REPORT

OF THE

ASTRONOMER ROYAL

TO THE

BOARD OF VISITORS

OF THE

ROYAL GREENWICH OBSERVATORY

Read at the Annual Visitation of the Royal Observatory, 1948 June 5.

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CONTENTS

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Read at the Annual Visitation of the Royal Observatory, 1948 June 5.

The Report here presented refers to the period from 1947 May 1 to 1948 April 30 and exhibits the state of the Observatory on the last named day.

I. GROUNDS AND BUILDINGS.

(a) Greenwich. War damage repairs to the Altazimuth Building (now serving as a Small Transit Pavilion) have been completed, and a new roof has been placed over the Upper Record Room. Boundary fences of the main and Christie enclosures have been repaired. The old Upper Computing Room has been made into a Control Room for the six quartz clocks; it has been provided with a new ceiling and re-decorated, as has the old Wireless Room. The Anemometer huts and Ball Turret on the roof of the Wren Building, and the Porter's Lodge, have been re-painted, and some external painting has been done, where urgently necessary, on the Yapp dome, R.T.C. pavilion, Vinery, and Stevenson screens. There is still a good deal of glass to be replaced in the Main Building, particularly in the West Library, where the books are suffering from dirt and damp, and some structural damage has yet to be repaired. Glass is also required for the Octagon Room, and blast damage is still outstanding there and elsewhere. The 28-inch and 26-inch domes, both of which are now empty and neither of which is probably suitable for transfer to Herstmonceux, are in a bad state of repair and very unsightly; pending a final decision on their fate, no work on them has been undertaken.

(b) Abinger. A new sliding shutter has been fitted to the roof of the Bamberg transit hut. A number of dangerous trees in the immediate vicinity of the buildings or bordering on public footpaths have been felled. The lavatory facilities have been extended, and minor works of repair and maintenance carried out. Fluorescent lighting has been installed throughout the offices, laboratories, workshop and control room.

Admiralty approval has been given for acquiring the tenancy of a private house in the district for use as offices, stores, hostel and canteen, and to provide accommodation for some married staff.

(c) Herstmonceux. Conversion work in the Castle and huts is proceeding, and it is expected that "Stage I" of the move will take place in August, except for the Solar Department, which will follow after a few months more. Some of the huts are already in use as a hostel for Dockyard and other workmen, canteen staff, etc., and the remainder are nearly ready for furnishing. The chronometer workshop in one of the huts is well advanced, and the Astronomer Royal's residence in the Castle is

approaching completion. The Nautical Almanac quarters, in the brick huts, still require a fair amount of work, but it is expected that they will be ready in time. Work on the chronometer rating rooms, in the Castle, has had to be postponed, because of alterations required in the Great Hall, immediately above them; the Hall is to serve as the Observatory Library, and it will be necessary to reconstruct the floor with steel supports before it can sustain the weight of books involved. A gallery is to be built along one side of the Great Hall, to carry additional book-stacks. As an interim measure for Stage I, some rooms on the upper floor are being converted into temporary chronometer rating rooms. The road from the West Lodge to the Castle and the huts has been repaired and coated with tarmac.

A start has also been made with the Solar Building; the access road to it is partly constructed, and the foundations of the building itself have been laid. The Newbegin dome will be erected on this building, and will house the Newbegin refractor, with the 4″ Photoheliograph attached to it. The telescope itself will be used for occultations, and also for instruction of junior staff, demonstrations, and miscellaneous tasks. The building, which was designed in the Observatory, provides also for both the Greenwich and Newbegin spectroheliosopes, and for the $3\frac{1}{2}$-prism Littrow spectrograph. It contains a darkroom, a small workshop, and an office and workroom arranged to accommodate a measuring machine. The main office work of the Department will be carried on in the Castle, but provision is made for work in the new building also, so that time spent in waiting for clear skies on doubtful days need not be wasted. It is planned to mount a Shortt master pendulum on the main pier; although this will not be thermostatically controlled, it will serve to carry the time between radio signals, and it will in fact be the nearest approach to a precision standard at Herstmonceux for some years.

It is proposed to construct a cellar just outside the building on the east side. This is intended for a spectroheliograph employing large glass prisms and a spectrograph with large liquid prisms; both of these require steady temperature conditions.

A general outline of the proposals for buildings to follow Stage I was submitted at the end of October, so that full estimates of the total cost of the move could be prepared. This work has taken some time, and no further appropriation, beyond the unexpended balance of what had already been voted for Stage I, was made in the Estimates for 1948-49. The difficulties which may result are discussed in Section XI.

II. INSTRUMENTS, APPARATUS AND LIBRARY.

During his visit to Australia, the Astronomer Royal made enquiries as to the possibility of obtaining the Transit Circle of the Melbourne Observatory, which has been inactive, for use as a second instrument at Greenwich. Such an instrument will be needed, largely for differential work, when the Airy Transit Circle is finally retired. Following on these enquiries, the Government of Victoria generously offered to present the instrument to the Royal Observatory outright, and this offer was gratefully accepted. The instrument is of 8-inches aperture, though with smaller collimators, and is reversible. It has an impersonal micrometer, to which a motor drive can readily be fitted. The whole instrument, together with elaborately-numbered and indexed photographs, has been safely received at Greenwich, and is at present stored there. It will be erected at Herstmonceux before the Greenwich R.T.C. is moved.

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

The Cookson floating zenith telescope, from the Cambridge Observatory.

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

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

A 16-inch coelostat and spectroscope slit from the Royal Astronomical Society.

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

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

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

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

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

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

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

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

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

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

To the Royal Observatory, Cape of Good Hope:-

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

To the Imperial College of Science and Technology:-

6-inch equatorial, Simms No.2.

To the Meteorological Office:-

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

To the 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.

Harrison's Time Machines Nos. 1 and 3 are still at the Chronometer Depot at Bradford-on-Avon, where they will undergo necessary repairs as soon as pressure of other work permits.

Large Refractors

During the autumn, the 28-inch and 26-inch telescopes were dismounted by a joint team comprising a group from the Observatory workshop, under the direction of the Foreman, and a group from Chatham dockyard. The cost was very considerably less than the estimate obtained from a private firm. Several constructional details of the 28-inch mounting (the old Merz 13-inch mounting) proved to be quite unknown, and a high degree of skill and care on the part of those engaged was demanded, and shown. The north pier, a single 5½-ton casting 22 feet high, which must be a unique specimen, was successfully run out through a breach in the dome wall, down a ramp and on to a lorry. The entire telescope (except for the lens and some minor parts) was transported by road to Herstmonceux, and is now in store in one of the brick huts. The drive is to be altered to a synchronous motor drive and the necessary parts have been sent to Sir Howard Grubb, Parsons and Co., for the purpose. The 26-inch telescope was dismantled by the same team; it had already been decided to insert roller bearings in both axes of this instrument, and consultations had taken place with a representative of Sir Howard Grubb, Parsons and Co., on the subject. It was agreed that it would be advisable to send almost the whole telescope to Newcastle, as the necessary changes are extensive. This has now been done, and the details of the work are being prepared there.

The objectives of both these telescopes are at Greenwich; the 26-inch objective was recently examined and appeared to be in good condition after the various journeys it has made.

Newbegin Refractor

The Newbegin telescope is about to be brought from Herstmonceux and provisionally erected in the Central Store, so that the best method of attaching the photoheliograph can be fully studied. When the dome is ready, the telescope will be finally erected at Herstmonceux, and it should then be possible to detach the photoheliograph from its present mounting, many parts of which are almost worn out, and to re-mount it on the Newbegin telescope with practically no interruption in its work. The Cooke sidereal clock, also part of the Newbegin gift, will also be brought to Greenwich for conversion to mean solar time; it will be used to provide approximate seconds-signals for the Solar Building.

Bamberg Transit

The Bamberg broken transit, which had been very thoroughly reconditioned in the Observatory workshop, was installed at Abinger in July. The pivots had been chromium-plated and then lapped by hand with extensive Mikrotast measurements. Their final figure departed from the circular by a very few hundredths of a micron only. The actual operational figure, including the effects of oil and all errors of reading, is such that a whole night's levels frequently fall well within an overall range of a second of arc, and so far as can be judged by appearance the chromium is standing up well to wear. The final scatter of a night's observations is about two thirds of that previously obtained with Small Transit D.

Small Transits

Small Transit D itself had meanwhile deteriorated; it was withdrawn from use in January, since it could no longer make a sufficient contribution to justify the labour involved. Transit C is at present being modified at Greenwich to replace it; the pivots have been plated and figured, the new illumination-system has been installed, and a weight-relieving gear is being added. Transit B, which is at present in use at Greenwich with stainless steel pivots, is continuing to give good service, but all these non-broken instruments suffer from the drawback that the striding-level must continually be removed and replaced, with a risk of affecting its zero, and with the serious disadvantage that the level can only be placed on the pivot in certain positions, so that unequal wear results. A scheme for hanging the level by long invar rods, so that it can stay permanently in place, is under consideration, and some work has also been done on an optical levelling method involving a mirror mounted on a reversible pendulum as a standard vertical plane.

Quartz Clocks

The six quartz crystals, groups A and F, were installed at Greenwich early in the summer of 1947 and have steadied down so satisfactorily that they are already among the best in the Observatory. (This is no doubt partly due to the fact that they had previously been run for extended periods in the Post Office laboratories). However, the heat developed by their driving and auxiliary circuits is such that the apparatus is running dangerously near the temperature at which breakdown may be expected. Arrangements are being made to ventilate the cubicles to a variable extent, so as to permit control at a lower temperature. The temperature is also seriously dependent, at present, on the mains voltage, and a voltage-regulator is to be installed.

Control Room

At Abinger, the new control room has been completed sufficiently to bring it into full operation. The work has taken three years, and though a considerable number of unforeseen changes in requirements have occurred since it was first planned it seems well adapted to present needs, and the general work of signal-reception and clock-comparison has been greatly facilitated. The experience gained will be of great value in planning the arrangements at Herstmoncuex.

The new signal-transmitting motors have been received from Messrs. Muirhead, but much experimental and constructional work will have to be completed before they can be installed. As other more urgent work, such as modifications to the crystal thermostat control circuits, still remains to be completed, it is unlikely that the motors will be brought into use before the end of this year. Trouble has been experienced recently with the moving-coil chronographs. They have given long and valuable service, but the stock of replacement coils has been exhausted and no new source of supply has been found. The moving-coil units have accordingly been replaced with modified and rewound polarized relays, which have a very light moving unit. They are giving a performance which compares favourably with that previously obtained.

A contract has been placed for the supply of two Belin chronographs similar to those used at the Bureau International de l'Heure. These chronographs are specially designed for the recording of mean-time and rhythmic time-signals, and should meet the long-felt need for a permanent record to supplement the precision measurements made possible with the decimal counter chronometers. A R201 triple diversity receiver

has been made available on loan by the War Office in order to investigate its suitability for the reception of distant radio time-signals. The tests are delayed, however, pending completion of negotiations for the erection of suitable aerials.

Further experiments on reception of long-wave time-signals have been carried out and, as a result, a new prototype receiver has been installed and compared with the previous model. From the experience gained, and as a result of further experimental work in the electronics laboratory, a new design has been prepared and four receivers are now under construction. Two will be used at Abinger, and two at Greenwich in replacement of the Admiralty pattern long-wave receiver now temporarily employed.

The old control room has now been completely cleared of equipment with the exception of the pendulum clocks, and will be used to house the quartz clock obtained from the Physikalische Technische Reichsanstalt. An examination of this clock and of its short-term performance has been completed at the Post Office Radio Branch Laboratories, and is summarised in Radio Branch Report 1610. It is hoped to set the clock in operation at Abinger, together with new divider equipment and the original German phonic motor, and to determine its stability over long periods.

Photographic Zenith Tube

Much further experimental work has been carried out for this instrument. In several cases the employment by the makers, in trial work, of gears and materials that were unsuitable had in fact the valuable result of drawing attention to difficulties that might also arise, to a much smaller but perhaps still significant extent, with first-class equipment. As a consequence it now seems likely that the differential roller will be preceded by a fairly high-quality screw, and will in itself give a speed-reduction considerably smaller than had been contemplated. The carriage will probably not run on mechanical flats but will be suspended, and the azimuth will be determinable without traversing the carriage over a longer (and thus less-worn) range than that of normal operation. If the trials along these lines prove successful, all precision parts of the movement will be controlled entirely by elastic links, with no parts subject to mechanical wear. Present indications are that the scatter in positional accuracy in the relevant directions will be only a very few tenths of a micron at most. It is hoped that these tests will be completed shortly, so that the final stages of construction can be proceeded with.

The electrical method of studying the stability of level of a mercury surface, which was mentioned in the last Report, has been developed and tested. Two stainless steel disks are mounted close above the mercury, and the two condensers so formed are placed in two arms of a bridge circuit. The sensitivity is limited by the fact that with small gaps the voltage must be kept low, or else the mercury surface is seriously distorted by electrostatic attraction. With increased circuit-stability and lower voltages the method appears promising, but further study has been held up by staff losses. In the course of this work, an opportunity arose of testing out the method by which it is proposed to level the stellar plate of the Zenith Tube; it was found to be satisfactory for the purpose. A description of the method has been published.

Some tests were made of the new Furt microphotometer developed by Messrs. Ferranti, to study its usefulness as a pure position-measuring instrument for stellar images etc. Direct visual methods were found to be slightly better for ideal test-objects, but it appears possible that if somewhat greater electrical stability can be attained the microphotometer might be superior, especially for photographic images and irregular objects generally.

Horizontal Transit Instrument

Work on this instrument has been postponed, for the most part, owing to pressure of other needs and loss of staff. Preliminary measurements have been made to test the method of determining the deviations of two types of optical square proposed for the instrument. A paper has been submitted for publication on the effect of atmospheric disturbances on apparent star-places; this investigation was undertaken in connection with the proposed motor-drive for this and other transit-instruments.

Mirror Transit-Circle

Progress has been made with the design of the proposed Mirror Transit-Circle mentioned in the last Report. A model has been constructed in which the usual counterpoise-weights are replaced by disk-shaped floats running in mercury troughs. The pivots are inverted, so that the axis lies below the Y's, and the instrument is floated up into the Y's by operating small plungers in auxiliary cylinders. The pivot-load can be very delicately controlled and very smoothly applied by this method, and in principle it can readily be reduced to zero every time the circle reading is to be changed; whether this is in fact desirable can probably be decided only in actual use, but it seems probable that a very low loading will be found practicable, and possible even that oil can be eliminated. It is proposed to use the pivot-testing telescope also as an azimuth reader. Word has been received from Dr. de Barros of Oporto, who visited the Observatory last year, that he is now proposing to construct a Mirror Transit Circle, and these proposals form at present the basis of his plans also. Close contact will be maintained on the subject.

Reversible Transit-Circle

A considerable amount of further study of this instrument has been undertaken. The end-thrust bearings of the axis were self-aligning ball-races whose total weight was considerable. Owing directly to their self-aligning construction, their weight wedged them downwards, so that they always bore on the end-faces of the axis mainly at the lowest parts. It was thought that the resulting couple, when the axis was rotated, might be responsible for the apparent change in pivot-errors, introduced by rotating in the opposite direction. Accordingly, the ball bearings were removed and plain fixed bronze end-bushes substituted. So far as tests have gone, there seems to be an improvement.

The continued discrepancies between different methods of pivot-testing, and the fact that in all of them the apparent elliptical term changed its phase (and often also its amplitude) when the testing apparatus was rotated or otherwise varied, prompted the introduction of a new method which should eliminate these defects. A plane mirror was kinematically mounted in a cell with three adjustable feet, and these were held firmly against the west end of the axis by a 50-lb pull applied from within the cube. The normal end-thrust on the axis had to be removed for this purpose, and the instrument was therefore held up to register against the east pier by an 8-lb weight pulling on a string. Tests have shown that the elliptical component which is now obtained is essentially unchanged by rotation of the cell, and it probably represents mainly a true variation in flexure of the axis; similar tests with the axis reversed will be needed for final confirmation. The amplitude of the component is about $\frac{1}{3}''$, which is considerably larger than any true ellipticity

of figure shown by the mikrotast results; the phase implies that the axis-flexure is greatest when the telescope is nearly vertical, and this does in fact appear the most probable situation in view of the structure of the cube. To a first approximation, the flexures of the two halves of the axis should be equal and in the same phase, and the effect on the telescope itself should be comparable with their difference. If this is either a maximum or a minimum at the zenith, it will be eliminated by reversal automatically, i.e. without need for a distinction between north and south stars. If this does not hold, neglect of axis-flexure will introduce instrumental terms of the $\Delta\alpha\delta$ type into the star-places, and it seems possible that this is in fact a major cause of such effects in some instruments.

Preliminary observations for runs with the microscopes of the west pier showed considerable evidence of screw-errors. A testing apparatus similar to that used at the Cape was accordingly constructed from surplus equipment, and although it suffered from some defects it did suffice to confirm the suspected trouble, and to determine its magnitude. It was found that there were real progressive screw-errors, some of them rather large; there was also an apparent periodic error, but this was shown to be of psychological origin, and not instrumental, though it probably does enter into the work as a real error. The setting of the micrometer-wires was influenced by the phase, at that point, of the "comb" which is used to identify the whole minutes, and the phase of the periodic error could be changed by moving the comb to a new position. Accordingly, the combs are being replaced by straight-edges, with a row of small holes well away from the edge to serve as identification-marks. The drills for boring these small holes had themselves first to be made in the workshop. The new arrangement has eliminated the apparent periodic errors; it may be remarked, however, that similar errors were found in the study of the Cape instrument. It is of course possible that the tester reveals exactly the effect which actually occurs in normal use, but it seems possible also that the effect may be different with the tester and the regular circle-divisions.

Airy Transit Circle

Observations of level and nadir had been giving trouble for some time; a stage was finally reached where the mercury-pool sometimes gave no image at all and sometimes two or even three. By covering different parts of the objective it was verified that different parts of the pool gave different images, sometimes well defined ones, and it has been found necessary to substitute a spare pool from the old altazimuth. Further study is planned, but it does appear advisable in all such instruments to have a mercury-pool which can be reversed, and to test it regularly by reversing it.

Yapp Reflector

The mirrors were aluminised in 1946 May, but the instrument remained inactive until November owing to delay and indifferent success in blooming the prisms and lenses of the spectrograph. In 1946 December the 36-inch mirror was given a light alcohol wash, and even at that early date was found to be in poor condition. It was however used until 1948 March, when further action became unavoidable. Several areas each a couple of inches across had by then lost all their coating, and the reflection coefficient of the remainder, after a fresh wash, was estimated to be about 30%. The mirror was therefore cleaned off as well as possible and silvered in

April. However, surface blemishes remained visible on the glass, and were still traceable after the silvering. It is not clear how much of this disappointing situation is due to poor aluminising and how much to the deposit of chemically-active dirt; moreover, it now appears possible that in so far as the actual aluminising may have been faulty, latent consequences of previous deposits may have been contributory factors, even though such blemishes were not noticed on the occasions of previous silverings. The Cassegrain mirror is still in good condition, and the difference between the two confirms, though in an exaggerated degree, what was already familiar from other pairs of aluminised mirrors, one facing up and one down, in the conditions which prevail at Greenwich. It has been decided that, inasmuch as the Observatory does not yet possess an aluminizing plant capable of handling the 36-inch disk, the expense and delay involved in aluminizing are not warranted so long as the telescope remains at Greenwich. Since the spectrograph is primarily an ulta-violet instrument, the effectiveness of the whole assembly will be very gravely reduced until it is moved to Herstmonceux, but there does not appear to be any way out of this difficulty. It emphasises the need for accelerating the whole move.

Some experience has now been gained with the 16-inch Metropolitan-Vickers evaporating plant which was installed at Greenwich during the year; satisfactory mirrors of chromium, aluminium, and gold have been made for test or actual use, and it is proposed to experiment with alloys, such as white gold. It is intended to obtain a 36-inch plant for Herstmonceux; in addition to its direct advantages for the Yapp, this will also provide useful experience when a plant for the Isaac Newton 100-inch has to be designed.

Astrographic Telescope

The Astrographic Telescope has been employed for experimental work on photoelectric guiding. The method has so far been applied to right ascension only, but both coordinates can readily be controlled. The results are still preliminary, but are being closely studied both from the point of view of transit-circle work and also from that of supplying the Isaac Newton telescope with fully automatic guiding which should be capable of correcting atmospheric effects several times a second.

Library

The annual examination of the Library is in progress. The appointment of a Librarian, which was approved by the Admiralty (as mentioned in last year's Report), has not yet been made, owing to the difficulty in deciding the rate of remuneration and to the fact that, as is becoming increasingly plain, the proposed scale and standing cannot in any case attract a person with the required scientific and educational qualifications. The condition of the library is highly unsatisfactory at present, as the existing staff cannot be spared for the necessary periods; but even if this were not so the Observatory definitely requires a Librarian with considerably more qualifications than can be expected from a Clerical Officer who has had a few weeks' course in librarianship. It is to be hoped that the position may be reconsidered at a suitable level. A start has at last been made in dealing with the heavy arrears of binding.

III ASTRONOMICAL AND RADIO OBSERVATIONS.

Airy Transit-Circle

Restricted observations have continued; during the year there were

114	observations	of	the	Sun
88	"	"	"	Moon
1	"	"	"	Mercury
12	"	"	"	Mars
4	"	"	"	Jupiter
8	"	"	"	Saturn
3	"	"	"	Uranus

together with 1230 transits and 939 zenith distances of stars in the clock and azimuth lists.

Shortage of staff and the continued investigations on the R.T.C. have delayed the final stages of work on the First Greenwich Catalogue for 1950. (1931-40). However, plottings of right ascension and declination have been completed for over 2000 stars between 0° and +24° declination, not contained in the Albany General Catalogue. Computations of the mean positions and corresponding epochs, for application to proper motion work, are in progress.

Reversible Transit-Circle

The list of stars to be observed with the Photographic Zenith Tube has been prepared. The provisional list was revised for photographic magnitudes by direct comparison with Franklin-Adams plates; the final list contains 255 stars, all within 15′ of +50° 52′ declination at present. Observation of these, together with a suitable belt of FK3 stars, will be begun with the R.T.C. as soon as the current pivot-studies can be terminated. The Naval Observatory, Washington, has generously undertaken also to observe these stars.

Yapp 36-inch Reflector

107 spectra of 53 stars of spectral types B to M have been photographed with the 3-prism train, and the aluminized mirrors, in the blue-violet region. Of these, 8 spectrograms were double exposures on bright late-type and faint early-type stars, taken to estimate the sensitivity of the method for detecting hot companions in late-type spectroscopic binary systems. The long spell of anticyclonic weather in the spring of 1948 was marked by relatively clear night skies but was accompanied by such poor seeing that photography with the slit spectrograph was usually tedious and sometimes impracticable.

Cape Zone Photographs

During the year 33 plates of the declination zone -56° to -60° have been measured and reduced, bringing the total to 64 of the 90 secured. In addition, all

23 plates of the series with longer exposures have been measured and reduced. Thus of the zone total (including long-exposure plates) of 113 plates, over three-quarters have been completed, covering the region between 15^h and 8^h. Standard coordinates are computed as far as 11^h. The remainder of the zone comprises a section of the Milky Way, where no long-exposure plates are needed to augment the number of stars per plate, but where the computation and measuring for any one plate are correspondingly heavier.

Approximate rectangular coordinates and image diameters of all stars measured between 16^h and 8^h have been forwarded to the Cape to facilitate identification of these stars on the plates taken there for deriving their photographic and photovisual magnitudes.

Time Service

The following observations for clock error have been obtained during the periods stated:-

Abinger, Small Transit D (to Jan. 20)	73
Abinger, Bamberg (from July 13)	188
Greenwich, Small Transit B (year)	270
Total	531

The large number of observations (especially at Greenwich) has been made possible only by having two duties on one night whenever practicable. This, together with the fact that very few observers were engaged (at Greenwich only two) has considerably steadied the personal equations, and a noticeable improvement in overall accuracy has resulted, in addition to improvements of instrumental origin. At the same time, the greatly increased number of fairly steady quartz clocks now available to the Observatory has made the drawing of reliable clock-error curves less difficult. Intercomparisons between the 12 clocks at Abinger, the 6 at Greenwich, and some others at the Post Office Radio Branch and the N.P.L., are made by differencing the times of reception of the GBR 1000 signals, and the most suitable crystals out of a total of nearly 30 can thus be readily identified and used for prediction and control of signals, and as primary standards.

Quite apart however from this direct contribution to the increased accuracy and reliability of the service, the use of clocks at four establishments possesses many other advantages. By a statistical analysis of the reception times of the GBR time-signals on clocks at each establishment, it is possible to estimate the magnitude of the signal erratics and errors of radio-reception. By applying the final published corrections derived for the GBR time-signals to a clock at an establishment which has not directly contributed to their assessment, an independent estimate of the uniformity of the adopted time-system may be deduced. A recent analysis of the results for 1946 has shown that the mean deviation of the 1000 GBR signals from a smooth curve was reduced during the year from 0.9 to 0.4 milliseconds. This is further reduced to 0.3 milliseconds if corrections are applied for known variations in the lag of the land-line from Abinger to the transmitter at Rugby. The mean absolute value of the error of radio-reception, measurement, and other local errors was reduced in the same period from 0.3 to 0.2 milliseconds. At the end of 1946, the corresponding radio-reception erratics for the Post Office Laboratories and the National Physical Laboratory were 0.3 and 0.2 milliseconds respectively. The values

of the erratics were also examined for a period at the end of 1947, and were found to be too small to be detected by the simple methods of analysis previously employed; they are estimated to be of the order of one-tenth of a millisecond.

The long-term accuracy of the best crystals is now sufficient to show up effects due to the earth's polar motion. If the earth's rate of rotation as a whole were constant, and if a perfect clock were available, polar motion would introduce spurious clock-error at any observatory that was not on the equator, since evidently all meridians must pivot about their mid-points when the poles move. As long as available clocks could not show this effect, it was immaterial whether the zero meridian was regarded as pivoting about Greenwich or about its mid-point on the equator, and in the former case (the actual one) the longitude of Greenwich itself could be permanently zero by definition. It has now become inexpedient to continue this convention; the mean longitude is still zero, but the actual value must be regarded as fluctuating. If an up-to-date knowledge of the polar movement were available, allowance for the displacement of the meridian would permit a more certain assessment of clock performance; the determination of changes in the quadratic term is much more difficult if these are overlaid by a smooth systematic variation which may exceed 20 milliseconds each way in the course of the year. The international latitude results are not available soon enough for this purpose; but the Washington results, obtained from the Photographic Zenith Tube, are reduced very promptly and are of high quality. For some considerable time now the results have been sent to Greenwich by air-mail as soon as each group has been reduced at the Naval Observatory. This welcome cooperation is of great value; the longitude of Washington (+77°) is sufficiently near 90° for this component to be practically sufficient by itself, and the corrections so obtained have been used for assessing frequency-drift since 1947 July. For the purpose of computing the final Greenwich Mean Time the effect of polar motion is re-introduced; the time is thus that of the actual (variable) meridian, and any arbitrariness in the adopted polar motion is almost completely eliminated. However, since many users of precision time-signals are more interested in their physical uniformity than in their astronomical significance, a column has been added to the published "Times of Reception" giving the polar correction explicitly. This procedure admittedly provides only an approximate correction for the effects of polar motion, but it is believed that the residual uncorrected effect is too small for any crystal to detect at present. If the polar motion could be computed in advance and included in the Almanac, it is probable that only the uniform time would be employed, and would of course be called Greenwich Mean Time; unfortunately, this is not the case, and the question of nomenclature is somewhat difficult.

The Bureau de l'Heure has now recommenced publication of the regular tables and graphs relating the time finally adopted at fourteen observatories to the mean of them all. The results for 1946, which have recently appeared, fully confirm the view that the final Greenwich times were very smooth and also very closely correct; the extreme range of Greenwich on the mean is from +15 to -37 milliseconds. These curves are not corrected for polar motion; using the results for the International Latitude Variation Service which have now become available for 1946, the corrections to be applied to the time determinations of each of the 14 observatories can be computed and allowed for. Only the Greenwich and Washington curves are smooth enough to be materially improved by this action; the curve "Greenwich minus Mean" becomes a steady linear drift from 0 to -20 milliseconds throughout the year, and the curve "Greenwich minus Washington" shows a steady value of +40 ms in the first quarter of 1946, followed by a drift from +40 to +10 ms in the second quarter and a steady value of +10 ms for the remaining six months. The Greenwich drift might in

principle be due to errors by the other 13 observatories, but this seems unlikely since the Washington drift on the mean is in the opposite direction; the Greenwich-Washington difference, and especially its change of 30 ms in three months, cannot be explained in this way, and appears considerably larger than any possible reception-lags. The importance of these comparisons will evidently increase as instrumental accuracy improves; meanwhile there can be no doubt that Greenwich and Washington show the smoothest curves at present, with Greenwich somewhat the better of the two.

Of the Abinger and Greenwich clocks, C3 and D3 (Abinger) and A1, A2 and F1 (Greenwich) are the best at present; C3 and D3 have in fact superseded the Post Office Group IV for long-term prediction, the latter having deteriorated. Group IV will be withdrawn shortly for modification, and it is fortunate that the Greenwich groups have settled down so rapidly. Up till February, the Greenwich-Abinger comparisons involved use of a land-line; since that date, the installation of decimal counters at Greenwich has made possible a direct use of GBR in addition.

Routine transmissions and receptions have continued. The long-wave and short-wave 1000 and 1800 transmissions are controlled from Abinger; the hourly signals to the Post Office and the "six-pips" to the B.B.C. are available from both stations. The six-pips service is also relayed to the Post Office for distribution to Service users. British long-wave and short-wave signals, and signals from America, France and Russia are received at Abinger and also, partially, at Greenwich. The WWV signals (seconds contacts superimposed on a standard frequency) which are transmitted continuously, are received at both stations, but have not yet been included in the "Times of Reception", mainly because they are received at variable times. A series of time comparisons with WWV made every few minutes over some hours indicates that the accuracy of measurement, including effects due to changes in the transmission-conditions, corresponds to a mean error of ±0.3 ms and there seems little doubt that the reception could be reduced to some standard time with sufficient accuracy.

In August it was decided to try transmitting the 1800 signal to Rugby on a direct current line, while keeping the 1000 signal on the voice-frequency channel hitherto used. Comparison showed that the lag of the D.C. line is smaller, and much more constant from day to day, than that of the V.F. channel; the maximum variation in five months was about 6 ms as against 12 ms for V.F. From 1948 January therefore, both transmissions have gone by the D.C. line; the short-period variations occurring in the ten minutes between test signal and signal proper are now about ±0.5 ms.

Since 1944 it has been the rule to limit deliberate changes in the rate of the signal to one millisecond per day, so as to cause the minimum inconvenience to users whose main concern was the interval (i.e. frequency) rather than the absolute time. If, as a result of reassessment of clock error, particularly after a period of poor observing weather or unpredictable changes in clock rate, it appeared that the signals were in error, readjustment of the time signals was made by jumps of 40 milliseconds (or multiples of 40 milliseconds) in preference to deliberate gross adjustments of rate. Such jumps, when required, were always introduced for the GBR 1000 signal on a Wednesday.

The limitation of jumps to 40 milliseconds has proved to be a serious handicap; it has meant in practice that signals have frequently been transmitted systematically in error over a period of some weeks. As from May 1, therefore, corrections will be applied as required, but only on Wednesdays, to the GBR radio time-signals in jumps of 20 milliseconds (or multiples of 20 milliseconds). At the same time, the deliberate adjustments in rate will be normally limited to 0.6 milliseconds per day.

The 2 Mc/s daily frequency transmission from Abinger, originally introduced to provide a convenient means of making frequency comparisons between the clocks used for the control of the time service, has proved to be of much wider interest. Details were therefore published in the technical press in November, and the facility is now in very general use. From October, an estimate of the transmitted frequency has been based on daily comparisons with the Abinger standards, which are combined numerically into a "mean crystal". Comparisons are effected by means of a frequency comparator of very high accuracy, which is a slightly modified version of a Post Office design. A special receiver for comparing the frequency of the Droitwich 200 kc/s transmission with any of the Abinger standards has also been designed and constructed. It incorporates a new type of synchronized oscillator, developed in the laboratory, which appears to be adaptable to a wide range of uses. A short report is being prepared for publication. From 1948 March 2, daily comparisons of the frequencies of C3 and D3 with that of the Droitwich 200 kc/s transmitter have been made and the results communicated to interested establishments. The whole question of the future programme of standard frequency transmissions in this country is now under consideration, and the Royal Observatory is co-operating with the other departments concerned in the formulation of definite proposals for a service which will also carry superimposed time signals.

As no detailed information was available on the interference which may be caused to radio-reception at Herstmonceux by the Pevensey radar station (not at present in operation) tests were carried out in the neighbourhood of the similar station at Bawdsey. Interference on frequencies used for radio time-signals was less than had been expected, and the tests showed that it would be possible to select suitable reception sites in an area behind and within two miles of the Bawdsey station. The results were not altogether conclusive, as owing to different aerial characteristics, transmitter power, and local conditions, the level of interference at Herstmonceux may be different from that at Bawdsey. A further series of tests is therefore planned when the Pevensey station is in full operation.

Tests have also been made on reception-conditions in the Rugby district; the proposed standard frequency service, as well as a possible reserve Time Station, may ultimately be established in this area, and it was desired to determine the degree of interference which might arise from the high power transmitters there. Tests were made at a site only two miles from the Post Office Radio Station, and in the direction of the British Broadcasting Corporation station at Droitwich. It was proved that reception of the normal range of foreign radio time signals could be obtained with complete freedom from significant interference. As a part of the same field programme, simultaneous film records of the GBR and Rugby short-wave time-signals applied to a cathode ray oscillograph were taken at the Rugby site and at Abinger, in order to obtain some indication of the variations which might be expected in the relative effective travel time of short-wave and long-wave signals. When the short-wave time-signals were first introduced, it was realised that accurate monitoring of the transmissions might not be possible at Abinger, which is within the skip area of the transmitters. It is for this reason that, in the final published corrections, the reception times of the British short wave time-signals are given in units of hundredths of a second only. The work of reading up the film records has been long and laborious, but is now almost completed.

While the equipment was at the Rugby site, film records were obtained of the GBR time signal dots on an oscillograph without the interposition of a radio receiver, for comparisons with the build-up of the signals at the output of the long wave receivers at Abinger. Further tests on similar lines, planned in the light of the experience gained, are contemplated.

The total amount of computation, and also of installation and maintenance work, has steadily increased in the Time Department. Some simplifications of method have proved possible, but the work of intercomparison is so extensive that the load on the staff remains heavy. Nevertheless, some arrears remaining from the war period have been made up, and the distribution of the "Times of Reception" has been accelerated. At the date of the last Report these figures were some 18 months in arrears, but results have now been completed for 1947 December. Some progress has also been made with copy for the "Greenwich Observations".

Photoheliograph

Photographs of the Sun were obtained on 276 days, a second photograph being taken on 228 days. 24 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, only one day is unrepresented in the combined series for 1947.

Consignments of solar negatives received from the Cape during the year cover the epoch 1947 January to December inclusive. 17 negatives which were required to fill gaps in the combined Greenwich-Cape series for the epoch 1943 January to 1946 December have been received from the Director of the Kodaikanal Observatory.

222 plates have been measured during the year to complete the measurement of the combined series from 1944 January 5 to 1945 June 30.

Computations of sunspot positions and areas have been made for the combined series from 1941 December 5 to 1945 June 12.

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 153 as compared with 112 for the previous epoch. After the exceptionally high monthly value of 206 for 1947 May, the index remained high until October, after which it fell sharply, reaching 87 in February. In April, however, the curve rose abruptly to a very high level again, due largely to an abnormal number of medium-sized spot groups. It may be noted that short-wave radio fade-outs were infrequent from November to February inclusive, and that only two geomagnetic disturbances reached the intensity at Abinger of a small storm during the same four months of a general epoch that will probably prove to be the peak of a very notable maximum of sunspots.

Although no giant spot group occurred as in the two preceding report periods, several spot groups had areas exceeding 1000 millionths of the sun's hemisphere. Their dates of central meridian passage were:- May 4.9, July 17.9 and 20.5, August 4.0, 7.2 and 13.0, October 26.8, March 3.1 and 14.9, April 17.2 and 25.8. The latitudes of these spots ranged from 9° to 25°.

During the year, the copy for press of the "Greenwich Photoheliographic Results" for 1939 and 1940 has been completed. Tables of the mean areas of sunspots and faculæ for each synodic rotation included in these years, and of the mean heliographic latitude of sunspots, have been communicated to the Royal Astronomical Society.

Spectrohelioscope

This instrument was used on 162 days, but on 31 days observations were limited to a few minutes because of poor observing conditions. 81 solar flares were observed in $H\alpha$ during the year; 3 were of major importance, i.e. of intensity 3 on the International scale. 671 measures were made of line-of-sight velocities of bright and dark flocculi. The 267 measures of bright flocculi also provide equivalent line-widths of $H\alpha$. Photometric measures were made on 181 patches of bright flocculi. Line-of-sight motions were measured in 27 prominences.

On ten occasions line-of-sight velocities measured on the sun's disk exceeded 100 km/sec. the greatest being 170 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.

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

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

At times, especially from May 16-30 and July 29-August 2, solar flares were very frequent, though few were both intense and prolonged. The great magnetic storm beginning on July 17 at $17^h\ 48^m$ was most probably related to an intense flare of more than 3 hours duration, the occurrence of which, on July 16, was notified to the Astronomer Royal by the Director of the Carter Observatory, New Zealand.

Well-defined geomagnetic crochets, indicating bursts of ultra-violet radiation synchronous with the visible solar flares, were recorded on the Abinger magnetograms, beginning respectively on May $6^d\ 10^h\ 14^m.0$, August $1^d\ 15^h\ 16^m.7$, March $20^d\ 12^h\ 23^m.7$ and April $20^d\ 12^h\ 23^m$ U.T. Others that were less definite occurred as follows:- June $14^d\ 10^h\ 36^m$, August $24^d\ 13^h\ 37^m$, August $31^d\ 14^h\ 54^m$ and September $2^d\ 08^h\ 57^m$.

In addition to the selected data of sunspots and flares issued from Greenwich to radio research centres, an informal liaison over solar observations in general has been maintained with the Radio Group of the Cavendish Laboratory, Cambridge; the Radio Research Station, Slough, of the National Physical Laboratory; and the Operational Research Group of the Ministry of Supply.

An examination is being made into the contribution of flare-active sunspots to the general statistical relationships between sunspots and geomagnetic storms, involving size of sunspot and time of central meridian passage.

IV MAGNETIC OBSERVATIONS.

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

Absolute observations of declination, of horizontal intensity with the Schuster-Smith coil-magnetometer and of vertical intensity with the Dye coil-magnetometer are made every week-day. The measurements both of the horizontal and vertical components of magnetic intensity are dependent upon electrical standards. Observations of magnetic inclination with an inductor have been taken frequently for purposes of comparison.

The values of the several electrical standards employed were re-examined at the National Physical Laboratory in June 1947, and the Observatory is indebted to the Director for this periodical service. The variations of declination and of horizontal and vertical intensity have been recorded photographically both on slow-run and quick-run recorders. The base-line values of the magnetographs are remarkably steady.

It may be remarked that a century of photographic recording of the variation of the magnetic elements by the Royal Observatory was completed on 1947 September 27. As regards the reduction of observations, the mean hourly ordinates of all the traces have been read off to date. The reduction of absolute observations is complete to 1947 December 31, and with provisional constants to the present time. The tabulation of results for 1947 awaits the receipt of the final list of International "quiet" and "disturbed" days, the preparation for publication being otherwise in an advanced state.

The mean values of the magnetic elements at Abinger for the year 1947 are given below. The values for the years 1944, 1945 and 1946 are given for comparison.

Year	Declination (West)	Horizontal Intensity	Vertical Intensity	Inclination
1944	10° 7′.8	0.18566	0.43189	66° 44′.3
1945	9 59 .5	0.18573	0.43207	66 44 .3
1946	9 51 .1	0.18569	0.43235	66 45 .4
1947	9 43 .1	0.18577	0.43246	66 45 .2

The weekly report of mean hourly values of declination has been sent regularly to several offices for publication or information - a service maintained in conjunction with Eskdalemuir Observatory. Weekly reports of the magnetic character of each day (i.e. the three-hourly range indices, on a scale of 0 to 9, and the daily character figure on a scale of 0 to 2, estimated in accordance with the scheme adopted at the Washington Meeting of the International Union of Geodesy and Geophysics, September 1939) are also communicated to a number of geophysical research centres to assist their projects. Further progress has been made in the application of this scheme retrospectively to years prior to 1940, and the three-hourly range indices for each day throughout the years 1928 to 1939 have now been estimated. Much unpublished material has been supplied, on request, to certain organisations engaged on radio research.

During the past twelve months there have been 15 magnetic disturbances reaching the dimensions of a "storm"; 3 of these reached the dimensions of a "great storm" (a range of 30′ in declination and 150γ in horizontal intensity is considered the lower limit for a "storm"; 60′ or 300γ for a "great storm").

Mr. S. K. Runcorn of Manchester University was at the Abinger station from November 27 - 29 and from December 13 - 16, engaged upon the testing and adjustment of instruments intended for use in deep mines in connection with Professor P. M. S. Blackett's hypothesis of the magnetism of massive rotating bodies.

Mr. C. L. Hawson, Officer in charge of Lerwich Observatory, visited the station from December 17 - 21 and carried out a further series of comparison observations of vertical intensity with a portable balance magnetometer of the Copenhagen (La Cour) type, with a view to re-standardising the instrument.

Fr. O. Cardus S. J. of the Ebro Observatory, Tortosa, Spain, visited the station on September 2.

Several tubular compasses have been tested and adjusted at the station by officers of the Hydrographic Department of the Admiralty.

A specimen of the improved type of Copenhagen "B.M.Z." Vertical Intensity variometer, the property of the Meteorological Office, was tested at the station, April 5 - 19, in view of the intention to obtain a similar instrument for the use of the Royal Observatory.

V METEOROLOGICAL OBSERVATIONS.

During the past twelve months registration of atmospheric pressure, temperature of the air, evaporation, pressure and velocity of the wind, and the amounts of rainfall, sunshine, and cloudiness at night has been maintained continuously. Estimates of visibility have been made by eye at definite hours. The measurement of the amount of solid matter polluting the air has been continued, using an Owens automatic filter.

A night-sky camera has been constructed for use at Herstmonceux. An ordinary spectacle lens was tried, in order to save the cost of a camera lens, and was found to be satisfactory. Consultations have taken place with the Meteorological Office on the most suitable site in the Herstmonceux grounds for a meteorological enclosure.

The tabulation of meteorological results for 1947 is complete and the preparation of copy for press is well advanced.

The following details of the weather refer to the period of twelve months ending 1948 April 30.

The mean temperature was 53.°0, which is 3.°3 higher than the average for 100 years 1841-1940 and constitutes a record for warmth. All months without exception has mean temperatures well above average - a rare circumstance which had not occurred since 1911.

The highest temperature in the shade was 93.°0 registered on June 3. Temperatures exceeding 80° were recorded in the Stevenson screen on 32 days, at least four occasions occurring in each month from May to September and twelve in August. On three days (June 2 and 3, July 28) the temperature in the Stevenson screen exceeded 90°. If however, "open screen" temperatures are considered valid (as was the case until the end of 1937) the number of days with temperatures above 80° is increased to 49, and above 90° to 9 - in each case a number without precedent in the Greenwich series.

The lowest temperature was 21.°0, which occurred on December 1. Temperatures of 32.°0 or below were recorded on 27 days, 10 of which were in February. There was no frost in March.

The mean daily horizontal movement of the air was 244 miles which is 13 miles below the average for 50 years 1867-1916. The greatest daily movement was 723 miles, which was recorded on January 13; the least daily movement was 25 miles registered on February 29. The maximum pressure reached was 36.2 lbs to the square foot, on March 31.

The total duration of bright sunshine, as recorded, was 1529.9 hours, representing 34 per cent of the total theoretically possible. There were 68 entirely sunless days. There were 45 nights on which a complete unbroken trace of δ Ursæ Minoris was obtained by the night-sky camera. The number of nights on which no trace of this star appeared was 61, while on a further 36 the record was not more than ten per cent of the amount possible.

The total rainfall during the twelve months was 17.228 inches, which is 7.102 inches less than the average for 100 yards 1841-1940. There were 147 days on which rainfall exceeding .005 inch was recorded. The wettest month was January, in which a total of 3.21 inches was recorded. The last six months of 1947 were the driest on record, the total of 6.26 inches being below the previous lowest total (1921) by 0.33 inch. The months chiefly responsible were August (0.09 inch) and October (0.14 inch) - in each case the driest of its name in the whole Greenwich series.

VI CHRONOMETERS.

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

The number of Admiralty chronometers and watches on charge to the Royal Observatory is 20,743. Of this total 372 chronometers (Patt. H.S.1), 325 chronometer watches (Patt. H.S.2 and H.S.6), 297 deck watches (Patt. H.S.3), 20 dashboard watches (Patt. H.S.4), 93 pocket watches (Patt. H.S.5), 72 stop watches (Patt. H.S.7), 90 wrist watches (Patt. H.S.8) and 75 wrist chronographs (Patt. H.S.9) are rating or ready for issue but reserved. The remainder, consisting of 470 Patt. H.S.1, 3501 Patt. H.S.2 and H.S.6, 7091 Patt. H:S.3, 1576 Patt. H.S.4, 1527 Patt. H.S.5, 595 Patt. H.S.7, 1962 Patt. H.S.8, 2230 Patt. H.S.9 and 423 other assorted types are held in store awaiting adjustment, rating or repair. Chronometers and watches in use at the Royal Observatory number fifteen. The stock of watches 6B/60 held on behalf of the Air Ministry totals 285, of which 73 are rating and 212 await repair. In addition there are 243 chronometers and watches deposited for various reasons.

During the year a total of 5,769 chronometers and watches was received and 6,012 issued. This represents a fall in the number of instruments handled; the receipts and issues were, however, steady throughout the year, which suggests that a normal level of work has now been reached. The routine computing and notation work of the Depot is completely up to date.

The above issues include the following special items:-

(a) Twenty-six chronometers of navigational standard were supplied to the Trade for sale to British ships whose needs could not be met from the usual sources of supply.

(b) Seventeen chronometers and seven watches belonging to the French Hydrographic Service, and two watches, the property of the Greek Government, were returned to the owners during the year.

(c) At the request of the Ministry of Agriculture and Fisheries 196 Deck watches were transferred to that Department for sale to fishermen for navigational use.

(d) Admiralty approval was obtained for the disposal of chronometers and watches of obsolete types whose further maintenance was considered uneconomical, and 25 chronometers, 233 chronometer watches and 734 deck watches were sold accordingly. Tenders have been invited recently in respect of a further 81 chronometers and 116 chronometer watches.

The total number of repairs and adjustments was 1,632, including 25 for the Air Ministry. Of this total, 27 chronometers, 27 chronometer watches, and 1,165 other instruments were dealt with in the Repair Shop; the remaining 413 had to be sent to out-workers. This represents a substantial increase in the number sent out; it was necessitated by the losses in staff which occurred during the year. The work of the remaining repairers has now been mainly directed to the navigational wrist chronographs required in large numbers for the Naval Air Arm.

To achieve the aim for which the Observatory watch repair shop was established, intensive effort will be necessary to increase the staff of the shop as soon as the removal to Herstmonceux is satisfactorily completed. In this connection a comprehensive staff scheme comprising apprentice, improver and journeyman watchmakers, capable of dealing with all types of chronometers and watches, was submitted to the Admiralty in the latter part of 1947, but full approval for its adoption has not yet been given.

The restoration of Harrison's No.1 timepiece, mentioned in the last report, has been held in abeyance through pressure of other work in the watch repair shop and is unlikely to be restarted for some months. The machine No.3 also remains unassembled. During the redecoration of the Navigational Room of the National Maritime Museum the Harrison No.4 and Larcum Kendal timepieces were removed to Bradford-on-Avon where they were examined and re-oiled as necessary.

The Shelton clock in use at the Magnetic Station was thoroughly overhauled at Bradford-on-Avon and subsequently re-installed at Abinger. The clockwork drives for the slow and quick run magnetographs, which have proved troublesome in operation, are at present being reconstructed in the watch repair shop.

In June 1947, the Air Ministry intimated a wish to adopt, for aircraft navigational instruments, including clocks and watches, a system of maintenance, testing and supply similar to that which has proved efficient in the case of Hydrographic chronometers and watches. At the same time the Ministry asked whether the Admiralty could undertake this service, for the Air Ministry navigational watches, as an alternative to the duplication by the Ministry of the organisation already in existence at the Observatory.

In connection with this request, details of the amount of work involved and its cost to the Observatory Vote were prepared and submitted to the Hydrographer. A decision is awaited on this proposal, which will eventually entail the handling of an additional 10,000 watches per annum.

VII PUBLICATIONS.

General difficulties in all questions of printing are still very marked, and the production and distribution of Greenwich Observations has not yet been resumed. Arrangements have now been made for these volumes to be prepared by varityper, and reproduced by photo-lithography. The Stationery Office will undertake the binding. Two varitypers have been acquired, and the recruitment of two typists, who will have to be specially trained for these machines, has been authorised. Advertisements for the positions have, however, been considerably delayed.

The following other publications have appeared during the year, some of them considerably delayed by similar difficulties.

L. S. T. Symms and C. J. A. Penny, Errors of Time Determination. M.N. **106**, 390.

H. W. Newton, Sudden Commencements and Sunspot Data. M.N. (G.S.) **5**, 159.

H. W. Newton, Geomagnetic "Crochets" and allied Solar and Radio Data. M.N. (G.S.) **5**, 200.

Sir H. Spencer Jones, Modern Astronomical Instruments (Trueman Wood Lecture). Journ. R.S.A. **95**, 812.

R. H. Tucker, on the Mean Solar to Mean Sidereal Gear Ratio. Observatory **67**, 185.

Sir H. Spencer Jones, The Development of Navigation. Journ. Inst. Nav. **1**, 1.

Sir H. Spencer Jones, Time Determination and Time Keeping. Journ. Inst. Nav. **1**, 109.

D. H. Sadler, Altitude Corrections for Coriolis Forces. Journ. Inst. Nav. **1**, 22.

D. H. Sadler, the Navigational Work of the Nautical Almanac Office. Journ. Inst. Nav. **1**, 148.

H. W. Newton, Sudden Commencements and other small characteristic impulses. Terr. Mag. and El. **52**, 441.

H. W. Newton, A distinctive Geomagnetic Epoch, 1941 June 9-14. Observatory, **68**, 60.

D. S. Perfect, A Method of setting two Opposed Opaque Mirrors parallel. J. Sc. I. **25**, 15.

Sir H. Spencer Jones, John Couch Adams and the Discovery of Neptune. C. U. P.

Some other papers have been in the press for a considerable period.

Publications of the Nautical Almanac Office are dealt with below.

VIII 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.

During the year five temporary Assistants (Scientific) have been recruited to fill vacancies on the junior staff and have been given an intensive training with a view to their permanent establishment. Pending assimilation of the present staff to the scientific grades and the subsequent recruitment of senior staff to the approved complement, the Office is still grievously handicapped by staff shortage; recruitment has been made more difficult by the uncertainty of the date of the move to Herstmonceux.

The delays in printing have to a large extent been overcome and it is hoped that it will prove possible in future to advance gradually the publication dates of the almanacs. This year delays have occurred in the final stages only, outside the control of the Office.

The Nautical Almanac

The delays in the final printing and binding of the Almanac for 1949 meant that it did not appear until April 14.

The first part of the "Nautical Almanac" for 1951, containing the fundamental ephemerides of the Sun, Moon and planets, has been distributed and that for 1952 should be ready by about August.

No changes have been made in the contents and presentation of the published Almanac. It has been decided however to include an ephemeris of Pluto as from 1950. Some work has been done on the contents of the separate supplement but it is not yet possible to predict a date for its publication.

Occultations and Eclipses

Besselian elements for 2678 stars of magnitude 7.5 or brighter occulted during 1950 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 81 stations for 1362 stars, the other 1316 having been discarded as not observable under suitable conditions. After computation a further 103 stars were rejected and the elements of the remaining 1259 stars will be published in the "Nautical Almanac" for 1950. The predictions for 1950 have been completed; they number 11,067.

The discussion of the occultations observed in 1943 has been completed and published, together with provisional solutions for 1944 and 1945, in "Astronomical Journal" Vol. 53, p. 163. It has been decided to publish all observations of occultations received in the Office, whether previously published or not, in one combined list, showing in a condensed form details of the observation and reduction together with residuals from the adopted solutions for each lunation. This list will be circulated to all observers and will be included for permanent record in the annual volumes of the "Greenwich Observations". The list for 1943 is in preparation. Further observations for 1943 have recently been received and will be included in the rediscussions which it is later hoped to make, taking limb corrections into account.

The duplicate reductions for 1944 have almost been completed and it is hoped to complete and publish the discussion before the end of the year. 98 observations have been received during the year, 51 having been received in April.

For 1945, 1946, 1947 and 1948 the numbers of observations received since the last report were 22, 235, 506 and 19 respectively.

Abridged Nautical Almanac and Air Almanac

The "Abridged Nautical Almanac" for 1948 was published in June. Although the earlier stages of composition for 1949 were well up to schedule there has been considerable delay in printing and publication will not take place till May.

During the year, four parts of the "Air Almanac" have been published, the last part for 1947 and all three parts for 1948. The first part of 1949 should be available shortly.

No change has been made in the contents or presentation of the "Abridged Nautical Almanac" but proposals have been drawn up and submitted to the Admiralty for its complete revision, the main change being in the tabulation of Greenwich Hour Angle instead of Right Ascension, with consequent rearrangement.

In conjunction with the revision of the "Abridged Nautical Almanac" the provision at present made for astronomical navigation at sea has been investigated. Limitations of time and staff have prevented this being as comprehensive and as detailed as could have been desired; however, the conclusions, which are at present under consideration by the Admiralty, are quite definite and should result in a revision of the methods at present in use, with considerable gain in efficiency.

The astrograph tables have been omitted from the "Air Almanac" as the astrograph is no longer used; otherwise there is no change in the contents or presentation.

The Star Almanac

Arising from suggestions made at the Conference of Commonwealth Surveyors in August, detailed proposals and specimens have been drawn up for a special almanac for topographical surveyors. These are at present under consideration by a technical committee.

Apparent Places of Fundamental Stars

The volume for 1948 was not published until October 17, the delay having occurred in the final printing stages. For 1949, in spite of delays in the receipt of computations from abroad, more than half the printed sheets have been received and it is hoped that publication will take place in July.

The whole of the computations for 1949 were supplied by the Offices to which the calculations were originally allocated, but the Office of the "Connaissance des Temps" has been working under difficulties and finds it impossible to prepare its calculations up to schedule. It has therefore been agreed that, for the volume for 1950, the Nautical Almanac Office will be responsible for the computations for the first 216 stars of the normal Paris allocation. All of this work has been completed, using the National Accounting Machine, and an account of the method is being published in "Monthly Notices of the Royal Astronomical Society".

Copies of the mean places for 1949 and 1950 have been distributed to the several Offices responsible for the computation of the apparent places, and those for 1951 should be distributed in May.

General Navigation Work

The Office continues to be responsible for the computational work necessary for the latticing of Admiralty charts required for the Decca system of navigation.

During the year computations were provided for 34 charts of the English Chain, thus completing the coverage at present required. In addition some 600 simultaneous observations of Decca and geographical co-ordinates were reduced to provide the data for an analysis, carried out by the Admiralty Signal and Radar Establishment, into the behaviour of the system. It is likely that the work of the Office will grow as further chains are set up in Britain and elsewhere. The comprehensive report on the computation of Decca Lattices has now been completed and prepared for reproduction by photolithography.

Until shortly before the recent war the Nautical Almanac Office had not for many years played an active part, other than the routine publication of the "Abridged Nautical Almanac", in the provision for astronomical navigation. It is evident that the Office is the most suitable institution to act as an authority on the provision to be made for astronomical navigation at sea or in the air. Steps are accordingly being taken to build up a really complete specialized Library of almanacs and tables for astronomical navigation, and to prepare technical assessments of the many new publications as they are issued. The first results of this policy are the comprehensive surveys of Almanacs and reduction tables for surface navigation referred to above.

It is therefore unfortunate that owing to the restricted quarters at present occupied by the Office, it was impossible to accommodate the R.A.F. specialist navigation course for their usual visit. Herstmonceux Castle will provide better opportunities for such visits.

Illumination Diagrams

Master diagrams for the "Daylight and Moonlight" diagram required by the Air Ministry have been provided for 1947 June to 1949 May.

Proof-Reading

During the year 2504 pages of first proofs and 3136 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 at much the same level as previously. This and other information for diaries and similar publications is supplied on the normal basis.

Other Publications

A photolithographic reprint of "Planetary Co-ordinates for 1940 - 1960", of which the type, plates and stock were destroyed in 1940, was published in July. Also, there has been recently published for general sale a reprint of the "Five-figure Trigonometrical Tables", which was originally prepared by the Office for the War Office in 1941; an intensive proof-reading of the latter was necessary before printing could take place from the type, which had been standing for six years.

Distribution of publications

During the year, all war-time editions of the Office publications, which had either not been distributed or had been lost in transit, have been distributed; it is now thought that all institutions on the exchange list, (with some few exceptions that have ceased to exist or have suffered change of circumstance), have received all publications to which they are entitled. The sale of Office publications abroad is being seriously disturbed by exchange difficulties, and consequently a rather wider free distribution, particularly of the international volume of "Apparent Places of Fundamental Stars", is being made.

Machines

As a result of a close study of the application of punched-card machines to astronomical computation, mainly at the American Nautical Almanac Office, approval has been sought for the installation of complete punched-card equipment in the Office. This equipment would be available not only for the routine work of the Office, particularly on the navigational side, but also for much systematic computation and analysis of observations for other Departments of the Observatory.

Pending a decision, no changes have been made in the present equipment, though the National machines are showing signs of the hard usuage they have had, and will shortly have to be replaced if they are to continue to carry the whole burden of the routine work of the Office.

IX PERSONAL ESTABLISHMENT.

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

(a) Observatory Staff

Chief Assistants	- R. d'E. Atkinson, M.A., Ph.D., One vacancy.
Assistants	- R. T. Cullen, A. Hunter, Ph.D., P. J. Melotte, H. M. Smith, B.Sc., A.M.I.E.E., F.Inst.P.
Senior Scientific Officer	- W. Jackson.
Secretary and Cashier	- H. G. Barker.
Junior Assistants (Higher Grade)	- H. W. Acton, H. H. J. Barton, E. A. Chamberlain, H. F. Finch, B.Sc., F. Jeffries, E. G. Martin, H. W. Newton, G. W. Rickett, L. S. T. Symms.
Higher Clerical Officer	- J. H. Whale.

Experimental Officer	- A. E. Cordwell.
Head of Repair Shop	- D. W. Evans.
Junior Assistants	- K. C. Blackwell, Miss C. E. Chapman, C. C. Harris, P. S. Laurie, B. R. Leaton, Miss E. M. Moore, P. L. Rickerby, J. L. Rudd, A. Shortland, R. H. Tucker, G. F. Wells.
Clerical Officer	- Miss H. Pettican.
Assistants (Temporary)	- V. Barocas, Ph.D., A.Inst P., Miss C. J. A. Penny, B.Sc., G. B. Wellgate.
Assistant Experimental Officer	- J. D. Pope, B.Sc.
Temporary Assistant (Scientific)	- Miss P. M. Morris.
Clerical Assistants	- Miss F. E. A. Jeffries, Miss C. Ryall.
Hostel Warden	- Mrs. A. Hewitt.
Temporary Clerks (II)	- Miss B. G. Collett, F. A. Everest, Miss R. O. Pavey, P. A. Hogan.
Temporary Clerks (III)	- B. J. Harris, Miss M. Lawrence, Mrs. L. E. Nicholls, Miss J. J. Peters, N. S. C. Rhodes, E. C. Smith.
Typing Staff	- Miss V. A. Bennett, Miss B. I. Dean, Miss B. A. Martin,
Laboratory Assistants	- L. J. Bates, A. V. C. Cross, H. G. Gill, D. C. Smith.

(b) Nautical Almanac Office Staff

Chief Assistant as Superintendent	- D. H. Sadler, M.A.
Assistant	- Miss F. M. McBain, M.A.
Junior Assistants (Higher Grade)	- A. E. Carter, A. J. Daniels, S. G. Daniels, H. W. Richards, B.Sc., W. A. Scott, B.Sc.
Junior Assistants	- W. G. Grimwood, G. A. Harding, Miss M. R. Rogers, E. Smith.
Clerical Officers	- Miss J. E. Perry, Miss Y. I. Reddy.
Clerical Assistant	- Miss I. M. Restorick.
Temporary Clerks (II)	- Mrs. E. F. M. Freeman, W. A. Hulme.
Assistant Experimental Officer	- Miss D. M. Fooks.
Temporary Assistants (Scientific)	- A. Beck, M. P. Candy, J. D. W. Cox, Miss E. J. M. Grove, K. A. Miller.

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

Mr. W. M. Witchell, Assistant, retired on April 26 after nearly 54 years' unbroken service. This constitutes a record for the Royal Observatory, and is all the more remarkable in that during his whole service Mr. Witchell was never absent on sick leave.

Miss D. J. Ifield, Miss J. Mounteney and Miss J. E. Pullen, Junior Assistants, resigned on marriage during the year.

Mr. J. J. McLoughlin, Clerical Officer, died on August 26.

Mr. O. Nourse, Mr. J. B. Parker and Mr. R. M. J. Withers, Assistants (Temporary) left to take up posts elsewhere.

Mr. W. Jackson, Senior Scientific Officer, joined on November 17, Mr. J. H. Whale, Higher Clerical Officer, on July 28 as Assistant Secretary and Cashier, and Miss H. Pettican, Clerical Officer, on October 13.

During the year the following appointments were also made: Mr. A. E. Cordwell, Experimental Officer; Miss D. M. Fooks, Assistant Experimental Officer; Miss J. E. Perry and Miss Y. I. Reddy, Clerical Officers.

Mr. D. W. Evans was appointed Head of the Chronometer Repair Shop as from 1947 May 1.

Six Temporary Assistants (Scientific) Mr. A. Beck, Mr. M. P. Candy, Mr. J. D. W. Cox, Miss E. J. M. Grove, Mr. K. A. Miller and Miss P. M. Morris have joined during the year.

The industrial staff employed in all branches consists of a Foreman of Observatory, six laboratory mechanics, three watch adjusters and repairers, one mechanic, two boiler attendants, one driver, one storehouse assistant, three messengers, one head gardener, five gardeners, four nightwatchmen, two skilled labourers, seven labourers, one laboratory boy and two cleaners, a total of forty.

The regrading of the scientific staff has made regrettably little further progress. The fact that it has still not come into effect is holding up urgently needed recruitment; even vacancies in the existing complement cannot be filled when there is doubt what the future status of the post will be. For three years now the Observatory has had a definite vacancy for a second Chief Assistant, but the post could not usefully be advertised for this reason. Since both Chief Assistants were absent on loan during the entire five previous years, in addition, the inability to recruit at this level has been a particularly grave disadvantage; moreover, the ill effects will probably be felt for some time yet. The status of this post has now been fixed, but an advertisement which was submitted for it two and a half months ago has not yet appeared. A number of other administrative decisions are also outstanding, some of them since more than a year ago; several are of a relatively trivial and formal nature.

X ISAAC NEWTON OBSERVATORY.

A Board of Management has been constituted to direct the scientific work with the 100-inch telescope of the Issac Newton Observatory, which is to be sited in the grounds of the Royal Observatory at Herstmonceux. The Board consists of the Astronomer Royal as Chairman, the Directors of the Royal Observatory, Edinburgh, of the Cambridge Observatory, and of the Oxford University Observatory as *ex-officio* members, together with four nominees of the Royal Society and four of the Royal Astronomical Society, each to serve for four years, one nominee of each Society

retiring annually; the Secretary of the Board of Management is to be the Secretary of the Greenwich Observatory.

The Council of the Royal Society appointed as its nominees Dr. C. R. Burch, The Lord Cherwell, Sir Thomas Merton and Sir Geoffrey Taylor; the Council of the Royal Astronomical Society appointed Dr. A. O. Rankine, Dr. J. A. Carroll, Professor P. M. S. Blackett and Professor F. J. M. Stratton. The order of retirement, to commence from 31 December 1948, is the order in which the names of the nominees of each Society are given.

The Administration of the Isaac Newton Observatory is to be vested in the Astronomer Royal and an Annual Report is to be prepared for the consideration of the Board of Visitors of the Royal Observatory. It was agreed at the first meeting of the Board that the Report shall relate to the twelve months preceding 1 May each year.

The Board held three meetings in the year ending 30 April. The types of observation to be undertaken with the telescope have been considered: they include stellar spectroscopy and spectrophotometry, star counts, galactic structure, the investigation of the distribution and extent of obscuring material, spectral classification with a slitless spectroscope, the determination of radial velocities, and observations of extra-galactic nebulae. The alternatives of a straight paraboloidal reflector with Newtonian, Cassegrain, and Coude foci, and with correcting lenses for direct photography, or of a combined instrument of the Schmidt-Cassegrain type have been discussed. The advantages and disadvantages of various alternative optical designs were summarized in a memorandum by Dr. Burch and a 2-sphere 1-plate aplanat design was considered in some detail. This design involves the mechanical difficulty that the tolerance in alignment of the aspherical secondary with the spherical primary is very small. The effects of flexure were discussed by Mr. B. N. Wallis F.R.S., at the request of the Board. He concluded that the degree of structural rigidity required cannot be attained by any known structural forms or materials, but that the effects of flexure could be compensated by thermally expanding and contracting the main members of the telescope tube.

An alternative design is the Ross-Schmidt system, proposed by Dr. J. G. Baker of Harvard, in which a Ross field-corrector lens pair is combined with a Schmidt aspherical plate. The plate is mounted in an aperture-stop in the incoming beam, and the lens is placed in the converging beam reflected by the primary. Coma, astigmation and field-curvature can be corrected by the doublet, and spherical aberration by the plate. At the request of the Board, Dr. E. H. Linfoot and Mr. C. G. Wynne are investigating such systems.

A Committee consisting of Professor H. H. Plaskett, Sir Geoffrey Taylor, Dr. R. d'E. Atkinson, Mr. J. M. Ford, Mr. C. C. Inglis, Dr. A. Porter, Professor A. Tustin, Dr. A. Uttley and Professor F. C. Williams has been appointed to consider the application of servo methods to the movement and setting of the telescope. Another Committee consisting of Professor P. M. S. Blackett, Lord Cherwell, Dr. R. d'E Atkinson, Dr. J. A. Carroll and Dr. A. Uttley has been appointed to consider the problems of automatic guiding by the use of photo-electric or other method. Both Committees have met during the year.

A team from the Telecommunications Research Establishment, Malvern, under the direction of Dr. Uttley has developed a photo-electric method for automatic following

of a telescope, which has been tried on the 13-inch astrographic refractor at Greenwich. A control to an accuracy of one second of arc has been so far obtained, the focal length being about 11 feet. The sensitivity is about 2^m below that of the eye when used for guiding on cross-wires. These results are preliminary and are capable of improvement.

As Dr. Uttley was due to make an official visit to the United States, the Servo Control Committee felt that this would provide a valuable opportunity to obtain information about the system of control which has been developed for the 200-inch telescope, and also for the study of the methods of driving and control of other large telescopes. Approval was obtained for the extension of Dr. Uttley's visit, the extra expense being defrayed from the Royal Observatory vote.

The problems of manufacture of large glass mirror disks have been under investigation by Messrs. Pilkington Bros. Ltd. It is proposed to make the 100-inch disk of pyrex glass, and to cast it as a solid disk, the lower face being given a concave curvature of approximately the required amount. Experimental castings of disks of various sizes have been made and it is expected that the casting of the 100-inch disk can be undertaken about March 1949.

XI GENERAL

During the year a number of astronomers and geophysicists, mostly from overseas, visited the Royal Observatory and the Nautical Almanac Office. They included Dr. G. Shajn, Director of the Simeis Observatory; Professor B. A. Orlov of the Pulkova Observatory; M. P. Bourgeois, Director of the Royal Observatory, Uccle; Dr. K. Erkman and Dr. O. Sipahioglu, Director and Assistant Director of the Istanbul Observatory; Messrs. Finsen and Hers, of the Union Observatory, Johannesburg; Father J. O. Cardus, of the Del Ebro Observatory, Tortosa; Dr. Madeira, of the Lisbon Observatory; Dr. Gulatee, of the Survey Institute, Dehra Dun, Dr. W. A. Marrison, of the Bell Telephone Co.; Dr. J. Tuominen of the Astronomical Observatory, Helsinki; Mr. J. M. Rayner, Chief Geophysicist, Bureau of Mineral Resources. Geology and Geophysics, Australia.

The Controller and Deputy Controller of the Navy paid visits to the Nautical Almanac Office during the course of the year.

Twenty-one Officers of the Commonwealth Survey Conference came to the Royal Observatory on August 25, General Ydigoras Fuentes, Guatemalan Minister in London, in September, and Professor Alexopoulos of Greece, Comdr. Miguel Pedrozo and Lieut. Grunwaldt of the Argentine Naval Commission at various dates.

The Astronomer Royal attended the meeting of the Executive Committee of the International Council of Scientific Unions at UNESCO House, Paris, in July.

Mr. Sadler returned in May from a visit to the United States of America, where he had been studying the applications of punched-card and other modern computing equipment to astronomical calculations, at the Naval Observatory, Washington, and other centres.

Dr. Atkinson visited Germany and Austria, primarily with a view to the reorganisation of the Kanzelhöhe Observatory and to arrange for the results obtained to be made available to the Royal Observatory. With the friendly co-operation of the Austrian authorities concerned he was able to arrange for a change of staff and for an increase in the amount of work undertaken. A new observatory tower was constructed by British troops on the Gerlitzen Gipfel, nearly 400 metres higher up, on which was erected a dome whose pieces were mainly in the neighbourhood but not yet assembled; the coronograph from the Kanzel which had not been very effective at the lower level, was transferred to this tower. The spectrohelioscope was arranged for instantaneous conversion to a spectroheliograph and modified so that the whole sun could be viewed at once; other apparatus was modified and adjusted. Arrangements were also made for coronal results to be sent to London, Washington, Schauinsland and Wendelstein by teletype daily, and for the Wendelstein results to be sent to London and the Kanzel, in addition to existing addresses. It was arranged that the Kanzel results should be regularly forwarded to Schauinsland for inclusion in the monthly Bulletin of Solar Observations prepared by the Fraunhofer Institut and published by the French. Copies of this Bulletin now reach the Royal Observatory regularly, and are distributed from it to other interested centres in England. Recently a request was sent to the Kanzel for information on major flares to be added to the coronal teletype whenever they occur; the Kanzel can also in case of need send photographs of the Sun to fill gaps in the Greenwich series. Questions of the status of the Kanzel Observatory, and its possible association with the Observatory of Vienna or the Austrian Academy of Sciences, were discussed but could not be finally settled. It is hoped that some financial support may be forthcoming from the provincial governments of Styria and Carinthia. Dr. Atkinson returned to Greenwich on August 22.

The Astronomer Royal gave the Presidential Address at the inaugural meeting of the Institute of Navigation on September 19. At the same meeting, Mr. Sadler gave a talk on "The Navigational Work of the Nautical Almanac Office".

Mr. Smith and Mr. Pope visited Paris in November to see the work of the Bureau de l'Heure, the Laboratoire National de Radioelectricité, and other scientific institutions. Visits were also paid to various firms engaged on the manufacture of frequency-standard equipment, and to Etablissement Bélin, from which firm two chronographs have since been ordered.

It has already been mentioned that "Stage I" of the Herstmonceux move is planned to take place in August. This is intended to include the Nautical Almanac Office, the Chronometer Depot, the Magnetic and Meteorological Department and the Secretariat; the Astronomer Royal will probably transfer his residence somewhat earlier, and the Solar Department will wait until the Solar Building (but not the cellar) is ready. At present no date for any further stage of the move can even be guessed at, and indeed the completion of Stage I cannot in fact at present be guaranteed.

The removal of the Royal Observatory from Greenwich to Herstmonceux would even under normal conditions have entailed considerable disorganization to the work of the Observatory. The difficulties of the present times, by delaying the completion of the move, will greatly increase this disorganization. It is hoped that some further funds will be forthcoming to allow Stage I to be completed, but there is no provision in the estimates for the current financial year for a further stage of the work to be commenced. It would be wasteful to disband the present force of workmen

with so much still to be done; but even more regrettable is the effect on the output of the Observatory of each month of delay in completing the move. The 26-inch and 28-inch refractors and the Melbourne transit circle are out of action; the completion of the Photographic Zenith Tube may be expected before long. Buildings to house these instruments are required. At Greenwich the Yapp reflector, as already explained, is handicapped in that it cannot profitably be re-aluminised as long as it remains there, while latitude variation observations are in abeyance because the resumption of observations with the Cookson telescope for a short period is not advisable. The Photographic Zenith Tube, when installed at Herstmonceux, will provide both time and latitude variation.

The actual output of the Observatory is thus much reduced at present; and, apart from this, the situation which will hold from the end of Stage I until completion of the move will be gravely disadvantageous in other ways. The Observatory will be divided between Greenwich, Abinger and Herstmonceux, so that only one of the three branches will have ready access to the Library, and the facilities of the Workshop will also be available only in a very limited and unsatisfactory degree; this will be true, no matter when the Library and Workshop themselves actually move. Most serious of all, though least obvious in its effects, is the fact that both Herstmonceux and (still more) Abinger will have a marked excess of observers over instruments; already many valuable years of what should have been training have been lost, older observers are retiring, and new staff who have never made an observation are increasing. Even if the dismemberment of the Observatory could be terminated tomorrow, there would be a large amount of ground to make up, and the effect on the standards of observational skill will plainly become more serious the longer the unification is delayed. It is therefore much to be hoped that the authorities concerned will realise the very pressing need to accelerate the present slow progress; in the long run it would result in a financial saving.

From the point of view of its preservation as an Ancient Monument, the Castle will also require some fairly substantial expenditure before very long. An extensive stretch of the old garden wall blew down in one of the winter gales; no funds are at present available for its repair and it appears possible that a further fall is imminent. The bridge over the north moat is also in a state of disrepair, caused by the ravages of the ivy, with which it was overgrown.

Although the hostel arrangements will cater reasonably well for unmarried staff, no quarters are yet available for married men. Admiralty action has recently been taken to obtain a small allocation of "traditional" houses from the Ministry of Health, and it is believed that Hailsham Rural District Council is prepared to erect these when they are in fact authorized. Their number is only sufficient for Stage I. But apart from these few, married members of the staff, some of whom have had as much as six years war service, will be faced with a separation-period which is likely to last for a year at least. The continuance of a similar situation through all later stages of the move would cause grave dissatisfaction and discouragement, and would be bound to have an adverse effect on the smooth running of the Observatory. It is evident that further official action on a somewhat increased scale will be essential if the later stages are not to fare even worse than the first, and if they are to fare better in any way a different approach to the subject is called for. Astronomer Royal has included in his proposals to Admiralty a requirement for houses for senior Observing staff; these could be built on the edge of the Observatory property, and would have the advantage, from the official point of view, that members of the staff could be required to vacate them when they

retired; this is not of course, the case with housing provided by Local Authorities. The nature of night observing duties requires observing staff to be resident within easy access of the Observatory; otherwise loss of observations is inevitable at times when the sky clears suddenly. It is fairly normal for an Observatory to be provided with houses for observing staff and it is really essential when, as at Herstmonceux, the Observatory is in an isolated area. The need did not exist at Greenwich, from the nature of the situation in a closely built-up area. The Local Authority is not in any case prepared to supply houses (within any foreseeable period) for personnel not already on the Observatory staff; the Observatory at present lacks a Chief Assistant, a Superintendent of the Magnetic and Meteorological Department, a senior Assistant in the Nautical Almanac Office, a Librarian and several Watch Repairers. A number of additional vacancies for senior scientists will occur when the new complement becomes effective, and a proportion of those who would be suitable for such positions will certainly be married men; there is a serious likelihood that they will refuse to consider any offer under present conditions, since it would mean a separation from their families of altogether indefinite exten These is evidently a grave risk that the increase in complement, which has been approved in principle, may be nullified in practice through an unrealistic approach to the housing problem, quite apart from the general hardship which is, as yet, the only prospect for existing married staff of the later stages.

H. SPENCER JONES
Astronomer Royal

ROYAL OBSERVATORY, GREENWICH.
1948 May 17

C.B.H. 27537