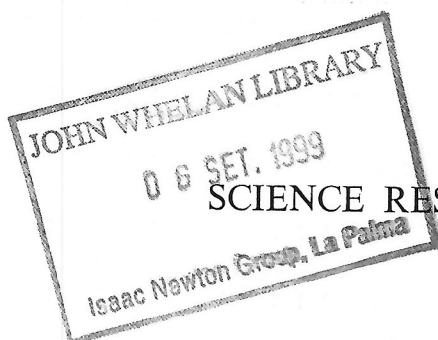




SCIENCE RESEARCH COUNCIL

THE REPORT OF THE ROYAL GREENWICH OBSERVATORY

FOR THE PERIOD

1978 OCTOBER 1 TO 1979 SEPTEMBER 30

Director

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I INTRODUCTION

Policy

The long standing and traditional service rôle of the RGO—as the source of astronomical information for navigation and observation, together with the provision of the national time service—continues essentially unchanged although, with the use of modern techniques, the effort devoted to these services has been reduced considerably over the decade. Today, the main function of the Observatory is the provision of telescopes, instruments, measuring machines and all the apparatus of modern observational astronomy for the benefit of all UK astronomers. This activity took a major step forward in the spring and summer of 1979 when the Isaac Newton Telescope was closed at Herstmonceux for modification prior to its move to a first class observing site in the northern hemisphere. Following the signing of an agreement with Spain in May work started on the construction of a new building and dome for the INT at the Roque de los Muchachos Observatory, a new international observing site, on La Palma, Canary Islands. A full report on the La Palma Observatory is given later in this report. These traditional and new service functions of the Observatory accounted for about half of the total manpower available during the past year and as a result it was possible to commit only 14 per cent of the manpower to research. This level of research activity is a continuing source of concern since the ability to provide efficient and up-to-date services depends to a large extent on the existence of a viable and lively inhouse research programme.

Organization

In order to ensure that the available research effort is concentrated into the most effective areas and coordinated in the most efficient way steps were taken during the year to recruit a new head (SPSO) of a combined Astrometry and Astrophysics Division. Dr J. V. Wall was selected for this new post and will take up his duties on 1979 November 1. The decision to set up a satellite laser ranging facility at Herstmonceux has necessitated some reorganization within the Almanacs and Time Division and transfers from other Divisions to provide staff for this activity.

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GLOSSARY OF ABBREVIATIONS

AAO	Anglo-Australian Observatory	LPO	La Palma Observatory
AAT	Anglo-Australian Telescope	RL	Rutherford Laboratory
ANU	Australian National University	ROE	Royal Observatory, Edinburgh
CCIR	International Radio Consultative Committee	SAAO	South African Astronomical Observatory
ESA	European Space Agency	SRC	Science Research Council
ESO	European Southern Observatory	UCL	University College, London
IAU	International Astronomical Union	UKAEA	United Kingdom Atomic Energy Authority
ICST	Imperial College of Science and Technology, London	UKIRT	United Kingdom Infrared Telescope
IOA	Institute of Astronomy, Cambridge	UKSTU	United Kingdom Schmidt Telescope Unit
IPCS	Image Photon Counting System	VLBI	Very Long Baseline Interferometry
INT	Isaac Newton Telescope		
IUE	International Ultraviolet Explorer (Satellite)		

Staffing

At the end of the report year the agreed complement was 237 with 231 staff in post and five advertised vacancies being processed. Recruitment of skilled computer software staff has continued to be difficult mainly due to the large discrepancy in salaries offered in government service compared with the private sector. During the year it was necessary to survey the work of the whole establishment in an attempt to transfer staff, particularly computer programmers, systems analysts and electronic engineers to the most urgent projects. Some transfers were made but problems remain. The difficulty of recruitment in these fields is well-known but we are increasingly concerned about the need to provide support in these areas for La Palma and other priority projects. The distribution of staff between the various occupational groups on September 30 was as follows: Senior Staff—8 (including 2 on "individual merit"); Science Group—84½ (including 5 Research Fellows); Professional and Technology Group—39; other Non-Industrials—37½; Industrials—62.

Buildings

Work on the extension to the Physics Block was completed during the year whilst the other major scheme, the new wing of the West Building, progressed well with completion expected early in 1980. These new buildings will allow a very important re-location of staff bringing all the research astronomers closer to the other groups, notably the engineers, instrumental scientists and the computing section. It is particularly important that the data-handling and image-processing now involved in most observational astronomy becomes an integral part of the work of the computer department. The new STARLINK node, which will link to the image-processing centres being set up around the country and centred on the Rutherford and Appleton Laboratories, will be part of this new centre of activity.

The extension of the Physics Block will allow the Instrumental Science Division to undertake the new tasks which are involved in telescope instrumentation. Here there is a rapidly growing emphasis on electronics, notably in developing the new diode array detectors which will soon become the most important detectors for spectrographic and photometric observations.

Extensive modifications to existing buildings have been carried out to meet the requirements of the Fire Regulations and the Health and Safety at Work Act. Fire resistant doors and emergency lighting have been installed in both the Castle and West Building.

The antiquated switchboard and telephone system have become a

source of worry but lack of funds and Post Office effort have prevented any progress towards a modern installation.

RGO Establishment Committee

The RGO Establishment Committee (membership: page 52) met three times at Herstmonceux during the year. Standard items of business included consideration of the Director's report for the previous year and advice on the preparation of the Forward Look.

Prior to the formation of the Science Research Council a Board of Visitors acted as an adviser to the Astronomer Royal and as a watchdog on the activities of the Observatory. The demise of the Board of Visitors left a gap in the independent support and criticism provided for the Director, and the Establishment Committee was intended to fill this gap. Unfortunately it failed because no essential rôle could be defined in the face of the other Committees and Boards which have to take a detailed interest in the Observatory. The Establishment Committee has therefore now been disbanded.

2 NATIONAL FACILITIES

La Palma Observatory

International Negotiations. Negotiations with the Spanish authorities on the form of an International Agreement to cover the establishment of an international observatory on the island of La Palma were successfully completed with the simultaneous signature of all three levels of the Agreement, in Spain, on 1979 May 26.

Site Development. Following the establishment of access roads to the various telescope sites by the Spanish authorities and the placing of the first building contract, the site has now been opened up for construction, with cleared areas for material storage and hatted accommodation for site labour erected in positions adjacent to the first building works, i.e. the 2.5-m telescope building.

1.0-metre Telescope. Construction of the 1.0-m telescope at the works of Messrs Grubb Parsons in Newcastle is now well advanced and completion is expected in late 1979 in readiness for works testing. On satisfactory completion of these tests, the La Palma Division team will carry out its own tests on the control system using the first Interdata 8/16 E computer and associated peripheral equipment.

The building for this telescope is now at the sketch plan stage and working drawings in readiness for tendering should be complete by 1980 April.

2.5-metre Isaac Newton Telescope. Following the placing of a contract for removal and modification of the telescope with Grubb Parsons on 1979 April 4, the telescope has been dismantled and transferred to Newcastle for modification prior to shipment to La Palma. The removal work commenced on 1979 June 4 and was completed at Herstmonceux by June 10. The building at Herstmonceux has now been handed back to SRC in a safe and weather-proof condition.

A contract for construction of the new building was placed on 1979 June 19 with Huarte y Cia. of Madrid and work has commenced on the site with the expectation that the building will be sufficiently complete by 1980 June for installation of the new dome and that the building will be completed ready for use by 1981 mid-October.

A contract for a new dome for the building was placed with Brittain Steel Co. of Vancouver B.C. on 1979 April 27 and work is well in hand for installation of the dome during the latter part of 1980, so that the heavy components of the INT base and polar disc can be lifted into position in the new building in 1980 December.

A new mirror in Zerodur for the primary of the INT was accepted in 1978 September. This new mirror is to a very high standard and is well within the specification required.

Instrumentation. The preliminary designs for the facilities associated with the entrance slit of the INT coude spectrograph are complete and ready for detailing. Development of suitable camera designs continues. A contract has been placed with the University of St Andrews for manufacture of a spectrograph based on the Richardson Brealey design for the 1.0-m telescope. Invitations to tender for the detail design and manufacture of the guidance box for the 1.0-m telescope have been issued.

4.2-metre Telescope. Work has proceeded slowly on design due to the limited funds available. At present studies are being carried out on the design of the servo-control system, various technical aspects of the mounting design and a re-appraisal of the tube design arising from the change from $f/3.2$ to $f/2.8$ in focal ratio to achieve the maximum economy of cost in the telescope and building integration.

A purchase order for the 4.2-m Cervit blank for the primary mirror was placed with Owens-Illinois on 1979 March 8 and rough-machining of the blank is now almost complete in readiness for delivery to the UK in 1979 December. A suitable transit case which will also serve to transport the finished mirror is being constructed in the USA.

Following earlier studies based on the functional requirements for the building, revised sketch plans are in hand to reduce the cost of construction. These plans are based on the $f/2.8$ telescope configuration

and it is expected that a revised estimate of cost will be available in 1979 November.

Isaac Newton Telescope

INT Operation. On 1979 March 4 the INT was closed down.

The available time on the telescope was allocated by the Panel for the Allocation of Telescope Time (PATT). During the operational period there were 20 different applicants for time of which 15 were from 13 universities or other research establishments and five from the RGO. Eight of the applicants had projects which were undertaken jointly with members of the RGO and three of the university projects were jointly undertaken with another university or research establishment.

During the five month period observing was carried out on 80 nights and 179 spectra, seven direct photographs, 32 electronographs and 156 other observations were obtained. There was a total of 568 hours of clear sky. Of the 80 nights when observing was carried out 17 were clear throughout, 25 were 50 per cent to 99 per cent clear and 38 were less than 50 per cent clear; no observing was possible on 73 nights. The number of instrument changes was 26 and there were 29 end changes. The primary mirror was realuminized once during the year. No maintenance of telescope and dome contactors has been possible this year. The scheduled time was diverted to LPO engineering tests.

The telescope was managed by Willmoth and maintained by the Engineering Division which provided on-call technicians to cover night-time emergencies.

Instrumentation. The Interdata 8/16 computer has been up-dated to 8/16E, allowing extension of the memory to 128 kbytes. Programming continues on the telescope and dome control functions.

The automated prime focus assembly is being modified to improve stability and to allow attachment to the new telescope top end assembly. The Wynne three element corrector design has been adopted and contracts are being placed for manufacture. The increased back focal distance that this corrector provides will allow the autoguider for the electronographic camera to be external to the tube; the assembly is being modified accordingly.

The contract for manufacture of the guidance system has been placed and progresses satisfactorily. Suitable autoguider and TV systems are being developed in the Instrumental Science Division.

Detail design of the Cassegrain spectrograph is now complete. Manufacture both within the Engineering Division and by outside contract progresses satisfactorily.

The Image Photon Counting System (IPCS) has been delivered and commissioned. It is now in use at the SAAO.

Steavenson Telescope

The structure of the new observatory in the Sierra Nevada in southern Spain was completed and the whole building finished externally by the start of winter 1978/79. The internal accommodation of the observatory was almost completed by the end of 1979 September and should be ready to accept the telescope by the summer of 1980.

The telescope has been substantially complete for approximately one year now but use at RGO has shown up some problems with backlash; these have now been corrected.

Equatorial Group Telescopes

36-inch Yapp Reflector. Between 1979 January and July the telescope was solely devoted to commissioning Boksenberg's Image Photon Counting System (135 nights). This is the third such system to be built by UCL; it is now in use on the SAAO 1.9-m reflector and is eventually intended for the LPO.

The telescope was assigned to visiting observers on 70 nights. Visitors included Fawell (UCL); Jenkins (Cambridge); Howarth (UCL); James (Manchester); Blackman (Sussex); McKeith (Belfast); Jelley (Harwell); Scaddon (ICST).

The RGO took up 108 nights for developmental work on the telescope and its common-user instrumentation. The RGO took a further 28 nights for research.

An acquisition and guidance box has been built for this telescope which will carry the 90-mm and 40-mm McMullan electronographic cameras, the People's photometer or the Cassegrain camera. This box has been successfully tested, but in the progress of these tests it has been found that the telescope does not image as well as its design predicts or with the linear resolution of which modern detectors are capable. Work aimed at improving the imaging with this telescope is continuing.

The facilities in this telescope's dark-room have been improved; notably with the provision of a clean air unit which is essential for critical electronography.

30-inch Coudé Reflector. The 30-inch telescope has had very little use this year. Primary causes have been lack of available manpower for essential maintenance and the unavailability of electronographic image

tubes. Even during periods when the telescope has been in use, observers have had to work with instrumentation which was not fully serviceable. Some effort has been directed to these jobs during the year. Walker has continued to develop the moving-plate system for the EMI image tube and Pike has been working on the data reduction programme. Gossler (Armagh) and Walker used the system to make observations of P Cygni. The Durham University group visited RGO for a month to make further observations with their diode array system.

Lowne and Jackson have performed an experiment, under R. G. Bingham's direction, to measure the polarisation in the spectrograph with each of the three common-user gratings.

26-inch and 13-inch Refractors. Both refractors were used regularly, mainly for RGO research projects.

The 13-inch refractor was used by summer vacation students and also by University of Sussex MSc students as part of the instrumental astronomy course hosted by RGO.

Instruments for General Use

Electronographic Cameras. Two "Travelling" McMullan 40-mm electronographic cameras have been built and tested. One has been successfully used for observing runs on the 1.2-m telescope at Calar Alto and on the Soviet 6.0-m telescope. It has proved to be much simpler to set up and run than the standard camera as well as being lighter and more compact. The second camera is mainly for use at Herstmonceux.

Photometers. The photometers have been rewired and both Travelling and People's photometers are now fully operational. The Travelling photometer has been in Tenerife for most of the year and has been used by RGO observers and by groups from Hatfield and Sussex for observations of BL Lac objects. Some parts of the Nova software for use in Tenerife have been rewritten in Nova assembler with a corresponding increase in speed and efficiency in data gathering. The People's photometer has been used on the INT and 36-inch telescope.

Two new amplifier/discriminators have been acquired with the low dead-times of 10 ns. A data acquisition programme has been written for the two-star photometer with star/sky chopping.

Measuring Machines

GALAXY, Coradograph, Zeiss Ascorecord. On GALAXY 540 plates were measured during the year, almost all in two opposite orientations. The majority (370) was for the Southern Sky Survey, with the next

major usage being the measurement of Hartmann test plates, 65 for the ESO 3.6-m and 1.4-m telescopes and 33 for the UKIRT. Forty-five plates were measured for a variety of RGO projects and 25 for several external users (Andrews, Argue, Fusi-Pecchi, Wayman).

After being out of action in October and November, because of a damaged encoder, the Coradograph has been in almost constant daily use, with very little time lost due to breakdowns. The link to GALAXY, via the mini-computer, makes it an extremely useful adjunct to GALAXY. Its main usage has been in the initial scanning of some 160 plates of the Southern Sky Survey, and in the setting up of plates generally prior to measurement in GALAXY. Additionally it is used for relatively low precision but rapid measurement of other plates and prints, usually for identification purposes.

The Zeiss Ascorecord was used to produce 27 700 measurements on 1609 parallax and 250 other assorted plates. 50 000 measurements (including training sessions) on 142 PZT plates were also completed.

PDS Microdensitometer. The performance and reliability of the PDS computer system have been enhanced by the installation of a new DEC processor (PDP11/34) and a 9-track 1600 bpi tape deck. A handler for the 9-track tape has been written in FORTH and is currently being tested before release for general use; it is intended that the existing 7-track tape drive will remain available for the foreseeable future.

Waite has designed and built a mount which holds electronographic films taut during measurement. The 40-mm version will be installed on PDS later this year, and one for 85-mm electronographs is under construction.

Other Measuring Machines. The Hilger microphotometer was overhauled during the year. The Askania iris photometer was taken out of service.

Digital-Image Processing Facility

In the absence of hardware dedicated to this project, software development continued on existing computers. The INT instrumentation computer (Interdata 70) was transferred to the Castle for the period January-June, but was then split; the processor was sent to South Africa for use with the IPCS and the peripherals were attached to the Interdata 7/16 associated with the 36-inch telescope.

Substantial improvements were made to the software for analysis of IPCS and similar data. User-requested features have been added, and the system expanded by D. J. King to handle the larger-format data

produced by the IPCS with an external memory. Pike wrote software to handle the preliminary reduction of data from the imaging Fabry-Perot interferometer built by K. Taylor. He also carried out tests of various image-processing algorithms. Hartley and Pike investigated various techniques for displaying images on the FR80 at RL and on the Versatec printer/plotter.

Software development was also continued on the ICL 1903T but the slow response for interactive work and the adverse effect on all other users led to the effort being concentrated on Interdata computers.

Hartley assisted the Disney Panel in the preparation of the proposals for the STARLINK network of computers for digital-image processing, particularly in the specification and selection of the image-display systems.

3 RESEARCH PROGRAMMES

Extragalactic Studies

Positions and Identifications of Radio and X-ray Sources. In the programme to determine astrometric positions of radio sources, a further 355 plates in some 60 fields have been obtained with the two Herstmonceux refractors. Measurement and reduction have been completed by Clements who has also completed his investigation of the systematic difference between results from the two refractors. The differences amount to an average of about 0".1 in each coordinate but show no apparent dependence on declination or right ascension. A catalogue of optical positions of 38 sources, based on observations made with the INT, the two refractors and the Cambridge Schmidt telescope, has now been published.

Predictions of lunar occultations of strong radio sources for 1979 were issued by Morrison to 25 radio observatories, and special predictions were made for occultations of NGC 6440 and selected pulsars.

Mayo, McHardy and Cooke (Leicester) searched ten new or revised 2AR/3A error boxes using the AAT. Type II Seyferts or peculiar emission line galaxies were found in three. Other boxes contained clusters, or groups, of galaxies for which redshifts and approximate velocity dispersions were found. In one box an apparently normal (i.e. no emission lines) elliptical galaxy appears to be the X-ray source.

Clusters of Galaxies. Dickens, Dawe (UKSTU) and Lucey (RGO/Sussex) have continued their work on the Centaurus I cluster (HMS 1247-4102). Radial velocity estimates for 150 cluster members, obtained previously with the AAT, show a bi-modal redshift distribution which has been interpreted as due to two clusters superposed along the line of

sight. The velocity dispersion of each cluster is very much less than that originally attributed to combined data; as a consequence the derived virial mass and M/L are significantly lower. Redshifts for a further 25 galaxies in the region were obtained with the AAT in 1979 July. Dynamical studies of two additional rich clusters have been initiated.

The AAT redshift data obtained by Dickens, Dawe, Lucey, and Mitchell (IOA) for 120 galaxies in the rich cluster field 0330-54 have now been completely reduced. Two rich clusters (Calan 0340, Klemola 8) and several groups have similar velocities, and thus probably form a supercluster. A third rich cluster 0328-557 in the region is a background system. Magnitudes for galaxies in the Klemola 8 cluster have been obtained from UKSTU plates by Currie (RGO/Sussex).

Currie and Wood are carrying out further photometry of these and other clusters from electronographic calibrations of UKSTU plates. Extensive photographic photometry software, some by courtesy of Godwin (Oxford), has been developed for use at RGO and the Rutherford Laboratory. The software effectively removes electronographic field distortion by the use of a transformation determined from the relative coordinates of stars and galaxies on film and plate.

Vidal has continued work on the evolution of galaxies in clusters; a major programme of galaxy classification in 21 X-ray clusters has been completed. A significant correlation has been found between the percentage of (E+So) galaxies in a cluster and its X-ray luminosity. This correlation supports the idea that spiral galaxies may evolve into So's by interaction with their inter-cluster environment. Vidal has shown that the Space Telescope should allow bright galaxies in clusters to be classified to $z \sim 0.8$; thus it will soon be possible to test whether the central galaxies in very distant compact clusters are still spirals (*i.e.* So's in the making). For future observational programmes, a catalogue of 49 faint compact clusters ($0.3 < z \leq 1.0$) in the region of the south galactic pole has been produced. In the course of this work, a new derivation of the formula for the surface brightness at the centre of galaxies was obtained.

Routine galaxy classification at RGO is now being carried out by Monk; it was felt that it would be an advantage to have one staff member trained and experienced in this task to provide a service for others. Initially 550 galaxies of 16-17 magnitude have been classified in the Virgo, IC 4329 and Centaurus clusters as part of the Dickens cluster programme.

Galaxies. In collaboration with Axon (Sussex), K. Taylor has continued the work on the velocity field of M82. A software package has been developed for reducing photographic image tube velocity data. Johnson

B and *V* band electronography of M82, obtained at the Wise Observatory, Israel, was digitized using the PDS microdensitometer; the contours appear to fit a normal late-type spiral galaxy, although towards the centre there is evidence for redistribution of light due to dust scattering. The isophotes are distinctly perturbed in the region of the minor-axis emission-line filaments investigated spectroscopically.

Narrow-band electronography of the hot-spot galaxy NGC 1808 was completed on the Danish 1.5-m reflector at ESO, La Silla. The final data will be in the form of two-dimensional maps of the physically important line ratios over the whole nuclear complex. Clearly visible on the *V*-band electronograph are ~ 5 kpc long filaments emanating from the disc of NGC 1808. This is the first time that jet-like phenomena have been clearly identified with the disc of a galaxy, rather than the nucleus.

Optical Monitoring of Radio and X-ray Sources. Lloyd has essentially completed the measurement and reduction of plates taken during the past six years, and light curves have been produced for some 30 quasars, BL Lac objects, and Seyfert galaxies. It is evident that the variations of the luminous quasar 3C273 have undergone a fundamental change in form.

Star Clusters

Globular Clusters. E. A. Bingham began the measurement of electronographs of ω Cen in *B* and *V*. A star field containing many photoelectric standards has been measured and reduced using the PDS machine. Martin, Penny (SAAO) and Davies have been doing similar work on the clusters M15 and M67; they are investigating the use of a beam splitter technique to obtain simultaneous *B* and *V* electronographs.

Martin has made observations on the DDO system of stars in NGC 6752 using an electronographic camera in order to make abundance studies in galactic globular clusters. E. A. Bingham and F. Fusi Pecci (Bologna) have obtained a colour-magnitude diagram for this cluster to $V = 19^m.0$ from a single pair of plates taken with the 1.5-m Loiano telescope.

Open Clusters. Andrews has obtained additional photoelectric *UBV* observations on the SAAO 1.0-m telescope of the double-lined binary κ Crucis II-23 at phases not well covered by previous work. The variation in the ultraviolet and the lack of eclipses are confirmed; the former is interpreted as being due to a gas stream.

With the SAAO 1.0-m telescope Martin, Penny and Davies have obtained photoelectric *BVR* measures in NGC 3766 and NGC 6281. They are investigating the use of an electronographic camera for *I* measures and simultaneous *B* and *V* measures.

Hanson reviewed the Hyades cluster distance for IAU Symposium No. 85, *Star Clusters*. Recent astrometric progress has substantially improved the accuracy of the observations. Trigonometric parallaxes yield a mean Hyades distance modulus $m-M = 3^m.25 \pm 0^m.06$. The close agreement of the results indicates that the overall mean Hyades distance modulus $m-M = 3^m.30$ may be used with confidence in cosmic distance-scale calibrations.

Variable Stars

RR Lyraes. Davies has analysed *BVI* observations and a mean velocity curve of the RRab star UV Octantis, to obtain radii using the van Hoff method.

Andrews has continued the analysis of the variables in NGC 4590. In particular, using the 1.0-m telescope of the SAAO he has made photoelectric observations of the star V₃ which has been shown to be a multi-mode pulsator. The mean colour corresponds to that expected for the changeover from *ab* to *c* type pulsation.

Cepheids. Martin has completed his analysis of *BV* photographic photometry of cepheids in the Magellanic Clouds. Analysis of *BVI* observations of LMC cepheids is also complete and analysis of similar material for stars in the SMC is in progress. Some additional *BVI* observations for ten cepheids in the LMC were obtained.

Novae. Andrews continued the study of the spectra of Nova Cygni 1978 and showed that the behaviour of the absorption and emission lines during the month after maximum can broadly be explained by a single velocity of ejection with a large variation in the position of the absorbing and emitting regions as the shell expands and thins.

Mayo, Wallis and Jones are securing *UBVRI* colours of dwarf novae at quiescence and at outburst using the Tenerife flux collector. Their aim is to amass data for about 30 such systems with a view to disentangling the light contributions of hot spot, accretion disk and stars.

Other Stars. Andrews has secured more *UBVRI* observations of southern super-super-giants; he confirms that HR5171 is now redder and cooler than it has been for 20 years.

Walker has obtained photometry of the ApSi star HR3413 showing a double humped light curve in five colours. The radial velocities and equivalent widths of spectral lines from spectra obtained by Dworetsky (UCL) and Lloyd are being evaluated.

X-ray and Radio Variables. Murdin and collaborators identified a variable radio source ($\lambda = 2$ cm) with A1710-34. They obtained an

improved position of the X-ray source with the *SAS-3* satellite; it was consistent with the position of the radio source.

Timing observations of the Crab Nebula pulsar were made by Korakitis (research student) and were used to provide an ephemeris for Professor P. V. Ramana Murthy of the Tata Institute of Fundamental Research, India, who was searching for atmospheric Cerenkov radiation caused by high energy gamma radiation from the Crab pulsar. Korakitis also obtained a linear polarization curve of the pulsar. He has prepared this material from his DPhil. Thesis at the University of Sussex.

Bailey has discussed his observations of the dwarf novae Z Cha, WX Hyi and V436 Cen, and the polars (systems comprised of a red dwarf and a magnetic white dwarf) AM Her and VV Pup.

Monitoring of Cygnus X-1 in the *V*, *B* photometric bands by Walker has continued in collaboration with the staff of the Instituto de Astrofísica de Andalucía. Analysis of a year's data suggests that a single unchanging period does not fit the observations and a re-analysis using independent data obtained in the USA is now being undertaken.

Mayo and Watson (University of Leicester) obtained photometric observations of Cir X-1 through an X-ray transition, and of Cen X-4 and SS433. A search for periodicities in 4U 1648-58 yielded no evidence for orbital motion. An optical light curve for 2A 0311-227 was obtained.

Murdin with several collaborators concluded a theoretical study of Cir X-1 in which several lines of evidence (the shape of the X-ray intensity curve, its X-ray spectrum, the way the X-ray intensity curve has changed, the radio outbursts) all tend to show Cir X-1 is an eccentric binary star. This is evidence tending to confirm its origin as a runaway star from the nearby supernova remnant G 321.9-0.3.

Parkes, Murdin and Mason identified 4U 1258-61 with a shell star. High resolution spectra confirmed the existence of the shell and its variability, a prediction of which had been made on the basis of the properties of the X-ray source.

Stellar Atmospheres and Evolution

Stellar Atmospheres and Abundance Studies. Pagel continued to study the composition of HII regions in southern external galaxies, using AAT/IPCS observations, in collaboration with Edmunds (Cardiff) and Chun and M. G. Smith (Oxford). NGC 1313 (SBd) and NGC 6822 (Irr) have uniform oxygen abundances intermediate between those of the two Magellanic Clouds, in agreement with previous indications of small or zero abundance gradients in irregular and barred spiral galaxies.

Studies of red giants in globular clusters have been continued by Pagel in collaboration with Mallia (Oxford) and Watts (Research Student, University of Sussex) using high-dispersion spectra from the AAT and IPCS. From recent data it was found that there are strong variations in metallic line strength across the red giant branch of ω Cen, corresponding to a range in iron abundance from about 1/50 to 1/10 solar. This covers a good part of the range in metal abundances inferred from observations of RR Lyrae stars in the cluster, and strengthens the view that changes in underlying composition contribute substantially to the great width of the giant branch in $B-V$, as well as mixing effects revealed by strong CN features in some of the stars.

Stellar chromospheric Mg^+ features were observed by Pagel using the IUE satellite in collaboration with Stickland at the IUE ground station, Villafranca, and were analysed in collaboration with Wilkins (temporary ASO). The FWHM is proportional to W_0 (Ca^+) measured by O. C. Wilson over a range of 12 magnitudes in luminosity and has been interpreted in terms of a simple Doppler broadening model simulating microturbulence in an optically thick atmosphere.

D. L. Harmer continued her investigations of the variable supergiant HR 8752, making observations with powerful coude spectrographs at the Dominion Astrophysical Observatory, Victoria, BC, and at McDonald Observatory, Texas. Several significant changes in the spectrum have occurred during the past year. Circumstellar shell features of the cool supergiant ρ Cas are also being studied.

A cross-dispersing grism system for the Unit Spectrograph was developed from specifications by D. L. Harmer, Lowne and C. F. W. Harmer. In collaboration with Worswick and Goldsmith (MSc student) the system was tested on the 36-inch telescope with observations of the Orion Nebula. The optical system worked well and it was shown that good relative line fluxes can be obtained.

Planetary Nebulae and HII Regions. [OI] $\lambda 6300$ electronographic imagery of the Orion nebula by K. Taylor, Worswick and Axon (Sussex) has revealed a family of semi-stellar knots that are invisible on comparable $H\alpha$ exposures. They are in a region near to the high-velocity Herbig-Haro object discovered by Münch and Taylor (1974, *Ap. J.*, **192**, L93) and they appear to be associated with the Becklin-Neugebauer infrared source. Their anomalous [OI] intensity leads to the suggestion that they are also Herbig-Haro objects, possibly generated by the stellar wind of the BN source.

R. G. Bingham continued his work with Scarrott (Durham) on nebular polarimetry. The previous work with the Durham group and Murdin on η Carinae was written up and published. A polarization study of M42 (the Orion nebula) and M43 suggests that the two are physically con-

tiguous and that the dividing dark lane is internal to the nebulae rather than a foreground feature. A major programme on Herbig-Haro objects has been started to investigate whether some are reflection nebulae rather than the intrinsically luminous shocks suggested by Dopita.

Taylor has studied the velocity field of the planetary nebula NGC 650/1 in $H\alpha$ and [NII] $\lambda 6584$, using observations secured with his Fabry-Perot monochromator at the Mt Wilson 60-inch telescope in 1975. The triple structure of the emission-line profiles has been successfully modelled on the basis of a cylindrically-symmetric double-cone geometry, compatible with model shells derived by Reay and his collaborators at Imperial College.

Worswick has begun a programme to study the variation of physical conditions (density, temperature, ionization, filamentary structure) in planetary nebulae. IPCS spectra of NGC 6543 have been obtained using the 36-inch telescope.

Supernova Remnants. Clark and Murdin identified the optical/radio/X-ray source at the centre of the supernova remnant W50. This object, SS 433, has excited world-wide interest because of its extraordinary properties, notably the very large and variable red and blue shifts displayed by $H\alpha$ and other emission lines, probably due to relativistic Doppler shifts (0.25c). Many theoretical models have been proposed, and an entire session devoted to SS 433 formed one of the highlights of the IAU General Assembly in Montreal. Clark and Murdin took spectra of filaments associated with W50 while commissioning the La Palma IPCS at SAAO; it showed a Puppis A like spectrum with nitrogen enrichment and they have speculated that the filaments have been excited by SS 433. Clark and Murdin have also continued their research programmes on gaseous supernova remnants in collaboration with Danziger (ESO). They have mapped the velocity field of the majority of remnants in the Galaxy and LMC, to investigate dynamical evolution. A colour-graphics system developed by Hartley is now being used for the presentation of velocity data. They have also mapped some SNRs in their coronal-line emission; [Fe XIV] $\lambda 5303$ and [FeX] $\lambda 6374$ delineate the hot plasma component responsible for X-ray emission so that the data complement X-ray studies by Clark and Tuohy (ANU) of galactic and LMC SNRs using the *HEAO-A* and *B* satellites. They have continued spectroscopic investigation of galactic and LMC optical remnants to study the evolution of line ratios and deduce (with suitable modelling) the corresponding changes in temperature, density and chemical composition. The remnant MSH 11-54 was found to have fast-moving knots enriched in α -particle elements, similar to Cas A.

Galactic Astronomy

Solar Neighbourhood. Work on the South Galactic Cap field (for which astrometric results have now been published) has been concentrated on improving the photometric results. Corben has obtained at SAAO a large number of photometric observations, evenly spread over the field, in order to improve the calibration of field errors. A research student (de Peralta) has developed computer programs for differential comparison between photometric measurements on Schmidt plates using Chebyshev polynomials.

The main astrometric reduction program has been recoded for the IBM 360 computer at Rutherford Laboratory.

The trigonometric parallax programme with the 26-inch refractor has continued; 356 plates were exposed and 610 plates, including many from previous years were measured. Two fields were reduced. Observations and measurement for a further 24 fields have been virtually completed.

Hanson has evaluated the frequency distributions of trigonometric parallaxes determined at the four observatories which have published the greatest number. He has studied their absolute zero points, systematic differences and external errors. His method is to fit the observed distribution by convolving power-law space distributions with Gaussian observational errors. Given a nominal correction to absolute, the zero point of the *General Catalogue of Trigonometrical Parallaxes* is confirmed to within $\pm 0''.001$ without the systematic observatory differences generally found from comparisons using multiple observations. The external error estimates agree with other recent determinations and indicate precepts for a new General Parallax Catalogue. The space distributions of stars selected for parallax observation give useful information to aid luminosity calibrations.

Jones, Alexander and J. E. Sinclair have prepared their narrow-band photometry of 1251 faint red stars for publication. Calibrating stars aside, 91 stars are newly discovered or confirmed red dwarfs. Their derived space density is still insufficient to account for the "missing mass" in the solar vicinity but there is still a major uncertainty because of the small number of stars observed.

D. L. King has half completed the measurement of the radial velocities of those nearby stars observed by Wallis, Jones and their collaborators. Wallis and Jones are studying velocities of distant red giants in the South Galactic Cap using spectra obtained with the IPCS at Sutherland; the aim is to delineate the velocity field perpendicular to the plane beyond its present limit of 1500 pc.

In collaboration with Clube (ROE), Dawe (UKSTU) and Heck (IUE, Villafranca), Jones has compared the maximum-likelihood algorithm

for determining statistical parallax due to Clube and Dawe with that of Heck. Fictitious data showed that both algorithms gave the correct solution; previous divergent solutions must have arisen for astronomical rather than statistical reasons.

Solar System

Dynamics of the Earth-Moon System. Morrison has reduced and analysed timings of lunar occultations 1600–1860 and solar eclipses 1600–1700, to improve upon previous determinations of variations in the Earth's rotation. Investigations have continued into the shape of the lunar profile deduced from grazing occultations, and into the causes of "fading" occultations.

Occultations by Planets and Satellites. The search for occultations of stars by planets, minor planets and satellites was continued by G. E. Taylor. Eighty astrometric plates were taken for direct use in this project or for use by Shor (Leningrad) in the improvement of the orbits of minor planets; the plates were measured and reduced by Clements. Predictions of the occultations were issued on a world-wide basis and led to observations in the USA of an occultation by the minor planet 18 Melpomene. The results have now been analysed.

Dynamics of Satellites and Ring-Systems. A. T. Sinclair worked on a theory of the nature of the rings of Uranus, in conjunction with Dermott and Gold at Cornell University. Subsequently D. B. Taylor and A. T. Sinclair have been examining the nature of orbits at a 1:1 resonance, which is the type of orbit postulated for the ring particles. Taylor has been investigating existing theories of the secular motion of planets, with a view to extending this work. The programme of observations of the position of Saturn's satellites has continued.

Solar Rotation. The study of the solar rotation during the period 1885–1960 was completed; some early photoheliograms were remeasured to give improved positions for selected single sunspots. These positions and later published positions were analysed and the results were published (8). Observations made during the 17th century are being studied (using material in the RGO archives and rare-book collection) to ascertain if other reports of variations in the rate of rotation can be confirmed.

Deflection of Light by the Sun. To mark the centenary of Einstein's birth, the astrometric plates taken at the time of the 1919 Solar Eclipse by the expedition from the RGO to Sobral in Brazil were remeasured and reduced by Clements and Harvey. The use of a modern measuring machine and a different method of reduction produced a much less

ambiguous result from the Astrographic plates and a lower standard error from the 4-inch plates than had been obtained previously. The accordance of the observed deflection of light by a gravitational field with the prediction of Einstein's theory is now stronger.

Research and Development of Astronomical Instruments

Spectrographs. R. G. Bingham completed a critical review of the basic design of grating spectrometers and spectrographs (7). This review describes a new approach to the design of these instruments which is more systematic than any available previously. In particular, the common emphasis on the size of the collimator aperture as a criterion of efficiency is shown to have little rigorous applicability, even in principle. The methods described should be useful both in the design of individual auxiliary instruments and in preparing schemes for complete observing systems.

R. G. Bingham and Clarke (Glasgow) have found two methods of increasing the efficiency of spectrometers in the presence of polarizing gratings, irrespective of the source polarization. Work on this is continuing. In a related study, Lowne measured the polarization in the coude spectrograph of the RGO 30-inch telescope.

Two-dimensional Fabry-Perot Interferometer. TAURUS, an imaging Fabry-Perot interferometer designed by K. Taylor in collaboration with P. D. Atherton of Imperial College, gives two-dimensional seeing-limited velocity fields of emission line objects. First astronomical results were produced on the 36-inch reflector at Herstmonceux in April and included a complete velocity map of the post-eruptive galaxy M82 at a velocity resolution of 30 km s^{-1} . The system, designed for compatibility with the IPCS as a detector, can operate at a variety of spectral resolving powers chosen so that galactic nebulae, spiral galaxies and active galaxies can all be studied at an optimum velocity resolution.

The microprocessor systems for the interferometer have been designed by N. M. Parker and following the observing run in April a new remote controller has been produced incorporating a floppy disc and more sophisticated software. Other improvements are also being incorporated and the first run on a large telescope is scheduled for 1979 November on the SAAO 1.9-m reflector.

Four-star Photometer. Construction and testing of the 4-star photometer proposed by Walker has continued. A working system has been on the Steavenson 30-inch reflector for some months and has been used for tests on the stability of the instrument head. More exhaustive tests need to be conducted before the final electronics are designed and built.

Research and Development of Electronic Imaging Devices

Electronographic Cameras. (30, 31, 32) Investigations have been carried out by Powell into the causes of geometrical distortion in recent batches of electronographic tubes. Chemical contamination has been identified as the major cause and steps have been taken to avoid it. A method of projecting fiducial marks on to the photocathodes of electronographic tubes has been developed and will be incorporated on future replacement tubes for McMullan cameras.

The construction of the TV-electronograph viewer has been finished and it is undergoing preliminary tests. Noise in the TV camera system is proving to be a limitation and investigations are in progress with the aim of reducing it.

Further work has been done by Davies on the measurement of the characteristics of nuclear and photographic emulsions used for recording electronographic images. A system for the routine testing of emulsions has been established.

Solid-State Detectors. Work has continued on the application of a General Electric charge injection device (CID) as a two-dimensional astronomical detector. P. R. Jorden has established the conditions for nondestructive read-out and has designed new circuit boards which will enable multiple read-outs to be summed to give a high signal-to-noise ratio. An LSI-11 microprocessor is being incorporated for control and data handling, and a Ramtek image store will be used for image display. It is expected that the first use of the detector will be with the Durham University polarimeter on the Wise Observatory 1.0-m telescope in Spring 1980.

Photon Counting Reticon Detector for SAAO. Following the work done by Shectman (Michigan State University) and others on the use of intensified Reticon silicon-diode linear arrays for photon counting, a detector of this type is being built for use with the image tube spectrograph at SAAO. A two-row 936 element array has been chosen and there will be two or three additional single-stage electrostatic image intensifiers following the existing three-stage EMI intensifier at present used with photographic recording. A preliminary design has been worked out by A. R. Jorden and some components purchased; completion is scheduled for 1980 December.

TV Cameras for Acquisition and Guiding. An investigation is proceeding on the choice of TV cameras for the La Palma Observatory. An intensified silicon target vidicon (ISIT) camera has been modified and is undergoing tests. Short integrations on the target (up to several seconds) can be used when the target region of the tube is cooled to about

– 10°C; a small vortex-tube air cooler is sufficient to provide this cooling. An analogue video magnetic disc recorder is being used to give a continuous display with improved quality by dark field subtraction, and to store several fields for reference purposes.

Autoguiders. Autoguider systems are being developed by Thorne for the La Palma telescopes. They are based on the FW130 deflectable photo-multiplier, and an M6800 microprocessor will be incorporated for control and data processing. As well as providing guiding error signals, a continuous measurement of seeing will be available. The development is at an early stage; a simpler autoguider, also using a FW130, has been built at UKAEA, Harwell, and has been operated on the 36-inch telescope at Herstmonceux where it will eventually be installed. It is providing useful information on the performance of this type of guider.

Optical Design

Wynne investigated the design of prime-focus field correctors with aberrations as low as 0".25 for use at sites with very good seeing.

R. G. Bingham investigated theoretically the use of a two-mirror prime-focus focal reducer on various telescopes and found that a larger scale reduction can be obtained with parabolic primary mirrors than when using the primary of a Ritchey-Chretien telescope. As most of the optical power is obtained with mirrors, this device has a very wide spectral range and is especially appropriate for solid-state detector arrays.

C. F. W. Harmer is designing a new camera lens for use with the TAURUS Fabry-Perot interferometer (see page 22).

Further optical-design programs from Imperial College were installed on the ICL 1903T and the IBM 360 computers.

Wynne has continued giving training in optical design to Bingham and C. F. W. Harmer.

4 NATIONAL AND INTERNATIONAL SERVICES

Time and Latitude Service

Photographic Zenith Tube. The programme for the determination of universal time and the variation of latitude by astronomical observations with the PZT was continued under the direction of O'Hara; 2653 star transits were recorded on 123 nights and the results were sent weekly to the Bureau International de l'Heure (BIH) and monthly to the Inter-

national Polar Motion Service (IPMS). Work on the development of an automatic control system for the PZT has continued while keeping the telescope in regular operation.

Project MERIT. Wilkins, as Chairman of the IAU Working Group on the Determination of the Rotation of the Earth, took part in the preparation of a proposal for a special period of international collaboration in the monitoring of Earth-rotation and the intercomparison of techniques (known as Project MERIT). This proposal, which was endorsed at the IAU General Assembly in August, is primarily concerned with the introduction of modern techniques, such as laser ranging and VLBI, for the regular determination of the variations in the rotation of the Earth; there will be a special campaign during 1983/4 when the classical and modern techniques will be used simultaneously.

Atomic Time. Under the direction of Pilkington, the local atomic time scale, TA(RGO), was formed throughout the period by combining the scales of from two to four of the six caesium-beam atomic clocks at RGO. Corrections derived from inter-comparison of all the clocks were, as usual, applied to maintain the continuity and uniformity of TA(RGO). Some preparatory work for the rebuilding of the electronics was carried out.

Radio Time Signals. The RGO continued to provide the BBC 6-pips time signal (UTC), and to monitor the radio time-signals on GBR and a small number of other signals. Four receivers (one on loan from USNO) were used to monitor the timing of the Loran-C emissions, and so contribute to the accuracy of this navigation system; the results are used to link the RGO clocks and time-scales to international atomic time, TAI.

Time Comparisons by Satellite. Regular observations were made of the radio signals from the Navigation Technology Satellites NTS-1 and NTS-2; most of the equipment used was lent by the US Naval Research Laboratory, which also funded the observations. Observations of NTS-2 were a contribution to the development of the NAVSTAR-GPS system that is expected to become operational in the mid-1980s to provide world-wide facilities for position determination and time comparison, with precisions of about 10 m and 100 ns respectively, and will also yield information on Earth rotation. Observations of NTS-1 were resumed after NTS-2 failed in order to support users requiring precise time in remote locations. Emissions from NTS-1 were terminated in mid-September. A control system based on a micro-computer was developed at RGO and used to permit unmanned operation of the receiver; a tracking antenna-mount to be controlled by the same system was installed on the roof of the West Building.

Publications. The results of the time and latitude service have been published as follows during the period of this report:

Greenwich Time Reports (quarterly) 1978 January–December.
Time Service Circulars A (weekly) and *B* (monthly).
Time Service Notices (irregularly)—11 issues.

Publications, Information and Data Services

Most of the work on the preparation of publications (other than scientific papers) and on the provision of information and data services has been carried out in the Publications and Data Services Section of HM Nautical Almanac Office, under the supervision of Yallop and in the Public Information Unit under the supervision of Wood and, later, O'Hara. The lunar occultation data service is provided by the Dynamics and Occultations Section of the Office under the supervision of Morrison.

Almanacs and Ephemerides. The preparation and publication of almanacs, ephemerides and tables for astronomy and navigation is undertaken in close cooperation with the Nautical Almanac Office of the US Naval Observatory. The following volumes were published during the year:

The Astronomical Ephemeris 1980.
The Nautical Almanac 1980.
The Air Almanac 1979 (in two parts).
The Star Almanac for Land Surveyors 1979 and 1980.
Astronomical Phenomena 1981.
Planetary and Lunar Coordinates 1980–1984.

The last two publications were published jointly by the US Government Printing Office and Her Majesty's Stationery Office under a new joint marketing agreement; the first was printed only in the USA, although some of the pages were composed in the UK, while the second was printed only in the UK. They are intended for use by both professional and amateur astronomers for the preparation of local almanacs and newspaper articles as well as for observing and computing purposes.

Agreement was reached with the US Naval Observatory on the use of the new title *The Astronomical Almanac* for the continuation of both *The Astronomical Ephemeris* and *The American Ephemeris and Nautical Almanac* for the years 1981 onwards. The drafting of new auxiliary material was largely completed and first proofs were received. The Almanac will be printed only in the USA but will be published jointly at equivalent prices.

Annals, Bulletins and Reports. Preparatory and editorial work was

carried out for the publication of observational results in the series of *Annals* and *Bulletins*. *RGO Bulletins No. 184*, Double Star Observations made with the 28-inch Refractor 1963–1970, R. W. Argyle, M. P. Candy and L. S. T. Symms, was published during the year. *The Report of the Royal Greenwich Observatory for 1977/8* was published in July. A list of recent RGO publications is given on the back cover.

Information Services. The number of requests from the general public for astronomical information continues to increase each year. More than 2300 enquiries were received by letter or telephone and were answered by the staff of the Public Information Unit, HM Nautical Almanac Office, and the Time Department. In addition the Office answered 236 chargeable requests for data. Guided tours of appropriate areas of the Observatory were provided for 62 educational or professional parties, including 5 parties of navigating officers from the Royal Navy and other countries. In addition, facilities were provided for three visits by television film crews and by radio and newspaper representatives. Members of the staff, in their own time, have also given courses and single lectures on astronomy and the work of the Observatory to a variety of lay audiences in south-east England.

Lunar Occultations Data Service. Predictions for the occultations of stars by the Moon in 1979 were issued for 90 places and reproducible lists and maps were prepared for publishers in other countries. About 10 000 timings of occultations were received and reduced, and the observers were notified of the residuals. The tabular material relating to the collected observations of occultations 1860–1942 was copied on to microfiche in preparation for publication. The supply of other occultation data and the analysis of the observations are described on pages 13 and 21.

Solar Activity Service. The work on the Solar Activity Service was reduced prior to its complete closure at the end of the report period. Observations of the Sun in white light and $H\alpha$ were stopped in March, and correspondingly the content of the Solar Activity Circulars was reduced; 15 requests for "historical" data on solar activity were received and answered.

The tasks of completing the measurement and reduction of the photoheliograms and the preparation of the photoheliographic results up to the end of 1976 continued and were nearly completed by the end of the report year.

Other Data Services. HM Nautical Almanac Office has continued to supply special data for astronomers and others in the form of technical notes and data sheets.

Two *NAO Technical Notes* were issued:

No. 48 Approximate Lunar Coordinates. (B. Emerson).

No. 49 Lunar Occultations of NGC 6440, 1980-82. (L. V. Morrison).

Three *RGO Astronomical Information Sheets* were issued, including:

No. 29 Polynomial Coefficients for Astro-navigation, 1979

Special ephemerides of local sidereal time, of twilight, and of the rising, transit and setting of the Moon were computed and distributed for Herstmonceux and 29 other observatories; these ephemerides are used by observers for both planning and current purposes. Copies of ephemerides and other data were supplied on magnetic tape when appropriate.

Satellite Laser Ranging

The proposal described in last year's report for a UK satellite laser ranging facility was approved by the Council on November 27 and subsequently by the Department of Education and Science. Planning and preparatory work was carried out in collaboration with staff at the University of Hull which is responsible for the design, assembly and testing of the laser, detection and timing subsystems, under the general supervision of Wilkins and Professor Ramsden; the project manager is Pope. Visits were made to several European laser ranging stations to discuss technical matters and future cooperation. Staff from the Technical University of Graz, Austria, which is also about to build a similar system, visited both RGO and the University of Hull to discuss the specifications for the optical sub-systems and mount and other aspects of design of the two systems.

Stellar Reference Frame

Meridian Astronomy at Herstmonceux. Under the direction of Tucker, the prime programme of observations of Sun, Moon and Planets, and fundamental stars, has continued with the Cooke Transit Circle. A few observations of stars in the Zodiacal belt (ZC programme) and of Northern PZT stars (NPZT programme) have been made during the report year. The number of minor planets in the observing programme has been increased.

The observations of FK4 stars in a sixteen-year period have been used to investigate various instrumental parameters, and the first independent Herstmonceux system has been established, defined by adopted places and revised proper motions of the 76 Azimuth stars and the 235 Clock stars. All observations are now being reduced on this system. Results for the FK4 and FK4 Supp stars are being sent to Heidelberg for inclusion in FK5.

With regard to the planned modernization of the Cooke Transit Circle, the digital read-out of meteorological readings is now at the testing stage. More measurements have been made in preparation for mounting a grating in place of the movable glass circle as part of the electronic circle-reading system developed at the National Engineering Laboratory.

Some special observations were undertaken to examine an apparent discordance between the FK4 system as realized by the SAO catalogue and the AGK 3 catalogue in a region of the sky near the pulsar 1913 + 16.

Meridian Astronomy on La Palma. The plans for the building to house the Brorfelde Transit Circle on La Palma have been revised with a view to reducing the cost, in consultation with the staff of Copenhagen University Observatory, who have proposed a radical new type of construction with light-weight material of high thermal insulation.

A Hewlett-Packard 2113 computer is being interfaced to the Brorfelde instrument as a real-time process controller, in place of the HP 2100 formerly used for this purpose. It is proposed to link the process controller to a fast modern computer (HP 2117) by means of a DS 1000 system. This computer will perform the input and output facilities, and handle much of the data-processing required in the operation of the automatic transit-circle.

Cape Photographic Survey. Computer programs have been developed, on the NOVA mini-computer, to enable much of the GALAXY setting-up procedure to be performed on the Coradograph, leading to a more more efficient use of GALAXY. Three hundred and seventy plates were measured during the year; a peak rate of measurement of 100 plates/month has been achieved.

Programs for collating and examining the overlapped plates have also been developed.

Academic Services to Universities

Sussex University. The following members of staff hold visiting appointments: F. G. Smith and Pagel (Professors); Murray, Dickens (Readers); Pagel (MSc examiner); Jones and K. Taylor (Lecturers). Murray gave eight lectures with Jones on Galactic Kinematics and Structure for the MSc course.

Seven DPhil students have worked under supervision at RGO (S. Caldwell, M. J. Currie, R. Korakitis, M. T. A. T. Lago, Mrs. M. T. de Peralta, J. R. Lucey, D. C. Watts) and four MSc students have undertaken projects at RGO as part of their degree requirements (C. Goldsmith, B. Heath, B. Trimmer and T. Harriott (p/t)).

A two-week course in Instrumental Astronomy for MSc students was again organized at RGO by D. L. Harmer. Ten staff members assisted with lectures and demonstrations.

A further series of 23 joint colloquia was held at the University and RGO.

Sandwich Students. Six students spent a total of 28 months undergoing training at RGO, mostly in the fields of computing and electronics. Just over half of this training effort was financially supported in part under Government Training Scheme arrangements. The students came from: Brunel and Loughborough Universities; Dundee College of Technology, Birmingham and Thames Polytechnics.

Vacation Students Course. Ten students from seven UK universities attended the 1979 eight-week summer vacation course in astronomy which was organized by Argyle under the general direction of Pagel. As in previous years, each student worked on an individual project under the supervision of a member of staff, attended lectures and gained experience of night observing.

Pagel served on the Organizing Committee and as Local Organizer of the SRC Introductory Course for Research Students and contributed six lectures on Stellar Atmospheres, the origin of the elements and a guide to the astronomical literature. The course was held at RGO from September 10-21 and was attended by 30 students, 12 lecturers and six seminar speakers.

Other Academic Services. Dickens was an external PhD examiner for Oxford University.

Technical Services to Universities

Visiting Observers. Several groups of university observers visiting RGO were provided with assistance in the setting up of their equipment and interfacing problems. Updated star positions and finding charts were also provided for many observers.

Armagh, Dunsink and Cambridge Universities. GALAXY was used for 60 hours to measure plates for these universities.

Cambridge Observatories. Various mirrors have been coated.

Durham University. Further assistance has been given with building a 40-mm McMullan electronographic camera; this is now complete and has undergone initial tests. The tube has been supplied on loan from RGO.

Anti-reflection coatings have been produced for specific wave-bands on various colour filters for the Durham polarimeter.

McMullan has kept in touch with the work at Durham on the development of a detector using Plessey silicon-diode arrays. A further batch of arrays has been obtained from Plessey and loaned to Durham. Progress continues to be encouraging: astronomical observations were made on the RGO 30-inch coude spectrograph in August.

Imperial College and Manchester University—Kottamia Support. As part of the Anglo-Egyptian agreement members of the Engineering Division have visited Kottamia to carry out maintenance and improvements to the 74-inch telescope and associated facilities. The work included an improved sidereal drive system.

London University. Two telescope mirrors have been coated

Manchester University (Jodrell Bank). A 40-mm travelling electronographic camera was transported to the Soviet 6.0-m telescope at Nizhnif Arkhyz and set up at the prime focus by Powell. It was used in a collaborative programme between Jodrell Bank (D. Walsh and I. Browne) and the USSR Academy of Sciences Special Astrophysical Observatory aimed at the optical identification of radio sources. The camera was left at the telescope to be used by the Russian observers on a subsequent run before being returned to the RGO. Prior to sending the camera, McMullan visited the telescope to assess the problems involved in fitting the camera; on his return a special acquisition and guiding system was built in the RGO workshop in the very short time of one month by Mayhew. Lowne carried out some of the optical tests.

Oxford University. C. F. W. Harmer calculated the tolerances and manufacturing details for the camera for the Oxford low-dispersion spectrograph (120 Å/mm) to be used on the 1.0-m LPO telescope. This camera is an f/5.3 off-axis flat-field Maksutov system to be used with a Reticon detector.

St Andrews University. The serial CAMAC system of the St Andrews scanner was debugged and the scanner installed on the 0.75-m telescope at SAAO by van Breda. It has been used for observing runs on the 0.75-m and 1.9-m telescopes by RGO and SAAO staff.

Wavelength-specific coatings have been produced on transmitting and reflecting optical components of the St Andrews DAO-pattern spectrographs.

General Services to Astronomy

International Astronomical Union. F. G. Smith is Vice-President of

Commission 50 and a member of the organizing committees of Commissions 38 and 48; he is an IAU delegate to CCIR. Pagel is a member of the organizing committee of Commission 36. Murray is President of Commission 24 and a member of the organizing committee of Commission 37, ESA HIPPARCOS Science Team and ESA Astronomy Working Group. McMullan is a member of the organizing committee of Commission 9 and of the Working Group on Photoelectric Image Detectors. Wilkins is a member of the organizing committees of Commissions 4, 5 and 31, and a member of the Joint Working Group of Commissions 4 and 16 on Rotational Elements of the Planets; a member of the Commission 5 Working Group on UDC 52 and Chairman of the Working Group on Astronomical Data; Chairman of the Working Group of Commission 19 on the Determination of Rotation of Earth; and an IAU delegate to CODATA. Tucker is President of Commission 8. Jones is Chairman of the Working Group of Commission 25 on Reproduction of Photoelectric Systems Photographically and Electronographically. A. T. Sinclair is a member of the Joint Working Group of Commissions 4 and 16 on Rotational Elements of the Planets and a member of the Working Group of Commission 20 on Satellites. G. E. Taylor is Chairman of the Working Group of Commission 20 on Prediction of Occultations by Satellites and Minor Planets.

National Societies and Committees

- (i) *Royal Society*: F. G. Smith is a member of the British National Committee for Geodesy and Geophysics and he and G. E. Taylor are members of the British National Committee for Astronomy; Murray and Wilkins are members of the Space Ranging Research Committee; Wilkins is a member of the Geodesy Sub-Committee and G. E. Taylor is a member of the Sub-Committee for Optical Tracking of Satellites. McMullan is RAS representative on the Optical and Quantum Electronics Sub-Committee of British National Committee for Physics.
- (ii) *Royal Astronomical Society*: Jones is a Vice-President and he and Pagel are editors of *Monthly Notices*; R. G. Bingham and Andrews are members of Council.
- (iii) *Institute of Physics and Physical Society*: D. L. Harmer is Secretary of the Optical Group.

SRC Boards and Committees. F. G. Smith and Pagel are members of the ASR Board and Pagel is a member of its Theory Panel; he is a member of the IUE Committee and he, Murray and Dickens are members of the Panel for the Allocation of Telescope Time of which Alexander is Technical Secretary; Harding is Secretary and Murdin a member of the Scientific Committee on Optical Telescopes; Harding is also SRC Technical Liaison Officer for AAO, SAAO and Kottamia;

Thomas is Secretary of the RGO Establishment Committee; Dickens and Murdin are members and Jones RAS assessor of the Astronomy II Committee; Dickens and Murdin are members of the Space Telescope Advisory Panel; R. G. Bingham is a member of the UKIRT Steering Committee; Wilkins is a member of the Data Advisory Panel and a member of the Central Review Board Panel C; K. F. Hartley is a member of the Technical Sub-Committee of the Image Processing Panel and he and Murdin are members of the STARLINK Scientific Advisory Group. Hartley is also a member of the Software Working Group.

Other Appointments. F. G. Smith is a member of the SAAO Advisory Committee; he is a member of the AAO Board and President of the International Scientific Committee of Roque de los Muchachos Observatory; Pagel deputized as a member of the AAO Board and is a member of the Editorial Board of *Reports on Progress in Physics*. Wilkins is Secretary of the Federation of Astronomical and Geophysical Services; Jones is a member of the *EXOSAT* Observing Programme Panel. Andrews is an editor of *The Observatory*. van Breda is a member of the *IUE* Observing Committee. G. E. Taylor is Director of the Computing Section of the British Astronomical Association. Harding is Secretary of the International Scientific Committee of Roque de los Muchachos Observatory.

Organization of Symposia. Pilkington was a member of the Scientific Organizing Committee of IAU Symposium No. 82.

Herstmonceux Conference. The 23rd annual Herstmonceux Conference on Cataclysmic Variables was held in the Castle on April 2 and 3 and was attended by about 50 visitors including Bath (Oxford), Chevalier (Kitt Peak), Goss (Groningen) and Weiler (Bonn). The scientific organizers were Andrews and D. H. Clark.

Contract Work for Outside Bodies

The 40-mm McMullan electronographic camera for ESO has been completed and acceptance trials were conducted in May in Geneva. Commissioning at the prime focus of the ESO 3.6-m telescope at La Silla is scheduled for the end of 1979.

Hartmann test plates were measured on GALAXY for the ESO 3.6-m and 1.4-m telescopes and UKIRT.

About 500 Schmidt plate overlays were produced for the AAO on the ICL 1903T computer.

Miscellaneous Services to Outside Bodies

A photon-counting detector employing a cooled Reticon self-

scanned diode array is being built for the image tube spectrograph at the SAAO. Preliminary design work and the purchase of major components have been completed and it is hoped that the detector will be ready by the end of 1980 when the IPCS on loan to SAAO returns to RGO.

The collaboration with Copenhagen University Observatory on electronographic cameras, which was established in 1975, has continued. The Danish 40-mm camera and an RGO 85-mm camera (on loan) were shipped to La Silla and installed on the Danish 1.5-m telescope by McMullan and R. Florentin Nielsen of CUO during 1978 November. Both cameras have since been used regularly by CUO and RGO astronomers.

The 40-mm cameras at SAAO and the Wise Observatory were supplied with replacement tubes as needed although production difficulties delayed the despatch of a grade 1 tube to the Wise Observatory. Various accessories for updating the cameras at AAO and SAAO have been supplied.

A special set of anti-reflection coated *UBVR* filters of equal thickness have been sent to SAAO for the 40-mm camera.

The Penny beam splitter has been fitted with a new set of dichroic filters (coated at RGO by Jackson) and sent to SAAO on loan.

C. F. W. Harmer carried out final rebalancing of the optical design of the lens for the RL fast-cycling bubble chamber following a change in the functional specification.

R. G. Bingham and Lowne modified the design of the proposed 10- μ m spectrometer for the UKIRT to suit a specified cryostat, and provided detailed manufacturing tolerances.

Milsom continued his period of duty at SAAO; he assisted with the development, commissioning and maintenance of instrumentation for the SAAO telescopes.

Gietzen has acted as consultant to the AAO on the provision of optical test facilities, and has advised AAO and SAAO on new instrumentation and the modification of existing equipment.

Walker has continued to advise and assist the Instituto de Astrofísica de Andalucía on the building of a new Spanish observatory to house the Steavenson telescope.

Herstmonceux Castle, Grounds and Exhibition

Herstmonceux Castle. Discussions continued with the Ancient Monument Section (AMS) of the Department of Environment on the problems arising from the inability of AMS to allocate effort to carry

out repairs to the outer fabric of the castle, and in 1978 November AMS stated that while they could continue to give advice on the preservation of the fabric they could no longer undertake to carry out the work with the direct labour force. RGO in consultation with the Council Works Unit has therefore assumed responsibility for this work but during the past year it has been possible to carry out only urgent repairs needed for safety reasons.

Grounds. A contract was placed for maintenance of the woodlands and a programme of thinning and general maintenance started by the contractor. The maintenance schedule introduced two years ago for the grounds and gardens continued to operate satisfactorily.

Exhibition. A new astronomical exhibition, occupying a large part of the West Room was produced by a specialist outside firm working from sketches and ideas provided by the Exhibition Committee and was installed in time for the reopening at Easter. The new displays have proved popular with visitors. The visitors tea-room was enlarged and new toilet facilities (including toilets for the disabled) were provided. With the removal of the INT from Herstmonceux there is no longer a large telescope for visitors to see. The total number of visitors admitted was 45 219 a decrease of 5 per cent over the previous year (47 575).

5 INTERNAL FACILITIES AND SERVICES

Central Computer Services

The Computer Department is responsible for the operation and provision of basic software for the ICL 1903T computer system, for the use of the GEC 2050 remote-job-entry link to the IBM 360/195 computer system at the Rutherford Laboratory, and for the development of software for the digital image processing facility (see page 12). The Department also provides assistance to programmers through advisory and punching services and, where appropriate, by operating auxiliary machines.

The ICL 1903T computer was operated for two shifts (up to 16 hours) on 250 working days throughout the year, providing an average of 293 hours of useful time each month. At the start of the report year between 200 and 250 jobs were being run each day, whereas at the end the figure was nearer 350, and occasionally over 400; this increase was made possible by recent enhancements to the hardware, by the tuning of the operating system and other software improvements. Of the useful time 43 per cent was devoted to research programmes, 37 per cent to national and international services and 20 per cent to systems overheads, including software development and maintenance. Usage of

the IBM 360/195 increased to 38 hours, mainly for large-scale computations in engineering, astrometry and celestial mechanics.

The principal enhancements to the central facilities were as follows; a line scanner, previously part of the ICL 1906A at the Rutherford Laboratory, was brought into operation to provide 16 terminal lines (instead of 8) at speeds of up to 120 characters per second (instead of 10); a Tektronix 4010 graphics display unit was added; a 13-year old plotter was replaced by a Calcomp 1039 plotter; an off-line Versatec electrostatic printer/plotter was installed; the original 7-track magnetic tape units were replaced by a set of four newer ones from the Appleton Laboratory; and two graphics packages, SIMPLE PLOT and GINO-F were purchased to facilitate the use of the new hardware facilities.

Engineering Services

Engineering Division. Following the removal from Herstmonceux of the Isaac Newton Telescope for modification prior to installation on La Palma, manpower previously dedicated to supporting the telescope's operation has been redirected to the manufacturing and commissioning phases of instrumentation for the INT on its new site. While the work of the Engineering Division is concentrated mainly on support for the La Palma Observatory Project it continues to maintain installations and services at Herstmonceux and carries out such improvement as the approved programme demands and facilities permit.

Electronics and Electrical Engineering (Gill). A detailed proposal for the rebuilding of the GALAXY electronics has been completed and work continues on schemes for renewing the electronics associated with the Greenwich Time Service. The department is increasingly involved in system control work in association with the LPO Division for which it is also providing comprehensive test and commissioning facilities. An example is a CAMAC test system currently under development.

During the past year the electrical supply to the Observatory has been improved by the addition of a new substation and main distribution switchboard together with a new diesel generator standby installation.

Engineering Workshops (A. D. White). The new telescope interface facility, capable of simulating the cassegrain and prime-focus instrument interfaces of most large telescopes, has been commissioned and is used for test and development programmes associated with instruments produced at RGO and by outside manufacturers. The manufacturing phase of the INT cassegrain spectrograph is well advanced and work continues on improvements to the Observatory's wide range of precision instrumentation.

Design Office (Crumph). Throughout the year effort has been concentrated on the detail design of instructions for the INT and on building layouts for the La Palma site. The office continues to provide its basic services to RGO and associated universities on the design of astronomical instruments and the preparation of material for exhibitions, lectures and publications.

Telescope Management (Willmoth). With the cessation of INT operation at Herstmonceux observational work is concentrated in the equatorial and meridian groups of telescopes. A small team provides engineering support for observers and is carrying out a programme of minor improvements to the telescopes and associated facilities.

Works Group (Drummond). The small extension to the Physics Block has been completed and the photographic suite it houses is in operation. The major extension to the West Building, covering an area of 1000 m² is nearing completion and is due for occupation by the end of 1979. Throughout the Observatory site planned maintenance and an ongoing development programme ensures that buildings and services are capable of maximum utilization.

Laboratory Services

Vacuum Physics (Powell). The routine processing of image tubes has continued throughout the year. The problems mentioned last year, and some others which became evident at a later date, have now been overcome. A contract has been placed with Instrument Technology Ltd (ITL) of St Leonards-on-Sea for the manufacture and reprocessing of the tubes and the Observatory will be relieved of this routine work. ITL engineers started in August learning the techniques involved.

Quality control of electronographic emulsions has continued and there has been a marked improvement in the quality of the films received from the manufacturers.

Optical Laboratories and Design (R. G. Bingham). The Optical Design Section under the direction of Professor C. G. Wynne has been closely involved with the design of instruments for the La Palma Observatory. Work has included the detailed optical design of the proposed new coude spectrograph for the INT, detailed final balancing of the Wynne corrector for the prime focus of the INT, and the design of eyepieces for the 1.0-m telescope. Test procedures have been prepared for the optics of the 1.0-m telescope.

Wynne redesigned the prime focus field corrector of the 4.2-m telescope following the change in the focal ratio to $f/2.8$.

Lowne has tested prototype optical systems for the 2.5-m telescope and investigated diffraction limited resolution in the proposed coude

spectrograph. He has also carried out laboratory experiments on the proposed method of alignment of the 1.0-m telescope.

Lowne also tested a number of diffraction gratings during the year and, in anticipation of an increase in this work, has designed a permanent laboratory test facility which is now being built. An autoguider test facility, previously designed, has been manufactured and commissioned.

The Coating Laboratory has coated optical components for RGO and for a number of outside institutions. At present the 36-inch telescope aluminizing plant, which has been fitted with an electron beam evaporation source and monitoring devices, is being used but the sizes of components that can be coated is rather limited. A purpose designed box coater (internal dimensions 80-cm cube) has been ordered from Electrotech Ltd and delivery is expected early in 1980; this will permit a wider range of components to be handled, and more sophisticated coatings to be applied, with considerably greater ease of operation.

Microprocessor Applications (van Breda). A floppy disc based version of FORTH was purchased this year and has been used extensively for programme development. Consequently there has been very little use of cross assemblers on the ICL 1903T or IBM 360.

Microprocessors are now being designed into five Automation Department projects; one of these (CID solid-state detector) uses a DEC LSI11 microprocessor, also to be programmed in FORTH.

Additionally, the Electronics Department is making use of developments carried out by the Automation Department to design microprocessors into new LPO instruments and for the testing of CAMAC modules.

Two new amplifier/discriminators have been acquired with the low dead-times of 10 ns. A data acquisition programme has been written for the two-star photometer with star/sky chopping.

Photographic Section (Calvert). The photographic section moved into new accommodation in the Physics Block extension in September. New equipment includes Durst colour processors.

Libraries and Archives

Libraries. All books published prior to 1800 were weeded from the open shelves, as were any publications of which similar or earlier editions were reported as having been sold at auction. All these, plus the original rare-book collection are being catalogued and described by Miss B. J. Tilley, a sandwich student from Birmingham School of

Librarianship. Much of the pre-1939 scientific stock was also moved from the ground floor of the Castle to clear space for the rearrangement of the periodical collection. The cataloguing and classification of the more modern books continues. Trials, using the link to the IBM 360/195 computer at RL, were completed on the Famulus suite of programs and work was commenced on building a computer-held file. A catalogue of periodicals and observatory publications is being compiled. The collection of modern 35-mm transparencies has been reorganized and a computer-produced KWIC index is being prepared.

Archives. The question of the future of the RGO Archives has been resolved and proper facilities for storage and conservation are to be provided. A new complement post was created for a Senior Conservation Officer. A calendar (a detailed list of the contents) of the Flamsteed papers was started by Miss F. Willmoth, a summer vacation student. Assistance was given to 18 visitors, some from overseas and some of whom stayed for several days or weeks. Over 80 postal enquiries were answered.

The first 30 volumes of the Airy papers were microfilmed (12 reels, 1296 frames); in many cases the microfilms are clearer than the originals.

General Administration

Personnel, General Administration and Finance. On the Personnel side, the section carried out the normal duties associated with staff changes. During the year, 39 staff left, 512 applications for employment were received, 154 applicants were interviewed at 45 separate Interview Panels, 52 offers of appointment were issued of which 13 were declined and 39 accepted. In addition six staff joined as a result of SRC promotion exercises making the total number of staff joining 45. The amalgamation of Central Office superannuation files with local files was completed, 27 superannuation cases were dealt with. The section handled the paper work for local reviews and continued to issue the Information Bulletin at monthly intervals.

On the General Administration side, a new Industrial Supervisor post was created. This officer has replaced the Sections Industrial Leading Hands and undertakes a variety of tasks including making arrangements for essential cover during unpredictable absence of certain service staff (security wardens, telephonist, etc). The section serviced an increased number of functions held in the Castle (training courses, meetings and conferences).

A new Executive Officer post was created in the Finance Section to handle the contracts and financial status reports for the La Palma operation and to provide costing information for other projects. The volume of work in this section has increased significantly over the last

two years; total spent in 1976/7 was £1710k compared with £3123k in 1978/9 and the number of orders has increased from 1954 (including 46 tender cases) in 1976/7 to 3393 (including 201 tenders) in 1978/9.

The RGO Establishment Committee considered the report on overheads prepared by Management Services Unit, SRC, and concluded that there was little scope for significant savings under this head.

Training

During the academic year 25 members of staff were engaged in day release courses, including two studying for PhD, two for MSc at the University of Sussex and four for BSc at Brighton Polytechnic. One MSc degree and two BSc degrees were awarded to staff who successfully completed their courses. External courses covering a wide range of technical and management topics were attended by 31 staff; 63 staff attended internal courses at RGO and other SRC establishments. In total, training activities accounted for three per cent of salaries and wages of the Observatory.

Health and Safety

The Safety Committee met four times during the year and its membership was increased to include Safety Representatives (nominated by Staff Side and the Trade Unions). A regular schedule of monthly safety inspections has been introduced; these inspections have brought to light a number of hazards and potential hazards and steps have been taken to deal with these. These inspections are supplemented by safety audits undertaken by the Safety Officer and a significant improvement of the awareness of safety matters by staff has been noted.

Fire certificate work in the Physics Block has been completed; work on the fire certificate requirements for the remainder of the West Building is in progress. Phase 2 of the Fire Alarm system (covering the West Building) was commissioned in February; the final stage of the Fire Alarm system covering telescope buildings, Works Pound and other outbuildings is scheduled for completion in 1979 December.

Safety Induction talks have been started and first-aid training has continued. Three general Safety Information Circulars and various Safety Instructions have been issued. Close collaboration with the Rutherford Laboratory Safety Group and other appropriate organizations has been maintained.

6 GENERAL

Official Visitors

Mrs. Maria Garcia-Alegre and Mr. Luis Tomas-Roij from the

University of La Laguna in Tenerife spent four weeks in October observing on the 30-inch coude telescope and tracing their spectra on the PDS microdensitometer.

Dr. Begoña de Luis Fernandez and Miss Conchita Perez Garcia of the Universidad Nacional de Educacion a Distancia visited the RGO in October to gain further knowledge of astronomy under a scheme sponsored by Professor Francisco Sanchez Martinez of Universidad de La Laguna, Tenerife.

Five engineers from the Optical Branch of the Chinese Machinery Society, led by Mr. Chou Li-Wei, Senior Adviser to the Optical Department, Worth Industries Corporation, Peking visited the RGO in October. Their particular interests are in the design and manufacture of photoelectronic tubes and optical design and they spent a large proportion of their time in the Vacuum Physics Department.

Dr. Flavio Fusi Pecci from the Observatorio Astronomico visited the RGO during part of November and December to work on photometry in the globular star cluster M15 with Dickens, E. A. Bingham and the Galaxy Department.

Mr. P. Read, SAAO spent six weeks in January and February at RGO during which he was involved with the IPCS tests.

Dr. H. J. Fogh Olsen and Dr. L. Helmer of Copenhagen University Observatory, Brorfelde, brought the entire staff of the Meridian Department to RGO for a three day course in March in fundamental astronomy. The personal contacts and friendship made during this highly successful visit will be of great value in the development of the Anglo-Danish collaboration in Meridian Astronomy on La Palma.

The Chairman of SRC, Professor Sir Geoffrey Allen, escorted the French Ambassador, Monsieur Sauvagnargue, the Scientific Councillor to the French Embassy, Monsieur Bretan and Mr. K. E. G. Barker from the Science and International Relations Branch of DES around RGO in July.

The International Association of Institutes of Navigation visited RGO in September to see an exhibition of current NAO publications and items of navigational interest from the Archives and rare book collection.

Members from the Universities of Cambridge, Durham, Manchester, Oxford and Sussex and from Armagh Observatory, Mill Hill Observatory and IAA Granada, Spain used the PDS microdensitometer at various times throughout the year.

Members of the Astronomy Centre at the University of Sussex have visited RGO on numerous occasions to take part in seminars and

discussion groups and for private study. Personnel from the following establishments also paid brief visits to RGO during the year:

AAO—Dr. G. Bothwell, Dr. D. Morton; Instituto de Astrofísica de Andalucía—Dr. V. Costa, Dr. S. Vidal; Appleton Laboratory—Dr. J. Hall, Dr. D. J. Stickland, Dr. R. Street; Armagh Observatory—Mr. M. Coyle; Australian National University—Dr. H. Hyland; Bologna University—Dr. F. Fusi Pecci, Mr. M. Voli; Brighton Polytechnic—Dr. D. Longley; Cambridge, Department of Geodesy and Geophysics—Dr. J. A. C. Horsfall; Canterbury, New Zealand—Professor R. H. T. Bates; Cape Town University—Dr. D. Kurtz; CAS/ROE—Mr. G. Walker; Computer Application Services—Mr. B. Alexander, Mr. G. Walker; Copenhagen University Observatory—Dr. E. Høg, Dr. H. J. Fogh Olsen; County Planning Office, Lewes—Mrs. Hinze; Disney Committee on Data Analysis—Professor Alexander; Dominion Astrophysical Observatory, Canada—Professor S. Van den Bergh; University of East Anglia—Mr. J. Shirley; Edinburgh University—Mr. M. Millar; ESO—Dr. K. Kiln; Harwell—Dr. J. V. Jelley; Hull University—Dr. R. Hyde, Dr. Whitehead; Hunting Survey Ltd.—Mr. Cooper, Mr. Cox, Mr. Dukes, Mr. Matheson, Mr. Payne, Mr. Webb; ICL—Mr. I. Fleming; Imperial College—Mr. N. Vine; International Commission on Illumination—Dr. A. Fisher; Lancaster University—Mr. P. R. Chippendale; Leicester University—Professor K. Pounds; Merseyside County Museums—Mr. J. Ravest, Mr. R. Smith; Millimetre-Wave Telescope Project Team—Mr. Benham, Mr. Brooks, Dr. Hall, Dr. Hills, Mr. Street; Mullard Space Science Laboratory—Dr. J. Zarnecki; National Engineering Laboratory—Mr. Nimo, Mr. Tweedie, Mr. Winning; NERC, Institute of Oceanographic Sciences—Mr. D. Pugh; University of Newcastle upon Tyne—Dr. F. R. Stephenson; Oxford University—Professor D. E. Blackwell, Mr. C. Beckett, Mr. D. Blisset, Dr. M. Shalhiz; Perkin Elmer—Dr. D. R. Chapman, Mr. P. York; Public Records Office—Mr. D. Borlaw, Mr. A. Medlicott; RAE, Farnborough—Dr. Davidson, Dr. Gooding, Dr. Merson; Royal Commission on Historic Manuscripts—Miss M. Sweet; Rutherford Laboratory—Mrs. K. Crennell, Miss P. Gamse; SAAO—Dr. I. Glass, Mr. G. Woodhouse; SAAO Advisory Board—Professor E. E. Baart, Professor C. Engelbrecht, Dr. M. W. Feast; Solar System Committee, Secretary—Mr. P. J. Casey; Surrey University—Mr. R. G. S. Clarke; Toronto University—Mr. G. Good; US Navy—Dr. R. Harrington; US Naval Observatory—Dr. P. K. Seidelmann, Dr. T. C. Van Flandern, Dr. G. Westerhout; US Naval Research Laboratory—Mr. H. Warren; Vatican Observatory—Father E. J. Bendetti; Yale University—Mrs. L. Stryker.

Senior and Junior SRC Induction Courses were held at RGO in

May; Officers from HMS *Mercury* and the Canadian Armed Forces also visited RGO as part of their courses.

Staff Changes

Miss J. E. Perry (EO) retired in February after 32 years' service at RGO.

Mr. G. Clark (Gardener) retired in June after 32 years' service.

Dr. D. V. Thomas (SPSO) transferred to Swindon in July.

Staff: Degrees Awarded

Mr. G. M. Appleby and Mr. P. Gibbs were awarded BSc degrees by Brighton Polytechnic.

Miscellaneous

Mr. G. Gutsell, Craftsman Chargehand, was awarded the BEM in the 1979 Honours List.

Professor C. G. Wynne was awarded the Gold Medal of the RAS for his manifold contributions to the design of astronomical telescopes and instruments.

Professor F. G. Smith accepted the Freedom of the Worshipful Company of Clockmakers.

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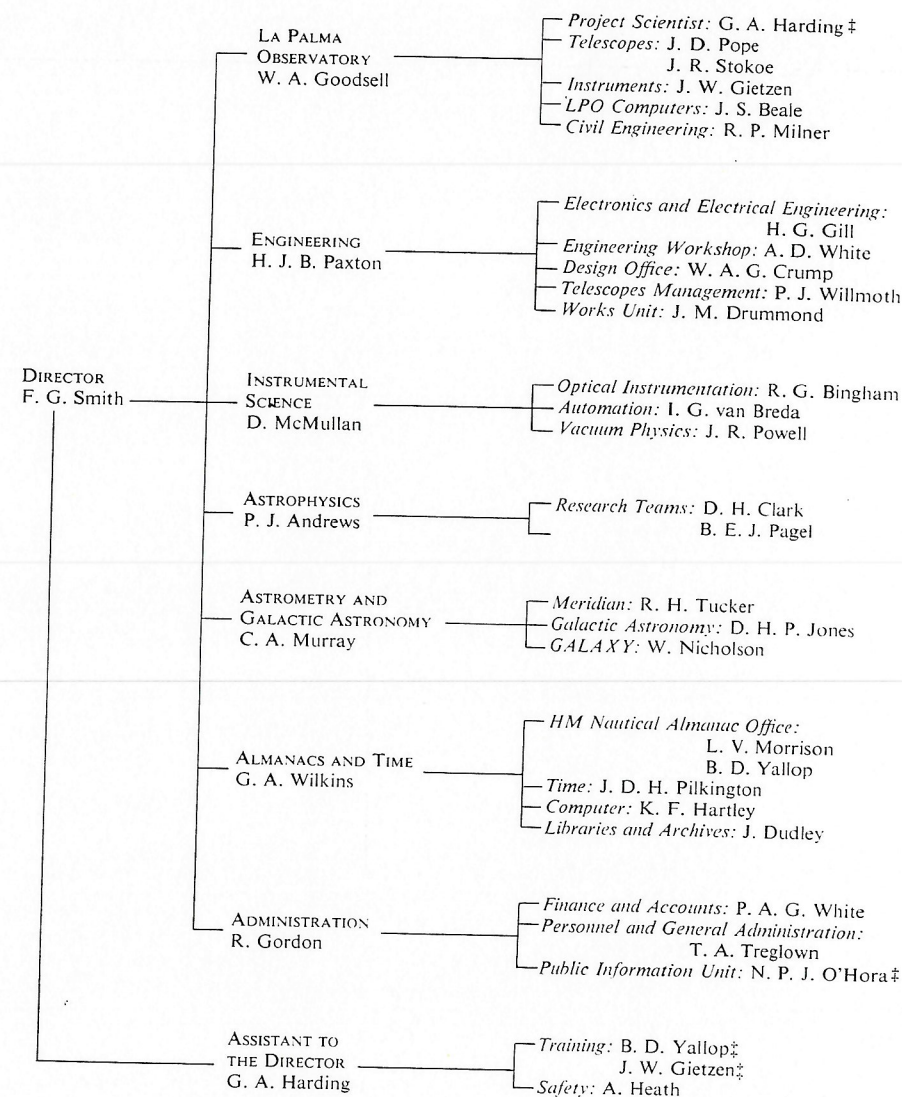
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ABBREVIATIONS

SO	Assistant Scientific Officer	PSO	Principal Scientific Officer
CA	Clerical Assistant	p/t	Part-time employee
CO	Clerical Officer	PTO	Professional and Technology Officer
CSO	Chief Scientific Officer	SDP	Senior Data Processor
CSO (IM)	Deputy Chief Scientific Officer (Individual Merit)	SEO	Senior Executive Officer
DOA	Drawing Office Assistant	SO	Scientific Officer
DP	Data Processor	SPSO	Senior Principal Scientific Officer
EO	Executive Officer	SPSO (IM)	Senior Principal Scientific Officer (Individual Merit)
EO	Higher Executive Officer	SRF	Senior Research Fellow
SO	Higher Scientific Officer	SSO	Senior Scientific Officer
JRF	Junior Research Fellow	Suptg Eng	Superintending Engineer
PTO	Principal Professional and Tech- nology Officer	Supt Typist	Superintendent of Typists
PRF	Principal Research Fellow	†	Part time responsibility

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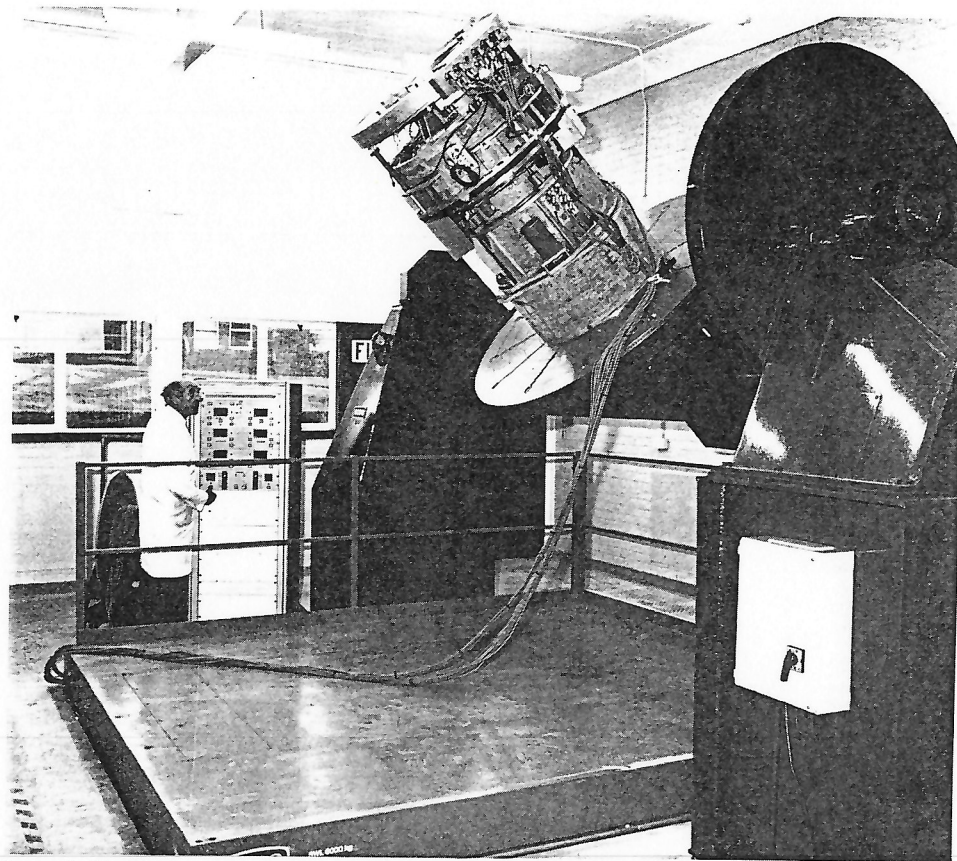


PLATE I. *The RGO Telescope Simulator.* The RGO telescope simulator is capable of representing the cassegrain and prime-focus instrument interfaces of most large telescopes. Based on a standard welding manipulator the facility has a capacity of 6 tonnes and is able to reproduce most telescope positions. The rising floor permits accurate representation of the cassegrain instrument clearance and there is ample head room for the largest prime-focus instruments. The simulator will be used principally as a test-bed for instruments built at RGO and by outside manufacturers. With a suitable star simulator, the facility can also be used by observers to familiarise themselves with the use of instruments before they are taken overseas (see page 36).

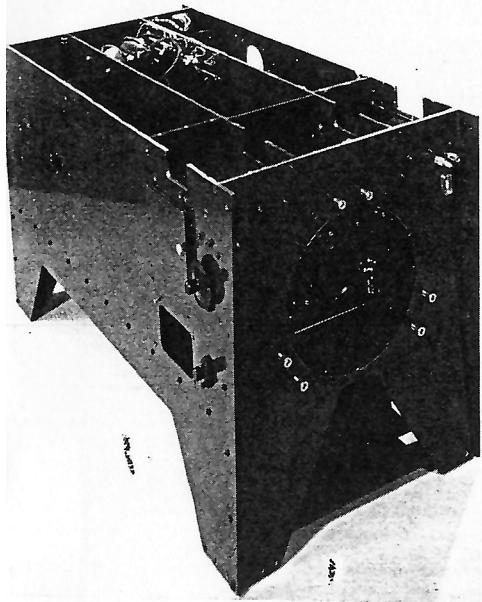
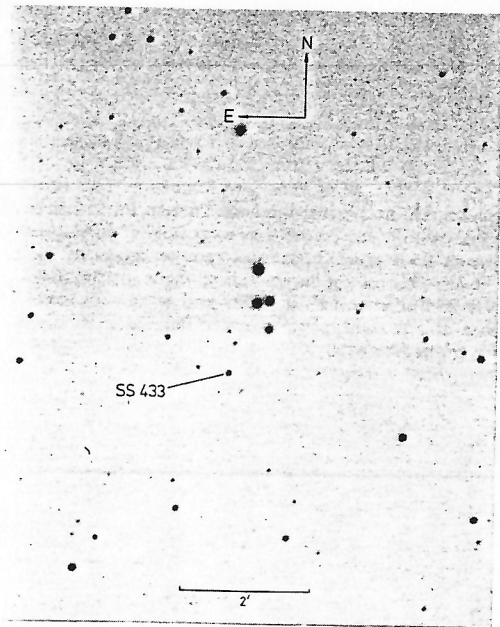


PLATE II (a). The *TAURUS* Fabry-Perot Interferometer. TAURUS is a new imaging device developed jointly by the Royal Greenwich Observatory and Imperial College. It uses a Fabry-Perot interferometer and a photon counting system (IPCS) as its detector to produce a data array of three dimensions (two for coordinates and one for wavelength) for an extended emission-line source. The device is highly efficient at obtaining seeing-limited velocity data over fields of 5 arc-minutes, and has been used successfully on the 36-inch telescope at Herstmonceux and on the 1.9-m SAAO telescope in South Africa (see page 22).

PLATE II (b). The Field of SS433. The plate shows the field of the object SS433 photographed with the 26-inch telescope at Herstmonceux. Astrometry of this plate showed its coincidence with a point radio source measured with the Cambridge radio interferometer. It is also coincident with an X-ray source at the centre of the supernova remnant W50, and is the origin of two outflowing relativistic jets of material manifesting themselves in Doppler shifting of spectral lines (see page 19).



SOLAR BUTTERFLY DIAGRAM 1874-1976

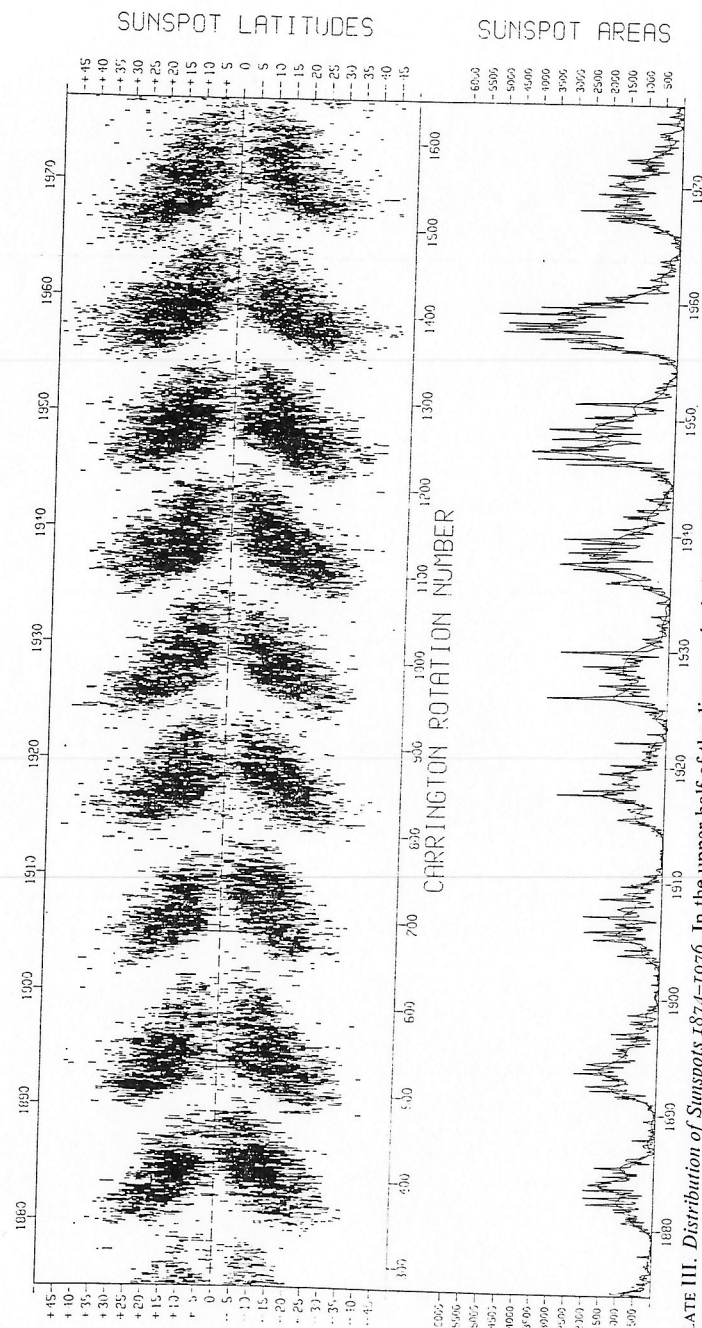


PLATE III. *Distribution of Sunspots 1874-1976*. In the upper half of the diagram the latitude of each sunspot group is plotted against date to produce a "butterfly diagram", which shows at a glance the progressive change in the distribution of the sunspots during each solar cycle. The data were obtained from the Greenwich photoheliographic observations made during the period 1874-1976. The diagram was produced on a Calcomp graph plotter attached to the ICL 1903T computer. In the lower half of the diagram the mean total daily sunspot areas for each synodic rotation in months of the visible hemisphere of the Sun is plotted to show the variation in the level of solar activity during the period (see page 27).