Observatories.

1934.	Paris $9\frac{1}{2}^h$ Rhythmic.	Nauen 12^h Rhythmic.	Annapolis 17^h.	Bordeaux 20^h Rhythmic.
	s.	s.	s.	s.
January	− ·026	·000	+ ·016	− ·004
February	− ·046		+ ·006	− ·025
March	− ·046		− ·021	− ·029
April	− ·012	− ·017	− ·014	+ ·002
May	− ·022	+ ·007	− ·012	·000
June	− ·023	+ ·024	− ·010	− ·001
July	+ ·008	+ ·033		+ ·037
August	− ·001	+ ·017		+ ·025
September	− ·021			+ ·014
October	− ·017			+ ·009
November	− ·015	+ ·008		+ ·007
December	+ ·005	+ ·012		+ ·016
Mean	− ·018	+ ·013	− ·009	+ ·004
Number of comparisons	301	178	56	356

The sign + means late on Greenwich. The reference point for all comparisons is the commencement of the signals. The Nauen times have been referred to the Eichelberger system of star places. The Annapolis signals have been corrected for lag of land line to Washington and by $0^s \cdot 02$ for time of travel. A correction of $0^s \cdot 005$ has been applied to all signals for lag in reception. Relative personal equations have been applied to the time observations.

VII.—Chronometers.

The number of chronometers and watches belonging to the Admiralty now at the Observatory is 2,387. Of this total, 197 chronometers, 211 chronometer watches,

227 hack watches and 49 pocket watches are being rated. Five are in regular use in the Observatory. The remainder, consisting of 386 chronometers, 889 chronometer watches, 209 hack watches and 158 pocket watches, are kept in storage.

In addition to Admiralty chronometers there are 30 chronometers and 26 watches deposited at the Observatory for various reasons.

During the year ended 1935 April 30, a total of 1,563 chronometers and watches has been received and 1,753 issued. The number sent for repair was 915, viz., 876 for the Admiralty and 39 for the Indian Government.

During the year, 23 chronometers, 34 chronometer watches, 5 hack watches, and 3 pocket watches have been sold out of surplus stock.

VIII.—Printing and distribution of Greenwich Publications.

The printing of the Volume of "Greenwich Observations for 1933," and its separate parts, is completed. Part of the MSS. of Greenwich Observations 1934 has been forwarded to H.M. Stationery Office for printing.

The distribution of the "Second Greenwich Catalogue of Stars for 1925" and of Volume II of "Observations of Stellar Parallax" is in progress.

IX.—Personal Establishment.

The permanent staff at the present time is constituted as follows:—

Chief Assistants.—Mr. Greaves, Dr. Woolley.

Assistants.—Mr. Bowyer, Mr. Davidson, Mr. Melotte, Mr. Witchell.

Junior Assistants (Higher Grade).—Mr. Acton, Mr. Cullen, Mr. Newton, Mr. Stevens.

Junior Assistants.—Mr. Barton, Mr. Blackwell, Mr. Chamberlain, Mr. Finch, Mr. Jeffries, Mr. Martin, Mr. Rickerby, Mr. Rickett, Mr. Symms and Mr. Wells.

Clerical Assistant.—Mr. Edney.

16 Computers, including 7 ladies, are employed at the Observatory.

Mr. H. H. Furner, Assistant, retired on November 25, after 46 years' service, 37 of which were in an established capacity. For 12 years Mr. Furner had been in general charge of the transit circle: he was also in charge of the double-star observations with the 28-inch equatorial. Consequent upon Mr. Furner's retirement, Mr. Melotte was promoted to Assistant, Mr. Newton was promoted to Junior Assistant (Higher Grade), and Mr. Blackwell was appointed Junior Assistant.

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

Branch.	Established Staff.	Unestablished Staff.
Transit Circle and Zenith Telescope.	Mr. Cullen, Mr. Acton, Mr. Symms, Mr. Blackwell.	Mr. Slator, Mr. Diston, Mr. Grimwood, Mr. Stockwell, Miss Powell.
Time Signals and Chronometers	Mr. Bowyer, Mr. Rickett ...	Mr. Harris, Mr. Shortland, Mr. Rudd.
Thompson and Yapp Equatorials.	Mr. Davidson, Mr. Martin ...	Miss Cumberledge, Miss French.
28-inch Equatorial	Mr. Acton	—
Astrographic Equatorial ...	Mr. Melotte, Mr. Jeffries, Mr. Finch.	Miss Jeffries, Miss Moore.
Photoheliograph and Spectrohelioscope.	Mr. Newton, Mr. Barton ...	Mr. Laurie.
Small Transit	Mr. Finch	Mr. Grimwood.
Magnetic and Meteorological ...	Mr. Witchell, Mr. Stevens, Mr. Wells, Mr. Rickerby.	Miss Clack, Mr. Dennis.
Secretariat and Library ...	Mr. Edney, Mr. Chamberlain ...	Miss Brickman.

Since the year 1847, unestablished computers have been employed in the Observatory on general computing and various miscellaneous duties. Changed conditions have made the continuation of this system undesirable ; proposals have therefore been submitted to the Admiralty for its termination. These proposals are now under discussion.

The staff of workmen now employed consists of a foreman of works, two joiners, a mechanic, a gate porter, three messengers, two of whom perform in turn the duty of night watchman, a gardener, four labourers and a charwoman. There is also a mechanic at Abinger who has charge of the engines and acts as caretaker.

X.—General Remarks.

The visitors to the Observatory during the year have included the Rajah of Parlakimedi, the Minor Rajah Sahib Bahadur of Khetri, the Turkish Ambassador and Professor Brunner of Zurich.

Dr. E. Johansson, of the Upsala Observatory, and M. and Mme. R. Brisse, of the Paris Observatory, have studied some of the work of the Observatory during the year.

Commander R. V. Wheatley, R.A.N., visited the Abinger Magnetic Station for a course of instruction in January.

Two pen and ink drawings of the Royal Observatory, made by Gasselin in 1699, have been presented to the Observatory by the Right Rev. J. H. Greig, late Lord Bishop of Guildford. These drawings, made 24 years after the foundation of the Observatory, are earlier in date than any other known drawings or prints of the Observatory.

The original manuscript of the observations of Flamsteed, first Astronomer Royal, which was deposited, sealed up, in 1706 by Flamsteed with Sir Isaac Newton, has been presented to the Observatory by the Radcliffe Trustees. The manuscript contains the alterations and emendations made by Halley and, as thus altered, was published in 1711 without Flamsteed's authority. In 1715 Flamsteed obtained possession of all the copies then remaining of this unauthorised publication and committed them to the flames.

The Radcliffe Trustees have also presented a manuscript volume of observations made by Bliss at Oxford during the time when he was Astronomer Royal.

The azimuth pillar, erected in 1824 between Hawke Wood and Pole Hill, Chingford, by Pond, then Astronomer Royal, to serve as an azimuth mark for the new Troughton transit instrument, has long ceased to be visible from Greenwich even under the best conditions. It is now an object of curiosity to visitors to the site. The pillar is on land which is vested in the Epping Forest Commissioners (City of London Corporation). The Corporation has agreed to affix an inscription to the pillar, explaining the purpose for which it was erected and used. The Greenwich meridian, as changed in 1850 and adopted by international agreement in 1884 as the line of zero longitude, passes 19 feet to the east of the pillar.

The line, marking the Greenwich meridian, in the stone strip let into the pathway in Greenwich Park, adjacent to the north boundary wall of the Observatory, has been re-cut, and a descriptive plate has been mounted adjacent to the line by H.M. Office of Works.

The measurements of atmospheric pollution referred to earlier in this Report give an indication of the serious pollution of the atmosphere at Greenwich in the form of fine suspended particles. Surrounded as the Observatory is by extensive built-up areas on all sides, with many works and factories in its neighbourhood, astronomical observations are carried on under increasing difficulties. The pollution of the atmosphere is shown in other ways by the considerable sulphur-dioxide content,

which causes rapid tarnishing of silvered mirrors and circles, and by the precipitation of solid matter in the form of soot and particles of hard grit, which necessitates frequent cleaning of bearings and pivots of instruments to prevent scoring. The condensation of moisture from hot gases ejected from the tall chimneys of near-by power stations is often a source of trouble. A further difficulty is due to the increasing brightness of the sky at night, resulting from the introduction of new forms of street lighting. The installation of mercury vapour discharge lamps for lighting certain streets in the near neighbourhood of the Observatory is causing me much concern, as photographic work with rapid plates at low altitudes in the directions in which this lighting is used is rendered practically impossible. The extension of similar lighting still nearer to the Observatory would seriously interfere with some of the programmes of observation. The mercury discharge lamp is rich in radiations in the blue and ultra-violet regions of the spectrum ; so far as the effect on the work of the Observatory is concerned, the sodium vapour discharge lamp, whose yellow light is essentially monochromatic, is much to be preferred. Representations have been made to the Greenwich Borough Council on the subject of the interference caused by recent street lighting developments. The Council has the matter under consideration.

H. SPENCER JONES.

Royal Observatory, Greenwich.
1935 May 2.

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