EXTRACT FROM

A Personal History of the Royal Greenwich Observatory at Herstmonceux Castle 1948 – 1990

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5 S.R.C. TAKES CONTROL – 1972 TO 1981

A DECADE OF GROWTH AND TRANSITION

5.1 Introduction

The decade following the 16-year term of office of Sir Richard Woolley as Astronomer Royal was a period of rapid change in the character of the Observatory. Up to this time there had been only 11 Astronomers Royal in 296 years but, following the loss of the title, there were three Directors in the next decade. More significantly, the main function of the Observatory changed dramatically. Instead of carrying through long-term programmes of observation and associated research, it became primarily a developer and manager of overseas observing facilities for other astronomers. There was considerable growth in the budget and some increase in the complement, especially in respect of the design of telescopes and instruments. The programmes of observation and research continued, as did the provision of general services for almanacs and time, but at a reduced priority.

The three Directors were Professor Margaret E Burbidge, Dr Alan Hunter and Professor Francis Graham Smith. They had three quite different backgrounds and styles. Burbidge was an observational astronomer from a university environment and had had no experience of managing a multi-purpose organisation. Hunter, on the other hand, had joined the Royal Observatory at the start of his career, had been seconded to Admiralty work during the war, and had, in effect, been deputy-director to Woolley. He had the task of carrying through the restructuring of the RGO for its new role while overseeing the celebration of its 300-year history. In contrast, Graham Smith had had a university career in radio astronomy in Cambridge and Manchester, where he had been involved in major multi-user telescope projects. He had also had experience in management at the Appleton Laboratory, which was another SRC establishment. His main task was to oversee the building of the ‘Northern Hemisphere Observatory’ on a good overseas site.

5.2 The Burbidge period, 1972 to 1973

Professor Margaret Burbidge was unable to take up her appointment as Director of the RGO until 12 July 1972, although she did visit the Observatory at the beginning of June for two days. The title of Astronomer Royal was conferred on Sir Martin Ryle, FRS, who was the senior radio astronomer in the University of Cambridge. Dr Alan Hunter was the Acting Director of RGO during the first half of the year. He instituted a series of Senior Staff Meetings (SSM) the object of which was “to advise the Acting Director (and further ahead the new Director, if she concurs) on policy matters; and to promote discussion of, and diffuse news on, matters of departmental interest”. We held the first of the new Senior Staff Meetings on 13 December 1971. The members were Lynden-Bell, McMullan, Murray, Pagel, Whale and myself. Other department heads were co-opted as appropriate. Murray and I were given oversight of the Solar and Time Departments, respectively. Lynden-Bell resigned later in the year to become Professor of Astrophysics in the University of Cambridge.

The appointment of Margaret Burbidge created considerable attention in the national press and a 3-page article about her was published in the *New Scientist* (28 September 1972) under the heading “The astronomer who came back”. She was

described as “a delicate silver-haired figure” and the writer continued “Her manner is attractive. Her warmth, charm, and the breathless enthusiasm of her voice, as if everything were new and fresh, give an aura both of innocence and total self-certainty.” On the other hand, her husband Geoffrey was described as “a large, loud man, well known (and unpopular in some circles) for saying what he thinks, and saying it in no uncertain terms”. Her technical abilities were recognised by the award of the degree of Honorary Doctor of Science by the University of Sussex during the IAU General Assembly in 1970. Then it was said that she was “not only a distinguished astronomer but also a wife and mother. She has done outstanding work in many branches of astronomy, including abundances in stellar atmospheres, galactic rotation and the study of quasars, and she also discharges the important task of preventing the speculations of Geoffrey Burbidge, Fowler and Hoyle from departing too far from the observational evidence.”

Margaret Burbidge did continue the SSMs, but she also invited her husband to attend, even though he had no position within the RGO. (He had, I believe, an unpaid position in the University of Sussex.) The contrast between the two of them soon became apparent. There was, however, one point on which they were agreed: the Isaac Newton Telescope was in the wrong place and should be moved to a better site overseas. She was, however, away from Herstmonceux for quite long periods and so Hunter, in effect, continued as the acting Director!

By this time the campaign for a ‘Northern Hemisphere Observatory’ on a mountain-top site was well under way. Some (probably including Geoffrey Burbidge) argued that the job of managing the construction of such an observatory should not be given to the RGO since, it was claimed, the RGO had failed in the building of the INT. They did not recognise (or realize) that the RGO had originally been excluded from responsibility for the INT, but had found itself having to take on the job at a late stage without being given appropriate resources. Some initial studies were, however, carried out at the RGO. In particular, by March 1972 Pope, who had returned from his duty in Australia for the AAT, had examined a number of optical configurations for a large altazimuth telescope and had prepared a table of comparative costs.

Under SRC it had become necessary to prepare much more detailed proposals for new expenditure and so in January 1973 five committees were set up to deal with the coordination of budgeting, of decisions and of action. The names and chairmen of these committees were:

1. Telescopes and telescope instruments – Pagel;
2. Detectors – McMullan;
3. Laboratory and workshop equipment – McMullan;
4. Measuring – Murray; and
5. Computers – myself.

A further committee, no. 6, on Information services, chaired by Hunter was also set up; it covered libraries, archives, publications, dissemination of information and public relations. The last two activities were becoming more important and took up more and more staff time. I was a member of this committee.

The formation of the South African Astronomical Observatory led to a very considerable reduction in the RGO’s involvement. The SAAO decided to set up a new

observatory at Sutherland in the Karoo and to move the 74-inch telescope from the Radcliffe Observatory in Pretoria to Sutherland. There was a corresponding reduction in the complement of the RGO.

The extent of Margaret Burbidge's absences from Herstmonceux are shown clearly in the Information Bulletins that were circulated to the staff. Shortly after taking up her appointment she "visited Washington at the end of August for a meeting of the Space Science Board, and went on to the Lick Observatory for a few nights' observing". During the autumn she was away from 25 September to 13 October, during which time she attended a meeting of the Anglo-Australian Telescope Board in Canberra. Then she left on 2 November to attend a meeting of the Space Science Board in Washington, followed by an observing run in Arizona, and she returned on 13 November. This was followed by an absence in the USA from 6 to15 December.

A similar pattern of foreign travel followed in 1973: she was away 6 February to 3 April; she went back to the USA for meetings on 11 to 13 April and then again from 25 April to 7 May and from 2 June until 4 July; she left on 16 July for a prolonged visit overseas from which she returned early in September. During this visit she attended the IAU General Assembly in Sydney. She was at Herstmonceux for the weeks beginning 10 September and 1 October. In between she went to meetings in the USA and Brussels and afterwards she went back to USA between 9 and 16 October.

Shortly after her return she was involved in a car accident for which she required treatment in hospital and then convalescence in a nursing home. This may have been the trigger that prompted her resignation, but she had probably already concluded that she could not combine all her earlier interests with the task of directing the RGO. We were also aware that she was unhappy because her daughter had accompanied her husband back to California after a wet summer in Sussex. The following quotation is from Information Bulletin No. 198 for 10 December 1973.

"Dr A Hunter succeeded Mrs Burbidge as Director on 1 December. Mrs Burbidge made a rapid recovery from the quite serious injuries she sustained in a road accident on 20 October, and was able on 15 and 16 November to direct packing from a wheelchair at the Castle, within two days of first being allowed out of her bed by her consultant. In an astonishing feat of endurance she fulfilled her last international engagement as Director by travelling (using crutches and a wheelchair) by air via California to Australia to attend the Anglo-Australian Telescope Board meetings in Canberra from 23-27 November. In what must be the understatement of the year, she writes "I am glad I made the effort to go, although it was indeed an effort!". She has cabled the following message for inclusion in this Bulletin.

"Regret accident prevented my giving personal farewell message. Regret also circumstances were not different so we could have had a long association together. My best wishes to all of you for a successful future. MARGARET BURBIDGE."

5.3 The Hunter period, 1973 to 1975

When Alan Hunter became Director he was promoted to the grade of Chief Scientific Officer, but his previous position as Deputy Director in the grade of DCSO was left unfilled. Instead, David Thomas was appointed to a temporary position as Assistant to the Director at SPSO level; this was later made permanent when Graham Smith became Director. He was given direct responsibility for the information services,

library and archives. and the RO Annals and Bulletins. Shortly afterwards, in February 1974, Mr. R. (Bob) Gordon, who had been a Senior Executive Officer in SRC London Office, joined to fill a new post at Principal level as Head of the Administration Section.

Hunter continued to hold monthly Senior Staff Meetings with some of its members acting for other departments. Then in May 1974 it was announced that this would be formalised in a divisional structure. I was given responsibility for the oversight of the Time Department as well as for the NAO. The Computer Section of the NAO became a separate department within the "Almanacs and Time Division". The Library and Archives were added, together the responsibility for the editing of RGO publications, to my Division in 1977.

The other divisions were: Astrophysics, with Dickens as acting head since Pagel had 'asked to be relieved of as many administrative duties as possible'; Astrometry and Galactic Astronomy, headed by Murray; Instrumentation and Engineering, headed by McMullan; and Administration, headed by Gordon. Surprisingly, the NHO pre-project team was excluded from this divisional structure. Advisory Panels involving a much larger number of staff were set up for some activities. Accordingly, the Information Services Committee later became the Advisory Panel on 'Information activities'

The proposals for the Northern Hemisphere Observatory were considered by a Review Panel of the Astronomy, Space and Radio Board (ASRB) of SRC and it recommended that the RGO should have the prime responsibility for the construction and operation of large national ground-based facilities, including the proposed NHO. As a consequence, an RGO Restructuring Panel, chaired by M O Robins, an SRC Director, was set up in May 1974 to advise on the changes in the character of the RGO and on the redeployment of its staff that would be necessary. Much of the discussion concerned the complement required for the new activities and the extent to which current activities would need to be reduced.

In August 1974 it was announced that Professor F Graham Smith, FRS, would be the next Director of RGO after Hunter retired at the end of 1975. Before the announcement Pope had been called to State House to meet an unnamed person about the NHO. He found himself being introduced to Graham Smith and told, confidentially, that he was going to be the next director of the RGO. He wanted to learn all about the present state of planning at the RGO for the NHO. He took up the vacant DCSO post as Director-Designate on 1 October 1974 and devoted himself primarily to NHO matters. Thomas continued to act as the Assistant to the Director as an SPSO. W A (Bill) Goodsell joined as Project Manager for the NHO in March 1975; he had previously been the project manager for the Anglo-Australian Telescope.

Hunter restored the publication of an annual report that covered all the activities of the Observatory and included a staff list and organisation chart. The first of them was for the calendar year 1974 and it had a monochrome blue cover with a picture of the dome of the INT. It also had 4 pages of photographs and graphs from selected projects. The report for 1975 covered only the first 9 months and thereafter the reports were for the academic year. The last one was for the year 1979/1980.

When Hunter retired he generously refused any personal present, but instead the proceeds of a retirement collection were given to the RGO Club for the installation of a filtration pump so that the swimming pool at the north end of the formal gardens could be brought into general use.

5.3.1 The Northern Hemisphere Observatory

The proposals for the NHO envisaged three new telescopes for complementary programmes with mirrors of diameters 1.0, 2.5 and 4.2 metres. At first the feeling amongst the RGO astronomers was that the Isaac Newton Telescope should stay at Herstmonceux and I used to hear the arguments to support this view discussed at lunch. Then one day in November 1974 Graham Smith announced that it had been decided at a meeting on the previous day that the INT should be moved to the NHO site. (I understand that Lovell has said that it was FGS' proposal.) I was then surprised to hear the same astronomers backing this decision, which was surely the second nail in the coffin of the RGO as it took away the most important telescope from Herstmonceux.

There were two principal arguments for leaving the telescope at Herstmonceux. Firstly, that it would be almost as cheap, and possibly cheaper, to buy a new telescope to a modern design without incurring the costs of moving and modifying the INT, which is an equatorial telescope, for a significantly different latitude. Not only was it necessary to make considerable changes to the mounting, but it was also decided to replace the mirror. (This would, however, have been needed even if the telescope had not been moved.) Secondly, a large telescope in Sussex could be used for appropriate types of astronomical programmes without incurring the expense and time of long-distance travel. Moreover, it could be used for testing new instruments and for giving new observers experience in the use of a large telescopes without using telescope time that could otherwise have been used for more valuable observations. The engineers at Herstmonceux later found that they had to build a build a telescope simulator when they came to build large, heavy instruments for use on the telescopes on La Palma. My understanding is that these arguments were ignored because it was considered that it would weaken the case for the NHO if it were argued that the INT could make useful observations at Herstmonceux. Moreover, it was considered that the RGO would devote effort to using and maintaining the INT instead of giving priority to the NHO.

The site-testing expeditions, which were started in 1973, led eventually in 1975 to the choice of the island of La Palma in the west of the Canary Islands as the first choice for the site of the NHO. The Observatory itself would be at the top of a mountain ridge overlooking the caldera of an extinct volcano. It would be at a height of 2300 m, and so was expected to be above the clouds that often engulfed the lower slopes of the island. The occurrence of earthquakes in the southern part of the island appears to have been discounted. Then there followed protracted negotiations with the Spanish Government before the conditions for the new international observatory were agreed. Ireland and Holland joined with the UK in funding what became known as the Isaac Newton Group of telescopes, while Sweden and Germany also wished to place telescopes on the mountain-top site. The observatory was given the Spanish name for the mountain, which was known as La Roque de los Muchachos — the Rock of the Boys. Spanish astronomers were entitled to a significant proportion of the observing time on the telescopes. It was necessary to build a road up the mountain before construction work could begin and so our engineers found themselves with time in hand. An RGO office was established in the coastal town of Santa Cruz and RGO staff on extended tours of duty lived there.

The events leading up to the establishment of the observatory on La Palma have been described in an unpublished illustrated article, which was written in 1999 by John Pope, with the title "Where on Earth shall we put our big telescope ?". There is a copy in RGO Archives. John took part in some of the exploratory expeditions. The teams

that evaluated the sky conditions were led by Bennett McInnes from ROE, while George Harding was responsible for the general direction of the work. RGO staff were also involved in the commissioning of the Anglo-Australian Telescope, and later in its use. Assistance continued to be given to the SAAO.

5.3.2 Celebration of the Tercentenary

The Royal Observatory was founded at Greenwich in 1675 and so there were many special events to celebrate its Tercentenary in 1975. It was appropriate that Hunter, who had joined the RO some 38 years earlier should be Director for this period, and that Humphry Smith, who had joined in 1936 before Hunter, should be Chairman of the Tercentenary Committee that organised the events at Herstmonceux. The Tercentenary was also celebrated by the National Maritime Museum at Greenwich, which had care of the Old Royal Observatory, as it was then known.

A preliminary outline of the proposed activities at Herstmonceux was circulated in July 1974 and staff were asked to volunteer for overtime and weekend working during the first two weeks of August 1975. There was a trial run for Dome B (36-inch telescope) in August 1974. A list of the planned activities is given in IB 210 for 8 May 1975 and a short account of them is given in IB 211 for 14 August 1975. A 4-page account of the events is given in the annual report for 1975. Some highlights are mentioned here.

The Queen visited Greenwich on 20 May, nominally as part of the celebration of European Architectural Heritage Year, and she re-inaugurated the 28-inch telescope, which had been moved back to Greenwich from Herstmonceux, and she toured the special Tercentenary Exhibition in Queen’s House.

Princess Anne attended a Garden Party at Herstmonceux on 18 July during which she unveiled a bust of Flamsteed, the first Astronomer Royal, and inaugurated a large commemorative sundial made from stainless steel. There were many special guests and all present staff and many long-serving former members of the Observatory were invited to attend, giving a total attendance of nearly 900. It was a fine, warm sunny day. My job was to escort the High Sheriff of Sussex and his wife, and so I had a good view of the ceremony — as can be seen in the photograph in the annual report!

There had been a competition amongst the staff for suggestions for a permanent memorial of the anniversary. Gordon Taylor had originally suggested a large garden sundial in the south courtyard of the Castle, but he had then designed the equiangular sundial that was adopted. It is an unusual design and the shadow of the vertical gnomon shows Greenwich Mean Time, rather than local apparent time. It was intended that it should be adjusted to show British Summer Time, but during the ceremony Hunter announced that it would always show GMT as a sign of the link with Greenwich. Consequently part of the mechanism was never used. I was given the job of verifying that Taylor’s design was valid before the contract for its construction was placed.

The bust of Flamsteed was carved by G (Danny) Elliott, a stone-mason who was working on the Castle at the time. I do not know whether it was his idea to carve the bust; he had to work from a portrait. A bronze copy was presented to the Royal Society. Some years later the plinth was moved from the upper part of the formal garden to a place close to the Castle; this was probably the time when the original stone bust was moved inside the Castle and a copy put in the garden.

An international conference on “The origins, achievements and influence of the Royal Observatory, Greenwich, 1675-1975” was held at the National Maritime Museum just before the Garden Party. Nine present and former members of the staff were amongst the speakers; I presented a paper on the changing role of the NAO. In addition an international scientific symposium was held during the following week at Herstmonceux on “The Galaxy and the Local Group”. I was not concerned with the scientific programme, but I was responsible for the local arrangements. My secretary, Pat Hanning, was in her element as she had had a lot of experience with the organisation of the IAU General Assembly when she was Sadler’s secretary. The only room that was large enough was the Long Gallery (or Ballroom) and so we even had to obtain carpeting to deaden the sounds of people moving around.

The telescopes and various other aspects of the work were put on display during two periods. During a week at the end of June about a thousand members of scientific societies and establishments visited the site by invitation and during two open weeks in August (including the weekends) nearly 22000 visitors were admitted. Surprisingly, this caused much less disruption to the work than might have been expected. An illustrated booklet, postcards, slides and various free duplicated pamphlets were made available to the visitors.

Professor W H McCrea of the University of Sussex was commissioned to write a short history of the RGO and this was published as an 80-page illustrated booklet. In addition, a three-volume history of the *Greenwich Observatory* was published by Taylor and Francis. The authors were Eric Forbes (early history), Jack Meadows (Airy onwards) and Derek Howse (buildings and instruments) and I later became friends with all three of them. I regret, however, that I did not buy a set of these volumes; I did not realize at the time that I would later become so interested in the history of the RGO. *The Times* and *Nature* produced special supplements and many individual articles were published in a wide variety of popular magazines and scientific journals.

In addition, there were TV programmes, the Royal Mint struck a set of three commemorative medals and the Post Office issued first-day covers with a stamp featuring Flamsteed House. A commemorative plate featuring the first 11 Astronomers Royal and scenes at Greenwich was produced by Wedgwood; it is illustrated on the cover of the annual report for 1975.

The RGO Club celebration took the form of a Country Dance Party, with displays and music appropriate to the time of Charles II, as well as dancing to the Magham Ranters. (Magham Down is a nearby village.)

5.4 The Graham Smith period, 1976 to 1981

When Graham Smith took over from Hunter on 1 January 1976, he had already been at Herstmonceux for over a year and so he was familiar with the activities and many of the staff. He did not live in the Castle, but rented a cottage at nearby Bodle Street. His primary concern was with the Northern Hemisphere Observatory, but he took an interest in, and was generally supportive of, the other activities. Several significant changes and developments during his period of office are mentioned in this section, while further details are given in later sections of this chapter.

Graham Smith felt that it was important to cultivate the public image of astronomy and of the RGO in particular, and so he followed up the Tercentenary celebrations by creating an exhibition in the Castle. This had the bonus of giving

visitors the opportunity to see a little of the interior of the Castle as well as the gardens. Creating the exhibition took a lot of effort by astronomers and by the staff of the Engineering Workshop and Drawing Office, but I believe it was eventually judged to have been worth the effort. (See section 5.5.8.4) Members of the public were able to see the Isaac Newton Telescope from a visitors' gallery and arrangements were also made to allow them to see some of the telescopes in the Equatorial Group.

Graham Smith also wanted to move the other astronomers from the Castle to the West Building so that they would be closer to the NHO project team and to the instrument development and engineering departments with whom they were expected to collaborate in planning the new observatory and its equipment. Moreover, increases in the staff of the NHO team were planned. Consequently, office space was at a premium and it was decided to make new offices for the NHO team in the basement of the Chronometer spur of the West Building. This basement had been designed to withstand enemy attack and to provide a secure environment for the time service in the event of war. It was partly below ground and had only narrow high-level windows. In the spring of 1976, holes for full windows were laboriously cut in the thick reinforced concrete walls. The first step was to use circular diamond drills to cut holes that were about 4 inches in diameter. (The discarded pieces of cores were about 9 inches long and I still have one in my shed as a souvenir.) Consequently, the cost of providing these extra rooms was probably very much more than the original estimates.

At the time, this basement was used for the storage of the archives and unsold copies of the Royal Observatory publications and of the large volumes of *Greenwich Observations* in particular. The archives were transferred to the bottom of the atomic-clock cellar at the south end of the Time Block and the stocks of publications were drastically reduced. I believe some were offered to other astronomical organisations, some were offered for sale to the public and the rest were dumped in unused wells in the grounds.

A few years later the Labour Government was looking for ways of providing extra work for the construction industry and the RGO was able to able to obtain special funding for the construction of an extra spur on the West Building. This was parallel to the Chronometer Block, but started from the south end of the Time Block. This new wing was occupied by the Astrophysics Division in November 1979. The STARLINK VAX 11/780 computer was installed in its basement in March 1980. (See section 5.5.3.4).

There were several changes in the senior staff of the RGO during this period. H J (Joe) B Paxton was appointed Head of Engineering in March 1976, presumably so that McMullan could concentrate on the development of new instruments. David Thomas moved to a post in the administration of SRC at the beginning of July 1979; the office had moved from London to Swindon by this time. His post as Assistant to the Director was taken by George Harding, who combined it with his duties as Project Scientist for the NHO. Shortly after this, it was announced that Dr Jasper Wall had been appointed as Head of a new Division of Astrophysics and Astrometry, which came into being on 1 November 1979, the day that Wall took up his appointment. He later became the last Director of the RGO. Murray continued his research in astrometry without any managerial responsibilities, although he continued to take a direct interest in the GALAXY measuring machine as well as in the work of the Meridian Department.

In his New Year message for 1980 Graham Smith announced that he would be leaving the RGO to become the Director at Jodrell Bank, in succession to Sir Bernard Lovell, and that he planned to return there in April 1982. In the event he left at the end of September 1981. There was an open advertisement for his successor. I understand that Bernard Pagel and Bob Dickens applied, but the appointment of Alexander (Alec) Boksenberg was announced in an SRC press release on 20 March 1981. The Science Research Council became the Science and Engineering Research Council (SERC) on 1 April 1981.

Denis McMullen resigned in April 1979 to return to Cambridge. George Harding retired in November 1980 on his 60th birthday; he had joined the NAO at Greenwich in 1938 and had transferred to the A&A Department in 1957. He was Officer-in-Charge at the RO at the Cape from 1969 to 1971 and was Deputy Director of the new South African Astronomical Observatory from 1972 to 1975. His place as Assistant to the Director was taken by Peter J Andrews at PSO level. Harding had, in effect, acted as Deputy Director at RGO, although he had neither the title nor the grade (DCSO) that had been held by Hunter. Graham Smith needed another senior member of the staff who could act for him in his absence but who would not otherwise be involved in the administration of the Observatory. He asked me to do this and so for about a year I had the title of Deputy Director. As far as I can recall, the only occasions on which I had to act in this capacity were to make presentations to staff who were retiring or leaving after a significant length of service. Bob Gordon, as Head of the Administration Division, was able to deal with the paperwork when Graham Smith was away. My penultimate task was to make the presentation of a cheque to Graham Smith just before his retirement and to receive from him a cheque for twice the amount to be used for the establishment of social and recreational facilities at the La Palma Observatory. The next evening the RGO Club organised a social evening in honour of Professor and Mrs Smith.

5.5 Departmental matters 1972 to 1981

The following sections for Engineering and Technology and for Astrophysics and Astrometry are very short since I had no involvement in these activities and full accounts are given in the annual reports for the period.

5.5.1 Engineering and technology

5.5.1.1 The La Palma Division

In the annual report for 1974 the Northern Hemisphere Observatory Project Team is listed with 4 persons. W A (Bill) Goodsell was appointed as NHO Project Manager on 17 March 1975. (Goodsell was in the grade of Superintending Engineer, which was equivalent to a Deputy Chief Scientific Officer.) John Pope became his deputy and George Harding the Project Scientist. By the end of the year the NHO Division is listed with 10 engineers and scientists, and by September 1977 it had doubled in size. Pope was head of the telescopes department, J W Gietzen and J S Beales, headed the instruments and computers departments, while R P Milner was the civil engineer. The project received its formal approval in May 1979 when the international agreement for the use of the Spanish *Roque de los Muchachos Observatory* on the island of La Palma in the Canary Islands was signed. From then on

the name *Northern Hemisphere Observatory* and the acronym *NHO* were dropped, but for convenience the name *La Palma* was used in connection with the RGO activities on the island. The NHO Division became the La Palma Division. The first *La Palma Newsletter* was issued in July 1979. J W Gietzen was promoted to SPSO on 1 October 1980 as officer-in-charge on La Palma.

The Isaac Newton Telescope was dismantled and the parts were lifted out of the dome early in June 1979 and taken to Grubb Parsons at Newcastle for rebuilding for the new latitude. The task took 6 days. The aluminising plant was removed from the dome on 9 February 1981, for modification prior to its transfer to La Palma.

Graham Smith announced during National Astronomy Week in 1981 that the new 4.2 metre telescope would be known as the William Herschel Telescope. The costs of the 1-m telescope were shared with the Netherlands and Ireland. It was named the Jacobus Kapteyn Telescope (JKT).

In addition to the 3 reflectors for astrophysics, the UK agreed to share with Denmark the costs of construction and operation of an automatic transit circle, for which the basic instrument would be provided by Denmark.

5.5.1.2 Engineering Division

The change in the character of the RGO is shown by the growing numbers in the Engineering Division, which was headed by Joe Paxton, who had transferred from RAL. The staff list in 1980 shows 65 persons in the following groups: Electronics and Electrical Engineering Department; Engineering Workshop; Design Office and Site Services.

Neil Parker transferred from RAL to the Electronics Dept in October 1976. He became deputy director in the final years of the RGO.

5.5.1.3 Instrumental Science Division

The team in the Instrumental Science Division, headed by Dennis McMullan, was strengthened by both internal transfers and by the recruitment of a series of well-qualified staff. Richard Bingham headed the optical instrumentation group and also acted as deputy head of the division. In addition, Charles Wynne of Imperial College was appointed as a consultant and was often at Herstmonceux. Two of the recruits were, however, lost to the division, but were gained by the A&T Division when they were promoted to PSOs. John Pilkington succeeded Humphry Smith as head of the Time Department in 1976 and Ken Hartley succeeded Albert Carter as Head of the Computer Department in 1978. John Powell became head of the Vacuum Physics Department and Ian van Breda came in 1976 to head the Automation Department. The twin brothers, Tony and Paul Jorden, did not join at the same time, but Tony came in 1977? and Paul came in 1978?. David Thorne joined them in 1978.

Important developments during this period included the use of CCD arrays to replace both film and the new electronographic cameras. Mini-computers, such as the PDP11/34 for the PDS measuring machine, and micro-processors came into use. (The Herstmonceux Conference in 1977 was on Digital methods in Astronomy.) The RGO was given responsibility for 3 instruments (including CCD detectors) for 4.2 m telescope.

5.5.2 Astrophysics and astrometry

5.5.2.1 Research teams

The annual report shows that in 1980 most of the 37 persons in the Astrophysics and Astrometry Division were allocated to research teams. These changed with the staff who were available and with the development of the research projects themselves. The Division was headed by Jasper Wall, who was supported by Bernard Pagel, as an Individual Merit (IM) DCSO, and two IM SPSOs, Bob Dickens and Andrew Murray.

The research is described in detail in the annual reports. Murray successfully presented the scientific case for the HIPPARCOS astrometric satellite, but this sophisticated mission did not produce its results until the 1990s.

5.5.2.2 Meridian Department

The Meridian Department was headed by R H Tucker. The primary programme of observations on the Cooke RTC continued and the results were prepared for publication. Murray and Graham Smith visited Brorfelde in Denmark in 1975 for discussions with Danish astronomers in meridian astronomy. Later an agreement was signed with the Copenhagen University Observatory to automate the Carlsberg Meridian Circle for operation jointly on La Palma.

5.5.2.3 Photographic Astrometry Department

The Photographic Astrometry Department, headed by Bill Nicholson, was primarily concerned with the use of the GALAXY measuring machine for the automatic measurement of astrometric plates from major surveys, such as the Second Cape Photographic Survey, but it was also used for many smaller projects. This machine was installed in 1972. It was so large that it had to be assembled in the sub-basement of the West Building, which had been previously used for quartz-crystal clocks. The main frame was delivered in January and the installation was completed in August. The associated computational work added considerably to the workload of the 1909 computer. A Nova mini-computer was added in 1975. The new software for processing the data from GALAXY was written by Nicholson and Dorothy Hobden, who had been transferred from the NAO for this purpose. GALAXY was used by students from Sussex and by astronomers from overseas, including Floor van Leeuwen, a student from Leiden, who later joined the RGO staff to work on the HIPPARCOS project. (See section 6.3.2.2)

In addition, a Zeiss Ascorecord measuring machine, which was digitised but operated manually, mainly by E D Clements, was used for many programmes, such as the optical positions of radio sources and the determination of the Einstein deflection at eclipses.

5.5.3 Developments in computing

5.5.3.1 The central computer facilities

The load on the ICT 1909 computer continued to increase so that double-shift working was introduced in 1972. The use of the remote consoles, which had been introduced in the autumn of 1970, had to be restricted as they made inefficient use of the computer since the Executive operating system had been designed before such facilities were available. The duties of the shift leader are set out in a note by the head

of the NAO Computer Section (Albert Carter) in a note dated 1974 April 26. He also pointed out that the payment of a responsibility allowance was being sought since the staff for computers used for administrative purposes were in a higher grade.

NAO Computer Circular no. 73 contained advice to programmers about the various sources of information about computers and programming techniques. It included a list of the circulars that were still relevant and a list of the manuals and books that were available. These lists show clearly that new programmers faced a daunting task before they could expect to become proficient. The series of NAO Computer Circulars, which provided mainly information about local facilities and procedures, ceased, however, in December 1971 with the revised version of no 74, although no. 75 on the use of "JEAN on remote consoles" was issued in the previous August. Their place was taken by short NAO Computer Notices of only short-term validity and by "The NAO Computer Users Guide", in which the material was presented in a more systematic fashion.

The Users Guide took advantage of the availability of new manuals provided by ICL. It was edited by David Chapman, an AEO who had joined the Computer Section in 1969 and who had been regraded as an SO in 1971. Unfortunately, he left in November 1973 on promotion to HSO in the Magnetic Dept. At this time Carter was also supported by Dorothy Hobden and John Carey, who had been promoted to HSO in 1971 and June 1973, respectively, so that David realized that he could not expect an early promotion in the Computer Section. Catherine Hohenkerk was transferred from the Solar Department to the Computer Department at the end of 1974. The experience that she gained there proved invaluable when she was later transferred to the NAO.

A GEC 2050 remote job-entry terminal was installed in June 1973 to provide access to the much more powerful computer ICT 1906A computer at the Atlas Computer Laboratory, but it was many months before the link became fully operational. The first useful work carried out by the link was for a trivial, but urgent, task for me on 14 December 1973. It later gave us access to the IBM 360/195 at the Rutherford Laboratory.

Proposals for the upgrading of computer facilities were considered by the SRC Computer Review Panel, whose chairman was Dr. Geoff Manning of the Rutherford Laboratory. I was the representative of the RGO and I submitted an initial bid for the replacement of the central processing unit (CPU) of the 1909 in April 1970. My recollection is that Manning and others took the view that we should change to IBM or rely on the link. I took the view that we did not wish to suffer the disruption that would be caused by changing the computer and the software. Eventually the central processor of the 1909 was replaced by an ICT 1903T CPU in January 1974 and it completed its acceptance trials in the following month. The main store was increased from 32 K to 96 K words and the computing speed was increased considerably. Two extra exchangeable-disc drives were installed at the same time to provide quicker access to data-files than was possible with magnetic tape, but we did not then get approval to add two 9-track magnetic tapes as we would have wished. This would have given us compatibility with new IBM and other systems using 8 bits (a byte) instead of 6 bits for each character, as well having greater speed and capacity. We did, however, obtain them later in the year and we obtained 4 more disc drives (from ACL) in 1975.

The Executive program for the 1909 was replaced by the more sophisticated GEORGE 3 operating system on the 1903T. This allowed greater use of remote console

typewriters so that programmers could interact directly with the 1903T. David Chapman wrote a guide to the new GEORGE operating system that was to be introduced on the 1903T computer before his transfer. These improved facilities led to a drop in the use of the GEC 2050 link to ACL, but a note by Carter and myself argued the case for retaining it. This was accepted and it remained in use until June 1983. The new operating system made possible a greater level of interactive working and 5 alpha-numeric visual display units (VDUs) simulating teletypewriters were installed at the end of 1974 to supplement the 3 teletypewriters that were already in use. A scanner for 16 terminals was installed in January 1979.

One aspect of the work in which I took a personal interest, although I was not a direct user, was that of astronomical data in machine-readable form. NAO Computer Circular no. 74, which was compiled by Dorothy Hobden, contained a list of the files for ephemerides and catalogues that were then available. The topic was the subject of a "literature discussion" on 21 June 1971 and was taken up in Computer Notice 6/71. Our efforts were dwarfed by those of the Stellar Data Centre at Strasbourg and thoughts turned to the possibility of a central data bank for the UK with access via remote terminals.

In December 1975 there was a cash crisis within the RGO (and SRC?) and staff were requested to economise in their use of computer consumables, such as line-printer paper, and double-shift working was stopped. Stringent economy measures were called for in July 1976, but as far as I can recall there were no further cuts in the level of working.

5.5.3.2 On-line and other computer facilities

By this time I had ceased to be a user of the system and so I found it more difficult to keep up with operational details, but my position on the SRC panel did, however, mean that I learnt about the new developments in other establishments. The RGO Advisory Panel on Computers that was set up at the Senior Staff Meeting on 1 January 1973 had its first meeting the next day under my chairmanship, and with Carter as its secretary. In addition to the central processing facilities the panel was responsible for the oversight of all "on-line computer projects" for the control of instruments, for data recording and real-time processing. The minutes record 5 such projects for telescopes and instrumentation and 7 for measuring machines.

In addition the panel considered the acquisition for programmable desk calculators that would replace the manual and electromechanical desk machines previously used. It was then expected that such machines would cost less than £500, but Dickens requested a calculator costing £2000. He was asked to circulate a proposal giving the reasons for this particular choice, but I do not recall whether his arguments were accepted. A Commodore PET desk computer was in use in the Time Department in 1979. These devices were much more powerful than the small programmable pocket-sized calculators that came into widespread use during this period and for which the NAO (especially Yallop and Sinclair) developed techniques for their use for astronavigation. This led to the publication in 1981 of *RGO Bulletin* no. 185 giving *Compact data for navigation and astronomy for 1981-1985*.

This decade saw major developments in computing as mini-computers were introduced and eventually became powerful enough to do the work previously done by large main-frame computers. An example of this has already been mentioned in connection with the new GALAXY measuring machine as after a few years a Nova

mini-computer was attached to it for control purposes and for carrying out some of the data-processing previously done on the ICT 1909 computer. A two-week training course in the use of mini-computers was held in June 1974. The lectures during the first week were given by RGO staff, while those during the second week were given by staff from the Rutherford Laboratory. Demonstrations were given on the mini-computer for the INT. The development of new instruments with microprocessors saw the introduction of yet another programming language, FORTH.

5.5.3.3 New facilities for document preparation

In the NAO we had had a direct interest in the introduction of new facilities that could be used for the preparation of our printed publications and of other reports and documents with a high-quality appearance. The use of computer composition was refined and the more flexible UDS 6000 automatic typewriter was used for tables, reports and other text documents. (See section 4.3.4.2]

Two Data Logic word processors were installed for use for secretarial work at the end of February 1980. One was for the NAO, since I had taken the primary role in obtaining them, and one was for the typing pool, which had moved from the Castle to the new wing of the West Building. At this time word-processing software was quite new, as was the ability to display a large range of characters on the monitor screen of a computer. The printers used interchangeable “daisy wheels” and the text could be stored on a “diskette” for printing or amendment. The cost was considered to be very high, but they significantly increased the productivity of the typists. I suspect that my drafts became rougher as corrections and amendments became so much easier. As far as I am aware they were not then used at all by scientific or technical staff.

The need for the use of punched cards for input to the computer was reduced when an ICL ‘Matador’ system was installed in January 1972 to provide direct encoding on magnetic tape from a keyboard.

A facsimile machine (fax) was installed in 1981 to improve the link between RGO and La Palma.

5.5.3.4 Changes of staff and new developments

Dorothy Hobden was transferred to the Astrometry Division on 1 January 1975 and her place as deputy-head of what had become the RGO Computer Department was taken by John Carey. Albert Carter retired on 30 June 1977 and his place was taken (six months later) by Dr. Ken Hartley, an SSO in the Physics Department. He was well-fitted to deal with the next major developments in the computer facilities.

At about this time there was, however, a wasteful diversion as Graham Smith, the new Director of the RGO, suggested that the RGO should install new computers to a design that was then being developed at Jodrell Bank for the control of the radio telescopes and for the processing of the large quantities of data that they generated. This project was allocated to Dr John Beale, who had joined the RGO from CERN in 1973 and who, from the middle of 1976 onwards, was concerned with the computers for the NHO. I did not support this idea as I considered that it would require RGO staff to be involved once again in the development of basic software rather than in applications programming. The project was eventually abandoned in favour of the SERC-wide STARLINK project. This involved a network of VAX 11/780 computers coordinated by the RAL and using common software, especially for the new field of “digital-image processing”. The new computer was installed in the new wing of the West Building in

March 1980 and was brought into operation in May. There was an official inauguration in October 1980.

The RGO Computer Committee was re-formed under my chairmanship in July 1980. It was concerned with both Starlink and the 1903T, which remained in use for other computing work until March 1983. There was a sub-committee on the training of staff in computing as this type of activity was becoming more and more dominant throughout the Observatory. There was also a separate Starlink Local Management Committee that included representatives of external users.

5.5.4 H. M. Nautical Almanac Office

5.5.4.1 Retirements of Donald and Flora Sadler

Donald Sadler retired from the RGO on 18 February 1972 after a year during which he had been 'disestablished' and free from any routine duties. He had hoped to do some research in celestial mechanics, but he soon realized that he was not likely to be able to make any useful contribution and so I believe that he spent most of his time sorting, weeding and annotating the archives of the Office. I then had very little knowledge of the archives and I did not have time to take any real interest in them. When I examined these archives in the Cambridge University Library in the 1990s I saw the evidence of his work, but I wondered whether he had discarded papers that a trained archivist would have saved. He did, however, write a very interesting historical account of the 'records and files' of the NAO as well as a description of what he had found. He may also have made notes for use in writing his history of the NAO.

The presentation on his retirement was made by Dr Hunter, then Acting Director, in the Long Gallery, and it was followed by a talk by Phil Laurie about the early history of the Nautical Almanac and of the NAO. The retirement present from the staff took the form of a dining chair.

After his retirement he continued to take an active interest in astronavigation and in time systems. He started to write a general history of the NAO, but he could not find enough original unpublished information and so he abandoned this task. Instead he drafted "A personal history of H.M. Nautical Almanac Office, 30 October 1930 – 18 February 1972". He also collected reminiscences from long-serving members of the staff, but he did make much use of them in his account. His papers were passed to me after his death and I transcribed and edited the personal history (of nearly 180 A4 pages). I could not find a publisher in the 1990s, but it has now been 'published' on the website of the NAO, which is now at the UK Hydrographic Office at Taunton. I hope to transcribe the letters from the staff 'one day', before they are passed to the RGO archives at Cambridge.

Further details of his life are given in an article in *Gemini* (by me) and in other obituaries that were published after his death on 24 October 1987 at the age of 79. (See appendix G.7.)

Flora Sadler continued to work in the NAO as a PSO (part-time) until her retirement on 11 April 1973. She had joined the staff on 20 September 1937. While at Herstmonceux, she had been responsible for the oversight of the printing of the publications and for the occultation programme. She had been the first woman secretary of the Royal astronomical Society from 1949 to 1954 and the Secretary of IAU Commission 17 (The Moon) from 1955 to 1964. She and Donald continued to live at

Cooden Beach, but she moved to Aberdeen in the 1990s. She died on Christmas Day 2000.

Other long-serving NAO staff who have died since their retirements are Walter Scott, Harold Richards, Albert Carter, Eric Smith, Miss Marion Rodgers and George Harding. (See also appendices C.7 and G.7).

5.5.4.2 Other NAO staff matters

My review of the NAO staff position in June 1972 shows that the Office was then split into three sections: the Publications and Information Services Section with 5 members of staff, although Eric Smith was just about to retire; the Computer Section with 15 members; and the Occultations and Dynamics Section with 7 members. In addition, Pat Hanning and Audrey Turner (part-time) provided secretarial and library services. Some proofreading was also done by former members of the staff. Unfortunately, I do not have at hand "the accompanying 'summary review' of the work of the Office", but the notes in the staff review show that much of the work required contributions from more than one section. Moreover, I was concerned that the pressure to extend the computer service and to carry out more pure research meant that there would be insufficient resources to meet future requirements for major changes in the principal ephemerides. The effects of the introduction of computers are shown clearly by a comparison with the NAO staff list in the *Nautical Almanac for 1954* as it shows 27 members, of whom only 5 worked in the Machine Section.

The retirement of Mrs Sadler and the subsequent promotion and transfer of Dr. Bernard Yallop from the Astrometry Department on 1 October 1973 led to a reorganisation in which he took charge of the Publications and Data Services section and Leslie Morrison headed the Occultations and Dynamics Section. Brian Emerson moved to the former and Gordon Taylor moved back from navigation to occultation work. In the meantime we had recruited Fred Watson and Jane Biggin, while Graham Appleby transferred from the Solar Department. Audrey Turner resigned shortly afterwards and her place was taken by Mrs Valerie Bacon.

The formation of the Almanacs and Time Division in May 1974 had little direct effect on the NAO, but it did mean that I had less time for direct involvement in its work. At the beginning of 1976 the staff of the Time Department, then 8 in number, moved into the NAO spur as Graham Smith wished to move more astronomers from the Castle to the West Building. (See section 5.4.) Later in the year the NAO gave up another room to accommodate a member of the staff of the Meteorological Office, which had decided to make regular observations from the site. Although we had General Notices for the Division we did not have a formal meeting for all the staff of the Division until Humphry Smith's retirement in June 1977.

Other staff changes in the NAO included the loss of Jane Biggin, who resigned in 1975 soon after gaining an MSc at the University of Sussex, and Fred Watson, who moved to the Royal Observatory at Edinburgh in December 1976, and the gain of Catherine Hohenkerk in 1978, who moved from the Computer Department. She had previously served in the Solar Department; she obtained a BSc degree by part-time study in 1981. Don Taylor joined as an SO on 1 February 1979 to work mainly with Andrew Sinclair on dynamical astronomy. He had been a PhD student at the University of Glasgow.

My promotion meant that I was expected to become more involved in the administration rather than the practice of science and so I attended Senior Management Seminars at the Civil Service College at Sunningdale in Berkshire in October 1972 and June 1975. I served on various SRC and Royal Society committees. For example, I was an ex officio member of the British National Committee for Astronomy. I was a member of the SRC Central Review Board for Group C, which dealt with the promotions of scientific staff, from 1978 to 1981, and I was chairman of Panel C3 (mainly for ASOs) in 1980 and 1981. I also chaired SRC working groups on librarians and information officers and on the training of ASOs.

An NAO staff reunion was held on 19 October 1974 to mark the 25th anniversary of the move from Bath to Herstmonceux. There was a large attendance of about 100, including guests and some other RGO staff who had strong connections with the NAO. There were tours of the Observatory in the afternoon followed by a slide show as the weather forecast suggested that it might not be suitable for walks around the gardens and gardens. A supper was served in the dining room before a social dance to records in the Long Gallery. Unfortunately, I do not have any photographs of the event. The previous year on 1 August 1973 there had been smaller gathering of 15 members of the NAO staff who had been evacuated from Greenwich to Bath in September 1939; five of those still in post were present, but 4 were unable to attend.

Pat Hanning continued as my secretary until the end of 1976, when she was promoted to Senior Personal Secretary and became secretary to the Director, Graham Smith. She was replaced by Lynne Stuart, who had been the head of the Typing Pool.

5.5.4.3 NAO publications

The publication of the *Astronomical Ephemeris for 1973* did not take place until October 1972, much later than usual and than was desirable. The delay was only partly due to our use of the Linotron 505 filmsetter for composing the main pages in our half of the volume. I do not recall whether USNO were late in sending the material for their half of the almanac, but I am fairly sure that we did not succeed during the decade in again achieving publication a year in advance. Although the printed volume was late we did make available data in advance to organisations that needed them. During the IAU General Assembly in Sydney in 1973 I sought opinions about the changes in content and arrangement that astronomers would like to see. Most were content, but the discussions led to my preparing *NAO Technical Note 31* in 1974 setting out some ideas on the future publication of astronomical ephemerides. In October 1975 Ken Seidelmann, who was to replace Ray Duncombe as director of the US NAO, came to Herstmonceux for discussions about the revision of the AE, and we were able to present a mock-up of AE 1981 at the IAU General Assembly at Grenoble in August 1976.

We had hoped that USNO would be able to prepare a new set of planetary ephemerides using a newly adopted set of astronomical constants in time for publication in AE 1981, but they were delayed until AE 1984. We did, however, go ahead with the other changes and we were finally able to agree on a common title, namely *The Astronomical Almanac*, to replace the two titles, *The Astronomical Ephemeris* and *The American Ephemeris* which had same content inside the covers. This also made it possible for printing to be carried out only in the USA, although we continued to supply reproducible copy for those parts for which we had the prime responsibility. The sales of the AE in the UK did not justify a separate printing, but the AmE was used in the USA by astrologers, as well as by astronomers! The change of title depended on there

being an amendment to the Act of Congress that authorised the production of *The American Ephemeris*. Ken and I persuaded the Scientific Director of USNO, Gart Westerhout, to try to obtain agreement for the change when we had a working lunch in October 1978 during one of my visits to Washington. He did obtain the agreement of the US Navy Department and then an amendment was attached to a Bill that otherwise had no relevance to astronomy!

We continued to distribute printed copies of *Advanced Data for the AE* up to 1980, but for the years 1981 onwards the data were made available only on magnetic tape. We did, however, start to publish jointly (in 1979 for 1981) a booklet called *Astronomical Phenomena* that contained the information about eclipses, risings and settings, etc, that were needed for minor local almanacs.

We also continued to produce the *Astrophysical Observers Almanac* for 1972 onwards, but after a few years the lists of stars and other objects were omitted and the Almanac contained mainly the rising and setting data for the Sun and Moon for particular observatories. The number of observatories gradually rose and reached 32 for 1977, but we only needed to produce one copy for most places. We also supplied other ephemerides for special purposes as well as diagrams of daylight and moonlight conditions. Data on sky brightness due to twilight and moonlight were also supplied to the SRC Panel on the allocation of telescope time.

The Office also provided astronomical data for civil purposes for newspapers and other organisations and individuals, either regularly or to meet special requests. A series of *Astronomical Information Sheets* was started in 1976.

The Office continued to produce the *Nautical Almanac*, the *Air Almanac* and new editions of the *Sight Reduction Tables* for both marine and air navigation in cooperation with the Americans. At first Gordon Taylor was in charge of the work, but then Bernard Yallop took over the responsibility for the navigational publications. There was little change in the almanacs and tables, although the NA for 1977 was published with a stiff paper cover, instead of the traditional plain blue hard cover. The availability of small computers and programmable hand-held calculators gave rise, however, to an increasing requirement for the supply of data in forms that were suited to these devices. *NAO Technical Note no. 44*, which was prepared by Andrew Sinclair, gave data for astronavigation in 1978, while no. 46, by Yallop, gave appropriate formulae, which were based on the use of economised polynomials as described in *Interpolation and Allied Tables* in 1956. Eventually in 1981 *Compact data for navigation and astronomy for the years 1981-1985* was published as *RGO Bulletin* no. 16. Although I had drawn attention to this technique at the IAU General Assembly in 1961 we did not use it in the AE until 197?, and then only for a half-daily ephemeris of the true geocentric distance of the Moon. I did, however, persuade Ken Seidelmann to agree to use it in the *Astronomical Almanac* for1981 onwards to replace the hourly ephemeris of the Moon, which gave first differences, by a daily tabulation of the coefficients of fifth degree polynomials. This not only made interpolation much easier, but it also reduced the number of pages from 122 to 23.

The Star Almanac had been almost unchanged since its introduction for 1951 and so I sought the opinions of users about possible changes. As a consequence new material was introduced in SA 1973 and 197?. The tabulations in the previous volume were composed automatically from our magnetic tape on a Linotron 505 phototypesetter. (See section 4.3.4.2) A few years later there was an industrial dispute

within H.M. Stationery Office and the Unions refused to accept our magnetic tapes and so SA 1977 was composed manually and we produced copies of *Advanced Data for A.E. 1980* by xerography from computer listings.

A new edition of *Planetary Co-ordinates* (see section 2.2.4.2) was needed for 1980-2000 and so I decided that we should extend its scope so as to make it useful for a much wider variety of purposes. Consequently it included geocentric as well as heliocentric planetary coordinates, lunar coordinates, information on eclipses and the phases of the Moon, and 'observability data' for the planets. We also made it a joint publication with USNO, although we produced all the copy. We knew that the new planetary ephemerides that were being developed by USNO would not be available in time and so we published in 1978 the booklet *Planetary and Lunar Coordinates for the years 1980–1984* as an interim measure.

We would have liked to prepare fully revised editions of the *Explanatory Supplement* and of *Interpolation and Allied Tables*, but we had to be content with making only minor amendments or with unaltered reprints. The Supplement was reprinted with amendments in 1972, 1975 and 1977), while IAT ran to at least 7 impressions. In 1975 HMSO even reprinted *5-figure Tables of Natural Trigonometric Tables*, which had been first published in 1947. We did not receive any 'royalties' from the sale of our books, but on the other hand we did not have to subsidise the *Astronomical Ephemeris*, whose sales probably did not cover the costs, nor did we have to expend effort on keeping records and accounts.

The Royal Navy continued to send its trainee navigating officers from HMS Dryad and HMS Mercury to the RGO for a tour of the activities, with the NAO acting as host. There were also visits by parties of Canadian naval officers who were attending a Maritime Advanced Navigating Course.

5.5.4.4 Occultations

During the 1970s there was a considerable expansion in 'research activities' by the staff of the Office. The main programme for the prediction of occultations of stars by the Moon was followed up by a major effort to use past occultations, eclipses and transits to determine the past variations in the rotation of the Earth. The prediction of occultations by planets, minor planets and satellites gave rise to successful observations. Theoretical studies of the orbits of the satellites of the planets were supplemented by new observations. The interest in the orbit of the Moon and the rotation of the Earth led to an involvement in observational programmes for lunar and satellite laser ranging. The interest in time scales and the system of astronomical constants was maintained and new activities included the analysis of observations of spectroscopic binaries. The results of this work were published in refereed journals, RGO Bulletins or NAO Technical Notes.

There was an increase in the number of observations of the times of occultations of stars by the Moon, probably because the computer made it feasible to reduce the observations as they were received and to inform the observers quickly about the results, and so encouraged them to make more observations. About 8500 observations were received in 1971. The computer also made it possible to re-reduce all the observations (over 50000) that had been collected since 1943. The results were published in 1978 in *RGO Bulletin* no. 183 under the title *Catalogue of observations of occultations of stars by the Moon 1943-1971*. The 16 pages of explanatory notes are printed on paper, but the catalogue itself was provided as a set of 5 microfiche, each

containing 7 rows of 14 pages, each 12 mm x 9 mm. Another departure from tradition was that the catalogue was ascribed to one person, L V Morrison, although it did acknowledge that many members of the NAO staff had been involved in its production.

The computer was also used to take into account 'limb corrections' that were derived from a digitised version of the Watts' charts of the limb of the Moon. These charts were printed in a large volume and so their digitisation using the D-Mac was itself a major task. These charts had been prepared by C B Watts at the US Naval Observatory from a very large number of photographs of the Moon and they showed how much the apparent shape of the Moon differed from a circle as it appeared to wobble in its orbit around the Earth. When these limb corrections were included in the reduction the occultation observations gave improved estimates of the differences between the 'observed and computed' positions of the centre of Moon. These differences were only partly due to errors in the theory of motion; they mainly reflected the differences between the scale of universal time (UT) in which the times of the observations were recorded and the scale of ephemeris time (ET) used in the theory. The differences UT – ET were themselves due to variations in the rate of rotation of the Earth.

Atomic Time replaced ET as the uniform time-scale for current use, but it was necessary to use ET for studies of the past variations in the rotation of the Earth, the causes of which were of considerable geophysical interest. Leslie Morrison then used occultation data to improve the estimates of these variations over the period since 1663, when it first became possible to measure UT with sufficient accuracy. The analysis of the data also yielded information about the stellar reference frame and other factors that affected the timings. Special predictions of 'grazing occultations' were issued as these give information about the latitude of the Moon, whereas most of the observations gave greater weight to its longitude. In appropriate cases, local 'expeditions' were organised with observers placed along the expected track. Morrison also collected observations of the transits of Mercury and, with C G Ward, a sandwich student, analysed them to determine an accurate value for the orbital acceleration of the Moon. This value was later confirmed by the lunar laser ranging observations.

Reports of 'fading occultations' were collected and studied by Graham Appleby as these often indicated that the stars were double. Photoelectric observations were made by some observers, including David Evans who had moved from South Africa to Texas, when the stars were considered to be double or of large angular diameter. For example, Morrison collaborated with Ian Glass at SAAO to determine the diameter of the star 31 Leonis. Predictions of lunar occultations of non-optical sources, such as radio and X-ray sources, were issued and sometimes Morrison assisted in the analysis of the data.

Gordon Taylor continued to predict occultations of stars by planets, minor planets and satellites in order to obtain better values of their diameters. Photoelectric observations were also used to look for the effects of atmospheres. One such prediction, made in 1973, led to the discovery in 1977 of the rings of Uranus by observations made from the Kuiper Airborne Observatory. This led to Gordon's appearance on the TV programme "The Sky at Night".

By the end of the decade it was clear that the timing of lunar occultations of stars was no longer useful for the determination of the difference UT – ET and the staff concerned were needed for other tasks. Consequently, the lunar occultation programme

was handed over to the Hydrographic Department in Tokyo at the beginning of 1981. Morrison was transferred back to the Meridian Department to work on the programme for the new automatic transit-circle on La Palma. Appleby and Harvey were transferred to the Time Department to work on the satellite laser ranging project. Taylor returned to the Publications and Data Services Section, but continued some work on occultations.

5.5.4.5 Dynamics

Andrew Sinclair took over my work on the orbits of the satellites of Mars. At first he was unable to get a significant value for the secular acceleration of Phobos, but after obtaining more observational data from the USSR he obtained a small value that was consistent with the accepted theory of tidal friction. Consequently, it was he who went to the USNO in August 1977 to attend a conference to mark the centenary of the discovery of the satellites. I did, however, present an historical review at an RAS Discussion Meeting that was held in May 1977. Dan Pascu from USNO, who had made recent observations of the satellites, also spoke about his work. I had been disappointed that I had not had the time to complete the work myself but many years later I came across a reference to my work that showed that it had, after all, been useful. The following quotation is taken from an article in a book on planetary satellites.

"At the time the Mariner 9 spacecraft went into orbit about Mars [in 1971] and began its observations of Phobos and Deimos, Wilkins' theory provided the best predictions of the satellites' positions. … Sharpless' ephemeris is in clear conflict with the most recent observations of Phobos' position; …" [J. B. Pollack, 1977, in J. A. Burns, ed., *Planetary satellites,* pp 339-340. University of Arizona Press.]

Sinclair's main work was, however, on trying to explain, for example, the relationships between the periods of the satellites of Saturn. (Many of the ratios of the periods are close to the ratio of two small integers, such as 2:1 or 4:3. There are also similar 'commensurabilities' amongst the orbits of the planets.) He and I wrote a review paper on the dynamics of the planets and their satellites that was published in the proceedings of a symposium on planetary science that was held by the Royal Society in 1973 to mark the 500th anniversary of the birth of Copernicus. The paper was based on the lecture that I had given at the conference. We also prepared an exhibit on occultations and dynamics for a Royal Society conversazione and this was also displayed at the University of Newcastle and at the museum of the City of Portsmouth. Sinclair also made observations of the satellites using the 13-inch and 26-inch telescopes and he used them to provide improved predictions.

Brian Emerson developed a program for the determination of the periods in data that varied with time and he used it in collaboration with other astronomers, especially R F Griffin at the University of Cambridge, to analyse data on spectroscopic binaries.

5.5.4.6 Lunar and satellite laser ranging

A new phase in the work of the NAO and, later, of the Time Department began when Professor Stuart Ramsden, of the Physics Department at the University of Hull, sought the help of the NAO in connection with a project to build a lunar laser ranging system. (I have a vague recollection that he first telephoned Sadler, who then referred him to me; if so, it must have been before February 1972.) The project needed a powerful laser system that could be used with a large telescope to send laser pulses to the retroreflectors that the American astronauts in the Apollo project had placed on the surface of the Moon. The Soviets also used unmanned spacecraft to place Lunakhods,

fitted with retroreflectors, that could move over the surface. The role of the NAO was to provide predictions for the observers and to assist in the analysis of the data, which consisted of the times of transit of the light to the Moon and back. The project had clear applications to the study of the motion and rotation of the Moon and to the determination of the rotation of the Earth and it was said to provide a test of Einstein's theory of general relativity. By this time, observations had already been made successfully at the Macdonald Observatory in Texas using a 104-inch reflector, but observations from several stations around the world were needed if the full benefits of the project were to be obtained.

I readily agreed to assist. The initial proposal involved cooperation with a group in South Africa, but this was abandoned when it became clear that the SRC would have to meet almost all the costs of establishing and operating the system there. Instead we turned to cooperation with a group in Australia in the Division of National Mapping, which was the equivalent of our Ordnance Survey. This group had plans to build a special-purpose observatory near Canberra on a mountain that was close to the valley containing the large radio telescope of the American Deep Space Tracking network at Tidbinbilla. Our initial contact was with Peter Morgan, who visited the RGO in September 1974.

Just before that I had visited the Macdonald Observatory while on holiday in the USA and so I had a better idea of the nature of the project. I was on duty for the visit itself as I made a special journey by air from Washington to Texas and then to Omaha in Nebraska to rejoin my family and our hosts Dr & Mrs Duncombe from the US Naval Observatory.

In 1975 we obtained approval for this LLR project, in which Hull would provide the laser and Andrew Sinclair would spend a year in Australia to work on the programs for data reduction and analysis. He went in June 1975 and gained experience that was to prove invaluable in the later UK project for satellite laser ranging (SLR). Andrew's wife Janet took special unpaid leave to go with him and I believe that she obtained a job at the Mount Stromlo Observatory. In 1976 I attended a conference on LLR in Austin, Texas but, for reasons that I do not recall, the formal cooperation with Australia was abandoned. I did, however, visit the site in 1979 while observations were being made; I was then attending the IUGG General Assembly in Canberra.

In 1974 Desmond King-Hele and others developed a proposal for a UK SLR project in which the RGO would participate. My recollection is that Humphry Smith was the contact as the main RGO interest was in the determination of the variations in UT and in polar motion. I did, however, endeavour to publicise both the LLR and the SLR projects by, for example, talking about them at a meeting of the Association of British Geodesists in November 1974. The SLR proposal was, however, not approved by SRC, probably because it appeared to be more relevant to NERC and to have less astronomical interest than the LLR proposal. The Royal Society held a discussion meeting on lunar and satellite ranging in February 1976 and so the value of this new technique came to the attention of a much wider and more influential group of scientists. A meeting to discuss a revised SLR proposal was arranged for 5 July 1977 (my birthday) and I was invited to attend. I did not do so as I had learned the previous afternoon that my elder son, Michael, had been killed in a mountaineering accident near Chamonix. Nevertheless, I was asked by the group to act as secretary and to prepare the formal proposal to be submitted to SRC. The proposal was approved by the ASR Board in the following July, by the Council in October and by the Department of Education

and Science in November. This proposal involved the RGO playing a major role in operating the system at Herstmonceux.

At this time there was a delay in the negotiations for the NHO and so Graham Smith decided that John Pope should examine the proposal for the telescope for the new system. He reported that the telescope proposed by the team at the University of Hull would not be adequate for the job and he recommended that we bought a telescope from an American company. Unfortunately this involved a significant increase in the cost of the project and so we had to go back to SRC. I had the task of presenting the case to the committee, but I was successful and the project went ahead. The responsibility for the day-to-day management of the project within the RGO was given to John Pilkington, who had replaced Humphry Smith as head of the Time Department. (See section 5.5.6.4)

5.5.4.7 Other international activities

My involvement in the preparation of the IAU (1964) System of Astronomical Constants and my subsequent position as President of IAU Commission 4 led naturally to my becoming chairman of another working group to consider the need for further changes in the system and in the definition of ephemeris time (ET). In particular, it was necessary to take into account relativistic effects in timekeeping. I must admit, however, that my knowledge and understanding of the theories of relativity was insufficient to allow me participate fully in the discussions that led to the introduction of ‘dynamical timescales’ by the IAU in 1976. It appears that I was not the only one in this position as the names and definitions were changed yet again in the 1990s. Even the new values for the constants proved to be premature as further changes were made during the preparation of the new set of ephemerides for 1984 onwards. Nevertheless, I contributed a paper about nutation at an IAU Symposium at Kiev in 1978. Sinclair and I also participated in an IAU working group on cartographic coordinates and rotational elements of the planets and satellites that was set up in 1976. This was chaired by Merton Davies of the Rand Corporation; we became good friends and he used to send me a Rand Calendar each year. He played a major role in the mapping of Mars after the Mariner and Viking missions and he was given full credit for this in a book by Oliver Morton.

At the IAU General Assembly in 1970 I was asked to take on two new roles that were only indirectly related to the main work of the NAO. It is probable that Sadler put forward my name as his replacement as an IAU representative on the Council of the Federation of Astronomical and Geophysical Services (FAGS). (See section 4.3.4.7) It is likely that he also suggested me for the position of chairman of the IAU Working Group on Numerical Data and hence of representing the IAU on the ICSU Special Committee on Data for Science and Technology (CODATA). I accepted both invitations although I did not know what would be required of me, nor did I realize that these activities would continue for the next 9 years and that I would find them so interesting and rewarding.

The meetings of the Council of FAGS were usually held in Paris, but every four years they were held during the General Assembly of the International Union of Geodesy and Geophysics so that there could also be a meeting with the heads of the various services in the Federation. My first meeting was held on such an occasion at Moscow in August 1971 and I took the opportunity to visit the Institute of Theoretical Astronomy in Leningrad on the way. I took my elder son, Michael with me, as he was

learning Russian at school. The head of the Institute, Professor Chebotarev, together with his son, showed us around Leningrad on the Sunday and in the evening we went to his apartment for supper to celebrate his birthday! One of the members of the Institute, Dr V Shor, was interested in the satellites of Mars and he subsequently sent us the Russian observations that were used by Sinclair.

It was the custom for the Unions represented on the Council to take in turns to provide the secretary. I did not know of anyone else in the IAU who would take on the job and so I served as secretary from 1975 to 1979. I had been made a Vice-President in 1973 and one of the members of the Council expressed his surprise at my becoming secretary instead of waiting my turn to become President! The meetings of the Council took only half a day and I found that I could get an early plane from Gatwick to Paris and return home the same evening. I resigned the position after I had taken on the much more time-consuming post of chairman of the MERIT working group. (See section 6.3.4.4)

When I succeeded Charlotte Sitterley, who was then about 70, as chairman of the IAU Working Group on Numerical Data I found that it was primarily concerned with physical and chemical data of interest to astronomers, rather than with astronomical data. One of my first tasks was to prepare a survey of astronomical data activities. Over the next 6 years I widened the scope of the activities of the group and I convinced the IAU Executive Committee that it should be replaced by a working group on astronomical data within Commission 5 on Documentation. At that time this commission was primarily concerned with libraries and abstracting services and so it had members who were interested in the problems of computer databases and information retrieval that were of concern to the working group. The President of the Commission asked me to prepare a survey of abstracting and information services in astronomy and so I became more familiar with the scope of these activities. I continued as chairman of the group for another term and then in 1979 I became Vice-President of the Commission, which broadened its name to ‘Documentation and astronomical data’ to emphasise the scope of its interests. (See also section 5.5.7)

During this period the working group organised two international conferences at Strasbourg, where there was a stellar data centre (CDS) within the university. The first, in 1976, was on the ‘compilation, critical evaluation and distribution of stellar data’; I was chairman of the scientific organising committee and Carlos Jaschek (the head of CDS) and I edited the proceedings. One of my papers advocated the use of SI units in astronomy as I felt that astronomers should abandon c.g.s. units, which were no longer used in physics, nor taught in schools and universities. I was a member of the organising committee for the conference in 1981 on ‘automated data retrieval in astronomy’ and I contributed a paper on ‘aids to the retrieval and evaluation of astronomical data’.

I found that CODATA was different in many ways from the astronomical organisations with which I had so far been concerned. It held an annual general assembly that was only for representatives of national committees and interested scientific unions. The former usually came from major organisations such as the National Bureau of Standards in the USA and they tended to dominate the proceedings. Once again, I found that it was primarily concerned with physical and chemical data and so I and other Union representatives agitated for a broadening of its scope to cover the geosciences (including astronomy) and the biosciences. As a result I was made chairman of an advisory panel on the geosciences and I prepared a *Guide for the presentation in the primary literature of numerical data derived from observations in*

the geosciences that was published in 1979 as *CODATA Bulletin 32*. I later prepared a *Guide to the presentation of astronomical data* that was published in 1982 as *CODATA Bulletin 46*.

CODATA held a general conference every two years to which all were invited. The general assembly was held at the same time. These meetings were almost invariably held in interesting locations and so my collection of travel slides increased dramatically! I ceased to be the IAU representative in 1979, but I remained in touch and I attended the CODATA conference in Ottawa in 1986.

During this period the IAU General Assemblies were held in Sydney (1973), Grenoble (1976) and Montreal (1979). I took leave before the assembly in Sydney to go on a coach tour of the observatories in New South Wales. We started from Canberra and so I visited the Mount Stromlo Observatory before the tour started. We first went to the Parkes Radio Observatory and then to see the Anglo-Australian Telescope in the final stages of its construction on Siding Spring Mountain. From there we went to the Culgoora Solar Observatory, which has a large circle of radio dishes as well as some optical telescopes. Finally we saw the stellar interferometer at Narrabri. While in Sydney I renewed my friendship with Peter and Mary Gillingham and with Denis and Elza Winch. Both Peter and Denis had worked at the RGO and, at different times, they had lived in the same house quite close to my home. Denis came to work in the Magnetic Department on sabbatical leave in the spring of 1968 for 4 months. I also saw them, and their families, again when I attended the IUGG General Assembly in Canberra in 1979 in connection with Project MERIT. (See section 6.3.4.4)

5.5.5 Solar Department and meteorology

The work of the Solar Department continued with low priority during the early years of the decade. Phil Laurie, who had been its head since 1957 was transferred to full-time duty as Archivist on 1 October 1974. His place was taken for a short time by Alan Powell and then by David Stickland on a part-time basis. There were two assistants to take the daily photographs of the Sun (in both white light and Hα) and to measure the positions and areas of the sunspots and other features on the surface. There was also continuous monitoring of radio reception to detect sudden atmospherics and ionospheric disturbances. Current information was distributed in *Solar Activity Circulars*, but the measurement and publication of the photoheliographic results was many years in arrears.

I had made enquiries about the value of the RGO data when I was at an Australia solar observatory in 1973 and was told, in effect, that the RGO was far behind the times. Not surprisingly, Graham Smith decided that the service should be closed and he obtained the agreement of IAU Commission 10 (Solar activity) at the IAU General Assembly in Grenoble in 1976. The centenary plate had been taken on 17 April 1974 and the last daily plate was scheduled for14 January 1977. Weekly photographs and monitoring were continued while efforts were made to catch up on the backlog of photoheliographic results. Stickland left in 1978 to serve at the control centre for the International Ultraviolet Explorer satellite in Madrid. Responsibility for the completing the work was then transferred to Yallop in the NAO. The last optical observations were made in March 1979. The service was formally closed on 31 August 1979. The photoheliographic results for 1972-1976 were finally published in 1980. Yallop and Hohenkerk prepared and published in 1980 a ‘butterfly diagram’ showing the variations in the distribution of the sunspots with latitude and time over the period 1874-1976. It had been agreed that the Heliophysical Observatory at Debrecen in Hungary would

continue the series and so some duplicate plates were sent there for use in tests to ensure a homogeneous continuation of the Greenwich series.

The solar plates and prints were transferred to the archive store in the atomic-clock cellar in the West Building. The solar building became available for later use for the SLR project. The 6.25-inch refractor, which had been given by Newbegin, was transferred to the Old Royal Observatory at Greenwich for educational use.

Woolley had stopped the RGO's daily recording of the meteorological conditions at Herstmonceux, but the Meteorological Office decided that the series should be resumed. A site visit was made in January 1976 and the first observer moved into an office in the NAO spur in October. A full series of observations began on 1 November 1976.

5.5.6 Time Department

John Pilkington replaced Humphry Smith as head of the Time Department on 1 October 1976, but Smith stayed on 'special duties' until 3 June 1977. He also continued as chairman of the Directing Board of the Bureau International de l'Heure. Smith had served as Head of the Time Department for 40 years and had held many international offices. He was awarded the O.B.E. in the New Year Honours List in 1973. Unfortunately, the Time Department lost the services of Joy Penny at this time as she took voluntary premature retirement (VPR) in order, I understand, to look after her mother. She had joined the department in Edinburgh in 1944. Her retirement meant that the staff of the Observatory, and of SRC, lost "a formidable fighter for the rights of the staff".

5.5.6.1 Introduction of the new definition of UTC

The beginning of 1972 saw the introduction of the new system of Coordinated Universal Time (UTC) that was derived directly from International Atomic Time (TAI). It differed from it by an exact number of seconds and leap seconds were introduced occasionally so that UTC remained close to Universal Time (UT), which depended on the variable rotation of the Earth. (See section 4.3.3.4)

The change had two additional consequences for the UK. Firstly, the BBC 6-pips time signal was changed in two ways. The addition of a leap second was marked by the emission of a seventh pip and the last pip was always lengthened so that if only 5 pips were heard the listener would know whether it was the first or last pip that been lost. Secondly, the signal continued to be known as the Greenwich time signal and it was normally referred to as GMT. Thus once again, the meaning of GMT was ambiguous, as this abbreviation was used for both Greenwich mean solar time, which closely followed the variations in the rotation of the Earth and was the argument in the tables in the navigational almanacs, and for coordinated universal time, which was based on International Atomic Time (TAI). A change in the meaning of GMT had previously occurred in 1925 when the start of the day in the *Nautical Almanac* was changed from noon to midnight to conform with civil practice and with the recommendations of the prime meridian conference in 1884. The *Nautical Almanac* continued to use GMT with its original meaning, but it eventually changed to the heading "UT (GMT)". Sadler mourned the change in the meaning of GMT and used to wear a black tie to mark the occasions, usually on New Year's Eve, when a leap second was introduced.

I do not know whether Smith proposed the form of the change in the 6-pips signals, but it is possible that he did so. (There ought be correspondence about this in the RGO archives.) The 50th anniversary of the start of the 6-pips time signal was celebrated on 5 February 1974 and Smith was interviewed on both BBC radio ("Today") and TV ("Nationwide"). (See also section 6.3.4)

5.5.6.2 Atomic time and related activities

John Pilkington had been involved in the discovery of pulsars at Cambridge in 1967, but he had to catch up on developments in time-keeping and in the methods of transferring time accurately from one place to another. He and Henry Gill took an atomic clock to the National Physical Laboratory (NPL) and the Post Office Research Centre in November 1976. At the end of the month he and Smith went to Washington to attend the annual meeting on Precise Time and Time Interval (PTTI). Afterwards he visited various establishments in the area that were concerned with time and the related satellite programs.

The Time Department maintained several caesium frequency standards in operation to form the Greenwich atomic timescale, which it compared with the timescales distributed by other countries. The results were then used, in arrears, to form the international atomic timescale, which existed only on paper! The RGO continued to be responsible for sending the UTC signal to the BBC for rebroadcasting in the UK and throughout the world on the BBC World Service programmes. Although the pips gave the time to low precision with an error of about 0.05 seconds, the time delays in passing it around the world were greater than this and so they were not suitable for some applications. The NPL was responsible for providing the signals that were broadcast by the BBC from Rugby for those who required time to a much higher precision. Smith and I visited the NPL in May 1976 (before I knew who would replace Smith) for a discussion on future cooperation in time-service matters and it was agreed the two sets of standards should be used to form a single scale. One of the RGO standards was kept in operation for 10 years, and set a world record for this type of atomic-beam tube.

In 1975 the US Naval Research Laboratory lent the RGO a receiver for time signals from the first Timation satellite (NTS-1) and special aerials were installed on the roof of the West Building. The RGO started tracking NTS-2 in July 1977, shortly after its launch; it carried two caesium clocks. A PET personal computer was used for the automatic control of the tuning of the receiver for the signals from the satellite in the spring of 1979. The programming language used was BASIC. Later in the year the PET was used for the RGO's first computer-controlled altazimuth 'radio telescope' for automatically tracking such satellites. At the beginning of 1980 the department monitored to the time signals from the Meteosat geostationary satellite in order to assess their suitability for providing the time service for the La Palma observatory.

There was conference on intercontinental time comparisons by satellite at the University of Sussex early in September 1977 and the participants visited the RGO. Pilkington went to Paris later in the month for discussions on the program. In March 1980 I attended the first meeting (in Toulouse) of a working group of the European Space Agency (ESA) on the LASSO project to test the feasibility of using lasers to synchronise clocks using a satellite in a geostationary orbit. It was hoped that the RGO's SLR system, then under development, would be used in the experiment. More appropriately, Pilkington attended the second meeting that was held in Paris later in the

year, but in the end the RGO did not participate. He also attended the meeting of the Consultative Committee for the Definition of the Second (CCDS).

5.5.6.3 Earth rotation and geodesy

The Time Department continued to use the PZT to monitor the variations in UT compared with the Greenwich atomic timescale and the apparent variations in the latitude of the telescope that were due to 'polar motion' (PM), that is the motion of the axis of rotation of the Earth within the Earth. In 1978 Pilkington and I attended an IAU symposium on 'Time and the Earth's rotation' that was held at San Fernando in Spain, where the Spanish nautical almanac was produced. It was clear that the astrometric methods for determining UT, PM and accurate geodetic coordinates on the Earth's surface would be superseded by new methods using the techniques for navigation by satellites, for laser ranging and for radio interferometry. At the end of the symposium I was appointed the chairman of an IAU working group on the determination of the rotation of the Earth that would study the relative advantages of the available techniques and make proposals for future international services. This activity led to Project MERIT, and eventually to the new International Earth Rotation Service (IERS). The discussion of this project is deferred until section 6.3.4.4.

In 1979 the department participated in a campaign of observation of signals from the Transit navigational satellites to determine precise geodetic coordinates of the observing stations. The following year it participated in a similar campaign that was aimed at linking the geodetic networks in eastern and western Europe. A receiver was borrowed from Oxford University. Such Doppler measurements were not made during the MERIT Short Campaign in August to October 1980, although PZT observations were scheduled on every day. Just before this there was a thunderstorm on the night of 14/15 July 1980 and some electronic components were damaged in the PZT and RTC buildings.

5.5.6.4 Satellite laser ranging

The Time Department was given the responsibility within the RGO for the installation of the satellite laser ranging system, which had been approved in the autumn of 1978. (See section 5.5.4.6) Pilkington, Sinclair and I immediately visited the Institute for Satellite Geodesy at Kootwijk in Holland to gain a better appreciation of what was involved. We were accompanied by John Pope, who had been temporarily seconded to the SLR project while also working on the NHO project, and by Phil Cottrell, who was in charge of the Engineering Workshop. Sinclair and I went in November to a meeting in Bavaria of the European SLR group, which had adopted the acronym EROS, to discuss the distribution of predictions and observations. We took the opportunity to visit the nearby SLR station at Wettzell. Pope and Cottrell went there the following week and then went on to the French station at Grasse, near Nice, to study the requirements for the telescope. Later there were discussions with the Technical University of Graz in Austria and, early in 1980, the same telescope was ordered by both of us from Contraves Goerz in Pittsburgh.

At first, Appleby, who became available when the occultation programme was closed, and Harvey, who was transferred from the Astrometry Department, worked on the software for the PDP 11/34 computer while in the NAO, but they were transferred to the Time Department at the beginning of 1981. Although Sinclair remained in the NAO he was regarded as a full member of the SLR team and he played a major role in the

development of the computer software. Dr Paul Sharman was recruited in February 1981 to strengthen the effort available for work on the hardware, which was done in close collaboration with staff at the University of Hull, especially with Dennis Hall and Bob Hyde, who became our main contact and made frequent visits to Herstmonceux. The university group was responsible for the laser, the detector package and the timing system.

The building that had been used for solar observations was available, but modifications were required. A new 'eyelid' dome was installed in February 1981 so that the telescope would be able to follow the satellites across the sky without any need for a rotation of the dome. The room beneath the dome was converted for use for the laser, timing and computer systems, while the adjacent office on the north side was used for the control desk. Our use of the system was conditional on the approval of the Civil Aviation Authority, which required that we shut down the laser if any aircraft were to approach the beam The concern was that the beam would blind any pilot or passenger who looked directly into it. Consequently, we had to have a radar system for distant aircraft and we had to have an observer in the dome to look for low-flying aircraft or gliders. We were able to obtain a surplus military radar and it was mounted in a small radome on the roof of the control room. It too had to be under computer control so that it would automatically follow the movements of the telescope.

The telescope was installed on its pier on 3 July 1981. It is illustrated and described as follows in the Information Bulletin for 1 October 1981. "The 'dustbin' shaped tube housed the 50 cm Cassegrain receiving telescope, the secondary mounting of which can be seen through the end of the window. The smaller tube on the right houses the 10 cm refractor transmitting telescope, which is fed by the Coude optical path, part of which can be seen on the extreme right. The large square balance weight at the Cassegrain focus will be replaced by the detector package at present being manufactured at the University of Hull. The SLR telescope can now be driven under computer control."

The subsequent stages of the installation and the use of the system are described in section 6.3.4.2

5.5.7 Libraries and archives

During the first few years of this period the RGO library, the NAO library and the RGO archives were run largely independently, although an Information Services Committee, chaired by Hunter, was set up January 1973 to coordinate the work on them, on publications and the supply of information to the public. This became known as the Advisory Panel on Information Activities in December 1974. Joan Perry was the RGO librarian, while Audrey Turner and later Valerie Bacon (from January 1974) looked after the NAO library as part of their clerical duties. Phil Laurie was formally given full-time responsibility for the archives on 1 October 1974 until his retirement in March 1977. He was awarded an M.B.E. in 1975.

In May 1977 the Library and Archives Department was formed within the A&T Division so that I had overall charge of these activities. It was agreed that the department should be headed by a professionally-qualified librarian/archivist and Janet Dudley took up her appointment on 1 February 1978. She had previously been an assistant librarian at the Royal Aircraft Establishment at Farnborough. Valerie resigned in December 1978. Joan Perry remained in post until her retirement in February 1979, and was replaced by David Clarke. Janet was extremely keen and very competent so

that major changes were made. The NAO library was integrated with the main library and became, in effect, the West Building library. Some books and journals were interchanged between the two buildings so as to reduce the need for the scientific staff to go to the Castle. She also introduced a loan-slip system to replace the use of a book in which borrowings were recorded.

While reorganising the bookstock Janet made full use of UDC (see section 2.2.7.6), which she had used at RAE. She also paid greater attention to the rare books and in July 1980 she arranged an exhibition of them at the time of a visit by a group of Government librarians (who were probably members of the 'Circle of State Librarians'). At the beginning of 1981 the name 'Airy Collection' was introduced as Airy had collected many of them during his period as Astronomer Royal. Janet also arranged the sale of some duplicates on the understanding that the receipts would be used for the rebinding of other books in the Collection.

The Information Bulletins show that Janet was an active traveller and made visits to the USA, as well as to many meetings and organisations in the UK. She and I attended a meeting of astronomy librarians that was held at the Institute of Astronomy at Cambridge in March 1978. This may have been when Kemp, the ROE librarian, was preparing a union catalogue of the holdings of astronomy serials by the UK libraries.

5.5.7.1 Archives

In July 1978 Graham Smith wrote to the Keeper of Public Records and others drawing attention to need to provide extra facilities and staff for the processing and conservation of the RGO archives at Herstmonceux or to transfer them to the Public Record Office. Janet argued strongly for the former and her arguments convinced me, Graham Smith and the SRC that they should be retained by the RGO.

The archives and the remaining surplus publications had been dumped in the atomic-clock cellar when the basement of the Chronometer Wing was converted to offices for the NHO team. (See section 5.4) The first step was to provide proper arrangements for the use of the cellar as a permanent store for them. Consequently, they had to be moved yet again early in 1979 from the cellar to off-site storage while an extra floor and shelving were installed. Temporary storage space had also to be found for NAO files and publications that had been kept in room 90 on the top floor of the NAO spur that was taken over by staff dealing with public information. The NAO archives were added to the main collection; most of them dated from Sadler's appointment as Superintendent in 1936 as almost all of the earlier material had been scrapped when Comrie needed the room for other purposes. The solar records and photographic plates were also transferred to the atomic-clock cellar.

Work started at the end of 1978 on the long-term task of microfilming the early archives to reduce the amount of handling by researchers and for extra security. The work was done by the Public Record Office at Kew. The archives were supplemented by the acquisition of the papers of the late Professor R. O. Redman that related to the AAT and the NHO. Janet also obtained from the Meteorological Office some early material from the Kew Observatory. Historical items were loaned to other organisations, such as the Hastings Museum, for use in their exhibitions. Astronomy books and other items were also loaned to a local girls' school, Ancaster House, as part of an exhibition to celebrate the 75th anniversary of the school. Portraits and other historical pictures

and artefacts, some of which were quite valuable, also received her attention, as did the slide collection, which was of both current and historical interest.

Janet also obtained approval for the recruitment of a conservation officer and the setting up of a conservation laboratory for the care of the valuable documents in the collection. Tony Bish was recruited from the conservation department of the East Sussex County Council in January 1981 and the laboratory was set up in the east wing of the Castle.

The use of the archives increased during this decade and visitors to the RGO to use them included Professor A J Meadows (3 months in 1973), Derek Howse (National Maritime Museum), Eric G Forbes and Professor W H McCrea, all of whom wrote books on the history of the RGO. There were also visitors from overseas, including Professor J Ed. Kennedy from Canada.

5.5.7.2 Information retrieval

During the years 1970 to 1976 I was a member of an international working group that was concerned with the revision of the Universal Decimal Classification for astronomy (UDC 52). This was used for both the shelving books in libraries and the retrieval of information from abstracting journals and various indexing systems. (Public libraries in the UK tended to use the similar Dewey decimal classification, while most libraries in the USA, and the Royal Astronomical Society, used the Library of Congress classification, which was much less appropriate for scientific and technical applications.) The chairman of the working group was Alasdair Kemp, the librarian at the Royal Observatory Edinburgh. Valerie Bacon helped me in the work of preparing the revised schedule for publication and in producing a guide for users. Unfortunately, the guide was never published as other jobs had to be given higher priority.

My interest in books and ‘library affairs’ had led to becoming a member of IAU Commission 5 on Documentation, although I do not recall when I first attended a meeting of the Commission. My involvement became much stronger when ‘astronomical data’ was added to its title (see 5.5.4.7) and this was recognised when I was appointed Vice-President in 1979. Commission 5 has an unusual status as it is regarded as a sub-committee of the Executive Committee and membership does not count against the normal maximum of membership of 3 commissions by any member of the IAU. Moreover the President (and Vice-President) serve for two terms and so I was committed to serve for 12 years, so taking me beyond my retiring age. My duties as Vice-President were, however, negligible.

My involvement in library activities also led to my being appointed in 1979 as the chairman of a working party on the groups for librarians and information officers within the SRC Central Review Board for Group C.

5.5.8 General matters

5.5.8.1 Administration Division

At the beginning of this period the head of the General Office, John Whale, carried the title of Secretary and Cashier and the grade of Senior Executive Officer. Bob Gordon was appointed at the higher grade of Principal in February 1974 to head the Administration Section, which became the Administration Division later in the year. At first there was a rather unusual arrangement in that he acted as understudy to “Mr.

Whale in preparation for his assuming the duties of Secretary and Cashier when Mr Whale retires in the Spring of 1975".

Throughout the period there were changes of structure as well as a high turn-over in the staff. For example, in 1974 there were 8 Clerical Officers, but only one of them was still in post in 1980 when there were 9 COs. A comparison of the reports for 1974 and for 1980 also shows that the contributions of the industrial staff became more clearly recognised. In 1974, they are given in a single list without any indication of their jobs, but in 1980 they are shown with their grades in the appropriate department.

Canteen. Following the retirement of Mrs Marples in 1975, a new manageress was appointed from outside, but she left in 1978. Then Margaret Brett, who had been a young assistant when I joined the RGO in 1951, was promoted to Head Cook/Supervisor at a time when the canteen was to be run with a reduced staff level. Staff were asked to reduce their "demands for waitress service to the minimum". In earlier years the canteen staff frequently served the 'top table' that was used by senior staff, especially when visitors were present.

Mrs Marples was awarded a BEM in 1979. This was several years after her retirement, but only a few months before her marriage to Sir Richard Woolley.

5.5.8.2 Conferences and education

Throughout this period the annual Herstmonceux conferences were continued. In 1975 there was also a special international symposium to mark the Tercentenary of the Observatory. In 1976 the second AAT Symposium was held in Herstmonceux. The first had been held during the previous year in Sydney.

The summer vacation courses for students also continued. The 1979 course left without any prank, but IB 240 records that the following poem was left in an astronomical book.

We three observers from Herstmonceux are
Bearing plates we travel afar
Telescope mounting
Timing, counting
Guiding on a yonder star

Star of wonder, star prolate
Shine at all those working late
Westward driving
Still surviving
Guide until the perfect plate.

Sandwich students were taken on and pre-university students were employed as temporary ASOs. My own son, David, worked with Pagel from January to July 1978 before going to Trinity College to read mathematics, and he was taken on again in 1979 and 1980 so, presumably, Pagel must have found him to be a useful assistant.

A new series of lunch-time talks for staff about the work of the RGO was given in November 1979. This proved to be popular and so another series was started in April 1980. The talks were not restricted to astronomy and engineering. Janet Dudley spoke twice about the library and archives and Derek Ellwood, the head gardener, gave a slide show on ‘a year in the Castle grounds. He gave the show again during the evening of Friday, 16 December 1980, so that family members and friends could enjoy it. Another innovation was a hobbies and handicrafts exhibition, without fees or prizes, that was held in the Drawing Room of the Castle at the end of January 1980.

A special conference for about 100 teachers from East Sussex schools was held in the Castle in July 1981. The theme was the importance of the RGO as a resource in environmental and heritage education. Half a dozen members of the staff gave talks and there was an exhibition of books and periodicals. Nathy O’Hora, an RGO Information Officer, organised the RGO side of the arrangements.

IB 254 (1 Nov. 1980) refers to the start of the work on the ‘RGO Lecture Theatre’. IB 259 (1 April 1981) refers to the completion of the ‘Conference Room in the Castle’ and lists the various items of projection and recording equipment that were available. I assume both of these items refer to the Lady’s Bower room (in the south of the east wing) that was used first of all by the Solar and the M&M Departments and then by the General Office. The Office staff must have moved to the ground floor rooms after the astronomers had moved to the West Building. See section 6.4.1.1 for the later use of this conference room.

An almost complete list of the conferences and workshops held in the Castle is given in final issue (no.16) of the RGO house journal *spectrum* that was issued in October 1998 just before the final closure of the RGO.

5.5.8.3 Training

Training courses on topics of interest to many staff were held in-house, but otherwise, members of the staff attended specialist training courses elsewhere. [The IBs contain many examples; 246] Attendance at MSc and PhD courses at the University of Sussex was encouraged and many staff gained additional qualifications and promotion as a result. Various members of the staff acted as Training Officer in turn. Humphry Smith is listed in 1976 and was succeeded by Yallop in 1977. Geitzen was an additional Technical Training Officer from 1978 to 1980, when Alfred Heath was appointed.

5.5.8.4 Public exhibition

Graham Smith had hoped to open the public exhibition in the Castle for the summer season in 1976, but it was not ready and so another period of open days was organised during August. The exhibition was, however, opened on Monday, 4 April 1977, by Patrick Moore prior to its opening to the general public on Good Friday. 8 April. The opening ceremony in the Long Gallery was attended by 45 representatives of the press and about 85 guests from local and national organisations. The resulting publicity boosted the number of visitors over the Easter weekend from 1610 in 1976 to 4188. The RGO Club arranged a “very successful social” during the evening after the opening ceremony.

The exhibition occupied the two room on the ground floor of the north wing that had previously been occupied by the Meridian Department. There was a management committee chaired by Graham Smith, while Paxton and Thomas were responsible for the procurement and arrangement of the exhibition. Other members of the staff prepared

particular areas; for example, Humphry Smith supervised the Time and Navigation area. There was also a shop.

A series of free leaflets about different aspects of the work of the Observatory were produced for visitors at about this time. (I have 14.) A glossy booklet with colour photographs and an orange cover was produced for the Tercentenary and it served for the rest of the decade. It was priced at 30 p. the inside front cover shows Graham Smith and Hunter on the south bridge of the Castle. David Calvert, a Senior Photographer, who had developed an amateur interest in local history, wrote a booklet on *The History of Herstmonceux Castle* a few years later. It is undated, but it went on sale for the first time in 1982. It acknowledges the help of Hunter, Laurie and O'Hora and it was printed by SERC.

Graham Smith also encouraged the use of the Castle and grounds for other events, such as the fete that was held in June 1981. Further publicity was gained from tree-planting ceremonies by the Men of the Trees in November 1979 and 1980.

5.5.8.5 Public Information

The post of Public Information Officer was part-time and was allocated to members of the staff in turn. Roger Wood held the post in 1977 and he was succeeded by O'Hora in 1979, by which time 3 part-time post were assigned to the Public Information Unit. The NAO supplied much of the basic information in its *Astronomical Information Sheets*, but its staff did not have to deal with all the telephone calls and correspondence that was involved.

The Unit also dealt with the 'media' as the Castle and astronomy continued to interest the general public. An example was the 'Horizon' programme on Gravitation in 1973; some members of the RGO staff took part.

5.5.8.6 Miscellany

The published annual reports that cover the years 1974 to 1980 give details of the official activities. The internal Official Circulars announced major changes and events, but the Information Bulletins record a variety of other activities and events. The IBs were compiled at irregular intervals by Anita Hewerdine and Pat Hanning, and then more regularly and frequently by Sylvia and Sarah Smith. They were circulated to the staff and mainly contain information about staff changes and about visits and visitors. They contain occasional references to the activities of the RGO Club, about which further information is given in appendix D. There are also occasional paragraphs about new developments and events, such as the following items.

The moat provided a temporary nursery for cygnet named Copper which had been taken as a young chick to a local RSPCA nature reserve.

Sodium street lights were installed in the grounds in 1979.

The Staff Suggestions Scheme generated several useful ideas for safety and savings.

A course of 12 lectures on First Aid was given by a member of the St. John's Ambulance Association.

5.5.8.7 Scientific societies

Hunter continued to serve as the Treasurer of the Royal Astronomical Society while he was Director of the RGO. Graham Smith served as President for the period 1975-1977. Pagel (1973-1975) and Murray (1975-1977) served as Foreign Correspondents. Members of the RGO spoke about their work at the meetings of the Society

Sadler continued to play an active role in the Institute of Navigation and was almost certainly responsible for my election as a Fellow in 1979.

5.6 Overview

The period 1972 to 1981 was a period of great change for the RGO. It seemed, however, that its future was assured as it had three clear purposes:

> to build and then operate the new UK components of the new observatory on the island of La Palma and to participate in the development of new instrumentation;
>
> to carry out astronomical research and related programmes of observation and measurement; and
>
> to provide national and international services in astronomy.

During his last few months in office Graham Smith had even been seeking an increase in the complement so that the RGO would be able to carry out this large range of activities.

This period also involved major changes in the character of the work as electronic computers and microprocessors began to play a dominant role in almost all fields. Moreover, film was being replaced for the recording of images by new charge-coupled devices (CCDs) that gave images as digital arrays. The CCDs were more sensitive than film and, although they were then of lower resolution, the digital arrays could be processed by powerful minicomputers to remove blemishes and to give striking images in false colour.

The role of the astronomers had also changed dramatically as they were no longer needed to use their eyes to guide the telescopes or to measure the images on photographic plates. The RGO remained a predominantly optical observatory, but the research astronomers had to take into account the data from other wavelength ranges.

New techniques were also about to supersede the traditional use of observations of stars for the measurement of sidereal time and for the monitoring of the variations in the rotation of the Earth.