Proceedings of Observatories

ROYAL GREENWICH OBSERVATORY

(*Director, Sir Richard Woolley, O.B.E., F.R.S., Astronomer Royal*)

ROYAL OBSERVATORY, CAPE OF GOOD HOPE

(*Director, Professor R. H. Stoy, C.B.E., H.M. Astronomer*)

(Report for the year ending 1963 March 31)

INSTRUMENTS

(a) *Herstmonceux*

A design for the proposed Mirror Transit Circle has been worked out in detail with Messrs. Grubb Parsons. A specification and about 45 General Arrangement drawings are now on file.

The new Cassegrain grating spectrograph constructed in the workshop has been mounted on the 36-inch reflector and is now in full use. The existing exposure-meter has been modified to work with the new spectrograph and also to control intermittent exposures to the hollow-cathode reference lamp during the star exposures. Special equipment has been made to cut, mark and store the plates used, which measure only 25 mm × 10 mm or 15 mm × 7 mm.

Work continues on the 30-inch coudé spectrograph. The optical components had just been received from the manufacturers at the end of the report year.

The photographic zenith tube has been completely overhauled for the first time since its installation in 1955. All the control circuits have been renewed and the console has been modified to simplify future maintenance. The photographic chronograph has been replaced to determine whether the somewhat defective performance of the contact system is due to faulty contact operation or to some irregularity in the motion of the plate carriage.

(b) *Cape*

The construction of the 40-inch reflector at Grubb Parsons was virtually complete at the end of the report year. The vacuum tank for its aluminizing plant was delivered in July. The windows, piping, vacuum pumps and other auxiliary equipment have been fitted and the preliminary tests run in March were very encouraging.

The conversion of the 30-inch Steavenson reflector into a folded Cassegrain has been completed, though it is, of course, still possible to use the Newtonian focus when required. This telescope promises to be a very useful and convenient instrument for photo-electric photometry.

Much time and effort has been given to the construction of a faint-star photometer for use with the 40-inch reflector and possibly also at Pretoria. Various parts of the equipment are being tried out on the Victoria Telescope.

The pendulum clock installation has now been completely replaced by two quartz crystal oscillators previously in use at Greenwich and Abinger.

POSITIONAL ASTRONOMY

(i) *Fundamental*

A new observing programme of about 6 000 stars was begun at Herstmonceux on July 1. The stars are principally drawn from the Mt. Wilson *General Catalogue of Radial Velocities*. Observations of positions will enable improved proper motions to be obtained for a large number of stars of special interest. All FK4 and FK4 (Supp.) stars are also being observed. During the report year 10 078 stellar observations were made.

An observer's reporting console came into full use during the year. Details reported by the observer on punched cards interleaved with the cards containing the recorded contact times are available immediately. Much office work previously necessary has thereby been eliminated.

The intermediate stages in the reductions for the AGK3R observations, using the 1201 computer, have been largely completed and a start has been made on the final computer runs, in which one card is processed for each of the 75 000 observations of this programme. Collimation, level and zenith-point corrections have been adopted and azimuth star observations have been analysed to give the average diurnal change of azimuth independent of adopted star places.

At the Cape, observations for the *Third Cape Catalogue for 1950.0* and for the $-40°$ to $-52°$ zone of the *Faint Star Catalogue* have been continued. Both of these catalogues, which are being observed concurrently but independently, are intended for integration into an international scheme analogous to the AGK3R project in the northern hemisphere. The aim of the scheme is to provide a series of well placed, well observed reference stars in the southern hemisphere. The Washington Observatory is kindly supplying working lists and the apparent places of all stars observed. During the past year 5 994 transit observations were made for these programmes.

(ii) *Photographic Astrometry*

A major effort has been devoted at Herstmonceux during the past few years to measuring proper motions in the Large Magellanic Cloud, in ω Centauri and in such objects as M52 and M67. The Observatory is peculiarly well fitted to engage in large-scale undertakings of this sort, and it may be said that the results now beginning to emerge fully justify the substantial labour involved.

Investigation of the proper motions of stars in LMC Field I down to $V = 14{\cdot}5$ has been completed during the year and a general photometric and astrometric study of the field down to this limit appears in *R.O. Bulletin* No. 66. The plate limit of the second-epoch plate used in the investigation was not quite as faint as that of the old plate. In order to improve the proper motions of stars near the plate limit a new modern plate has been obtained with the Cape astrographic telescope and sent to Herstmonceux for measurement.

Two of van Maanen's plates of M67 and one modern plate, taken with the 60-inch reflector at Mount Wilson, have been measured at Herstmonceux. The area covered by the 60-inch field contains over 500 stars down to $B = 17$ in the central region of the cluster. Proper motions for almost all these stars have also been obtained from a plate pair taken on the 26-inch refractor. Comparison between the reflector and refractor proper motions reveals systematic differences depending on colour as well as on magnitude.

A pair of 60-inch plates of M52 have also been measured, giving proper motions of nearly 500 stars.

Measurement has been completed on all stars in the annulus round the centre of ω Centauri. Proper motions of 4 939 stars down to approximately $B = 16{\cdot}75$ have been determined.

The meridian places of the Cape zone stars are being strengthened by measures made on photographs taken with a new four-component astrometric lens by Taylor, Taylor and Hobson. This lens is used with a yellow filter and a fine-grain panchromatic plate that together give a very restricted pass band. During the year 397 plates were taken with the new lens, completing the photography for the zone $-40°$ to $-52°$. The other zones will be started when the camera has been re-mounted.

The *Cape Photographic Catalogue for 1950·0* is now nearing completion. Proper motions have been derived for the stars between $-76°$ and $-80°$, and the reductions of the positional measures to 1950·0 have been completed for the $-80°$ to $-84°$ zone and started for the remaining area between $-84°$ and the pole. The measurement of the supplementary photometric plates was completed for the $-80°$ to $-84°$ zone and started for the $-83°$ to $-87°$ zone.

The 26-inch Thompson refractor at Herstmonceux secured 1 414 astrometric plates during the year, mostly on the parallax programme.

The derivation of proper motion in declination for stars previously observed for parallax with the Victoria refractor has been continued, and 769 plates for this purpose were measured during the year. Proper motions have now been derived for all the 1 811 stars for which a parallax has been published by the Cape. The list giving the results for the last 811 stars will appear as an *R.O. Bulletin*. There remain about 2 200 parallax plates to be measured. These are mainly second series of plates for stars that were observed early in the programme and which appeared to merit further attention.

RADIAL VELOCITIES

Observations for the bright A star radial-velocity programme were continued at Herstmonceux until the end of June, using the 1-prism spectrograph attached to the Yapp 36-inch reflector. In the vast majority of cases at least five spectra of each star have now been obtained. The measurement of these spectrograms is nearly complete, and an analysis of the results is in progress.

The new grating spectrograph gives dispersions of 80 and 40 A/mm with the $f/1{\cdot}75$ and $f/3{\cdot}5$ Schmidt cameras respectively when the grating is used in the third order. On good nights it is possible to obtain spectra of stars of the sixth magnitude (photographic) in about six minutes with the 80 A/mm camera, using unbaked Kodak IIaO plates and a trail width of 0·40 mm on the plate. About 200 spectra of standard stars have been secured. An investigation is being made into the suitability of various lines for radial-velocity measurement. The possibilities of using the grating in the second order with Kodak IIaF plates for radial-velocity work on late-type stars are being explored.

Spectra have been taken with the grating spectrograph to obtain radial velocities of 11 stars which are possible members of the Hyades cluster. Observations of RR Lyrae variables brighter than $10^{m}{\cdot}0$ (photographic) have been commenced. Several spectra of Nova Herculis 1963 have been obtained with the 40 A/mm camera.

Work on the main Cape radial-velocity programme has continued on the 74-inch reflector at Pretoria as steadily as other work will permit. During the year 759 Cassegrain and 90 coudé spectra were measured. About 120 of the programme stars, having at least four accordant observations each, have been assigned final velocities and will be combined with the 227 stars reported as complete in last year's report to form the fifth instalment of the "Fundamental Data for Southern Stars" series.

The working list has been enlarged by 534 stars, mainly rather faint nearby or subdwarf stars. The extension of this programme to the twelfth magnitude has been rendered possible by the new E-camera. This is an $f/1$ Schmidt camera which, when used on the Cassegrain spectrograph, gives a dispersion of 170 A/mm.

From a study of the suitability and stability of the coudé spectrograph for radial-velocity work have been derived the systematic corrections and weights that have to be applied to coudé spectra when they are combined with ones taken with the Cassegrain spectrograph. The I.A.U. radial-velocity standards with declinations between $-82°$ and $+38°$ have been investigated: no systematic effect depending on declination appears to be present.

LARGE MAGELLANIC CLOUD

In Variable Field I, work on the photometry and proper motions of the bright stars down to visual magnitude 14·5 has been completed. The properties of some of the fainter stars in the field are being studied utilizing Radcliffe 74-inch plates in order to ascertain the nature of the stellar population of the LMC in various selected areas. There is good evidence for a large age spread over different parts of the field, the Cloud members themselves being confined to very definite areas. The proper motions indicate that nearly all the blue stars are Cloud members whilst most of the stars of intermediate colour are foreground galactic stars: the very red faint stars are distributed over the field in the same way as the blue members, suggesting that they too are Cloud members.

In Variable Field II, light curves in B and V have been obtained for 15 cepheid variables with mean B magnitudes brighter than 16·0. Concerted S. African efforts are being made to extend the photoelectric sequence beyond the present limit of $B = 16$ in order to be able to measure the fainter cepheids in the field. Visual estimates have indicated at least a further 30 cepheids, of which 15 have well determined periods. A study of the brighter stars in this field has resulted in a programme, now nearing completion, involving the measurement on three plates in B and V of some 1 300 stars down to visual magnitude 14·5.

CLUSTERS

The main measuring programme on ω Centauri has now been completed. For an annulus between radii 8′ and 22′ of arc, photometry in B and V has been finished for 4 500 stars down to an approximate limit of 16·0 in V. For an inner annulus between radii 3′ and 8′, 2 414 stars have been measured in B and V to a limit of about 14·7 in V. Preliminary

results indicate that the cluster has a relatively low central density and is heavily truncated. A statistical study of the distorted shape of the cluster carried out with the ICT 1201 computer shows no significant difference between the *average* ellipticity and orientation of the stars on the inner and outer annuli, but star counts in the very centre do show a more circular distribution.

Measurements have been made on plates of ω Cen and NGC 6397, taken with the 74-inch telescope in Pretoria using an objective grating, with a view to investigating the properties of the grating and its possible use in setting up faint photographic magnitude standards. The results of these measures are very encouraging: the grating constant is almost the same at all magnitudes, referred to photoelectric values. An improved grating has been constructed and sent to Pretoria, where test plates are being taken.

A series of B and V plates of the globular cluster NGC 6522 and the surrounding field, obtained with the Radcliffe 74-inch reflector in 1959, have been reduced with a photoelectric sequence supplied by Eggen. An H–R diagram for NGC 6522 has been obtained for stars brighter than $V = 17{\cdot}0$, $B = 18{\cdot}5$, in spite of the crowded nature of the field and the consequent difficulty of separating cluster members from field stars. The colour indices of six variables identified as cluster members and some red giants indicate that Baade overestimated the visual absorption in this field by $0^{m}{\cdot}6$.

PHOTOMETRY

At the Cape, the general three-colour photometric programmes have all been continued. The 24-inch Victoria refractor is being used to observe stars of astrophysical interest with magnitudes between 6·5 and 12, while the astrographic refractor and the 18-inch reflector are both employed on observing HR stars south of + 10° declination. The former is used for stars between − 4° and − 64° and the latter for the equatorial zone between + 10° and − 10°, which is particularly important for standardization purposes as it can be observed equally well from both hemispheres.

The results of photoelectric observations made at the Cape between 1949 and 1961, which were given in Cape Mimeogram No. 12, have been revised. Many MK spectral types kindly supplied by Dr Bidelman or specially classified at the Cape have been added, and also $U-B$ colours for many of the brighter stars. The revised catalogue, which is to be published as *R.O. Bulletin* No. 64, gives V and $B-V$ for 5 000 stars, $(U-B)_c$ for 4 000 of these and $(U-B)$ for 2 000.

STELLAR ATMOSPHERES

Coudé spectrograms of five cool stars (dwarfs or subgiants) obtained by the Astronomer Royal with the 100-inch telescope on Mt Wilson have been studied in detail. The equivalent widths of many atomic and molecular lines have been measured and are used as the observational basis of a new method of differential curve-of-growth analysis for evaluating elemental abundances in terms of those in the solar atmosphere, assuming negative hydrogen ions to be the sole source of opacity.

Metallic relative abundances have been estimated in the B4p star 3 Centauri A from measurements on a Radcliffe coudé spectrogram of the star. Similar work is in progress on the "manganese" star κ Cancri.

Abundance ratios of Si, Mg, He and C derived from Mt Wilson spectra of 30 peculiar A stars suggest that there exists a group of stars in which the Si/Mg ratio is ten times higher than normal. Work has commenced on estimating relative abundances of the Fe-peak elements in the Ap stars.

High-dispersion coudé spectrograms obtained by Dr Sargent at Mt Wilson have been used for line identifications in the hydrogen-deficient star υ Sagittarii. KrI, FI and GeII are identified definitely for the first time in stellar spectra.

SOLAR PHYSICS

The Sun was photographed at Herstmonceux in white light on 275 days and in Hα light with the Lyot filter on 228 days. The level of activity continued to fall, only 9 sunspot groups exceeding 500 millionths of the visible hemisphere in maximum area being observed, against 15 in the previous corresponding period. From present tendencies, it would appear likely that the minimum phase of this cycle should fall between mid-1964 and mid-1965.

The usual two photographs of the Sun in white light were obtained at the Cape on 340 days. The flare patrol was maintained with the Lyot Hα heliograph which was run on 289 days for a total of 1 843 hours. After development the films, some 7 400 feet in all, were sent to the Dunsink Observatory where they were examined, measured and the appropriate data prepared for circulation to all interested bodies.

The central line of the annular solar eclipse of 1963 January 25 crossed South Africa and passed within 100 miles of the Observatory. At the Observatory the magnitude of the eclipse was 96 per cent and, in spite of some passing cloud at the crucial phases, the observing conditions were

moderately good. A few plates were taken with the white-light heliograph and a continuous series of Hα photographs were obtained by hand-operating the Lyot heliograph, which requires a complete solar disk and full sunlight for its normal automatic operation. But the most important series of observations was a set of 230 accurately timed photographs taken on 35 mm film with a specially built camera attached to the astrographic telescope.

TIME SERVICE

During the first quarter of the year, 56 plates were obtained with the P.Z.T. and the results communicated weekly to the Bureau de l'Heure and the office of the International Polar Motion Service. From July 23 advantage was taken of the availability of the astrolabe for current time determination to overhaul the P.Z.T. Regular observations were resumed on February 11.

With the Danjon astrolabe, 249 groups were observed during the year. Reduction of the accumulated observations was brought up to date in May. Corrections have been derived to the adopted zenith distances of each star at transit, and group corrections have been determined in time and latitude. No significant closing error in time has been detected, but the closing error of $0''.25$ in latitude can be compensated by an empirical correction of $-0''.06 \sin(\odot - \alpha)$ to the observed latitude. The difference between the astrolabe (standard observer) and the P.Z.T. for the year 1961 was astrolabe $0^s.245$ west and $1''.49$ south of the P.Z.T.: the measured intervals on the ground are $0^s.240$ and $2''.00$. The apparent discrepancy is mainly due to the different systems of star places used for the two instruments.

Since July the astrolabe has been used instead of the P.Z.T. to define the Herstmonceux system of time and latitude. Empirical corrections of $-0^s.005$ and $+1''.49$ have been applied to the astrolabe results to preserve the continuity of the system.

Coordination between the time and frequency services of the United Kingdom and the United States of America has continued. The difference between the emission times of the radio time signals from GBR and WWV has not exceeded three milliseconds. The carrier frequencies of the coordinated transmissions have been offset from values based upon 9 192 631 770 c/s as the nominal caesium frequency by an amount, agreed internationally, which brings the time signals into general agreement with U.T.2. The offset for the calendar year 1963 is -130 parts in 10^{10}, as for 1962.

In August a programme was devised at the National Physical Laboratory for the utilization of the artificial satellite "Telstar" in an attempt

to ascertain the difference between the time systems of the U.K. and the U.S.A. The experiment involved the simultaneous transmission in both directions over the Telstar circuit of precise time signals from quartz clocks installed at Goonhilly (U.K.) and Andover (U.S.A.). The very high frequencies used, 4 and 6 Gc/s, are unaffected by ionospheric conditions. This experiment established that at the end of August the U.S. signal WWV was emitted 1·6 milliseconds in advance of the U.K. signal MSF (and GBR).

NAUTICAL ALMANAC OFFICE

The routine calculations and proof reading involved in the preparation and printing of the publications for which H.M. Nautical Almanac Office is responsible have been continued. The volumes issued during the year were as follows:

Astronomical Ephemeris 1964—published in November.

Astronomical Ephemeris 1967—first part distributed in November.

Nautical Almanac 1964—published in February.

Star Almanac 1963—published in July.

Air Almanac 1962 Part III—published in May.

Air Almanac 1963 Parts I and II—published in August and December.

The following special publication was issued during the year:

Sight Reduction Tables for Air Navigation (A.P.3270) for Equinox 1965·0—published in March.

The programme for optical lunar occultations has continued unchanged. Predictions for 1965 have been completed. The observations made during 1961 have been reduced but limb corrections have still to be derived. About half the observations received from 1943 onwards have been prepared for reduction with the improved lunar ephemeris and the application of limb corrections.

A new and extended list of zodiacal radio sources was prepared. Sources are included if they have a flux greater than 20 units, if they appear in two or more surveys, or if they have been given a probable identification with an optical object. Predictions of occultations of radio sources for 1963 were prepared using this list and were distributed. The number of stations for which predictions are supplied has risen to twenty-three.

Investigations have been made to find a simple method for determining azimuth (to about 0°·1) of celestial bodies; a graphical method has been proposed and a rough copy has been made. At the request of the Air Ministry, a diagrammatic slide-rule has been designed for the determination of the Sun's azimuth, to assist navigation in the desert.

The ICT 1201 computer was used for the routine calculations of the Office, including the production of data for the Hydrographic Department and for the Ministries of Defence and of Aviation (584 hours), for reduction of solar plates and of data from the Reversible Transit Circle, the Photographic Zenith Tube and the Astrolabe (669 hours) and also for many research problems (266 hours). The need for its replacement by a more powerful computer has now become urgent.