REPORT

OF THE

ASTRONOMER ROYAL

TO THE

BOARD OF VISITORS

OF THE

ROYAL OBSERVATORY, GREENWICH

Read at the Annual Visitation of the Royal Observatory, 1947 June 7.

THE BOARD OF VISITORS

The President of the Royal Society.	Sir Robert Robinson.	
The President of the Royal Astronomical Society.	Prof. W. M. H. Greaves.	
		To serve until June 30th
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Read at the Annual Visitation of the Royal Observatory, 1947 June 7.

The Report here presented refers to the period from 1946 May 1 to 1947 April 30 and exhibits the state of the Observatory on the last named day.

1. BUILDINGS, GROUNDS, MOVABLE PROPERTY AND LIBRARY.

War damage repairs have continued throughout the year but are still confined to items essential to performance of work or to prevent further deterioration. They include the Central Store, Porters Lodge, south boundary fence and Rugby Clock room. The south portico of the Altazimuth Dome is being rebuilt and the damaged shutter of the collimator repaired. Repairs to the north boundary fence are now in progress.

A very limited amount of interior and exterior decoration has been done.

A new dial for the Shepherd 24-hour clock near the main entrance has been supplied by Messrs. James Cooke and Son, of Stechford, Birmingham. An exact copy has been made of the original dial, which was damaged when the entrance was destroyed during the war; the makers of the dial have generously presented it to the Royal Observatory without any charge.

At the Abinger Magnetic Station the entrance roadway has been resurfaced with concrete, the gateway has been widened, and the drive has been resurfaced with tarmac. The entrance gates and adjacent fencing, which were damaged by the fall, during a heavy gale, of two large beech trees near the entrance, have been replaced.

The rooms at the Magnetic Station, originally used to house batteries and engines and subsequently for time service equipment, have been converted for use as dark rooms. The fittings, including wet and dry benches, were designed by the Admiralty Photographic and Instrument Research Laboratory and were made by the Construction Department, H.M. Dockyard, Chatham.

For the better reception of foreign time signals, 98-ft. Adastra masts have been erected on Wotton Common. One of the masts, which received damage during a heavy gale, has been repaired.

The roofs of the two small transit huts at Abinger were damaged by the winter gales. The roof of one hut received further damage after repairs had been completed and is now awaiting repair.

Modifications are in progress to the electrical supply installation at Abinger. A new cable has been laid across the courtyard between the diesel-generator house and the main switchboard. The supply cable is overloaded and the installation of a new cable is under consideration.

Mr. A. M. Newbegin has generously presented to the Royal Observatory the whole of the equipment of his private Observatory at Worthing. This includes:-

An equatorial telescope by Cooke, with three objectives ($6\frac{1}{4}$ inch; $4\frac{1}{4}$ inch; and 3 inch); a 3-prism Evershed solar spectroscope; 2 micrometers and various eye-pieces, including a Dawes solar eye-piece.

A Cooke dome, 22 feet in diameter, covered with zinc.

Two observing ladders in oak.

A spectrohelioscope, made by Mr. Newbegin, consisting of a coelostat and second mirror, a plane grating by Michelson (15000 lines), 2 concave mirrors, together with 2 spare plane mirrors, 2 spare concave mirrors, and spare motor with rheostat control. One set of mirrors is of fused silicon.

A Cooke sidereal clock, with mean time dial in addition; a synchronome electric clock; an 8-day chronometer by Hughes, No.1895; and a complete photographic map of the normal solar spectrum.

The whole of this equipment has been stored at Herstmonceux, pending installation there.

The following instruments are on loan to the Royal Observatory:-

The Cookson floating zenith telescope, from the Cambridge Observatory.

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 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.

A Zeiss Spiral Micrometer with 4" glass scale, 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 small transit instrument, of the broken type, with stand, by Bamberg, from the Royal Observatory, Edinburgh.

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 Imperial College of Science and Technology -
6-inch Equatorial, Simms No.2.
To the Meteorological Office -
A dip inductor for use at Lerwick Observatory, Shetland Islands.
To the National Maritime Museum -
Harrison's Time Machines, Nos.2 and 4 and the copy by Larcum Kendall.
To the Science Museum -
A number of astronomical instruments of historical interest.

Harrison's Time Machines Nos.1 and 3 are at present undergoing or awaiting repair at the Chronometer Depot at Bradford-on-Avon.

The Bamberg Broken Transit Instrument, on loan from the Royal Observatory, Edinburgh, has been completely overhauled, preparatory to being brought into regular use for time determinations. In the past difficulty has been experienced from wear of the pivots of the small transit instruments; the effects of pivot errors on the observed transit times cannot be allowed for and the determinations of level error with a striding level are impaired. The pivots have therefore been heavily plated with chromium and then ground and lapped in the workshop to a high degree of precision. An impersonal micrometer, formerly belonging to the Cooke transit, damaged by enemy action, has been fitted, while a second altitude circle and reading microscope have been added. The system of field illumination, designed by Dr. Atkinson, has also been fitted.

Owing to shortage of staff and pressure of immediate work it has not been possible to conduct the annual examination of the Observatory Library before the close of the year. The Admiralty has now approved the appointment of a full time Librarian, to cope with the formidable task of re-organization, re-indexing and physical removal of the library to the new site, and it is hoped that an appointment will shortly be made. The first task will then be to complete the annual stocktaking.

The Library has suffered badly in recent years from the errects of war damage and cramped space, and removal to Herstmonceux will afford a welcome opportunity for it to be expanded and re-arranged on a permanently satisfactory basis.

II. ASTRONOMICAL OBSERVATIONS.

Airy Transit Circle. - Observations made with this instrument include:

79	observations	of	the	Sun
46	"	"	"	Moon
17	"	"	"	Venus
3	"	"	"	Jupiter
2	"	"	"	Uranus and Neptune
7	"	"	"	Vesta

In addition 844 transits and 643 zenith distances of stars in the clock and azimuth lists were observed.

During the year alterations have been made to both the level and azimuth of the instrument, caused by the continued subsidence of the E pier.

First Greenwich Catalogue of Stars for 1950 (1931-40). - Some progress has been made in deriving the final places of stars in Part I, and the proper motions of over 2,100 stars in the zone +0° to +24° declination not contained in the Albany General Catalogue.

Reversible Transit Circle. - The instrumental equipment is now being completely overhauled in preparation for the observation of time and latitude stars to be used with the photographic zenith telescope at Herstmonceux.

The collimator houses, and collimating telescopes are again serviceable after satisfactory tests for alignment with the transit circle.

More investigations of the irregularities of the pivots have been made. The observations referred to in last year's report were completed at the end of May and revealed differences depending on the direction in which the instrument is turned. These differences suggested that the end pressure which holds the axis up to its bearing might be excessive and might be causing a slight torque in the axis. The spring thrust exerts a pressure of 32 lbs: it was withdrawn and replaced with a bracket carrying a 3 lb. weight, fixed to the arm.

With the original testing system, consisting of a collimating lens mounted inside one pivot and a small dot in the other pivot, the image of the dot being observed in a special pivot telescope, which is mounted on the pier opposite to the dot, it had been found impossible to secure uniform definition of the dot for all positions of the telescope, either when a dark dot in a bright field or a bright dot in a dark field was employed. The apparent pivot errors contained a second harmonic term whose phase was changed either by rotation of the collimating lens or by rotation of the cell in which the dot is mounted. The differences in the inferred pivot errors according as the telescope is turned in the direct or reversed direction are also in the form of a second harmonic term. It was therefore decided to try a different method of investigating the pivot errors.

A 4-inch aperture telescope was fitted with the eye-end and micrometer of the original pivot telescope and with an adaptor for a Bohnenberger eye-piece. An adjustable mirror was fixed inside the cube of the instrument, so that the wire of the pivot telescope and its reflected image could be viewed for the purpose of the observations.

This arrangement gave uniform definition in every position of the instrument, but the mounting of the mirror proved to be insufficiently stable. A special casting was then made for carrying the mirror, the casting being bolted to a machined surface in the cube. A second harmonic term was present in the results, which could be interpreted as an effect of flexure. Efforts to secure greater stability reduced the amplitude of this term but it was not found possible to eliminate it entirely. It is probable that the axis of the telescope is not equally stiff in all directions, and this method of observation cannot discriminate between a true ellipticity of the pivots and axial flexure.

The collimating lens and dot apparatus were then replaced, the telescope without the negative lens being used instead of the original pivot testing telescope. The results were generally similar to those obtained previously and it was found that the alteration to the end thrust had not removed the discordance depending on the direction of turning. The apparent pivot errors are larger when the telescope

is turned with decreasing settings than when it is turned with increasing settings, but the amplitude and phase of the discordance vary with the position of the cell in which the dot is mounted.

If the second harmonic terms are regarded as spurious and are eliminated from the observations, the residuals from numerous series of determinations made in 1940, 1945, and 1946 by various methods, with black dots, bright dots, two different pivot telescopes, and by the use of the collimating lens or the mirror are closely accordant, though the range in each coordinate is only about 0".04. These residual effects are somewhat irregular and are undoubtedly true pivot errors. The question at present remains undecided whether any portion of the second harmonic terms are due to true pivot errors or are effects introduced by variable definition when the optical system in the telescope is rotated relatively to the pivot testing telescope, or by axial flexure when the mirror is employed. The changes in amplitude and phase of this term indicate that the major portion cannot be attributed to true pivot errors. It may be mentioned, however, that the tests of the pivots made with the mikrotast gauge, after the figuring of the pivots had been completed, showed an almost complete absence of any ellipticity. The residual errors derived from the mikrotast observations are in close agreement, both qualitatively and quantitatively, with the errors derived from the observations with the pivot testing telescope when ellipticity terms are eliminated. The agreement is much closer than would be expected, because the mikrotast observations involve a combination of errors at three points of each pivot; they should reveal any ellipticity but are not well adapted for determining small errors of an irregular nature.

If it is assumed that the mean of the complete series of observations obtained in 1946 March to May, in which the dot was rotated into four positions at 90° apart, for each of four corresponding positions of the collimating lens, represent the true effects of pivot errors, an investigation has been made of the influence of pivot errors on observed times of transits. The effects of the pivot errors on the determinations of collimation and of azimuth have been taken into account. The total range of the effect, expressed in equatorial time, does not exceed 0.004 seconds, except at zenith distances greater than 70°N for clamp E, or greater than 70°S for clamp W, when it increases to 0.008 seconds. The effects of the true pivot errors are no doubt considerably smaller than these figures suggest and are probably negligible except possibly at the extreme zenith distances.

Some results have been obtained from transits made over the period 1937 October to 1940 September.

The system of the FK_3 was adopted for azimuth error from stars between +75° and +90° declination and for clock error mainly between +30° and -20° declination.

The results given below are provisional but serve to illustrate differences in right ascension varying with declination. No corrections have been applied for errors of pivots.

R.T.C. - FK_3 in equatorial time.

	Approx. Z.D.	Approx. Dec.	R.T.C.-FK_3 $\Delta\alpha \cos\delta$	No. of Stars	Wt.	
	°	°	s			
North	75.0	+53.5	+.0019	14	37	Observations below pole
	65.0	+63.5	+ 43	11	33	
	55.0	+73.5	+ 47	31	109	
	43.5	+85.0	+ 5	14	43	
	33.5	+85.0	+.0048	13	40	

	Approx. Z.D.	Approx. Dec.	R.T.C.-FK_3 $\Delta\alpha \cos\delta$	No. of Stars	Wt. - *continued*
	°	°	s		
North	25.0	+76.5	+.0084	28	105
	15.0	+66.5	- 61	11	41
	7.5	+59.0	+ 33	28	99
	2.5	+54.0	.0000	28	104
South	2.5	+49.0	+.0007	19	69
	7.5	+44.0	- 60	21	75
	15.0	+36.5	+ 20	8	36
	25.0	+26.5	+ 78	30	140
	35.0	+16.5	+ 8	38	165
	45.0	+ 6.5	- 65	51	207
	55.0	- 3.5	- 54	29	124
	65.0	-13.5	- 7	37	126
	75.0	-23.5	+.0094	16	50

The weight depends on the number of observations.

It is seen that in general, the right ascensions are in agreement around the zenith, but those in the polar region differ from those near the equator by about ten milliseconds. When the pivot errors from the 1946 March to May data are applied, the main features as outlined are not materially altered. As 83 groups extend between six and twelve hours in R.A. and 35 groups extend over more than twelve hours, the observations will provide material for control of the periodic errors in R.A. of the FK_3 system; discussion is being deferred, however, until more observations have been obtained.

Photographic Zenith Tube. - The construction of this instrument by Sir Howard Grubb Parsons & Co. is still in progress. Tests on the mechanisms for constraining and driving the carriage have been carried out at the works of Messrs. Grubb Parsons in conjunction with the Observatory. Preliminary tests were made in July 1946 on a small scale model; the results were encouraging but could only be regarded as tentative firstly on account of the difference in scale and secondly because the tests were at that time inevitably made under static conditions which are unrepresentative both dynamically and in duration. These tests were however useful as an indication of the requirements to be met in final tests and in revealing certain features of the system. For example, the spring constraint differs from the ball constraint in being susceptible of adjustment, and the method, since adopted, of adjusting for minimum rotation of the carriage was suggested by the results of the preliminary tests. The carrying out of final tests has had to await the completion of certain components of the instrument itself and is therefore still incomplete. An important modification of the photographic timing-system has been made. In the original design the optic axis was horizontal so that the coordinates on the timing plate were in the right ascension and vertical directions. Knowledge of the vertical coordinate is, however, required only to comparatively low accuracy whereas the declination coordinate is critical. The system has therefore been redesigned so that, the optic axis being vertical, the coordinates on the plate are in right ascension and declination; this change results also in simplification of mechanical design of the constraint and motion of the carriage of the timing-plate. Unfortunately the erratics of motion of the stellar-plate carriage are liable to be greater in the vertical than in the horizontal direction owing to asphericity of the balls on which this carriage rolls. The effect of such erratics is to produce variations of scale value on the timing-plate which introduce irregularities in the time scale (though not, if the centring is correct, in the declination component). This cause of error may however be eliminated by the introduction of a small auxi-

liary carriage which slides, instead of rolling, on an optically flat surface, and is connected to the main carriage by a spring linkage which provides flexibility in the vertical direction. In the completed design two such timing systems are to be provided on an east-west diameter on either side of the annular stellar carriage. By this means additional accuracy in the time scale is to be expected, while combination of the measurements in declination of the records obtained by the two systems secures a complete check of the motion of the stellar carriage under the actual conditions of operation. This provides a solution of the problem of replacing the earlier visual and long drawn-out static tests by a dynamic test of adequate precision and relevance suitable for use during the initial investigations of performance; it can also be applied in the ultimate use of the instrument, whenever it is considered desirable, to derive, from the records made primarily for time determination, the latent additional information they contain concerning the erratics of motion in declination.

Tests have also been made on the stability of the mounting of the stellar plate holder. In the main these have given satisfactory results, but have indicated certain weaknesses for the elimination of which further attention is required.

Further consideration has been given to the details of the mechanism for reversing the rotary. One of the minor improvements contemplated is the introduction of air-buffers to avoid any trace of bumping against the fixed stops.

In addition to the experimental tests carried out at Messrs. Grubb Parsons, auxiliary experimental work has been done in the Optics Laboratory at the Observatory. For example, preliminary tests were made of the optical system of the photographic timing method with respect to distortion of the projector and selection of the most suitable type of photographic plate. We are indebted to Mr. Wilfred Taylor of Messrs. Cooke Troughton & Simms for assistance in connection with the selection of the most suitable projector and for carrying out independent tests for this purpose. The construction of the auxiliary unit which is required to actuate the Arditron lamp has been completed. This was designed so that a frequency of 10 flashes per second can be employed when this is required in work on the Horizontal Transit Instrument. It is also suitable for use in experimental work on the P.Z.T., but for exclusive use on the P.Z.T. where the higher frequency is unnecessary a modified form of unit would suffice. Experimental work is also in progress at the Observatory relating to the design of the system of supporting and adjusting the mercury basin, and to the design of basin best suited to give the immunity from tremors and ease of cleaning.

In the Report for 1945 mention was made of the introduction of an optical method of setting the height of the mercury surface. By this method the surface is set to a specific height with respect to that region of the telescope tube which is at the same level. Constancy of scale value is thus preserved only provided the tube length is invariable. It was intended therefore to measure the temperature of the tube and to vary the position of the fiducial point at which the optical settings were made so that in spite of expansion of the tube the optical criterion corresponded to a fixed scale value. The method has recently been modified to avoid the necessity of making the temperature measurements and resetting the fiducial point. An invar pendulum is suspended from the top of the tube and at the side so that its lower end is a little above, and to the side of the mercury basin. A plane mirror which has its reflecting side downwards is attached to the bottom end of the pendulum, and forms part of the optical system. This system is such that settings made on a fixed fiducial point correspond to constant difference in height between the mercury surface and the plane mirror and therefore approximately to constant scale-value.

Some preliminary investigation has been made of the departure from true level, and of the stability of level, of a shallow pool of mercury. The question is of importance in the use of instruments other than the P.Z.T. There appears to be but little direct experimental evidence available, and none at all to the order of accuracy required: namely 0".01. The method which seems to give the best promise of securing adequate sensitivity is electrical rather than optical.

A brief description of the optical method of levelling the stellar plate has been prepared for publication, since this was considered to have possible application for other purposes.

The special Measuring Machine which was designed for measuring the stellar plates of the P.Z.T. has been completed by the Cambridge Instrument Company and received by the Observatory, where preliminary tests have been carried out. In connection with the measurement of such plates it is hoped shortly to carry out some experiments in the Optics Laboratory to determine whether greater precision and ease of setting than is possible visually can be obtained by the use of a photometric device recently developed by Messrs. Ferranti Ltd. and exhibited by them at the Physical Society's Exhibition in April 1947.

Horizontal Transit Instrument. - Direct work on the construction of this instrument has been considerably delayed by the prior claims of other work. The construction of the glass optical components of the variable-deviation system, and also of a special set of polished stainless steel blocks for the timing-system has been completed. Some of the experimental work referred to under the heading of the Photographic Zenith Tube is applicable to this instrument also; for example, the work on the Arditron Lamp, on the selection of photographic plates, and on the mercury basin.

A considerable amount of experimental work on the development of an electrical drive of the D.C. motor-generator type suitable for operating the variable-deviation system has been brought to a satisfactory conclusion: adequate rapidity of response to hand control and stability of motor-speed over a wide range have been achieved. As was pointed out in the previous report, this work is of wider importance; and in point of fact the development of a similar electrical system, intended for incorporation in the Bamberg Transit Instrument, has been nearly completed. We are indebted to Dr. Uttley of Telecommunications Research Establishment for his suggestions and help in the early stages of this work.

In designing a system by means of which the maintenance of bisection of a stellar image is to be secured it is clearly important to have quantitative information concerning the erratics to which the position of the image is subject on account of atmospheric irregularities. Investigation of such erratics has been carried out in America, for example by Schlesinger; but it was considered that direct information of the conditions pertaining to this country would have greater relevance. Consequently an investigation has been in progress of which the essential feature is a micrometric examination of the stellar trails provided on a number of plates taken with the Cookson floating zenith telescope. By this means information on the short period stability required from the motor drive has been obtained and a rough estimate has been made of the probable error in time-determination due to atmospheric erratics.

Mirror Transit Instrument. - Some preliminary consideration has been given to the design of a transit circle in which the moving parts are reduced to a minimum, and in which an accurate control of the instrumental errors is possible. The moving portion consists of a mirror supported by trunnions to the east and west. Two

horizontal viewing telescopes in the meridian, to the north and south of the mirror, are used for star observations and also as collimators. A general discussion of the principles of the instrument is in course of publication by the Royal Astronomical Society.

Cape Zone Photographs. - The 90 plates of the declination zone -56° to -60°, taken with the wide-angle lens at the Cape Observatory, have been received. It was found that the region from 22 hours to 4 hours of right ascension, where the zone is nearest to the pole of the Milky Way, did not contain sufficient stars to provide a uniform distribution of stars in a zone catalogue. The 23 plates covering this region have therefore been rephotographed at the Cape with a longer exposure and are expected to be received at Greenwich shortly.

The standard co-ordinates of 3500 stars between 14 hours and 2 hours of right ascension have been computed. 23 plates have been measured and reduced, giving rectangular co-ordinates for 3750 stars.

Yapp 36-inch Reflector. - The main and auxiliary mirrors of the reflector were sent away for aluminising on 17th January 1946. The lenses and prisms of the spectrographs were sent at the same time for blooming with a non-reflecting coating. There was serious delay in completing this work. The main mirror was away for $3\frac{1}{2}$ months and it was not possible to remount it until May. Opportunity was taken when the mirror was remounted to give the telescope a thorough overhaul, as it had been out of use during the war period, with the mirror dismounted, so that the telescope could not be moved. The optical parts of the spectrograph were not received back until October. Neither the aluminising nor the blooming was particularly satisfactory and it is clear that work of this nature should be undertaken at the Observatory, both to obviate the long delays when it is done commercially and also to ensure coatings of better quality.

25 spectra of 10 bright stars, with spectral types from A0 to K0, have been photographed with the 3 prism train in the blue-violet region. Comparison with spectra of the same stars secured previously with silvered mirrors and unbloomed prisms shows that there has been a satisfactory gain in the extension of the spectra into the ultra-violet and an appreciable saving in the exposure time for the same density of spectrum.

The recording microphotometer has been completely overhauled preparatory to the detailed examination of the spectra.

Photoheliograph. - Photographs of the sun were obtained on 255 days. The number of photographs selected for preservation is 489 including 19 with double images for determination of the zero of position angle. The zero has also been determined regularly by a visual method. From reports received from H.M. Astronomer at the Cape and from the Director of the Kodaikanal Observatory, India, no days are unrepresented in the combined series for 1946.

Consignments of solar negatives received from the Cape during the year cover the epoch 1945 October to 1946 December, with the exception of the interval 1946 March 15 to May 30; the consignment for this period has been dispatched but has not yet been received at Greenwich. A request has been sent to the Director of the Kodaikanal Observatory for 17 negatives to fill gaps in the combined Greenwich-Cape series for the epoch 1943 January to 1946 December.

As stated in last year's Report, a number of solar negatives on a scale of 3 inches to the sun's diameter were received from the solar observatory on Kanzelhohe, near Villach in Upper Carinthia, Austria. During the current year, 155 negatives have been received covering the period 1945 July 25 to 1946 May 10.

385 Cape plates, 16 Kodaikanal plates and 8 Washington plates have been measured during the year to complete the measurement of the combined series from 1940 December 9 to 1944 January 4.

Computations of sunspot positions and areas have been made for the combined series from 194C May 1 to 1941 December 4 and for areas alone up to 1943 October 4.

Daily sunspot numbers based on Wolf's system of counting have been sent to the Director of the Zurich Observatory for incorporation in the *Quarterly Bulletin on Solar Activity*.

Provisional mean daily sunspot numbers, based on the Greenwich observations, are sent monthly to various research centres, which also receive early notification from Greenwich of sunspot groups of area greater than 500 millionths of the sun's hemisphere. To the list of eight centres given in the last Report, the following have been added by request:-

Cavendish Laboratory, Cambridge: Department of Natural Philosophy, The University, Edinburgh: Admiralty Signal Establishment Extension, Nutbourne: and the radio research station of the Ministry of Supply.

The provisional mean monthly sunspot number for the twelve months is 110 as compared with 48 for the previous epoch. This marked rise in sunspot frequency includes the occurrence of three giant groups with respective times of central meridian passage and latitudes as follows:- July 26.8 (22° north): March 10.2 (23° south) and April 6.8 (24° south). The approximate maximum areas were 3950, 4300 and 5400 millionths of the sun's hemisphere. Thus, within fourteen months, the great sunspot of 1946 February, which with its peak area of 4900 millionths had become the greatest in the Greenwich records, has now been surpassed. Moreover, the spot of 1947 March (the predecessor of the April spot) and that of 1946 July are probably the third and fourth largest. The appearance of these giant spots together with the general rise in frequency of all spots since the sunspot minimum of 1944.2 point to a high solar maximum yet to be reached.

The preliminary study of the sudden commencements of magnetic storms recorded at Greenwich-Abinger for the years 1879-1944 has been completed, and the results are being published by the Royal Astronomical Society in *Geophysical Supplement*.

Spectrohelioscope. - This instrument was used on 158 days, but on 27 days observations were limited to a few minutes because of poor observing conditions. 35 solar flares were observed in $H\alpha$ during the year; 1 was of major importance, i.e. of intensity 3 on the International scale. 390 measures were made of line-of-sight velocities of bright and dark flocculi. The 154 measures of bright flocculi also provide equivalent line-widths of $H\alpha$. Photometric measures were made on 104 patches of bright flocculi. Line-of-sight motions were measured in 37 prominences.

Line-of-sight velocities measured on the sun's disk exceeded 100 km./sec. on four occasions, the greatest being 235 km./sec. outwards from the chromosphere. These motions were of absorption markings associated with solar flares.

Details of solar flares and times of observation with the spectrohelioscope are sent quarterly to the Director of the Meudon Observatory for incorporation in the quarterly Bulletin, published from Zurich under the auspices of the International Astronomical Union.

Four of the twelve research centres receiving sunspot data from Greenwich are immediately notified of the occurrence of any flare of intensity 3. The Solar Physics Observatory, Cambridge, is also informed of any unusual chromospheric activity.

The Brentwood radio station of Cable and Wireless Limited continues to report direct to the Royal Observatory any radio fade-out while it is in progress. This information is very useful in connection with the observation of solar flares. Other ionospheric data are sent regularly to Greenwich by the Superintendent, Radio Research Station, Slough, the Engineer-in-Chief, Radio Branch, G.P.O., and the Controller (Engineering), B.B.C.

One solar flare of intensity 3 and three flares of intensity 2 were observed on the disk in the region of the great July sunspot.

The occurrence of a flare of unusual intensity and duration on July 25 was recognised as highly probable from a report from Cable and Wireless Limited of a complete and prolonged fade-out beginning at 16^h10^m U.T. Confirmation of such a flare observed in *Hα* came from a telegraphed message from Dr. M. A. Ellison who had observed the early stages and maximum of the flare from Sherborne. Thereupon, a warning from Greenwich of an impending geomagnetic storm (the flare being in the central part of the sun's disk) was circulated to research centres some hours before the storm began, $26\frac{1}{2}$ hours after the peak brilliance of the flare. A contact print of a spectroheliogram, kindly sent later by the Director of the Meudon Observatory, showed the enormous extent of this solar flare.

The unfavourable weather during much of the time of the disk passages of the two other great sunspots enabled only a very imperfect sampling to be made by direct observation of the degree of chromospheric activity associated with these spots. But the absence of flares that were both intense and prolonged, when the spots were in the central part of the sun's disk, may be inferred, for the Greenwich daylight hours, from the general absence of important radio fade-outs at those epochs. It is therefore in accordance with these observations that no great magnetic storms occurred about March 10 and April 7, though one of lesser magnitude began on March 8. A short-lived but severe magnetic disturbance (H range 370γ: V 345γ: D 65') on April 17-18 is an interesting case, at present obscure in its relation to any specific solar flare. A major fade-out, denoting a flare of prolonged intensity, occurred on April 15 at 14^h57^m, nearly 46 hours before the "sudden-commencement" of this geomagnetic storm. The active chromospheric region suspected is that in the wake of the great sunspot (itself nearly two days out of sight around the west limb), but unless very extended in longitude, no directive solar-particle stream from this region would have been expected to reach the earth from this excentric position on April 15. A spectroscopic record of the sun's disk at 15^h U.T. on that day would provide very useful evidence. On April 6, a good example of a geomagnetic "crochet" (U.V. solar radiation effect), indicating an intense solar flare, though probably not of long duration, was recorded on the Abinger magnetograms. The movement began sharply at $11^h51.7^m$ U.T., reached a maximum amplitude of -40γ in H at 11^h55^m and ended at about 12^h10^m. A corresponding fade-out began sharply at about 11^h54^m and lasted generally for about 15 minutes on a number of channels. No solar observation was possible owing to cloud. Subsequent enquiry showed that a sharp increase of "solar noise" had been recorded at the Cavendish Laboratory, Cambridge, and by the radio research department of the Ministry of Supply at 11^h57^m or 58^m and had lasted for nearly 10 minutes.

A paper on geomagnetic crochet-occurrence at Abinger, 1936-1946, and allied solar and radio data has been completed during the year and sent to the Royal Astronomical Society.

III. TIME SERVICE.

The installation of the twelve quartz clocks and their associated equipment was completed in October by the engineers of the Post Office Radio Branch. From February 6th, when the rhythmic signal transmitting motor was transferred to the new control room, the whole of the quartz clock equipment has been operated from the battery supply. This has considerably reduced the number of failures due to interruption in the electricity mains supply. The twelve clocks are divided into four groups, classified under the letters B to E; the clocks in each group being numbered from one to three. Two remaining groups, A and F, with phonic motors on loan from the Observatory, are at present running on test at the Post Office Radio Branch Laboratories, prior to their installation at Greenwich.

It has been the general experience with standards of this type that during the initial period of operation the crystal is subject to a rapid and unpredictable frequency drift; the performance of the Abinger clocks during the year has shown some improvement in the stability of the rates. The clocks that have performed most satisfactorily are B1, B2, C3, D3 and E1 and for this reason these have been used to operate the phonic motors, and have been employed for prediction purposes in connection with the transmission of the time signals. B2 has normally controlled the motor used for the emission of the rhythmic time signals, and has provided the source of standard frequency for the experimental 2 Mc/s transmissions. During the period April 16 to July 4, when B2 was subject to some variations of rate, these functions were performed by the clock D3.

The performance of only five clocks can be directly determined, as there are only five sets of frequency dividers, each of which operates a phonic motor. The performance of the remaining seven crystals can be judged only from figures given by the beat counters. These counters have not proved satisfactory, especially when pairs of clocks with large relative rates are involved. Similar difficulties have been experienced elsewhere, and this matter has received attention at the Post Office Radio Branch Laboratories. A new form of beat indicator has been designed, and will be fitted in the Greenwich installation. The present beat counters at Abinger will be replaced by the improved pattern as soon as supplies become available. As an interim measure, in order to keep a check on the Abinger clocks, a simple frequency comparator, for use in conjunction with a decimal counter chronometer, has been constructed in the electronics laboratory and is now in regular use. Although by this means frequencies may be compared with an accuracy of the order of one part in 10^{11}, only instantaneous relative values are determined and these may differ slightly from the mean daily rates.

The reserve phasable phonic motor, which is provided with rhythmic contacts of the drum pattern, has been fitted with two sets of additional cam-type contacts of a new design, which are being tested prior to their incorporation in the new signal transmitting motors now nearing completion at the factory of Messrs. Muirhead & Co. These contacts, designed to operate at intervals of one minute or longer, were tested at a speed of 61 operations per minute in order to compare the magnitude of the contact variations with those observed in the present type of drum contacts. It was found that the mean scatter was reduced from 0.10 milliseconds to 0.06 milliseconds, which was not sufficient improvement to warrant their use at the higher speeds in the new motors, as they are noisier in operation, more costly, and subject to greater wear than the drum type.

The installation in the new control room is nearing completion, but progress has been show, largely owing to the fact that the staff engaged on this work is also responsible for the maintenance of the operational equipment. With the necessarily

complex instruments now employed for precision time-keeping, efficient maintenance and adjustment has become an important section of the work of the department, and great attention is being paid to the practical design of new items of equipment to facilitate testing and rapid replacement of defective units. All essential parts of the system will, where possible, be duplicated, in order to permit observing staff, who may not necessarily be fully acquainted with all the technical details of the operational equipment, to switch over from a faulty unit to a reserve.

Five electronic send relays of an improved design, which allow for convenient maintenance without removal of the chassis from the rack, have been built and installed. By means of a switching panel, the send relays can be connected at will to the four outgoing lines, and provision is also made for switching the Post Office lines to the various test positions necessary for the location of faults by the Post Office engineers.

Several modifications have been made to the decimal counter chronometers, which have been remounted on standard 6′6″ racks together with associated units. Provision has been made for the selection of one of four standard count frequencies, and a device has been fitted which enables the counter to start and stop on consecutive pulses on the same channel. Seconds impulse dials for checking comparison times have been provided. In addition to the plug and jack selection panel of the type previously used for the connection of clock and radio signals to the counter, sets of push button switches have been provided, which are connected to the circuits normally required during the daily routine.

Four National H.R.O. and two Hallicrafter SX 28 radio receivers have been modified for time signal measurement and special attention has been given to the screening of leads to and from the sets in order to minimise interference arising from other apparatus in the department.

During the period May-July 1946, Small Transit B was in use at Abinger for astronomical observations for the determination of clock errors. The instrument was then removed to Greenwich, its place being taken by Transit D. The numbers of observations secured at Abinger during the two periods were 40 and 73, making a total for the year of 113. During the period August 1946 to April 1947, 99 observations were taken at Greenwich with Transit B, these observations being combined with those secured at Abinger into a system upon which the performance of the various clocks has been assessed.

At the request of the Director of the Commonwealth Observatory, Mount Stromlo, Canberra, a special programme of observation was undertaken to obtain an improved value of the longitude of the Mount Stromlo Observatory. This involved the erection at Abinger of a rhombic aerial in order to receive special radio time signals emitted by the transmitter, VHK_{14}, at Belconnen, near Canberra. Assistance in the erection of this aerial was given by 90 Group, Air Ministry, whose cooperation was much appreciated. Good reception of the time signal emitted at 19.00^h U.T. (10.350 Mc/s) was maintained, in general, over the period August to December, after which the programme was discontinued. The England-to-Australia radio link was effected by means of the rhythmic time signals emitted from Rugby (GKU_3) on a frequency of 12.455 Mc/s. Reception at Mount Stromlo of these signals was not at first satisfactory, but was greatly improved when, with the assistance of the Engineer-in-Chief, Radio Branch of the G.P.O., arrangements were made for the transfer of GKU_3 from a directional to a non-directional aerial. A discussion of the results shewed that no correction to the adopted longitude of Abinger was necessary, but that the previously accepted longitude of Mount Stromlo placed the Observatory $0^s.103$ too far to the East.

The normal programme of time signal transmission and reception has been continued at Abinger. There has been some increase in the number of time signals received. These now include transmission from France, Russia (Moscow and Tashkent) and America, as well as the long wave and short wave British time signals. In addition daily comparisons have been made, when reception conditions permitted, between the Abinger clocks and the seconds pulses superposed on the WWV standard frequency emissions of the Washington Bureau of Standards.

Damage caused by icing to the aerial at the Rugby radio station prevented transmission of the GBR 10.00 and 18.00 signals between February 8 and April 13, 1947. During this period the emission of the signal was transferred to the station GBZ at Criggion, which operates on a frequency of 15.2 kc./s. Although in this way continuity of the signal was assured with an adequate accuracy for navigational needs, the very slow and unsteady build-up of the radiated signals, combined with variations in land-line lag and signal strength at the receiver, made some loss of precision inevitable.

On April 18th at 11.00 U.T. a special time signal consisting of ten minutes of mean time seconds dots was sent out from the Observatory and radiated by the British Broadcasting Corporation for the purpose of timing the Heligoland demolition seismic experiments. At the request of Prof. Lindblad, Director of Stockholm Observatory, arrangements are being made to transmit a time signal consisting of a continuous series of rhythmic dots from 11.05 to 16.20 U.T. during the eclipse on May 20, 1947. These signals will be radiated from Rugby GBR on 16 kc./s and from two suitably directed short wave transmitters which have been allocated for the purpose by the cooperation of the Engineer-in-Chief, Post Office.

At Greenwich a Dent regulator controlled by Shortt 67 has been providing a reserve service of six-dots time signals for the B.B.C. and hourly signals for the Post Office. Comparisons between this clock and those at Abinger have been made daily over a land-line. The batteries, charging equipment, and control board for the six quartz clocks have been installed and work is in progress in preparation for the delivery of the clocks themselves.

The staff of the electronics laboratory has cooperated in the design of equipment for the control room, and in the construction of some of the units. The experimental transmitter, which was described last year, was in use until April 23 for the radiation of the 2 Mc/s standard frequency transmissions. An aerial matching unit has been designed and made, and a considerable increase in radiated power has been effected. A 300 watt transmitter has now been adapted for this purpose, and has been in use since April 24. In the design of the 100 kc./s to 2 Mc/s converter great attention has been given to securing a high phase stability. Reception is reported to be entirely satisfactory at the Post Office Research Laboratories and at the British Broadcasting Corporation Receiving Station, and precision frequency comparisons are made daily. A voice announcement has replaced the morse call sign previously employed and at the end of each transmission, a provisional correction to the radiated frequency is given. Comprehensive switching, modulating and monitoring equipment for semi-automatic operation of the transmitter has been designed, constructed and tested, and is now in course of installation.

The long wave receiver, fully described in the 1945 report, has been further modified. A new radio-frequency unit, with higher gain to permit effective operation on GBZ, which gives a lower signal strength than GBR, has been designed and is now under construction. Other modifications have been made to make the receiver self-checking in its adjustments, and more compact.

The possibility of using frequency dividers of the pulse counting type down to very low frequencies, thus dispensing with phonic motors, is being investigated. There are many applications in which the erratics inherent in phonic motors cannot be tolerated, and it is expected that this divider may find uses apart from the long wave receiver testing equipment for which it was primarily intended. For this testing equipment special linear time base circuits have been designed and tested and a portion of the cathode ray tube equipment has been constructed.

IV. CHRONOMETERS.

The rating and supply of chronometers and watches to H.M. Ships continues in requisitioned premises at Bradford-on-Avon.

The number of Admiralty chronometers and watches on charge to the Royal Observatory is 20,920 all of which are held at Bradford-on-Avon. Of this total 376 chronometers (Patt. H.S.1), 352 chronometer watches (Patt. H.S.2 and H.S.6), 430 deck watches (Patt. H.S.3), 162 dashboard watches (Patt. H.S.4), 109 pocket watches (Patt. H.S.5), 81 stop watches (Patt. H.S.7), 104 wrist watches (Patt. H.S.8), and 422 wrist chronographs (Patt. H.S.9) are rating or ready for issue but reserved. The remainder, consisting of 251 Patt. H.S.1, 3673 Patt. H.S.2 and H.S.6, 7580 Patt. H.S.3, 1465 Patt. H.S.4, 1451 Patt. H.S.5, 475 Patt. H.S.7, 1562 Patt. H.S.8, 2050 Patt. H.S.9 and 377 other assorted types are held in store awaiting adjustment, rating or repair. Nine chronometers and watches are in use at the Royal Observatory.

The stock of watches 6B/60 held on behalf of the Air Ministry totals 250, of which 73 are rating, 22 are in reserve and 155 await repair.

In addition there are 345 chronometers and watches deposited for various reasons.

During the year ended 1947 April 30 a total of 9,454 chronometers and watches was received and 11,461 issued. The number sent for repair was 2,138 including 3 for the Air Ministry. The year under review saw a considerable falling off in the number of transactions which, in the latter months, were approaching the pre-1939 level. The routine computing and notation work of the Office is completely up to date.

With one exception the recovery and return to owners of chronometers loaned to the Admiralty for the duration of the war, was completed during the year.

The supply of chronometers and watches for use on ships transferred to Commonwealth and Foreign Governments was continued. In addition, although no surplus has been declared at present, assistance was given by the sale of chronometers from Admiralty stocks towards meeting the demands from the Mercantile Marine which could not be met from normal trade sources. A total of 34 chronometers and watches was supplied from Bradford-on-Avon for this purpose.

A total of 1,605 stop watches Patt. H.S.7 and 4,055 wrist watches Patt. H.S.8 was declared surplus to requirements and transferred to the Ministry of Supply Disposal Department to be sold.

The standard clock at the Liverpool Chart & Chronometer Depot was removed to Bradford-on-Avon in July 1946 and after overhaul was re-installed in its original position at the Chart & Chronometer Depot, Sheerness on 12th December 1946.

The number of chronometers and watches repaired and adjusted in the Observatory watch repair shop during 1946/7 was 1,973 which included 32 chronometers and 227 Chronometer watches. With the termination of the chronometer making firm of Messrs.

V. Kullberg, consequent upon the death of Mr. S. Lundqvist, the repair shop will be required to undertake more chronometer repairs. The shop is now equipped and competent to complete all work ancillary to the general overhaul of chronometers and watches which may be necessary to maintain the standard of these instruments efficiently.

The three larger Harrison timepieces, formerly displayed at the National Maritime Museum, were brought from the Museum to Bradford-on-Avon in July 1946. They had been stored at Cambridge throughout the war years and the steel work of Nos.1 and 2 had become badly rusted in parts. The overhaul of No.2 was entrusted to Mr. Evans in the watch repair shop, the work being completed satisfactorily and the machine returned to the Museum for exhibition in going order on 17th October 1946. The restoration of No.1 has now been put in hand and is expected to take longer as a number of parts will certainly need remaking. The machine No.3, dismantled by Lt. Commander Gould in 1939, is still unassembled. In connection with the maintenance of these historical horological pieces, Lt.Commander Gould has generously presented to the Observatory fourteen manuscripts and notebooks compiled whilst he was engaged on the restoration and maintenance of the machines between 1921 and 1939.

V. NAUTICAL ALMANAC OFFICE.

The routine calculation and proof-reading involved in the preparation and printing for which the Office is responsible have been continued throughout the year. The efficiency of the Office remains seriously impaired by staffing difficulties, the present staff being still considerably below pre-war level in both numbers and gradings.

Delays in printing have been even greater during the last year than previously, and the publications of the Office are seriously behind schedule. At one time during the year, the printers were more than 800 pages behind the agreed schedule for composition; although these arrears have now been largely reduced they have caused serious delay in the subsequent stages of production.

The Nautical Almanac. - Despite every effort on the part of the Office to have the Almanac for 1948 published before the end of the year, the above mentioned printing difficulties have caused so much delay that publication will not take place till the beginning of May.

The first part of the *Nautical Almanac* for 1951, containing the fundamental ephemerides of the Sun, Moon, and planets, has been similarly delayed in printing and the usual advance distribution will probably be delayed until June. This distribution is being extended to cover the principal observatory in each country, and it is hoped that this will obviate the sporadic demand that has been experienced recently.

No changes have so far been made in the contents and presentation of the Almanac. Some work has been done on the contents of the separate supplement, the continued shortage of staff and printing difficulties make it impossible to predict a date for its publication.

Occultations and Eclipses. - The occultation programme has been further increased. Predictions are now being computed for the German stations and it has proved necessary to add several new stations. Extra predictions were done for 1947 and 1948 for some of these stations, involving about 1140 computations.

Besselian elements for 2680 stars of magnitude 7.5 or brighter occulted during 1949 were received from the office of the *American Ephemeris*. These stars were examined by means of the occultation machine and preliminary times and position angles recorded for 82 stations for 1312 stars, the other 1368 having been discarded as not observable under suitable conditions. After computation a further 92 stars were rejected and the elements of the remaining 1220 stars will be published in the *Nautical Almanac* for 1949. The predictions for 1949 have not been fully completed but the number will be about 11,400.

The receipt of observations is becoming somewhat more regular although observations for the war years are still being received. During the year the numbers of observations received for the years 1943, 1944, 1945 and 1946 were 14, 44, 271 and 540 respectively.

The discussion of the occultations observed in 1943 is approaching completion and it is hoped that the results will be published shortly, together with provisional solutions for 1944 and 1945. For most of the observations for 1944 one reduction has been done; duplicate computations will be undertaken whenever staff is available.

The path of the total solar eclipse of 1948 November 1 was computed for every minute for the part crossing Kenya Colony and for two positions near the Farquhar Islands. Notes on these portions of the path were circulated and charts were prepared for the use of the Radcliffe Observatory, Pretoria.

Abridged Nautical Almanac and Air Almanac. - Printing difficulties have caused so much delay in the production of the *Abridged Nautical Almanac* for 1948 that publication will not take place until May.

During the year, two parts of the *Air Almanac* for 1947 have been published, and the third should be available shortly.

No change has been made in the contents or presentation of the *Abridged Nautical Almanac* or *Air Almanac* for 1948.

Apparent Places of Fundamental Stars. - The volume for 1947 was not published until October 25 due to printing difficulties. It is hoped that the publication date will be much advanced for 1948.

The computations for 1948 were done by the offices originally responsible for them although material for 159 stars normally received from Berlin was also received from the office of the *American Ephemeris*.

In order to ensure that the several offices which compute apparent places of stars for this volume should have a consistent set of mean places in ample time for their calculations, it has been decided to print the first 35 pages of the volume, containing the mean places, and to distribute lightly bound copies of these pages a few years in advance of publication. As an introduction to this scheme, copies of the mean places for 1948 have been distributed, those for 1949 should be available for distribution soon and first proofs for 1950 have been received from the printer.

General Navigation Work. - The question of the production and supply of charts for use with the Decca system of navigation has been discussed by representatives of of all the interests concerned. As a result it was decided that the Office should be responsible for the computations for the hyperbolic lattices required for Admiralty charts. This work, while of no astronomical bearing, is peculiarly suitable for the experience and equipment of the Office and is a natural extension of the astronomical

navigational work. The present programme for the English Chain requires about 50 charts, for 16 of which the computations have been completed. It is anticipated that another year will be required to complete this programme.

Various methods for doing these calculations have been examined and have been embodied in a report *The Computation of Decca Lattices* which will be published shortly. A simple method for the direct determination of position from hyperbolic lattice co-ordinates has also been devised and a description has been circulated.

The fourth R.A.F. specialist navigation course comprising eight officers from the Empire Air Navigation School, Shawbury, visited the Office from May 27-30 inclusive, to see the work of preparation of the *Air Almanac* and *Astronomical Navigation Tables* and to discuss matters connected with astronomical navigation.

The contact with practical navigators was again both stimulating and constructive. The discussions on the practical aspects of air navigation with particular reference to the contents and presentation of air publications were of considerable value and gave pointers for possible future development.

Ryde Night Illumination Diagrams. - During the year diagrams have been issued for the last four months of 1946 and for the first eight months of 1947. Two special diagrams were prepared for August 1949 for the War Office.

It has been decided that these diagrams are no longer required and the work on their preparation has therefore ceased.

The Air Ministry require a somewhat simpler "Daylight and Moonlight" diagram for which it was decided that the Office should provide master copies. One master diagram is required for each month and twelve have been provided for 1946 June to 1947 May. Subsequent diagrams are in course of preparation.

Proof-Reading. - During the year 2780 pages of first proofs and 2065 pages of stereo proofs or machine sheets, depending on whether the publication is printed from stereo plates or movable type, have been read. The first proofs have in almost all cases been read in duplicate, due to the necessity of using less highly trained staff on this specialised work.

Repayment Work. - The demand for lighting-up times, Moon's phases and times of moonrise and moonset continues on much the same level as previously. This and other information for diaries and similar publications is supplied on the normal basis.

Machines. - During the year four hand machines and one electric machine were declared redundant to the needs of the Office and have been transferred to other departments.

VI. MAGNETIC OBSERVATIONS.

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

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. Observations of horizontal intensity with a unifilar magnetometer and of magnetic inclination with an inductor have been taken frequently, however, for purposes of comparison.

The variations of declination and of horizontal and vertical intensity have been recorded photographically both on slow-run and quick-run recorders. The base-line values of the La Cour magnetographs continue to be remarkably steady.

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 1946 December 31 and with provisional constants to the present time.

The tabulation of results for 1946 awaits the receipt of the final list of International "quiet" and "disturbed" days, the preparation for publication being otherwise in an advanced state.

The mean values of the magnetic elements at Abinger for the year 1946 are given below.

The values for the years 1943, 1944 and 1945 are given for comparison.

	Declination (West)	Horizontal Intensity	Vertical Intensity	Inclination
	° ′			° ′
1943	10 16.2	0.18556	0.43172	66 44.5
1944	10 7.8	0.18566	0.43189	66 44.3
1945	9 59.5	0.18573	0.43207	66 44.3
1946	9 51.1	0.18569	0.43235	66 45.4

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. Weekly reports of the magnetic character of each day (*i.e.* the three-hourly range indices, on a scale of 0 to 9, and the daily character figure, on a scale of 0 to 2, estimated in accordance with the scheme adopted at the Washington meeting of the International Union of Geodesy and Geophysics, September 1939) are also communicated to a number of Geophysical research centres to assist their projects.

Some progress has been made in the application of this scheme retrospectively to years prior to 1940, and the three-hourly range indices for each day throughout the years 1937, 1938, 1939 have been estimated.

During the past twelve months there have been 18 magnetic disturbances reaching the dimensions of a "storm"; four of these reached the dimensions of "great storm". (A range of 30′ in declination and 150γ in horizontal intensity is considered the lower limit for a "storm"; 60′ or 300γ for a "great storm".) The most severe of these storms occurred on July 26-27 when a range of 925γ in horizontal intensity and 620γ in vertical intensity was recorded.

Mr. C. L. Hawson, Officer-in-charge of Lerwick Observatory, visited the magnetic station August 26 - September 6 and carried out a further series of comparison observations of vertical intensity with a portable balance magnetometer of the Copenhagen (La Cour) type with a view to restandardising the instrument.

Seven variometers for measuring changes in Vertical Magnetic Intensity have been tested at Abinger and certificates issued embodying the instrumental constants which were determined.

Magnetic Charts. - A revision of the Admiralty Charts of Magnetic Declination has been carried out with a view to the issue of an edition for the epoch 1947.5. The reduction to the epoch has been completed and new isogonal lines have been drawn. For the construction of these charts the position Long. $94\frac{1}{2}^\circ$ West, Lat. $73\frac{1}{4}^\circ$ North, has been adopted as the position of the north magnetic pole. This position is a provisional position based upon recent observations in the Canadian Eastern Arctic. There is strong evidence that the north magnetic pole is considerably to the north of the Ross-Amundsen position, hitherto adopted.

VII. METEOROLOGICAL OBSERVATIONS.

During the past twelve months 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. The measurement of the amount of solid matter polluting the air has been continued, using an Owens automatic filter. The Department of Scientific and Industrial Research (Atmospheric Pollution Section) has undertaken the maintenance and operation of an instrument for measuring gaseous (sulphur dioxide) pollution and the instrument was installed by them in the Christie Enclosure at the beginning of November.

The night-sky camera, which was temporarily removed to a position on the lawn near the Christie Building on 1940 November 18, was replaced on its original pier to the north of the Small Transit pavilion on August 15, 1946.

The tabulation of meteorological results for 1946 is complete and the preparation of copy for press is well advanced. The following details of the weather refer to the period of twelve months ending 1947 April 30.

The mean temperature was 48°.4 which is 1°.3 lower than the average for 100 years, 1841-1940. The highest temperature in the shade was 87°.0, registered on July 24. Temperatures exceeding 80° were recorded on 9 days.

The lowest temperature was 9°.0, which occurred on February 24 and was the lowest recorded since 1895 February 8. Temperatures of 32°.0 or below were recorded on 75 days, 26 of which were in February. February's mean temperature was 10°.5 below the average for 100 years.

The mean daily horizontal movement of the air was 273 miles which is 16 miles above the average for 50 years, 1867-1916. The greatest daily movement was 675 miles, which was recorded on April 23; the least daily movement was 58 miles, registered on January 21. The maximum pressure reached was 35.0 lbs. per square foot, on March 16.

The total period of *bright* sunshine recorded was 1238.9 hours, only 27.7 per cent of the total theoretically possible. There were 85 entirely sunless days, 69 being in the five months November to March. There were 28 nights on which a complete unbroken trace of δ Ursæ Minoris was obtained by the night-sky camera. The number of nights on which no trace of this star appeared on the plate was 98, while on a further 38 the record was not more than ten per cent of the amount possible.

The total rainfall during the twelve months was 30.63 inches, which is 6.30 inches more than the average for 100 years, 1841-1940. There were 203 days on which rainfall exceeding .005 inch was recorded. The wettest month was March, with 5.216 inches, a total never before approached in March during the period beginning 1815, and more than one inch higher that the previous high record of March 1916.

VIII. PRINTING AND DISTRIBUTION OF GREENWICH PUBLICATIONS.

Printing and distribution has not yet been resumed owing to the acute difficulties over materials and labour. As a result of a recent conference with Stationery Office and Admiralty representatives, proposals for resumption on a severely utilitarian basis have been submitted together with a time-table, and it is now expected that a programme of printing, designed to abolish arrears in five years, will shortly begin.

IX. PERSONAL ESTABLISHMENT.

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

(a) *Observatory Staff.*

Chief Assistants	- R. d'E. Atkinson, M.A., Ph.D., One vacancy.
Assistants	- R.T. Cullen, A. Hunter, Ph.D., P.J. Melotte, H.M. Smith, B.Sc., A.M.I.E.E., F.Inst.P., W.M. Witchell, B.Sc.
Secretary and Cashier	- H.G. Barker.
Junior Assistants (Higher Grade)	- H.W. Acton, H.H.J. Barton, E.A. Chamberlain, H.F. Finch, B.Sc., F. Jeffries, E.G. Martin, H.W. Newton, G.W. Rickett, L.S.T. Symms.
Assistant Experimental Officer	- J.D. Pope, B.Sc.
Head of Repair Shop	- a vacancy.
Junior Assistants	- K.C. Blackwell, Miss C.E. Chapman, C.C. Harris, P.S. Laurie, B.R. Leaton, Miss E.M. Moore, Miss J. Mounteney, Miss C.J.A. Penny, B.Sc., P.L. Rickerby, J.L. Rudd, A. Shortland, R.H. Tucker, G.F. Wells.
Departmental Clerical Officers	- Mrs. D.A. Estherby, J.J. McLoughlin.
Clerical Assistants	- Miss F.E.A. Jeffries, Miss C. Ryall.
Assistants (Temporary)	- V. Barocas, Ph.D., A.Inst.P., A.E. Cordwell, O. Nourse, G.B. Wohlgemuth, R.M.J. Withers, M.A.
Hostel Warden	- Mrs. A. Hewitt.
Temporary Clerks Grade II	- Miss B.G. Collett, Mrs. D.A. Cairns, Miss P.B. Hill, P.A. Hogan, S.R. Plester, Mrs. M.M. Pratt, A.J. Wool.
Temporary Clerks Grade III	- Miss A.L. Chapman, B.J. Harris, Miss K.M. Hempstead, Mrs. L.E. Nicholls, Miss R.O. Pavey, Miss J.J. Peters, Miss J. White.
Temporary Shorthand Typist	- Miss B.A. Martin.
Temporary Typists	- Miss B.I. Dean, Miss M.A. Way.
Laboratory Assistants	- L.J. Bates, H.G. Gill, D.C. Smith.

(b) *Nautical Almanac Office Staff.*

Chief Assistant as Superintendent	- D.H. Sadler M.A.
Assistant	- Miss F.M. McBain, M.A.
Assistant (Temporary)	- J.B. Parker, B.A.
Junior Assistants (Higher Grade)	- A.E. Carter, A.J. Daniels, S.G. Daniels, H.W.P. Richards, B.Sc., W.A. Scott, B.Sc.
Junior Assistant as Secretary.	- Miss D.J. Ifield.
Junior Assistants	- W.G. Grimwood, G.A. Harding, Miss J.E. Pullen, Miss M.R. Rodgers, E. Smith.
Clerical Assistants	- Miss Y.I. Reddy, Miss I.M. Restorick.
Temporary Clerks Grade II	- Miss D.M. Fooks.
Temporary Clerks Grade III	- Miss S.B. Cauchois, Miss P.R. Clare, Mrs. E.F.M. Freeman, Mrs. P.M. Gilbert, J.E.W. Holborow, W.A. Hulme.
Clerk-Shorthand-Typist	- Miss J.E. Perry.

Dr. R. d'E. Atkinson, Chief Assistant, who had been loaned for special duties in another Department of the Admiralty, returned on June 6.

Dr. D. S. Perfect, Scientific Officer, has been retained throughout the year on loan from the Department of Scientific and Industrial Research.

Mr. H. Warden, Head of Repair Shop, retired at his own request on April 30.

Mr. G. A. Harding, Mr. B. R. Leaton and Mr. R. H. Tucker returned from H.M. Forces during the year.

Mr. J. D. Pope, Assistant (Temporary), was appointed Assistant Experimental Officer on March 12.

Mr. A. E. Cordwell, Mr. O. Nourse and Mr. J. B. Parker were appointed during the year as Assistants (Temporary).

Miss C. E. Chapman and Miss E. M. Moore were appointed as Junior Assistants.

Mrs. J. Bennett and Mrs. V. H. Rogers, Junior Assistants, have resigned.

Miss H. F. Scagell, Hostel Warden, was transferred to a larger Admiralty Hostel and replaced by Mrs. A. Hewitt, on November 27.

The industrial staff employed in all branches consists of a Foreman of Observatory, six laboratory mechanics, six watch adjusters and repairers, four messengers, two boiler attendants, three skilled labourers, one driver, six labourers, two gardeners, four nightwatchmen, one caretaker, three cleaners, two hostel maids and one laboratory boy, a total of forty two. Of this total seven have been engaged during the year for maintenance duties at Herstmonceux Castle. Mr. A. J. Johnson returned from service in H.M. Forces on October 28.

Mr. W. Le Brun, the senior watch repairer, died suddenly on January 16.

X. GENERAL.

During the year, Senor Manuel de Barros, of the Oporto Observatory, and Senor Martin Lórón, of the Madrid Observatory, visited the Observatory and stayed for some time to study various aspects of its work.

Dr. G. Abetti, Director of the Arcetri Observatory, Florence; Prof. J. H. Oort, Director of the Leiden Observatory; Dr. J. Jackson, H.M. Astronomer at the Cape; and Dr. Rutllant, of the Santiago Observatory, made visits to the Observatory.

Dr. van Dijl of the Radio laboratory at the Hague and M. Janouchevsky were amongst the visitors to the Time Department at Abinger.

The Swedish and Dutch Hydrographers, and Dr. J. Verstelle of the Dutch Hydrographic Department, visited the Nautical Almanac Office during the year to study the methods of producing Decca charts.

The First Sea Lord visited the Nautical Almanac Office on 25th February.

The Astronomer Royal, accompanied by Mr. Smith, visited Germany and Austria in June and July. The observatories at Göttingen, Heidelberg, Vienna, and the solar observatories at Schauinsland and Kanzelhöhe were visited. Arrangements were made for the assistance of the Astronomisches Rechen-Institut and for the continuation of the work of the Kanzelhöhe Solar Observatory. The Astronomer Royal gave some lectures in Vienna, under the auspices of the British Council. In September the Astronomer Royal and Mr. Smith visited Hamburg as guests of the British Naval Commander-in-Chief, Germany, and attended meetings of Directors of German observatories at the Bergedorf Observatory to discuss current problems and questions of international co-operation in astronomy. Mr. Smith subsequently visited a number of other German establishments in February. Dr. Atkinson left in April for a visit to Germany and Austria to make permanent arrangements for the future of the Kanzelhöhe Observatory and for a closer co-operation between this observatory and Greenwich.

The Astronomer Royal gave an address at a special service held in Burstow Parish Church on the 18th August to commemorate the tercentenary of the birth of the Rev. John Flamsteed, first Astronomer Royal.

The Astronomer Royal attended the commemorations of the centenary of the discovery of the planet Neptune, held in Cambridge and in Paris in October and gave an address in Cambridge on "John Couch Adams and the discovery of Neptune".

In December the Astronomer Royal visited Copenhagen to take part in the commemoration of the quatercentenary of the birth of Tycho Brahe.

The Astronomer Royal was a member of the Royal Society Delegation to the Indian Science Congress held in New Delhi in January. After the end of the Congress he visited the Kodaikanal Observatory, the Nizamiah Observatory, Hyderabad, and various scientific institutes in India.

The Astronomer Royal gave an address in Brussels on the 25th January on "The Life and Work of Sir Isaac Newton" in connection with the commemoration of the tercentenary of the birth of Newton. He also visited the Uccle Observatory.

At the invitation of the Commonwealth Government, the Astronomer Royal visited Australia in February to study the astronomical work being undertaken in Australia and to make recommendations about future developments.

Mr. Sadler left in April for a visit to the United States to see the work of the American Nautical Almanac Office, and to study the application of punched-card machines and other modern computing equipment to astronomical calculations.

Dr. Hunter was selected as a member of the British eclipse expedition to Brazil to observe the total eclipse of the Sun of the 20th May. This expedition, under the auspices of the Joint Permanent Eclipse Expedition, was in the charge of Dr. J. A. Carroll. Dr. Hunter assisted in the assembling and testing of the equipment prior to its dispatch by sea. The plane in which Dr. Hunter, in company with two other members of the expedition, was travelling to Brazil crashed at Dakar on the 13th April. The crash cost the lives of the two other members, but Dr. Hunter fortunately escaped with severe cuts and abrasions. As some of the optical equipment was also smashed, it was impossible to proceed with the expedition, which had to be cancelled.

Reference was made in last year's Report to the need for regrading the staff of the Royal Observatory, including the Nautical Almanac Office, on the basis of the reorganised Scientific Civil Service. This regrading has been approved in principle, but various details as to complements and assimilation terms remain to be discussed.

The purchase of Herstmonceux Castle as the future home of the Royal Observatory was completed during the year. About 370 acres of land surrounding the Castle have been acquired and will provide adequate space for the erection of the various instruments. The removal from Greenwich to Herstmonceux will be conditioned to a large extent by the rate at which building can be carried out. It is planned to erect during the present financial year a new solar building to house the photo-heliograph, two spectrohelioscopes, and spectrographic equipment. The 26-inch and 28-inch refractors, which it is difficult to protect against deterioration in their damaged domes, will be dismounted and stored at Herstmonceux until buildings and domes can be provided to house them. It is hoped that the staffs of the Nautical Almanac Office, of the Solar, Chronometer, and Magnetic and Meteorological Departments, and of the Office will be transferred to Herstmonceux during the year. Because of the present difficulties about housing accommodation for staff, one of the temporary huts at the Castle will be adapted for use as a hostel.

On the occasion of the commemoration of the tercentenary of the birth of Sir Isaac Newton, in London in July, the President of the Royal Society announced that the Chancellor of the Exchequer had agreed to provide funds for the construction of a reflecting telescope of 100-inches aperture, to be associated with the name of Sir Isaac Newton and to be available for use by qualified astronomers from all observatories in Great Britain. It has been decided that the Isaac Newton telescope will be erected in the grounds of the Royal Observatory at Herstmonceux. The telescope will be under the administrative control of the Astronomer Royal; a special Board of Management will be responsible for the scientific direction, including the designing of the telescope, the supervision of its construction, the consideration of programmes of observation, and the allocation of observing time between the various users of the telescope. The board of Management will consist of the Astronomer Royal (Chairman), the Astronomer Royal for Scotland, and the Directors of the Cambridge and the Oxford University Observatories as ex-officio members, together with four Fellows of the Royal Society and four Fellows of the Royal Astronomical Society. The telescope will enable British astronomers to undertake many programmes of observation which have hitherto been impossible because of the restricted light-gathering power of the largest telescope at present in use in Great Britain.

H. SPENCER JONES
Astronomer Royal

Royal Observatory, Greenwich.
1947 May 20.