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, 1951 June 2

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CONTENTS

		Page
I	Grounds and Buildings	3
II	Instruments, Apparatus, and Library	5
III	Astronomical and Radio Observations	10
IV	Magnetic Observations	18
V	Meteorological Observations	19
VI	Chronometers	21
VII	Nautical Almanac Office	23
VIII	Publications	27
IX	Personal Establishment	28
X	Isaac Newton Observatory	31
XI	General	32

C.B.H. 30009 - Wt. 3617 - Dd. 315 - 280 - 5/57

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The Report here presented refers to the period from 1950 May 1 to 1951 April 30 and exhibits the state of the Observatory on the last named day.

I. GROUNDS AND BUILDINGS

(a) Greenwich. Further repair of war damage has been carried out. Flamsteed House itself, including the historic Octagon Room, has now passed out of the jurisdiction of the Observatory. The House has been converted into two flats for Naval Officers of the Royal Naval College, and it has been occupied by them since March 3. The Wren building has been taken over by the Ministry of Works, and it is understood that it will be treated as an Ancient Monument. Repair work is in progress; it is found that extensive dry rot has developed, as a result of the neglect to replace windows and to repair other war damage. The Ball-Lobby had been provisionally repaired in advance of this work, the Ball mechanism repaired and replaced, and all arrangements made for dropping the Time Ball again daily, starting of the first day of the Festival of Britain.

In the Old Building and Airy T.C. pavilion, all damaged window-sashes and frames have been replaced, and the roof has been overhauled. The covered way, and the greenhouse on the courtyard side of Flamsteed House, have been removed. A new door and frame have been provided from the courtyard to the Airy T.C. pavilion, the transom above the old one being bricked up and the wooden porch removed. Leaks in the Astrographic dome have been repaired, and the old Small Transit pavilion roof has been repaired and re-covered.

The covering of the 28-inch dome, which was badly damaged and most unsightly, has been removed, and a horizontal corrugated-iron roof has been laid, a little above the dome-rail, the entire framework of the dome being still in place, though steadily deteriorating. The Civil Engineer, Deptford, has attached a couple of panels of sheet aluminium to the framework, to test its suitability for re-covering, supposing it is decided to preserve the dome as a landmark. The dome, though a characteristic feature of the Observatory in recent times, is, however, only about 60 years old, while the building on which it stands is ill-adapted for any useful purpose.

The "New Building" is still in need of further work. The Thompson dome has been partly repaired but still leaks, and much of the bomb-damage to the building itself has had only temporary repairs. A serious gas-leak in the building was discovered, and the entire service was disconnected and replaced by fresh connections to the workshop and the toilet hot-water supplies, the only points at which gas is

now required. The hot-air furnaces had been feeding carbon monoxide to the rooms for some time, and on investigation cracks leading from the flues to the air-ducts were discovered. Temporary repairs have been made, and it is hoped to do more during the summer.

Exterior painting has been done on the Old Building, (including the Airy T.C. shutters), the Porter's Lodge, the steelwork of the Cooke T.C. pavilion, and the Yapp reflector dome. Parts of the Cooke pavilion steelwork are not accessible, and on removal to Herstmonceux the construction will have to be modified. Interior decoration has been done in the Altazimuth dome (housing the small transit), the Porter's Lodge, and the Ladies' rest room and toilets.

The transfer of shelves, records, and stocks of Greenwich and Cape publications from Greenwich has proceeded, involving nearly continuous weekly deliveries by road transport.

(b) Abinger. A new generator house has been erected to house the emergency power supply equipment. A bathroom has been added to the Caretaker's residence.

(c) Herstmonceux. No actual work has yet started on the sites of either the meridian group or the equatorial groups, but planning has proceeded. The exact locations have been selected for the individual meridian instruments, with the differences in latitude and longitude adjusted for convenience to integral multiples of 1/10" and 10 milliseconds respectively. Lines have been surveyed out to the proposed azimuth-marks for both the Cooke and the Melbourne Transit-Circles. The positions which had been provisionally selected for the P.Z.T. and the Bamberg were altered, in April, to facilitate a re-location of the P.Z.T. control-room and observers' building, in conformity with the views of the Architect. Tenders have been invited for the Cooke R.T.C. pavilion. The general layout of the Equatorial group has been agreed with the Architect. The three-dome building to house the reflectors, referred to in the last report, is now to be north of the three isolated refractor domes, but its general arrangement and functions are still essentially as originally outlined in 1947. The appearance, both individually and for the group as a whole, owes very much indeed to the Architect, and it is considered that the final result will be satisfactory both functionally and aesthetically: it is pleasant to record that there has been no pressure to sacrifice any functional requirement, however trivial, to other considerations. The Architect's proposals include a layout for a number of official staff houses, but the question of actual approval to build these is still outstanding.

A run-off housing for the coelostat of the spectroheliograph cellar has been completed and installed, and the air-conditioning has been installed and tested. Seepage of water into the cellar has given trouble and work is in hand to correct it. A coelostat-mounting, arranged for the primary mirror to traverse from NE to NW of the secondary one, has been provisionally designed, but it is not yet known whether parts of some existing mounting can be used in this.

The adaptation of the Great Hall of the Castle as a library is nearly complete. The constructional work and the decorations have been completed; cork tiles have been laid on the floor, including the gallery floor, and hot water radiators have been installed. The lighting installation is under consideration. Tenders for the supply of shelving will soon be invited. The offices for the Department of Astrometry and Astrophysics, and the rooms to be used for the Optics Laboratory have been completed.

Much progress has been made in fencing the grounds, the fencing material being obtained from the woodland areas. These areas have been thinned where necessary to improve their condition, and an appreciable revenue has been obtained from the sale of timber.

The grounds are open to the Public on Wednesday and Thursday afternoons each week from April to October inclusive at a charge of 1s. per head, so that the Public has an opportunity of seeing the historic Castle and the gardens.

II. INSTRUMENTS, APPARATUS AND LIBRARY

The following instruments are on loan to the Royal Observatory:

The Cookson floating zenith telescope, from the Cambridge Observatory.

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

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

A 16-inch coelostat, 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 following instrument, borrowed for observation of the Solar Eclipse of 1932, August 31, is stored at the Royal Observatory:-

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

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

To the Royal Observatory, Cape of Good Hope:-

Clocks, Dent 1916 and Dent 2013.

To the Imperial College of Science and Technology:-

6-inch equatorial, Simms No.2.

To the Meteorological Office:-

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

To the 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 South Bank Exhibition of the Festival of Britain:-

The Airy Sidereal Standard Clock and one Time Signal transmitting motor.

To the Cambridge University Observatory:-

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

Further progress has been made on the repair of Harrison's Time Machine No.1. Mr. D. W. Fletcher, Superintending Civil Engineer, H.M. Dockyard, Chatham, is keenly interested in this horological work and is voluntarily undertaking a substantial part of it. No further progress has yet been made on No.3.

Airy Transit-circle

The improvement in the seeing of the reflected image of the spider webs during nadir observations with the Cooke reversible instrument, resulting from the new method of supporting the mercury bath above floor level from the piers, was such that it was decided to employ a similar arrangement for the Airy instrument. In addition, a simple lens of approximately $8\frac{1}{2}$ inches focal length was mounted between the illuminating lamp and the eye-end of the instrument when pointed on the nadir, to direct a more convergent beam of light into the Bohnenberger eyepiece, as it had been found that the previous beam did not fill the objective. These two modifications have resulted in a better-defined and more constant reflected image.

Cooke Reversible Transit-circle

The investigation of the screw errors of the microscope micrometers mentioned in last year's report was discontinued, after two of the twelve screws had been tested, when it was decided to replace the present micrometers with photographic recording equipment. Contact has been made with a firm who have experience in the manufacture of this type of apparatus.

One of the collimators, whose object glass is similar in aperture and focal length to the telescope itself, was set up on the proposed site of the meridian group of buildings at Herstmonceux, and azimuth marks in the form of illuminated pinholes were examined with it at distances of approximately 400 and 1200 feet, respectively, to decide whether the seeing would be so much impaired, at the greater distance, as to negative the obvious advantage of distance as such. It is intended to repeat the experiment in the summer, when conditions for observing the marks will be at their worst, before a final decision is made as to the position of the azimuth marks.

As mentioned last year, the objective of this telescope has a large amount of off-axis coma and is unsuitable for fundamental meridian work, and particularly for the observation of the Sun and Moon. The verdict based on astronomical observations was confirmed by laboratory tests and by computation, and a new coma-free lens has now been ordered.

An investigation into the causes of the large changes with temperature of collimation-error of this instrument has been commenced. To surmount the difficulty, usually experienced in sunny weather, of measuring the collimation-error in the standard manner, using the separately housed collimators, the measurements are being made by the method of level readings on the nadir before and after reversal of the telescope in its Y's. Measures are taken every two hours throughout the day and evening. In the ordinary way, a large part of the effort required for reversal was devoted purely to dismounting the pulpit from the reversing-stand, and re-mounting it afterwards. A separate pulpit has now been obtained; by this means, and by leaving the cumbrous micrometer-drive disconnected, reversal has been reduced to a fairly rapid one-man operation, and a single observer, can, with practice, accomplish the reversal with an interval of only fifteen minutes between the nadir readings before and after reversal. It is hoped that a change in sign of the temperature-coefficient resulting from a reversal of some part of the instrument, e.g. the micrometer box or the telescope tube, with respect to the central cube, may give an indication as to where the changes of collimation originate. If they can be traced and cured much observing time expended in determining the instrumental constants would be saved for more useful work on the heavens.

Photographic Zenith Tube

The bulk of the constructional work on this instrument has been completed. In the near future a preliminary complete assembly will be made so that various tests of performance can be carried out before the components are finally cleaned and painted. One point of uncertainty which can only be settled by test in situ is whether or not the stellar-plate carriage must be clamped during reversal of the rotary; it is hoped that this will be unnecessary, but provision has been made for introducing clamping if required. Certain features of the work carried out during the current year may be briefly summarized.

The control and indicating console, the chronographic system, and the carriage drive mechanism have been completed. Trial of the clutching system showed the necessity of providing a larger impulse than had been anticipated in order to keep the time-uncertainty of operation within the tolerance. A new mercury floating basin has been constructed of similar design to that of the new U.S.A. instrument, and tests at Abinger have confirmed the efficacy of floatation as an anti-vibration device. The mounting of the tilted focussing plate has been designed so that it is adapted for use with the standard plate holder. The plate itself is located in defined geometrical relation to the normally used horizontal plate by being supported on two knife edges.

The auxiliary framework which surrounds the telescope and supports the synchronous motors, the reversing mechanism and other components, was originally planned to be supported on four pillars let into the concrete pier. With this arrangement problems of the relative positioning of parts arose. It was decided, after inspection of a temporary partial assembly of the instrument, that it would be preferable to enlarge and strengthen the sole plate and to support the pillars from it. The whole instrument thus becomes self-contained. A rearrangement of the

essential features of the building has also been made. The relatively small circular platform for the operator has been enlarged into a complete floor, with a trap door for access to the mercury basin and with sections removable for cleaning purposes. The shutter and the small derrick for lifting components are to be mounted on girders supported by the end walls of the building. Detailed designs for the support of the derrick and shutter have been prepared.

Further attention has been given to the question of measuring machines for the P.Z.T. The results of tests made in the Laboratory at Abinger and of tests made subsequently by the N.P.L. show that the machine which it had been hoped to use for measurements of the stellar plate is not suitable either in design or construction to give the accuracy desired, though it will probably suffice for the measurement of the chronographic plates in which optical premagnification is used, and where orientation is not critical; it will thus meet a requirement which was not foreseen until the photographic chronograph had been developed.

The design is under consideration of a special machine for the stellar measurements, which is to satisfy the following requirements:-

The machine is to be capable of measurement in the x-co-ordinate only, measurements in the y-direction being derived from measurements made in the x-direction after the plate has been transposed by rotation through a nominal angle of 90°. Translational motion of the plate (without measurement) in the y-direction is to be provided. An advantage of such a design is that the error of angle between the ways need not be explicitly determined since it appears always in conjunction with the arbitrary orientation of the plate. This error is not only not easy to determine with precision but is liable to variation which would necessitate frequent redetermination. The critical quantity is the angle of transposition, and it is proposed to determine this for each plate by autocollimation on a 90° stainless steel prism mounted on a turn-table which carries the plate. The angle of the prism, which should in fact be very stable, can be pre-measured or checked at any time on the bench. As the means of measurement a calibrated scale with a comparator system employing two microscopes is to be used, instead of a screw.

If it is decided to use a visual method of observation, consideration has been given to the possibility of employing superposed fields of view and securing exact superposition of image and a scale division by the use of a single optical micrometer as an alternative to the use of separate fields and two micrometers. The possibility of replacing visual observation by a physical microphotometric criterion is, however, under consideration. Special attention will be given to the mechanical constraints to secure the necessary coplanarity and collinearity of essential components.

Horizontal Transit Instrument

Preliminary investigational work on this instrument has been in progress. It had previously been decided to use a single optical square, transposed during each observation, instead of the two separate optical squares in the original design. Collimation error is then more readily avoided and, moreover, the wedge micrometer, which it was decided to use, must be transposed, so that the additional transposition of the optical square added no further mechanical complication.

A fundamental requirement of the instrument is constancy of the optical square during the period of observation of a single star. Since this period is only of the order of two minutes the thermal changes, with due precautions, will be small.

It seemed probable that the more important cause of change might be mechanical distortion due to the inevitable change of posture after transposition. The method of transposition, decided upon mainly for mechanical reasons, is rotation through 180° about a vertical axis, combined with rotation through twice the zenith distance about a horizontal axis. One merit of this method is that flexural error vanishes in the zenith, since there is no change of posture, while in the horizon it must be very small since the plates of the built-up pentagonal prism are vertical for each posture. For intermediate zenith distances there is a quasi-symmetry and the effect of flexure will presumably be small over a reasonable range about the zenith. It is, nevertheless, very important to have maximum rigidity of the prism and experiments have been made to determine the relative rigidity of two different types. In one the silica plates are fused to a triangular base by means of two feet; in the other, kindly loaned by Messrs. Cooke, Troughton and Simms, the plates are wrung and cemented to the base over their entire width.

To perform a direct test by measuring the change of deviation with posture, as was originally intended, is very laborious and, for that very reason, unsatisfactory, because the time required for the test is so great that there is no assurance that change of posture is the only variable. An alternative procedure was therefore adopted in which the posture was maintained constant and mechanical force was applied to the plates. As the application and removal of this force is only a matter of seconds, the consequent flexures must be due to it alone.

The results of these measurements show that the wrung and cemented type of construction is much superior in rigidity. The other type has two possible merits: firstly it should be feasible to work on the thickness of the feet until the deflection of both plates is made equal; secondly the more open design at the base permits greater freedom for air circulation and may thus be less liable to trouble from air pockets and stratification.

A marked improvement of rigidity of both types was obtained by cementing a silica bar across the tops of the mirrors. This is a partial approach to the box type, originally suggested for this instrument, which has great rigidity. A decision on the type to be adopted will shortly be made. It is hoped that it will then be possible for the construction of the instrument to be resumed.

Astrographic Telescope

This instrument is now again in full use; fuller indeed than in the years immediately prior to the war, for no other general-purpose refractor is now available at Greenwich. A crack, obviously of many years' standing, in the tube of the 3-inch finder was found in February to have progressed so far as to make replacement of the whole tube imperative. Opportunity was taken whilst doing this to furnish the finder eyepiece with a graticule of 1° squares for convenience in use with the B.D. charts, and to bloom all eight of the finder's optical surfaces.

A camera designed and constructed in the workshop, and using a Ross aircraft reconnaissance lens of $5\frac{1}{2}$ inches aperture and 34 inches focal length, now awaits installation for testing on star fields; it is hoped to use it in a new programme now under consideration.

Vacuum Aluminizing Plant

In addition to its use for aluminizing various of the smaller mirrors at Greenwich and Herstmonceux, and also certain 16-inch coelostat mirrors to be used at

the 1952 eclipse, this plant has been employed to gain experience in the "blooming" of optical surfaces with anti-reflection coatings of magnesium fluoride. In addition to the finder of the astrographic, the lenses of the similar finder on the Yapp 36-inch reflector have been satisfactorily bloomed, with a notable increase in transmission.

Small Transit C

Work on this instrument was described in the previous report. On trial, it was found that the new illumination system was not bright enough, and it was necessary to remodel the source of light and make other changes. This work has been completed. Before bringing the instrument into use, various ways of eliminating the present procedure for obtaining the level were considered; the continual placing of a striding-level onto the pivots wears pits in them, besides apparently disturbing the level itself, and a permanently-hung level was clearly preferable if it could be arranged. It was finally achieved by mounting the level rigidly on the horizontal axis of the telescope itself, so that it always reverses with the instrument; it follows that it cannot be read unless the telescope is pointing near the zenith, but there appears to be no disadvantage in this. The instrument was mounted in the old Small Transit pavilion, which had been overhauled and re-wired where necessary, and the level-determinations show a definite improvement on the old method, besides being quicker to obtain; parallel and simultaneous observations with the small transit instrument in the Altazimuth pavilion were on the point of starting at the end of the report year.

III. ASTRONOMICAL OBSERVATIONS

Airy Transit Circle

The Sun, Moon and Planets have been under observation throughout the year. Observation of the stars in a narrow belt around the Herstmonceux zenith, for use with the photographic zenith telescope, together with stars from the FK3 catalogue contained in a wider belt, on which the PZT star places will be based, was completed by April.

The following observations have been obtained during the year.

Sun	127	Mars	5	Neptune	16
Moon	91	Jupiter	19	Ceres	9
Mercury	6	Saturn	18	Pallas	14
Venus	37	Uranus	14	Vesta	8

Four observations were made of Metis, and one each of Massalia, Bellona and Harmonia.

Transits for the determination of clock and azimuth errors numbered 2090 while the PZT programme accounted for 2113.

The total numbers of transits and zenith distances secured with the instrument on these programmes are 4752 and 3887, respectively.

Astrographic Refractor

The main programme of this instrument is the systematic observation of the position of the minor planets Ceres, Pallas, Juno and Vesta, with the object of

improving the knowledge of the position of the equinox. The numbers of plates of these asteroids secured during their 1950 apparitions were respectively, 13, 17, 16 and 32. All the plates of Juno and Ceres and some of the Pallas ones have been measured and reduced; measuring is proceeding of the rest of the Pallas plates, and standard co-ordinates are being computed for these and the Vesta plates. Six plates of Juno and five of Pallas have been obtained during their 1951 apparitions: so far these have been no more than examined to identify the planets, which are this year exceptionally faint and happen to appear in particularly rich star-fields.

In addition, 10 search-plates have been taken to recover Massalia, Bellona and Metis for the Meridian Department. It is a striking illustration of the post-war state of minor planet work that an object as bright as Massalia ($8^m.5$) was so far off its published course that the $2\frac{1}{4}°$ field of the astrographic telescope was insufficient to reveal it on the first search-plate, exposed on the ephemeris place. Positions from the successful search-plates and from suitably-spaced confirmation-plates have been communicated to the Minor Planet Centre at Cincinnati.

A considerable amount of time has been spent in a systematic investigation of various recommended procedures in reducing astrographic plates, especially those exposed on positions well away from the centres of the catalogue plates, so that positions of the comparison stars have to be extracted from different plates of the same zone, different zones of the same catalogue, or even from different catalogues which may have quite different systems of listing star positions. Methods suitable for different combinations of circumstances, all of which could arise in practice and some of which have in fact done so in the recent work of the department, have been critically assessed.

At the suggestion of Professor R. O. Redman, long exposures have been made on regions containing the most intense discrete sources of galactic radio noise, the intention being to repeat the plates after the lapse of a year so as to discover whether any very faint object shown has a large proper motion. Negative and positive results of this experiment will be equally welcome as giving some information about these "radio stars", none of which has been satisfactorily identified with a visible object. Three first-epoch plates have been secured in the direction of the source in Cassiopeia, three towards that in Coma Berenices, and one towards that in Cygnus. One second-epoch exposure on the Coma source was taken through the glass of the photographic plate (due allowance being made for the change of focus), but direct superposition of this on the corresponding first-epoch plate suggests that however suitable this method may be for the accurate measurement of a proper motion once suspected, it is not well adapted to the detection of a small displacement in one object amongst scores to be examined. Future second-epoch plates will therefore be taken direct, and glass positives, prepared either from them or from the earlier plates, whichever may be the more exposed, will be used for detecting any proper motion that may be large enough to be seen. Experiments are in progress for determining the optimum conditions for preparing suitable positions.

Of the 23 plates obtained of 5 comets observed during the year, perhaps the most useful have been five of 1951a secured during a sequence of fine February mornings which was the more unexpected as occurring in the midst of three months' rain of severity unexampled in the 110 years during which records have been kept at Greenwich. Positions from these plates communicated to the I.A.U. Bureau at Copenhagen have been used by several computers in deducing orbits.

The 10-inch guiding telescope was used to observe occultations of several of the Pleiades in the early morning of October 28. The observed times have been communicated to the Nautical Almanac Office.

The 3-inch Cooke lens used at the 1948 eclipse was mounted temporarily beside the astrographic refractor in order to determine its optical distortion by means of star-field photography. Reduction of the plates by zones shows no measurable distortion even at points well beyond the limits of the 2° field to which its use was confined at the eclipse.

Yapp 36-inch Reflector

With the one-prism train 105 spectra of 72 different stars have been secured in a year that must be accounted very poor from the point of view of observing weather. A few of these were for examining the spectra of late-type binaries in the ultra-violet; the remainder were for studying the incidence of emission in H and K or for correlating luminosity effects with anomalous trigonometric parallaxes in Ko sub-giants. Three spectra of the subsiding Nova Lacertae were also obtained.

An exposing shutter enabling direct photography to be carried out at the Cassegrain focus has been fitted to the telescope, but bad weather in the winter has prevented its use in this way for exposures on the radio sources in the Galaxy, and this work will not be started until after the re-silvering customary in the late spring.

Cape Zone Photographs

The last Report noted that reduction of the measures of these plates could not be completed until further magnitudes and colours were available for the satisfactory determination over the whole zone of the errors of position depending on these two factors. The work has thus been in abeyance for twelve months, but on the last day of the report year the necessary data arrived from the Cape. It now remains to compute and to apply the small colour-magnitude corrections to the measures, and then to convert them to right ascensions and declinations. For the majority of the stars, for which standard co-ordinates could be computed from moderately good meridian places before measurement started, this latter process can be done most economically by applying to the catalogue places the relatively small differential corrections indicated by comparing the measures with the standard co-ordinates. For the fainter stars, however, only crude places exist, and although these were sufficient for identification during measurement of the plates, this abbreviated procedure is not possible. Here the computations will be much longer, the process being in fact the converse of the calculation of standard co-ordinates from known places.

Photoheliograph

The Sun was photographed on 277 days, a second photograph being taken except on 35 days. The granulation of the photosphere is clearly shown on a number of the plates. 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, three days are unrepresented in the combined series for 1950 viz. April 23, July 3 and July 5. Positives on glass for these three days have been kindly presented by the Director of the Mount Wilson Observatory.

Consignments of solar negatives have been received from the Cape for the first half of 1950, and those for the second half are in transit.

Measurement of the combined series has been completed from 1947 May 6 to 1948 November 1. Computations of sunspot positions and areas have been made from 1946 November 25 to 1947 November 20.

During the year, the 1939 volume of the Greenwich Photoheliographic Results has been completed by varityper and sent for reproduction to the Hydrographic Office. One hundred and nineteen pages of proof for the 1937 volume have been received from H.M. Stationery Office. Tables giving for each synodic rotation in 1946 (1) the daily mean areas of spots and of faculae and (2) the mean heliographic latitudes of spots are being published in Monthly Notices of the R.A.S.

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 70 showing an appreciable decline from the value of 119 for the preceding period.

The largest sunspot of the year crossed the Sun's disk from April 12 to 25 in latitude 13° north. Its area near central meridian passage on April 18.8 was 2300 millionths of the Sun's hemisphere which makes it the largest group since 1950 February. Other spots reaching a maximum area of 1000 units or greater crossed the central meridian on December 13.3, January 29.3 and February 25.0.

A determination of the Sun's rotation period from recurrent sunspots for the cycle 1934 to 1944 has been completed. The derived value of the diurnal sidereal motion with respect to solar latitude is in satisfactory agreement with the values given by comparable data for the five preceding eleven-year cycles. Analysis of the data gives no evidence of any change in the rate of rotation, such as has been suggested by spectrographic observations.

The departmental set of Greenwich Photoheliographic Results from 1874 to 1936 has been bound in 23 volumes by H.M. Stationery Office.

Spectrohelioscopes

Observations of the Sun's disk in $H\alpha$ were made on 137 days, but on 23 days observations were restricted to a few minutes by adverse sky conditions. Thirty-one solar flares were observed, but of these only one (that seen at the west limb on April 25) was of major importance. After 1950 May, during which month a number of short-wave radio fade-outs were reported, solar flare occurrence dropped abruptly and, with the exception of a few short periods, remained at a low minimum until the early months of 1951. Meanwhile, sunspot frequency, still moderately high, declined rather sharply after August. The larger spots that have since appeared have mostly been subnormal in flare occurrence. In the case of the large sunspot in April only one intense flare and eight minor flares were observed in a total observing time of twenty-three hours in nine days.

In contrast to this general low level of chromospheric activity, there appeared to be established a well-defined solar M-region that gave rise to a distinctive 27-day sequence of six small geomagnetic storms, commencing on August 7, September 3, September 30, October 28, November 24 and December 22. A great storm on August 18-20 may have been related to a sunspot with C.M.P. on August 16.3, but the connexion is not clearly established.

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.

Besides following the progress of solar flares, 102 measures of line-of-sight motions of dark hydrogen flocculi on the disk were obtained. On 3 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. Thirty-seven photometer measures were made on patches of normal bright flocculi, in addition to 20 sets on solar flares. Nineteen prominences were examined at the Sun's limb.

A small camera box has been fixed to the Newbegin spectrohelioscope to enable the $H\alpha$ line and adjacent spectrum to be readily photographed on 35 mm. film, alternating with visual observations in the field of the spectrohelioscope. The Michelson grating of this instrument is being aluminized in the vacuum distillation plant at Greenwich.

In connexion with the fuller recording of solar flares by radio technique, the sudden phase anomaly indicator receiving GBR Rugby on a frequency of 16 kc./s (18.7 kilometres) was altered in July, so as to record sudden enhancements of atmospherics on a frequency of 27 kc./s (11.1 kilometres). This change was desirable because of extended periods when GBR was not transmitting on this low frequency. The recording of sudden enhancements of atmospherics has not, however, proved as satisfactory as was hoped with the modified equipment, and arrangements are in hand for the construction of a new receiver which will enable a choice of operating frequency over a fairly wide range to be made. Meanwhile, some sources of electrical interference within the Castle buildings have been located and suppressed.

The Astronomer Royal for Scotland has kindly reported by telegram the occurrence of the more important flares either observed directly or recorded on the S.P.A. recorder at Edinburgh. The Engineer-in-Chief, Cable and Wireless Limited has continued his useful co-operation in reporting by telephone to Herstmonceux radio fade-outs while still in progress. The services rendered by the Joint Radio Propagation Bureau (Admiralty) are very helpful in expediting solar information issued from the Observatory for the information of radio research centres.

Solar Eclipse, 1948 November 1

Work on the results of the 1948 eclipse is proceeding. Trial reductions at three different parts of the three-minute run gave approximate corrections to the Moon's place, but made it seem possible that there was room for improvement in the method by which the limb-contours were being reduced in Washington. The Washington observers found great difficulties in the way of actually making a change of the kind suggested, but have in the meantime forwarded a more recent and much-improved contour for librations corresponding approximately with the librations at the time of the eclipse. Discussions, and independent reduction of this, are proceeding.

The reductions have been advanced sufficiently to establish the suitability and accuracy of the method of observation. Plans have accordingly been developed for a more extensive application of the method at the total eclipse of 1952 February 25. It is proposed to make observations at two places near Khartoum, just outside the region of totality on both sides of the central line, and also at two places near Basra, similarly placed with respect to the central line. Long focus cameras will be used at the Khartoum sites to photograph the eclipse with a view to obtaining the precise contour of the Moon's limb at the time of the eclipse.

Time Service

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

At Greenwich 320 observations were secured on 166 nights, and at Abinger, 249 on 123 nights, making a total of 569 observations during the twelve months covered by this report. Transit C, referred to in last year's report, has been set up in the Small Transit Pavilion at Greenwich, and is undergoing final adjustments. It has not yet therefore been possible to release Transit B for return to Abinger, which station has been without a second instrument since January 1948. The levels used with the Bamberg and Small Transit instruments were recalibrated by an optical method in the laboratory at Abinger.

The adopted longitude of the Small Transit mounting in the Altazimuth Dome at Greenwich was changed from 0s.150 E to 0s.145 E on July 1 as a result of a special local survey.

In order to provide as uniform a time system as possible for the assessment of performance of the standard quartz clocks, corrections have been applied to the observations to minimize the effects of the annual fluctuation of the Earth's rotation and of the polar motion. The effect on time determinations of the polar motion has been estimated, as in previous years, from the current latitude variation observations of the U.S. Naval Observatory, made with the photographic zenith tubes at Washington and at Richmond, Florida, the results being forwarded weekly by air-mail.

The astronomical observations, corrected for polar motion and annual fluctuation, are referred to quartz clocks at Abinger, Greenwich and elsewhere. The silk-suspended Z-cut quartz ring oscillators introduced at the Post Office Research Station, Dollis Hill, in 1948 and 1949 have continued to show a marked superiority over the GT-cut quartz plate type. Two quartz ring oscillators are now in use at Abinger and have already shown themselves to be better than any previous Abinger clocks. The first of these, which was installed in May, had practically no ageing effect and rapidly settled to a frequency drift that was indistinguishable from zero, thus greatly enhancing the value of the clock. By the end of 1950, after barely six months of operation, the clock was brought into use as a primary long-period standard. The second quartz-ring was installed in September, and had settled to a practically constant drift in frequency by the end of 1950; it is now in use as the reserve Abinger standard.

The modification of the clock cellars at Abinger from rack-mountings to single pier-mountings is now more than half completed. One cellar is in full operational use, with two quartz-ring oscillators and one adjustable-frequency GT-plate oscillator. A second cellar is in partial use, with one adjustable-frequency GT-plate oscillator and two oscillators temporarily fitted with ordinary GT-plate crystals, until the next two quartz-rings are delivered. The third cellar is in process of modification, and should be in use before the end of 1951. The remaining cellar contains the last rack-mounted GT-plate oscillators, and will be modified to single-pier mounting in due course for the purpose of housing oscillators of experimental design during tests. The three adjustable-frequency oscillators, from which are selected the transmitting standards, were previously kept as a complete group; there was a risk of disturbance of them all whenever adjustments were made on any one of them. In future, they will be dispersed among the three operational cellars.

The service of International Time Signals and of Six Pips Time Signals broadcast by the B.B.C., together with the Hourly Signals used by the Post Office for the control of the Speaking Clock, has been maintained from the phonic motor transmitters at Abinger.

Since October 1 a five-minute series of dots, each of approximately one-tenth of a second in duration, and at intervals of one second, have been radiated at 0955-1000 and 1755-1800 G.M.T. daily. These signals are convenient for checking the performance of high-precision quartz-crystal controlled standards of time and frequency. The rhythmic series formerly sent at these times is still required by users for checking chronometers by the method of coincidences, particularly for navigation and for field survey work. The rhythmic signals are therefore radiated at 1001-1006 and 1801-1806 G.M.T. daily. The transmission of the mean time signal before the hour and rhythmic signal after the hour conforms with international usage.

The service of radio time signals controlled by the Royal Greenwich Observatory is designed to provide reasonable world-coverage, and is accordingly transmitted on long waves from Rugby (GBR, 16 kc/s) and on associated short-wave transmitters selected to meet summer and winter conditions. Both the mean time and rhythmic series are radiated in this way, thus providing users in most parts of the world with a choice of suitable signals on at least one wave-length. The preliminary signals for determination of line-lag continue to be radiated at 0946-0950 and 1746-1750. Arrangements are being made for the long-wave transmitter GBZ to act as reserve in the event of the non-availability of the GBR transmitter.

The reserve service of Hourly Signals to the Post Office and Six-dots Signals to the B.B.C. was maintained from Greenwich throughout the year.

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 Co. Ltd., regular information is received concerning quartz clocks and frequency standards at Dollis Hill, Banbury, Rugby, Teddington, Tatsfield and Great Baddow.

The clocks at Dollis Hill have continued to serve as long-period standards for use in the Time Service. Interest in the older quartz-ring oscillators has declined somewhat with the advent of the silk-suspended rings described last year, though they still have great value as long-period standards. At Banbury, the usefulness of the clocks has been marred by a long series of troubles in the power supply arrangements. The standards at Rugby were installed for the control of the new service of standard frequency transmissions from MSF, and include one silk-suspended ring of very high stability. The necessity for occasional re-adjustment of the frequency of this oscillator impairs its value as a long-period standard clock, but it provides a powerful control on frequency variations at all stations receiving the transmissions.

At the National Physical Laboratory a new standard fitted with a silk-suspended quartz-ring was brought into use in May, and has displaced the GT-plate oscillator as the primary quartz standard. It has further increased the value of the Teddington reception of the GBR time signal as a completely independent indication of the erratics of the transmitted signal. Similar independent checks upon the Time Service are provided by the regular comparisons made with the local standards at Tatsfield and at Great Baddow, as described in the previous report. The German quartz clock

PTR VIII has been set going at Abinger, and regular comparisons with the other Abinger clocks have been carried out since June 27. The performance appears comparable with that of a normal GT-plate oscillator.

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 routine 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 1950, together with the quarterly supplements giving reception times for the WWV time signals of the U.S. Bureau of Standards. The Time Service Circular containing frequency estimates referred to a uniform time system has been published about the middle of each month for the preceding month. The Time Service Monthly Frequency Estimate, prepared at the same time, gives direct assessment of the predicted, current and revised frequencies of selected quartz crystal standards, and is sent to the Post Office Laboratories at Dollis Hill and Banbury. The Time Service Weekly Frequency Estimate was discontinued on September 30, as its primary purpose was to supplement the GMT frequency transmissions from Abinger (2 Mc/s), which ceased on that date consequent upon the inauguration of the MSF transmissions. The material for the volumes of Greenwich Observations has been prepared up to the end of 1949.

In the Electronics Laboratory a considerable amount of design and experimental work has been carried out on new types of crystal drive circuits working with extremely low amplitude of crystal oscillation. Three separate forms of circuit have been subjected to careful test and analysis, and the most promising design is now being constructed in prototype form. Some delay is being experienced in the delivery of special high-stability components, but it is hoped that the experimental oscillator will be in operation by the end of the year. Similar delays have arisen in the development of an improved type of quartz crystal oven: the oven control circuit, which is operated from battery supplies, has already been tested and found satisfactory.

To facilitate the careful checking of the performance of the quartz crystal drive circuits, an accurate phase-meter has been constructed, which is capable of measuring phase variations of less than one-hundredth of a radian. It has proved of the greatest value in the checking and adjustment of the rebuilt amplifiers of Post Office design. A new form of regenerative divider has been developed, and the prototype is performing satisfactorily. It is proposed to replace all the dividers at Abinger and Greenwich with the new pattern. A special receiver has been built and installed at Abinger for the comparison of the standard frequency transmissions from Rugby (MSF, 60 kc/s) with the Observatory standards. Messrs. Standard Telephones and Cables, Ltd. kindly gave a 60 kc/s quartz crystal filter for use in the new receiver.

A new type of electronic pulse divider, converting from 100 kc/s to 1 pulse per mean time second, has been developed, and is undergoing reliability tests. The same units can be arranged to delay a pulse by any desired interval within the range 0s.0000 to 0s.9999, in steps of 0s.0001, the delay time being selected by means of four decade switches. It is also possible to arrange the units to give pulses at intervals of one sidereal second. Another use for the pulse divider is as a new form of decimal counter chronometer, which besides having certain advantages over

the type now in use in the Department is also considerably more compact. A complete decimal counter chronometer of this type has been built for the Control Room at Greenwich.

The programme of trans-Atlantic measurements of radio propagation velocity, referred to in the report last year, was finally abandoned, owing to the impossibility of securing an adequate standard of reception of the Rugby radio signals at the U.S. Naval Observatory. The special long-wave receiver, which had been constructed at Abinger, was returned to this country, and has now been overhauled and prepared for installation at Greenwich. The programme for the completion of the Greenwich control equipment is thus making slow but steady progress.

The special standard frequency receiver prototype was completed and put into operation, but tests showed that interference between the WWV transmissions on 5 Mc/s and 10 Mc/s and those on the same frequencies from Rugby made accurate measurement difficult.

IV. MAGNETIC OBSERVATIONS

Regular measurements of horizontal and vertical intensity and of declination and inclination have been continued for the purpose of calibrating the base lines of the recording instruments. The base-lines have remained very constant.

Weekly reports of the mean hourly values of declination and lists of character figures, K-indices and other magnetic data continue to be supplied to interested establishments. Lists of K-indices are now also sent to the "Journal of Atmospheric and Terrestrial Physics" in which they are being published alongside the corresponding values obtained at Eskdalemuir and Lerwick.

To meet the demand from time to time for the loan of magnetic records, and as a precaution against loss of the original traces, photostat copies have been made regularly since 1950 November 22. The copies are negatives, laterally reversed, from which positive copies of the originals could at any time be obtained; but they are themselves equally suitable for direct measurement when required.

Facilities and assistance have been made available to the Hydrographic Department and to the Royal Aircraft Establishment, Boscombe Down, for the calibrating of Tubular Compasses at Abinger. Messrs. Watts have had almost exclusive use of the large test hut for testing variometers for Geophysical prospecting, and assistance has been given to Messrs. Elliott Brothers in their work upon an airborne magnetometer for the Ministry of Supply. BMZ 35, the property of the Air Ministry, was recalibrated at Abinger during the year.

Following receipt at Abinger, as mentioned in the last report; of three QHMs from the Danish Meteorological Institute, a series of observations was made for the purpose of comparing the Abinger standard Schuster-Smith magnetometer with the standards in use at other stations. The first observations were made in May, a second set being secured in November after the instruments had been sent to Eskdalemuir and Lerwick. The project was not as successful as had been hoped, owing to the breakage of two of the suspensions between the times of despatch and return of the instruments to Rude Skov. The final report of the intercomparison received from Charlottenlund shows the following residuals referred to the mean of the four stations.

Abinger	-4.8γ	Eskdalemuir	+6.6γ
Lerwick	-2.3γ	Rude Skov	+0.5γ

A repetition of the comparison is proposed.

A comparative study of the magnetograms of five American Observatories, published by the U.S. Coast and Geodetic Survey, and of the Abinger records has been made to obtain a better understanding of the character of Sudden Commencements and other world-wide movements. For this purpose, the small-scale reproductions of the American magnetograms are suitably enlarged by an epidiascope in conjunction with a special device made in the workshop. Facilities for an extension of this study to other movements have been granted by the Superintendent, Meteorological Office, Edinburgh, who has kindly loaned certain records obtained at Eskdalemuir and Lerwick.

The copy for publication of the Magnetic and Meteorological results for 1938, including diagrams of storm disturbances, has been completed and sent for reproduction. The varityping of the 1939 copy is now in progress. Arrangements have been made for the transfer of much of the preparation of numerical material contained in the annual volume to the punched-card machines.

Mean annual values of the magnetic elements at Abinger for the years 1947-1950, with estimated values for 1951, are given below:-

Year	Declination (West)	Horizontal Intensity	Vertical Intensity	Inclination
1947	9° 43.′1	0.18577	0.43246	66° 45.′2
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 10.8	0.18648	0.43304	66 42.1

Classifying as "storms" and "great storms" disturbances having a lower limit in the range of 150γ and 300γ respectively in H or 30′ and 60′ in declination, the number of "storms" was 18 and the number of "great storms" 1, the latter occurring during the period August 18-20.

V. METEOROLOGICAL OBSERVATIONS

Following the termination at the end of May of the full scale programme of observations, eye observations of temperature and pressure have been made daily at 0900 together with measurements of rainfall. Wind records have also been maintained with the Robinson and Osler anemometers. Recording has continued with the night-sky camera and sunshine recorder throughout the year.

The highest shade temperature was 89.°3 registered on June 7, the corresponding reading in the open stand being 89.°8. Temperatures exceeding 80° were recorded on the Stevenson screen on 11 days, 6 of these being in June, 1 in July, and 4 in August. The lowest temperature was 23.°6 on December 6, the corresponding reading in the open stand being 22.°6. Temperatures of 32° and below were recorded on 37 days.

The maximum wind pressure was 28.0 pounds to the square foot on February 4.

The recorded duration of bright sunshine was 1243.9 hours, 27.8 per cent of the total theoretically possible. There were 82 entirely sunless days. The figure for December was 11.2 hours, the lowest for any month in the Greenwich records. On 34 occasions the night-sky Camera gave a completely unbroken trace of delta Ursae Minoris. The number of nights on which no trace of this star appeared was 70, with a further 44 on which not more than ten per cent of the amount possible was recorded.

The total rainfall during the twelve months was 31.100 inches, which is nearly 7 inches above the average for the hundred years 1841-1940. There were 202 days on which rainfall exceeding 0.005 inch was recorded. The wettest month was February with a total of 5.939 inches, this being by far the highest rainfall in February recorded at Greenwich, the previous highest being 4.03 inches in 1866, and the driest month was October, with 0.351 inches, this being the second lowest rainfall in October recorded at Greenwich, the lowest being 0.140 inches in 1947. The rainfall during the last six months covered by this report was 20.62 inches, and during the first four months of 1951 was 14.16 inches. The totals exceed the highest recorded at Greenwich for the corresponding periods by 2.02 inches and 1.31 inches respectively.

In view of the pending complete cessation by the Observatory of meteorological observations at Greenwich, and the accompanying inconvenience to the Meteorological Office, which has no other station in the vicinity, it is proposed that a local institution shall undertake to furnish meteorological data from May 1. To provide an overlap, readings of temperature and rainfall will continue to be made at Greenwich for a few months. Sunshine and night-sky records will be maintained for a time for purposes of comparison with Herstmonceux.

At Herstmonceux a Campbell Stokes Sunshine recorder, similar to that in use at Greenwich, was set up in June on the East Tower of the Castle, where a pier had been specially constructed to receive it. Regular sunshine records have been obtained since July 1. Comparison of these records with those secured at Greenwich reveals not only a general increase in duration of sunshine, but also a much greater intensity at Herstmonceux, exemplified by the lateral spread of the traces. The records are measured by an observer (BR) experienced in the measurement of the Greenwich traces, and specimen strips have been measured by the current Greenwich observer (GW). As an additional check and precaution against false comparisons of duration, samples of traces from both stations have been sent to the Meteorological Office for measurement. Agreement between the Herstmonceux and Greenwich observers is almost exact, but both read the Herstmonceux traces slightly low on the Meteorological Office measurements for the summer months. The question of what allowance should be made for spread of the traces is one which is open to doubt and becomes most serious on summer days when there is broken cloud in an otherwise transparent sky.

From July 6-7 night-sky records have been obtained at Herstmonceux using a recorder erected temporarily on the north roof of the Solar building. Times of opening and closing the shutter differ slightly from those adopted at Greenwich, but comparisons of the two sets of records expressed in percentages of the exposure times indicate on the whole a longer duration of clear sky at Herstmonceux. This is particularly so during the long winter nights at a time when an increase in the percentage value has greatest significance consequent upon the long exposure times. The ratio of the percentages "δ U Min/Polaris" are at times considerably larger at Herstmonceux. These figures are taken to be a measure of the greater transparency of the skies at Herstmonceux. The effect is most apparent during November when Greenwich experiences sky fogs. A similar effect could arise from a difference in

the lenses used in the two cameras, but such a difference is not believed to exist. As a precaution, however, it is intended to carry out a direct comparison of the cameras by setting them to record side by side.

The following table contains a summary of the sunshine and night-sky records.

Month	Sunshine Herst.	Sunshine Gr.	Polaris Herst.	Polaris Gr.	δ U Min. Herst.	δ U Min. Gr.	δ U Min/Pol. Herst.	δ U Min/Pol. Gr.
	Hours		%		%		%	
1950 July	222.0	166.5						
Aug.	190.5	154.8	65	62	60	58	.92	.93
Sept.	123.3	102.1	39	39	35	35	.90	.90
Oct.	123.9	84.9	58	57	51	51	.88	.89
Nov.	71.9	34.6	45	31	41	25	.91	.81
Dec.	41.4	11.2	38	32	32	24	.84	.75
1951 Jan.	70.3	30.6	38	37	33	32	.87	.86
Feb.	76.7	45.9	41	45	35	38	.85	.84
Mar.	119.5	68.3	40	34	35	28	.88	.82
Apr.	209.4	153.5	61	55	57	48	.93	.87

The total sunshine recorded at Herstmonceux during the 10 months was 46.5 per cent greater than the total recorded at Greenwich.

Plans have recently been received from the Consulting Architect of the hut designed to accommodate the anemograph, standard barometer and recording thermometers. It is hoped that the construction of this building and the lay-out of the Meteorological Enclosure will not be long delayed, so that a full-scale programme of meteorological records can be commenced at Herstmonceux. In preparation for this, a room has been prepared in the basement of the Castle where the recording barometer, formerly in use at Greenwich, has been installed.

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 15031. Of this total 112 chronometers (Pattern HS1), 149 chronometer watches (HS2), 306 deck watches (HS3), 24 dashboard watches (HS4), 270 wrist chronographs (HS9) and 120 ATP watches are rating or ready for issue. There are 11 Pattern HS1, 36 HS2, 25 HS3, 4 HS4 and 137 HS9 undergoing repair in the Chronometer workshop. The remainder, consisting of 669 HS1, 2888 HS2, 5781 HS3, 1039 HS4, 505 HS5, 412 HS6, 58 HS7, 93 HS8, 1584 HD9 and 593 ATP watches are held in store awaiting adjustment, rating or repair. Chronometers and watches in use throughout the Observatory number seventeen. In addition to the foregoing, 200 chronometers and watches are deposited in the Chronometer Department for various reasons.

During the year 6292 chronometers and watches were received and 6741 issued. These figures include the following non-routine items:

(a) 308 chronometer watches of non-standard type sold.
(b) 12 deck watches transferred to the Pakistan Government.

(c) 8 chronometers sold on behalf of the Pakistan Government.
(d) 1 chronometer watch returned to the War Dept. after overhaul.
(e) 1 chronometer repaired and rated for the Ministry of Supply.

The total number of chronometers and watches repaired and adjusted was 3433 including one for the War Office, one for the Ministry of Supply, three for the Canadian, one for the Australian, one for the Zew Zealand, and five for the Pakistan Governments. Of the total number repaired seven chronometer watches, twenty-seven deck watches, nine beacon watches and 1756 wrist chronographs were dealt with in the chronometer workshop.

There has been a steady increase in the work of the department throughout the year. Increasing demands from service sources and the need to build up a greater reserve of efficient chronometers and watches was responsible for a substantial rise in the number of instruments repaired.

All chronometers and watches on charge to the Royal Observatory were accounted for at the Annual Audit. The records of the department are completed to the current date.

The Shortt Free Pendulum No. 40 with its precision Slave Clock has been mounted in a temperature controlled clock room under the West Courtyard to provide a more accurate time standard. A mean solar dial is now operated in the Solar dome and an hourly signal is transmitted to the Solar office to afford a reliable time base on the recorder for the Sudden Phase Anomaly Indicator.

In addition to the normal repair work the Cooke regulator from the Solar Dome, the Shelton regulator from the Abinger Magnetic Station and the Free Pendulum and Slave Clock (Shortt 40) were overhauled in the Chronometer Workshop. The Dent Sidereal Clock with chronometer escapement, formerly used for many years as the sidereal standard at the Royal Observatory, was thoroughly overhauled at Herstmonceux in April. The clock was subsequently installed at the South Bank site of the Festival of Britain, where it forms part of the exhibit showing the development of time standards.

Last year's report included mention of a project for improving the performance of the marine chronometer so that its error could be relied upon to within ten milliseconds throughout the day. A chronometer fitted with remontoire mechanism was tested at Abinger and at no time throughout a period of 48 hours did its actual error deviate by more than six milliseconds from a uniform rate. The tests were made at normal room temperature. Development of the idea was continued on a limited scale and rating was carried out over a wide range of temperatures going down to -20°C. It was found that rewinding of the remontoire could not be relied upon at temperatures below -10°C. In view of this failure the remontoire method has been discarded and a new approach has been made by reconstructing the existing fusee. Results obtained to date show a deviation of about thirty milliseconds from the predicted error. It is felt that a compromise can be achieved between this figure and the ten milliseconds originally aimed at. The reconstructed fusee is a less complicated form of control than the remontoire mechanism.

During the year the staff of watchmakers was augmented by the engagement of three journeymen and one improver, and a skilled labourer was recruited to deal with ancillary jobs in the repair shop. In order that output may be further increased approval has been sought for an extension to the present workshop accommodation and the engagement of five additional watchmakers.

The repayment work undertaken by the Chronometer Department for the Air Ministry has also increased during the year. This is due to the arrival of Mark 7A navigational wrist watches from the repair contractors for testing and subsequent distribution to R.A.F. units. The test period for watches of this type occupies five days in two positions with a percentage of the watches being tested in extremes of heat and cold.

Watches of various types belonging to the Air Ministry at present on charge to the Royal Observatory comprise: 52 Pattern 6B/60, 109 6B/159 (Mk 7A) and 248 6B/346 (Mk 11) rated and ready for issue with 99 6B/60, 868 6B/159, 345 6B/346 and 55 unclassified types awaiting repair.

During the year 4840 Air Ministry watches have been received and 5106 issued. The number sent for repair included 133 6B/60 and 100 6B/346.

VII. 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.

Although the junior staff has been fully up to complement for most of the year, it has not proved possible to fill the vacant post of Scientific Officer, which has now essentially been unfilled since 1945. The almost complete absence of suitable candidates is most disturbing.

During the year the Office recruited two Assistant Experimental Officers, (Miss P. V. Knight and Mr. D. A. Harragan) and one Senior Assistant (Scientific); the Office was fortunate in obtaining the lengthy computing experience of Mr. J. H. Barry in the latter capacity.

The Nautical Almanac

The Almanac for 1952 was published in April. The first part of the Nautical Almanac for 1954, containing the fundamental ephemerides of the Sun, Moon, and planets, has been distributed to at least one observatory in each interested country.

As announced in the report last year, there have been three major changes in the Almanac for 1952: ephemerides of Ceres, Pallas, Juno and Vesta have been included; The apparent places of stars have been replaced by an extended list of mean places; the elements of occultations have been omitted, but the apparent places of occulted stars retained.

Occultations

Of the 2899 conjunctions during 1953 of stars with the Moon examined by means of the occultation machine, 1442 were discarded as the resulting occultations were not observable under suitable conditions. Preliminary times and position angles were recorded for 84 stations for 1457 stars. After computation a further 99 stars were rejected, and the apparent places of the remaining 1358 stars will be published in the Nautical Almanac for 1953. The predictions for 1953, involving 11,955 separate prediction computations, are complete.

The examination of the 2914 conjunctions received from the U.S. Naval Observatory for 1954 has not yet been started, as the Occultation Machine is still undergoing tests of accuracy and consistency after a thorough overhaul and some changes in design. Originally built by Mr. Wescott in the Observatory workshops, after an original design by Mr. J. D. McNeile, the machine has been in constant use for 15 years, during which time it has been involved in no less than six removals. Apart from the necessary adjustments and replacements to allow for wear, several important improvements in design have been introduced. The "moon" system has been remade by the National Physical Laboratory to an ingenious design by Dr. Perfect to allow of more accurate setting of the limb of the moon on a station; the sloping bar constraining the moon to move in its orbit has been replaced and redesigned, and the means of setting the slope improved by the adoption of a projection method; a device has been added to indicate the areas of the earth in sunlight, twilight and darkness; and the settings of the earth in declination and hour angle have been made more accurate. The overhaul has been carried out in the Observatory workshops under Mr. Wescott's guidance.

Preliminary tests have shown a marked improvement in accuracy, but it is too early to say whether the machine times will be sufficiently accurate to make unnecessary the prediction computations that have been made in previous years. Some revision of the prediction programme is, however, likely.

The discussion of the observations of occultations for 1947 has been published in Astronomical Journal, Vol. 55, No. 8. The reductions for 1948 have been completed and the discussion is in hand. For 1948, 1949, 1950, and 1951 the numbers of occultations received during the year have been 230, 473, 915 and 48 respectively. It is clearly impossible to advance the date of the annual discussions until observers transmit their observations, reduced or unreduced, within a reasonable time of their being made. This difficulty will be enhanced in future when the reductions are done on the punched-card machines.

The preparation of the combined list of all occultations included in the annual discussions, for publication as an Appendix to Greenwich Observations, has been completed for 1943 to 1947 inclusive. In last year's report it was stated that the first list would contain the years 1943 to 1945 only: as there was delay in obtaining suitable forms, it was decided to include the years 1946 and 1947, thus economizing in the listing of stations and observers, and bringing the list up-to-date with the discussions. The actual typing on the Varityper machine has been done by the Office computing staff. Copies of the list will be sent to all observers.

From September onwards members of the Office staff, on a volunteer basis, have endeavoured to observe all occultations visible at Herstmonceux, using generally the Newbegin telescope but occasionally a 4-inch tripod-mounted refractor. The weather has been particularly unfavourable and only 11 observations have been secured. Previous to September Mr. Taylor had observed 11 occultations with the 4-inch.

Abridged Nautical Almanac and Air Almanac

The Nautical Almanac, abridged for the use of Seamen, for 1951 was published in July; this is the last edition to appear in the form that was essentially introduced in 1914, though much modified in 1929. As stated in last year's report, all the daily pages for the edition for 1952 were in proof in May, but a year later the Almanac has still not been published; publication should now take place early in May.

Nevertheless, it has been possible to meet some of the urgent requirements from navigational schools and others by the supply of advance proofs. The general reaction to the revised form is favourable and, in fact, several applications have already been received from both home and abroad for permission to reproduce the daily pages photographically. A gratis supplement is being issued with the Almanac to enable the G.H.A. method to be used for the latter part of 1951.

During the year the three parts of the Air Almanac for 1951 have been published, and the first part for 1952 has been printed but is still awaiting binding. No change of content or presentation has been made.

The Star Almanac

The first edition of this volume was published for the year 1951 in September; it is hoped that the edition for 1952, in which no substantial changes have been made, will be published in July.

Apparent Places of Fundamental Stars

The volume for 1951 was published in October. No machine sheets have yet been received for the edition for 1952 and publication will again be delayed, probably to September. 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 for 1954 were distributed in April to the several Offices responsible for the computation of apparent places.

General Navigational Work

The navigational work of the Office, additional to that involved in the routine compilation of the almanacs, continues to be high, particularly in regard to air navigation. Arising from the conferences referred to in last year's report, the Office has collaborated with the Nautical Almanac Office of the U.S. Naval Observatory in the compilation and proof-reading of a new set of tables for air navigation. It has also made some theoretical and numerical investigations into refraction at low altitudes and great heights.

It has been decided, with the generous permission of the U.S. Hydrographer, to reprint photographically U.S. Hydrographic Office Publication H.O. 214 "Tables of Computed Altitude and Azimuth" for use in the Royal Navy. The Office is responsible for the editing of the British edition, including the provision of suitable explanations and illustrations. This decision, which will result in the tables being produced economically and in time for use with the new G.H.A. Almanac in 1952, will bring to an end the project of entirely new tables for surface navigation, for which the Office had prepared complete specifications and specimens.

An exhibit, illustrating the principles of astronomical navigation, has been designed for the Festival of Britain; it will be shown in the Festival Ship "Campania".

The whole of the computational work of latticing the North British (former North-Western) Decca Chain was completed in February. This was achieved in such short time by the use of junior staff on overtime at piece-work rates for the lengthy work of inverse interpolation, the use of the punched-card machines for subsequent sub-tabulation and preparation of copy, and the introduction of a new method, known

as the "rectangular grid" method, for the computations close to the stations. A paper describing this method, which was first proposed in 1946 but then regarded as impracticable for the cartographers who have to draw the actual lattices, is in an advanced state of preparation; the method, and the relative tables, should be of great value to surveyors using movable Decca stations.

Difficulties have arisen in the siting of the stations for the South-Western Chain, and geographical co-ordinates are not yet available. It is hoped to do practically all the computation for this Chain on the punched-card machines.

Proof-reading

During the year 3003 pages of first proofs and 2112 pages of stereo proofs or machine sheets, depending on whether the publication is printed from stereo plates or movable type, have been read. First proofs are read in duplicate, so that there have been over 8000 separate readings.

Repayment Work

The demand for miscellaneous information has shown a slight increase over recent years. After a long period of unchanged charges, these have recently been increased by about 55 per cent.

Machines

All the punched-card equipment, with the exception of the card-operated typewriter, was delivered and installed during the year. The dates on which the various machines were handed over to the Office were: Sorter May 22; Reproducer May 18; Collator August 23; Tabular May 25; Calculator, Model 602A February 19.

The last-named, which is the only machine that can multiply, is the key-machine as far as the general computing work of the Office is concerned; in spite of this, the other machines have been kept 60 per cent occupied since their installation. Unfortunately, the Calculator was delivered from the U.S.A. without the relays for division, so that there is still a considerable lack of flexibility for complicated calculation. It is hoped that most of the routine work will in future be done by the punched-card machines.

Although considerable work has already been done, the past year has been mainly used to obtain experience of the application of these machines to the types of work for which they were not designed. Even the simplest calculation, judged from the computer's standpoint, will mean considerable planning and many detailed "set-ups" on the machines; once done these are, of course, permanent. In many cases, the fundamental formulæ have to be revised and put in a form suitable for the new medium of calculation. The change-over of the whole work of the Office to the punched-card machines thus involves a particularly heavy peak load of planning, which must be done quickly if full advantage is to be taken of the machines. The difficulty is accentuated by the fact that several large pieces of work (such as the calculation of new altitude and Azimuth tables for surface navigation), which it was intended should be used as "background" work, are now no longer available.

Everything so far indicates that the machines will be most successful in doing a large proportion of the computing work of the Office quickly, efficiently and, most important, with substantial relief of the staff from routine repetitive work. It will, however, always be necessary for much preliminary work and independent checks to be done by hand.

The Senior Rolling Total Tabulator has an additional counter which enables the machine to work in decimal or sexagesimal measure at will; otherwise the Model 602A Calculator is the only machine unfamiliar to British users of punched-card methods. It is, in fact, a general purpose relay calculating machine, capable of a limited amount of programming by means of a plug-board and possessing some logical control through selectors; iterative sequences (e.g. for inverse interpolation) are thus possible. It will be used for most of the calculation at present done on hand machines, including the looking-out of mathematical tables.

The whole installation will, however, find its most efficient operation in the analysis of observations, in the formation of tables or ephemerides by numerical integration or sub-tabulation, and in the summation of series of terms.

A Facit Model XL was acquired during the year, and a Varityper has been on loan for two months during the typing of the occultation observations.

Work for other Departments

It is the hope that the punched-card machines will eventually be used for routine calculation, particularly statistical analysis, by other Departments of the Observatory. Work is at present being done, on a small scale, for the Meridian, Solar, Time, and Magnetic and Meteorological Departments; generally each Department is co-operating by the punching of initial data on cards. The largest work so far undertaken is the calculation of apparent places of the 256 stars in the programme for the Photographic Zenith Tube. Calculations for part of 1949, 1950 and 1951 have been completed but have not so far been passed to the Meridian Department.

VIII. PUBLICATIONS

Production on Vari-typer machines has continued throughout the year. It has been found that the work flows smoothly when the department responsible for a particular section in hand is located at Herstmonceux. The two machines, supplied by H.M. Stationery Office, are in need of complete overhaul, and much time has been lost owing to mechanical breakdowns; two new machines have been ordered from H.M. Stationery Office.

The 'Greenwich Observations' for 1937, which is the last to be produced by letterpress, has not yet been completed. There has been a very long delay in delivery of proofs of the section "Photoheliographic Results". This affected not only the complete volume, but also the separate publication of the section "Astronomical Results" which contains the contents pages for the complete volume. The separate section "Magnetic and Meteorological Results" has been published and distributed; the remainder of the volume should be completed shortly as a steady flow of proofs of the Photoheliographic Results is now being received. Proofs of about half of the section have now been received.

The following sections have been typed by Varityper and sent for reproduction by photolithography: Magnetic and Meteorological Results 1938, Astronomical Results 1938, Photoheliographic Results 1939. The second volume of "Observations of Colour Temperatures of Stars" and the section Magnetic and Meteorological Results, 1939 are in hand.

The following other publications have appeared during the year:

H. Spencer Jones. The Determination of Precise Time (Arthur Lecture). Smithsonian Report for 1949, pp. 189-202.
The Earth as a Timekeeper, Proc. R. Inst. *34* pt. 4.
The System of Astronomical Constants. Bulletin Astronomique *15*. 247.
The Structure of the Universe (Chap. X in 'A Century of Science, 1851-1951'. Hutchinson 1951).
Astronomy (Scientific Thought in the 20th Century. Watts & Co. 1951 pp. 59-78).

R. d'E. Atkinson. Some Problems of Interplanetary Navigation. J. Inst. Nav. *3*. 365.

D. H. Sadler. Maximum-Interval Tables. Math. Tables and Other Aids to Computation. *4*. 129.
The Selection of Stars for Navigation. J. Inst. Nav. *4*. 31.
Procès-Verbaux des Séances de Colloque International sur les Constantes Fondamentales de l'Astronomie. Bulletin Astronomique. *15*. 1.

H. W. Newton. The Greenwich Sunspot Observations, Scientia, Sixième Série 44 ème Année 306.
A Significant Time-Distribution of Great Solar Flares and Great Geomagnetic Storms, Observatory, *70*, 233.

H. W. Newton and H. F. Finch. Solar Activity and Geomagnetic Storms, 1950 Observatory, *71*, 45, 1951.

H. M. Smith. Progrès recents dans la Conservation de l'Heure. Journ. Suisse d'Horlogerie. No. 3-4 1950. 61.
The Determination of Time and Frequency. J.I.E.E. *98*. pt. II. 143.

H. F. Finch. On a Periodic Fluctuation in the Length of the Day. M.N. *110*. 3.

J. G. Porter and D. H. Sadler. Stellar Aberration. M.N. *110*. 467.

J. G. Porter. The Minor Planets. (Presidential Address to British Astronomical Association.) J.B.A.A. *61*. 1.

F. M. McBain. Discussion of Occultations observed in 1947. *Ast. Journ. 55*. 247.

IX. PERSONAL ESTABLISHMENT

The assimilation of the scientific staff to scientific grades is now complete. New rates of night-observing allowance have been approved and applied retrospectively.

Vacancies for a Chief Assistant and four other senior scientific staff still exist, together with vacancies for two junior staff.

Mr. R. T. Cullen, Principal Scientific Officer and Head of the Meridian Department, retired on 31 December, 1950, after 49 years in the Observatory.

Mr. L. S. T. Symms has been promoted to Principal Scientific Officer as Head of the Meridian Department.

Mr. H. G. Gill has been promoted to Senior Assistant (Scientific).

Miss A. M. James, B.Sc., has been established in the grade of Assistant Experimental Officer.

Mr. A. P. Lamb and Mr. A. E. Whitaker have passed the examination for Assistant Experimental Officer, and have been retained in the Observatory.

Mr. M. P. Candy has been established in the grade of Assistant (Scientific).

Miss A. R. Hewerdine and Miss C. V. Hewerdine have been established as Shorthand Typists.

Miss R. Weakley has been established as a Vari-typer operator.

Mr. G. E. Taylor, Assistant (Scientific), married Miss V. D. Strong, Established Vari-typer operator on 19 March, 1951. Mrs. Taylor is remaining in her position in a temporary capacity.

The following officers left during the year:- Miss C. M. Cannell, Mr. G. Gaughan, Mrs. E. M. Harris, Miss M. R. Hawkes, Mr. P. Hogan, Mr. E. N. Jackman, Miss B. H. Payne, Mr. J. C. Rudge, Mr. E. G. Shepherd, Mr. J. D. Winter (on military service) and Mrs. J. I. Wool, Temporary Assistants (Scientific); Mr. W. A. Hulme and Miss H. Pettican, Clerical Officers; Miss O. M. Garrett, Established Shorthand Typist; Miss V. A. Bennett, Established Typist; Mrs. E. Ramsay, Hostel Warden and Miss S. C. Chapman, Assistant Hostel Warden.

The following officers have joined during the year:- Mr. D. Harragan, Assistant Experimental Officer; Miss P. V. Knight, Temporary Assistant Experimental Officer; Mr. J. H. Barry, Senior Assistant (Scientific); Mr. B. T. Archer, Miss W. Barton, Miss J. E. Buchan, Miss A. M. Crisford, Mr. J. L. Hicklin, Miss I. S. Manning, Miss J. H. Phillips, Mr. M. J. Pearce, Mr. E. G. Shepherd, Miss V. E. Terry and Mr. R. W. L. Trundle, Temporary Assistants (Scientific); Miss S. M. Billenness, Clerical Officer; Mrs. V. Hyde, Temporary Shorthand Typist; Miss I. Bishop, Temporary Typist; and Mrs. E. M. P. Marples, Hostel Warden.

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 Officers	W. Jackson, M.A., G. B. Wellgate.
Senior Experimental Officers	H. H. J. Barton, E. A. Chamberlain, F. Jeffries, E. G. Martin, G. W. Rickett.
Experimental Officers	K. C. Blackwell, A. E. Cordwell, C. C. Harris, P. S. Laurie, B. R. Leaton, P. L. Rickerby, J. L. Rudd, A. Shortland, R. H. Tucker, G. F. Wells.
Temporary Experimental Officer	Miss C. J. A. Penny, B.Sc.

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, J. D. Pope, B.Sc., A. E. Whitaker.
Temporary Assistant Experimental Officers	M. L. Nunn, D. C. Smith.
Clerical Assistant	Miss C. Ryall.
Senior Assistants (Scientific)	H. G. Gill, Miss F. E. A. Jeffries.
Assistants (Scientific)	Miss P. M. Morris, Mrs. B. G. Tucker.
Assistants (Scientific) Temporary	B. T. Archer, J. N. Bird, J. E. Buchan, J. L. Hicklin, Miss H. Howe, A. Jones, C. M. Lowne, Miss I. S. Manning, Miss M. A. Newman, N. P. O'Hora, Miss D. E. Pankhurst, M. J. Pearce, Miss J. H. Phillips, N. S. C. Phodes, 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.
Senior Experimental Officers	H. W. P. Richards, B.Sc., W. A. Scott, B.Sc.
Temporary Senior Experimental Officer	A. J. Daniels.
Experimental Officers	A. E. Carter, W. G. Grimwood, G. A. Harding, Miss M. R. Rodgers, E. Smith.
Assistant Experimental Officers	Miss D. M. Fooks, 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.
Senior Assistant (Scientific)	J. H. Barry.
Assistants (Scientific)	M. P. Candy, 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 E. J. M. Grove, Miss A. J. Nevell.

(c) SECRETARIAT

Secretary and Cashier	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.
Established Shorthand Typists	Miss A. R. Hewerdine, Miss C. V. Hewerdine.
Established Vari-typer Operator	Miss R. Weakley.
Established Typist	Miss V. L. Wells.
Temporary Shorthand Typist	Mrs. V. Hyde.
Temporary Vari-typer Operator	Mrs. V. D. Taylor.
Temporary Typist	Miss I. Bishop.
Temporary Clerk	Miss J. A. Morris.
Hostel Wardens	Mrs. D. I. Hewitt, Mrs. E. M. P. Marples.

The industrial staff employed at Greenwich, Herstmonceux, and Abinger total 72, 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:- one Foreman of Observatory, nine watch repairers, two watchmaker apprentices, five laboratory mechanics, one mechanic, one storehouse assistant, one head gardener, one forester, five messengers, one packer, three boiler attendants, two drivers, five skilled labourers, four night-watchmen, one caretaker, three gardeners, seven labourers, two switchboard attendants, seven part-time cleaners and eleven Hostel domestic staff.

X. ISAAC NEWTON OBSERVATORY

Sir Thomas Merton 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 December 31, 1954.

Dr. J. A. Carroll was nominated by the Council of the Royal Astronomical Society as a member of the Board of Management, to succeed Professor P. M. S. Blackett, who retired on December 31, 1950.

The Board of Management held one meeting during the year, on March 30.

The Spectroscope Committee held a second meeting on May 12, and prepared an interim report, for examination by the Mechanical Design Committee, from the point of view of fitting the spectroscopes into a practicable telescope mounting. A final report must be deferred until a decision is reached on the design of the mounting.

The Committee on Mechanical Design held two meetings on October 31 and December 4. Alternative designs of mounting considered were: a horse-shoe mounting modelled on the design of the 200-inch Hale telescope; a mounting of the 120-inch Lick

fork design; an improved fork type, suggested by Mr. G. T. Smith Clarke, with larger bearings for the upper end of the polar axis; alternative inverted fork type designs, based on the suggestions of Mr. F. J. Hargreaves. Small models, made by Mr. Smith Clarke, were useful in considering the relative advantages and disadvantages of these designs. A definite decision has not yet been reached; a proposal made by Mr. B. N. Wallis for reducing deflections in the telescope tube and enabling a great saving in weight to be effected may have an important influence on the design, and results of tests of the proposal are awaited. The horse-shoe type of mounting has been discarded, however, as unsuited to the latitude of Herstmonceux.

Some development work has been carried out, under the direction of Professor A. Tustin, in the Electrical Engineering Department of Birmingham University, on methods of photo-electric guiding. Two devices are under development: (a) a photo-electric control of the position of a photographic plate to maintain the register of a selected star image; (b) a photo-electric control of the position of a star image symmetrically on the slit of a spectroscope. It is intended, when the designs have reached a final state, to try them out at Greenwich on the 36-inch reflector.

The 98-inch disk has been ground and polished on both faces by Sir Howard Grubb, Parsons and Co. Dr. Linfoot, on behalf of the Board of Management, made a detailed inspection in collaboration with representatives of the firm, to decide which was the better face for figuring. Diamond milling of the disk, as the first step in the process of obtaining the spherical figure, was then commenced. In the course of this work, some cracks developed along cords in the glass, which have a higher coefficient of expansion than the rest of the disk. Work was stopped for a time but, after discussion with the firm, it has been resumed with a reduced depth of cut; no further development of the cracks has so far occurred.

For the large correcting plates, some consideration has been given to the alternatives of a poured disk of stirred optical glass of high ultra-violet transmission, specially annealed, and a disk of selected plate glass.

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 -

Professor Aung Hla, Rangoon University.
Professor A. C. Banerji, Allahabad University.
Dr. N. G. Pereira de Barros, Lisbon Observatory.
Mr. Beard, New Zealand Survey and Christchurch Observatory.
Dr. W. Becker, Hamburg Observatory.
Mr. Lloyd V. Berkner, Department of Terrestrial Magnetism, Carnegie Institute, Washington.
Professor N. T. Bobrovnikoff, Director, Perkins Observatory, Delaware, Ohio.
Dr. P. Bourgeois, Director, Royal Observatory, Uccle.
Mr. Cox, Lick Observatory.
Professor W. M. H. Greaves, Astronomer Royal for Scotland.
Professor Y. Hagihara, Director, Tokyo Observatory.
Professor C. E. Hesthal, State University, Columbus, Ohio.
Dr. W. Horn, German Hydrographic Institute.
Dr. J. G. Irwin, Kirkwood Observatory, Indiana University.
Dr. J. Jackson, late H.M. Astronomer, Royal Observatory, Cape.

Professor V. V. Michkovitch, Director, Institute for Theoretical and Applied Astronomy, Belgrade.
Rektor S. Nydells, Navigation School, Gothenburg.
Professor J. H. Oort, Director, Leiden Observatory.
Dr. Piggott, Department of Scientific and Industrial Research.
Professor Pollak, Eire Survey Department, Dublin.
Captain B. C. Porter, Director, Compass Observatory, Slough.
Dr. L. Randić, Belgrade Observatory.
Dr. C. Schalén, Uppsala Observatory.
Dr. F. B. Schmeidler, Munich Observatory.
Mr. P. Serson, Dominion Observatory, Ottawa.
Dr. A. H. Shapley, U.S. Bureau of Standards, Washington.
Professor A. N. Singh, Lucknow University.
Dr. W. H. Steavenson, Cambridge Observatory.
Professor J. Stebbins, Lick Observatory.
Dr. O. Strassl, Göttingen Observatory.
Mr. P. Tuseth, Norwegian Hydrographic Office.
Mr. R. O. Vicente, Lisbon University.
Mr. W. J. Youden, U.S. Bureau of Standards, Washington.

Visits have been paid by a considerable number of organized parties from Congresses, Institutions, Scientific and Technical Societies etc.

Mr. J. M. A. Danby of Christ Church, Oxford, spent 6 weeks in the Nautical Almanac Office, and Mr. V. C. Reddish of the Wigan and District Mining and Technical College spent 8 weeks in three Departments of the Observatory at Greenwich, as vacation students.

Other visitors during the year included the Admiral President of the Royal Naval College; the Hydrographer of the Navy; Sir H. Emerson and Mr. A. Barker of the Ministry of Works; Sir Vincent Baddeley; the High Commissioner of Ceylon; the Counsellor of the Nepalese Embassy; and Akenzua II, Oba of Benin, Nigeria.

Dr. Atkinson visited Bonn, Göttingen, and Hamburg in July to lecture to the astronomical departments, by invitation of the Foreign Office.

Mr. Sadler gave a lecture on 'A review of methods of astronomical navigation in the air' to the R.C.A.F. Specialist navigation course on their visit to the Central Navigation School, Shawbury.

The Astronomer Royal was awarded the Mitchell Memorial Gold Medal by the Stoke-on-Trent Association of Engineers.

The Minister of Education has nominated the Astronomer Royal as Chairman of the Board of Governors of the National College of Horology, and also as a member of the newly constituted Advisory Council of the Science Museum.

In the report last year it was stated that the building for the Cooke R.T.C. was not expected to be completed before the spring of 1951; that the building for the Photographic Zenith Tube was planned to be completed in the summer of 1951, the pavilion for the Melbourne R.T.C. by the middle of 1952; and it was hoped that the buildings for the 26-inch and 28-inch refractors would be completed during 1952. No further building has, however, yet been started and it now seems improbable that the target date of the end of 1953 for the completion of the removal of the Observatory to Herstmonceux will be attained.

The Consulting Architect was the Architect of two of the buildings at the South Bank Exhibition of the Festival of Britain and of the alterations at the Memorial Theatre, Stratford-on-Avon, and had to give priority to this work. He is now able to concentrate on the design of the new buildings to be erected at Herstmonceux. The Hydrographer has instituted monthly Progress Meetings, at which the designs can be considered, and progress reviewed with the Architect, the Civil Engineer-in-Chief of the Admiralty, and the Astronomer Royal. An appreciable acceleration of the remainder of the work can consequently be expected with some confidence. The construction of the Meridian Group is likely to commence this year. Rapid progress is being made in the design of the Equatorial Group and it is expected that the construction of the whole of this group can be commenced in the spring of 1952. With the completion of these two groups, it will be possible to resume a full programme of astronomical observations, which have been on a much reduced scale during the past eleven years.

The experience so far obtained of the conditions for observations at Herstmonceux indicates that they are fully up to expectation. Comparative records of sunshine at Greenwich and Herstmonceux have now extended over nearly one year and during this period the amount of sunshine at Herstmonceux was nearly 50 per cent higher than at Greenwich. The greatest excess of sunshine at Herstmonceux occurs during the afternoon, and a substantial part of the difference must be due to a greater amount of cumulus cloud at Greenwich. The night sky records show only a moderate excess of clear sky at Herstmonceux, but there is a great difference in quality. The transparency of the sky at Herstmonceux is much better, and the definition is on the average considerably superior. The freedom at Herstmonceux from the glare of artificial lights at night will be of great benefit in all types of observation. The commencement of night observations, free from the difficulties under which they have been carried on for many years at Greenwich, is looked forward to with eagerness and with high expectations.

H. SPENCER JONES
Astronomer Royal

ROYAL GREENWICH OBSERVATORY,
HERSTMONCEUX.
1951 May 11.