REPORT OF THE ASTRONOMER ROYAL

to the Board of Visitors of the Royal Greenwich Observatory

Read at the Annual Visitation of the Royal Greenwich Observatory, 1952 June 7.

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REPORT OF THE ASTRONOMER ROYAL TO THE BOARD OF VISITORS OF THE ROYAL GREENWICH OBSERVATORY

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The Report here presented refers to the period from 1951 May 1 to 1952 April 30 and exhibits the state of the Observatory on the last named day.

I. GROUNDS AND BUILDINGS.

(a) Greenwich. As mentioned in last year's report, the Wren building has been taken over by the Ministry of Works, and will be treated as an Historic Monument. Extensive dry rot was found in the roof and particularly in the main supporting beams; the delay in repairing war damage and the lack of windows for some twelve years were undoubtedly contributory factors. Rolled steel joists have been inserted temporarily to carry the weight from above, by means of straps and bolts passing through the lead flats. While the repairs to the roof are in progress, a temporary roof has been provided over the Octagon Room. The replacement of all damaged woodwork has been completed and work on the ceiling is in progress.

The exterior painting of the south side of the Old Building and of the Airy Transit Circle pavilion, and the interior painting of the main floor of the New Building, of the Gate Porter's Lodge and of the Sheepshanks dome have been completed. The old covering of the Thompson dome has been replaced with aluminium sheeting. Extensive repairs to the Sheepshanks dome and shutters have been carried out. The window arches on the south side of the Photoheliograph dome have been rebuilt and a portion of the wall has been repointed.

The hot air furnaces of the New Building have been overhauled and the ducts have been repaired. Though the system is now in a satisfactory condition, the special grade of anthracite for which the system was designed is no longer available, and a suitable substitute has not yet been obtained. The provision of a Ladies' Toilet in the Old Building, work on which was started in 1940 but shelved during the war, has been completed.

In the Christie Enclosure, the exterior steelwork of the Cooke Reversible Transit Circle pavilion and of the Yapp dome, and the louvres of the collimator houses have been repainted.

(b) Abinger. The walls of the Time Department Building and of the Laboratories have been treated with a water-proofing solution. All unpainted exterior woodwork at Feldemore has been treated with wood preservative.

(c) Herstmonceux. The Ministry of Works has taken over responsibility for the maintenance of the exterior walls of the Castle, which are of the original brickwork. The replacement of portions of the stonework of the south gateway and towers, which have weathered badly, is making slow progress; it has already extended over more than two years. Meanwhile, the two state bedrooms over the gateway, reserved for the use of official visitors, remain out of use.

The roadway to the east gate has been regraded, widened, and provided with a proper foundation and drainage. It will give access to the Equatorial Group on the north and to the Isaac Newton Reflector on the south. A temporary roadway has been laid to provide access to the Meridian Group during its construction.

The contract has been placed for the pavilion to house the Cooke Reversible Transit Circle. Contracts for the building to house the Photographic Zenith Tube, the building to hold the control console for this instrument, and the pavilion for the Bamberg Broken Transit Instrument are due to be placed. The foundations and piers for the instruments and the foundations for the buildings themselves are to be constructed departmentally. After the Cooke R.T.C. has been erected at Herstmonceux, the pavilion which houses it at Greenwich will be dismantled and re-erected at Herstmonceux to house the Melbourne R.T.C.

The Consulting Architect has progressed the designs for the Equatorial Group of six telescopes. All details have been settled and the plans are now in an advanced stage. It had been hoped to start construction of this group this summer but, as a consequence of the economy drive, it has been decided that the work cannot be started during the present financial year.

Preliminary plans of the building to house the Time Department, the Nautical Almanac Office, the Workshops and to provide storage accommodation have been prepared by the Architect as a basis for discussion.

The adaptation of the Great Hall of the Castle as a library has been completed, except for the lighting, the installation of which is in progress. The main entrance doorway has been reconstructed and new doors have been provided. The shelving for the books has been constructed and erected by Messrs. Libraco Ltd., who have also supplied card catalogues and other accessories. The large oak table from the Octagon Room at Greenwich has been brought to Herstmonceux and placed in the library for the display of current periodicals and publications. The removal of the library books from Greenwich to Herstmonceux has commenced.

As a first stage in the scheme for landscaping in and around the groups of instruments, several areas have been planted with trees and shrubs and protected with rabbit-proof fencing.

A messenger's lobby has been provided within the west entrance of the Castle. The black paint has been removed from the main staircase, the surrounds, and the two doors on the first floor; the woodwork has been lightly stained and polished. The beautiful carved woodwork of this magnificent staircase can now be seen to full advantage.

The adaptation of the two rooms on the ground floor on the north side of the Castle, which will provide office accommodation for the Meridian Department, has been commenced.

Borings have been made on the sites of the principal instruments for consideration by the Consulting Engineers, to provide a basis for deciding how deep it is necessary for the piers to extend. Surveys of these sites have been in progress to provide the Architect with precise information about differences of level.

II. INSTRUMENTS, APPARATUS, AND LIBRARY.

The following instruments are on loan to the Royal 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, from the Royal Astronomical Society.

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

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

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

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

A small transit instrument, of the broken type, with stand, by Bamberg, from the Royal Observatory, Edinburgh.

A 4-inch astronomical telescope and stand, from the Oppenheimer Casing Co. (U.K.) Ltd.

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

Two 35-mm. cinema cameras, from the Admiralty Research Laboratory.

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

The 6-inch lens of 45-feet focus, the property of J. H. Worthington Esq., which is stored at the Royal Observatory, was loaned to the Director of the Helwan Observatory, Egypt, together with camera and plateholders, for the photography of the corona at the total solar eclipse of February 25 at Khartoum.

The following instruments have been lent by the Royal Observatory.

To the Royal Observatory, Cape of Good Hope:-

Clocks, Dent 1916 and Dent 2013.

To the Imperial College of Science and Technology:-

6-inch equatorial, Simms No.2.

To the Cavendish Laboratory, Cambridge:-

A synchronome slave clock.

To the National Maritime Museum:-

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

To the Science Museum:-

A number of astronomical instruments of historical interest.

To the Cambridge University Observatory:-

A gravity drive clock and five plate-holders for use at the 1952 eclipse.

A comparison image micrometer.

The Cookson Floating Zenith Telescope, which has been on loan from the Cambridge Observatory since 1911, has been dismantled preparatory to its return to Cambridge in the near future.

Work has been completed on Harrison's Time Machine No.1. This work, which was undertaken without charge by Mr. D. W. Fletcher, lately Superintending Civil Engineer, H.M. Dockyard, Chatham, has been carried out with great skill. When Lieut. Commander R. T. Gould restored this timepiece, he left the temperature compensation inoperative; Mr. Fletcher has succeeded in bringing it into action and has made various other improvements. No further progress has yet been made with the renovation of No.3.

Harrison's Time Machine No.4 and the Larcum Kendall copy, shown as on loan to the National Maritime Museum, have been examined and cleaned in the Watch Repair Shop at Herstmonceux. These instruments, together with Harrison No.1, will be loaned to the special exhibition, 'The British Clockmakers' Heritage' to be held at the Science Museum, 1952 May to September, after which they will be returned to the National Maritime Museum.

The Sheepshanks Equatorial has been completely dismantled and reconditioned in the Workshop, and has been re-erected in its reconditioned dome.

The Field Equatorial and Altazimuth Instrument have been removed from Greenwich to Herstmonceux and stored in the Instrument store.

A Zeiss plate measuring machine has been purchased from the Fraunhofer Institut, Freiburg im Breisgau. This machine, by which both co-ordinates are measured together, will take plates up to 30 cms. by 30 cms. in size, and forms a useful addition to the measuring equipment.

Cooke Reversible Transit-Circle.

The new coma-free objective ordered for this telescope has been delivered. It will be tested on the bench and, after having been fitted to the instrument, on stars, before final acceptance.

A contract has been placed for the manufacture of cameras to be fitted to the circle microscopes, so that the circle readings can be photographically recorded.

The investigation into the causes of the large changes with temperature of the collimation-error of this instrument, to which reference was made in last year's report, showed that there was a strong correlation between the changes of collimation and the rate of change of temperature. Series of measures of collimation were obtained in four conditions of the instrument, by rotating the micrometer box through 180°, rotating the eye-end half of the telescope tube through 180°, and rotating the objective and cell through 180°. Analysis of these observations showed that the major portion of the effect is attributable about equally to the eye-end

half of the telescope tube and to the combination of the objective-end half of the tube with the central cube. As it was not possible to rotate the objective-end of the tube relative to the cube, the contributions to the total effect from the cube and from the objective-end of the tube could not be separated. It appears probable that with changing temperature there is a slight warping of the two portions of the tube. The contributions to the changes of collimation made by the micrometer box and by the objective and cell were much smaller but were significant, being several times greater than their probable errors.

The maximum effect was obtained in the condition of the instrument in which the first series of observations were made. In that condition the collimation error changed by +0".178 ± 0".004 per degree F change of temperature per hour. In one condition of the instrument the component effects practically cancel one another, so that the collimation error was found to change only by +".003 ± 0".004 per degree F change of temperature per hour. The instrument can be used in this condition, so that the troublesome effect of drift of collimation error with rate of change of temperature will be essentially eliminated.

In addition to the changes of collimation with rate of change of temperature, there are much smaller changes with the temperature itself. Practically the whole of this effect can be traced to the eye-end half of the telescope tube; it cannot be eliminated by any relative positioning of the separate components. In the condition in which the instrument will be used, a change of temperature of 1°F causes a change of collimation of +0".0085 ± 0".0015. The effects of change of temperature can be allowed for.

The results of this investigation are being written up for publication.

Photographic Zenith Tube.

The instrument, together with the new sole plate and supporting pillars, has been assembled in the works of Sir Howard Grubb Parsons & Company for tests of performance to be made. One result of these tests was that clamping of the stellar plate carriage during reversal is not necessary.

Some trouble was at first experienced with the reversing mechanism, but this was overcome in due course. Another trouble was vibration of the stellar plate carriage as a whole. This was traced to the synchronous motors, and was much enhanced when, as frequently occurred at this stage, one of the motors settled into an asynchronous type of running. This trouble was cured, and the amplitude of vibration was much diminished by additional bracing of the supporting pillars. The motors, clutches, and the rotary reversing solenoids have been enclosed and air will be drawn past them to minimize any temperature effects.

At various stages of the tests chronographic records were taken both for single runs and for complete cycles which, together with observations made with the reversal autocollimator, provide checks on the mechanical performance. Measurements of these photographic records were made both in the laboratory at Abinger and on the Zeiss machine at the National Physical Laboratory. The results were generally satisfactory; in the meantime the instrument was dismantled for the carrying out of various finishing processes.

A minor alteration to the rotary, which had appeared for some time to be desirable, has been effected, providing easy access to the rotary stops so that they can be readily removed for servicing. Before this alteration such access would have been possible only after extensive dismantling of the instrument.

The stellar shutter has been completed. Tests show that its speed of operation and degree of repetition fulfil the requirements laid down. Construction of the tilted focussing plate and of the auxiliary equipment for controlling the height of the mercury basin have also been completed.

The control and indicating console has been delivered to Herstmonceux: delivery of the instrument itself, now contingent on the finishing processes, should not be long delayed.

Measuring Machine for P.Z.T. stellar plates.

Considerable further work has been done on the design of this machine, and to assist development and discussion a full scale model has been constructed. The optical system has been so arranged that settings can be made either by means of a microphotometric criterion or visually. Construction of the auxiliary electrical equipment required for the microphotometric method has been completed; when delivery of the necessary photocells has been made it is proposed to carry out an adequate bench-test of the method before proceeding to actual construction. The microphotometric method has the following advantages:

(a) Relative ease of observation and absence of fatigue and consequently, other things being equal, probable superiority in speed of operation.

(b) An appreciable superiority in precision, especially for faint or ill-defined images.

(c) Superiority in sensitivity. Since measurement is possible at lower contrast between image and background than with a visual setting, it is possible that the measurable range of stellar magnitude may be extended.

Although the use of a microphotometric method, based on the scanning method due to Dr. Furth, had previously been considered, the decision to adopt a microphotometric criterion was made after seeing the Double-Trace Scanning Microphotometer shown by Dr. Rymer of Reading at the Physical Society Exhibition of Scientific Instruments in 1951: its essential features appeared to be suitable to the present purpose. It has the advantages of being less cumbrous, more flexible, and superior in the method of setting. On a cathode ray tube two traces are formed, one of which is the mirror image of the other. The criterion of setting is coincidence of these traces, which is preferable to the setting of a single trace to a fixed fiducial line. Shortly afterwards Dr. Rymer very kindly demonstrated the instrument at Reading, discussed its application to our purpose, and provided details of his circuits.

In considering the design of the measuring machine, based on this principle, it was clear that the system of employing superposed fields of view, referred to in last year's report, was ill adapted to the microphotometric method, and was therefore abandoned; and that the proposed use of a ruled glass scale as the basis of measurement was readily adaptable to a compensating optical system which eliminates the effect of any residual drift in the position of the source of light.

An experimental optical system was set up in the Optical Laboratory to test various points in practice, including the micrometer system which is of the rotated plate type.

One feature of the mechanical design which, from the operational point of view, is a great improvement on the previous instrument is the use of a turn-table to rotate the plate holder and fiducial optical square through 90°. Previously the square plate holder had to be lifted by hand clear of the machine and replaced after rotation.

The turn-table is located on the Y-carriage and moves between two adjustable stops which are provided for easy and rapid rotation of the nominal 90°. The actual angle of rotation is measured for each stellar plate with high precision on the autocollimator.

Another proposal tending to ease and safety of operation is the provision of a bench jig which, by using a simple optical projection method, will enable the plate to be lined up before its holder is located on the turn-table.

At various stages during the development of the design much help and encouragement has been given by discussions with the National Physical Laboratory. The construction of the model has been facilitated by the recent installation of a small lathe in the laboratory.

III. ASTRONOMICAL AND RADIO OBSERVATIONS.

Airy Transit-circle.

Except for 8 observations of some faint difficult PZT stars the observing programme has been restricted to the Sun, Moon and planets.

The following observations have been obtained during the year.

Sun	143	Jupiter	26	Ceres	8
Moon	93	Saturn	16	Pallas	3
Mercury	12	Uranus	6	Vesta	15
Venus	59	Neptune	14	Metis	2

Transits for the determination of clock and azimuth errors number 1688.

The total number of transits and zenith distances secured with the instrument are 2301 and 1414 respectively.

Except for some computations on the proper motions of the 2100 stars not contained in the Albany G.C. very little progress can be reported on the first Greenwich Catalogue for 1950, owing to shortage of staff; the available staff have been fully occupied with current reductions and overtaking war-time arrears.

Astrographic Telescope.

A camera designed and constructed in the workshop round a $5\frac{1}{2}$-in. Ross aircraft reconnaissance lens has been mounted on this instrument. Star-field tests show that coma is appreciable at 3° off axis, and plates taken with the instrument will not be usable for accurate positional work beyond this; but for search purposes (for example, when a newly-discovered comet is reported but no ephemeris is available, or in the case - deplorably frequent since the interruption in minor planet work caused by the war - of an asteroid seriously off its predicted course) a field 10° in diameter can be covered on a single plate. An appreciable saving of plates and of observing time on the 13-in. photographic telescope can thus be expected.

Systematic observations of position of the brightest four minor planets continues to be the main programme with this instrument. Ceres, Pallas, Juno and Vesta have been photographed during the year on 19, 43, 13 and 27 plates, respectively. All the plates outstanding from last year are now measured and reduced, together with 52 of the 102 comprising the current year's output.

Practical considerations connected with the limited number of observers, the other functions of the telescope, the distribution of the minor planets in R.A. and, last but not least, the weather, make it impracticable to confine astrometric observations of these objects strictly to the meridian without seriously reducing output. Comparison between the residuals from plates taken at widely different hour angles shows, however, no dependence of the accidental error on hour angle. Systematic differences may exist, however, and a start has been made with a special series of plates of a suitable star-field designed to test this point.

In addition to the main programme, 9 plates of Nemausa were obtained in response to the appeal of the Copenhagen Observatory for accurate places of this planet, which will serve for deducing systematic corrections to fundamental catalogues. Four exposures on Eunomia and four on Iris during their recent oppositions will enable the very considerable errors of their respective ephemerides to be corrected. The best-observed comet of the year was 1951 l P/Schaumasse, of which 17 plates were secured over a period of nearly three months. All these plates have been measured and reduced and the resulting places communicated to Cincinnati Observatory (minor planets) or to the Central Bureau of Astronomical Telegrams (comets).

Occultations have been observed with the 10-in. guiding telescope during photographic duties: nine successful observations have been communicated to the Nautical Almanac Office.

Yapp 36-inch Reflector.

The output of this telescope, already kept low by London's pall of smoke, which obscures the Greenwich sky to an even greater extent than immediately before the war, has been further reduced during the past year by illness amongst the observers. Where a full rota of observers cannot be maintained, duties are concentrated on instruments that can be more efficiently used than one designed for the spectrum range suffering most heavily from absorption. Furthermore, the programme of examining Ko sub-giants for luminosity effects correlated with anomalous trigonometric parallaxes is now directed towards fainter stars. These two factors account for the fact that only 46 spectra of 30 stars have been secured with the main reflector. The 7-in. guider has been used for observing 9 occultations which occurred during the photographic duties.

Some experimental direct photographs of the full Moon at the Cassegrain focus have shown unexpectedly high resolution, considering that the limb is necessarily $\frac{1}{4}^\circ$ off axis and that the figure of the mirror is not as good as could be desired.

Cape Zone Photographs.

The colour-magnitude corrections referred to in the last report have been computed and applied to all the stars. For the stars for which moderately good meridian places were available at the beginning of the work, the process of differentially correcting the original place by means of the measured residual is now under way, and of the 113 fields 105 have been completed. For the fainter stars, it was only

possible to compute recognition co-ordinates from crude initial places, and the measured residuals are too large for the differential correction method to be accurate. For these stars the full reverse computation from measured co-ordinates to R.A. and Dec. will shortly begin.

Photoheliograph.

The Sun was photographed on 297 days, a second photograph being taken except on 15 days. The granulation of the photosphere is clearly shown on a number of the plates, especially in May and March. Since the removal to Herstmonceux, the record of solar photographs shows a marked improvement, not only as regards numbers, but also in the quality of the photographs obtained. Thirty-one plates with double images were taken for determining the zero of position angle, which was also regularly checked by a visual method. From reports received from H.M. Astronomer at the Cape and the Director of the Kodaikanal Observatory, India, no day is unrepresented in the combined series for 1951.

Consignments of solar negatives have been received from the Cape in duplicate from 1950 July 1 to 1951 June 30, and a single series from 1951 July 1 to December 31.

Measurement of the combined series has been completed from 1948 November 2 to 1950 December 31, involving more than 21,000 measures of spot-groups, component spots and faculae. Computations of sunspot positions and areas have been made from 1947 November 21 to 1949 December 31.

The printing of the Greenwich Photoheliographic Results for 1937 has been completed and the volume published. The publication is still awaited of the 1939 Results, for which varityper copy was ready in 1950 November. The first 70 pages of the 1940 Results have been prepared. The varityper copy for the 1945 Results has been nearly completed. The MS. copy for press for 1947 is practically complete.

Daily sunspot numbers based on the Zürich system of counting have been sent to the Director of the Federal Observatory, Zürich, for inclusion in the Quarterly Bulletin on Solar Activity. Several radio centres in this country are also sent a monthly mean value. The mean daily sunspot number for the twelve months covered by this report is 57, showing a decline from the value of 70 for the preceding period.

The largest sunspot of the year crossed the central meridian on 1951 May 16 and attained a maximum area of nearly 5000 millionths of the Sun's hemisphere, the mean area for the disk passage being 3900 millionths. The occurrence of so large a spot group four years after sunspot maximum is exceptional. The giant group is in point of fact the fourth largest in the Greenwich records according to the mean area for the disk passage. No geomagnetic disturbance occurred when the spot was in the central half of the Sun's disk.

A group with C.M.P. on June 18.5 attained an area of 2350 millionths and was associated with a high degree of solar noise according to information received.

In contrast to these great spots, there were six consecutive spotless days from February 26 to March 2. The non-appearance of any small high latitude spots suggests that solar minimum will not be reached for at least eighteen months.

An investigation has been made into area changes in sunspots and solar flare incidence. The incidence of intense solar flares appears unrelated to any systematic area change in the associated sunspot. A short paper describing the results is being published in "The Observatory".

A study is being made of the giant spots (mean area greater than 1500 millionths of the Sun's hemisphere) recorded since 1874.

Three prints and one positive on glass of the great sunspot of 1951 May were sent for exhibition at the Science Museum, South Kensington.

Spectrohelioscopes.

Observations of the Sun's disk in $H\alpha$ were made on 132 days, but on 33 days observations were restricted to a few minutes by adverse sky conditions. Thirty-five solar flares were observed, but of these only two (on May 18 and September 3 respectively) were of major importance. The frequency of flares has, in fact, become progressively less during the report year. Since January, from a total watch with the spectrohelioscope of 24.3 hours on 46 days, only two minor flares have been observed. A fade-out on short-wave radio transmission on April 22 (indicating a solar flare of moderately high intensity) was reported by Cable and Wireless Limited as the first since November 6. The occurrence of this flare on April 22 is also indicated on the S.E.A. (sudden enhancement of atmospherics) recorder at Herstmonceux. The occurrence of a few minor flares is indicated between November 6 and April 22. From this sampling, it appears that, with a few exceptions, flare activity is now at a low level, although as remarked earlier, sunspot minimum may not occur for at least another eighteen months. The twelve-monthly period under review was, however, an active one for solar particle radiation, as shown by the frequency of geomagnetic disturbance that can be ascribed chiefly, though not entirely, to solar M-regions. A general inverse correlation has been shown between these sequence storms and the large sunspots. A recent example of a 27-day sequence of small storms included disturbances lasting about a week and commencing respectively on January 10, February 6, March 4 and March 30. Disturbance recurred on April 27. A recent storm on April 21 would appear to be associated with a growing sunspot with central meridian passage on April 18.5.

Reports of solar flares, their times of occurrence, positions and highest intensity observed with a wedge photometer were sent quarterly to Meudon for subsequent inclusion in the Zürich Quarterly Bulletin. Copies of these lists are sent to the usual radio research centres and to the Director, Meteorological Office, Air Ministry, London.

A new S.E.A. recorder was installed on November 28. The receiver is working on a frequency of 27 kc/s (11.1 kilometres), but the equipment enables a choice to be made of the operating frequency over a fairly wide range. The original recorder has again been modified to serve as a sudden-phase anomaly indicator (combined amplitude of sky and ground waves) receiving G.B.R., Rugby, on a frequency of 16 kc/s (18.7 kilometres). A double-pen recorder produces the dual traces for direct comparison to be made. Acknowledgment is gratefully made to Mr. J. A. Ratcliffe, Cavendish Laboratory, Cambridge, for advice and help in the construction of the new S.E.A. recorder.

With a small camera attachment to the Newbegin spectrohelioscope, a few experimental plates of the $H\alpha$ region have been secured and microphotometer tracings obtained from them. The present infrequency of flares has restricted this preliminary work, intended as an additional record to the visual observations of flares. Dr. C. R. Burch has kindly presented an accurately figured $1\frac{1}{2}$ inch flat for use with this camera.

Besides following the progress of solar flares, 148 measures of line-of-sight motions of dark hydrogen flocculi on the disk were obtained. On six occasions the measured velocity exceeded 100 km./sec. Similar measures were also made on many patches of normal bright flocculi around sunspots, but these rarely show significant line-of-sight motions. Forty-four photometer measures were made on patches of normal bright flocculi, in addition to 26 sets on solar flares. Forty-one prominences were examined at the Sun's limb.

The helpful co-operation has been continued by the Joint Radio Propagation Bureau (Admiralty) in the telephonic distribution of current solar data issued from Herstmonceux for use at a number of radio research centres.

Solar Eclipse, 1952 February 25.

The programme of the eclipse expeditions was in the first place to apply, for geodetic purposes as well as for the purposes of pure astronomy, the technique first tried out at Mombasa in 1948. This involves fixed cinema-cameras, at stations just outside the belt of totality, arranged to obtain several thousand accurately-timed pictures of the thin remaining crescent of the Sun, at the time when its position-angle is changing very rapidly.

For astronomical reasons it was decided to have a station on each side of the track, in a region where the weather chances were good; the Sudan was clearly indicated for this. For geodetic reasons it was desired to have stations as far apart along the track as practicable; the weather prospects being very bad west of the Sudan, and the outlook both meteorologically and politically being at least unfavourable east of Basra, the total available length of track was less than ideal; but the difference in effort between three stations and four being small it was decided to have a pair of stations, one each side of the track, in the Persian Gulf as well as in the Sudan. In addition, it was hoped to obtain a small number of large-scale photographs, at both the Sudan stations, for the purpose of determining the Moon's limb-profile at the exact libration of the eclipse, since the profile enters into the reductions. For this purpose these stations each had a photoheliograph-type camera, fed by a coelostat and using $5\frac{1}{2}$-inch wide "topographic base" film. They were to take roughly one picture per minute for 20 minutes before and after mid-eclipse; and if this programme were successful at both stations it would completely cover both limbs of the Moon with good overlaps. The scale was chosen to suit the photoelectric measuring machine in Washington.

A considerable amount of time was spent on the design and equipment for the expeditions; this work was entirely carried out in the Greenwich Workshop, with the exception of the electronics equipment and chronographs, which was done at Abinger.

The four cine-cameras used were fitted with electrical contacts in phase with the pressure plates of the cameras, for recording the time of each exposure. It was also arranged for three fiducial points to be photographed on each frame.

Occulting shutters were constructed for each camera, with electrical contacts to determine time factors during the eclipse. The 9″ Photoheliograph and Hodgson Telescopes were fitted with magnifiers to give an image of the Sun 4 inches in diameter.

The coelostats used were not designed for the required latitude, and had to be adapted by means of metal wedges; this also necessitated alterations to the driving blocks.

The four stations were located as follows: (1) 27 miles N.W. of En Nahud (Sudan); (2) at Tendelti (Sudan); (3) at Bat'ha (Iraq); (4) near Al Jahara (Kuwait). One observer from Greenwich went to each station, Dr. Atkinson to En Nahud, Mr. Cordwell to Tendelti, Mr. Pope to Iraq, and Mr. Blackwell to Kuwait; the Helwan Observatory supplied three observers for the Sudan stations and in addition shared the expense of this part of the programme. The two stations in the Persian Gulf were the guests respectively of the Basra Petroleum Company and the Kuwait Oil Company, whose generous help was of the greatest value; and at each of these stations an assistant was recruited and trained locally. In fact, even the double programme of the Sudan stations proved quite manageable with only two men, given proper rehearsals.

All four stations succeeded in setting up their apparatus in accordance with the plan, and getting adjusted and carrying out rehearsals well ahead of the eclipse date. All four were, however, severely hampered by dust, both in the form of strongly-driven clouds and in the form of almost imperceptibly fine penetrating deposits. The dust storms made it impossible to lubricate most parts of any exposed mechanisms, such as coelostat-drives, but it was found practicable to clean these repeatedly, and then run them dry except for the governor-bearings. In some cases chronometer-rates were very badly affected, but this could be accepted. The most serious consequences were in unforeseen jammings of camera-magazines during the eclipse itself; these occurred both in the cinema-camera of No.1 station and in the photoheliograph of No.2, though they had not occurred in rehearsals at all. In both cases they were cleared and a reserve magazine got in in place of the faulty one; but the cinema-programme was only about four minutes long at all stations, and at No.1 station as a result only about the last minute of the four was obtained. At No.2 station it is believed that the cinema-run was satisfactory, or fairly so; and on the photoheliograph only one or two exposures were lost. No.3 station had cloud. No.4 is believed to have obtained a satisfactory cinema film. The examination of the films has been delayed by illness contracted by Dr. Atkinson at the end of the expedition.

Time Service.

Throughout the year the Time Service has been based upon astronomical observations made at Greenwich using Small Transit B and at Abinger using the Bamberg Broken Transit instrument.

At Greenwich 201 observations were secured on 160 nights and at Abinger 308 on 135 nights, making a total of 509 observations during the twelve months covered by this report. Transit C was included in the equipment sent to the Sudan for the observation of the eclipse of February 25, so that the position of one of the observing stations could be accurately determined. It was dispatched on December 4 and has not yet been received back. Routine re-calibration of the Bamberg level has been carried out twice during the year and no change in scale value has been detected.

The analysis of the performance of the clocks has been continued and has provided strong evidence that the annual fluctuation in the rate of rotation of the Earth is subject to considerable changes in phase and amplitude. The values obtained for 1950-51 are significantly smaller than those given by many previous concordant analyses. It is consequently not practicable to apply corrections month by month to the time determined astronomically so as to produce a uniform time system. The best quartz clocks must be accepted as defining a time system that is approximately uniform while the astronomical determinations of time over two or three years are used to determine for each clock the error at a given epoch and the rate. If the

annual fluctuation were constant its effects could be eliminated by comparing monthly mean errors of each clock, separated by an interval of twelve months; the true annual rates of each clock would then be determined. This technique is used as a control over the annual fluctuation but is only applicable to clocks of the highest precision with uniform runs extending over two or three years. Determinations of the annual fluctuation over a twelve-month period are now made every three months. As in previous years, the effect on time determination of the polar motion has been estimated from current latitude variation observations of the U.S. Naval Observatory. Comparison of the provisional corrections so determined with those based on the international latitude variation data, which are not available until much later, has shown satisfactory agreement.

At Abinger the quartz ring oscillator E5 has continued to show a high standard of stability. E6 is also operating satisfactorily, with a steady decrease in the rather large frequency drift. Two new ring crystal oscillators were installed in August as C5 and C6. The performance of C5 has been fair but that of C6, which had been equipped with long-life valves, was disappointing; minor modifications were made to the circuits of C6 in March and a considerably higher standard of short-term stability has resulted: it is too early to decide whether the long-term stability will show a corresponding improvement. If it does, similar modifications will be made to the circuits of C5. The modifications in B cellar were completed in August and the oscillators were set going with GT-plate crystals. It is proposed to replace the crystals in B5 and B6 with ring crystals when they are available from the Post Office Radio Branch Laboratories.

A three-phase 45 KVA diesel-driven AC generator has been installed and is fitted with automatic starting equipment which brings it into operation in the event of failure of the mains electricity supply. The 25 volt battery which operates a motor generator providing a 50 cycle AC supply for the quartz crystal thermostats in the event of mains failure has been replated.

At Greenwich two brief interruptions occurred in the HT supplies to the clocks, but no change of rate of the oscillators occurred. In November oscillator A2 was stopped while changing the main amplifier and buffer valves, causing a change of rate. In November the rate of A3 oscillator was re-adjusted and in December there was a violent change of rate of oscillator F3 for no apparent cause.

Twelve new regenerative dividers of the type described in last year's report have been made commercially to the pattern of the prototype made in the Electronics Laboratory. The three regenerative dividers in the Greenwich installation have now been replaced by the new type, and two further dividers have been added: work on the replacement of the dividers at Abinger is in hand. Two long-wave receivers and two decimal counter chronometers have been set up at Greenwich. One of the decimal counter chronometers is of the type developed in the Electronics Laboratory; the other is of the commercial type previously employed, modified to incorporate gate and trigger units of the new pattern. A transmitting motor, together with ancillary circuits for the transmission of the six-pips and the hourly signals, has been installed and a number of send relays with a control panel and line-meter panel are being installed. All this equipment has been made up at Abinger in complete rack units for ease of erection and wiring, and has been designed to facilitate its removal to a new site if and when required.

By the continued co-operation of the Post Office Radio Branch, the National Physical Laboratory, the B.B.C. Receiving Station, and the Research Division, Marconi's Wireless Telegraph Company Ltd., information is received concerning quartz clocks and frequency standards at Dollis Hill, Rugby, Teddington, Tatsfield, and Great Baddow.

The clocks at Dollis Hill have continued to provide information of great value in the operation of the Time Service. The ring crystal oscillator 9A maintains its high standard of performance and other ring crystal oscillators continue to serve as long-term standards. The new ring crystal oscillator, Q13, at the National Physical Laboratory is running satisfactorily and now provides useful data for the Time Service.

The International Time signals, the six-pips time signals, and the hourly signals used by the Post Office for the control of the Speaking Clock, have been sent out regularly from the phonic motor transmitters at Abinger. One of the Rhythmic Phaseable Phonic motors has been converted to provide seconds contacts. The reserve service of hourly and six-pips signals has been maintained from Greenwich.

Radio time signals from Australia, France, Germany, Russia, and the U.S.A. have been regularly received throughout the year. Daily frequency comparisons are made between the Observatory standards and the transmissions from Rugby (MSF 60 kc/s) and Droitwich (200 kc/s). The superimposed seconds pulses on the MSF transmissions are also checked at Abinger.

The preparation and distribution of the various Time Department publications have been continued. The Time Service Bulletin containing reception times of all radio time signals received at the Observatory has been published for each month of 1951. Three supplements to the Bulletin are also published. Supplement A contains the G.M.T. reception times of the WWV time signals of the U.S. National Bureau of Standards. Supplement B gives the G.M.T. reception times of the Rugby GBR radio time signals and corrections for the effects of polar variation and annual fluctuation, thus permitting a direct comparison between the GBR signals and a provisional uniform time system. Supplement C gives the reception times of the MSF seconds pulses which are also referred to a provisional uniform time system. The Time Service Circular, containing frequency estimates referred to a currently estimated uniform time system, are published about the middle of each month for the preceding month. The Time Service Monthly Frequency Estimate, prepared at the same time, gives estimates of the predicted, current and revised frequencies of selected quartz crystal standards and is sent to the Post Office and the National Physical Laboratory. Some progress has been made in the proof reading for the volumes of Greenwich Observations whose publication had been delayed by the War.

The Maintenance and Installation Section at Abinger undertook some of the preparatory work for the Solar Eclipse of February 25. Six radio receivers were modified and re-aligned, special recording units were constructed and tested, and rhombic aerials made up. Three chronographs were constructed, and two others fitted with DC motors, in the workshop at Abinger.

A millisecond printing chronograph constructed by Messrs. Edouard Bélin of Paris was delivered to the department for test.

At Greenwich the Time Ball was dropped to mark the opening of the Festival of Britain on May 3rd and then daily at twelve noon until work on the Octagon Room prevented its further use.

Details of the observations made at Abinger with the Bamberg Transit Instrument were transferred to punched cards for analysis by Hollerith equipment. As the equipment at the Nautical Almanac Office was in full use and not available for this work, a member of the Observatory staff carried out the machine operations with the Hollerith equipment of the Mathematics Division of the National Physical Laboratory, through the courtesy of the Superintendent of the Division. This Hollerith analysis has been supplemented by various investigations by conventional methods undertaken at both Greenwich and Abinger and the results are now being analysed and collated.

The higher standard of accuracy now demanded has made it necessary to employ rigorous computing procedure in cases where simpler graphical methods previously sufficed, and also to carry out the computing with an increased number of significant figures. Greater use is therefore being made of calculating machines. A Brunsviga and a Britannic machine have been supplied, while a National Accounting machine is held on loan from the Nautical Almanac Office in order that its value to the Time Department may be ascertained. It has already been employed for the analysis over a period of twelve months of the six-figure beat-counter readings at Abinger, for which it has proved particularly suitable.

The prototype crystal oscillator GI designed in the Electronics Laboratory, referred to in last year's report, has been in operation since November. It incorporates the GT crystal previously presented to the department by Messrs. Standard Telephones and Cables Ltd., which has since been resealed by the firm. The results obtained so far have been very encouraging. The temperature control circuits and thermostat are operating satisfactorily to within the very close limits demanded by the design, and the oscillator which maintains the crystal in oscillation at a low amplitude shows a very high standard of short-term stability. A second experimental oscillator G2 has been constructed and is in process of adjustment and installation.

Preliminary experiments have been carried out with a view to designing and constructing more accurate and convenient equipment for frequency comparison and some constructional work is in hand. Further experience with the pulse dividers developed in the Electronics Laboratory has provided adequate confirmation of their accuracy and reliability. The installation of pulse dividers has now become a necessary operational requirement, as the scatter of the seconds pulses derived from the phonic motors limits the precision of clock intercomparisons and of the measurement of radio signals such as the seconds pulses superimposed on the MSF transmissions.

A number of minor items of equipment have been designed and constructed in the Electronics Laboratory. A reserve 60 kc/s standard frequency receiver has been installed, and a prototype for the seconds pulses of the MSF transmissions has been completed and is now on test at Greenwich. A noise receiver, constructed by Messrs. Morley and Dukes under the supervision of the Cavendish Laboratory, Cambridge, was tested in the laboratory and installed in the Solar Department at Herstmonceux. A test set for this receiver has also been made. The phase-anomaly received originally constructed in the laboratory and then converted to operate as a noise receiver has since been re-converted for the recording of phase anomalies and has been re-installed in the Solar Department. A chronograph drive unit was constructed for the Chronometer Department, and a low-frequency oscillator for the Dye coil magnetometer of the Magnetic Department. Considerable assistance has been given to the Optics Laboratory in the design of the electronic equipment for the P.Z.T. Photo-electric Measuring Machine.

The equipment of the laboratory has been augmented by the addition of a Cossor double-beam industrial oscilloscope complete with a camera attachment, two Furzehill oscilloscopes, a Marconi signal generator and a Marconi low frequency circuit magnification meter.

IV. MAGNETIC OBSERVATIONS.

Measurements of horizontal and vertical intensity and of declination and inclination have been maintained for the purpose of establishing the base-line values of the recording instruments. The annual tests of the two potentiometers

used in conjunction with the Schuster-Smith coil and of one used in the Dye Coil circuit were carried out at the National Physical Laboratory. These tests showed little change, but a re-examination of the Z-potentiometer was made following a marked increase in the range of the base-line values given by the Dye Coil. Although a slight repair to the potentiometer was effected, great difficulty continued to be experienced in obtaining stability and sensitivity. The fault was eventually traced to the alternators. To meet the difficulty an experimental oscillator was constructed in the Electronics Laboratory and brought into use on April 5. Results obtained have so far been very successful, the range in the deduced values of the base-line having been halved, while eye-strain on the observer has been greatly reduced consequent upon increased stability of frequency. If the equipment continues to give satisfaction it is hoped to construct a permanent unit (incorporating some additional refinements) that will take the place of the alternator.

Some trouble has also been experienced with the Dip Inductor, but during these periods when difficulties have been encountered a satisfactory check on the Z base-line has been maintained using a BMZ instrument.

With the object of facilitating reproduction of the magnetograms for publication, a relay has been inserted in the time signal circuit to provide an increased light intensity for the hourly signals. This is an improvement on the former system of furnishing triple signals at the hour. The new system came into operation on December 28.

The older of the two 50-volt batteries, supplying current to the observing instruments, was renewed during the year, the responsibility of placing the contract and supervising the installation being undertaken by the Electrical Engineering Department, Chatham.

A Willmore Seismograph was installed at Abinger for a few days by Messrs. Hilger and Watts for testing under conditions free from vibration, which are not obtainable in London.

An analysis of the Greenwich and Abinger magnetic data covering the period 1916-51 has been undertaken to determine the diurnal variation and lunar effect under varying conditions. The data consist of the bi-hourly values of the three elements H, (North force during the period 1916-25 when records were being obtained at Greenwich), D and Z. These data are being punched upon Hollerith cards by Statistical Branch, Admiralty, and it is intended that the subsequent tabulation and analysis will be performed on the punched-card machines of the Nautical Almanac Office.

Preliminary work has begun upon preparation of the Admiralty Magnetic Charts for the epoch 1955. The charts will be for the elements: declination, horizontal intensity, inclination, vertical intensity, and total intensity. Recourse is being made to the past work of Vestine and others, but the very grave dearth of recent observational data, particularly in the vast ocean regions and central Asia, renders the task of constructing current charts of secular variation one largely of conjecture. Charts of the elements brought up-to-date with the resulting material are liable to serious errors. It is proposed to employ spherical harmonic analysis in an attempt to improve the charts in those regions where there are no observations, but the process is one of distributing the inaccuracies and it cannot repair the progressive falling off in accuracy resulting from the continued dearth of observational data over large regions of the Earth. This dearth of observations is greatly to be deplored.

Mean annual values of the magnetic elements at Abinger for the years 1948-1951, with the estimated values for 1952, are given below:-

Year	Decl. (West)	Horizontal Intensity	Vertical Intensity	Inclination
1948	9° 35.4	0.18593	0.43255	66° 44.4
1949	9 27.5	0.18607	0.43273	66 44.0
1950	9 19.7	0.18628	0.43288	66 43.0
1951	9 12.2	0.18648	0.43305	66 42.1
1952	9 5.2	0.18666	0.43323	66 41.4

Classifying as "storms" and "great storms" disturbances having a lower limit in range of 150γ and 300γ respectively in H or 30′ and 60′ in declination, the number of "storms" occurring during the twelve months covered by this report was 18 and the number of "great storms" 3. The latter occurred on September 25-26, October 28, and April 21.

V. METEOROLOGICAL OBSERVATIONS.

At Greenwich eye observations of atmospheric temperature have continued to be made daily at 0900 together with measurements of rainfall. Recording has continued with the night-sky camera and sunshine recorder throughout the year. Readings of the barometer and of the thermometers in the "Glaisher" stand were discontinued from 1951 May 1 and with the work of reconstructing the roof of the Wren building, wind recordings taken with the Osler and Robinson Anemometers also terminated at the end of April, the anemometers being dismantled on May 7. As a result of the same building operations the sunshine recorder was moved on 1951 May 4 from its former position on the roof of the Octagon Room to the roof of the South Wing of the New Building. On August 1 the sphere of this sunshine recorder was sent to the Meteorological Office, Harrow, to undergo tests, since when its place has been taken by a sphere, M.O.L3, on loan from the Meteorological Office. A comparison of the total sunshine recorded at Greenwich since the change with that of the previous twelve months shows no significant change in relation to the corresponding totals obtained at Herstmonceux and Kew.

The following observations refer to Greenwich:-

The maximum temperature recorded during the year was 84°.4 on July 28, there being six days, all in July, when the temperature rose above 80°. The lowest temperature was 21°.4 on January 27. The number of nights during which the temperature fell below freezing point was 42.

The recorded duration of bright sunshine was 1310.2 hours, the theoretical possible being 4493.0 hours. There were 65 entirely sunless days. On 31 nights the night-sky camera recorder gave a completely unbroken trace of δ Ursæ Minoris. The number of nights on which no trace of the star appeared was 80, with a further 51 on which not more than ten per cent of the amount possible was recorded. Loss of register occurred on eight nights.

The total rainfall during the twelve months was 24.65 inches, which is 0.32 inches above the average for the hundred years 1841-1940. There were 179 days on which rainfall exceeding 0.005 inch was recorded.

At Herstmonceux records have been obtained throughout the year with the Campbell-Stokes sunshine recorder and with the night-sky recorder. A comparison of these results with those secured at Greenwich during the same period confirm the earlier conclusions (derived from the results of the previous year) regarding the superiority of atmospheric conditions at Herstmonceux.

The recorded duration of bright sunshine was 1823.6 hours. There were 49 entirely sunless days. On 49 nights the night-sky camera recorder gave a completely unbroken trace of δ Ursæ Minoris. There were 78 nights on which no trace of the star appeared, with a further 30 on which not more than ten per cent of the amount possible was recorded.

The following table contains a summary of the sunshine and night-sky records at Herstmonceux and at Greenwich. The few nights on which there was a loss of register at one or other of the stations have been excluded when forming the comparison.

Month		Sunshine		Polaris		δ U. Min.		δ U. Min/Pol.	
		Herst.	Gr.	Herst.	Gr.	Herst.	Gr.	Herst.	Gr.
		Hours		%		%			
1951	May	198.2	119.6	39	38	35	35	.90	.92
	June	293.7	236.5	65	62	62	57	.95	.92
	July	248.8	188.9	55	55	49	50	.89	.91
	Aug.	175.3	149.9	56	51	50	47	.89	.82
	Sept.	129.0	103.7	54	41	48	36	.89	.88
	Oct.	140.9	94.0	57	49	54	42	.95	.86
	Nov.	72.7	54.5	41	41	35	34	.85	.83
	Dec.	66.9	30.1	43	41	39	35	.91	.85
1952	Jan.	102.0	41.7	46	42	40	36	.87	.86
	Feb.	91.9	52.4	49	40	41	32	.84	.80
	Mar.	96.6	69.7	37	29	31	23	.84	.79
	Apr.	207.3	166.5	54	49	47	44	.87	.90

Extension of the programme of meteorological observations at Herstmonceux awaits the erection of the building to accommodate the anemograph and the lay-out of the enclosure. Pending this the skeleton programme of observations is being continued at Greenwich.

Records of air pollution secured at Greenwich during the period 1947 August - 1949 March inclusive, which had formerly remained unmeasured, have been measured at Herstmonceux during the year and the results supplied to the Department of Scientific and Industrial Research.

VI. CHRONOMETERS.

The number of Admiralty chronometers and watches on charge to the Royal Observatory, exclusive of those in the hands of outworkers for repair, is 15077. Of this total 117 chronometers (Pattern HS1), 183 chronometer watches (HS2), 377 deck watches (HS3), 18 dashboard watches (HS4), 1129 wrist chronographs (HS9) and 441 ATP watches

are rating or ready for issue. There are 14 Pattern HS1, 47 HS2, 82 HS3, and 205 HS9 undergoing repair in the chronometer workshop. The remainder, consisting of 577 HS1, 2846 HS2, 5648 HS3, 1010 HS4, 519 HS5, 414 HS6, 98 HS7, 82 HS8, 996 HS9, and 274 ATP watches are held in store awaiting overhaul and rating. Chronometers and watches in use throughout the Observatory number seventeen. In addition to the foregoing, 218 chronometers and watches are deposited in the Chronometer Department for various reasons.

During the year a total of 8255 chronometers and watches was received and 8199 issued. These figures include the following non-routine items:

(a) 29 obsolete chronometers sold.

(b) 6 chronometers transferred to the Ministry of Supply.

(c) 8 deck watches transferred to the Pakistan Government.

The total number of chronometers and watches repaired and adjusted was 4513 including four for the Ministry of Supply, one for the Colonial Office, six for the Canadian and three for the Pakistan Governments. Of the total number repaired forty-three chronometers, eighty-nine chronometer watches, 139 deck watches, four beacon watches and 1695 wrist chronographs were dealt with in the chronometer workshop.

The work of the department again shows considerable increase in all respects over the previous year. The number of transactions involving Admiralty timepieces is up by approximately one-third and the volume of recording, rating and computing work is correspondingly increased, so that it is only with difficulty that the departmental records are kept up-to-date. At the Annual Audit all chronometers and watches on charge to the Royal Observatory were satisfactorily accounted for.

New watches which have been in store for over seven years and are now being brought out for overhaul and rating begin to show signs of deterioration due to the action of ageing oil. To renew their storage life it is considered desirable that the systematic cleaning of all reserve and repairable stocks should be put in hand, thus preventing more serious damage to pivots and pinions.

The time standard available in the Department has been augmented by the loan from Abinger of a B29 Radio receiver and a chronograph drive unit which makes it possible to receive and record daily the rhythmic signals from Rugby.

In addition to coping with additional repairs to chronometers and watches, the chronometer workshop has, during the year, overhauled and cleaned the Free Pendulum movement Shortt No.49 and the Dent regulator No.2012 in use at Abinger; the modification of the second La Cour clock used in conjunction with a magnetometer at Abinger was completed. Alterations to the recording unit attached to the occultation machine used in the Nautical Almanac Office were also carried out. Only a limited amount of work has been possible on the task of modifying the Hamilton chronometer in order to obtain a greatly enhanced performance.

The examination and cleaning of Harrison No.4 and Larcum Kendall No.1 timepieces was undertaken in the chronometer workshop.

The extension to the chronometer workshop was completed in January 1952 and three of the authorized five additional watch repairers have been engaged and a fourth is waiting to report. One watch-maker improver left in December 1951 to take up other employment.

The department is frequently consulted by Admiralty departments and other Ministries on technical matters concerned with horology and in particular during the past year has been able to assist CINO and DUW, Admiralty, with advice on problems arising from failures of clock mechanisms used in underwater weapons. At the request of CINO a special syllabus of instruction on clock mechanisms was prepared by the head of the chronometer workshop, and twelve Mechanic Examiners drawn from Naval Ordnance depots throughout the country attended a course at Herstmonceux from February 26 to March 6. The question of arranging further courses from time to time is under consideration.

The volume of repayment work undertaken by the Chronometer Department on behalf of the Air Ministry continues to increase. The outside organization for the repair of Mark 7A navigational wrist watches has been expanded and deliveries are larger and more frequent. Deliveries of new Mark 11 navigation watches from Swiss manufacturers arrive regularly for acceptance test and subsequent distribution to R.A.F. stations. Far more paper work arises from these transactions than is the case with Admiralty receipts and issues.

Watches of various types belonging to the Air Ministry at present on charge to the Royal Observatory comprise: 117 Pattern 6B/60, 453 6B/159 (Mk 7A) and 492 6B/346 (Mk 11) rating or ready for issue, with 45 6B/60, 966 6B/346 and 54 of unclassified types awaiting repair.

During the year 7974 Air Ministry watches have been received and 7623 issued. The number sent for repair included 88 6B/60 and 250 6B/346.

VII. H.M. 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 throughout the year.

Some reduction in staff will be possible, through the concentration of routine computing on the punched-card machines; for this reason no attempt has been made to fill vacancies for junior staff. With the exception of special proof-reading by Messrs. A. J. and S. G. Daniels, outside work, which has been a feature of the work of the Office almost continuously since the days of Maskelyne, has been terminated.

The Nautical Almanac.

The Almanac for 1953 was published early in April. The first part of the Nautical Almanac for 1955, containing the fundamental ephemerides of the Sun, Moon and planets, has been distributed to at least one observatory in each interested country. No change has been made in the contents or presentation of the Almanac.

General Astronomical Work.

A start has been made on the calculation, from the appropriate tables, of the ephemerides of the Sun, Mercury, Venus and Mars for the years 1960-1980; this work is usually done in batches of 20 years and was last done about 1934. It has been found possible to use the punched-card machines for some of this work and good progress has been made. For the five outer planets, and the four minor planets, equatorial rectangular co-ordinates will be available directly from the numerical integrations on which the orbits will in future be based.

The conversion from heliocentric co-ordinates to apparent geocentric co-ordinates, and the calculation of the transit ephemerides, is being done by the punched-card machines for 1958 and 1959; the initial planning of this work has been heavy, but sufficient has been done to show that it can be done efficiently on the machines.

It is probable that many changes will be introduced into the basis of the fundamental ephemerides as a result of the resolutions of the Paris (1950) Conference on the Fundamental Constants of Astronomy; considerable work has been done on the detailed application of these changes. A comprehensive report, produced jointly with the U.S. Nautical Almanac Office, has been made to Commission 4 of the International Astronomical Union; 13 distinct changes are there proposed and analysed.

A systematic survey has been made of the possibility of planetary occultations; much work is involved usually with little reward. Several interesting phenomena have, however, been discovered and detailed predictions prepared.

Occultations.

The modifications to the design of the occultation machine described in last year's report have proved entirely satisfactory and have given increased accuracy, though not sufficient to make unnecessary the prediction computations that have been done in the past.

The predictions for 1954 have been calculated, from preliminary times taken from the occultation machine, on the punched-card machines. In spite of some difficulty with extreme grazes (for which the iteration process does not converge), the computations were done in very much shorter time than by hand. It is confidently anticipated that the modified method to be adopted for 1955 and future years will indicate the full efficiency of the punched-card machines for this complicated calculation.

The list of stations for which predictions are made has been revised. Care has been taken to ensure that all regular observers can conveniently obtain predictions; for those stations at which no occultations have been observed since 1943 predictions have been dropped.

Of the 2675 conjunctions during 1954 of stars with the Moon examined by means of the occultation machine, 1307 were discarded as the resulting occultations were not observable under suitable conditions. Preliminary times and position angles were recorded for 70 stations for 1368 stars. After computation a further 148 stars were rejected, and the apparent places of the remaining 1220 stars will be published in the Nautical Almanac for 1954. Copy has been prepared for all 70 stations, incorporating a total of 5885 predictions.

Elements for 2645, 2574 and 2501 conjunctions for the years 1955, 1956 and 1957 have recently been received from U.S. Naval Observatory.

The discussion of observations of occultations for 1948 is in course of publication in the Astronomical Journal. The reductions of observations for future years will be done by the punched-card machines; those for 1949 and 1950 are at present all ready for the machines. Although it will not be possible to incorporate corrections for irregularities in the Moon's limb until the publication of the limb contours now being prepared at the U.S. Naval Observatory, the necessary arguments for the charts

will be calculated on the machines at the same time as the rest of the reduction. This calculation will be extended backwards, as opportunity permits, to include all observations received since 1943. The punched-card machines will, of course, greatly facilitate the annual discussions.

For 1949, 1950, 1951 and 1952 the numbers of occultations received during the year have been 180, 1440, 1045 and 63 respectively. The total number of observations being made is rapidly increasing and, when accurate limb corrections are available, should lead to a significant improvement in the accuracy of the determination of the Moon's position. Since the last report, the staff of the Office have observed 21 occultations at Herstmonceux.

The combined list of all occultations included in the annual discussions for 1943 to 1947, referred to in the last report, is to be published as an Appendix to Greenwich Observations for 1939; publication, which has been much delayed, is expected at any time.

The Star Almanac.

The Star Almanac for 1952 was published in October.

The contents of the Almanac were discussed in some detail at a special meeting of the Conference of Commonwealth Survey Officers in July; no substantial criticisms were made, but as a result of requests expressed at that meeting four additional auxiliary tables are being introduced into the edition for 1953, which should be published in July.

Apparent Places of Fundamental Stars.

The volume for 1952 was published in September. About two-thirds of the machine sheets of the volume for 1953 have been received and read, so that it is hoped that publication will take place in June. No changes have been made in the content or in the allocation of the computations, which continue to be those accepted at the Zürich (1948) meeting of the International Astronomical Union.

Copies of the mean places of the stars for 1955 have been distributed to the several offices responsible for the computation of apparent places.

The Abridged Nautical Almanac.

The Abridged Nautical Almanac for 1952, in its entirely redesigned form, was published in May; the edition for 1953 should be published in the same month this year.

The Almanac has been well received and very few adverse criticisms have been made either in reviews or in the many letters from users; several suggestions for improvements in detail, notably in the binding, have been made and most of these will be incorporated into the editions for 1954 and subsequent years. There is every reason to suppose that the G.H.A. method will soon be universally in use at sea.

The Air Almanac.

During the year the three parts of the Air Almanac for 1952 have been published; these are the last editions to appear in the form that was originally introduced in 1937, though much modified in 1939 and 1944.

Beginning with the first part for 1953, the preparation of the Air Almanac becomes a joint undertaking with the Nautical Almanac Office of the U.S. Naval Observatory. The Almanac has been designed to meet the requirements of the air forces of the United Kingdom, United States and Canada; it is being published separately in the United Kingdom and the United States, but the two editions are being printed photographically from identical material. The unification of the Air Almanac and the Americal Air Almanac has necessarily involved changes in both, but none of these will affect the use of the Almanac in principle.

The changes in the Air Almanac are primarily in the arrangement, but not the content, of the daily pages; a star chart and sky diagrams have been introduced, and a refraction table for large heights and low altitudes has been specially computed.

The compilation of the first edition of a joint publication has given rise to numerous problems, ranging from the requirements for modified proof-reading techniques to the avoidance of words which are spelt differently in the two countries. Thanks to the generous and co-operative attitude of the U.S. Nautical Almanac Office, the many difficulties have been successfully overcome and complete copy for the first part of the Almanac for 1953 was ready for photographic reproduction in both countries by the agreed date of 1st February. The British edition has now been printed and is with the binders.

The unification of the two Air Almanacs, largely due to the initiative and powerful advocacy of Dr. G. M. Clemence, Director of the U.S. Nautical Almanac Office, represents a significant advance in international co-operation and in economy of computational effort and printing. The U.S. authorities have agreed to delegate the right to supply advanced proofs to H.M. Stationery Office which, in turn, has agreed to supply, at nominal cost, specially pulled proofs on glossy paper suitable for photographic reproduction to the official almanac-producing agency of any country. At the meeting of the MAP Division of the International Civil Aviation Organization in Montreal in October, the Air Almanac was accepted as the basis of an international air almanac and it is now probable that it will be reproduced, with language changes, in France. It is hoped that eventually it may become truly international.

General Navigational Work.

The navigational work of the Office, additional to that involved in the compilation of the almanacs, has again been heavy. The special efforts of the last few years, during which the complete provision of almanacs and sight-reduction tables for both sea and air navigation will have been revised, are, however, now nearing their end.

The Office is collaborating with the Nautical Almanac Office of the U.S. Naval Observatory in the production of "Sight Reduction Tables for Air Navigation", to be published in three volumes by U.S. Hydrographic Department as H.O. 249; the first of these volumes has already been issued. The tables will be published in this country by H.M. Stationery Office as A.P. (Air Publication) 3270; all copy, including the rewritten introductions, is now ready and the first volume will be issued before the end of 1952. In addition to providing some of the calculations for low altitudes, the Office has been responsible for the final proof-reading of all the volumes.

Progress with the British edition of H.O. 214, referred to in last year's report and to be known as H.D. (Hydrographic Department publication) 486, has been disappointingly slow. Volume IV (of six), covering latitudes 45° to 59°, has been printed and is now being bound; most of Volume I (latitudes 0° to 14°) has been printed.

As a result of several requests for a means of extending the tables of sunrise, sunset and twilight in the almanacs to higher latitudes, a series of diagrams has been prepared, which are now in course of publication by the Hydrographic Department.

The geographical co-ordinates of the stations for the South-Western Decca Chain only became available late in 1951, but in spite of other work on the punched-card machines all the results required for the small-scale charts have already been distributed. Apart from a few points for which special methods are required, the whole of the results will be available by the end of May. The early completion of this work would have been impossible without the punched-card machines; the final results will occupy some 700 double-foolscap sheets of printed figures, of which six copies are required for distribution to the various authorities.

This has been the first Chain for which it has been possible to plan the computations as a whole, and to present the final results in a complete form. It is also the first Chain for which the "rectangular grid" method has been fully used; permanent tables for the use of this method have now been prepared on cards and are being considered for publication by the Hydrographer.

Data for some additional charts for the North British Chain were also computed during the year.

Proof-reading.

During the year 2447 pages of first proofs and 2703 pages of stereo proofs or machine sheets, depending on whether the publication is printed from stereo plates or movable type, have been read for the normal publications of the Office.

In addition 909 pages of H.O. 249 and 120 pages of machine sheets of the "Five-figure Tables of Natural Trigonometrical Functions", which was reprinted during the year from the standing type, have been read.

Machines.

The card-operated typewriter has still not been delivered, but all difficulties connected with its supply now appear to have been overcome. It has also proved impossible to obtain the relays for division on the 602 Calculator. In other respects, the punched-card installation has been complete throughout the whole year, and it is thus possible to make some assessment of its value to the Office. In many ways the year has not been typical, since there has necessarily been a high percentage of experimental and planning work which has made it difficult to prepare jobs for the machines in advance. Even so, the machines have actually been in operational use (excluding demonstrations) for over 65 per cent of the available time and have got through a lot of work. With the short runs and frequent changes of set-up that normally arise in astronomical (as contrasted with commercial) work, this represents not much less than the attainable maximum.

This year's experience has demonstrated that the machines can be efficiently used for astronomical computing. The chief difficulty is likely to be organizational, in that it is impossible to get the best out of the machines when firm dates cannot be given for the availability of data for urgent jobs. For instance, the machines were kept free of large astronomical programmes during the summer in anticipation of the urgently required Decca calculations but, because of delay in receipt of the basic data, this work could not be started until the end of the year, by which time

the astronomical work was equally urgent. Also, very considerable work had been expended in planning the calculation, on a systematic basis, of the apparent places of stars for the P.Z.T. programme; the gap between observations at Greenwich and Herstmonceux has robbed the machines of the final routine calculations, which could have been fitted in efficiently during the summer. At present there is a large accumulation of work for the machines, and some will have to be delayed rather longer than is desirable.

In addition to the work referred to earlier in the report (fundamental ephemerides, solar and planetary conversion, predictions of occultations, Decca lattices), the machines have been used for the calculation of apparent places of stars, for the copy for the Abridged Nautical Almanac and for many small jobs. Several such small runs have been done for other Departments of the Observatory, and there are a number of large jobs pending.

The machines have given satisfactory service throughout the year and have required little more attention than the usual maintenance. Two additional 80-column hand punches were obtained during the year.

VIII. PUBLICATIONS.

The two outstanding sections of the "Greenwich Observations" for 1937, viz., "Astronomical Results" and "Photoheliographic Results" were published and distributed during the year, but the complete volume is still awaited.

Production of copy by Vari-typers for reproduction by photolithography has continued. Mrs. Taylor, one of the two operators, resigned in September and her place was taken by Miss Page who, after a course of instruction at H.M. Stationery Office, started in January the preparation of copy of "Photoheliographic Results, 1945". Two new machines were received at the end of October, one a model A.20 Math and the other a model AE.20 Math.

Copy for all the outstanding sections of "Greenwich Observations" for 1938 and 1939 as well as Volume II of "Colour Temperatures of Stars" was completed during the year and the section "Photoheliographic Results" for 1940 and for 1945 are in hand. The rate of preparation of copy by Vari-typer is not sufficient for the production of two volumes of "Greenwich Observations" in a year. In order that the arrears of publication can be dealt with in a reasonable time, the Admiralty has been asked to approve the temporary addition to the complement of a third Vari-typer operator.

The rate of printing has been even more disappointing than the rate of production of copy. None of the copy sent during the last two years has yet been printed. A letter drawing attention to this has been sent to the Director of Printing and Binding, H.M. Stationery Office, and a reply is awaited.

The following other publications have appeared during the year:-

Royal Greenwich Observatory. Mean Areas and Heliographic Latitudes of Sunspots in the year 1945. M.N. 110. 501.

Mean Areas and Heliographic Latitudes of Sunspots in the year 1946. M.N. 111. 448.

H. Spencer Jones. General Astronomy (3rd edition: Edward Arnold & Co.).

Life on Other Worlds (2nd edition: English Universities Press).

R. d'E. Atkinson. The Computation of Topocentric Librations. M.N. 111. 448.

R. d'E. Atkinson. and D. H. Sadler. On the Use of Mean Sidereal Time. M.N. 111. 619.

D. H. Sadler (and G. M. Clemence). Unification of the Air Almanac and the American Air Almanac. J. Inst. Nav. 4. 386.

D. H. Sadler. The Construction of Hyperbolic Lattices. J. Inst. Nav. 4. 237.

The Refraction Table in the Air Almanac. J. Inst. Nav. 5. No. 3 (in press).

The Accuracy of Astronomical Observations at Sea. J. Inst. Nav. 5 No. 3 (in press).

H. W. Newton and W. Jackson. Observational Aspects of Solar Corpuscular Radiation. Seventh Report on Solar-Terrestrial Relationships, 107. (International Council of Scientific Unions.)

H. W. Newton and M. L. Nunn. The Sun's Rotation Derived from Sunspots 1934-44 and Additional Results. M.N. 111, 413.

H. W. Newton and H. Finch. Magnetic Storms and Solar Activity 1951. Observatory 72, 44.

H. M. Smith. The Estimation of Absolute Frequency in 1950-51. I.E.E. Monograph (in press).

F. M. McBain. Discussion of Occultations observed in 1948. Ast. Journ. (in press).

J. G. Porter, D. H. Sadler (and G. M. Clemence). Aberration in the Lunar Ephemeris. Ast. Journ. (in press).

J. G. Porter. Punched Card Machines at Herstmonceux. J.B.A.A. 61. 185.

The Discovery and Nomenclature of Meteor Streams. J.B.A.A. 62. 101.

W. A. Scott. An Elementary Account of Hyperbolic Lattice Computations. Hydrographic Dept. Professional Paper. No. 9.

H. Barton, P. Laurie, and N. Rhodes. Solar Flare 1951 May 18. Observatory 71, 170.

P. J. D. Gething. Accretion and the Origin of Comets. M.N. 111. 468.

G. E. Taylor. An Occultation by a Minor Planet. J.B.A.A. 62. 176.

Occultations of Asteroids by the Moon. J.B.A.A. 62. 177.

IX. PERSONAL ESTABLISHMENT.

Vacancies for a Chief Assistant, two senior scientific staff, and one junior experimental officer are still unfilled. A provisional ceiling which has been imposed for the current financial year will prevent the filling of other vacancies for the time being.

Mr. P. L. Rickerby has been promoted to Senior Experimental Officer.

Miss C. J. A. Penny, B.Sc., and Mr. J. D. Pope, B.Sc., A.M.I.E.E., have been promoted to Experimental Officers.

Miss C. M. Ryall has been regraded as Assistant (Scientific), and Miss E. J. M. Grove has been established as an Assistant (Scientific).

Mr. A. C. S. Wescott, Head of the Royal Observatory Workshop, has been regraded to the Technical Works, Engineering and Allied Class, Grade 2, with retrospective effect to January 1946.

The following officers left during the year:- Mr. W. Jackson, Senior Scientific Officer; Mr. A. J. Daniels, Temporary Senior Experimental Officer (who joined the Observatory staff at Greenwich in 1899 as a computer); Miss D. M. Fooks, Assistant Experimental Officer; Mr. M. L. Nunn, Temporary Assistant Experimental Officer; Mr. J. N. Bird, Miss J. E. Buchan, Mr. J. L. Hicklin, Mr. M. J. Pearce, Temporary Assistants (Scientific), and Miss I. Bishop, Mrs. V. D. Taylor and Miss V. L. Wells, Typing staff.

The following officers have joined during the year:- Dr. G. A. Wilkins, Ph.D., Scientific Officer; Dr. P. J. D. Gething, Ph.D., M.Sc., and Mr. P. A. Wayman, B.A., Temporary Scientific Officers; Mr. A. S. Milsom, Assistant Experimental Officer (re-joined from Military Service); Mr. D.R.A. Christie, Mr. R.G. Lorton, Mr. J.E.W. Marten, Miss M. A. Jeffrey, Miss S. W. Slater, Temporary Assistants (Scientific); and Miss S. K. Page, Miss J. A. Pumfrey and Miss E. M. Swanborough, Typing staff.

The staff of the Royal Observatory is now constituted as follows.

(a) Royal Observatory.

Chief Assistant as Senior Principal Scientific Officer	- R. d'E. Atkinson, M.A., Ph.D.
Principal Scientific Officers	- H. F. Finch, B.Sc., A. Hunter, Ph.D., H. W. Newton, D. S. Perfect, M.A., D. Phil., H. M. Smith, B.Sc., M.I.E.E., F.Inst.P., L.S.T. Symms.
Senior Scientific Officer	- G. B. Wellgate.
Temporary Scientific Officers	- P. J. D. Gething, PhD., M.Sc., P. A. Wayman, B.A.
Senior Experimental Officers	- H. H. J. Barton, E. A. Chamberlain, F. Jeffries, E. G. Martin, P. L. Rickerby, G. W. Rickett.
Experimental Officers	- K. C. Blackwell, A. E. Cordwell, C. C. Harris, P. S. Laurie, B. R. Leaton, Miss C. J. A. Penny, B.Sc., J. D. Pope, B.Sc., A.M.I.E.E., J. L. Rudd, A. Shortland, R. H. Tucker, G. F. Wells.
Head of Royal Observatory Workshop	- A. C. S. Wescott.
Head of Chronometer Repair Shop	- D. W. Evans.
Assistant Experimental Officers	- A. M. Allen, L. J. Bates, P. M. Corben, G. L. Fuller, B. J. Harris, A. P. Lamb, C. A. Murray, M.A., A. S. Milsom, E. A. Whitaker.
Temporary Assistant Experimental Officer	- D. C. Smith.
Senior Assistants (Scientific)	- H. G. Gill, Miss F. E. A. Jeffries.
Assistants (Scientific)	- Miss P. M. Morris, Miss C. M. Ryall, Mrs. B. G. Tucker.

Assistants (Scientific) Temporary	- B. T. Archer, D. R. A. Christie, Miss H. Howe, A. Jones, R. G. Lorton, C. M. Lowne, Miss I. S. Manning, J. E. W. Marten, Miss M. A. Newman, N. P. O'Hora, Miss M. A. Jeffrey, Miss D. E. Pankhurst, Miss J. H. Phillips, N. S. C. Rhodes, Miss S. W. Slater, R. W. Teague, Miss V. E. Terry, R. W. L. Trundle, P. J. Willmoth.

(b) Nautical Almanac Office.

Superintendent as Senior Principal Scientific Officer	- D. H. Sadler, M.A.
Principal Scientific Officers	- Miss F. M. McBain, M.A., J. G. Porter, B.Sc., Ph.D.
Scientific Officer	- G. A. Wilkins, Ph.D.
Senior Experimental Officers	- H. W. P. Richards, B.Sc., W. A. Scott, B.Sc.
Experimental Officers	- A. E. Carter, W. G. Grimwood, G. A. Harding, Miss M. R. Rodgers, E. Smith.
Assistant Experimental Officers	- Miss M. McI. S. Gibson, B.Sc., J. S. A. Green, D. Harragan, Miss A. M. James, B.Sc.
Temporary Assistant Experimental Officer	- Miss P. V. Knight.
Temporary Senior Assistant (Scientific)	- J. H. Barry.
Assisants (Scientific)	- M. P. Candy, Miss E. J. M. Grove, K. A. Miller, Miss I. M. Restorick, G. E. Taylor.
Assistants (Scientific) Temporary	- Miss W. Barton, Miss A. M. Crisford, Miss B. A. Crowley, Miss A. B. Grogan, Miss A. J. Nevell.

(c) Secretariat.

Secretary and Cashier as Higher Executive Officer	- H. G. Barker.
Higher Clerical Officer	- J. H. Whale.
Clerical Officers	- Miss S. M. Billenness, F. A. Everest, Miss J. E. Perry.
Librarian	- W. P. Preston.
Clerical Assistants	- Miss B. E. Carey, Mrs. L. E. Nicholls.
Temporary Clerk	- Miss J. A. Morris.

Established Shorthand Typists	- Miss A. R. Hewerdine, Miss C. V. Hewerdine.
Established Vari-typer Operator	- Miss R. Weakley.
Temporary Shorthand Typists	- Mrs. V. Hyde, Miss E. M. Swanborough.
Temporary Vari-typer Operator	- Miss S. K. Page.
Temporary Typist	- Miss J. A. Pumfrey.
Hostel Wardens	- Mrs. D. I. Hewitt, Mrs. E. M. P. Marples.

The industrial staff employed at Greenwich, Herstmonceux, and Abinger total 78 including Hostel staff, who, although not borne on the Observatory Vote, are attached to the Establishment for administration and pay.

The various grades are as follow:- ten watch repairers, two watchmaker apprentices, five laboratory mechanics, one mechanic, one fitter, one storehouse assistant, one head gardener, one forester, five messengers, one packer, three boiler attendants, three drivers, four skilled labourers, four nightwatchmen, one caretaker, five gardeners, seven labourers, two switchboard attendants, nine part-time cleaners and twelve Hostel domestic staff.

X. ISAAC NEWTON OBSERVATORY

Sir Geoffrey Taylor was renominated by the Council of the Royal Society as a member of the Board of Management of the Isaac Newton Observatory to serve for a further period to 31 December 1955.

Lord Cherwell was nominated by the Council of the Royal Astronomical Society as a member of the Board of Management, to succeed Professor F. J. M. Stratton, who retired on 31 December 1951.

Expenditure of preliminary expenses amounting to £6000 has been approved for the current financial year, but instructions have been received that, in view of the present state of financial stringency, no commitments which will involve payments being made beyond 1952/53 should be entered into without prior approval.

Some further diamond milling of the 98-inch disk, for obtaining the spherical figure, has been carried out. No tendency for the cracks, mentioned in last year's report, to extend has been found. As diamond milling introduces larger surface strains than a conventional grinding tool with loose abrasive, the diamond milling has been stopped. Dr. Bowen, Director of the Mount Wilson and Palomar Observatories, has reported that cracks of a similar nature developed during the work on the 200-inch disk. No measurable increase of the extent of the cracks occurred during the whole of the grinding and polishing processes. The final Hartmann and knife-edge tests of the mirror showed no indication of the presence of the cracks, which have not in any way affected the proper functioning of the mirror.

Further consideration of the mechanical design has been postponed pending the results of an investigation of a novel method of controlling the flexure of the telescope, which was suggested by Mr. B. N. Wallis.

XI. GENERAL.

During the year a number of astronomers and geophysicists visited the various establishments of the Royal Greenwich Observatory, including the Nautical Almanac Office. They include:

Prof. E. N. da C. Andrade, Director, Royal Institution.

Dr. C. S. Beals, Dominion Astronomer, Ottawa.

Dr. G. van Biesbroeck, Yerkes Observatory, U.S.A.

Prof. P. M. S. Blackett, Manchester University.

Dr. C. R. Burch, Bristol University.

Sen. A. P. Botelheiro, Lisbon Observatory.

Mr. P. S. Christensen, Director, Optical School, Copenhagen.

Dr. Mary Conway, Dunsink Observatory.

Dr. Theodore Dunham, University of Rochester, U.S.A.

Dr. W. D. George, National Bureau of Standards, Washington.

Prof. W. M. H. Greaves, Astronomer Royal for Scotland.

Dr. F. Gürsey, Istanbul Observatory, Turkey.

Dr. K. G. Henize, Lamont Hussey Observatory, University of Michigan.

Mr. K. J. Hume, Head of National College of Horology.

Dr. C. G. Lacombe, The Observatory, Rio de Janeiro.

Dr. J. Larink, Hamburg Observatory, Bergedorf.

Mr. J. C. Lieuwen, Kweek School, Amsterdam.

Dr. J. W. Maccoll, A.R.D., Fort Halstead.

Dr. M. R. Madwar, Royal Observatory, Helwan, Egypt.

Mr. A. Maxwell, Jodrell Bank Experimental Station of University of Manchester.

Dr. J. A. N. Moos, Bombay.

Dr. Edith Müller, Zürich and Cambridge Universities.

Mr. P. Naur, Copenhagen Observatory.

Mr. A. M. Newbegin, Paignton.

Mr. J. A. Preiss, Arnaments and Aircraft Experimental Establishment, Boscombe Down.

Captain Fernandez de la Puente, Deputy Director, Naval Observatory, San Fernando, Spain.

Prof. R. O. Redman, Director, The Observatories, Cambridge.

Captain M. Rodriguez, Naval Observatory, San Fernando.

Dr. A. Scheibe, Phys.-Technische Bundesanstalt, Braunschweig, Germany.

Dr. K. Schütte, Munich Observatory.

Sir George Simpson, late Director, Meteorological Office.

Prof. L. B. Slichter, University of California, Los Angeles.

Mr. H. Stanseby, Director, Radio Experimental and Development Branch, P.O. Engineering Dept.

Dr. A. D. Thackeray, Director, Radcliffe Observatory, Pretoria.

Dr. J. Tuominen, University Observatory, Helsinki, Finland.

Prof. H. C. Urey, University of Chicago.

Prof. Rasa Vodusek, Ljubljana, Yugoslavia.

Other visitors included Dr. H. W. Dodds, President, Princeton University, U.S.A.; Rt. Hon. P. C. Gordon Walker, Secretary of State for Commonwealth Relations; Admiral Sir Cecil H. J. Harcourt, Commander-in-Chief, Nore; Air Commodore Sir Adrian Chamier.

A party of 24 delegates from the Commonwealth Survey Officers' Conference visited Herstmonceux on July 1f. Dr. C. R. Burch brought a party of 25 research workers and senior students from the Physics Department of Bristol University on June 19. Visits have been paid also by a number of organized parties from the British Council and various Institutions and scientific Societies.

Mr. C. B. Bull of Birmingham University visited the Magnetic Observatory, Abinger, to obtain experience in magnetic observations before going on an expedition to Spitsbergen.

The Astronomer Royal attended the General Assembly of the International Union for Geodesy and Geophysics in Brussels in August, and the meeting of the Executive Committee of the International Astronomical Union in Paris in September; he afterwards visited the Observatory of Haute Provence, St. Michel, Basses- Alpes.

Mr. Sadler attended the meeting of the MAP Division of the International Civil Aviation Organization in Montreal in October; he afterwards visited the U.S. Naval Observatory, Washington.

Mr. Sadler and Mr. Richards attended several of the meetings of the Conference of Commonwealth Survey Officers in London during July.

The Astronomer Royal was elected an Honorary Fellow of the Royal Society of Edinburgh.

Dr. Wilkins was awarded the Ph.D. degree for a thesis submitted to the University of London. Mr. Pope was accepted as an A.M.I.E.E. Mr. Bates and Mr. Gill qualified for the Higher National Certificate in Telecommunications.

The Trustees of the National Maritime Museum have been informed officially that approval has been given to the recommendation of the Board of Visitors that the old buildings of the Royal Observatory at Greenwich should be used as an astronomical and navigational annexe to the National Maritime Museum. It is the intention of the Astronomer Royal to leave in the old buildings at Greenwich the historic instruments belonging to the Observatory; they include a mural quadrant by Abraham Sharp, Flamsteed's assistant; Halley's transit instrument, the first transit instrument to be used in England; the 8-foot mural quadrant, by Graham, known as the Iron Quadrant, used by Halley and Bradley; the 8-foot mural quadrant by Bird, known as the Brass Quadrant, used by Bradley and Maskelyne; the 12½-foot zenith sector with which Bradley discovered the aberration of light and the nutation of the Earth's axis; the transit by Bird, made famous by Bradley's observations; the 6-foot mural circles by

Troughton and by Jones; Troughton's transit, used by Pond and Airy; and also Airy's transit circle, installed in 1851, which by international agreement defines the prime meridian and which is still in use; this famous instrument will remain in the position it has always occupied, marking the zero of longitude. Visitors will thus be able to see these instruments, which have played an important part in the development of astronomy; and also the famous Octagon Room, Flamsteed's original observatory in the building specially designed for the purpose by Wren and, as he said in a letter to Bishop Fell, also 'for the Observator's habitation and a little for pompe'. The Shepherd 24-hour electric clock, outside the Main Gate of the Observatory, will remain in position, and it is the intention of the Director of the National Maritime Museum that the old custom of dropping the time-ball at 13 hours daily (which was commenced in 1833 and which provided the first public time signal in Great Britain) shall be continued. It is gratifying that it will thus become possible for the public to see Flamsteed's Observatory and the historic instruments.

The Observatory was founded in the interest of navigation and has throughout its history been closely associated with the advancement of navigation. The National Maritime Museum includes a navigation section, in which the history and development of navigation are illustrated. It is thus particularly appropriate that the old Observatory will become an annexe of the National Maritime Museum.

Amongst its various responsibilities, the Observatory undertakes the preparation of world magnetic charts for the Admiralty. The first magnetic chart, showing the variation of the compass, was constructed in 1700 by Edmond Halley, who afterwards became the second Astronomer Royal. As more than two-thirds of the surface of the Earth is covered by water, magnetic data for the ocean areas are essential if magnetic charts are to be of the accuracy needed for sea and air navigation. Since wooden ships gave place to ships of iron and steel, magnetic data have not been so readily obtained at sea. For many years the Department of Terrestrial Magnetism of the Carnegie Institution, Washington, operated a non-magnetic ship and the data obtained by it were made freely available to all; in addition it sent observers to many parts of the world where magnetic surveys had not been made, so that the knowledge of the Earth's magnetic field was greatly improved.

The non-magnetic ship, the 'Carnegie', was unfortunately destroyed by an explosion in 1929. Since that date the magnetic data obtained in ocean areas have been very scanty. As the magnetic field of the Earth is constantly changing in a manner that is not uniform and is not predictable, it is inevitable that the magnetic charts are today less accurate than those of twenty years ago, and that with further lapse of time they will become increasingly unreliable, unless suitable steps are taken to repair the deficiencies in the knowledge of the Earth's magnetic field over the oceans.

Before the war the Admiralty had undertaken the construction of a non-magnetic ship. This ship, the R.R.S. RESEARCH, was launched in 1939. But the outbreak of war prevented her completion; in the changed financial situation after the war, the Admiralty felt unable to provide the funds for completing and operating this ship, for a purpose that is of interest, not merely to the United Kingdom, but to many other countries also. The decision that the ship is to be broken up has now been given.

During the war the magnetic airborne detector was developed as a method of detecting submarines. This equipment is capable of measuring variations in the total intensity of the Earth's field with high accuracy; with suitable modifications, three components of the field can be recorded. The way is thus opened for magnetic surveys to be made by aircraft, and for data to be accumulated with great rapidity.

What is now needed is that such surveys should be made as soon as possible over the more accessible ocean areas: if reliable data are available for the greater part of the Earth's surface, harmonic analysis can be used as a means of interpolation in the regions that are not so conveniently accessible to aircraft.

The growing accumulation of observations waiting to be published is a matter for serious concern. On the outbreak of war "Greenwich Observations" for 1937 was in the hands of the printer. Publication was then stopped, and it was not until 1948 that it was decided to proceed with publication. It was then agreed that the volume for 1937 should be printed, but that subsequent volumes, star catalogues, and other publications, should be reproduced from typed copy by photolithography. The preparation of copy and publication at the rate of two volumes a year was planned; if this rate were maintained, the arrears would even then not be overtaken for about a further 12 years. The preparation of copy by Vari-typer has not yet reached the rate of two volumes a year, though the initial work, which involved planning for a great variety of tabular matter, was necessarily the slowest. But the rate of publication has lagged far behind the rate of preparation of copy, so that the arrears are now greater even than they were in 1948. It cannot be too strongly emphasized that long delays in publication appreciably reduce the value of the observations; moreover, many requests for data that are not available because of publication delays have to be met by copying out results, which puts an additional burden on the staff.

The slow progress in the removal from Greenwich to Herstmonceux is the cause of great disappointment and of a deep sense of frustration. It is nearly four years since the first sections of staff were moved to Herstmonceux; but the photoheliograph and spectrohelioscope are the only instruments that have been installed. The 26-inch and 28-inch refractors remain dismantled in store at Herstmonceux. The principal equatorial instrument in use at Greenwich is the 36-inch reflector, with a spectrograph designed primarily for work in the ultra-violet. This telescope is the one that works with the lowest efficiency at Greenwich, for the sky has still further deteriorated there since the end of the war. Of the sunshine recording stations in the London area, Greenwich has as low a sunshine total as any; moreover, mercury vapour lamps have recently been installed along the main road over Blackheath, so that there are now two roads running east-west immediately to the south of the Observatory, one lit with high pressure gas and the other with mercury vapour lamps, making the sky at night extremely bright. The Cooke Reversible Transit Circle is the next instrument scheduled for removal to Herstmonceux; it is useless to start any large programme of observations with it until after it has been installed in its new site. The separation of the Observatory into three separate sections, at Herstmonceux, Greenwich, and Abinger involves increased industrial staff and increased expenditure; it causes a great loss of flexibility and much administrative inconvenience. But the most serious disadvantages of the division are the loss of observations and the lack of training in observing of many junior members of the staff at the time when they are best adaptable to learn. The meridian group is to be proceeded with, but it is already far behind schedule, while the cuts imposed this year have prevented the construction of the equatorial group being commenced. It is much to be desired that this group should be started next year, even if the construction has to proceed in stages instead of as a complete group, as had been intended.

H. SPENCER JONES
Astronomer Royal

ROYAL GREENWICH OBSERVATORY,
HERSTMONCEUX.
1952 May 6.