REPORT

OF THE

ASTRONOMER ROYAL

TO THE

BOARD OF VISITORS

OF THE

ROYAL OBSERVATORY, GREENWICH

Read at the Annual Visitation of the Royal Observatory, 1942 June 6.

THE BOARD OF VISITORS

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	Prof. R. H. Fowler	1943
	Dr. C. G. Darwin	1944
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Nominated as Fellows of the Royal Astronomical Society	J. Evershed Esq.	1942
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	Dr. R. Stoneley	1944
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The Report here presented refers to the period from 1941 May 1 to 1942 April 30 and exhibits the state of the Observatory on the last-named day.

I. Buildings, Grounds, Movable Property and Library:-

A building has been erected at Time Station A to provide suitable and adequate housing for three Shortt free-pendulum clocks and for the quartz clock, with a minimum expense and labour. It consists of two separate clock chambers, inside a main brick and concrete room, approximately 25 square feet in area. The outer room is heated by hot-water radiators, the clock chambers being electrically heated, with thermostatic control. The slave clocks and ancillary equipment will be installed in the outer room. Progress on the building, which has now been completed, was slow; the installation of the necessary wiring, preparatory to the erection of the standard clocks, is in hand.

No further damage from enemy action was sustained during the year. No structural repairs to the war damage have been effected but the temporary repairs, made to prevent the deterioration of buildings and domes, have in some cases been improved upon. A wooden framework, covered with felting, has been erected to close the large gap over the south portico of the altazimuth building and a similar construction is being provided for the north attic of the Main Building. Further repairs have been made to the shutters of the Airy Transit Circle room, to render them usable for transit observations. The ceilings of the transit and chronograph rooms have been repaired. Improvements to daylight lighting of some of the offices have been effected by use of Luxoid glass substitute. Gaps in the fence of the Christie Enclosure have been closed with barbed wire.

All instruments, which are not in use, have been protected from deterioration by the use, where necessary, of rust proofing oil and grease. The pivots of the Reversible Transit Instrument were carefully examined six months after such protection and were found to be in perfect condition. All instruments have been examined at regular intervals.

The dome motor of the 26-inch refractor, which had been under repair, has been re-erected.

The drilling machine and circular saw, with morticing attachment, have been fixed in position in the workshop and wired for power.

A 5,000 gallon water tank has been erected in the Observatory courtyard.

The third two-pen chronograph, mentioned in last year's report, has been completed in the workshop. A vibration machine, for testing the rates of aircraft watches under vibrations similar to those to which they are subjected in aircraft, has been constructed in the workshop.

Contacts of the Ritchie type have been made and fitted to the Dent mean time clock. The Dent sidereal clock is being fitted with similar contacts.

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

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

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

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

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

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

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

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

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

A 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.

A Shortt free-pendulum clock, No. 61, a radio receiving set, a chronograph and a Brunsviga calculating machine, from Mr. H. R. Fry.

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 Science Museum:-

A number of astronomical instruments of historical interest.

To the National Maritime Museum:-

Harrison's Time Machines Nos. 1, 2, 3 and 4, and the copy of No. 4 by Larcum Kendall.

Photoheliograph object glass No. 5 and a case containing some smaller instruments belonging to the Royal Observatory are for the present stored elsewhere in suitable accommodation.

The annual examination of the Observatory Library has been made. Eighteen books are missing and cannot be traced at present. Of these, thirteen were reported missing last year. Four books which were reported last year as missing have since been recovered.

II. Astronomical Observations:-

Transit Circle. As mentioned in the last report, observations of the Sun, Moon and planets, together with accompanying clock and azimuth stars, were terminated in September 1940. Fundamental positional astronomy has since suffered a serious loss by the destruction of the Poulkovo Observatory, during the bombardment of Leningrad. It has therefore been decided to resume observations with the Airy Transit Circle, on a very restricted programme. Damage by enemy action to the shutters and ceiling of the transit pavilion, to the chronograph room and to the chronograph has been made good; minor damage to the transit circle and collimators has also been made good. The instrument is being overhauled and it is hoped that observations, more particularly of the Sun, may be resumed shortly. Meridian Observations of the Moon, which do not form a portion of the regular programme of observations at the Royal Observatory, Cape of Good Hope, have been undertaken with the Reversible Transit Circle at the Cape Observatory, because of the cessation of observations at Greenwich.

The results given by the observations of the Sun, Moon and planets for the year 1937 have been completed. The results for the year 1938 are in hand. The corrections to these observations for variation of latitude have been adopted from data provided by the International Latitude Service applicable to the Greenwich meridian. The new programme of observations with the Cookson floating zenith telescope, which was commenced in 1936 after the removal of the telescope to the new site adjacent to the Reversible Transit Circle, has not yet provided group corrections of sufficient accuracy for a reliable determination of the latitude variation.

Observations of the minor planets, Ceres, Pallas, Juno and Vesta have been made, when possible, since 1935, for the control of the equator point. The observed positions for the years 1935 and 1936 have been published in *Greenwich Observations*, together with comparisons with the ephemerides given in the *B.A.A. Handbook*. The ephemeris of Vesta, computed by Mr. B. F. Bawtree, was stated to give the apparent places for the equinox of date; the ephemerides of the other planets, computed at the Astronomical Institute, Leningrad, were assumed to be on the same system, in the absence of any statement to the contrary. In preparing similar data extending to 1940, it was found that the places for Ceres, Pallas and Juno were not on the same system as those for Vesta. The ephemerides of these planets are only approximate, but the best accordance with observation is obtained if they are assumed to give true places referred to the mean equinox for the beginning of the year. The revised data for Ceres, Pallas and Juno in the years 1935-6 will be printed in the *Greenwich Observations* for 1937.

From 1937, places of these four planets are given each year in *Kleine Planeten*, published by the Recheninstitut, Berlin. The places are stated to be true places referred to the mean equinox of the beginning of the year. This is not correct for

Vesta, however, astrographic places being given for this planet. For the comparison with the observed geocentric places, precession, nutation and planetary aberration must be applied to the positions of Ceres, Pallas and Juno, given in *Kleine Planeten*, whilst precession, nutation, stellar aberration and planetary aberration must be applied to the positions of Vesta.

The ledgering of the observations made in the zone 0° to 24° north declination is almost complete. The reduction of observations of other stars, made during the years 1931 to 1940, is in progress. Positions in star catalogues are now referred to an equinox at the beginning, half or quarter century. Recent Greenwich catalogues have been referred to the equinox of 1925.0; the catalogue for the zone +0° to +24° Dec. will be referred to the equinox of 1950.0. This involves carrying the positions forward from 1935 to 1950.

Reversible Transit Circle. The division errors of the fixed circle, whose determination was completed in 1940, have been analysed. The most noticeable feature in the division errors is a cyclic error, recurrent every $2\frac{1}{2}$°. Its amount is as follows:-

0°0′	+″.03	1°0′	+″.06	2°0′	-″.03
5	+ .11	5	- .03	5	.00
10	+ .19	10	- .12	10	+ .01
15	+ .12	15	- .01	15	- .08
20	+ .07	20	+ .11	20	- .18
25	+ .03	25	+ .03	25	- .07
30	- .01	30	- .06	30	+ .03
35	+ .02	35	- .07		
40	+ .05	40	- .10		
45	+ .08	45	- .13		
50	+ .13	50	- .16		
55	+ .11	55	- .09		

The existence of this error emphasises the importance of determining the division error of every graduation.

Superposed on this cyclic error are periodic errors, with periodicities of 15°, 30° and 60° and semiamplitudes 0″.022, 0″.023 and 0″.077 respectively. The residual errors, though showing some systematic tendencies, are mainly accidental, corresponding to a probable error of about ± 0″.05.

Cookson Zenith Telescope. Observations with this telescope have been discontinued since 1940 September, when the instrument was partially dismantled. The measurement and reduction of the plates have been completed but their discussion, for the derivation of the latitude variation, has not yet been commenced.

From the discussion of the observations from 1911 to 1936 it was concluded that there was a wind effect on the measured north zenith distances, represented by 0″.0535 cos (θ-28°.5), where θ represents the wind direction, measured from north through east. An analysis of the observations with the Transit Circle, in the years 1915 to 1921, of declinations of stars south of the zenith, arranged according to the

two opposite prevailing winds, N to E and S to W (which correspond closely in the mean to the extreme values of the wind effect in the latitude variation observations) gives the following differences from the *Preliminary General Catalogue* of Boss:

Wind direction	Greenwich - Boss
N to E	+ 0".24 - 0".21 sin α - 0".02 cos α
S to W	+ 0 .14 - 0 .17 sin α - 0 .01 cos α

Thus the declinations are measured larger by about 0".10 when the wind is NE than when it is SW. This effect is of about the same magnitude and in the same sense as that given by the latitude variation observations.

This agreement indicates the importance, in fundamental positional astronomy, of applying latitude variations determined at the Observatory, in preference to those derived by the International Latitude Service. The effects of any systematic annual fluctuation in mean wind direction, which might introduce spurious annual or semi-annual terms, are thereby eliminated.

Thompson Equatorial. The policy of measuring plates that had been accumulated before the outbreak of the war, in view of the risk of the destruction of the plates by enemy action, has been maintained. During the year 325 plates have been measured, and the parallaxes of 13 stars have been determined. The measurement and reduction of the special plates obtained for the determination of the proper-motions in R.A. and Dec. of stars, whose parallaxes have been measured, have been continued. 60 fields have been measured and the reduction of the plates is well advanced.

5 spectrograms of Nova Lacertae 1936, have been lent to Dr. Brück of the Cambridge Observatory, for study.

Observations of Eros. The discussion of the whole of the material obtained around the favourable opposition of Eros in 1931 has been completed and published as a Memoir by the Royal Astronomical Society.

The final value of the solar parallax from the complete programme is 8".790 ± 0".001. This value is appreciably smaller than the value adopted by the Paris Conference of 1896, 8".80, and somewhat smaller than most recent determinations of the solar parallax. A value of 8".80 cannot be reconciled with the Eros observations, which show a satisfactory degree of internal consistency. The mass of the Earth, derived from the secular acceleration of the inner planets, corresponds, on the other hand, to a solar parallax smaller than 8".79. Differential atmospheric dispersion is a possible source of systematic error, but, since Eros is somewhat redder than the average comparison star, its general effect would be for the derived solar parallax to be somewhat too large. The low value of the parallax cannot therefore be explained in this way. A detailed discussion of the effects of difference in colour between Eros and the comparison stars shows that they are largely random in nature and small in the mean.

The disentangling of the lunar equation from the residuals of Eros, affected, as they are, by inhomogeneities in the reference star places, was difficult and several solutions were made, both from right ascension and declination observations. The final value of the coefficient of the lunar inequality is 6".4390 ± 0".0015. The ratio of the mass of the Earth to the mass of the Moon, inferred from the lunar inequality in conjunction with the value obtained for the solar parallax, is 81.277 ± 0.021. The constant of nutation can be inferred from the mass of the Moon and the

constant of precession. The value so derived was known not to be in agreement with the value given by direct determination; the new value of the mass of the Moon has not removed this discordance but has somewhat increased it. On the other hand, the Eros observations cannot possibly be reconciled with the value of the mass of the Moon inferred from the observed value of the nutation.

Photoheliograph. Photographs of the sun were obtained on 248 days. The number of photographs selected for preservation is 450 including 20 with double images for determination of the zero of position angle. The zero has also been determined regularly by a visual method.

From reports received from H.M. Astronomer at the Cape and from the Director of the Kodaikanal Observatory, five days appear unrepresented in the combined series for 1941.

The computation of spot positions and areas measured on the Greenwich plates have been made from 1939 September 19 to 1940 March 9, and areas alone up to 1940 August 26. The copy for press for the first six months of 1939 is being prepared.

The usual yearly abstract of tables of mean areas and mean positions of sunspots for the year 1938 has been communicated to the Royal Astronomical Society.

The computed times of central meridian passages of spots with areas of 500 millionths or greater have been notified, as soon as each spot appeared, to the Superintendent, Radio Research Station of the National Physical Laboratory, the Controller (Engineering) British Broadcasting Corporation, and the Engineer-in-Chief, Cable and Wireless Limited.

Sunspot frequency continues to decline generally, but there have been at least four notable periods of activity represented by big sunspots exceeding in peak area 1000 millionths of the sun's hemisphere. The extensive stream with central meridian passage on September 16.9 U.T. and the big single spot with C.M.P. on February 28.8, both reached 2000 millionths in area. These two giant groups were associated with "great" magnetic storms which began $1^{d}.3$ and $0^{d}.5$ after the respective times of central meridian passage of the group centres. More definitive data are given by the spectrohelioscope observations. Of the two other big spot groups with areas exceeding 1000 millionths, one was associated with a small magnetic storm. Of nine other spot groups with maximum areas between 500 and 1000 millionths, four were associated with magnetic storms of which one was the third "great" magnetic storm (July 4-5) recorded during the year.

Daily sunspot numbers based on Wolf's method of counting have been supplied to Professor Brunner for incorporation in the I.A.U. Solar Bulletin. Mean monthly values have been sent to several research centres in this country.

Spectrohelioscope. The spectrohelioscope was used on 162 days, but on 50 days observations for a few minutes only were possible owing to poor skies.

The observations were chiefly directed to the location of bright chromospheric eruptions (seen in Hα) especially any that might occur near sunspots in the central region of the disk.

122 measures of radial velocity were made, chiefly on bright and dark flocculi associated with sunspots. Photometric measures were also made on a number of normal bright flocculi and on the higher emission patches of eruptions.

24 bright eruptions were observed, of which two (September 17 and March 3) were of marked intensity. By far the most extensive in area was that on February 28, but its maximum brightness (central intensity peak) is known to have been missed owing to clouds. Solar phenomena associated with the "great" magnetic storms of September 18-20 and March 1-2 are described in communications to *The Observatory*.

The occurrence of a brilliant eruption and synchronous radio fade-out (also indicated by a typical movement on the magnetic traces) preceding both these "great" storms, provides a measure of the effective time of travel from sun to earth of the solar corpuscular stream, if it be assumed that the ejection took place near the time of peak intensity of the chromospheric eruption. The deduced time-interval is $20\frac{1}{2}$ hours for the September storm and $19\frac{1}{2}$ hours for the March storm. Similar interrelated phenomena give $18\frac{1}{2}$ hours as the time-interval for the "great" storm of 1941 February 28 - March 1.

The brightest eruption observed during the year was that on March 3 seen from $11^h\ 20^m$ to $12^h\ 00^m$ U.T. at a position 42° west of (i.e. past) the central meridian and preceding the great sunspot. The peak intensity rose to about $2\frac{1}{2}$ times the intensity of the continuous spectrun 15A from *Hα*. Emanating from the brilliant patch was a dark filament which appeared to cross the disk and to project beyond the limb as a prominence 3′ in height. The maximum values observed for the components of radial velocity were -130 to +145 km./sec. On April 13, another similar dark filament, also associated with a bright eruption 56° west of the sun's central meridian, had maximum measured velocities of -235 to +45 km./sec. Changes in appearance and in velocity were too rapid in both cases for detailed observation. In each case, a sudden radio fade-out was associated with the eruption.

A paper entitled "Characteristic Radial Motions of *Hα* Absorption Markings seen with Bright Eruptions on the Sun's Disk" was communicated to the Royal Astronomical Society at the March meeting. This paper includes observations made with the spectrohelioscope at Greenwich chiefly during 1936-39.

The Engineer-in-Chief, Cable and Wireless Limited, continues to notify the Observatory of the occurrence of radio fade-outs whilst in progress.

Quarterly returns of bright eruptions observed at Greenwich are sent to several research centres in this country as well as to Professor Brunner. Mr. M. A. Ellison, who observes with a spectrohelioscope at Sherborne, notifies the Observatory of any major chromospheric eruptions observed by him, in addition to sending his sunspot observations during the winter months.

The mirrors of the Coelostat were re-aluminised during December.

III. Time Service:-

The two time-service stations, referred to in the previous report as Stations A and B, have been maintained in full operation throughout the year. Each station maintains a complete time service, involving transit observations, clock comparisons and transmission of time signals along the Post Office lines to Rugby Radio and to the British Broadcasting Corporation. The time signals from Rugby are normally radiated from the station at which conditions happen to be most stable; instructions are given to the Engineer-in-Charge, Rugby Radio, which signals are to receive preference. If, because of any technical trouble developing at a station or on the line between it and Rugby, signals from only one station are received at Rugby, they are transmitted, whether that station was previously sending out the signals or not.

If the clocks are running equally well at the two stations, it is intended that the two stations shall alternate at approximately monthly intervals in sending out the signals.

During the period covered by this report, the Rugby time service has been operated continuously from station B, where the clocks are better mounted than at Station A, except on a few occasions when technical trouble at the station or line faults made it necessary for the signals from station A to be transmitted.

The "six-dots" time service to the British Broadcasting Corporation and the hourly signal transmissions to the Post Office, which also control the Talking Clock, have been normally operated from Station A. The service from station B has continued in full operation, although these signals have only been required occasionally.

Transit observations for the determination of clock error were made at station A on 116 nights and at station B on 137 nights during the year. The observations at the two stations have been combined for the determination of clock error, so that a total of 253 observations during the year is available. The relative personalities of the observers at station A have been determined from a special series of observations, in which observers were employed in pairs. The two observers observed the same transits, symmetrically on either side of the meridian, before and after reversal of the instrument. Errors in star places and errors of instrumental origin were thus eliminated. The personalities so determined were in good agreement with those obtained from the comparison of the residuals of the observations by different observers from the smoothed clock curves, Weighted means of the results of the two determinations have been adopted and applied from January 1.

Approximate personalities of the observers at station B have been determined from the residuals from the smoothed clock curves and have been adopted provisionally, pending the accumulation of further data.

The usual regular check on the rhythmic time signals transmitted from Rugby at 10^h and 18^h has been maintained at both stations. The comparisons of the clocks obtained by means of the reception times of the 10^h signals have served as the link between the two stations.

Both stations have recorded, whenever possible, the American and German time-signals on short waves as well as on long waves. Station A has also maintained a check on the French signals at 8^h. The published final corrections have been based on the reception times at the two stations, when both are available.

At each time station, the Rugby signals are recorded against three standard clocks and the signal transmitter. Two sets of ten signals , preferably near the beginning and end of the transmission, are measured for each clock, the chronograph pen units being interchanged in the middle of each set. This method reduces the effects of short period erratics in the clocks and provides a strong link between the two stations. The same method has been extended to the receptions of foreign time signals.

A regular check is kept on the B.B.C. six-pips time signals; also on the Westminster Clock, by recording the radio broadcasts of 'Big Ben'.

The errors of the clock Shortt 4 at the Royal Observatory, Edinburgh, and of the clocks Shortt 13, Quartz 2 and Quartz 6 at the National Physical Laboratory are determined by means of the Rugby time signals and the results are communicated daily.

This co-operation by the Astronomer Royal for Scotland and the Director of the National Physical Laboratory is of great assistance and is much appreciated.

The published ocrrections to the times of the Rugby time-signals and to the foreign time signals are based on some or all of nine clocks, - seven Shortt clocks and two Quartz clocks. The continuous operation of two stations and the large number of clocks concerned has greatly increased the amount of computation involved in the preparation of these corrections, which is undertaken at Station A. A simplified and improved method of dealing with the data has therefore been introduced. The transit observations from both stations are now referred to each clock in turn. The observed errors are plotted against an ephemeris for each clock. The clocks that have the most uniform rates are selected to form the mean clock. Smooth curves are drawn through the observed points as they appear on each chart. The several slightly differing systems of time defined by these curves are finally combined into a mean system, from which the error of any clock at any instant can be deduced. The process of determining the final corrections to the times of the signals has been made largely differential and graphical methods have appreciably reduced the amount of computation. It is also possible to remove one or more clocks from the mean or to introduce additional clocks without difficulty.

Some changes in the routine of signal transmission and reception at station B have resulted in a distinct advance in the standard of accuracy of the Rugby rhythmic time-signals. The changes of signal rate intentionally introduced have been restricted to a maximum figure of 3 milliseconds per day per day and have normally not exceeded 2 milliseconds per day per day. By working on a "mean clock" it has been found possible to impose this restriction and at the same time to keep the signals sufficiently close to the times indicated by the transit observations. The value of the uncorrected signals as a standard of frequency has thus been increased. Attention has been paid to the question of variation of lag of long-wave wireless reception and, by taking appropriate precautions, it has been found possible to reduce the probably error of such variations to less than 0.5 milliseconds. Provision has been made by the Post Office for a return signal by wire along the Post Office lines between the station and Rugby. The reception of these signals has given an extremely satisfactory means of checking the time of transmission of the signals along the lines. It is now possible to make an accurate allowance for line-lag in setting the transmitter clock before the time signals are sent out. Provision of a similar return signal to station A has not been possible.

At both stations, the action of the "hit and miss" sychroniser of the transmitting clock is suspended during the signal period and an appropriate current through the magnetic corrector coils compensates for the normal losing rate of the transmitting clock, when removed from the control of the free pendulum.

The measurement of the various time signals against the available clocks and the intercomparisons of clocks at both stations are made with the aid of thermionic panel units, developed and constructed at station A. These units eliminate the variations of lag that are associated with mechanical relays.

It has been mentioned that the clocks at station B have performed consistently better during the year than the clocks at station A. This latter station was brought into use at short notice when the time service had to be transferred from Greenwich at the time of the heavy raids on London in the autumn of 1940. The accommodation for the clocks is very restricted and there is serious mutual interference between them, giving rise to fluctuations in rate. The new building, referred to at the beginning of this report, will eliminate these troubles and enable a time service of satisfactory accuracy to be provided by this station.

At station B, an investigation has been made of the various types of clock erratics, which has given some results of interest. Amongst these, it has shown clearly the superiority of quartz clocks over the best free-pendulum clocks in the matter of small erratic changes of rate.

IV. Chronometers:-

Throughout the year the work of the Chronometer Depot was carried on without interruption in the premises to which it was transferred in March 1941.

For security purposes, fire resisting doors have been fitted on the first and second floor landings. A brick and concrete store, with thermostatically controlled heating, has been erected in the garden at some distance from the main building. A large portion of the stock of chronometers and watches held at the Depot, together with some of the spare parts required for use in the watch repair shop, are kept in this store.

A further workshop to accomodate three additional watch repairers, has been prepared in order to deal with the increase in the number of watches requiring overhaul.

A vibration machine capable of holding 18 watches, made in the Observatory workshop, has been brought into use for testing watches used on the instrument panels in aircraft.

The $3\frac{1}{2}$-inch Lorch lathe, mentioned in the previous report, has been mounted in the upper repair shop and has proved useful for many types of work.

After a period of satisfactory operation, the Gibbs watch-rate recorder developed trouble. Examination showed that this was due mainly to changes in the values of the resistors in the multivibrator circuits. A number of the valves were also below standard. After a further period of satisfactory operation, trouble developed in the phonic motor and the coils of this motor are now being rewound.

The watch repair shop has continued to prove of great value in maintaining an adequate supply of watches of all types, thus ensuring that all demands for navigational watches are met. These demands are becoming more varied and from time to time necessitate alterations to standard designs in order to meet new conditions of service. With the assistance of the watch repair shop, advice is given on the practicability of adapting watches for additional services and the production of samples is arranged when necessary.

The experiments carried out by Chapman and Lewis in 1912 to determine the effect of magnetic fields on the rates of chronometers and watches have been extended by tests at the time service station A. The chronometers and watches have been tested in the uniform field at the centre of a large pair of Helmholtz coils, in field strengths up to 8.5 gauss. Tests have been made with vertical fields and with horizontal fields, in various orientations and investigations of the effects of shielding have been tested. The tests, which have extended over several months, are nearing completion.

V. Nautical Almanac Office:-

The routine calculation and proof-reading involved in the preparation and printing of the publications for which the Office is responsible have been continued

throughout the year. At the beginning of the year the Office suffered from the printing delays arising from the destruction of the type and plates for all its publications, as reported last year; this was accentuated by the necessity for a change of printing contract, so that the arrears of printing approached a dangerous level. The new printer has, however, done his utmost to overcome the arrears and the present position shows a decided improvement over that of a year ago; this improvement will not however be apparent in the dates of publication until next year.

The Nautical Almanac. Publication of the *Nautical Almanac* for 1942 was delayed, through causes entirely outside the control of the Office, until November 3, less than two months before the date to which it refers, but the edition for 1943 was published on April 3 - an acceleration of seven months - and it is expected that the Almanac for 1944 will be issued about January 1943.

The Occultation Reduction Elements for 1942, omitted from the Almanac for that year, have been published separately in the United States, through the co-operation of Dr. Dirk Brouwer, Director of Yale University Observatory and Dr. W. J. Eckert, Director of the *American Ephemeris.* Copies have been distributed to those likely to require them.

The omissions from the Almanac for 1942 referred to in last year's report have been continued for 1943 and it is likely that the Almanac will be standardised in its present form for the duration of the war. The continued omission of the occultation reduction elements is due to a deliberate change of policy, and from 1943 onwards no further reduction elements will be computed.

The tables for differential aberration have been remodelled to allow of a simpler application of this correction with more concise tabulation.

There is no likelihood of the separate Supplement, to which reference was made in last year's Report, being published during the war, but the Almanac itself contains essentially all the information that is required for its use.

The first part of the *Nautical Almanac,* containing the ephemerides of the Sun, Moon and planets, is set in type in advance of the remainder; that for 1946 is now nearly complete and most of the necessary information has been circulated to those of the other ephemeris offices with which communication is still possible, in accordance with the arrangements for interchange to avoid duplication.

A small amount of additional work has been rendered necessary by the failure of communications, but difficulties in this direction have not yet led to any serious increase of work.

The Moon's longitude, latitude and horizontal parallax, as taken from Brown's *Tables of the Motion of the Moon,* are only available at present to 1950; the necessary data for extension to the year 2000 were punched on Hollerith cards some twelve years ago. It is intended that the necessary summations for another ten or fifteen years shall be performed in the near future, and preliminary steps to this end are now in hand.

Little further work has been done on the series of independent checks, though it is hoped to have a complete scheme in operation shortly.

Occultations and Eclipses. As foreshadowed in last year's report a complete change has been made in the provision for the reduction of observed occultations, resulting in the abandonment of the occultation reduction elements first introduced

for the year 1937. Although this change has been accelerated by the war and the necessity for restricting computation to necessary data, the same decision would have been reached eventually. A detailed analysis of the occultations observed in 1937, 1938 and 1939, for which, especially for the latter two years, normal results could be expected, shows that the majority of the computed reduction elements are never used owing to the particular occultation not being observed; of the remainder most are used once only. The amount of work involved in the computation of reduction elements for a particular occultation can only be justified if several observations are to be reduced; for one or two observations the total work involved is greater than that of reducing the observations individually.

Since 1937 the Nautical Almanac Office has provided occultation observers not only with predictions but also with the heaviest part of the reduction; while, therefore, it was clearly not possible to continue computing the reduction elements, it was felt that the Office continued to have a certain degree of responsibility towards observers. Careful analysis has shown that, even in a normal year, it will be possible for the Office to do the actual reductions for all observations of the stars for which prediction elements are given, with less work than computing reduction elements, provided observers will do that portion of the reduction depending solely on their position and that of the star. Details of the revised method are given in the Almanac for 1943, and fuller particulars, including the proposed schemes for the despatch of observations to the Office and combined publication of the reduced occultations will shortly be published in the *Astronomical Journal*. This revision of the programme has the approval of the President of the Sub-Commission on Occultations of the International Astronomical Union (Dr. Dirk Brouwer).

Accordingly, no reduction elements have been computed for 1943 or 1944, and the number of stations for which predictions are being made has been still further reduced because of the impossibility of distribution during war-time. Dr. Adams of the New Zealand Astronomical Society having volunteered to have the predictions for Wellington and Dunedin computed and published in New Zealand, machine times and other necessary material have been sent to him, and these predictions will be omitted from the *Nautical Almanac* for 1944.

The revised scheme of reduction makes it necessary to give further information with the elements of occultations. The N.Z.C. number of the star is now given and the star names have been omitted to allow for the inclusion of the right ascension and further figures in the declination. On the prediction pages contracted star names have been used and the N.Z.C. number inserted. These changes were introduced in the *Nautical Almanac* for 1943.

For 1944, elements of occultations for 1640 stars, not fainter than magnitude 6.5, were received from the Office of the *American Ephemeris*. From material also supplied by Washington, elements were computed in the Nautical Almanac Office for 877 stars between magnitudes 6.5 and 7.5. These stars were put through the occultation machine and preliminary times recorded for 78 stations for the 1306 stars that were retained. Computation is not quite completed but it is estimated that a further 50 to 60 stars will be excluded. There will be approximately 1250 stars published in the elements of occultations for 1944. Over 3000 prediction computations have been done during the year. Although few predictions are being completed, machine times will be available for transmission to stations concerned, if communication is possible before they are required.

It has not yet proved possible greatly to improve the machine times and it is doubtful if the machine is capable of much improvement in this respect.

No special eclipse calculations have been undertaken.

Abridged Nautical Almanac and Air Almanac. There has been no change in the *Abridged Nautical Almanac*; the 1943 Almanac was published on April 2, and it is expected that the edition for 1944 will be issued in October or November.

Five quarters of the *Air Almanac* have been published during the year, as follows:-

1941 Third Quarter	June 10
1941 Fourth Quarter	August 20
1942 First Quarter	October 23
1942 Second Quarter	December 3
1942 Third Quarter	March 17

The Fourth Quarter of 1942 is expected to be published during May.

From 1943 the *Air Almanac* is to be issued three times yearly instead of quarterly. The first part of 1943 is mostly in proof, the copy for almost all of the second has gone to the printer, while the preparation of the third is in hand.

A revision of the *Air Almanac* has recently been planned in conjunction with the Air Ministry; although the changes are small in principle they will result in greater simplicity in use at the small expense of a slightly larger page. The main improvement consists of standardising the interval of tabulation for all bodies at 10 minutes (the planets were previously given at hourly intervals only); this allows a redistribution of data on the two pages for each day, one of which can now be regarded as a "night" page and the other as a "day" page. Other smaller changes are also being incorporated. It is intended to introduce the revised form from the first part of 1944 onwards and the first steps towards forming copy are already in hand.

The *Astronomical Navigation Tables* have now been finally completed and issued.

Apparent Places of Fundamental Stars. The second volume, for 1942, was affected by the delay mentioned in last year's Report, and publication did not take place until October 7.

The computation, for 1943, and 1944, of the apparent places of the 426 10-day stars normally undertaken by France, has been completed, and all copy for the volume for 1943 has been sent to the printer. Proofs of the greater part of the volume have been received and it is hoped that publication will take place in July or August. As for 1942 the calculation of the 32 additional circumpolar stars, normally provided by France, was done in the Office of the *American Ephemeris*.

Copy for the volume for 1944 is already in hand, and the first pages will be sent to the printer about June; it is hoped that the volume will be published about May 1943.

Other Publications. The five-figure table of the natural trigonometrical functions for every 10″, prepared by the Office on behalf of the Ministry of Supply has now been issued, although it is not available for general sale.

Proof Reading. The amount of proof reading in the last year shows a decrease due to the completion of the *Astronomical Navigation Tables*. There have been 7,500 distinct readings representing 2,500 pages. The ratio of three readings to one page is due to the employment of junior staff on much of the proof reading. The position

during the year has occasionally been difficult, due to the intensive composition during the later months to compensate for the earlier lean months; in a normal year no great difficulty is expected with the present staff.

Repayment Work. There has been no significant increase in the volume of demands for lighting-up times, black-out times etc.; nearly 200 lists have been supplied, in addition to about 30 lists of Moon's phases and about 15 of moonrise and moonset. Amendments to these lists have been necessitated on several occasions by changes (often at short notice) in the Summer Time and Lighting Regulations.

Other astronomical information is occasionally supplied on the same basis of a small charge to cover cost of preparation and secretarial work.

Other Work. The additional work both for other departments of the Admiralty and for other Service Ministries has continued to increase. Most of this is purely computational, having no connection with astronomy or navigation. It is gratifying that it has been found possible to utilise both the staff and the machines, throughout the year, to their fullest capacity on work directly connected with the prosecution of the war.

During the latter part of 1940, the Office undertook, on behalf of the Air Ministry, the computation of the star curves used in the astrograph. The curves for all latitude bands were completed early in the year; new calculations for revised star pairs have recently been furnished for a number of bands. Various other astronomical calculations and investigations have been undertaken in connection with sea and air navigation. In particular, considerable time was spent on investigating the optimum method of star identification for the stars used in air navigation; this formed the basis for the present R.A.F. Star Charts.

Machines. No additions have been made to the mechanical equipment during the year.

VI. Magnetic Observations:-

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

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

The Observatory is indebted to the National Physical Laboratory for periodical re-measurement of the electrical constants of the potentiometers, which are essential accessories to the coil magnetometers. A complete re-measurement was made between April 8 and April 30. No appreciable difference from the values at present in use was found to have arisen since the measures were last made (January 1939).

The variations of declination and of horizontal and vertical intensity have been recorded photographically both on slow-run and quick-run recorders. Wide-range low sensitivity records of the variations of declination and of horizontal intensity have been regularly obtained.

The base-line values of the la Cour magnetographs are remarkably steady. The monthly ranges of observed base-line values do not normally exceed $0'.1$ in declination, 3γ in horizontal intensity and 5γ in vertical intensity. The greater part of

these ranges arises from uncertainties in the absolute observations caused by disturbances from electric trains. The smallness of the ranges is an indication both of the accuracy and consistency of the absolute observations with the coil magnetometers, and of the satisfactory design of the magnetographs.

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 1941 December 31, and with provisional constants to the present time.

The manuscript copy of the "Results of Magnetic and Meteorological Observations" for 1938 and 1939 was prepared for printing in due course. The copy for 1940 is also ready, except the Introduction, which is not yet written.

The tabulation of results for 1941 awaits chiefly the receipt of the list of International "quiet" and "disturbed" days, the preparation being otherwise in an advanced state.

The mean values of the magnetic elements at Abinger for the year 1941 are given below. The values for the years 1938, 1939 and 1940 are given for comparison.

	Decl. W.	Horizontal Intensity	Vertical Intensity	Inclination
1938	11° 1′.4	0.18522	0.43050	66° 43′.2
1939	10° 51′.9	0.18528	0.43074	66° 43′.5
1940	10° 43′.0	0.18533	0.43099	66° 43′.9
1941	10° 33′.8	0.18539	0.43128	66° 44′.3

The weekly report of mean hourly values of declination has been sent regularly to several offices for publication or information - a service maintained in conjunction with Eskdalemuir Observatory.

During the past twelve months there have been 12 magnetic disturbances reaching the dimensions of a "storm", three of which have been classified as "great storm". (A range of 30′ in declination or 150γ in horizontal intensity is considered the lower limit for a "storm"; 60′ or 300γ for a "great storm").

Magnetic charts showing the iso-magnetic lines in declination, horizontal intensity, inclination and vertical intensity are being prepared for the Admiralty. The charts of declination have been completed; those for the other components are well advanced. The previous edition of the declination charts was published in 1937; the previous editions of charts of horizontal intensity and inclination were published in 1922. Charts of vertical intensity have not previously been prepared.

VII. Meteorological Observations:-

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

The tabulation of meteorological results for 1941 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 1942 April 30.

The mean temperature was 49°.0 which is 0°.5 lower than the average of 75 years 1841-1915. The highest temperature in the shade was 91°.4 registered on July 8. Temperatures exceeding 80° were recorded on 19 days. The lowest temperature was 14°.9 on January 21. Temperatures of freezing point or below were recorded on 73 days, two of which were in May. The mean temperature for the month of January 1942 was 5°.1 below the average, for Feburary, 7°.4 below the average, and for May, 3°.9 below the average. Taken together, the months of January and February had a mean temperature lower than in any year since 1895. The number of days in February on which temperatures below 32° occurred was 26, which is the largest number ever recorded at Greenwich in that month.

The mean daily horizontal movement of the air was 247 miles, which is 10 miles below the average for 50 years 1867-1916. The greatest daily movement occurred on October 18 and was estimated to have been about 600 miles. The least daily movement was 86 miles on May 30. The greatest pressure reached was 21.0 lbs. to the square foot on April 28.

The record of air movement on October 18 is incomplete, because soon after 12 hours the Robinson anemometer was blown over and fell to the roof below. Apparently the revolution counting mechanism in its heavy metal box had been shaken loose by vibration at some previous time so that the box was held to its base by one screw only, which sheared under sudden strain. Opportunity was taken to carry out extensive renovation in addition to the necessary repairs. This was done in the workshop and the instrument was put into operation again on October 30.

The duration of *bright* sunshine recorded was 1317.4 hours, or 29.4 per cent. of the possible total. There were 90 entirely sunless days, 73 being in the five months November to March. No day in April was entirely sunless. There were 42 cloudless nights in the period, that is, nights on which a complete unbroken trace was obtained by the night-sky camera. The number of nights on which no trace of δ Ursæ Minoris appeared on the plates was 108 (against 82 last year), while on a further 39 nights the record was not more than 10 per cent. of the whole time of exposure.

The four winter months November to February were conspicuous for cloudiness. 50 nights were completely overcast and no sunshine was recorded on 62 days. The total amount of sunshine registered during these four months was 102.2 hours, that is only 55 per cent. of the average of 40 years 1897-1936.

The total rainfall during the period was 22.88 inches, that is 1.36 inches less than the average of 75 years 1841-1915. There were 131 days on which rainfall amounting to 0.005 inch or more was recorded.

The wettest month was August with 4.146 inches; the driest month, September with 0.689 inch. Taken together, September and October, with only 1.41 inches provided the lowest total in these two months ever recorded at Greenwich.

VIII. Printing and Distribution of Greenwich Publications:-

1. The distribution of *Greenwich Observations* for 1936, of *Observations made with the Cookson Floating Telescope, 1927-36 and Determination of the Variation of Latitude* and of the *Catalogue of 20554 Faint Stars in Cape Astrographic Zones -40° to -52°;* has been extended to observatories and institutions in the British Dominions

and Colonies, the United States and certain neutral countries. The distribution was made in small consignments, spread over several months and acknowledgment cards are coming through satisfactorily.

2. The MSS. for *Greenwich Observations* 1937 to 1941 are in preparation. No steps are being taken at present to proceed with the printing of these volumes.

IX. Personal Establishment:-

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

(a) Observatory Staff

Chief Assistants	- R. d'E. Atkinson, M.A., Ph.D. H. R. Hulme, M.A., Ph.D.
Assistants	- R. T. Cullen, A. Hunter, Ph.D., P. J. Melotte, H. M. Smith, B.Sc., A.M.I.E.E. W. M. Witchell, B.Sc.
Junior Assistants (Higher Grade)	- H. W. Acton, E. A. Chamberlain, F. Jeffries, E. G. Martin, H. W. Newton, G. W. Rickett, L. S. T. Symms
Junior Assistants	- H. H. J. Barton, K. C. Blackwell, H. F. Finch, B.Sc., C. C. Harris, T. W. W. Hodgson (on active service), P. S. Laurie, B. R. Leaton (on active service), P. L. Rickerby, J. L. Rudd, A. Shortland, R. H. Tucker, G. F. Wells
Head of Repair Shop	- H. Warden
Secretary and Cashier	- H. G. Barker
Clerical Officer	- N. J. Miller (on active service)
Clerical Assistants	- Miss J. Auckland, Miss F. E. A. Jeffries
Established Typist	- Miss C. M. Carr
Temporary Observing Assistant	- V. Barocas, Ph.D.
Temporary Junior Assistant	- Mrs. C. M. Bolus
Temporary Clerks	- Miss D. A. Bush, D. Oliver, N. S. C. Rhodes, Mrs. M. E. Higby, Mrs. R. Shortland
Temporary Typist	- Mrs. B. H. Upfold

(b) Nautical Almanac Office Staff

Chief Assistant as Superintendent	- D. H. Sadler, M.A.
Assistants	- Miss F. M. McBain, M.A., H. W. P. Richards, B.Sc.
Temporary Assistant (Special)	- R. H. Corkan, M.Sc.

Junior Assistants (Higher Grade)	- A. J. Daniels, S. G. Daniels W. A. Scott, B.Sc.
Junior Assistants	- A. E. Carter, W. G. Grimwood, G. A. Harding (on active service), Miss V. H. Hitches, Miss J. E. Pullen, Miss M. R. Rodgers, Miss M. C. Scadeng, E. Smith
Clerical Assistants	- Miss G. E. Jackson, Miss J. Mounteney, Miss V. F. Peasgood, Miss M. B. Simm, Miss R. E. West,
Temporary Clerk, Grade III	- Miss K. M. Restorick
Junior Assistant as Secretary	- Miss D. J. Ifield
Shorthand-Typist	- Miss M. N. Height

Dr. R. d'E. Atkinson and Dr. H. R. Hulme, Chief Assistants, and Dr. A. Hunter, Assistant, have been loaned for special work in other Departments of the Admiralty.

Mr. N. J. Miller, Clerical Officer, Mr. B. R. Leaton and Mr. T. W. W. Hodgson, Junior Assistants of the Royal Observatory Staff and Mr. G. A. Harding, Junior Assistant of the Nautical Almanac Office Staff have joined H. M. Forces.

Mr. L. S. T. Symms, Junior Assistant, Lower Grade, has been appointed to the Higher Grade in an acting capacity.

Mr. R. H. Corkan, M.Sc., Chief Assistant at the Liverpool Tidal Institute, was appointed Temporary Assistant (Special) on 21st July.

Dr. V. Barocas was appointed to the staff of the Royal Observatory on August 13 with the rank of Temporary Observing Assistant.

The staff of workmen employed at the Observatory consists of a Foreman of Observatory, two joiners, five watch repairers and adjusters in the watch repairing department, a gate porter, three messengers, five labourers and two charwomen. There is also a caretaker-mechanic at Abinger, a messenger at the Nautical Almanac Office, and a caretaker and a messenger at the Chronometer Depot. A skilled mechanic has been lent for duty at the Admiralty Research Laboratory, Teddington.

M. N. V. Pushkov, with the other members of the scientific mission from the U.S.S.R., visited the Royal Observatory on February 27. M. Pushkov visited the Magnetic Observatory, Abinger, on March 23.

H. SPENCER JONES,
Astronomer Royal.

Royal Observatory, Greenwich.
1942 May 14.

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