REPORT

OF THE

ASTRONOMER ROYAL

TO THE

BOARD OF VISITORS

OF THE

ROYAL OBSERVATORY, GREENWICH.

Read at the Annual Visitation of the Royal Observatory, 1946 June 1.

THE BOARD OF VISITORS

The President of the Royal Society	Sir Robert Robinson	
The President of the Royal Astronomical Society	Prof. H.H. Plaskett	
		To serve until June 30th
Nominated as Fellows of the Royal Society.	Sir James Jeans	1946
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	Prof. P.M.S. Blackett	1948
	Dr. G.M.B. Dobson	1949
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Nominated as Fellows of the Royal Astronomical Society.	Prof. W.M.H. Greaves	1946
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Savilian Professor of Astronomy at Oxford.	Prof. H.H. Plaskett	
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The Report here presented refers to the period from 1945 May 1 to 1946 April 30 and exhibits the state of the Observatory on the last named day.

I. BUILDINGS, GROUNDS, MOVABLE PROPERTY AND LIBRARY.

New piers and gates have been erected at the Main Entrance to replace the temporary structure built when the original gates were destroyed in 1941.

The Shepherd 24-hour clock and the public barometer, near the Main Entrance, were considerably damaged when the Entrance was destroyed. As both of these were always of great interest to the public, repairs have been undertaken. The public barometer has been reinstated; the repairs to the 24-hour clock have been completed but the clock is awaiting a new dial.

The dome of the Altazimuth Pavilion has been recovered and painted preparatory to repairs to the building itself.

The covering of the dome of the 28-inch equatorial, which was seriously damaged by blast on several occasions, is beyond repair. In view of the pending removal of the Observatory from Greenwich, the covering will not be renewed. When storage accommodation is available, it is proposed to dismantle the instrument and to store it, pending re-erection on the new site, in order to prevent deterioration of the telescope and mounting.

General repair work on a limited scale has been carried out, where necessary, to doors, window-frames and other minor fittings, but no attempt has yet been made to commence any structural repairs.

A portion of Flamsteed House was repaired sufficiently to enable the Astronomer Royal to resume occupation on October 1.

A new telephone switchboard has been installed in the Lodge.

A Nissen hut to serve as a temporary workshop for the Time Department, a small brick building to house a Diesel generating set and a temporary garage for Service vehicles have been erected at the Abinger Magnetic Station.

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

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

A 13-foot spectrohelioscope, complete with coelostat, but 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 Ordance 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. 1, 2 and 3.

To the Science Museum:-

A number of astronomical instruments of historical interest.

Harrison's Time Machine No. 4 and the copy by Larcum Kendall are at present undergoing repair and cleaning by the Chronometer Section at Bradford-on-Avon.

The remainder of the optical and other equipment which was removed early in the war from the Observatory to a place of greater safety has now been brought back.

The annual examination of the Observatory Library has been made. 19 books are missing and cannot be traced at present. Of these, 16 were reported missing last year. 5 books which were missing last year have now been located.

II. ASTRONOMICAL OBSERVATIONS.

Airy Transit Circle. The restricted programme of observations has been continued. Observations of the Moon were resumed from December 10. The observations include:

85	observations	of	the	Sun
24	"	"	"	Moon
22	"	"		Venus
8	"	"		Mars
10	"	"		Saturn
6	"	"		Vesta

In addition, 848 transits and 411 zenith distances of stars in the clock and azimuth star lists were observed. The progressive deterioration of the objective through atmospheric corrosion is making observations with this instrument increasingly difficult. Many of the circle divisions have become almost or completely invisible as a result of the frequent cleaning necessitated by the rapid tarnishing of the circle in the polluted atmosphere at Greenwich, with consequent decrease in the accuracy of the zenith distance observations.

Further modifications have been made to the apparatus for determining the line of collimation. Observations to investigate the diurnal changes of collimation are in progress.

First Greenwich Catalogue of Stars for 1950 (1931-40). Further progress has been made with the preparation of Part II of this Catalogue, comprising stars in the zone +0° to +24° of declination. More than 2100 of these stars are not contained in the Albany General Catalogue. The computation of the proper motions of the stars not in the General Catalogue, on the basis of the system of the General Catalogue, is in progress.

Reversible Transit Circle. After the termination of the war in Europe steps were taken to resume investigations with this instrument, which had been partially dismantled in September 1940. The objectives of the telescope and of the collimators, and the micrometer eye-end, were fitted into position. The micrometer eye-end was cleaned and oiled and broken wires were replaced; in the course of this overhaul, the unfixing of the critically adjusted frame carrying the moving wire was necessary and a fresh adjustment has been made.

In spite of the care taken to protect the pivots, by enclosing them in sealed wooden boxes, filled with rust-proofing grease, it was found, when the pivots were uncovered, that there were a number of spots on their uppermost surfaces showing slight corrosion. Minute elevations caused by rusting could be detected by touch and were carefully removed, by application with pegwood of a paste of oil and diamontine, after which the pivots were polished. Tests with the mikrotast gauge indicated that the pivot errors were satisfactorily small.

Special attention has been given to the accurate determination of the pivot errors, with the aid of the pivot-testing telescope. A collimating lens is mounted inside one pivot and a small dot in the other pivot; the image of the dot is observed in the pivot telescope, which is mounted on the pier opposite to the dot; the displacements of the dot, as the telescope is rotated, are measured. The object used in the early investigations was a small globule of mercury on a piece of microscope cover-glass, which appeared black in an illuminated field. The image was found to be not uniformly well-defined at all positions of the instrument. Tests of the pivot telescope, which incorporates a negative lens in order to give a long effective focal length, revealed some defects of adjustment. It was accordingly returned to the makers for adjustment. After this had been completed, further tests were made using small circular holes in tin-foil, viewed in a semi-dark field: with this type of object, the diffraction rings are visible and permit of a more critical estimation of the quality of the image. Satisfactory definition is obtainable only when the aperture of the objective of the pivot-testing telescope is considerably stopped down. It is found that the apparent pivot errors are changed not only by rotation of the collimating lens but also by rotation of the cell in which the pin-hole is mounted. Systematic differences in the micrometer readings are found to occur according to whether the telescope is turned in the direction corresponding to increasing circle readings or in that corresponding to decreasing circle readings. A series of observations is in progress combining four positions of the collimating lens, at 90° apart, four positions of the object 90° apart, and increasing and decreasing circle readings. On completion of these observations, a thorough laboratory test of the optics of the complete system will be made.

Photographic Zenith Tube. Construction of this instrument by Sir Howard Grubb, Parsons and Co. is proceeding. In the report for last year, the principal features of the design were enumerated. Certain modifications to the details of that design have since been introduced. (a) The use of balls to constrain the carriage in a horizontal plane has been discarded; a special spring-strip constraint has been designed by means of which it is hoped to obtain greater perfection in rectilinearity of the motion. The system is compensated with respect to uniform temperature variation; to ensure sufficient uniformity of temperature during the recordings made on any one star essential components are to be immersed in oil. (b) A differential-roller mechanism has been designed for driving the carriage. If tests on this satisfy the requirements, it will replace both the screw and the intermediary wedge. It appeared doubtful whether these would give the required precision of movement. Moreover the use of the wedge presented difficulties in attaining the extended range of motion that is requisite in connection with the adjustment of the instrument in azimuth. A further advantage of the new system is the considerably greater simplicity of construction. The variation of carriage-speed required to cover the range of declination employed will be made electrically instead of mechanically, by varying the frequency of the input to the phonic motor. Methods for adjusting the frequency have been investigated. A slave-model incorporating the essential features of the new systems of constraint and drive has been constructed and will shortly be tested. (c) Work on the photoelectric method previously proposed for the emission of electrical signals from the moving carriage has been brought to a successful conclusion and an account of it will shortly be published. But though the method has ample sensitivity and is satisfactory in operation in a fixed location in the laboratory, its application to

the P.Z.T. involving, as it does, the mounting of the lamp, the optical system, the two photocells and the preamplifier, on the rotary, is not only somewhat cumbersome but introduces requirements of rigidity in the mounting of the photocells and other components, which it would require considerable precautions to satisfy. Moreover some doubt was felt about the effect of atmospheric heating from the lamp and valves on account of their proximity to the aperture of the instrument. The necessity of attempting to overcome any of these difficulties has now been removed by the introduction of a new photographic method of timing the carriage. This method, which was originally devised in connection with the Horizontal Transit Instrument, has the further considerable advantage of eliminating the use of a precise chronograph such as would be required in conjunction with the photoelectric (or mechanical contacts) method, since the recording system itself acts as a chronograph. Preliminary experimental tests indicate that a precision in timing of the carriage of better than one millisecond can be attained without difficulty. It is hoped shortly to publish a more detailed description of the method.

In addition to these modifications two further points may be mentioned. (a) An optical method of levelling the photographic plate in relation to the rotary has recently been proposed. (b) The arrangements of the phonic-motor-drive have been modified, with resulting improvement of the details of the parts to be mounted on the rotary, and considerable simplification of the gearing.

The construction of the special travelling microscope for measuring the photographic records has now been completed by the Cambridge Instrument Company, and the making of certain final adjustments is in progress.

Horizontal Transit Instrument. Work on this instrument has been continued, but has been somewhat interrupted by the prior demands of the P.Z.T. The construction of the mountings and adjustments of the telescopic system have been completed. The mechanical design for the constraint and driving of the variable-deviation system has also been completed and the construction of the essential optical components is in an advanced stage. The application to this instrument of the balanced photoelectric system, which had been proposed for giving the timing-signals of the P.Z.T., was found to present considerable difficulty owing to the rotation of the system, required to adjust it to correspond to a star of any declination. The alternative photoelectric method, similar to that which has been used on the pendulum-clock, suffers from the serious defect that slit-width has an effect, equivalent to backlash, which, apart from the difficulty of determining it at any given time, is liable to variation due to instability of the photocell and its allied circuits. It was in the attempt to escape from this dilemma that the photographic method referred to in the section of this report dealing with the P.Z.T. was devised. As in the case of the P.Z.T. this method eliminates the use of a chronograph. Its application to the horizontal transit instrument is however rather more difficult in detail owing to the fact that, whereas the speed of the P.Z.T. carriage is constant, in this case the speed of the mechanism is subject to variations imparted by the manual adjustment required to satisfy the visual criterion of image-bisection. In consequence the recorded time-scale is not uniform, and in order to permit a sufficiently accurate interpolation to be made, the spacing of the known points of the scale will probably have to be 10 times less than in the case of the P.Z.T. This narrower spacing can, however, easily be achieved by suitable modification of the electronic-circuits.

A further point to which some consideration has recently been given is the choice of the electrical system best adapted to actuate the drive for the variable-deviation system, since this

affects the design of other parts of the instrument. This question is also of wider importance, as it relates to the more general application of drives for impersonal micrometers.

Cape Zone Photographs. With the continued interruption to the stellar parallax programme, help with the Cape programme of photographic astrometry has been offered to and accepted by H.M. Astronomer at the Cape. It is planned to measure and reduce at Greenwich the plates of declination zone -56° to -60° taken with the wide-angle lens at the Cape Observatory. Twelve plates covering R.A. 15h. to 18h. were received from the Cape on October 29: standard co-ordinates have been computed for 10 of these, and 7 plates have been measured and reduced, at the rate of 200 stars per plate. A further batch of 15 plates covering R.A. 18h. to 22h. was received on April 29. A preliminary estimate of the precision to be expected, based on a comparison between the overlap of preceding and following plates, shows a probable error of about ±0".10 in both co-ordinates.

Yapp 36-inch Reflector. In anticipation of resuming work at a site where the observing conditions will allow the 3-prism spectrograph, which was designed for ultra-violet work, to be used at maximum efficiency, the main and auxiliary mirrors of the Yapp reflector were sent to Sir Howard Grubb, Parsons and Co. for aluminising on January 17. This opportunity was also taken to send the lenses and prisms of the 3-prism spectrograph and the prism of the slitless spectrograph for "blooming" with a non-reflecting coating. In order to obviate the considerable delays which occur when such work is handled by commercial firms, it is proposed to instal vacuum evaporation apparatus at the Royal Observatory. A small plant for aluminising mirrors up to 16 inches in diameter has been made available by the Director of Scientific Research for this purpose. It is capable of dealing with all the smaller optical apparatus at present in use in the Observatory.

Photoheliograph. Photographs of the sun were obtained on 262 days. The number of photographs selected for preservation is 522 including 23 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 Kodaikánal Observatory, India, four days are unrepresented in the combined series for 1945.

The first consignment of solar negatives from 1939 June onwards, which had been retained at the Cape during the war, was received at Greenwich in July. Later consignments have brought the plates received up to 1945 October. From the Kodaikánal Observatory have come 52 photoheliograms and 42 zero plates which fill most of the gaps in the Greenwich-Cape series for the years 1939-42. (Unfortunately two of these plates, for 1941 May 31 and July 29, were broken in transit). Thirteen positives on glass have been kindly presented by the Superintendent, U.S. Naval Observatory, Washington. These fill the remaining gaps in the Greenwich, Cape and Kodaikánal series for the years 1940-44.

In April, 66 photoheliograms (diameter of sun's image = 3 inches approximately) covering the period 1945 April 14 to July 24 were received from the Solar Observatory on Kanzelhöhe, near Villach, in Upper Carinthia. This Observatory, 4500 feet above sea level, is one of four high-altitude stations set up by the Germans during the war for the study of solar phenomena in relation to ionospheric conditions for radio transmissions. The Observatory of Kanzelhöhe has been placed under the supervision of Professor Fell of Graz University, who has offered to place at the disposal of the Astronomer Royal the results of the observations, which are being continued. Solar charts of sunspots and faculæ together with other solar data in code-form have also been received for the period April 8 to July 24, 1945.

During the year, 94 Greenwich plates have been measured covering the period 1945 January 10 to June 12. To complete the measurement of the combined series of negatives for the period 1939 June to 1940 December, 173 Cape plates, 12 Kodaikánal plates and one Washington plate have also been measured. Computations of positions and areas of sun-spots have been completed for the Greenwich plates covering the period 1945 January 8 to June 12. Computations have been completed for the combined series up to 1940 April 30.

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. These centres include: Admiralty Signal Establishment: Australian Scientific Research Liaison Office: British Broadcasting Corporation: Cable and Wireless, Limited: Eskdalemuir Magnetic Observatory (sunspots not less than 1000 units reported): General Post Office, Radio Branch: Inter-Services Ionosphere Bureau: and the Radio Research Station.

The mean monthly sunspot number for the twelve months is 48 as compared with 16 for the previous epoch. The rise in sunspot frequency has been most marked during the last three months and includes the appearance in February of the largest spot-group yet recorded at Greenwich. The maximum area of this group was about 4900 millionths of the sun's hemisphere, and its mean area during its passage across the sun's disk (January 29-February 12), 4400 millionths. The group was of special interest because of the occurrence of solar flares and associated ionospheric phenomena including a geomagnetic storm on February 7-8.

The preliminary study of sudden commencements of magnetic storms recorded on the Greenwich-Abinger magnetograms during six solar cycles (1879-1944), has been completed. A paper has been prepared giving the results found in the observed diurnal and seasonal distribution of sudden commencements, together with other characteristics and their statistical relation to the sunspot cycle and to individual sunspots.

A comparison is being made for the year 1939 of the occurrence and character of the movements associated with sudden commencements at Abinger and at Lerwick. The Director of the Meteorological Office, Air Ministry, kindly arranged for the loan of the Lerwick magnetograms.

Spectrohelioscope. This instrument was used on 165 days, but on 34 days observations were limited to a few minutes because of poor observing conditions. Nineteen solar flares were observed in $H\alpha$ during the year; 5 were of major importance, i.e. of intensity 3 on the International scale. 577 measures were made of line-of-sight velocities of bright and dark flocculi. The 235 measures of bright flocculi also provide equivalent line-widths of $H\alpha$. Photometric measures were made on 97 patches of bright flocculi. Line-of-sight motions were measured in 26 prominences.

In March, the duplicate coelostat mirrors were rhodiumised by Adam Hilger, Limited.

Details of solar flares and of periods of observation with the spectrohelioscope are sent quarterly to the Director of the Zurich Observatory, for publication in the Quarterly Bulletins.

Four of the eight research centres, to which sunspot data are sent, 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, reports direct to the Royal Observatory the occurrence of any radio fade-outs while it is in progress. This information is useful in connection with the observation of solar flares. The Superintendent, Radio Research Station, Slough, continues to send the monthly bulletin of noon ionospheric data. The Controller (Engineering), B.B.C., sends periodical reports of ionospheric disturbances affecting B.B.C. short-wave circuits.

The giant February sunspot provided a number of chromospheric phenomena for observation with the spectrohelioscope. Four solar flares of intensity 3 were observed at Greenwich between February 1 and 11. A number of other flares were indicated by radio fade-outs, but could not be observed owing to cloud. One of these fade-outs, occurring on February 6 began at 16h 15m U.T. and lasted for nearly two hours. Although no report of a coincident solar flare has yet been received, it is probable that a flare of high intensity occurred at this time and was directly associated with the geomagnetic storm which began 18 hours afterwards on February 7. In the case of another geomagnetic storm, which lasted for 3 days, from March 23 to 26, it is uncertain, from the available solar and radio data, whether there was any connection with a spot-group which crossed the central meridian on March 27. However, an extensive flare within this group on March 27 appears to have been the percursor of an intense magnetic storm on March 28, which began abruptly 26 hours after the maximum of the flare. The Director of the Kodaikanal Observatory has kindly sent copies of $H\alpha$ spectroheliograms, which show this flare, covering an area of nearly 2000 millionths of the sun's hemisphere. The size of the related sunspot group at the time was about 600 millionths. No report has yet been received of a synchronous fade-out, which would have been expected on eastern channels.

III. TIME SERVICE.

The time service station at the Royal Observatory, Edinburgh, was maintained in operation, on a gradually reducing scale, until the end of January, when the equipment was dismantled and returned to Greenwich and Abinger. The Shortt clocks 3, 11, and 16, which were in use at Edinburgh, have been cleaned and overhauled, and will be re-mounted at Greenwich.

A secondary time service station is being installed at Greenwich. This station will provide a reserve time service, while the main station remains at Abinger. During the period of transfer of the time service equipment from Abinger to the new site for the Royal Observatory, it will take over the full duties of time service operation. On the completion of this transfer, time determinations will be continued at Greenwich for the period required for an accurate determination of the longitude of the new site.

The Shortt clocks 66 and 67, previously mounted at Abinger, have been thoroughly overhauled and have been remounted. Shortt 61 has been returned to Mr. H.R. Fry, who had generously loaned

it to the Royal Observatory for the duration of the war. One of the Dent Regulators from Abinger has been fitted with new contacts, and installed at Greenwich, under the control of Shortt 67, for the emission of the 6-dots time signals for the British Broadcasting Corporation, and of the hourly signals to the Post Office for the control of the Speaking Clock and of other services. These sginals are available from Greenwich as a reserve in the event of any failure of the signals from Abinger. The covering of the Altazimuth Dome, which was destroyed when the building was hit by a bomb, has been renewed, in preparation for installing a small transit instrument for time determinations.

Considerable rearrangement of the equipment at Abinger has been made, coincident with the installation of new equipment. The need to ensure uninterrupted operation of the time service has necessitated the rearrangement being made in several stages. All time service equipment has been removed from the two rooms previously used by the Magnetic Department as an engine room and battery room, which were adapted at the beginning of the war to provide a skeleton time service, in the event of interruption of the service from Greenwich. These rooms are being converted for use as dark rooms and for housing the continuous film developer and other equipment, needed for the increasing use of photographic and film technique in the time service. The Dent regulator used for the B.B.C. and Post Office signals has been removed to the main clock building, and placed under the control of Shortt 49. The various clock circuits, which previously terminated in the engine room, have been transferred. All operational work is at present being confined, as far as possible, to the main clock building, while the newer equipment is being installed in parallel in the new building. When the new installation has been completed, the operational equipment will be removed to the new building to make room for various experimental units and quartz clocks undergoing tests.

The new installation has been planned as a series of rackmounted units. Care has been taken in the design to make operation, adjustment, and servicing as convenient as possible. The radio reception and comparison equipment will be mounted on eight standard 6ft. 6in. racks, and the send relays and ancillary equipment on another four. Five racks are now in use for the quartz clock divider stages and beat counters. Progress in installation work has been slow, because of shortage of staff and of the constant demands for maintenance and servicing of the operational equipment.

The installation of twelve quartz clocks at Abinger is approaching completion. The C and D groups, each comprising three oscillators, have been running for some time on the battery installation. The E group is of a slightly different type, employing crystals with soldered connections; this group has no provision for rate adjustment, which may eliminate one possible source of variation. The original mains-operated B1 and B2 crystals have been disconnected and a new battery-operated B group has been formed, incorporating a new crystal as B1, the old B2 crystal, and the A1 crystal (formerly at Edinburgh) as B3. None of the standards has been in operation for a sufficiently long period to permit a proper determination of the ageing characteristics. The performance of C3, D3, E1 and E2, which have had the best runs, is determined in terms of the Post Office standards at Dollis Hill, and they are thus available for short-term prediction.

The performance of the Dollis Hill standards continues to be good, but IV C, which had run steadily with a unifrom frequency drift for some years, suddenly changed its rate of drift after a stoppage in the autumn. The change was partially marked by a number of changes in other standards, and it is strongly suspected that at about this time there was also a change in the rate of rotation of the earth. The scatter of time determinations with small transit instruments is such

that changes of the rate of frequency drift can only be determined over comparatively long periods, and then providing only that the change is from one steady value to another value, which is adhered to for many months. The much higher precision in time determination, which will be attained when the photographic zenith tube has been brought into operation, will make possible a considerably closer control over the performance of the standards.

The ancillary equipment for the quartz clock installation at Abinger is not fully completed. Five divider chains are in use, and the full complement of beat counters is connected. Various modifications to and readjustments of the different units have been made from time to time by the engineers of the Post Office Radio Branch Laboratories. The multivibrators, which provide an output of ten pulses per second from the 1,000 cycles per second output, remain to be aligned and adjusted.

Five phonic motors, and one phonic clock, are at present in operation. The phonic clock, which has contacts every second and every tenth of a second and is fitted with a dial and hands was originally operated by the 500 cycles per sidereal second output from the first quartz clock installed at the Observatory, which incorporated a Dye–Essen ring crystal. It has now been converted to operate on a 1,000 cycles per mean time second supply, which is the frequency of the output used for driving all the phonic motors at the Observatory. Two of the phonic motors are of a simple type with seconds contacts only. Two others are provided with a gearing of 365/366 to give contacts at every mean time second and at every sidereal second: the gearing ratio is not sufficiently exact to give correct sidereal seconds, but the inexactness in the ratio merely involves a small additional constant term in the rate of the sidereal time derived from the motor. One further motor of this type has been completed, but is at present being used by the makers in an investigation on lubrication. The fifth phonic motor is provided with a 60/61 gearing for the emission of rhythmic signals; a second motor of this type, formerly in use at Edinburgh, has been sent to the makers for minor alterations. The rhythmic signal phonic motors are phaseable, so that, by appropriate adjustment of phase, the rhythmic time-signals can be sent out exactly at the desired time. At present the D3 crystal output drives both the phonic clock and one of the phaseable phonic motors; using decimal counter chronometer technique, it is convenient to measure a rhythmic signal against the diminished seconds contact of the rhythmic phonic motor, and signals of American type (which consist of dots spaced at intervals of a mean-time second) against seconds contacts, allowance being made for the correction applied to the phaseable motor.

Although all rhythmic signals from the Royal Observatory are now controlled from phonic motors, the B.B.C. six-dots signals, the Post Office hourly signals, and various switching functions are still dependent on contacts on Dent regulator or Synchronome slave clocks. Some alterations are being made in the method of sending the six-dots signals. As originally designed, the Observatory clock merely closed a circuit at each of the six seconds of the signal, the battery and relay both being installed at Broadcasting House. Thus the monitoring meter at the Observatory showed no current flowing, except for the duration of the actual signal dots. It was not possible to detect any line faults until a signal had been missed. This circuit is now being brought into line with the other time-signal circuits operated from the Observatory, and double-current electronic send-relays are being installed at the two time service stations. These relays send a current of a few milliamperes along the line continuously, the current direction being reversed for the signal dots. A constant check on the line conditions is possible. The circuits from Abinger and Greenwich will both be connected through to Broadcasting House and the B.B.C. engineers will be able to tell at a glance whether they are in correct working order.

A new phonic motor transmitting unit has been designed in co-operation with Messrs. Muirhead and Co. Ltd., which will control all signals and switching. Four of these units have been ordered, two for each station. These units will provide a safeguard against the transmission of signals at an incorrect time, which is not impossible with the present Dent regulator control. The phonic motor will either remain in synchronism with the frequency of its drive, in which case signals will be sent out at the correct times, or it will drop out of synchronism, in which case it will stop and outgoing signals will be automatically suppressed. The two motors at each station will each feed double-current electronic send-relays, whose output will be taken by a pair of wires to the B.B.C. control room, thus providing a further safeguard against the possibility of incorrect time-signals being broadcast.

Astronomical observations for the determination of clock error were made on 78 nights at the Edinburgh station before it was closed down, and on 108 nights at Abinger. The observations at Abinger were formerly recorded against the sidereal clock Shortt 40, which was compared before and after each night's observation with one of the mean time quartz standards. The introduction of phonic motors with gearing to give sidereal time has simplified the procedure, as no comparisons are now required. Because of the scatter of the transit observations, tape chronographs are still employed for recording transit observations, although they have been entirely superseded by the decimal counter chronometers for all other comparison purposes.

The conditions for transmission of signals by land line between Edinburgh and Rugby were consistently more stable than those between Abinger and Rugby. With the impending closure of the Edinburgh station, efforts were made, in co-operation with the Post Office Engineering Department, to locate and correct the various sources of variation in the lag of the line from Abinger to Rugby. A number of modifications were carried out, various items of Post Office equipment were disconnected from the line, and the service was re-routed on a different circuit to London. Since the introduction of the pre-signal test at 09·45h, as mentioned in last year's report, it had proved possible to diminish the day-to-day erratics in the 10·00h GBR transmissions due to changes in the line lag, and, by arrangement with the Post Office, a similar facility was made available at 17·45h to permit readjustment before the 18·00h signal. The effects of short-period changes of lag remain. A number of special tests were radiated from the Rugby transmitter with the object of locating the cause of the variations, and for a short while the signals were sent from London to Rugby over a physical line, instead of over the usual voice frequency carrier circuit. The results were promising, and further tests are planned. It is hoped that the full co-operation of the Post Office Engineer-in-Chief's Department will clear up these problems.

Intercomparison between the two time service stations is possible either by line link or via the Rugby signals. A direct radio link would provide a more reliable connexion. Some experiments were made, by the co-operation of the Director of Radio Equipment, Admiralty, with the aid of the Admiralty Signals Establishment, using Navy mobile radio equipment. Two-way communication was estabilshed on a frequency in the 85-95 Mcs. band, and tests were made to ascertain if communication could be established on a near-optical path at a frequency of the order 300 Mcs. Test transmissions were also made with a standard service-type transmitter, working on a frequency of approximately 2 Mcs. Useful information was obtained.

As a result of these tests application was made to the Wireless Telegraphy Board for permission to operate a test transmitter from Abinger. A frequency of 2 Mcs. was allocated, and

regular transmissions have been made since October for half an hour per day following the 10·00h time signals. Two multiplier stages, with factors of 4 and 5 respectively, were designed and constructed in the electronics laboratory, and are controlled from one of the 100 kcs. crystal oscillators; a power output stage feeds the temporary "Adastra" aerial used for the intercommunication tests. No attempt has been made so far to provide any means of adjusting the frequency of the transmissions to the nominal value of 2 Mcs., but the actual frequency can be estimated with a normal accuracy of one or two parts in one hundred million. For half the transmission period, a 1,000 cycles per second modulation, of the same accuracy and stability, is applied, and this is interrupted at seconds intervals, and is also used to give the morse call-sign, G.M.T. The transmissions are received regularly at Dollis Hill and the radiated frequency is compared with the Post Office Radio Branch Laboratory frequency standards. A very high standard of accuracy of intercomparison has been attained. The results are communicated daily to the Observatory, and have proved to be of the greatest value in providing an alternative link between the two sets of standards. In addition, the transmissions have been received regularly by a number of other establishments, including the B.B.C. receiving station at Tatsfield, and the Aeronautical Inspection Directorate Test House at Harefield, both of whom are regularly informed of the departure of the radiated frequency from the nominal value. Although on a small scale, and of insufficient power to reach a wide range of establishments, these tests have thus developed into a service which is very greatly appreciated, and which has proved to be of material assistance. Further tests are contemplated, and these transmissions may do much to meet the need for such a service until a more comprehensive series of transmissions can be planned and inaugurated. The Director of Radio Equipment, Admiralty, has co-operated with the Observatory in this and many other radio matters, and it has now been approved by the Board of Admiralty that D.R.E. and other technical departments of the Admiralty should co-operate to the full with the Royal Observatory in the carrying out of its work. This formal sanction is greatly appreciated, and will ensure that the Observatory can call upon the departments concerned for expert advice and assistance, an arrangement which should materially assist in development work being accelerated, and the maximum efficiency being assured.

Apart from these special transmissions, the only means hitherto available for checking the frequency of frequency standards has been by the reception of the 10h Rugby 16 kcs. signals, special care being taken to transmit the signals so that the interval between corresponding signals on consecutive days is 24 hours to a high order of accuracy. These signals, with their slow build-up time and low frequency, are not well adapted for this purpose. Frequency transmission of the type sent out from the WWV station of the Bureau of Standards, on frequencies of 2·5, 5, 10 and 15 Mcs., with superimposed time signals in the form of short pulses at a repetition rate of one second, provide a control over both frequency and time. Since, in order to meet the needs for increased accuracy in the time service, the Observatory had found it necessary to plan for a comprehensive installation of quartz controlled frequency standards, much of the equipment, required for the control of a service of standard frequency transmissions, is available. The observational and prediction work required for the control of the time signals will serve for the control of frequency transmissions also. The question of the inauguration of standard frequency transmissions from Great Britain has been under discussion interdepartmentally and it has been agreed that, if such transmissions are undertaken, the responsibility for the control both of the frequency and of the superimposed time signals shall rest with the Royal Observatory.

The petrol driven generator set installed to provide an alternative supply of alternating current in the event of a failure of the supply mains had long become inadequate to carry the full

essential load, and it had also proved unsatisfactory both in starting and running. A new diesel generator set, of larger capacity, and fitted with self-starting equipment, has now been installed, but is not yet connected.

Much work has been done during the past year in the electronics laboratory, though progress has been limited by the lack of adequate staff. In addition to the work on the 2 Mcs. transmitter, referred to above, many units have been designed and constructed for incorporation in the rack mounted installation now in process of assembly in the new clock building. The long wave receiver, described in the previous report, has been in regular use. Two further receivers have been constructed, and these have embodied slight modifications which have appeared to be desirable as a result of experience with the first model. The ancillary equipment for photographic recording of cathode ray oscilloscope traces of the received signal is now being entirely redesigned, since difficulties had been experienced in operating the recording camera at an adequate speed for the original method proposed. The system now under construction in an experimental form is designed to make use of a time-base circuit applied to the tube, thus overcoming the need for high film speeds. The screened frame aerial, together with its control mechanism, constructed in the Observatory workshop, has been mounted and brought into use.

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 23,104 all of which are now held at Bradford-on-Avon. Of this total 253 chronometers (Patt.H.S.1), 359 chronometer watches (Patt.H.S.2 and H.S.6), 906 deck watches (Patt.H.S.3), 157 dashboard watches (Patt.H.S.4), 130 pocket watches (Patt.H.S.5), 306 wrist watches (Patt.H.S.8) and 2,001 wrist chronographs (Patt.H.S.9) are rating or ready for issue but reserved. The remainder, consisting of 166 Patt. H.S.1, 3191 Patt. H.S.2 and H.S.6, 6,341 Patt. H.S.3, 1,287 Patt. H.S.4, 1,215 Patt. H.S.5, 1,619 Patt. H.S.7, 4,091 Patt. H.S.8, 693 Patt. H.S.9 and 389 other assorted types are held in store awaiting adjustment, rating or repair. Three chronometers are in use at the Royal Observatory.

The stock of watches 6B/60 held on behalf of the Air Ministry totals 251 of which 105 are rating, 30 are in reserve and 116 await repair.

In addition there are 269 chronometers and watches deposited for various reasons.

During the year ended 1946 April 30 a total of 24,780 chronometers and watches was received and 13,983 issued. The number sent for repair was 2,783, including 59 for the Air Ministry. The cessation of hostilities and the subsequent pay-off of ships was responsible for the increased number of instruments received whilst reducing the number issued on service, although the latter is still more than five times greater than pre-war.

The routine work of the Office is maintained without arrears. The computation and logging of the rates of chronometers and watches under test and the notation of the individual instrument cards, showing all transactions, including transfers between H.M. Ships and Admiralty Chronometer Depots at home and abroad, are completed up to 30th April 1946.

Throughout the year ships of Allied and Commonwealth Governments were supplied with chronometers and watches from Hydrographic sources. Ten 8-day chronometers were supplied for the use of Australian merchant ships.

Progress was made in the recovery and disposal of chronometers loaned to the Admiralty during the war. In the past year 47 of these were returned to the owners who, in several instances, have expressed appreciation of the good condition of the instruments when returned.

On April 2 the Standard clock at the Dunfermline Chart & Chronometer Depot was taken down and removed to Bradford-on-Avon for storage.

The number of chronometers and watches overhauled and adjusted in the Observatory watch-repair shop during 1945/6 was 1,953 including 21 chronometers and 335 chronometer watches. The refitting of luminised dials and hands, and adjustment of the chronograph action in 6,695 wrist chronographs was carried through in addition to the above repairs.

The engraving, strapping and rating of the bulk of the wrist chronographs is almost completed; one woman is now retained in the repair shop to deal with the residue of this work. She is being trained to do the relacquering of brass cases and repolishing of wood boxes so that with the resilvering of dials already being carried out by the repair staff the shop will become independent of outside sources and delays.

In the course of the redistribution of the Time Service four free pendulum movements, Nos. 11, 16, 49 and 41 and the movements of five Regulators, in use at the Observatory, were thoroughly overhauled in the watch repair shop.

The reconditioning of the Harrison Time Machine No. 4 and its duplicate made by Larcum Kendall mentioned in Part I of last year's report was satisfactorily carried out by Mr. Evans. Some time was spent on the adjustment of these complicated pieces and their condition and performance is considered to be as good now as ever. There is little to choose between the two machines, for while Harrison No. 4 has a smaller temperature error and more consistent rate the Kendall is more free from positional errors. A full record was made of the process of dismantling, re-assembly and adjustment so that future overhauls should be facilitated. In order to preserve their appearance and to reduce the need for buffing and repolishing, both pairs of silver cases were rhodium plated.

Some modifications have been made in the watch repair shop to the occultation machine of the Nautical Almanac Office. The arrangement for measuring the position angle was replaced by a unit

consisting of two brass wheels of 360 teeth with intervening pinions and arbor, one wheel being engraved in arc and silvered. The unit, which was assembled and mounted in the repair shop, is operated by a milled knob which rotates the lens cell and indicator at a suitably slow speed.

Mr. H. Lauener, who left the Rolex Watch Company in January 1942, to assist in the watch repair shop, was released in August 1945 so that he could return to the Company to take charge of their repair section.

Mr. H. Warden was absent in Germany from 24th September to 23rd October 1945, having been seconded for duty in a technical capacity with the Hydrographic representative sent to that country to investigate the processes of manufacture and supply of chronometers and watches.

During the year Flight-Lieut. Harris, Empire Air Navigation School; Messrs. F.A. Gould, P.H. Biggs and F.H. Burch, Metrology Department, N.P.L.; and Dr. N.W. Doorn, Ryles Zee Instrumentatum, Leiden, visited Bradford-on-Avon to see the work in progress and discuss the methods and standards of rating.

V. NAUTICAL ALMANAC OFFICE.

The routine calculation and proof-reading involved in the preparation and printing of the publications for which the Office is responsible have been continued through the year. It has once again been necessary to restrict the astronomical work of the Office to that essential for the continuance of the Almanacs; in the first part of the year the Office was fully engaged with the work of Admiralty Computing Service, while in the latter part the efficiency of the Office has been seriously impaired by shortage of staff. The heavy demands for special work and for the overtaking of wartime arrears cannot adequately be met by the present staff, which is considerably below pre-war level in both numbers and gradings.

The Office has now ceased to have any responsibility, except in an advisory capacity, for the computational work of Admiralty Computing Service. On the establishment of the Mathematics Division of the National Physical Laboratory, which came into existence largely as a consequence of the war-time experience of Admiralty Computing Service, the additional staff attached to the Office was gradually disbanded and most subsequent computational work arising in the Admiralty has in fact been sent to Teddington. The nucleus of the computing staff there was formed by staff transferred from the Office. A full report of the work of Admiralty Computing Service is being published elsewhere, but it can here be stated briefly that in the last six months of its attachment to the Office over 20 technical reports were issued, the majority of which contained the results of simple or elaborate calculation performed in the Office. For several investigations, the Office has been asked to extend existing calculations since the disbanding of Admiralty Computing Service, but it is thought that such requests are not now likely to recur.

The output of the Office has been much restricted by the great delays in printing. At the end of 1945 the printers were more than 500 pages behind agreed schedule and it is only in recent weeks that the rate of composition has caught up with average requirements.

The Nautical Almanac. Every effort was made by advancing despatch of copy to have the Almanac for 1947 published before the end of the year but the above mentioned printing difficulties delayed the publication date to February 2.

The first part of the 'Nautical Almanac', which contains the fundamental ephemerides of the Sun, Moon and planets, has been completed for 1950; lightly bound copies of the printed sheets have been distributed to the Almanac offices and other authorities in accordance with international exchange agreements.

No changes have so far been made in the contents or presentation of the Almanac. The response to the circular letter to users for suggestions for alterations and additions proved most satisfactory but decisions have not yet been finally reached as to which are to be adopted, although it has been decided, in conjunction with the Office of the 'American Ephemeris', that differential co-ordinates of satellites VI and VII of Jupiter shall be derived from the more recent elements and tables of J. Bobone in 'Astronomische Nachrichten' 262, 321, 1937, and 263, 401, 1937; this will be introduced in the Almanac for 1948.

Some work has been done on the contents of the separate supplement but it is feared that the shortage of staff and printing difficulties will make it impossible to have the supplement ready for issue with the 1948 Almanac, though it is hoped that publication will be made during 1947.

An attempt is being made to complete, as opportunity offers, the calculations of the Moon's position up to the year 2000. Many of the Hollerith cards are now nearly 20 years old and obsolescent, and it is hoped to complete the stages of the work involving them while they can still be used.

Occultations and Eclipses. The occultation programme has been increased. Except for the German and Japanese stations, predictions are being computed for all stations included before the war and for one new station. Extra predictions were done for 1946 and 1947 for stations with which communication had been restored, involving about 900 computations.

Besselian elements for 2598 stars of magnitude 7·5 or brighter occulted during 1948 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 80 stations for 1261 stars, the other 1337 stars having been discarded as not observable under suitable conditions. After computation a further 98 stars were rejected and the elements of the remaining 1163 stars will be published in the 'Nautical Almanac' for 1948. The number of predictions computed for the year 1948 is about 6700.

Predictions for Auckland will be introduced with the other British Empire stations in the 'Nautical Almanac' for 1948.

The receipt of observations continues to be erratic. For 1943 a further 521 observations have been received so that the total number of observations for this year which have been reduced

and prepared for discussion is 811. Further observations are expected from a few stations in the near future. For 1944, a further 382 observations have been received while for 1945 and 1946 the numbers so far received are 394 and 14 respectively.

It is hoped that the discussion for 1943 will be undertaken very soon after receipt of the observations which are at present being sent to the Office.

Special eclipse computations were undertaken for the eclipse of 1945 July 9 to supply information required by various radio research stations. Local circumstances of the visual eclipse at heights of 100 and 300 kms. were supplied to four stations and the circumstances of the corpuscular eclipse for a height of 300 kms. for four different speeds of the corpuscles to three stations.

The track of the total solar eclipse of 1947 May 20 has been plotted on several charts for the use of members of the Joint Permanent Eclipse Committee. Special computations are likely to be required in the near future.

Abridged Nautical Almanac and Air Almanac. The 'Abridged Nautical Almanac' for 1947 was not published until March 1 although all of it had been passed for printing in October. No change has been made in the contents or presentation for 1947 or 1948.

A complete revision of the 'Abridged Nautical Almanac' is long overdue and it is hoped shortly to introduce a new edition incorporating the direct tabulation of Greenwich Hour Angle; such a revision has been planned since 1940 but circumstances have not been propitious for the introduction of a fundamental change, necessitating much consequential alteration in methods of use, training and auxiliary tables.

During the year, two parts of the 'Air Almanac' have been published, namely the second and third parts for 1946. The first part for 1947 was transferred to another printer and it is hoped that there will be very little interval between the first two parts for 1947. A table of nautical twilight is being introduced in this publication from the beginning of 1947.

The 'Air Almanac' is shortly due for a detailed revision, though no fundamental change of presentation is envisaged.

Apparent Places of Fundamental Stars. The volume for 1946 was not published until August 27 due to printing difficulties which have also seriously delayed the volume for 1947. All copy was sent between June and November but the first proofs have not yet all been received. Although the printer has been asked to give this volume priority it is not possible to give a probable date of of publication. The computations were done by the offices ariginally responsible for them.

For 1948, arrangements were made for the redistribution of the portion of the work normally received from Berlin, but it has fortunately since proved possible to obtain these computations from Professor Kopff in Heidelberg.

General Navigation Work. In addition to the preparation of the 'Air Almanac', the Office has been continuing to do a considerable amount of miscellaneous computing work for the Air Ministry in connection with astronomical navigation. In particular, investigations have been made into German and Japanese methods of astronomical navigation in the air, and into the design of new tables for air navigation for which a future demand is anticipated. This work has been handicapped by the inability to find a suitable person for a new post of navigational assistant.

During the year the Office has been continuing with the calculations for the hyperbolic lattices required for use with the Decca system of navigation; this work originally came to the Office through Admiralty Computing Service, but it is ideally suited for the Office proper – both in regard to its navigational function and of the nature of the calculation involved. Commander A. Schmidt, Royal Danish Navy, spent three weeks in the Office in February acquiring detailed knowledge of the organisation, machines, tables and methods of computing for this work preparatory to the setting-up of a computational section of the Danish Hydrographic Department.

It is to be regretted that this work has had to be temporarily suspended owing to shortage of junior computing staff.

The R.A.F. third specialist navigation course comprising nine officers visited the Office from May 1 – 4 inclusive, from the Empire Air Navigation School, Shawbury, to see the work of preparation of the 'Air Almanac' and 'Astronomical Navigation Tables' and to discuss matters connected with astronomical navigation. The Astronomer Royal gave a talk on May 3 on "The Determination of Time."

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 layout of air publications were of considerable value and gave pointers for possible future development.

A similar visit of the fourth course is due in May.

Ryde Night Illumination Diagrams. During the year, diagrams have been issued for the last four months of 1945 and for the first eight months of 1946; those for the rest of 1946 are in proof and should be issued early in May. Diagrams for the first four months of 1947 have been prepared for reproduction.

Specially prepared master diagrams for reproduction in India have been despatched up to the end of 1946.

The whole question of the continuance of these diagrams is under consideration; it is probable that they will be issued in a modified form after the end of 1946.

Several "solar location diagrams" have been prepared in collaboration with the "Codes of Practice Committee" of the Ministry of Works; it is interesting to know that increased attention is being paid to the important questions of siting of buildings to obtain optimum conditions of lighting.

Proof Reading. The amount of proof-reading has decreased due to the printer being so badly in arrears on schedule; there have been 4,700 distinct readings, representing 1,500 pages. The ratio of three readings to one page indicates that all first proofs are read in duplicate. This is still necessary owing to the enforced use of 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. The office is now well equipped with hand and electric calculating machines, as well as with three National Accounting Machines.

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 1945 December 31 and with provisional constants to the present time.

The tabulation of results for 1945 awaits the receipt of the final list of International "quiet" and "disturbed" days, the preparation being otherwise in an advanced state.

The mean values of the magnetic elements at Abinger for the year 1945 are given below.

The values for the years 1942, 1943 and 1944 are given for comparison.

	Decl. W.	Horizontal Intensity	Vertical Intensity	Inclination
1942 ..	10° 24′·8	0·18554	0·43146	66° 43′·9
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

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 Eskadelmuir Observatory.

During the past twelve months there have been 13 magnetic disturbances reaching the dimensions of a "storm", three 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 great storm on March 28–29 was the most severe since that of 1941 March 1. The extreme range in declination was 2°42′; in horizontal intensity, 1660γ; and in vertical intensity, 920γ.

Mr. J. J. White, of Lerwick Observatory, visited the magnetic station September 12–19 and carried out a long series of comparison observations of vertical intensity with a portable balance magnetometer of the Copenhagen (La Cour) type with a view to re-standardising the instrument.

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.

Observations of temperature, wind direction and strength, rainfall and a general weather note are sent daily to Instructor-Commander, Naval Meteorological Section, Royal Naval College, Greenwich, when the meteorological class is under instruction there.

The tabluation of meteorological results for 1945 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 1946 April 30.

The mean temperature was 51·4° which is 1·7° higher than the average for 100 years, 1841–1940. The highest temperature in the shade was 87·8°, registered on August 4. Temperatures exceeding 80° were recorded on 10 days, one of which was May 12 when the maximum was 86·0°.

The lowest temperature was 20·0°, which occurred on February 28. Temperatures of 32·0° or below were recorded on 45 days, two of which were in April. April, however, had a mean temperature 3·9° higher than the average for 100 years, while on two days at the beginning of the month, namely 3rd and 4th, the maximum temperature reached 76·8° and 79·7°, respectively, – values never before recorded at Greenwich so early in the year.

The mean daily horizontal movement of the air was 249 miles which is 8 miles below the average for 50 years, 1867–1916. The greatest daily movement was 779 miles, which was recorded on October 26; the least daily movement was 26 miles, registered on November 21. The maximum pressure reached 26·0 lbs. per square foot, on January 30.

The total period of *bright* sunshine recorded was 1314·0 hours, only 29·3 per cent of the total theoretically possible. There were 80 entirely sunless days, 60 being in the five months November to March. The amount of sunshine in September (61·4 hours) was easily the lowest total ever recorded at the Observatory in that month. There were 37 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 62, while on a further 57 the record was not more than ten per cent of the amount possible.

The total rainfall during the twelve months was 21·00 inches, which is 3·33 inches less than the average for 100 years, 1841–1940. There were 161 days on which rainfall exceeding ·005 inch was recorded. The wettest month was July, with 2·922 inches and the driest month, November with 0·156 inch. – a low total without parallel in November in the Greenwich records.

VIII. PRINTING AND DISTRIBUTION OF GREENWICH PUBLICATIONS.

MSS for the years 1937 to 1945 are complete or in various stages of preparation. Enquiries have been made of H.M. Stationery Office regarding the possibility of resuming publication but no decision has yet been reached.

IX. PERSONAL ESTABLISHMENT.

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

(a) *Observatory Staff.*

Chief Assistants	– R. d'E. Atkinson, M.A., Ph.D., 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.
Head of Repair Shop	– H. Warden.
Junior Assistants	– Mrs. J. Bennett, K. C. Blackwell, C. C. Harris, P. S. Laurie, B. R. Leaton (on active service), Miss J. Mounteney, Miss C. J. A. Penny, P. L. Rickerby, J. L. Rudd, A. Shortland, R. H. Tucker (on active service), G. F. Wells.

Departmental Clercial 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., J. D. Pope, G. B. Wohlgemuth, R. M. J. Withers.
Hostel Warden	– Miss H. F. Scagell.
Temporary Clerks Grade II	– Miss D. A. Bush, Miss B. G. Collett, Miss P. B. Hill.
Temporary Clerks Grade III	– Miss A. L. Chapman, Miss C. E. Chapman, L. G. Elstone, Miss K. M. Hempstead, V. J. Lawson, D. Oliver, Miss R. O. Pavey, S. R. Plester, Miss J. White.
Temporary Shorthand Typist	– Miss B. A. Martin.
Temporary Typists	– Mrs. M. K. Hayes, Mrs. B. H. Upfold.
Laboratory Assistant	– T. Hogan.

(b) *Nautical Almanac Office Staff.*

Chief Assistant as Superintendent	– D. H. Sadler, M.A.
Assistant	– Miss F. M. McBain, M.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 (on active service), Miss J. E. Pullen, Miss M. R. Rodgers, Mrs. V. H. Rogers, E. Smith.
Clerical Assistants	– Miss Y. P. Mundon, Miss K. M. Restorick.
Temporary Clerks Grade II	– Miss M. J. Matthews, Miss O. J. Ollis, Miss Y. I. Reddy.
Temporary Clerks Grade III	– Miss S. B. Cauchois, Miss E. A. Hazell, Miss I. M. Restorick, M. J. Roch, L. A. Straw.
Clerk–Shorthand–Typist	– Miss J. E. Perry.

Dr. R. d'E Atkinson, Chief Assistant, has been on loan throughout the year for special work in another Department of the Admiralty.

Dr. H. R. Hulme, Chief Assistant, who has been on loan to another Department of the Admiralty since 1940 March 11 resigned from December 15 on his appointment as Scientific Adviser to the Air Ministry.

Dr. A. Hunter, Assistant, was released from other Admiralty work on November 1, and returned to his duties at the Observatory.

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

Mrs. J. Bennett, Junior Assistant, Miss C. J. A. Penney, Temporary Junior Assistant, Mrs. D. A. Estherby, Temporary Clerical Officer and Miss H. F. Scagell, Hostel Warden, were appointed during the year.

Miss M. C. Scadeng, Junior Assistant, resigned on marriage on October 24.

The industrial staff employed in all branches consists of a Foreman of Observatory, four laboratory mechanics, seven watch adjusters and repairers, one machine operator, four messengers, nine labourers, three cleaners, two caretakers and two hostel maids, a total of thirty three in all. Mr. A. J. Johnson is still on active service.

X. GENERAL.

During the year parties of Naval Officers from the Royal Naval College have visited the Observatory at regular intervals.

The Astronomer Royal for Scotland visited the Observatory on several occasions.

Five small parties of U.S. Naval Officers were received at the request of the Flag Officer Liaison with the Commander, United States Naval Forces in Europe. Admiral Sir John Edgell, R.N., Rear Admiral Rushbrook, R.N., Admiral Thebaud, U.S.N. and Commander Schmidt, Royal Danish Navy, were received, and visits were also paid by U.N.O., representatives and astronomers from China, Cuba, Ecuador and the United States.

Professor Oort and Professor Minnaert of Holland made visits to the Observatory in November. A delegation of French astronomers, consisting of MM. Danjon, Chalonge, Couder, Lyot and Fehrenbach, visited the Observatory at Greenwich and at Abinger in January. Dr. Madwar, of the Helwan Observatory, paid a visit in November. Dr. Banerji, Director of Observatories in India, paid a visit in March.

Captain de la Puente, deputy director of the Instituto y Observatorio de San Fernando, has visited the Observatory at Greenwich and at Abinger to study the meridian equipment, the time service and the magnetic observations. He has also visited the Nautical Almanac Office with two computers from San Fernando, who are engaged in computations for the Spanish 'Almanaque Nautico', to study the methods of computation, particularly with the National Accounting Machine. It is hoped that this visit will lead to closer co-operation in astronomical computation with the Spanish Office, which is one of the five co-operating almanac offices.

The Astronomer Royal was one of the party of British scientists who attended, at the invitation of the Academy of Sciences of the U.S.S.R., the celebrations of the 220th anniversary of the founding of the Academy, held in Moscow and Leningrad in June.

The Astronomer Royal, as President of the International Astronomical Union, attended a meeting of the Executive Committee of the Union and of delegates of various countries, held in Copenhagen in March, arranged to discuss matters of organization and of international co-operation in astronomy, which could not be deferred until a General Assembly of the Union becomes possible.

Mr. Sadler, Superintendent of the Nautical Almanac Office, visited Germany in May to investigate, on behalf of the Director of Scientific Research, the development of mathematical computations in Germany.

Mr. Smith, Assistant in Charge of the Time Department, visited Germany in October, with a representative from the Post Office Radio Branch Laboratories, to investigate the quartz clocks developed by the Physikalische Technische Reichanstalt and by the firm of Rohde and Schwartz at Munich. In order that a thorough investigation could be made of its performance, one of the clocks from the P.T.R. was brought to this country. Because of the present shortage of staff and of accommodation at Abinger, arrangements have been made for the crystal and drive circuits to be tested at the Post Office Radio Laboratories; after these tests have been completed, the clock will be returned to the Observatory for investigation of its long-term performance and for comparison with the Observatory standards. Mr. Smith also visited a number of German astronomical institutions to obtain reports of their wartime activities.

The administrative and other staff of the Royal Observatory, who were moved from Greenwich to Abinger Hammer in the autumn of 1940, returned to Greenwich in July.

The premises at Abinger Hammer, which had been occupied by this staff, have been retained for use as an Admiralty Civilian Hostel, because of the serious difficulty of finding living accommodation in the Abinger area for staff employed in the Time Department.

Mr. P. J. Miller, the father of Mr. N. J. Miller, of the staff of the Royal Observatory, who was killed in 1943 while on active service with the Royal Air Force, has kindly presented a billiards table, which belonged to his son, for use in the staff recreation room and in memory of his son.

The time service station at the Royal Observatory, Edinburgh, was closed at the end of January after having been in operation for a period of five years. The co-operation and assistance of the Astronomer Royal for Scotland and of the staff of the Royal Observatory, Edinburgh, greatly helped in meeting the requirements for a considerable improvement in the accuracy of the time service under difficult wartime conditions, and ensured the maintenance of the service during the period when south-east England was subject to heavy attacks from the air. The provision of an exclusive line between the Royal Observatory, Edinburgh, and the Post Office Radio Station at Rugby, made possible a very high standard of smoothness in the radiated GBR time signals controlled from Edinburgh. In addition, the transit observations obtained at Edinburgh were used in conjunction with those obtained at Abinger for the determination of clock errors; these additional time determinations were of great value, because the scatter of the astronomical observations made with the conventional type of transit instrument is the most serious limitation on the accuracy now obtainable in the time service.

It was announced by the Admiralty on April 11 that Herstmonceux Castle in Sussex had been chosen as the future home of the Royal Observatory. The selection was made after examination of a

large number of sites, and after investigation of the meteorological and geological conditions of each. A Committee of the Board of Visitors, consisting of Professor Greaves, Professor Plaskett, and Sir George Simpson, inspected with the Astronomer Royal a selected short list of sites, and reported to the Board. The final choice of Herstmonceux Castle was made by the Admiralty in consultation with the Board of Visitors. The conditions for astronomical observations at this site appear to be as good as can be obtainable in England. Herstmonceux Castle, built in 1446 by Sir Roger de Fiennes, Treasurer to the Household of Henry the sixth, is probably the most beautiful early brick cuilding in the country and will provide a dignified future home for the Royal Observatory, appropriate to its long history and traditions. No plans for the removal of the Observatory from Greenwich to Herstmonceux have yet been made. New buildings and, in some cases, new domes will be required for housing the telescopes; the progress of the various stages of the removal will be conditioned by the rate at which building can be carried out.

When the removal has been completed, the Observatory will be able to face the future with confidence, freed from the disadvantages under which it has suffered in recent years. But work, meanwhile, is being carried on under conditions of special difficulty. With the various departments divided between Greenwich, Abinger, Bath and Bradford-on-Avon, administration is complicated, some duplication of effort is inevitable, and the advantages which accrue from the close contact of different departments are lost. The system which has been developed at the Royal Observatory is for the whole of the astronomical staff to share the regular observing duties. The continuous programmes of observation, such as fundamental determinations of position, stellar parallax determinations, latitude-variation observations, require a large number of trained observers. The present situation, in which a minority of the staff is at Greenwich along with the main instrumental equipment, leads to a serious lack of balance. The impossibility of using the 26-inch and the 28-inch refractors, because of the damaged condition of their domes, is regrettable, though the staff available at Greenwich would be insufficient to carry on full observational programmes with these instruments. More serious is the loss in observing experience and technique of the junior members of the staff, which is of special importance for the meridian observations with the transit circles. Until the removal of the Observatory to Herstmonceux is completed, the observational output must necessarily continue to be much reduced.

The staffing position at the present time is a source of much concern. Some of the senior staff have passed the normal age for retirement. Some of the departments are seriously understaffed. The recruitment of new staff is made difficult because of present uncertainties about future grading. Although the Royal Observatory is the oldest scientific institution in Great Britain, it was not included amongst the establishments to which the recommendations of the Carpenter Committee on the grading and terms of service of scientific staffs were applied. The terms of service of the Junior Assistants (Higher Grade and Lower Grade) in the Royal Observatory, including the Nautical Almanac Office, have been related to clerical grades in the Civil Service. In consequence, these grades have been recruited from persons with no basic training in science. As the work of the Observatory has widened in scope, the need for staff with specialized training and experience has increased. If the Royal Observatory is to be able to continue to make important contributions to the development of astronomical science, it is of vital importance that the basic grades should be recruited at a higher level. This matter is the concern not merely of the Royal Observatory; upon it depends in large measure the future of astronomical research in Great Britain. The great national observatory should provide one of the main outlets for research graduates in astronomy from the Universities. Proposals have been submitted for regrading the staff of the Royal Observatory, including the Nautical Almanac Office, on the basis of the reorganised Scientific Civil Service. Until there is a favourable decision on these proposals, the recruitment of staff to fill vacancies will present special difficulties, because the salaries and prospects of promotion at the Observatory under its present system of grading are markedly inferior to those in other scientific establishments.

H. SPENCER JONES.
Astronomer Royal

Royal Observatory, Greenwich.
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