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, 1949 June 11.

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CONTENTS

		Page
I	Grounds and Buildings	3
II	Instruments, Apparatus, and Library	4
III	Astronomical and Radio Observations	10
IV	Magnetic Observations	20
V	Meteorological Observations	22
VI	Chronometers	22
VII	Nautical Almanac Office	24
VIII	Publications	27
IX	Personal Establishment	28
X	Isaac Newton Observatory	31
XI	General	32

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Read at the Annual Visitation of the Royal Greenwich Observatory, 1949 June 11.

The Report here presented refers to the period from 1948 May 1 to 1949 April 30 and exhibits the state of the Observatory on the last named day.

I. GROUNDS AND BUILDINGS.

(a) Greenwich. All glass has been replaced, and windows and doors have been repaired, in the South Building. Temporary repairs in the north attic have also been carried out here, and the ceiling of the upper museum has been made good. Some re-wiring has been done, especially of workshop machines and lights. In the Central Store new window-sashes and door have been fitted, the roof has been repaired, new gutters and drainpipes have been installed and external painting has been carried out. In the Old Building, all damaged ceilings and walls have been replastered, and broken sashes have been replaced in the Airy Transit Circle room; some items of damage still remain however. The old Cookson hut has been fitted up to accommodate a petrol-driven A.C. generator which has been obtained in order to have a standby power-source for the quartz clock installation. The external steps to the roof of Flamsteed House have been extensively repaired, the balustrade and anemometer huts have been redecorated, and the roof over the Ball Lobby has been re-slated. A survey of the photoheliograph dome revealed dangerous weakness; the coping has been removed and the walls rendered. Flamsteed House and the Octagon room have had no further attention yet; the Octagon room in particular still lacks glass, and has blast damage which it may be difficult to make good in a suitable manner. The boundary fence of the Christie Enclosure has been repaired and strengthened with metal strip, as odd slats had repeatedly been forced out and thermometers stolen. Stevenson screens have been repaired and the metal-work of the Yapp dome has been repainted.

(b) Abinger. The premises at "Cornerways", Abinger Hammer, which were requisitioned during the war for use as offices and which, since the war, have been used as a staff hostel were vacated at the end of 1948. Negotiations for the tenancy of "Feldemore", Holmbury St. Mary, referred to in the previous report, were completed. The hostel was transferred there in January, 1949. The house provides also some office and storage accommodation for the Time Department and accommodation for seven married members of the staff.

Several of the halyards on the masts supporting the aerials on Wotton Common were broken during heavy gales. The masts were lowered for fitting new halyards and subsequently re-erected.

(c) Herstmonceux. The Astronomer Royal's residence, the Main Office, and the Head Messenger's cottage were completed and occupied in August and September; the Chronometer Department office, with the temporary chronometer rooms in the southwest first floor and the Chronometer Workshop in one of the huts, were completed soon after, and the Chronometer Department moved from Bradford-on-Avon in September. The second-floor hostel quarters in the Castle, the hostel common rooms in the huts, the remaining hostel bedrooms there, and the Refectory in the Castle were completed and taken into use as necessary about the same time. The premises occupied by the Chronometer Department at Bradford-on-Avon have been given up. The generous co-operation of the Hailsham Borough Council provided the Observatory with six houses from their Bagham Lane group, more than a year ahead of any which will be available from the special allocation made for the Observatory, and these six houses were just sufficient for the existing married staff from Bradford-on-Avon. The lack of houses for any other married staff has so far prevented the Nautical Almanac Office and the Magnetic and Meteorological Department from moving. The accommodation for the Nautical Almanac Office, in one of the huts, is ready for occupation. The Magnetic and Meteorological Department offices are not yet ready, but can be completed fairly rapidly when the need arises.

The Solar Building and the Solar Department offices were completed in April, with the Newbegin dome mounted on the building and painted, and coelostat piers for both the Newbegin and the Greenwich spectrohelioscopes erected on the south side. Final painting of the dome walls has been deferred, and linoleum is to be laid in the dome but this has been postponed until the work of mounting the telescope is complete. The building was designed to have quarter-circle curves at the two corners on the south-west, but the Civil Engineer found it impossible, when the time came, to obtain curved bricks of the kind which had been selected for the building, and ordinary square corners were substituted. The bricks were intended to match those of the Castle, but these have, of course, aged in the course of centuries; it is possible that time will diminish the present contrast. The cellar adjoining the building, which is planned for large prisms, has been started.

Reconstruction of the floor of the Great Hall, to enable it to carry the weight of books, is nearly complete, and the chronometer rooms, darkroom, and other quarters below it have been progressed. It is hoped to transfer the chronometers and watches from their present temporary quarters fairly soon, so that the rooms at present occupied by them may also be adapted for their permanent purpose.

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 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:-

Transit A: altazimuth B: object glass of photoheliograph No.1: clocks, Dent 1916 and Dent 2013.

To the Imperial College of Science and Technology:-

6-inch equatorial, Simms No.2.

To the Meteorological Office:-

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

To the 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.

The removal of the Chronometer Department to Herstmonceux and pressure of work have prevented any further progress in the repair of Harrison's Time Machines, Nos.1 and 3.

Reversible Transit Circle. The pivot-testing work described last year was continued and brought to a successful conclusion. Reversing the instrument showed that the separation between flexure and pivot-error could apparently be made with confidence, though this cannot in fact be absolutely proved. It rests on the assumption that flexure will show equally in both pivots. It this is not so, the position is very unfortunate; it was stated last year that if the east and west halves of the axis flex unequally, the telescope may be deflected in a way that will produce errors of the $\Delta\alpha\delta$ type which will not in general be eliminated by reversal,

but it is also true that if these two flexures are unequal they cannot be determined at all by this method, or indeed by any that has so far been proposed. The mirror transit-circle should in principle be free from this objection. The results actually obtained by the method of autocollimation on the end of the pivot were so consistent and so relatively easy to obtain that a very thorough series of tests was finally carried out. The mirror was used in four different positions on each pivot, and the measurements were made with circle-readings both increasing and decreasing. As stated last year, the flexure terms were in general considerably larger than the pivot errors. The results were analysed for harmonics up to the sixth by the method of 36 equally-spaced values, and the sixth harmonic still seemed to have an appreciable weight. The effect of rotating the mirror was not entirely zero, but was small enough to be satisfactory, and the pivot-error harmonics from the third to the sixth added up to a curve very close to what had been obtained from the entire mass of pre-war work by the Airy method after eliminating the second harmonic; the second harmonic, as was remarked last year, had proved large and unreliable by that method. Unfortunately, the difference between results obtained with increasing and with decreasing circle-readings has still not been adequately eliminated, and it is thus impossible to be sure what further apparent variation in the pivot-errors may be introduced by oscillating through moderately large angles about the zenith, as is of course done in actual use, instead of rotating steadily in one direction as is done in testing. The difference from the mean curve is however always small in tests, and will probably remain small in actual use.

The second harmonic (elliptical component) of flexure was studied in some detail, from the point of view of assisting Sir Howard Grubb, Parsons and Co. (and other makers) to eliminate it in future designs. Its theoretical value was calculated by that firm, from the drawings in their possession, but the first approximate results were of the wrong sign. It was then realized in the Observatory that the weight of the telescope would tend to contract the upper face of the cube in an east-west direction, when the telescope was horizontal, and this effect might have to be included in the calculations. Measurements were made with the eye-end and object-glass removed, and then with the telescope tubes removed as well, and the elliptical component did in fact change in the general way expected. The effect of increasing the total axis-load by varying the counterpoises was also studied, and it agreed with expectation. The full calculations would undoubtedly present a very complicated problem, but further work by Sir Howard Grubb, Parsons and Co. taking greater account of the detailed shape of the central cube, finally led to a calculated value which agreed with the experimental one within a factor of about two. It is understood that improved designs have been made as a result for future instruments and that the improvements have been incorporated in at least one instrument being made for export. It is hoped to prepare a paper on these results for publication, but time has not yet been found for this.

After the pivot-testing had been completed, the instrument was taken into use for a short period in the autumn; concurrently, however, further tests were made on the micrometer, which revealed a very unsatisfactory situation. Readings of the R.A. micrometer on a fixed vertical wire, or on a speck of dust on a fixed horizontal wire which was inserted for the purpose, showed a variation as the circle-reading was changed; readings of the Z.D. micrometer on the fixed horizontal wire, or on a speck of dust on a fixed vertical wire, showed similar changes; and readings of one moving wire on a speck of dust on the other naturally varied to correspond. It was evident that the wire-frames had play on their guides, and in fact the construction was such that this was inevitable. Even a ten-thousandth of an inch represents about a fifth of a second of arc, and it appears quit unlikely that the clearances

could all be machined to this accuracy. Extensive modifications were then carried out in the workshop, so as to convert the two mountings as far as possible to kinematic types, with the result that the faults in the R.A. micrometer were almost entirely eliminated. The Z.D. readings, however, still showed a variation with the circle-reading, and it has been decided to counterpoise the Z.D. micrometer frame. It is true that (except at one stage) these Z.D. variations have always correlated in a single-valued way (i.e. without hysteresis-loops) with the circle-readings, so that they could in principle be determined and applied; but it is hoped to eliminate them, and it would clearly be more satisfactory if this could be done. The work was delayed by the need to concentrate on the Newbegin telescope and the photoheliograph but is now being resumed.

At the same time it was discovered that the main drawtube (focusing tube) of the telescope, though it was fitted with push-pull screws for adjusting both focus and tilt, had no real clamp except those screws. It appears quite improbable that the clearances in a tube of this diameter could be much below a thousandth of an inch, and there seemed therefore to be an appreciable chance that both collimation and flexure would be somewhat indeterminate, perhaps with very slow hysteresis as the film of grease yielded. Clearances were therefore machined so that the inner tube should touch the outer one only at two pairs of "points", one at each end, and powerful spring plungers were added to force it into firm contact here at all altitudes. This seemed better than fitting clamps, partly because the construction is such that one of the clamps would have had to be almost inaccessible, and partly because they would in any case have constituted competing but non-kinematic constraints.

Mirror Transit-Circle. The model of this instrument was shown at the I.A.U. meetings in Zürich. Dr. Barros of Oporto is proceeding with his plans to construct such an instrument, even though Sir Howard Grubb, Parsons and Co. are unable at present to undertake any of the work. He has worked out a detailed design and has constructed some of the parts himself. No further work has so far been possible at Greenwich.

Photographic Zenith Tube. The experimental work has now been concluded. A number of comparative records of different forms of drive was measured in the laboratory at Abinger. These showed that the best results were obtained by the use of the differential roller with reduced magnification preceded by a screw. It has therefore been decided to adopt this form of drive. But in the general design of the rotary, provision has been made for easy transfer to an alternative form if unforeseen difficulties in actual operation should be encountered.

It has been decided to make all the carriage constraints elastic on the lines suggested in the previous report.

Certain simplifications of design have been made. The four chronographic records pertaining to a single star will be superposed, and the chronographic plate will only be moved between the observations of successive stars. This eliminates the need for fiducial marks on the plates, and thus simplifies the optical design of the chronograph and reduces the work of measurement. It also eliminates error due to misorientation of the measuring wire and facilitates the checking of N.-S. displacements of the carriage. In order to make this superposition feasible it is necessary to control the relative phases of the four series of traverses. Coltrol is achieved by adapting the time-sequence so that the traverse and rest periods of the carriage are specific factors of the flashing interval of the strobotron lamp, and by selection of the phase relation between the sequence and the flashes. It is also arranged that the complete record of a star is broken up into groups of four

for ease of identification and that the records of corresponding traverses are adjacent; the previous need for a mechanical method of securing this condition is thus eliminated. The optical method of levelling the stellar plate and squaring on the objective has been replaced by a simpler and better system. The use of the suspended silica rod by which, in conjunction with the optical method of setting, it had been proposed to maintain constancy of separation between stellar plate and mercury surface has been provisionally discarded because it only controls one of the factors upon which scale value depends. But since the relative importance of this factor is at present unknown, the possibility of restoring the rod in future, should the need be shown to arise, has been provided for.

Certain other features of the general design have been dealt with. Means of obtaining the absolute value of distance between the photographic plate and the mercury surface-in order to determine the displacement of the stellar plate from the gaussian plane have been added by the provision of a micrometric measuring-rod. Reduction of chronographic magnification has been made in order to accommodate the requirements of the new carriage constraints. The carriage clamp, which needed modification to remedy defects and to suit the new constraints, has been redesigned and improved. The rotary clamp, which had previously only been considered in principle, has now received detailed treatment. A satisfactory design for the stellar plate-holder, which needed modification to suit the new type of rigid spider mounting, has been completed. Attention has also been given to the design of the stellar shutter, and the relative merits of a number of types have been investigated. This feature of the instrument can, however, receive separate treatment, since it is external and therefore has no direct bearing on the main design. Further work has been done in the laboratory at Abinger on the errors of measurement of the stellar photographic records.

Some consideration has also been given to the question of the best type of housing for the Photographic Zenith Tube, and the general lines to be followed have been agreed.

The present position may be summarized by saying that the main features of the instrument have now all been decided; that the corresponding basic designs have been made, that the detailing of designs is in progress, and that some parts of the instrument have already been constructed.

Small Transits. Small Transit C, which was being modified last year, is now nearly ready for use. The reversing gear has been arranged to serve also as a counterpoise, so that the bearing area could be reduced to the narrow ring where the figure is really good. Small pressure-rollers have also been added in the micrometer, converting it approximately to a kinematic mounting; so long as there is play on the guides, there is in fact a serious possibility of a permanent error which does not go out on reversal. The instrument has not yet been fitted with the proposed hanging level, and will now be taken into use without waiting for this.

Astrographic Telescope. The experiments on photoelectric guiding which were being made with this instrument have been completed, and the results are being published by the Telecommunications Research Establishment. The apparatus was designed so that it could do the entire work normally done by the hour-angle clock-work drive, as well as correct for short-period atmospheric tremors. Under these conditions, the rapidity and sensitivity of response were not quite all that would be desired for the Isaac Newton Telescope. The Astrographic Telescope will have its normal drive restored, and it is planned to use it for some two-colour magnitude work on B type stars in clusters.

Newbegin Telescope. The Newbegin telescope has been entirely overhauled, painted, and lacquered. The four-inch finder, which was superfluous, has been removed. A dummy wooden model of the four-inch Dallmeyer photoheliograph was made and attached in various positions until the most suitable was determined. Suitable balancing arrangements for the real photoheliograph, as well as adequate cast clamps, for mounting it, were then prepared in the workshop and all arrangements for the drive and for illumination and control were fully worked out. The instrument was moved to Herstmonceux on April 25th and mounted and adjusted during that week. The date fixed for transferring the photoheliograph itself is May 2nd, and the Department will move the week after. The photoheliograph has been provided with an entirely new shutter, made in the workshop along the general lines of the old one (now worn out) but with an electric release instead of a string-operated one. This is already in operation. It is hoped that the Newbegin mounting, which is much more stable that the old one, will make it possible to use the shutter for double exposures, without risk of disturbing the adjustment in declination; with the old mounting this is impossible and double exposures for zero can only be taken with an independent obscuring-sheet in front of the objective.

The Greenwich spectrohelioscope will not be moved for the present, and one married member of the Department will remain at Greenwich also. The Newbegin spectrohelioscope will be installed at Herstmonceux as soon as possible, but some minor modifications are being undertaken to make it identical in layout with the Greenwich one. The two instruments will ultimately be side by side, and will work in the closest collaboration during flares and on other occasions when one would be insufficient.

Clocks and Radio Equipment. Some tests have been carried out on a new type of crystal oscillator, in which the amplitude of oscillation is greatly reduced. A suitable crystal for these experiments was presented to the Observatory by Standard Telephones and Cables Limited. This assistance is much appreciated; thanks are also due to Mr. Jacobsen of the same firm for his advice and help. A further crystal has since been made available by the Post Office Radio Branch in order that experimental work may be continued while the performance of the other crystal and drive circuit are being examined. The preliminary tests were very promising, and further work was commenced on an improved form of oven control circuit. Pressure of other work has necessitated the temporary stoppage of these investigations, but it is hoped that it will be possible to resume them before long.

The German quartz clock, PTR VIII, is now being installed in one of the clock rooms at Abinger. The temperature control circuits, frequency dividers, and power amplifier have been completely rebuilt. Work is in progress on the power supply circuits. Only the oscillator, buffer amplifier and motor are being retained unaltered.

Two tape chronographs of an improved and more compact design, primarily intended for field work, have been constructed. The Bélin chronographs have been received and, after some modifications, one has been installed in the Control Room to provide a permanent record of all radio time signals. The other has been placed in the cellar and will be used for the continuous and simultaneous recording of the time differences between six quartz clocks. At present it is being used for tests, made at the request of the Hydrographer, on the uniformity of rate of contact chronometers.

The design of the receiver units of the long wave reception and measuring equipment has been standardized, and three receivers have been completed. Two are

now in use for the routine work at Abinger. The Observatory is indebted to Standard Telephone and Cables Limited for their generosity in supplying the quartz crystals used in the selective stages of these receivers. A report has been prepared on the receiver units, and has been distributed on a limited scale. Design work on the ancillary equipment is approaching completion and special attention is being paid to the need to provide for easy maintenance and simplicity of operation. The R201 receiver loaned by the War Office has been returned owing to the difficulty experienced in obtaining suitable sites for the three aerials.

Some modifications and improvements have been made to the design of the Droitwich receiver, used to derive a 100 kc/s output controlled by the carrier frequency of the Droitwich transmitter. Two complete receivers have been constructed, one being in regular use in the Control Room, and the other serving as a reserve.

The experience acquired in the laboratory in the design of receivers working on 16 kc/s has been applied in the construction of a sudden phase anomaly recorder for use by the Solar Department, based on an experimental model developed at the Cavendish Laboratory, Cambridge. The instrument has been tested at both Abinger and Herstmonceux and is working very satisfactorily.

Library. Full checking of the Library has not been possible in recent years, owing to increasing shortage of staff. With the appointment of a Librarian to the staff of the Observatory, the situation is much more satisfactory, and a full check is in progress. It appears that the number of books missing is somewhat greater than in pre-war years, when an annual check was made, but not seriously so. The process of tracing missing volumes has only just begun, and it is expected that several will still be recovered.

III. ASTRONOMICAL AND RADIO OBSERVATIONS.

Airy Transit Circle. The following observations were obtained under the restricted programme

121	observations	of	the Sun
69	"	"	" Moon
7	"	"	Mercury
23	"	"	Venus
5	"	"	Jupiter
5	"	"	Saturn
5	"	"	Uranus
14	"	"	Neptune
5	"	"	Ceres

together with 1207 transits and 864 zenith distances of stars in the clock and azimuth lists.

From October 28 to November 15 the instrument was out of use while damage done to the roof during the war was being repaired.

The observation of the right ascensions and declinations of the stars in the observing programme with the Photographic Zenith Tube was transferred to the Airy

Transit Circle from the Reversible Transit Circle on March 21, when alterations to the micrometer end of the Reversible Transit Circle were undertaken. The stars are being observed together with a selection from the FK3 Catalogue of stars in the adjacent zones of declination, in order that the positions derived shall be on the FK3 system. As the Photographic Zenith Tube will be used for the determination of time, it is necessary that the right ascensions of stars shall be on the FK3 system, which is employed, by decision of the International Astronomical Union, as the basis for all time determinations. 146 observations of programme stars and 85 observations of FK3 stars have been obtained.

Progress with the final stages of work on the First Greenwich Catalogue for 1950 has again been delayed by shortage of staff and by the heavy demands on the time of the staff which the investigations with the Reversible Transit Circle have made. Computations of the proper motions of more than 2000 stars have been continued.

Reversible Transit Circle. Except for a short period during the autumn, when observations of the stars on the observing programme with the Photographic Zenith Tube were started, no observations have been made with this instrument. The stars on the Photographic Zenith Tube list are being observed at the Naval Observatory, Washington, by courtesy of the Superintendent. Preparations are in hand for observing them also at the Dominion Observatory, Ottawa. The instrumental investigations of the Reversible Transit Circle have been prolonged and have entailed a heavy load of work. They have, however, given much information of value about instrumental peculiarities and the ways in which systematic effects of instrumental origin can enter into the observations with meridian instruments. The investigations have not only been of intrinsic interest but they have led to appreciable improvements in this particular instrument. Inasmuch as the observations with the instrument will in consequence be of higher accuracy and will be less affected by systematic errors, the investigations have been well worth while.

Yapp 36-inch Reflector. Commercial aluminizing having been found unable to withstand the Greenwich atmosphere, the pre-war régime of six-monthly silvering of the 36-inch mirror has been reinstituted. New coats were successfully deposited on September 8 and May 5; the surface blemishes noted in the last report are no longer visible even at grazing incidence.

195 spectra of 72 stars of spectral types O to M have been photographed with the 3-prism train, some being double exposures on bright late-type and faint early-type stars. The increased exposures necessitated in the ultra-violet region for faint stars by reverting to a silvered main mirror have been partly offset by the use of the new Ilford Zenith Astronomical emulsion, which achieves a substantial increase of speed without the corresponding increase of grain size normally associated with faster emulsions. Gaps left in the observing list by the completion at certain R.A.s of the late-type spectroscopic binary programme have been filled by including some K_0 stars suspected of being intermediate in absolute magnitude between giants and dwarfs. Some preliminary work has also been done to assess the suitability of the slit spectrograph for measuring spectrophotometric gradients throughout the spectrum.

The vacuum distillation plant has been used for routine coating of some small mirrors in use in the Observatory. Supports which are in process of manufacture will make possible the aluminizing, if desired, of any of the 16-inch (nominal) coelostat mirrors in Great Britain. A series of test deposits, on glass plates, of aluminium, chromium, silver, gold, and palladium, and of alloys and multiple layers

of these metals, are being exposed, face up and face down, at Greenwich and at Herstmonceux, in order to assess the performance of such deposits in industrial and littoral atmospheres.

Cape Zone Photographs. With the measurement of a further 26 plates during the year, the 113 plates of the zone -56° to -60° are now completely measured and reduced. The total number of stars measured is 7630; each on at least two plates (since each photograph overlaps the next in R.A. by half its width) and about 15% of this total on four plates, since 23 plates covering the sparsely populated region between 22^h and 4^h were repeated with a longer exposure to make possible a more even coverage of the zone. A small number of stars beyond the declination limits quoted have been measured in order to link the zone with those immediately N. and S. of it. From the inception of the work, meridian places from the La Plata (1925) Catalogue were used, in the absence of more modern places, for the reductions. In order to preserve the continuity of the computation method the plate constants for the remainder of the zone were calculated using these places even after modern Cape meridian places became available towards the end of the measuring. The constants for the whole zone have now been transformed to those which would have been derived had the Cape places been used for the standard stars; it remains to correct the measured positions of the catalogue stars, by a differential method, from the La Plata system to the Cape system before proceeding with the examination of magnitude colour and position errors.

Ledgers containing approximate rectangular co-ordinates and image diameters for the whole zone have been sent to the Cape for use in measuring plates taken there for the photometric programme.

Photoheliograph. Photographs of the Sun were obtained on 276 days, a second photograph being taken on 246 days. 22 plates with double images were also taken during the year for determination of the zero of position angle. The zero has also been determined regularly by a visual method. From reports received from H.M. Astronomer at the Cape and from the Director of the Kodaikanal Observatory, India, one day (December 20) is unrepresented in the combined series for 1948.

Consignments of solar negatives received from the Cape during the year cover the period 1948 January to December inclusive. To fill gaps in the combined Greenwich-Cape series for 1947-1948, seven negatives have been received from Kodaikanal. The Director of the Mount Wilson Observatory and the Superintendent of the U.S. Naval Observatory, Washington, have each kindly provided one photograph. A plate for 1948 December 20 has yet to be obtained. 310 plates have been measured during the year to complete the measurement of the combined series from 1945 July 1 to 1946 May 5. Computations of sunspot positions and areas have been made for the combined series from 1945 June 13 to 1946 January 17.

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

The provisional mean daily sunspot number for the twelve months is 147, compared with 153 for the previous epoch. After a very high secondary peak in 1948 April, sunspot frequency declined generally until 1949 January. In February, the mean sunspot number rose to 183, but it now seems certain that the maximum of the cycle has been passed with its primary peak in 1947 May and secondaries in 1948 April and 1949 February.

The two biggest spots of the year, each exceeding 2000 millionths of the sun's hemisphere, appeared respectively in January and February. The first, with central meridian passage on January 22.7 U.T. was associated with a great geomagnetic storm and auroral displays on January 24-26. The onset of this storm was preceded about 40 hours earlier by an intense flare over the big spot group then 5° west of the central meridian. This flare was observed at Kodaikanal between 02.30 and 04.00 U.T. and the Director has kindly sent to Greenwich prints of the hydrogen and calcium spectroheliograms showing the flare in progress. The second sunspot, crossing the central meridian 2° south of the centre of the disk (as compared with 28° for the earlier group) had no associated geomagnetic disturbance of storm intensity. Available evidence shows that two intense solar flares occurred over this spot when in longitudes 51° east and 80° west respectively of the central meridian.

During the year, the copy for press of the "Greenwich Photoheliographic Results" for 1941, 42, 43, and 44 has been completed. Tables of the mean areas of sunspots and faculae for each synodic rotation included in 1941 and 1942, and of the mean heliographic latitude of sunspots, have been communicated to the Royal Astronomical Society.

Fifty pages of the *Daily Results* of the Greenwich volume for 1938 have been printed on the "Varityper" installed in the Secretary's office. The checking of these sheets has been nearly completed in readiness for their reproduction by photolithography.

The rotation period of the sun derived from the measures of long-lived sunspots is being investigated for the cycle 1934-44, as already done for earlier cycles covered by the Greenwich Observations since 1875.

Spectrohelioscope. During the year, the original and duplicate coelostat mirrors of the spectrohelioscope were gilded by evaporation in the vacuum equipment recently acquired by the Royal Observatory.

The instrument was used on 168 days, but on 44 days observations were limited to a few minutes because of poor observing conditions. 51 solar flares were observed in $H\alpha$ during the year; 2 were of major importance, i.e. of intensity 3 on the International scale.

405 measures were made of line-of-sight velocities of bright and dark flocculi. The 180 measures of bright flocculi also provide equivalent line-widths of $H\alpha$. Photometric measures were made on 144 patches of bright flocculi. Line-of-sight motions were measured in 24 prominences. On 5 occasions line-of-sight velocities measured on the sun's disk exceeded 100-km/sec., the greatest being 180-km/sec outwards from the chromosphere. These motions were of absorption markings associated with solar flares.

Details of solar flares and times of observation with the spectrohelioscope are sent quarterly to the Director of the Meudon Observatory for incorporation in the *Quarterly Bulletin,* published from Zürich under the auspices of the International Astronomical Union. Flares of importance 3 are also reported as soon as possible by telegram to Meudon for incorporation in "Ursigrams" broadcast from the French radio station of Pontoise.

Of the major solar flares observed during the year, that of May 21 was recorded practically from its onset. A light-curve derived from photometer measures of the central intensity of $H\alpha$ has been published in the "Observatory".

Well-defined geomagnetic crochets, indicating bursts of ultra-violet radiation from solar flares, were recorded on the Abinger magnetograms on December 9 at 11.49, February 1 at 12.20, and February 11 at 10.58. A small impulse, probably a tiny crochet, occurred on June 21, July 29, November 14, December 23, March 25, and March 26. It is noteworthy that no crochet was recorded on May 21 at about the time when the peak intensity of the above-mentioned flare occurred.

Considerable diversity of chromospheric activity was apparent as from one sunspot to another and as between collective groups of one epoch of the year and another. Several surges of chromospheric activity occurred, but generally speaking these active epochs were offset by longer periods when nothing special was observable even though a dozen groups of spots might be present. The average level of chromospheric activity during the disk passage of the big sunspots in January and February was not unusual, but as already stated there were three outstanding associated flares.

The examination has been completed, as far as present data will allow, of the contribution of flare-active sunspots to the general statistical relationships between sunspots of various area groupings and geomagnetic storms. The results are included in a paper published in "Monthly Notices (Geophysical Supplement)".

A useful liason concerning related solar and radio phenomena has continued between the Solar Department and several radio research centres.

Results recently published by the Radio Group of the Cavendish Laboratory, Cambridge have shown a remarkable correlation between solar flares and sudden phase anomalies recorded on very long radio wave reception (G.B.R. Rugby), the correlation extending down even to the minor flares. It was therefore decided to install a recording equipment (on the Cavendish Laboratory model) that would provide, in effect, throughout daylight hours a continuous record of the occurrence of flares and their approximate intensity, independent of the direct observations with the spectrohelioscope. A recording unit, constructed in the Time Department, was tested at Abinger in March and at Herstmonceux in April, and will shortly be installed in the Solar Department for regular use.

Since May 31, the Joint Radio Propagation Bureau (Admiralty) has undertaken the distribution by telephone of data from Greenwich, concerning the appearance of sunspots greater than 500 millionths of the Sun's hemisphere and of flares of major importance, to eight of the fourteen radio and other research centres in this country requiring the information. This service rendered by J.R.P.B. not only expedites the present distribution of data from Greenwich but will be of increased value when the Solar Department moves to Herstmonceux.

For the months of 1948 July and 1949 February, the Royal Observatory was requested by the Superintendent, Radio Research Station, Slough to co-operate in trial forecasts of ionospheric disturbance by obtaining as much information as possible on solar activity from day to day. Observations of solar flares made at Greenwich and Edinburgh, the Solar Physics Observatory, Cambridge, and the private observatory of Mr. Sellers at Muswell Hill were combined at Greenwich and reported by telephone to Slough. In addition, the respective Directors of the observatories of Canberra, Kodaikanal, Meudon and Wellington kindly collaborated. Unfortunately, there was a paucity of distinctive solar phenomena in July, but February provided better data to assist the forecasts.

The Brentwood radio station of Cable and Wireless Limited continues to report to the Royal Observatory any short-wave radio fade-out while it is in progress. Other ionospheric data are sent regularly to Greenwich by the Superintendent, Radio Research Station, Slough, and the Engineer in Chief, Radio Branch G.P.O. Records of bursts of solar radiation observable on radio wave-lengths (solar "noise") are sent by the Superintendent, Army Operational Research Group. Times of sudden phase anomalies recorded in the reception of very long waves (G.B.R. Rugby) are communicated by the Cavendish Laboratory, Cambridge.

Solar Eclipse, 1948 November 1. Dr. Atkinson and Mr. Pope went to Mombasa to observe the solar eclipse of November 1. The purpose of the observations was to obtain a timed cinema record of the rapid swing round in position angle of the narrow crescent of the Sun when nearly totally eclipsed. For this purpose a station a little outside the path of totality was required. A grant towards the expenses of the expedition was received from the Joint Permanent Eclipse Committee.

Two 35-mm. cinema cameras, of an obsolete R.A.F. pattern, were borrowed from the Admiralty Research Laboratory for use at the eclipse. Each was mounted on an iron bench some five feet long, with its own lens removed and a small telescope lens of about 40 inches focal length substituted. In front of the lens was placed an unsilvered glass prism whose front face was used as a mirror of low reflecting power; one or two green filters were also placed immediately in front of the camera. Under these conditions, with the lens stopped down to about f/24 and the shutter set at about 1/1000 sec., well-exposed pictures of the un-eclipsed sun were obtained, using panchromatic film, which showed a surprising amount of detail of small sun-spots. The solar image is about 1 cm. in diameter and, as had been anticipated. this is large enough to reveal atmospheric turbulence at the limb. The cameras run at speeds up to 24 frames/sec., and a contact was fitted on each so that the instant of shutter-opening could be directly recorded on a chronograph. The cameras were further modified so that on pressing a lever a small lamp was focussed on the corner of the film, for one or two exposures, at the same time that a contact was made which could be recorded on the chronograph; this appeared necessary as a method of identifying particular frames, and correlating them with the chronograph record of exposure-instants. The chronographs themselves were made in the Abinger workshops, together with the pen-circuit amplifiers, and they did in fact recover fast enough to give a clearly measurable trace at 24 contacts per second.

Four 50-foot collapsible radio-masts, which were overhauled and repaired at Abinger, carried the aerials for the reception of the time-signals, and formed the largest single item of the apparatus transported from England. Petrol driven generators and batteries were overhauled and tested at Abinger, where the whole of the equipment was packed in a specially prepared naval radio container for shipment. The two observers went out and back by air.

The cameras were not suitable for operation on their side; as the apparent motion of the Sun during the eclipse was almost vertical, while the long direction of the frame aperture was horizontal, it was decided to point the cameras downwards at a slope of 45°, and in such an azimuth that the reflected direction of motion would be horizontal. Coral block piers were constructed in nearly the right azimuth, with an angle-iron insertion to take the iron bench, in such a way that a small adjustment in elevation was possible so as to take out the last few minutes of azimuth-error.

Special time signals were sent out during the eclipse from Abinger via the Rugby radio station, with the co-operation of the Post Office.

The Resident Naval Officer at Mombasa was very helpful; in addition to providing labour and mechanical assistance, he allowed two of his staff to act as assistants during the observations. This made it possible to run two stations instead of one, which was very advantageous because the weather conditions at that time of year were not favourable and there was a considerable prospect of local cloud. The two cameras and chronographs were accordingly sited at two stations several miles apart.

At the second station, where the Greenwich time-signals could not be received, a contact-chronometer was used, which was compared with another at the main station both before and after. The actual weather conditions were in fact fine at both stations, between rain-storms. One film is of excellent quality, and the other is probably measurable but is appreciably out of focus, owing apparently to some last-minute error of setting. A micrometer has been specially adapted for measuring the position-angles of the three thousand crescent-images obtained on each film, but pressure of other work and shortage of staff have delayed measurement. It is thought that the data will be more than sufficient to appraise the usefulness of the method; this was the purpose of the expedition, and if the method is in fact as accurate as is hoped, there will be a strong case for a series of stations along the eclipse tracks of 1951 (Dakar, Gold Coast, East Africa) and 1952 (Gold Coast, Soudan, Arabia, Persia). The former eclipse is annular, and is thus slightly more favourable for this purpose than the latter one; in both cases, it would be hoped to obtain a direct geometric linkage between the survey-systems of the various areas. The accuracy obtainable will be limited, almost certainly, by ignorance about lunar limb-detail far more than by any other factor; there would be a case for a small number of large-scale photographs, taken during the eclipse, to show the limb-structure at the exact libration involved.

Time Service. Astronomical observations for the determination of time have been made throughout the year at Abinger using the Bamberg transit, and at Greenwich using Transit B. The number of observers has been limited in order to ensure that each is adequately represented in the results obtained over any period of a few weeks. Whenever possible two groups of observations are taken at each station on the same evening, which are separately reduced. At Abinger, a total of 320 observations were secured on 174 nights. At Greenwich, both observers had to discontinue observing in 1948 April for medical reasons; several temporary observers used the small transit instrument B during the summer, but their observations were not used for the determination of clock performance. By September, conditions had improved and, since October, the Greenwich small transit results have been used again. Of the total of 143 observations on 106 nights, 91 observations secured on 67 nights were used in the operation of the time service.

Up to the installation of phase-integrating rotary beat counters at Greenwich and Abinger in 1947, the only clocks for which satisfactory results could be obtained were those controlling phonic motors through the limited number of divider chains; intercomparisons of the remaining clocks were effected by impulse beat counters which were subject to frequent mechanical failure. The new counters have made continuous long-term intercomparison of all crystals possible, and the number of quartz clocks which can be considered for the operation of the time service has thus increased from eight to twenty-four. For a period, nearly thirty were available, but on June 21st the Post Office Group IV at Dollis Hill was taken out of service for major overhaul, leaving only the five ring-type crystals in operation. Not all

of the available crystals have a performance which is sufficiently good to justify their inclusion, and several can be ruled out on inspection. Nevertheless the increase in the amount of usable data has involved a corresponding increase in the computing work. Various experiments have been made in lay-out and presentation to ensure that the maximum of information about the clocks should be displayed in a convenient form with the minimum of delay.

Attention has also been given to the problem of developing improved methods in the prediction of clock corrections for the control of time signals. The observations for time determination have steadily become more numerous, and possibly more accurate, than those obtained during the war years, while the performance of the best clocks has shown a slight, but definite, deterioration; it is evident that the limit to the accuracy of the time service provided is still set not only by the scatter of the time-observations but also by the quality of the clocks available.

It had been anticipated that the quartz clocks would prove of such long-term stability that it would be necessary to remove the effect of polar variation from the time-observations in order to assess the clock performance adequately. This is done as a matter of principle but while the comparison of finally adopted time between Washington and Greenwich is thereby materially improved none of the quartz clocks available to the time service is capable of clearly showing the effect as an apparent deviation from uniformity of run and prediction is not appreciably facilitated by the correction. Instead of predicting clock corrections from long runs, it has been found better to take a shorter term view of the clock performance, giving much more weight to the recent observations. A long-term linear and parabolic ephemeris is still cleared from the results, for each clock selected as suitable; but after that, attention is focused on the last fifty observations only, and these are fitted to a linear ephemeris by least squares. It is this linear ephemeris which is used for prediction; it is re-computed as soon as five new observations are available, the oldest five being then dropped. The influence of the quadratic term actually used in the first ephemeris is thus slight, and the second stage can be put on a pure routine basis; in difficult cases, however, the highest grade of personal judgment has still to be relied on, and the long-term behaviour must be specially reviewed. The indications from the selected clocks are then co-ordinated to obtain the best estimate of clock correction. Since the adoption of this procedure, the number of occasions on which it has been necessary to introduce a "jump" into the signal has been much reduced.

A new service for the benefit of those departments and establishments which maintain accurate frequency standards is the systematic estimation of absolute frequency. A monthly circular giving the estimated frequencies has been prepared and distributed since 1948 April, and a similar weekly service was instituted in 1948 June. The information has proved useful to the recipients, in spite of some uncertainty in the estimate of frequency from the current observations. The definitive reception times of the radio time signals are of necessity published three or four months in arrear, which is too late to be of much use to those who wish to know the current performance of their frequency standards.

A preliminary study of the frequency estimation service over the comparatively short period since its introduction shows that the monthly estimate, made from ten to fourteen days after the end of the month treated, has been within ±1 part in a hundred million for 81% of the period and within $\pm\frac{1}{2}$ part in a hundred million for 70% of the period. Comparable figures for the weekly estimate were:- within one part, 53%; within half part, 23%. The maximum error has never reached two parts in a hundred million. These assessments of errors in the estimates are based on the

clock error curves used in the preparation of the bulletin of reception times, and this at once raises the question of the possibility of further modifying these curves. Examination of the charts shows that in general the adopted curves could not suffer an adjustment of more than 5 milliseconds at any point without failing to be in agreement with the observations, but there are occasions when a strong suspicion has been aroused that the observations over some four or six weeks have systematically differed from the general run over several months before and after. In such cases, unless the observations are smoothed very drastically, there is no alternative but to draw a curve showing an identical local deviation on all clocks. If the deviations are attributed to a cause which affects the observations in a systematic manner for some weeks and they are ignored in drawing a smooth clock-curve, the adjustment to the adopted line might amount to 20 milliseconds. The rates or frequencies defined by the finally adopted curves would be but little affected by such adjustments, provided that the curves remained fairly smooth; it would be very hard to justify any change as large as one half part in a hundred million in the frequencies defined from the adopted curves. This process of defining an absolute frequency estimate assumes that the period of the earth's rotation has remained constant over the period of several months for which the curves are drawn, an assumption which may not be strictly correct.

With the increase in routine computing, a welcome expansion in office space has resulted from the acquisition in February of the library at "Feldemore" for long-term computing work.

The routine reception and measurement of radio time-signals has been continued, some fifteen different signals being normally measured each day. All intercomparisons of clocks, and between clocks and radio time signals, have been made with the decimal counter chronometers. The standards of accuracy in measurement have been maintained, and, in the case of the GBR long-wave radio time-signals still further improved.

The Droitwich carrier frequency is measured daily at 10.30, and the corrections published in the monthly Time Service Circulars. Since the beat comparator is used not only for these measures, but also for routine intercomparisons between the standards, a duplicate instrument has been constructed and installed in accordance with the policy of providing a reserve for each instrument used in the regular operation of the service.

The service of time signals controlled from the Observatory has been maintained unchanged, except that from May 24 to 29 inclusive, while GBR was out of action for servicing, the long-wave time-signals were radiated from GBZ. The new phonic motors for the control of the time signals have been tested and one is in part operation. The driving amplifiers have been completed and work is in progress on other related equipment. A proposal is under consideration for the radiation from Rugby of mean-time signals in addition to the present rhythmic signals. Provision has been made on the phonic motors for the control of mean-time signals.

The 2 megacycle standard frequency transmission from Abinger has been continued and is proving of increasing value to other departments and establishments and to commercial firms. Owing to delays in concluding arrangements for the loan of a higher power transmitter and for the erection of an improved aerial system the original transmitter is still in use. The ancillary equipment, constructed within the Observatory, and originally intended for use only during a limited experimental period, has stood up well to daily use for some three and a half years; the whole equipment now requires complete rebuilding and it is hoped at the same time to make some modifications as a result of the experience gained.

Throughout the year the clocks C3 and D3 have been the only Abinger clocks used for long-term predictions. Each had one failure of temperature control during the year, D3 on May 10 and C3 on November 3. The clocks C1 and D1 have at times run uniformly for a few months and have been plotted for short periods. The E group was disturbed in June when the temperature control units were replaced by new units employing two thyratrons in parallel, to reduce the risk of faults caused by thyratron failure. This brings them into line with the equipment at Greenwich. None of the oscillators in this group has yet settled to a steady run. The B group has shown promise of improvement, but has not yet proved sufficiently steady to warrant plotting. In particular, the violent changes previously noted in B3, which had originally operated at Edinburgh as A1, appear to have ceased, and it is hoped that this oscillator will return to the excellent performance which it gave at Edinburgh. In spite of these slight improvements, the Abinger clocks remain inferior in quality to those at Greenwich and Dollis Hill; the Post Office Radio Branch has recently been approached with a view to further action being taken on this matter.

At Greenwich, the clocks A1 and F1 have continued to give the best performance as long-period standards, chiefly because they seem less affected by mains disturbances. There was a complete mains failure at Greenwich on January 1 which affected all the clocks; these two showed a rapid recovery, and were not seriously impaired as long-period standards. Of the remaining clocks, F2, which has always been subject to large erratic changes of frequency, developed a fault in the maintaining amplifier and has been removed for inspection. The frequency of A3 continues to increase very rapidly, a characteristic which has been attributed to an unduly protracted ageing process.

The clocks in service at Dollis Hill have been the five ring-crystal oscillators, groups 5 and 9. Of these, 9A and 5B have proved, like A1 and F1, to have a long-term superiority due to a smaller susceptibility to disturbance. 5C and 9C have given good results between the occasions of disturbance, July 20 and March 5. 9B suffers from a leak in the crystal holder, and has always been liable to large erratic changes, comparable with those formerly experienced on B3. The quartz clock B at the National Physical Laboratory has suffered several serious disturbances during the year and is not yet considered worth plotting. Comparing the clocks at the various stations, it appears that the Greenwich and Dollis Hill clocks are giving a similar standard of performance, while the Abinger clocks are of decidedly lower standard. Omitting the violently erratic F2 and 9B, the best Abinger clocks are comparable with the worst remaining clocks at the other two stations.

Reference was made in last year's report to tests carried out at Rugby and Abinger to determine the order of magnitude of the errors which may arise in monitoring the short-wave time signals at Abinger. As only simple equipment was used, and the duration of the trials was very severely restricted, the data obtained are somewhat limited. For the sample signals examined, reception at Abinger was not subject to effects arising from an abnormally long travel time, and there was no indication of day-to-day anomalies, though without much more extended tests it would be unwise to conclude that such anomalies may not occur. Under normal conditions the differential lag on long and short waves appears to be small, and more elaborate equipment would be required to determine the actual difference with precision. The results already obtained afford some justification for publishing the times of reception of the British short-wave time signals to three decimal places of a second instead of two places as hitherto, thus bringing them into line with the times published for other radio time signals. The published figures will be applicable to the majority of receptions though there is a risk that anomalous travel path may cause appreciable error in the measurements of occasional signals.

As the result of a suggestion by Mr. Ratcliffe of the Cavendish Laboratory, a programme has been arranged in co-operation with the U.S. Naval Observatory for the determination of the velocity of propagation of very long radio waves across the Atlantic. Conflicting results have been derived from the measurements, of limited accuracy, which have been made in the past. Using precise methods it is hoped to determine the relative times of arrival of the radio signals at each station with an accuracy of the order of a few tenths of a millisecond. An accurate determination of the speed of travel is not only of value in time service and longitude work, but it should also make it possible to discriminate between various theoretical assumptions on the mechanism of propagation. Measurements over a period of six weeks should provide an accurate determination of the velocity, but it is planned to extend the measurements over twelve months in order to decide whether the velocity has the same value under varying ionospheric conditions. By the co-operation of the Director of U.S. Naval Communications, the Navy transmitter at Annapolis, NSS, will transmit time signals on a frequency of 18 kc/s within five minutes of the normal times of transmission of the British radio time signals from Rugby, GBR, on a frequency of 16 kc/s. One of the standard long-wave receivers, which has been slightly modified for the purpose, will be used at Abinger for the reception of the signals. A new frame aerial is at present under construction and will be used for the routine receptions of the Rugby signals, thus setting free the rotatable frame for the special measurements. The signals will be recorded by photographing a cathode ray oscilloscope trace with a 35 mm. film camera. The cathode ray and and timing equipment is now under construction in the laboratory and a camera based on modifications of a standard REB4 unit is being made in the Workshop. For processing the film, modifications are being made to the automatic developing equipment and a film drier has been constructed. A continuous check will be maintained on the performance of the radio and measuring equipment, using the test oscillator at present employed for calibration of the long-wave receivers; it produces pulses similar in shape to those emitted by the Rugby transmitter, and the lag of the receiver can be measured. To ensure that the equipment used on both sides of the Atlantic will be identical in all significant respects, full details of all the equipment designed at Abinger have been forwarded to the U.S. Naval Observatory, and also to the Department of Engineering of the Pennsylvania State College, where additional records will be obtained.

Work has been resumed on the preparation of copy for the volumes of 'Greenwich Observations' from 1937 onwards. The copy for the period 1937-1940 is nearing completion.

IV. MAGNETIC OBSERVATIONS

Regular magnetic observations have been continued at Abinger throughout the year. Absolute measurements of horizontal intensity with the Schuster-Smith magnetometer, of vertical intensity with the Dye magnetometer, and of declination have been made every week-day, while measurements of inclination have been made frequently with an earth-inductor.

Variations of declination and of vertical and horizontal intensity are recorded photographically in slow-run and quick-run instruments, the base-lines of which have continued to be very constant. The Observatory is indebted to the Director of the National Physical Laboratory for the checking of the electrical standards of the Schuster-Smith and Dye magnetometers.

During the year two La Cour instruments, a "Q.H.M." and "B.M.Z." for the measurement of horizontal and vertical intensity respectively were purchased from the Danish Meteorological Institute.

A great deal of the computational work of the department is suitable for the use of punched-card machines and it is proposed to use these machines when they have been installed at Herstmonceux.

Special containers for storing the Abinger magnetograms have been ordered from the Stationery Office and should be ready soon.

The preparation of the copy for publication is in a satisfactory state, all of 1947 and much of 1948 having been completed. A start has been made in the publication of back numbers of the Greenwich Magnetic and Meteorological Observations. The 1938 copy is at present being vari-typed.

Mean annual values of the magnetic elements at Abinger for the years 1945-48, with an estimated value for 1949, are given below.

Year	Declination (West)	Horizontal Intensity	Vertical Intensity	Inclination
	° ′			° ′
1945	9 59.5	0.18573	0.43207	66 44.3
1946	9 51.1	0.18569	0.43235	66 45.4
1947	9 43.1	0.18577	0.43246	66 45.2
1948	9 35.4	0.18593	0.43255	66 44.4
1949	9 27.6	0.18596	0.43285	66 45.0

During the past twelve months there have been 18 disturbances of "storm" intensity, four of these being "great storms". The lower limit for a storm is a range of 150γ in horizontal intensity or 30′ in declination, 300γ or 60′ for a "great storm".

The weekly report of mean hourly values of declination is sent regularly to several offices, while weekly (and in one case daily) reports of C and K indices are sent to a number of centres engaged in geophysical and radio research. A monthly list of C and K figures is sent to Dr. Veldkamp at the De Bilt Observatory, Holland, representing the Association of Terrestrial Magnetism and Electricity of the International Union for Geodesy and Geophysics. Together with the C and K figures are sent details of "sudden commencements" and "crochets" appearing in the Abinger magnetograms, and any supporting ionospheric or solar evidence.

In connection with the projected removal of the Abinger magnetic station to an area free from rail disturbance, a survey was carried out in November in three regions in the Hartland area of North Devon to test their suitability as a site for a magnetic observatory. For these tests, the Q.H.M. was used for the measurement of horizontal intensity and, as the B.M.Z. had not then been received, a similar instrument was kindly lent by the Meteorological Office for the measurement of vertical intensity. These conveniently portable instruments gave results of high accuracy and proved to be well adapted for such a survey. While the sites proved fairly satisfactory magnetically, two of the sites were unsatisfactory in other respects. A search is being made for alternative sites which will be tested before a final decision on the future site for the Magnetic Observatory is made.

V. METEOROLOGICAL OBSERVATIONS

Registration of atmospheric pressure, air temperature, evaporation, pressure and velocity of the wind, and the amounts of rainfall, sunshine, and cloudiness at night have been maintained continuously, with estimates of visibility. Measurement of air-pollution, using Owens automatic filters, has been continued.

The tabulation of meteorological results for 1948 is complete, and the preparation of copy for press well advanced.

The mean temperature for the year was 50°.9 which is 1°.2 higher than the average for 100 years 1841-1940. All months except March and the three summer months June, July, August had temperatures above average, April being 4°.9 higher than the average. The highest shade-temperature was 91°.4, registered on July 28. Temperatures exceeding 80° were recorded in the Stevenson Screen on 9 days, while on 3 days during July (28, 29 and 30) the temperature exceeded 90°. The temperature of 84° on April 16 was the highest April temperature ever recorded in the Greenwich series of observations. The "open-screen" temperature of the revolving stand reached almost 95° on July 28. Lowest temperature was 22°.1, on December 26. Temperatures of 32° and below were recorded on 39 days, more or less evenly distributed over the winter months.

The mean daily horizontal movement of the air was 251 miles, slightly below the average for the 50 years 1867-1916. The greatest daily movement was 710 miles on April 4, the least daily movement 13 miles on October 30. The maximum wind pressure was 34.0 lbs. to the square foot on October 18.

The recorded duration of bright sunshine was 1416.9 hours, 31.6 per cent of the total theoretically possible. The three summer months June, July and August had noticeably small amounts of sunshine. There were 59 entirely sunless days. On 49 occasions the night sky camera gave a completely unbroken trace of δ Ursae Minoris. The number of nights on which no trace of this star appeared was 56, with a further 51 in which not more than 10 per cent of the amount possible was recorded.

The total rainfall during the twelve months was 20.270 inches, which is some 4 inches less than the average for 100 years 1841-1940. There were 139 days on which rainfall exceeding 0.005 inches was recorded. The wettest month was August, with a total of 4.061 inches, and the driest March, with 0.757 inches.

VI. CHRONOMETERS

The work of the Chronometer Depot was continued at Bradford-on-Avon until September 1948. The removal by road of some 20 tons of chronometers, watches and equipment was commenced on September 13 and continued until September 17, by which date the most valuable items had all been transferred to Herstmonceux. Consignments of office furniture and stores were forwarded by rail on ensuing days, and the requisitioned premises at Bradford-on-Avon were vacated and handed over to the Civil Engineer in Chief's department for derequisitioning on September 30. For about a month during the period of removal and settling in, issues of chronometers and watches were discontinued, emergency requirements being transferred to the Home Chart depots for action. All arrears of issues were cleared by the end of November.

The number of Admiralty chronometers and watches on charge to the Royal Observatory, exclusive of those undergoing repair, is 21,402. Of this total,

232 chronometers (Patt. H.S.1), 193 chronometer watches (Patt. H.S.2. and H.S.6.), 153 deck watches (Patt. H.S.3.), 20 dashboard watches (Patt. H.S.4.) and 251 wrist chronographs (Patt. H.S.9.) are rating or ready for issue. There are 3 Patt. H.S.1, 27 Patt. H.S.2, 7 Patt. H.S.3, 8 Patt. H.S.4 and 213 Patt. H.S.9 undergoing repair in the repair shop. The remainder, consisting of 562 Patt. H.S.1, 3,557 Patt. H.S.2 and H.S.6, 7,320 Patt. H.S.3, 1,449 Patt. H.S.4, 1,782 Patt. H.S.5, 780 Patt. H.S.7, 2,200 Patt. H.S.8, 2,196 Patt. H.S.9 and 429 other assorted types are held in store awaiting adjustment, rating or repair. Chronometers and watches in use at the Royal Observatory number twenty. The stock of watches 6B/60 held on behalf of the Air Ministry totals 265, of which 50 are rating and 215 await repair. In addition, there are 249 chronometers and watches deposited with the Depot for various reasons.

During the year a total of 5,715 chronometers and watches was received and 5,328 issued. These issues include the following items:-

(a) 55 chronometers and 10 deck watches were supplied to the Trade to assist with the equipping of Merchant Ships.

(b) The transfer to the Governments of India and Pakistan of 23 chronometers and watches belonging to those Governments and held at the Observatory since return from British and Allied ships.

(c) The sale of 81 chronometers and 116 chronometer watches mentioned in last years's report as obsolete and available for disposal.

The total number of chronometers and watches repaired and adjusted was 1,978, including 26 for the Air Ministry and 1 for the Pakistan Government. Of this total 2 chronometers, 2 chronometer watches and 1,194 other watches were dealt with in the chronometer workshop, where it is still necessary to concentrate mainly on the navigational wrist chronographs for the Naval Air Arm.

The scheme for watchmaker apprentices, mentioned in last year's report, has been approved and three apprentices have been authorized. The staff of the workshop has been augmented by the engagement of four journeyman watchmakers and one watchmaker apprentice. It is hoped to fill the remaining vacancies in the current year although lack of houses makes it difficult to attract competent men for the senior posts.

The clockwork drive of the slow-run La Cour magnetograph has been remade and returned to Abinger where it has now been functioning satisfactorily for some months. As the clock movements are constructed entirely of non-magnetic material, they are subject to very rapid wear, and to counter this troublesome feature it was decided to introduce a small amount of steel in the form of bushes and pivots. This should reduce the frequency of servicing without unduly affecting the magnetograph records. A similar clock belonging to the Air Ministry has also been thoroughly overhauled and the department has been asked to consider undertaking the maintenance of other clocks of the same type on behalf of the Ministry.

The Dent regulator used as standard in the Plymouth Chart and Chronometer Depot was taken down and overhauled whilst the Depot was being redecorated in December 1948.

Arrangements have been completed for the testing of Air Ministry navigational wrist watches at the Royal Observatory and for their subsequent distribution and maintenance by this department. The new watches, which are expected to arrive from

Switzerland at an early date, are adjusted to the Swiss "with mention" standard. They are in special watertight cases and have anti-magnetic screening which will enable them to remain unaffected by field strengths up to 150 oersteds.

During the year the work of the department has been seriously hampered by uncertainty regarding its removal to Herstmonceux, shortage of staff, and occupation of temporary accommodation pending completion of the rebuilding of the rating and store rooms below the Great Library in Herstmonceux Castle. Even the most urgent routine testing and maintenance work was kept going only at the expense of abnormally long hours by non-overtime staff, and by sacrifice of leave. It is hoped in due course to begin work of a research nature, particularly in connection with the lubrication of watch movements for extreme temperatures, a subject on which more information is needed.

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.

The Office is still seriously handicapped by staff shortages, especially on the senior and intermediate levels. Progress is, however, at last being made and it is hoped that most of the staffing difficulties will be overcome during next year. As a first step, Dr. J. G. Porter has been selected as a Principal Scientific Officer to fill what has essentially been a vacancy since 1941. Dr. Porter's wide knowledge of astronomy and his experience of astronomical computing will be of immediate service to the Office; he is expected to take up his appointment in August.

The Nautical Almanac. The Almanac for 1950 was published in March, there still being abnormal delays in printing and binding.

The first part of the "Nautical Almanac" for 1952, containing the fundamental ephemerides of the Sun, Moon and planets, has been distributed to at least one Observatory in each country. As a consequence of a request from Commission 13 of the International Astronomical Union, the positions of the Sun and Moon at the times of eclipses have been communicated to the U.S. Nautical Almanac Office up to 1955; accurate paths of total solar eclipses will in the future be made available about eight years in advance.

Apart from the inclusion of an astrometric ephemeris for Pluto from 1950, no change has been made in the contents or presentation of the Almanac. It is still not possible to give a firm date for the publication of the separate supplement.

Occultations. Besselian elements for 2675 stars of magnitude 7.5 or brighter occulted during 1951 were received from the Office of the "American Ephemeris". These stars were examined by means of the occultation machine and preliminary times and position angles recorded for 84 stations for 1394 stars, the other 1281 being discarded as not observable under suitable conditions. After computation a further 102 stars were rejected and the elements of the remaining 1292 stars will be published in the "Nautical Almanac" for 1951. The predictions for 1951 have been completed; they number 11,986.

For 1952 Besselian elements have been received for 2950 stars, and about one quarter have so far been examined on the machine.

The duplicate reductions of observations of occultations for 1944 and 1945 have been completed. The discussion for these two years has also been completed and will be published shortly in the "Astronomical Journal". The duplicate reductions for 1946 are nearing completion.

For 1945, 1946, 1947, 1948 and 1949 the numbers of observations received since the last report were 43, 83, 307, 458 and 35 respectively.

Abridged Nautical Almanac and Air Almanac. The "Abridged Nautical Almanac" for 1949 was published in June. The edition for 1950 has been delayed in the later stages of publication but it is expected to appear in May. Composition for 1951 is well advanced.

During the year, the three parts of the "Air Almanac" for 1949 have been published and the first part for 1950 should be available at the beginning of May.

No change has been made in the contents or presentation of these almanacs but a completely revised "Abridged Nautical Almanac" is being introduced from 1952. Throughout the year detailed discussions have taken place with representatives of all users of the Almanac, with the result that the original proposals submitted to the Admiralty have been subject to revision in detail, though the principal features have been accepted by the great majority of users. Every effort has been made, by lectures, articles in nautical publications, and other means, to ensure that the principles of the Greenwich Hour Angle method are fully understood and that all users have had an opportunity to express their views on the change. A full description of the new almanac, with specimen pages, illustrative examples of its use and list of contents has been published in "Admiralty Notice to Mariners" No.308 of 1949 February 8. The decision to defer the introduction of the new form until 1952 has been generally welcomed by the Merchant Navy.

Star Almanac for Land Surveyors. Agreement has been reached on the general content and lay-out of the special almanac for topographical surveyors, as proposed by the Office; approval has been given for the separate publication and for the Office to undertake its preparation. It has been decided to introduce the almanac for 1951 and the final details are now being discussed in the light of comments from users, to whom a full description with specimen pages had previously been circulated.

Apparent Places of Fundamental Stars. The volume for 1949 was not published until September, the delay having occurred in the final printing stages. For 1950, all the printed sheets have already been received and read, so that publication should take place during May.

For 1950, the Office was responsible for 216 stars of the original allocation of the Office of the "Connaissance des Temps"; otherwise the computations were supplied by the Offices to which they were originally allocated.

At the Zürich meeting of the International Astronomical Union, it was agreed by Commission 4 (Ephemerides) that the Office should make arrangements with the Institute for Theoretical Astronomy in Leningrad for sharing the computation from 1951 onwards for the 426 ten-day stars previously the responsibility of the Office of the "Connaissance des Temps". The Office has accordingly taken over permanently the computation for the 216 stars with right ascensions between 0^h and 12^h, for which star constants were available, and the Institute for Theoretical Astronomy has agreed, at rather short notice, to undertake the computation for the 210 stars with right ascensions between 12^h and 24^h.

Copies of the mean places for 1951 and 1952 have been distributed to the several Offices responsible for the computation of the apparent places.

General Navigational Work. In addition to the redesign of the "Abridged Nautical Almanac" very considerable work has been done in the field of astronomical navigation both at sea and in the air. As a result of the comprehensive survey of almanacs and reduction tables detailed proposals have been submitted to the Admiralty for the preparation of altitude-azimuth tables for surface navigation.

The Office has always lacked practical experience of navigational techniques, as well as first-hand knowledge of the dependence of accuracy of observation upon conditions, instruments, experience and other factors. The opportunity has therefore been taken of sending Mr. G. A. Harding on a three-months' cruise to the Mediterranean on board the surveying ship H.M.S. DALRYMPLE. Although it is realized that the conditions on a surveying ship are far from representative, Mr. Harding's reports and observations so far received contain much of interest, showing above all the influence of experience on accuracy of observation. He is due to return in May.

In air navigation, the Office has been primarily concerned during the year with the design of methods and tables for astronomical navigation in polar regions, and with associated problems. In conjunction with the Air Ministry, the present methods are kept continuously under review in the light of requirements and the numerous ideas, methods, almanacs and tables which are constantly being introduced throughout the world. The Superintendent lectured to the R.C.A.F. Specialist Navigation Course on its visit to the Empire Air Navigation School in March. Various special requirements have also been met.

The Office continues to be responsible for the computational work necessary for the latticing of Admiralty Charts for use with the Decca system of navigation. During the year the few remaining charts required for the English chain were completed, while many hundred special observations were reduced. Some computations have also been done for the Danish chain, in close co-operation with the Danish Hydrographic Department, which is latticing Danish charts for most of the area covered by the chain; five British charts covering other areas have been completed, but other British charts will not be latticed until the Danish programme is complete. The Superintendent visited Copenhagen in June in connection with the arrangements for interchange of computations.

Two new chains - the South-Western and the North-Western - are being set up in Great Britain and it is planned that they should be operational early next year. As the Office has so far not received any additional staff for any of this work of Decca lattices, no work on the new chains is at present possible.

Proof-reading. During the year 2352 pages of first proofs and 2523 pages of stereo proofs or machine sheets, depending on whether the publication is printed from stereo plates or movable type, have been read. The first proofs have in almost all cases been read in duplicate.

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

Other Publications. Photographic reprints of "Interpolation and Allied Tables" and the "Five-figure Logarithm Tables" (originally produced on behalf of Admiralty

Computing Service for the Optical Industry) have been issued during the year. Mr. W. A. Scott has prepared an elementary description of the computation of Decca lattices for issue as a Hydrographic Department Technical Publication.

Distribution of Reprints. Since the war no general distribution has been made of the papers, articles, reviews etc. contributed by members of the Office staff. A comprehensive distribution list has now been drawn up and an appropriate selection of the sixteen available reprints is ready for despatch; most of these are of navigational interest, while others are astronomical and some purely computational.

Machines. Approval has now been given for the installation of complete punched-card equipment in the Office; adequate provision for its housing has been made at Herstmonceux. During the last few months agreement has been reached with the British Tabulating Machine Company Ltd. on the detailed specification of most of the equipment and it is hoped that this will all be in operation within the next year.

Detailed discussions are still in progress regarding the design of the card-operated automatic typewriter, on the lines of the successful instrument at the U.S. Naval Observatory, to be used for the preparation of copy for subsequent photo-lithographic reproduction. In this connection two problems appear to require further research: the design of suitable figures for the typewriter, bearing in mind the subsequent photography and lithographic reproduction, and improvements in the standard and uniformity of this reproduction process. Considerable interest has been expressed by different organizations in these problems and it is hoped that a concerted effort will be made to provide adequate solutions.

The punched-card machines will be used in the first place for the routine computational work of the Office; they will be particularly useful for the large-scale programmes of additional work on the altitude-azimuth tables and the Decca lattices. They will gradually be extended to less routine work, including suitable computations and analysis from other Departments of the Observatory. In due course it is hoped to produce copy automatically for some of the Office publications - particularly the volume of "Apparent Places of Fundamental Stars".

VIII. PUBLICATIONS

Production of the Volumes of Greenwich Observations is now under way. H.M. Stationery Office are completing the Volume for 1937 in letter press and that for 1938 is under production at the Royal Observatory by the vari-typer process. Both will be issued in 1949. All subsequent Volumes will be prepared by vari-typer at the Royal Observatory, and it is hoped to produce at least two a year, in order to reduce at a consistent rate the arrears caused by war-time cessation and aggravated by post-war printing restriction.

The following other publications have appeared during the year:-

H. Spencer Jones. Astronomy through the Eighteenth Century, Phil. Mag. Commen. No. July 1948, p.10.

The Positions of the Magnetic Poles, Polar Record, Nos.35-6, December 1948, p.148.

The Age of the Universe, Proc. Roy. Inst., **34.** 70.

Time and Frequency Standards, J. Inst. Nav., **2.** 1.

R. d'E. Atkinson. A proposed Mirror Transit Circle, M.N. **107**, 291.

D. H. Sadler. The Provision for Astronomical Navigation at Sea, J.Inst. Nav. **1**, 290.

Tables for Astronomical Polar Navigation, **2**. 9.

Computing Methods, J. Inst. Actuar. Stud. Soc. **8**, 65.

Astronomical Computation in Japan, Observatory, **68**. 105.

H. W. P. Richards and D. H. Sadler. The Application of the National Accounting Machine to the Calculation of the Apparent Places of Stars, M.N. **108**. 154.

A. E. Carter and D. H. Sadler. The Application of the National Accounting Machine to the Solution of First-order Differential Equations, Q. Journ. Mech and App. Maths., **1**. 433,

H. W. Newton. Solar Flare Occurrence and Development - Phase of Sunspots, Observatory, **68**. 29.

Observational Aspects of the Sunspot-Geomagnetic Storm Relationships, M.N. (Geoph. Supp.) **5**. 321.

H. W. Newton and W. Jackson. Notes on the Sunspots of 1949 January and February and the Geomagnetic Storm and Aurora of January 24-26, Observatory, **69**. 1949.

H. Barton and H. W. Newton. A brilliant Solar Flare, Observatory, **68**, 191.

F. M. McBain. Discussion of Occultations Observed in 1943, A.J. **53**. 163.

V. Barocas and R. M. J. Withers. Effect of Atmospheric Variations on a Stellar Beam, Observatory **68**. 153.

Royal Observatory. Mean Areas and Heliographic Latitudes of Sunspots in the years 1939, 1940, 1941, 1942, M.N. **107**. 468; **108**. 177, 420, 505.

IX. PERSONAL ESTABLISHMENT

During the year the long awaited reorganization of the Royal Observatory staff was at last authorized, although in a number of cases matters of detail are still to be settled. The Astronomer Royal is now graded as a Chief Scientific Officer, the Chief Assistants (including the Superintendent of the Nautical Almanac Office) are Senior Principal Scientific Officers (with the possibility that on first appointment the junior Chief Assistant might be in a lower grade), and the Heads of Departments are Principal Scientific Officers (again with the possibility of a lower grade in individual cases). There is provision for six Senior Scientific Officers or Scientific Officers, eight Senior Experimental Officers, twenty-seven Experimental Officers or Assistant Experimental Officers and thirty-nine Scientific Assistants. At the moment one Chief Assistantship and one Principal Scientific Officer post are vacant and the candidate for another Principal Scientific Officer vacancy has been selected but not yet appointed; the Senior Experimental Officer grade is temporarily overfilled with a corresponding underbearing in the Senior Scientific Officer and Scientific Officer grades. There are considerable numbers of vacancies in the junior grades but a number of these should be filled shortly as a result of interviews which have already been held.

Authority was also received during the year for the temporary bearing of a trained Librarian and the post was filled on 1949 February 3 by the appointment of Mr. W. P. Preston. It is understood that the appointment will in any case cover the full period of the reorganization caused by moving the library to Herstmonceux and that the situation will thereafter be reviewed.

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

(a) Royal Observatory.

Chief Assistant (Senior Principal Scientific Officer)	- R. d'E. Atkinson, M.A., Ph.D.
Principal Scientific Officers	- R. T. Cullen, A. Hunter, Ph.D, H. W. Newton, D. S. Perfect, Ph.D., H. M. Smith, B.Sc., A.M.I.E.E., F.Inst.P.
Senior Scientific Officers	- H. F. Finch, B.Sc., W. Jackson, M.A.
Temporary Senior Scientific Officer	- G. B. Wellgate.
Senior Experimental Officers	- H. W. Acton, H. H. J. Barton, E. A. Chamberlain, F. Jeffries, E. G. Martin, G. W. Rickett, L. S. T. Symms.
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, G. F. Wells.
Temporary Experimental Officer	- V. Barocas, Ph.D., A.Inst.P.
Head of Chronometer Repair Shop	- D. W. Evans.
Assistant (Temporary)	- Miss C. J. A. Penny.
Assistant Experimental Officers	- A. M. Allen, L. J. Bates, J. D. Pope, B.Sc., R. H. Tucker.
Junior Assistant, Lower Grade	- Miss C. E. Chapman.
Clerical Officer	- Miss C. Ryall.
Assistants (Scientific)	- Miss B. G. Collett, A. V. C. Cross, H. G. Gill, Miss F. E. A. Jeffries, Miss E. M. Moore.
Assistants (Scientific) Temporary	- J. D. Ellenger, B. J. Harris, P. Hogan, E. N. Jackman, B.Sc., Miss M. J. Lawrence, Miss P. M. Morris, Miss R. O. Pavey, Miss J. I. Peters, N. S. C. Rhodes, D. C. Smith.

(b) Nautical Almanac Office.

Superintendent (Senior Principal Scientific Officer)	- D. H. Sadler, M.A.
Principal Scientific Officer	- Miss F. M. McBain, M.A.
Senior Experimental Officers	- A. J. Daniels, S. G. Daniels, H. W. P. Richards, B.Sc., W. A. Scott, B.Sc.,

Experimental Officers	- A. E. Carter, W. G. Grimwood, G. A. Harding, Miss M. R. Rodgers, E. Smith.
Clerical Officer	- Miss Y. I. Reddy.
Assistant Experimental Officer	- Miss D. M. Fooks.
Assistants (Scientific)	- K. A. Miller, Miss I. M. Restorick.
Assistants (Scientific) Temporary	- A. Beck, M. P. Candy, J. D. W. Cox, Miss E. J. M. Grove, Miss M. R. Hawkes.
Temporary Clerks	- Mrs. E. F. M. Freeman, W. A. Hulme.

(c) Secretariat.

Secretary and Cashier	- H. G. Barker.
Higher Clerical Officer	- J. H. Whale.
Clerical Officers	- Miss J. E. Perry, Miss H. Pettican.
Librarian	- W. P. Preston.
Clerical Assistants	- Miss B. E. Carey, Mrs. L. E. Nicholls.
Established Shorthand Typist	- Miss B. A. Martin.
Established Vari-typer Operator	- Miss V. D. Strong.
Established Typists	- Miss V. A. Bennett, Miss V. L. Wells.
Temporary Shorthand Typist	- Miss R. J. Harrison.
Temporary Clerks	- F. A. Everest, Miss J. A. Morris.
Hostel Wardens	- Mrs. D. I. Hewitt, Mrs. E. Ramsay.
Assistant Hostel Warden	- Miss S. C. Chapman.

Mr. P. J. Melotte, Principal Scientific Officer, retired on October 31 after 53 years 2 months unbroken service. This is only 6 months less than the record service of Mr. Witchell, who retired last year.

Dr. D. S. Perfect, Principal Scientific Officer, hitherto on loan from the Department of Scientific and Industrial Research, has been transferred permanently to the Royal Greenwich Observatory.

The following were appointed to the staff during the year:- Mr. W. P. Preston, Librarian, Mr. A. M. Allen, Assistant Experimental Officer, Mr. J. D. Ellenger, Mr. E. N. Jackman and Miss M. R. Hawkes, Scientific Assistants (Temporary), Miss B. E. Carey, Clerical Assistant, Miss V. D. Strong, Established Typist as Vari-typer Operator, Miss V. L. Wells, Established Typist, Miss R. J. Harrison, Temporary Shorthand typist and Miss J. A. Morris, Temporary Clerk. Mrs. E. Ramsay, Mrs. D. I. Hewitt, Hostel Wardens and Miss S. C. Chapman, Assistant Hostel Warden were transferred to the Royal Observatory for administration and pay purposes.

The industrial staff employed at Greenwich, Herstmonceux and Abinger total 71. They include Hostel staff, which although not chargeable to the Observatory Vote, nevertheless are permanently attached to the Establishment for administration and pay.

The various grades are as follows:- One Foreman of Observatory, six laboratory mechanics, seven watch adjusters and repairers, one mechanic, three boiler attendants, one storehouse assistant, four drivers, one head gardener, four gardeners, three messengers, four nightwatchmen, two skilled labourers, six labourers, one packer, one caretaker, one watchmaker apprentice, eight part-time cleaners, two switchboard operators and fifteen Hostel domestic staff.

X. ISAAC NEWTON OBSERVATORY

Dr. C. R. Burch, who retired from the Board of Management on December 31, was renominated by the Council of the Royal Society to serve for a further period of four years.

Dr. E. Finlay Freundlich was nominated by the Royal Astronomical Society to succeed Dr. A. O. Rankine, who retired on December 31.

The Board of Management held one meeting during the year, when a preliminary report by Dr. Linfoot and Mr. Wynne on alternative optical designs, including Ross-Schmidt systems and Schmidt-Cassegrain systems, was discussed. Some consideration was also given to the problems of the mechanical design, particularly in conjunction with a memorandum prepared by Mr. B. N. Wallis on the flexure of telescope tubes.

As further progress in the consideration of the general design of the telescope is not possible until a decision can be made on the optical design, and as Mr. Wynne was engaged on some further computations in connexion with Ross-Schmidt systems, further meetings of the Board were postponed until these computations had been completed. Mr. Wynne's report was received while the Astronomer Royal was in the United States. It is hoped to arrange for a meeting of the Board in the near future for the discussion of alternate optical designs.

In the course of a visit to the United States for the Ministry of Supply, Dr. Uttley of the Telecommunications Research Establishment visited, on behalf of the Board of Management, the Mount Wilson, Mount Palomar, Lick, McDonald, McMath-Hulbert, and the Harvard Observatories to investigate problems of atmospheric seeing in relation to the question of photo-electric guiding, methods of telescope control, problems of mechanical design, and various optical questions. Dr. Uttley collected much useful information and brought back many drawings and photographs of various telescopes. His report (T.R.E. Memorandum Ref. N/A/8) has been circulated to members of the Board and of its Committees and will be of great value in the further consideration of all questions of design.

The Astronomer Royal took the opportunity, when visiting the principal observatories in the United States during the months of February, March, and April at the invitation of American astronomers, to discuss many matters connected with the design of the Isaac Newton Telescope and to study the design and performance of the various large telescopes. While in America, he was informed by Judge Hulbert, President of the Trustees of the McGregor Fund, that the Trustees had unanimously decided to make an outright gift to the Royal Greenwich Observatory, for use in the Isaac Newton Telescope, of a 98-inch glass disk in their possession, together with a

26½-inch disk for a secondary mirror, and the central plug from the large disk. The large disk, of pyrex glass, was cast in 1936 by the Corning Glass Company and was purchased by the McGregor Trustees for use in a large telescope for the Michigan Observatory, a project which was subsequently abandoned. The Astronomer Royal gratefully accepted this generous gift and, before leaving America, made arrangements with the British Joint Services Mission (Navy Staff) for the transport of the disks to England.

XI. GENERAL

Consequent upon the removal, now in progress, of the Royal Observatory from Greenwich to Herstmonceux, the title by which the Observatory should in future be known was considered. Because of the long association of the Royal Observatory with Greenwich since the year 1675, the adoption by international agreement of the Greenwich meridian as the zero of longitude, and the world wide use of a system of time zones based on that meridian, it was desired to retain the connexion with Greenwich in the new title. The King's pleasure has been taken as to a suitable new title and His Majesty's approval of the designation

THE ROYAL GREENWICH OBSERVATORY, HERSTMONCEUX

has been duly signified.

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

Dr. J. Jackson, H.M. Astronomer at the Cape.
Dr. W. H. van den Bos, Union Astronomer, Johannesburg.
Dr. R. v. d. R. Woolley, Commonwealth Astronomer, and Dr. C. W. Allen, of the Commonwealth Observatory, Mount Stromlo.
Dr. D. F. Martyn of the Australian Council of Scientific and Industrial Research.
Mr. Rayner, Chief Geophysicist, Australia.
Father O'Connell, Director of the Riverview College Observatory, Sydney.
Dr. C. S. Beals, Dominion Astronomer, Ottawa.
Professor S. A. Mitchell, late Director, Leander McCormick Observatory, Charlottesville, Va.
Dr. G. M. Clemence, U.S. Naval Observatory, Washington.
Miss Margaret Harwood, Director of the Maria Mitchell Observatory, Nantucket, Mass.
Dr. C. A. Federer, Harvard College Observatory and Editor of "Sky and Telescope".
M. Guyot, Director, and MM. Berger and Nardin, of the Neuchâtel Observatory.
Father Galdón, Director of the del Ebro Observatory, Tortosa.
Captain Fernandez de la Puente, Deputy Director of the Marine Observatory, San Fernando.
Captain Benito and Commander Cardona, Signals Department, Spanish Navy.
M. Verbaandert of the Uccle Observatory.
Professor Righini, Florence.
M. Michel de Coulon, Grenchen.
Dr. R. Tomaschek and Shakir Bey from Egypt.
Commander Gianelli, Argentine Naval Commission.
Mr. Ekanayaka, Ceylon.
Dr. Papapanos from Greece.
Dr. Chakrabarty, Director of the Alibag Magnetic Observatory, Bombay.

Mr. Runcorn of the Physics Department, Manchester University, visited Abinger Magnetic Observatory for the calibration of magnetic variometers used for measuring

in mine shafts the variation of horizontal intensity with depth beneath the surface; members of the Ordnance Survey visited the station for the testing of Wingfield tubular compasses; Lieut. Commander Penfold visited it for the testing of tubular compasses to be used in the Antarctic.

Miss Chou, Professor in the Sun Yat Sen University Observatory, Canton, worked in the Observatory, principally the Solar Department, for the greater part of the year, studying the details of the work and the methods of measurement and reduction of photographs.

The Astronomer Royal, President of the Union, Dr. R. d'E. Atkinson, Mr. D. H. Sadler, Mr. H. M. Smith, Dr. A. Hunter, Miss F. M. McBain, and Mr. R. T. Cullen attended the seventh General Assembly of the International Astronomical Union, held in Zürich in August. This first post-war meeting of the Union, which was well attended, provided an opportunity for meeting astronomers from all parts of the world and for the discussion of problems relating to the various fields of work in which the Observatory is interested. Various decisions reached at the meeting will have important bearings on the future work of the Observatory.

The Astronomer Royal also attended the General Assembly of the International Union of Geodesy and Geophysics, held in Oslo immediately following the meeting of the International Astronomical Union. Some of the resolutions adopted by the Association of Terrestrial Magnetism and Atmospheric Electricity are of importance for the magnetic work of the Observatory.

In October the Astronomer Royal attended the celebrations in Cracow of the 75th anniversary of the Polish Academy of Sciences, as the representative of the Royal Society, and subsequently visited all the astronomical observatories in Poland and gave a number of lectures under the auspices of the British Council.

In December the Astronomer Royal attended the third session of the General Conference of the United Nations Educational Scientific and Cultural Organisation, held in Beirut, as the British Scientific Delegate.

The Astronomer Royal spent the months of February, March, and April in the United States, during the course of which most of the American observatories were visited and the programmes of work, techniques of observation, and instrumental equipment were studied. He delivered a number of lectures and technical seminars, including the Penrose Memorial Lecture at the annual meeting of the American Philosophical Society, Philadelphia; the Arthur Lecture at the Smithsonian Institution, Washington; and the public lecture at the annual meeting of the National Academy of Sciences, Washington.

Mr. H. M. Smith attended the conference of the Société Chronométrique de France in Paris in April, and presented a paper on Radio Time Signals.

The regrading of the staff of the Royal Observatory on a scientific basis, which has been the subject of protracted discussions for nearly four years, has at last been accomplished. The new gradings correspond to those adopted throughout the Scientific Civil Service, and particulars are given under the section of Personal Establishment. Details of the terms of assimilation of individual members of the staff into the new grades remain to be discussed as well as some questions about complements. The Royal Observatory, the oldest scientific establishment in Great Britain and the one which is best known throughout the rest of the world, has thus

at last received official recognition as a scientific establishment; for when the Carpenter gradings were introduced after the first world war, they were not applied to the Observatory staff. The Royal Observatory will now no longer be under a serious disadvantage relative to other scientific establishments in the recruitment of properly qualified staff. The shortage of trained astronomers, resulting from the discontinuance of astronomical studies at the Universities during the recent war, is causing serious difficulties in filling vacancies, particularly in the senior grades; there seems no prospect of any appreciable improvement in this respect during the next few years.

The appointment of a qualified Librarian to the staff will make it possible for the heavy arrears of library work to be attended to, and for the problems incidental to moving the library from Greenwich to Herstmonceux to be dealt with. Binding is heavily in arrears, tracts and excerpts require to be sorted and arranged according to subjects; new shelf, subject, and author catalogues will be needed. The reorganization of the library will provide opportunity for books that have no further value to be discarded and for obvious gaps to be filled.

The rate of progress of the removal of the Observatory to Herstmonceux has been disappointingly slow. At the current rate of expenditure some fifteen years would have been required for the completion of the removal. But in the course of the debate on the adjournment in the House of Commons on March 25, the Civil Lord of the Admiralty announced that the end of 1953 had now been set as a target date by which the removal would be completed and that he was "endeavouring to take steps which will at least speed up the completion of the project and which may even bring it forward earlier than the target date". Beginning with the next financial year, a much accelerated rate of new construction is therefore to be expected. At the moment, however, it is the shortage of housing for the staff in the Herstmonceux area, rather than the slow rate of constructional work, which is holding up the move. The transfer of the Magnetic and Meteorological Department has been postponed on this account, while that of the Nautical Almanac Office has been considerably delayed; the Office is now scheduled to move to Herstmonceux early in October, though accommodation for it in the temporary hutments has been ready for some months. The Astronomer Royal, the Secretariat, and the Chronometer Department have moved to Herstmonceux during the year; a portion of the Solar Department has moved since the end of the report year.

The new site for the Observatory was deliberately chosen to be in a somewhat isolated area. The housing shortage is consequently particularly acute and is already proving to be a serious deterrent to applications for vacancies on the staff, particularly those in the senior grades. The special allocation of houses, through the Hailsham Rural District Council, from the Ministry of Health, will be of help in alleviating the housing difficulties, more particularly in the early stages of the move and for the junior staff. But the only way in which a satisfactory permanent solution can be found will be by the building of a number of official houses, outside any schemes of the local Council, It is hoped that there may be a favourable decision on this important question.

H. SPENCER JONES,
Astronomer Royal.

ROYAL GREENWICH OBSERVATORY,
HERSTMONCEUX.
1949 May 23.