REPORT

OF THE

ASTRONOMER ROYAL

TO THE

BOARD OF VISITORS

OF THE

ROYAL OBSERVATORY, GREENWICH.

Read at the Annual Visitation of the Royal Observatory, 1944 June 3.

THE BOARD OF VISITORS

The President of the Royal Society.	Sir Henry Dale.	
The President of the Royal Astronomical Society.	Prof. E. A. Milne.	
		To serve until June 30th
Nominated as Fellows of the Royal Society.	Sir Charles Darwin.	1944
	Sir Thomas Merton.	1945
	Sir James Jeans.	1946
	Sir George Simpson.	1947
	Prof. P. M. S. Blackett.	1948
	Dr. G. M. B. Dobson.	1949
Nominated as Fellows of the Royal Astronomical Society.	Dr. R. Stoneley.	1944
	Prof. W. M. Smart.	1945
	Prof. W. M. H. Greaves.	1946
	J. H. Reynolds, Esq.	1947
	Prof. H. Dingle.	1948
	Prof. W. H. McCrea.	1949
Savilian Professor of Astronomy at Oxford.	Prof. H. H. Plaskett.	
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The Report here presented refers to the period from 1943 May 1 to 1944 April 30 and exhibits the state of the Observatory on the last named day.

I. BUILDINGS, GROUNDS, MOVABLE PROPERTY AND LIBRARY.

No further damage by enemy action has been sustained during the year. Plate glass is being restored to windows broken in 1940, belonging to parts of the Main Building. The Ball Lobby has been redistempered and cleaned and woodwork on the roof of the Octagon Room coated with preservative. Re-labelling of books in the Library has been continued throughout the year. A regular inspection of instruments the use of which is temporarily discontinued has been made and steps taken where necessary to preserve their condition.

A new workshop was erected at Station A in October to cope with the increased demand for constructional work and apparatus needed by the Time Department.

Enlargement of the accommodation needed for the Time Department at Station A has continued throughout the year. One building equipped for use as a laboratory and for temporary office accommodation has been completed and put into use, and the construction of a second building to contain clock cellars, for the new quartz clock equipment, and permanent office accommodation, has been approved. It is now in course of erection and completion within the next few months is anticipated.

A bench grinder has been added to the equipment at Station A and a portable high speed drill with flexible drive has been constructed in the workshop.

One of the two-pen chronographs, constructed in the workshop, has been converted to give double speed, making the scale 100 mm. per sec.

Various mains units and chassis with component parts for rack mounting have been constructed in the workshop as equipment for the Time Department.

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.

Harrison's Time Machines Nos. 1, 2, 3 and 4 and the copy of No.4 by Larcum Kendall, nominally on loan to the National Maritime Museum, were removed to and stored in a place of safety on the outbreak of war, with the exception of No.3, which Lieut. Comdr. Rupert T. Gould R.N. (Retd.) has dismantled and is engaged, as opportunity permits, in the process of cleaning and re-assembling.

A portion of the optical and other equipment which was removed early in the war from the Observatory to a place of greater safety has been brought back; the remainder is for the present stored elsewhere.

The annual examination of the Observatory Library has been made. 20 books are missing and cannot be traced at present. Of these 15 were reported missing last year.

II. ASTRONOMICAL OBSERVATIONS.

Airy Transit Circle. A very restricted programme of observations has been maintained throughout the year. In all, 866 transits and 713 zenith distances were

observed of stars in the clock and azimuth lists. The Cottingham clock, with Riefler escapement, is used as the standard clock in connection with these observations. The observations also include

107	observations	of	the Sun
15	"	"	Venus
6	"	"	Mars
2	"	"	Jupiter
2	"	"	Saturn
1	"	"	Uranus
1	"	"	Vesta

The programme undertaken for improving the observation of collimation has been completed. Hitherto the observation has been possible only in daylight and was often extremely difficult. Apparatus including reflectors and artificial illumination has been constructed in the workshop and installed. The observation can now be made under uniform conditions at any time of the day or night and the difficulty of the observation is much reduced. Investigations of the diurnal changes in collimation are in progress.

Since the last report the bearings on the east pier have been raised twice. Until 1923 the level, apart from diurnal and annual variations, had remained very steady. In that year the east pier began to sink and from then to the present year it has been necessary to raise the east bearings 16 times, amounting in all to 250 seconds of arc; the east pier has thus sunk relatively to the west pier by approximately 1/12 inch in 21 years.

First Greenwich Catalogue of Stars for 1950. Observations for this catalogue extend over the period 1931-1940.

The examination of discordant observations led to the detection of errors affecting the R.A.'s varying with declination, introduced by the method employed in reading the transits from the chronographic records.

Since the introduction of the impersonal micrometer the registrations of transits are made by metal studs passing a fixed contact spring. All R.A.'s had been reduced from readings corresponding to the estimated centres of the studs.

When comparisons were made from readings taken at the beginning of the studs reduced to the centre, differences varying with the recorded breadth of stud were shown.

During the period 1931-1940 the transits were read by two persons, one from 1931 to 1934 Nov., the other from 1934 Nov. to 1940. Differences similar in character but considerably different in amount were given by each person. As the method of reading the beginning of the stud is uniform throughout and independent of fluctuations affecting the recorded breadth of the stud, the R.A.'s of this catalogue will be based on that system, and the necessary corrections applied accordingly.

These corrections taken from a smooth curve through the plotted values are as follows:-

Corrections to Right Ascensions

Dec.	Above pole		Below pole	
	1931 to 1934 Nov.	1934 Nov. to 1940.	1931 to 1934 Nov.	1934 Nov. to 1940.
°	s	s	s	s
+85	-.050	-.009	-.028	-.004
+80	-.037	-.006	-.020	-.001
+75	-.025	-.004	-.014	+.002
+70	-.018	-.002	-.011	+.003
+65	-.014	-.001	-.008	+.004
+60	-.010	+.001	-.006	+.004
+55	-.008	+.002	-.004	+.004
+50	-.006	+.002	-.003	+.003
+45	-.004	+.002	-.003	+.002
+40	-.002	+.001		
+35	-.001	+.001		
+30	.000	.000		

Below +30° no corrections are necessary.

Final places for 1950 have now been determined for stars in the zone +0° to +24° as far as 16^h R.A.

Places of stars in the first 12^h of R.A. of stars and between the equator and 21°N declination have been forwarded to Professor Brouwer, Director of the Yale Observatory, for use in the reduction of photographic plates taken at Yale with the wide-angle lens camera.

Reversible Transit Circle. A paper has been prepared for the Royal Astronomical Society giving an account of the preliminary tests of this instrument from its installation in 1936 to 1940 September, when observations had to be discontinued. The annual variations in level and azimuth are satisfactorily small, of the order of 1".5. The diurnal changes in azimuth, which in the absence of azimuth marks are difficult to control satisfactorily, appear to be small. The diurnal changes in level can be reduced by better thermal insulation of the piers. The collimation, under steady temperature conditions, shows a small dependence upon temperature; under conditions of changing temperature, the diurnal variation in collimation can reach 0".5. The observations have emphasised the importance of accurate control of the variations in collimation. Some conclusions are reached about the housing of meridian instruments.

Occultations. Two occultations were observed during the year.

Cookson Zenith Telescope. The observations made with this instrument according to the new programme from 1936 July, when the instrument was remounted on a site adjacent to the reversible transit circle, until 1940 September, when the instrument was partially dismantled and observations were suspended, have been reduced and the variations of latitude derived. The results have been communicated to the Royal Astronomical Society. The predominance during this period of the yearly component of the latitude variation over the 14-monthly component is noticeable. This is confirmed by the results of the International Latitude Service.

Investigations have been carried out to throw some light on the increased number of large residuals (of 1″ or greater) shown by the observations of recent years. The large residuals are found to be associated predominantly with a setting of the telescope so that, when more pairs than one are observed with the same setting, with rotations of the telescope between, the pairs that do not involve a setting of the telescope rarely show a large residual. It was therefore considered probable that anomalous surface tension effects might be responsible for the large residuals. A sensitive bubble was mounted across the annular float and series of observations of the displacement of the bubble after re-setting or reversing the telescope have been made. Though displacements of the order of one second of arc have occasionally been observed, the frequency of large residuals in the observations remains unexplained. The investigations have shown the sensitiveness of the instrument to wind effects; it is a necessary disadvantage of a floating instrument that, if the instrument is housed so that refraction anomalies are unlikely to occur, it is liable to be displaced by variable winds; whilst, if it is completely protected against possible displacement by wind, refraction anomalies are to be expected.

Photographic Zenith Tube. The construction of a photographic zenith tube has been sanctioned by the Admiralty and careful consideration has been given to the design of the instrument. The design is a considerably modified version of that of the photographic zenith tube of the U.S. Naval Observatory, Washington. This instrument, designed in the first place for the determination of the variation of latitude, has been adapted at Washington for the determination of time. The essential principle of the instrument is the same as that of the reflex zenith tube, designed by Airy and used at Greenwich for many years; the converging light from a star is reflected at a mercury surface, whose position is such that the light is brought to a focus at the second Gaussian point of the objective. The instrument is then insensitive to errors of level. By placing the flint component of the objective uppermost and by suitable separation of the two components, the second Gaussian point is brought below the objective, where a photographic plate can be placed. The objective and plate can be rotated through 180° and, from observations made symmetrically before and after meridian transit, measurements in the two co-ordinates enable both time and latitude variation to be determined. The primary purpose of the new instrument for the Royal Observatory is to enable time to be determined with a much higher precision than is possible with a transit instrument. The Superintendent of the U.S. Naval Observatory has kindly communicated full details of the adaptations made at Washington to enable the photographic zenith tube to be utilised for time determinations. The Greenwich instrument will have a clear aperture of 10-inches and a focal length of 11 ft. 3 ins. giving a scale of one minute of arc to one millimetre. The general principles of the design have been decided, but various points of detail have to be settled. The telescope will be constructed by Sir Howard Grubb, Parsons and Co.

Thompson Equatorial. 191 plates have been measured for the determination of stellar parallax, and the parallaxes of two stars have been derived.

Photoheliograph. Photographs of the sun were obtained on 253 days. The number of photographs selected for preservation is 481 including 19 with double images for determination of the zero of position. 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, two days are unrepresented in the combined series (Greenwich, Cape and Kodaikanal) for 1943. During the year, 246 Greenwich plates have been measured, covering the period 1941 October 20 to 1943 February 19.

The copy for press for 1939 has been prepared as far as possible without the requisite Cape and Kodaikanal photographs for the second half of the year. Arrangements have been made with H.M. Astronomer at the Cape for the Cape plates required to fill the gaps in the Greenwich series for 1939 and 1940 to be forwarded as soon as possible after the end of hostilities in Europe.

Computations of positions and areas of sunspots have been completed from the Greenwich plates covering the period 1941 June 27 to 1942 October 21.

Arrangements still hold for the central meridian passage time of large sunspots (> 500 millionths of the sun's hemisphere) to be reported without delay to the Superintendent, Radio Research Station, Slough, and to Cable and Wireless, Limited. Four such sunspots were reported. Similarly, sunspots of area > 200 millionths have been notified to the Controller (Engineering), British Broadcasting Corporation. For a trial period near sunspot minimum, commencing August 1, the times of central meridian passage of all spots are being reported to the B.B.C.

Sunspot frequency in general has slowly fallen during the twelve months, the mean sunspot number being 10 as compared with 21 for the preceding twelve monthly period. No sunspots were recorded at Greenwich during February, and only one very small spot, seen on two days, during April. The epoch of solar minimum seems now to have been reached, but may well continue for several months. The first definite high-latitude spot group of the coming cycle was seen from May 16 to 20 in latitude 41° south. In contrast to the diminishing frequency of sunspots and their associated phenomena, geomagnetic activity was considerable, including one great storm and a number of smaller ones, the latter including a persistent 27-day sequence.

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

Mr. M. A. Ellison has continued to send to Greenwich copies of his sunspot drawings as they were made during the winter months.

Spectrohelioscope. This instrument was used on 151 days, but on 42 days observations were limited to a few minutes because of poor seeing conditions. The frequency of observable phenomena in *Hα* on the observing programme has fallen considerably. 132 measures were made of line-of-sight velocities of bright and dark flocculi; 57 of these measures provide equivalent line widths of *Hα* over bright flocculi. Photometer measures were made on nine patches of bright flocculi.

Only two bright chromospheric eruptions (solar flares) were observed, neither being of major importance. The present infrequency of flares, particularly those of great intensity is reflected in the data of radio fade-outs reported by Cable and Wireless Limited. Only five fade-outs of the "ionospheric irruption" type were recorded during the year as compared with 15 in the previous 12-monthly period, and 74 and 98 during the maximum years of 1937 and 1938. It is of interest that one of the recent fade-outs, lasting for more than 1½ hours, occurred on February 10 during a period when collective observations showed not a single sunspot. No spectroscopic observations of the sun have come to hand to show whether a major solar flare did actually occur unassociated with a sunspot.

A paper dealing with the association of intense solar flares and geomagnetic storms occurring about a day later has been completed and published in the *Monthly Notices.* A second paper extending the examination to flares of lesser intensity and also including data of fade-outs is being published by the Royal Astronomical Society.

III. TIME SERVICE.

Throughout the year the time service has again been maintained from two stations, designated A and B. Each of the two stations is a self-contained unit, but the work of the two stations is closely co-ordinated. Signals from the clocks at either station can be recorded at the other station by means of the inter-station line, which forms a direct link between the two stations. For this purpose it was necessary to devise a rapid and accurate method of determining the lag of the inter-station line. This line consists of one channel each way in an 18-channel voice frequency carrier system, normally used for teleprinter traffic. At each station a key is fitted, by means of which the send and receive lines may be connected: an incoming signal is then returned to its station of origin. By direct looping of the line at station B and by passing the signal at station A through a relay, so that a signal of normal strength is sent to station B, a signal introduced into the loop will continue to circulate, provided the adjustments on the Post Office carrier system are accurate. By monitoring the signals at both stations over 100 complete loops, the average time for one loop is obtained with high precision. It is then assumed that half the loop lag is the lag involved in sending the signal either way: this may not be strictly accurate, but the main purpose is to control variations in lag. The standard of line adjustment required to enable the signal to continue to circulate is higher than for normal traffic, and the Telegraph Branch of the Post Office has been very helpful in keeping the channel well adjusted.

During the year, three quartz controlled frequency standards have been installed. These are of the Post Office group IV type, in which a GT-cut crystal is maintained in oscillation at 100 kilocycles per second by a bridge drive circuit, which reduces to a minimum the effects of variations in the supply voltages. The crystals are mounted in thermostatically controlled ovens, and the temperature range permitted by the modified Turner Circuit employed ensures that variations in frequency from this cause may be neglected. Regenerative dividers are used to provide an output at 1000 cycles per second to operate phonic motors designed and constructed by Muirhead and Co., Ltd. One standard installed at each station is equipped with motors having a 60:61 gearing, to provide rhythmic contacts for the purposes of the vernier time signal transmissions. These motors are also fitted with phasing controls, by which the rate of the controlling frequency standard may be compensated and the contacts set early to allow for the travel time of the signals over the land lines to the radio transmitting stations. The phasing controls have open scales graduated in tenths of a millisecond. The third standard, installed at station A, has a plain phonic motor, provided with seconds contacts.

The 10^h Rugby signals are normally controlled from the station at which the transmitting clock and the line to the radio station were the more stable; the 18^h signals are controlled from the station that acts as reserve for the 10^h signals. The first phonic motor transmitter to be received was installed at station B, and was brought into use almost immediately for the control of the rhythmic time signals. The 10^h signals have been operated from phonic motors since 26th February 1944 and the 18^h signals from 10th March. The introduction of phonic motor transmitting clocks has provided accurately spaced signals. The irregularities in the spacing of the signal dots from the pendulum transmitters previously used was such that it was necessary to measure identical sets of signals in the five minute series at the two stations in order to separate the discrepancies arising from irregular spacing of the signals from the erratics of radio reception and measurement. This expedient permitted more accurate comparisons between the two stations, but did not assist other users of the signals. A more serious source of error in the pendulum transmitting clocks was their tendency to wander by an unpredictable amount after

they had been set and checked, thus putting the signals in error by an amount that might be as large as five milliseconds; the high short-period stability of the quartz controlled phonic motors has reduced such errors to negligible amounts.

In order to provide a regular check on line-lag, the station that did not control the actual time signal from the Rugby station sends out a short series of dots immediately after the conclusion of the time-signal. These dots are checked back against the transmitting motor and thus give a measure of the lag of the line.

During the period from 1st April to 14th November, the build-up time of the transmitted signal was longer than normal and both field strength and build-up time were subject to greater variations, with consequent increase in reception errors. From 3rd to 6th July and from 24th September to 14th November, the signals were transmitted on a frequency of 15.46 kc/s., instead of the customary 16.00 kc/s. The rhythmic time-signals at 10^h and 18^h have been regularly transmitted on a group of short-wave transmitters, in addition to the long-wave transmissions.

The six-dots time-signals radiated by the British Broadcasting Corporation have been normally operated from station A, with station B acting as reserve. In addition to many transmissions on short waves, the number of transmissions on the medium wave programmes has been substantially increased in the current schedules. These signals are widely used and serve many useful purposes at the present time. The six-dots signals are also radiated hourly, with the exception of 10^h and 18^h, by three Admiralty stations on medium waves, to which are coupled stations on short waves, for the use of coastal shipping. The service of hourly signals to the Post Office, which provide also the control of the Talking Clock, has been maintained from both stations.

The number of transit observations during the year, which have been used for the determination of the finally adopted time, was 184 at station A and 116 at station B. The observations have been combined for the determination of the clock errors at both stations. With better clocks available the scatter of the transit observations has become more apparent and transits have been combined in groups of five for convenience.

The regular check on the 10^h and 18^h Rugby signals has been maintained at both stations. The short-wave signals have been recorded mainly at station A, where better aerial facilities are available and where reception is more reliable. Both stations have recorded, when possible, the short-wave American signals from NSS, which are controlled by the U.S. Naval Observatory; the German time-signals radiated at 12^h from DFY on the long wave-band and from DFC on the short wave-band have also been recorded. Station A has maintained a check on the French signals at 8^h. Some receptions have also been obtained of the Russian time-signals from Sverdlovsk and Tashkent, at 17^h from RPT and at 16^h from RSN. The American broadcasts from WWV, which are in the form of a standard frequency transmission on frequencies of 2.5, 5, 10 and 15 megacycles per second, modulated at 4,000 and 440 cycles per second, with seconds interval signals of five milliseconds duration, have been recorded at station A at intervals throughout the day whenever reception conditions permitted. These signals, controlled by the Bureau of Standards, Washington, are radiated all day. A remarkable degree of agreement has been noted in comparisons of both frequency and time; as a time signal, this form of transmission appears to be capable of a very high standard of precision and to be well adapted for accurate comparisons.

The determination of final corrections to the received times of British and foreign time-signals has been continued at station A, but the publication of the results has been delayed in order that full advantage might be taken of the improved running of the clocks, and the consequent smoothing of the effects of the scatter of the astronomical observations which is thus made possible. The preparation of these corrections is now complete to the end of 1943.

The time service is still being based fundamentally on the comparisons between the transit observations and the Post Office group IV standards, because the three quartz controlled frequency standards installed at the two time stations cannot be used as primary standards until the ageing of the crystals is complete. Intercomparisons between the Post Office clocks and the Observatory clocks are still possible only by means of the radio-link provided by the Rugby signals at 10^h. In order to eliminate the errors of radio reception, a direct line link has been installed between station A and the Radio Branch Laboratories. Unexpected difficulties have been encountered in using this line for clock-signals, but it is hoped that these will be shortly overcome. The figures communicated daily by the Radio Branch have been supplemented by information on relative rates, derived from automatic beat counters in operation between each pair of standards. These relative rates give, by integration, accurate intercomparisons of clock errors. Similar beat counters, of Post Office design and construction, will be incorporated in the Observatory installation. The Post Office standards are mains operated and complete stoppages of all the standards have been frequent. For long period prediction work, uninterrupted runs of many months are essential. The Radio Branch have now transferred their clocks to floating battery operation and it is hoped that stoppages involving all the standards will rarely occur. In order to provide the Post Office Radio Branch with the latest possible information on the performance of their primary standards of frequency, estimates of the rate of the standard IVA are communicated weekly and are based on the current charts of the performance of the various standards and on the most up to date transit observations.

The errors of the clock Shortt 4 at the Royal Observatory, Edinburgh, and of the clocks Shortt 13, Quartz 2, and Quartz 6 - until the latter stopped in July - at the National Physical Laboratory, have been determined by means of the Rugby signals at 10^h and the results communicated daily. These results have been of the greatest value during the period that the service has been based on a mean of Shortt clocks. The results for Shortt 4 are now communicated monthly. The results for the clock Quartz 2 at the National Physical Laboratory are still received daily; this clock, though more liable to slight variations of rate than the group IV standards, has been very helpful in the determination of discontinuities, when the Post Office standards have stopped. Its value for this purpose has been enhanced by the considerable improvement effected in the reception and recording arrangements at the Laboratory. It has also been of much value in the determination of final corrections.

Some of the free pendulum clocks have been stopped; others, that have been left running, are not regularly compared. As time signals are required to be transmitted at definite mean times, the fundamental time standards for time service purposes are rated to mean time. Clocks rated to sidereal time are required only for comparison with transit observations, where the use of meantime clocks would be inconvenient. A number of free pendulum clocks and also the quartz clock Q3 at station A are used for this purpose but, by means of comparisons with the mean time standards taken immediately before and after each time observation, the observed clock errors are transferred to the mean time standards. Phonic motors now under construction are being provided with gearing which will operate contacts every sidereal second and

every mean time second, when the motor is driven by a mean time standard. An exact gearing is not required; an approximate ratio merely introduces a small uniform rate into the sidereal clock thus made available for transit observing.

Two decimal counter chronographs, of the type referred to in last year's report, have been received and installed at station A. These counters give an immediate indication, to an accuracy of ten microseconds, of the time interval between two electrical impulses. Subsidiary trigger circuits were necessary before the counters would operate successfully on signals from Synchronome clocks and another type of drive circuit has been made for operating the counters on received wireless time signals. Both counters have been modified to enable them to operate from a 100 kc/s output from one of the quartz standards, instead of from their internal source. They have also been adapted to sum up a series of ten intervals and thus to give a mean measure in units of a microsecond. They have recently been applied to the measurement of received wireless time signals. One unexpected result has been noted; signals, which have given very poor records on the standard form of tape chronograph, have operated the counter satisfactorily.

A new building is in course of construction at station A to house the quartz standards already delivered (which are temporarily housed in an existing building) and others under construction. These standards will be operated in groups, each of three primary oscillators. Each group will be provided with a separate dual-float battery system as a precaution against stoppages affecting more than one group at a time. To guard against long stoppages of the mains supply, a petrol-electric set is available at station A and a diesel-electric set at station B. The emergency A.C. supply system at station A, referred to in the previous report, is still incomplete, but it is expected that it will shortly be finished. It will then serve as a stand-by plant for the operation of the oven circuits, for which alternating current is essential.

It is of interest to review the improvement in the Time Service which has already been effected by the introduction of quartz controlled clocks at the Observatory stations, and to attempt to forecast the prospects of further improvement. The performance of the service of signals radiated by the Post Office 16 kilocycle transmitter at Rugby can conveniently be separated into long term performance and superimposed fluctuations of short period. With the errors at present inherent in transit observations good long term performance requires that the service should be based on a battery of clocks which are so good that over periods of the order of three months all changes of rate in the clocks can be detected and evaluated by clock inter-comparisons alone, and that transit observations should be employed only for determining errors and rates, but not changes of rate. It is also necessary that the frequency drifts of the crystals should remain sensibly constant over much longer periods. If these requirements are satisfied, then by averaging signal receptions over periods of a fortnight or more any good substandard of frequency could be calibrated with an accuracy of one part in 10^9. But if this accuracy is to be achieved it is essential that precautions should be taken against stoppages of the cyrstals operating the primary clocks, as such stoppages are apt to produce changes both of rate and of frequency drift. Up to now all the primary clocks have been situated at other institutions, most of them have been mains driven, and stoppages from mains failures have been frequent, with the result that an accuracy of one part in 10^8 (corresponding to 0.9 milliseconds per day in mean signal rate) has not always been realised. In recent months the error of an interval of time as determined by averaging signal receptions over a period of a fortnight or more has occasionally been as great as three parts in 10^8 or even more than this. But battery

flotation has now been provided on the clocks used at present as primary standards, and quite apart from the introduction of quartz controlled clocks at the Observatory stations improvement in the long term performance of the signal service is to be expected.

The recent installation of quartz controlled clocks at the Observatory stations has not yet in itself materially improved long term performance. The crystals driving these clocks have not yet "aged", and consequently the new clocks cannot yet be treated as primary standards. During the "ageing" stage, which may extend over a period of the order of six months, the frequency of a crystal changes progressively in an unpredictable manner, and so no reliable extrapolation of the clock errors as determined from transit observations can be made. But when "ageing" is complete the crystal should settle to a steady frequency drift, that is, to a condition in which the rate of the clock changes slowly and uniformly; it then becomes possible to extrapolate the clock error in a satisfactory manner, and so to employ the clock as a primary standard. The present indication is that the ageing stage is now approaching completion and with a prospective increase in the number of primary clocks there ought to be a consequential improvement in the long period performance of the Time Signal service during the coming months.

But as regards short term performance the improvement in the service has been immediate. Before the introduction of the new quartz controlled clocks the time signals were actually operated by secondary clocks of the free pendulum type, and on the occasion of each signal the errors of these clocks had to be extrapolated from the results of comparisons between them and the primary clocks. These comparisons had to be obtained *via* the GBR signals themselves, that is, from measures involving a radio link, and they were affected by errors of radio reception and measurement (which however in the case of the Observatory stations and of the National Physical Laboratory have now been reduced to quantities whose average values irrespective of sign are of the order of ±0.5 milliseconds). A more serious circumstance was that considerable uncertainty was introduced into the extrapolation of the errors of the secondary clocks by the erratics to which the best pendulum clocks are subject. The result was that if the time signals were used to determine individual 24 hour intervals, errors whose average values irrespective of sign were of the order of ±5 parts in 10^8 were superimposed on the long term errors of rate of the signals. But the new clocks have materially improved this position. They cannot yet, as has been indicated above, be employed as primaries, and their errors still have to be extrapolated from comparisons with the primary clocks, but the period of extrapolation has been extended from 24 hours to five days, and the recent average error irrespective of sign in a 24 hour interval as defined by successive 10^h GBR signals has been reduced to about one millisecond, that is, to ±12 parts in 10^9. This average error (which is additional to any error of rate in the long term run of the signals) now arises mainly from the combination of variations in transmission time along the Post Office lines, and of variations in lag introduced at the radio transmitting station. As long as these variations remain at their present level it does not seem probable that there will be any further substantial improvement in short term performance, and there appears to be little prospect of the average error of individual 24 hour intervals defined by successive 10^h GBR signals being reduced materially below a value of ± one part in 10^8. This average value means that extreme errors of two or three parts in 10^8 must be expected occasionally in addition to the error of long term performance.

Returning to long term performance it is intended to install additional quartz controlled clocks at the Observatory stations; it is expected that, when all the crystals have "aged", the equipment, used in conjunction with existing transit

instruments, will ensure that the general run of the signals will specify intervals of time with a maximum error of about one part in 10^8. But it is probable that improvement beyond this figure will not be possible until the present types of transit instrument are replaced by a photographic zenith tube. The provision of the battery of clocks now contemplated, together with improved ancillary apparatus for the measurement of clock comparisons, will probably bring the Time Service to a point at which no further material improvement can be effected by developments on the purely horological side alone. Up to now the provision of better clocks and of more refined methods of radio reception and recording has improved the service, even although it is ultimately based on transit observations made with instruments of existing standard type. The provision of more accurate horological equipment has in fact made possible a more drastic long term smoothing of the transit observations, which appear to be subject to rather large accidental and quasi-systematic errors. But there is necessarily a practical limit to the improvement that can be effected by purely horological development, and although this limit has not yet been reached, it is being approached. The provision of an accurate standard of frequency is only one aspect of the Time Service which must also aim at the supply of correspondingly accurate absolute time. Both aspects of the work demand improved star places and substantial development in methods of observing transits of stars. Much thought has been given to the design of the photographic zenith tube, which is expected materially to improve the accuracy of the time determinations. Meanwhile consideration has been given to possible improvements in the accuracy of the time determinations with the small transit instrument. The chief source of error seems to be the determination of the level of the instrument. Laboratory tests have been carried out by an optical autocollimation method, which would enable the error of level to be determined for each star observation, with the telescope in the position in which the observation is made. In the laboratory a precision of about 0".1 in level error determination is easily attainable; no tests have yet been made in the instrument hut, where large variations of temperature make the conditions less favourable.

IV. CHRONOMETERS.

The rating and supply of chronometers and watches for use in H.M. Ships has been continued. During the past year, similar rating and supply of wrist watches and stop watches for the use of pilots and observers in aircraft of the Fleet Air Arm has been undertaken. The repair and adjusting of watches in the watch repair shop has continued on an increased scale, and the repair and adjusting of chronometers has been undertaken. The all-round increase in the volume of work has necessitated an increase in staff. One clerical officer, one engraving machine operator, two watch repairers and a chronometer repairer have been added to the staff.

Approval has been obtained for additional staff for the watch repair staff, but lack of accommodation in the present premises at the Chronometer Depot has prevented their engagement. Approval has been obtained for the erection of a prefabricated building to accommodate the watch repairers and ancillary staff, thus releasing rooms required for the increase in volume of the rating and testing. Two women are being engaged to deal with the increase in work occasioned by the engraving, rating and issue of wrist watches and stop watches.

The expansion of the workshop and of the types of work dealt with has led to a corresponding increase in the ancillary jobs, such as engraving, case polishing, silvering and boxing. The policy of equipping the workshop to undertake this work will result in increased efficiency and output.

The Taylor, Taylor and Hobson engraving machine, mentioned in the last report, was brought into regular use in June 1943; since that date all chronometers and watches issued for navigational service have been engraved with the H.S. pattern number.

A Western Electric watch rate recorder was obtained for the watch repair shop in February, 1944. Its use has resulted in an appreciable saving of time in the preliminary rating of watches after repair.

The standard clock from the Portsmouth Chronometer Depot has been cleaned and overhauled in the repair shop. A light and accurately balanced wheel mounted on a jewelled platform for use in the Ritchie contact system fitted to a Dent regulator, employed for transmitting the Greenwich time signals, has also been made.

The work of the Depot, both in testing and maintenance, becomes more varied each year.

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. Other demands on the computational facilities of the Office have made it necessary to restrict the astronomical work to the minimum required for the continuance of the Almanacs; consequently there has been little change in their content or in their presentation.

The Nautical Almanac. The Almanac for 1945 was passed for press on December 15 and published on March 28, although some copies were available earlier for distribution to institutions on the exchange list. As for the edition for 1944, it has been printed partly by photolithography and partly from stereo plates; this mixture, resulting from the destruction of the standing type and plates for the first part of the Almanac, occurs for the last time in 1945. The edition for 1946 is well advanced and it is anticipated that it will be available much earlier than in previous years.

No significant changes have been made in the Almanac; its reduced size can now be regarded as standardised for the duration of the war. The continued omissions, especially of the fuller Explanation, is undoubtedly becoming inconvenient, but they cannot be regarded as serious in present circumstances. The separate *Supplement*, required to complete the Almanac, has made little progress during the year.

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 1948 is complete and has been circulated to the other ephemeris offices, in accordance with the arrangements for interchange to avoid duplication. Most of the copy for 1949 is already at the printers.

Almost the whole of the remaining Hollerith tabulations required for the calculation of the Moon's position for the ten years 1951 - 1960 has been completed during the year. The further calculations required to obtain the longitude and latitude are being done stage by stage, as opportunity offers, on the National machines; it is hoped to complete the block of ten years before putting in hand the conversion to right ascension and declination, using Hollerith equipment. Although the actual amount of new calculation involved is relatively not very large, a considerable amount of work has been involved in examining and correcting previous Hollerith results. The ease and rapidity with which the National machine can

difference a function, or the sum of a series of functions, has enabled this powerful check to be applied much more frequently, providing an opportunity to control the building-up error arising in the summation of a large number of rounded-off quantities.

Occultations and Eclipses. The occultation programme, although it still occupies a sensible proportion of the normal work of the Office, has again been at its minimum level. Prediction elements for the year 1946 for stars of magnitude 6.5 to 7.5 have been supplied by the Office of the *American Ephemeris* as in the previous year.

For 1946, elements of occultations for 2540 stars, not fainter than magnitude 7.5, were received from the Office of the *American Ephemeris*. These stars were put through the occultations machine and preliminary times recorded for 78 stations for the 1272 stars that were retained. A further 76 stars were excluded after computation, and there will thus be 1196 stars published in the elements of occultations for 1946. About 4300 prediction computations have been done during the year, for stations in the British Empire, allied and neutral countries; although relatively few predictions are being completed, machine times for other stations will be available for transmission if communication is restored before they are required. As for 1945, the predictions for Wellington and Dunedin are being computed and published in New Zealand (in "Southern Stars") by the New Zealand Astronomical Society; machine times and other data have been sent to Dr. Adams.

The number of partially reduced observations of occultations received for completion of the reduction has been disappointing. So far, only 67, 30, 44 and 55 have been received for the respective quarters of 1943; there is some evidence to suggest that more may still arrive. The reductions for about half of these have been completed, but so far no arrangements for publication have been made.

No special eclipse calculations have been undertaken.

Abridged Nautical Almanac and Air Almanac. There has been no change in the *Abridged Nautical Almanac*. Although the last pages of the edition for 1945 were passed for printing in October, publication did not take place until the end of March; most of the proofs of the edition for 1946 have already been received and it is hoped that it will be published well before the end of the year.

The *Air Almanac* has been published in four-monthly parts as follows:

1944	January	to April	on July 21
"	May	to August	on November 3
"	September	to December	on March 3

The revised form, referred to in last year's report and introduced with the first issue for 1944, appears to have been well received; it is hoped that the present form may be standardised for some years to come.

Apparent Places of Fundamental Stars. The fourth volume, for 1944, was published on May 27. The whole of the volume for 1945 has been printed and the final reading of the printed sheets is almost completed; it is hoped that publication will take place in May or early June.

Copy for the apparent places of the 32 additional circumpolar stars, normally computed by France, was provided for 1945 by the Office of the *American Ephemeris;*

the apparent places of the 426 10-day stars also normally provided by France were computed by the Nautical Almanac Office using Hollerith machines. Similar arrangements have been made for these computations for the 1946 volume, for which all other computations have been received. Copy is being prepared and it should be published in April or May 1945.

Other Publications. No publications have been issued during the year.

The whole of the copy for the additional volume of the *Astronomical Navigation Tables* was sent to the printer on November 20; most of the proofs have been received and these are being read. This volume will be lettered Q and will cover latitudes N. 70° - N. 79°, though it can also be used in southern latitudes for declinations appropriate to the Sun, Moon and planets.

General Astronomical Work. As already mentioned, no work under this heading, other than that required for the routine preparation of the Almanacs, has been done during the year.

General Navigational Work. In addition to the preparation of the *Air Almanac* and the *Astronomical Navigation Tables*, and the solution of the various problems associated with these publications, the Office has been continuing to do a considerable amount of miscellaneous computing work for the Air Ministry in connection with air navigation.

During the autumn of 1943, specimens were drawn up for a new form of astronomical navigation tables to assist in a prolonged service trial of the method. Complete tables were prepared for one latitude (N. 53°) to cover the last three months of 1943, and were printed in the form in which permanent tables on this design might appear. Similarly the star curves and scales required for the service trial of the Longley Star Computor were completed early in January.

Although no visit has been made to the Office in the past year by the R.A.F. Specialist Navigation Course, preparations are actively in progress for the visit due early in May 1944. For this occasion several special notes describing the general work of the Office have been prepared and will be distributed.

Night Illumination Diagrams. The preparation of charts showing the actual illumination to be expected from Sun, Moon and stars during each night in various latitudes has been continued. The following computations and drawings have been completed:-

1944 January - April	(4 latitudes)
1944 May - August	(10 latitudes)
1944 September - December	(10 latitudes)

The computations for 1945 January to April for the 11 latitude bands are almost complete.

During the year a detailed examination was made of the ranges of latitude corresponding to particular tolerances in time and illumination factor. The 4 latitudes N. 40°, N. 45°, N. 52° and N. 60° used for the first part of 1944 were increased to 10 latitudes to cover the range S. 10° to N. 70°. For 1945 the original 4 latitudes are being revised and 11 latitudes used to cover the whole range from S. 10° - N. 74° on a much more uniform system.

These diagrams have been greatly appreciated by all three Services.

Proof Reading. The amount of proof-reading has increased slightly over the previous year, due primarily to the new volume of astronomical navigation tables; there have been 8,700 distinct readings, representing 2,900 pages. The ratio of exactly three readings to one page indicates that on the average all first proofs have been read in duplicate. This has been necessary owing to the enforced use of less highly trained staff on this specialised work.

Repayment Work. The volume of demands for lighting-up times, blackout times etc. remains at about the same level as last year. Rather more than 200 lists have been supplied, in addition to numerous times of the Moon's phases and lists of times of moonrise and moonset. Other astronomical information of a similar nature is supplied on the same basis of a small charge to cover cost of preparation and secretarial work.

Admiralty Computing Service. The Admiralty Computing Service has been formed by the Director of Scientific Research to co-ordinate mathematical and computing activities within the Research Departments of the Admiralty, and to centralise computations where suitable. The Nautical Almanac Office forms the nucleus of the new service, performing all the centralised computing and advising Departments on tables, methods and calculating machines.

During the year, the Office has gradually been building up and training additional staff to take on the additional work; the inflow of work has greatly exceeded the rate of recruitment and the training. It is clear that the demand for this type of mathematical and computing work is considerable; many more trained computers could be employed if they were available. But a computer requires many months of careful training even when he can be suitably chosen in the first place, and it is proving by no means easy to expand the computing staff with the present severely limited field of recruitment.

Since the formation of the Admiralty Computing Service early in 1943, the Nautical Almanac Office has undertaken 40 separate investigations, some of which have involved many man-months of computation. About half of these pieces of work have been completed, others are in hand, while some which have been allocated a low priority are only in the preliminary stages. None of the work has been of an astronomical nature and the Office has been solely concerned with the translation from the mathematical formulation of the problem to the presentation of the solution in numerical form; although in many cases it has been necessary to understand the physical background in order to complete the computation intelligently, this background does not form part of the work of the Nautical Almanac Office. No details are therefore given of the various pieces of computation.

In addition to the actual calculation undertaken, the Office has greatly extended the library, especially in the direction of applied mathematical text books, to meet the requirements of an expanding computing service. Individual members of the staff have been loaned for short periods to Departments for computations which could not be disassociated from their immediate background.

Other Work. In view of the additional work undertaken by the Office on behalf of the Admiralty Computing Service, there has been very little opportunity to do more for other Ministries than complete the work that was in hand before the inauguration of the Admiralty Computing Service. In addition to a few minor calculations, copy, suitable for reproduction by photolithography, for the 200 pages of the bomb ballistic tables was sent to the Ministry of Aircraft Production in December.

Machines. During the course of the year three Friden, Model D.1C, and two Marchant, Model ACT.10M, machines were added to the Office equipment of calculating machines. The Friden is a semi-automatic multiplying machine which has automatic division. The Marchant is a fully automatic multiplying machine with automatic multiplication and division; it is probably the fastest calculating machine of its type at present available. A fourth National Accounting machine with six registers and a twelve-column decimal keyboard has also been added to the equipment of the Office.

The combined work of the Office and the Admiralty Computing Service has not yet justified a complete Hollerith installation, which would be necessary adequately to deal with scientific computing. An arrangement has been arrived at by which any work suitable for the Hollerith machines can be done on a service basis by the British Tabulating Machine Co. This work can, if necessary, be supervised by the Office staff.

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 weekday. 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 comparison.

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.

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 la Cour magnetographs continue to be remarkably steady.

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 1943 December 31, and with provisional constants to the present time.

The tabulation of results for 1943 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 1943 are given below. The values for the years 1940, 1941 and 1942 are given for comparison.

	Decl. W.	Horizontal Intensity	Vertical Intensity	Inclination
1940	10° 43′.0	0.18533	0.43099	66° 43′.9
1941	10° 33′.8	0.18539	0.43128	66° 44′.3
1942	10° 24′.8	0.18554	0.43146	66° 43′.9
1943	10° 16′.2	0.18556	0.43172	66° 44′.5

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.

A portable Vertical Intensity variometer, with a duplicate set of magnets, has been examined and the constants of the instrument determined and duly certified to the makers.

Several officers of the Royal Artillery and of the United States Army have visited the Station to determine the index-errors of compasses attached to instruments in use by their Sections.

During the past twelve months there have been 21 magnetic disturbances reaching the dimensions of a "storm", one of which actually reached the dimensions of "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").

The harmonic analysis of the data interpolated from the Admiralty magnetic charts for the epoch 1942 has been completed. The harmonic coefficients derived from the vertical component of the magnetic intensity agree satisfactorily with those derived from the north and east components, confirming the hypothesis that the normal undisturbed magnetic field of the earth has its origin inside the earth.

The derived harmonic coefficients have been used for the computation of each of the four elements - declination, horizontal intensity, inclination, and vertical intensity - at intervals of 10 degrees in longitude and latitude, between latitudes 70° north and south, and at intervals of 10 degrees in longitude and $2\frac{1}{2}$° in latitude, from latitudes $67\frac{1}{2}$ degrees to the north and south poles.

Iso-magnetic lines, based on the computed values for each of the four elements have been drawn for the two polar areas, where the observational data are scanty. They have also been drawn for declination, horizontal intensity and vertical intensity, for the areas between latitudes 70° north and 65° south.

An isoporic chart has been prepared giving the mean annual change in vertical intensity, between latitudes 70° north and 65° south, as derived from a comparison of the computed values for the epochs 1922 and 1942. Similar charts for the other elements will be 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 1943 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 1944 April 30.

The mean temperature was 50°.9 which is 1°.1 higher than the average of 100 years 1841-1940. The highest temperature in the shade was 89°.0, registered on

July 31. Temperatures exceeding 80° were recorded on 10 days. The lowest temperature was 22°.7, on March 6. Temperatures of 32°.0 or below were recorded on 40 days. The mean temperature for January was 5°.0 above the average for 100 years, and was the highest average for January since 1921. There have been only two instances of a higher January average in the previous one hundred years.

The mean daily horizontal movement of the air was 250 miles, which is 7 miles below the average for 50 years 1867-1916. The greatest daily movement occurred on January 22 and was 677 miles. The least daily movement was 45 miles, on October 27. The greatest pressure reached was 17.5 lbs. to the square foot, on May 10.

The duration of *bright* sunshine recorded was 1468.3 hours or 32.7 per cent. of the possible total. There were 75 entirely sunless days, 58 being in the five months November to March. There were 34 cloudless nights in the period, that is, nights on which a complete unbroken trace of the star Polaris was obtained by the night-sky camera. The number of nights on which no trace of δ Ursæ Minoris appeared on the plates was 70, while on a further 40 nights the record was not more than 10 per cent. of the total time of exposure.

The total rainfall during the period was only 17.79 inches, that is 6.54 inches or 27 per cent. less than the average of 100 years 1841-1940. There were 141 days on which rainfall amounting to 0.005 inch or more was recorded. The wettest month was October with 2.340 inches; the driest month was March, with 0.108 inch. There is only one instance of a lower total in March at Greenwich during the previous 130 years, namely 0.038 inch in 1929.

VIII. PRINTING AND DISTRIBUTION OF GREENWICH PUBLICATIONS.

No steps are being taken at present to proceed with the printing of the annual volumes of Greenwich Observations. The MSS. for the years 1937 to 1943 are complete or in various stages of preparation.

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., F.Inst.P., W. M. Witchell, B.Sc.
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.
Junior Assistants	- Mrs. J. Bennett, K. C. Blackwell, Mrs. C. M. Bolus, C. C. Harris, P. S. Laurie, B. R. Leaton (on active service), P. L. Rickerby, J. L. Rudd, A. Shortland, Miss M. B. Simm, R. H. Tucker (on active service) G. F. Wells.

Head of Repair Shop	- H. Warden.
Secretary and Cashier	- H. G. Barker.
Departmental Clerical Officer	- J. J. McLoughlin.
Clerical Assistant	- Miss F. E. A. Jeffries.
Established Typist	- Mrs. C. M. Anderson.
Temporary Observing Assistants	- V. Barocas, Ph.D., A.Inst.P., G. B. Wohlgemuth.
Temporary Clerks	- Miss D. A. Bush, Miss C. E. Chapman, Miss B. G. Collett, Miss K. Hempstead, Miss P. B. Hill, D. Oliver, Miss C. Ryall, Miss J. G. Slade.
Temporary Typist	- Mrs. B. H. Upfold.

(b) *Nautical Almanac Office Staff.*

Chief Assistant as Superintendent	- D. H. Sadler, M.A.
Assistant	- Miss F. M. McBain, M.A.
Temporary Experimental Officer	- L. Fox, M.A., D.Phil.
Temporary Assistants Special	- R. H. Corkan, M.Sc., P. H. Haines, M.A.
Junior Assistants (Higher Grade)	- A. E. Carter, A. J. Daniels, S. G. Daniels, H. W. P. Richards, B.Sc., W. A. Scott, B.Sc.
Temporary Assistants	- Miss A. M. Hathaway, B.Sc., H. H. Robertson, B.Sc., Miss J. Staton, B.A., R. G. Taylor, B.Sc., E. M. Wilson, B.Sc.
Junior Assistants	- W. G. Grimwood, G. A. Harding (on active service), Miss V. H. Hitches, Mrs. G. E. Leach, Miss J. Mounteney, Miss J. E. Pullen, Miss M. R. Rodgers, Miss M. C. Scadeng, E. Smith.
Temporary Clerks, Grade II	- Miss K. Blunt, Miss M. J. Matthews, Miss O. J. Ollis, Miss K. M. Restorick.
Temporary Clerks, Grade III	- G. E. Colman, L. E. Macey, Miss Y. P. Mundon, Miss I. M. Restorick.
Junior Assistant as Secretary	- Miss D. J. Ifield.
Clerk-Shorthand-Typist	- Miss J. E. Perry.

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. B. R. Leaton and Mr. R. H. Tucker, Junior Assistants of the Royal Observatory Staff, and Mr. G. A. Harding, Junior Assistant of the Nautical Almanac Office Staff are serving in H.M. Forces.

It is reported with regret that Mr. N. J. Miller, Clerical Officer, and Mr. T. W. W. Hodgson, Junior Assistant, have been killed in action during the year. Both were Flight Lieutenants in the R.A.F., Mr. Miller as a fighter pilot and Mr. Hodgson as a navigation Officer in Coastal Command. They were exceptionally keen and able members of the staff and their loss, both personally and officially, is greatly felt.

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

Mr. H. H. J. Barton and Mr. H. F. Finch were promoted to Acting Junior Assistants, Higher Grade on July 26.

Dr. L. Fox, Temporary Experimental Officer, and Miss A. M. Hathaway, Mr. H. H. Robertson, Miss J. Staton, Mr. R. G. Taylor and Mr. E. M. Wilson, Temporary Assistants, have been appointed to the staff of the Nautical Almanac Office during the year.

Miss J. Auckland and Miss G. E. Jackson, Junior Assistants in the Nautical Almanac Office and Miss C. M. Carr, Established Typist in the Secretariat, have married during the year and have been retained in their existing grades in a temporary capacity.

There have been various changes during the year in the personnel of the staff of temporary clerks but the numbers employed have remained substantially the same. Additions, as shown above, have in the main been of technical and specialised staff required to cope with the inauguration of new types of work and research, both in the Royal Observatory and the Nautical Almanac Office.

The staff of workmen employed in all branches consists of a Foreman and an Assistant Foreman of Observatory, nine watch adjusters and repairers, one machine operator, one joiner, five messengers, six labourers, three charwomen, two caretakers, a laboratory boy and a part time gardener, a total of 31 in all. A skilled mechanic is still lent for duty at the Admiralty Research Laboratory, Teddington. Mr. S. E. Bass and Mr. A. J. Johnson, members of the industrial staff, are on active service abroad.

X. GENERAL.

Visitors. The High Commissioner for South Africa visited the Royal Observatory, Greenwich on June 23. The President of the Board of Education, the Rt. Hon. R. A. Butler, accompanied by Mrs. Butler and Mr. Stephen Courtauld, were visitors on August 28.

At the request of the British Council, nine representatives of the Polish National Council, including Dr. Stanislaw Celichowski and Bishop Karol Radonski, were received at the Observatory on June 25.

On February 14, a visit was paid by Dr. P. M. Millman (F/O, Royal Canadian Air Force) of the staff of the David Dunlap Observatory, Canada.

During the year, the Commodore of the Royal Naval College, Greenwich, the Dean and the Commander have each visited the Observatory. Visits have also been paid by members of the professorial staff of the College.

Several U.S. Navy Officers have been shown the Observatory at the request of the Flag Officer Liaison with Commander United States Naval Forces in Europe, (Rear Admiral Sir Geoffrey Blake). Amongst these visitors have been Rear Admiral Watson, U.S.N., Read Admiral Redman, U.S.N., Admiral Wilson U.S.N., Colonel F. A. Meyer, Deputy Adjutant-General U.S. Service of Supply and Commanders Stanford and Jackson, U.S.N.

Other visitors for whom special requests were made include:- L/Cdr. Vielle of the British Air Commission accompanying Colonel Thurlow, Cmdr. Smith and L/Cmdr. Holt of the U.S. Air Force, Lt./Colonel Darling, R.A. and eleven other officers from the Royal Artillery Depot: two parties of Royal Air Force officers from the Central Navigation School and one party each of Chinese, Netherlands and Norwegian Naval Officers. On two occasions, representatives from the British Broadcasting Corporation were admitted to see the Observatory prior to overseas broadcasts on the subject of the Royal Observatory.

Throughout the year, parties of 12 naval officers from the Royal Naval College, Greenwich, have visited the Observatory, first at weekly intervals and later, fortnightly, as from September 1. In addition, special visits have been arranged on request for groups of technical officers, including classes for the Electrical Engineers, Naval Constructors, and the Naval Meteorological Section.

At the request of the Superintendent, W.R.N.S. (O.T.C.), Royal Naval College, facilities have been given for a party of 12 cadet officers to see the Observatory about once a month.

In all, 799 visitors (of whom 616 came from the Royal Naval College) were received.

H. SPENCER JONES,

Astronomer Royal.

Royal Observatory, Greenwich.

1944, May 19.

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