EXTRACT FROM

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

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2 THE FIRST PHASE OF THE MOVE

SIR HAROLD SPENCER JONES - 1948 TO 1955

2.1 Introduction

2.1.1 The initial moves to Herstmonceux

The first batch of moves of staff and activities to Herstmonceux took place in the second half of 1948. The Astronomer Royal and the Secretariat moved from Greenwich in August and the Chronometer Department moved in September.

The AR's private residence was provided in the north-east corner of the Castle, with the kitchen and dining room on the ground floor, a large panelled lounge and bedroom on the first floor and guest bedrooms in the attic. The administrative offices, including a very large office for the AR, were on the ground-floor in the south-east corner. The Chronometer Department was allocated space for offices and rating rooms in the north-west corner of the Castle, while the Chronometer Workshop was set up in one of the wooden huts, which had been fitted with extra north-facing windows. (Further details are given in section 2.4.)

During the following year 1949, the Solar Building was completed in April, and the telescopes and other equipment were then installed. The staff of the Solar Department and some of the staff of the Magnetic and Meteorology Department (M&M) moved from Greenwich. The Lady's Bower Room provided an open-plan office for the Solar Department and the M&M Department. Rumour has it that a fine painted ceiling was covered up during the conversion of this room.

The long-delayed move from Bath of the staff of H.M. Nautical Almanac Office (NAO) into the huts by the South Courtyard took place early in October 1949. There had, however, been no progress on the construction of the Meridian Group for the new Photographic Zenith Tube (PZT), the Reversible Transit Circle (RTC) and other astrometric instruments. Nor had work started on the buildings for the equatorial telescopes, and yet the target date for the completion of the move was still the end of 1953.

The delay was partly due to financial problems due to the poor economic situation in the country, but was also due to criticisms of the appearance of the new Solar Building. (See section 2.3.1). At the beginning of 1950 it was announced that Mr. B. O'Rourke, ARA, FRIBA, had been appointed by the Admiralty as the consulting architect for the Herstmonceux scheme as a whole. (See section 2.7.1) The completion of the move was to take seven more years!

2.1.2 Staff matters

2.1.2.1 Housing, the hostel and the canteen

Council houses on the Fairfield estate in Herstmonceux were ready in time for the move of the Chronometer Department, but the NAO staff had to move before the houses on the Denefield estate were ready. The single staff and the married staff who were waiting for houses lived in the hostel - the ladies were in the north attic of the Castle, while the men were in a hut to the south of the South Courtyard. The first Hostel Warden, who also looked after the canteen, was Mrs E Ramsey; she had rooms near to the kitchen, which was in the south-west corner of the Castle. The dining room was in the south side of the Castle between the tower and the kitchen. It was used by those in the hostel and also by the non-industrial staff at lunch-time. A hut in the courtyard of the Castle was used as a canteen for the industrial staff; it was linked to the dining room by a serving hatch. This was replaced by a window when the hut was demolished and a new serving hatch was made between the kitchen and the dining-room. Sylvia Chapman was the assistant warden.

By the time that I joined the RGO, Mrs Emily M. Patricia Marples, a war widow with a young son, Michael, had replaced Mrs Ramsey. Sylvia had left and was not replaced. Mrs Marples moved to a flat on the first floor; she used the room in the turret by the kitchen as her office. She was assisted by other ladies who lived in the village; one of them was Margaret Brett, who remained on the staff until 1990.

The Council houses on the Denefield estate became available gradually from the end of 1949. For example: George Harding moved into a flat in December 1949, Joan Perry moved in March 1950, and Albert Carter moved in soon after that; Gordon Taylor got a house on the Fairfield estate for his mother. The AR had concerns about housing; he wanted some houses on the estate, but the Admiralty decided against.

The men’s hostel was in a hut, built of breeze-block or similar material, with communal toilet facilities. Each room was plainly furnished with an iron-frame single-bed, a chest of drawers and a coat cupboard. Most rooms had a view to the south to the Pevensey Levels. The ladies had tiny single rooms in the north attic of the Castle. We all had our meals in the dining room of the Castle; breakfast was served on weekdays from 8 o’clock and on Sunday from 9; supper was at 5.30. Lunch was also provided on Saturday and Sunday, but otherwise we made use of the ordinary canteen facilities for lunch. The cost for one week in the hostel was £2 5s.

A high proportion of the non-industrial staff made use of the canteen for weekday lunches, which were served at 1 pm and which cost 1/6d each for two courses and a cup of tea. Meals had to be ordered in advance from a menu that was posted on the preceding day; there was usually a choice of three main courses. The meals were put out on the plates in advance, and kept in an oven, so that they could be served as quickly as Mrs Marples could take the money. There was always a good choice of second courses, with a variety of individual suet or sponge puddings being available. Some of us even had second helpings! The industrial staff were served at 12.30, although I believe that most brought packed lunches.

My recollection is that our beds were made and the rooms were cleaned by the hostel staff. I also recall a heated drying room and another room with an ironing board that we could use for our personal laundry, but I do not remember any special facilities for the actual washing; I assume that we must have used the sinks in the communal bathroom.

With one or two exceptions, the men and women living in the hostel were mainly new recruits in their late teens or early twenties. Some civil engineers and other persons who came to work at the Castle in connection with the construction work also stayed in the hostel for a while. For example, I recall an elderly surveyor, Mr James, and the engineer in charge of the building work would sometimes also stay with us.

The men living in the hostel in October 1951 included: Mike Candy and Johnny Green (NAO), Arthur Milsom, Mike Nunn and Norman Rhodes (Solar), David Smith (Chron. Office), Keith Jarrett and John Lipscombe (Chron. Workshop), and Jack Pike (the forester). There may have been one or two others. Patrick Wayman (Solar), another S.O. like myself who had been working for his Ph.D., came about a month after me. Others who came later included Eric Mitchell (Chron. Workshop).

The women included: Audrey Crisford, Mavis Gibson, Angela James and Flip (=Iris) Restorick (NAO), and Scrap Ryall (Chron. Office). Others who came later included Virginia Papworth. Some of them married men whom they had met in the hostel. (See appendix C.12)

Each new recruit coming to the hostel from outside the area who needed to go to a dentist would be recommended to go to Mr Quinton, who had his practice in Bexhill, and so he gradually took on more and more RGO staff. I continued to go to him after I had left the hostel and was living in Westham, which was actually much nearer to Eastbourne than to Bexhill. At first, I would take the train to Bexhill and then take a no 15 bus to Herstmonceux; my recollection is that we could arrange for an Observatory vehicle to meet us on such occasions.

2.1.2.2 Transport arrangements

Public transport to the Castle was provided only at infrequent and usually inconvenient times by a single-decker bus from Hailsham. Only a very few of the staff owned cars and so the RGO provided home-to-duty transport between the Castle and Herstmonceux village, Boreham Street and Pevensey Bay Halt. The first two runs connected with the number 15 Southdown bus, which ran at half-hourly intervals between Eastbourne and Hastings, on an inland route via Hailsham, Herstmonceux and Bexhill. The third run connected with the half-hourly train service on the coastal route between Brighton and Hastings, via Eastbourne and Bexhill. The vehicles used were provided by the Royal Navy and included a lorry with a tarpaulin cover and wooden benches. A charge was made for each journey: 3d to the village and 6d to Pevensey Bay Halt. Tickets had to be bought in advance.

The journey across the Pevensey Levels was described in 1949 by Dr J G Porter, then on the NAO staff, in the introduction to one of his radio talks on astronomy (“The Night Sky in December”) as follows:

“They take us to work in a lorry — five miles across the Marsh from Pevensey to the Observatory. It isn’t a comfortable ride, it isn’t even warm, but — well, if you know that part of Sussex, you’ll know that it’s about the only way to reach Herstmonceux Castle quickly. I’m sure you’d like to see us! — and by the way, what <u>is</u> the collective noun for a number of astronomers? There’s a gaggle of geese, a herd of deer, a brood of chickens, — would it be a huddle of astronomers? Well, never mind, the ride is worth while, for all its discomfort. The Marsh has a beauty all its own, and there is life there and movement, the air is clear and sparkling, and the morning mists go as soon as the sun rises. The blue sky is really blue, and the night sky has to be seen to be believed. That's why the Observatory has been moved down to this part of England, of course. So far only the Solar Observatory is working there, but already the results show that the move was justified."

"Down there, away from the street lamps, the nights are really dark, and the stars wonderful. The winter stars are always interesting, and at present there are four bright planets to be seen as well. But let me say something about the stars before I come to the planets; the stars of a winter's night. High in the east as soon as it is really dark, the eye catches the first glimpse of the Pleiades, that lovely little cluster of stars that is always difficult to count. Quite tiny — you can cover them with the finger of an outstretched hand — but very obvious all the same, once they have caught your attention. What a charming idea of the old astronomers to call these little stars after the daughters of Atlas, translated to the sky in answer to their prayer to be rescued from the giant Orion!"

The AR had a large green Daimler car and the services of two full-time drivers, Johnny Manser and Jim Clarke. The car was also used to take other members of staff to, for example, Polegate station when they needed to go to London on duty. For rail journeys, it was necessary to obtain in advance a rail-warrant, which would be exchanged for a ticket at the station.

2.1.2.3 Grading of staff

The Civil Service had a complex hierarchical grading structure with major differences in conditions between the white-collar non-industrial staff and the industrial staff. The main divisions in the non-industrial staff of the Observatory were for administrative classes, scientific classes and, later, the professional and technical classes.

In the AR's report for 1952 the astronomical staff were divided into three classes — the scientific officer class, the experimental officer class, and the assistants (scientific) — and to several grades within each of these classes. (Even then they were split between (a) Royal Observatory and (b) Nautical Almanac Office.) The grade of the AR is not given but he was a Chief Scientific Officer, while R. d'E. Atkinson (his Chief Assistant), and D. H. Sadler (Superintendent NAO) were Senior Principal Scientific Officers. The heads of the departments were Principal Scientific Officers, while their sections were usually headed by Senior Experimental Officers.

The staff in the secretariat (not yet called the General Office) were headed by H. G. Barker, a Higher Executive Officer, while his deputy, J. H. Whale, was a Higher Clerical Officer. There were several grades for the typists. There was a long list of the grades of the industrial staff, but no names were given.

2.1.2.4 Hours and leave

The Observatory hours were nominally from 9 am to 5 pm from Monday to Saturday, but (in common with rest of the Civil Service) we had the privilege of being allowed to leave at 1 pm on Saturdays. The times of arrival and departure of those using the official home-to-duty transport were adjusted to suit the times of the buses and trains. As a legacy from the war, our pay included an extra-duty allowance and so we were expected to sign in and out each day and to make up any time that we lost through lateness or early departures. The total of 44 hours actually included 5 hours for the lunch breaks, which were also a ‘privilege’.

Our annual leave allowances were reckoned in weeks of six days, but we could take short periods in units of half-a-day, except that an absence on a Saturday morning cost a whole day’s leave; staff were therefore reluctant to take leave on Saturdays. Leave allowances depended to a large extent on ‘class’, rather than on length of service. For example, scientific officers had a generous allowance of 6 weeks, but the scientific assistants were not so favourably treated. Applications for leave had to be approved in advance.

Further information about conditions of service and the changes in later years are given in appendix C.

2.1.2.5 The staff club

During the early years of the RGO at Herstmonceux the ‘Royal Observatory Social and Sports Club’ played an important role in giving members of the staff in different departments, classes and grades opportunities to get to know each other through meetings in a social environment. This applied especially to the staff who lived in the hostel, but the club facilities were very popular at lunch-times and the occasional special events in the evenings. The sports teams also involved a wide cross-section of the staff and so a good community spirit was built up.

The Club had the use of a large two-roomed hut by the South Courtyard. This provided a lounge and facilities for billiards and snooker, darts and table tennis. It was also used for social events and for a pantomime for the children of the staff. The Club also had the use of a sports field on the side of the east hill and of a tennis court at the end of the formal gardens of the Castle. Very few of the staff owned cars at this time and so official vehicles were made available for use by sports teams for away matches and other occasions, as well as for home-to duty travel.

The Club produced small duplicated magazine with the title *The Castle Review*. This contained reports on many current Club activities, such as sports, pantomimes and parties, outings and some General Meetings. In addition, the early issues contained interesting articles relating to the history of the Observatory and about the past and current experiences of members in, for example, foreign travels. There were also humorous articles and some poems.

A fuller account of the Club’s activities is given in appendix D.

2.1.3 My early days at Herstmonceux Castle (1951-1955)

In this section I hope to convey an impression of the first few years after I had left college and started work at the Observatory. For the first two years I was a single man and lived in the hostel at the Castle so that my work and most of my leisure activities shared the same environment and involved to a large extent the same people. Correspondingly my links with my family and friends in Croydon were largely limited to short weekends. I married Betty Deane from Croydon in 1953 and we lived at Pevensey Bay and then in Westham (to the west of Pevensey Castle), about six miles away from the Observatory. At that time we did not have a car, so that I would use the home-to-duty transport from Pevensey or cycle.

I took up my appointment in H.M. Nautical Almanac Office (NAO) on Monday, 4 October 1951. I travelled by train from East Croydon to Lewes, where I changed to the local train to Polegate; from there I was taken by the RGO car to the Castle. After the initial formalities were completed — I had to sign an Official Secrets Act form — I went to the NAO, where I had been allocated a table in a room with Johnny Green , who was a young, bright Assistant Experimental Officer. If I looked out of the window, I could see only the wall of the wooden hut on the opposite side of the road.

Formally, I was responsible to Dr J Guy Porter, who was in charge of Astronomical Division II, but in practice most of my work was given to me by Mr Donald H Sadler, the Superintendent of the Office. The title ‘Superintendent of the Nautical Almanac’ was first used in 1818 when Thomas Young took over the responsibility for the production of the Almanac from John Pond, the Astronomer Royal. Further details of the structure and work of the NAO are given in section 2.2.

First of all, I had to go through the basic training in numerical calculation that was then given to all new recruits to the Office by Albert Carter. He, quite rightly, made me do the same initial elementary exercises as the assistants who came straight from school! I was also taught to use a manually-operated Brunsviga calculating machine. I was soon to find that these were more flexible for general use than the electromechanical calculators that I had used at College.

I do not recall the nature of my first real task, but it was not long before I was given the first of many sets of proofs to read. Most of the pages contained columns of numbers, but others contained the text for the explanatory parts of the almanacs. Proofreading took about two hours of my time on nearly every working day for almost the next twenty years!

For most of the time I would be working on my own task and there was little interaction with other members of the staff, except when I needed information or advice. Interruptions were provided by the welcome visits of the assistants, who took it in turns to make and bring around morning coffee and afternoon tea. I soon realized that Johnny and Evelyn Grove were ‘going out’ together, as when it was her turn our cups were the last to be served so that she could linger a while for a chat. Miss Joan E Perry, the secretary of the Office, also came round from time to time, and she would also stop and chat to us. Mr Wenban, the Office ‘messenger’ used to bring around the ‘transits’ [see later], but he only spoke if we spoke to him.

For almost two years I lived in the hostel and so I wasted no time in travel to the Office or in the preparation of meals as breakfast, lunch and supper were provided. While I was living in the hostel, I cultivated some of the ground alongside the hut. I recall that Jack Pike, the forester who also had a room in the hostel, gave me some strawberry plants. Arthur Milsom was also quite keen, but his principal crop was tobacco! Jackdaws used to nest in the Spanish chestnut trees by the Castle and I have memories of Jack bringing to his room to feed some chicks that had fallen from their nests. He and his assistants are said to have planted over a quarter of a million trees on the estate.

We had an hour’s break at lunchtime; some of the staff brought sandwiches but the rest of us had lunch in the Castle. There was then time for a walk around the gardens and grounds or for a game of table-tennis or even for half-an-hour’s tennis.

I can recall no details now, but Patrick Wayman and I were invited to have lunch one day with Sir Harold and Lady Spencer Jones in their residence. It was probably early in 1952.

At first I spent my evenings in my office completing my thesis, but when that was finished I was soon involved in other activities. In the winter, I used to play in the Club’s second table-tennis team; this involved some travelling to away matches, in Eastbourne for example. During the weekends when I stayed at the Castle, I was able to enjoy walking in the Castle grounds or cycling to explore the area. I also played in the RGO mixed hockey team. Other indoor games, the preparations for the pantomime, and occasional social events made the winters pass quickly. In the summer, I played tennis, cricket and stoolball (a game played in Sussex by mixed or ladies teams), and occasionally some of us cycled to the beach at Pevensey Bay.

My initial appointment was as a ‘Temporary Scientific Officer’, but soon afterwards I was ‘established’, so that I had a permanent post and pension rights. Some months later I had a shock: my pay as a temporary SO had taken into account my two years of postgraduate study, but my pay in an established position should have been based on my age and so should have been significantly less. Moreover my establishment had been backdated to my initial appointment and I was expected to pay back the overpayment. I was dismayed and Mr Sadler was furious, but to no avail and so my monthly take-home pay was reduced even further for the next few months.

My NAO work gradually expanded as I was given new jobs. Some of them involved visits to other establishments in England and in the summer of 1955 I attended my first meeting of the International Astronomical Union (see section 2.2.7.2). This was held in Dublin, and it gave me a foretaste of the international cooperation and travel that were to dominate my later career, even though I continued to be based at Herstmonceux Castle. The technical activities will be described in their RGO context, while the associated social and personal activities will be described elsewhere in my separate autobiographical notes, which will also contain details of the RGO Club activities in which I continued to be involved.

2.2 H.M. Nautical Almanac Office (NAO)

2.2.1 The place of the NAO in the RGO

Until 1936 the Nautical Almanac Office (NAO) had been independent of the Royal Observatory, and the Superintendent, then L. J. Comrie, reported directly to the Hydrographer. Comrie was suspended from duty when an investigating team found that some of the staff were engaged on external work for which Comrie had not obtained prior approval. His young deputy, Donald Sadler, was appointed in his place. The Admiralty decided that Sadler should report to the Astronomer Royal, Spencer Jones, who in turn reported to the Hydrographer. Nevertheless, the budget and the staff complement of the NAO continued to be fixed separately from those of the RO and the change had little effect on the day-to-day work. The NAO was evacuated to Bath during World War 2 and Sadler took on the additional responsibility of the work for the

Admiralty Computing Service. Hence, for all practical purposes, the contacts between the NAO and the RO were negligible. It appears that Spencer Jones did not keep Sadler properly informed about the progress of the negotiations for the purchase of the Castle and of the arrangements for the move.

The feeling of separation between the NAO and the rest of the RGO must have been heightened when the move finally took place, since the NAO was accommodated in the two huts on either side of the South Courtyard while all the other scientific staff had offices in the Castle. Moreover, the NAO had its own secretary, Miss Joan Perry, and filing system, although it did make use of the services of the Typing Pool and all financial matters were dealt with by the Secretariat in the Castle. The NAO also had its own library and computing facilities; all the staff had calculating machines, whereas it appeared that a lot of the calculations in other departments were done with the aid of tables. By the time that I joined, the NAO had taken delivery of a set of punched-card machines.

There were also more subtle differences between the NAO and other Departments, although I was not aware of them at first since I had no contact with their work. Sadler had the reputation of being a ‘hard taskmaster’ as he insisted on high standards of work and timekeeping. The NAO staff were expected to have their morning coffee and afternoon tea at their desks, and to continue working, whereas other departments would gather for a general chat that could be quite lengthy. On the other hand, I think it was felt that he did his best to improve the conditions and advance the promotions of the NAO staff. One major difference in the conditions of service was that the NAO staff were not expected to undertake night-observing duties; this also meant they did not have the flexibility to arrive late and to take ‘time-in-lieu’ after scheduled observing duties. (This time off could be taken even if the person concerned did not come in for the duty when the weather conditions made observing impossible since the observer was expected to look out from time to time in case the conditions changed.) I am sure that there were quite strong feelings of ‘them’ and ‘us’ at first, but these diminished as staff got to know each other better. This was certainly the case for those of us who lived in the hostel and participated in the activities of the Social and Sports Club.

2.2.2 The structure and basic activities of the NAO

At this time the NAO was divided into four main parts:

Astronomical Division I, headed by Miss F M McBain (PSO);

Astronomical Division II, headed by Dr J G Porter (PSO);

Navigation Section, headed by Mr W A Scott (SEO);

and Machine Section, headed by Mr A E Carter (EO).

Within Astronomical Division I, Miss McBain was responsible for the oversight of the printing of all the publications; in particular, she monitored the quality of the proofreading of all members of the Office. She also organised the lunar occultation programme (see section 2.2.4.3). In these tasks she was supported by Miss M R Rodgers (EO) and Mr W G Grimwood (EO). Mr H W P Richards (SEO) had responsibility for the publication *Apparent Places of Fundamental Stars* and Mr J H Barry (SSA) prepared *The Star Almanac for Land Surveyors*.

Astronomical Division II was primarily responsible for the computations of the ‘fundamental ephemerides’ (see section 2.2.4.1) in the first part of the *Nautical Almanac,* which, in spite of its title, was used for astronomy and not for navigation. (The full title was *The Nautical Almanac and Astronomical Ephemeris*, but it was usually referred to as the NA. An ‘ephemeris’ may be described as calculated data about an astronomical event or about the positions of an astronomical body.) Dr Porter’s principal assistant was Mr E Smith (EO), who in turn was assisted by Mike Candy, then an SA. I was not expected to contribute to the normal work of the section, apart from proofreading.

The Navigation Section was responsible for the *Abridged Nautical Almanac* (ANA), for the *Air Almanac* (AA) and for other tables used in astronavigation. The section also carried out computations for the plotting of the hyperbolic lattices on charts for the Decca Navigation System (see section 2.2.5.3). Mr Scott’s principal assistant was Mr D A Harragan (AEO), who had served in the Royal Air Force.

The Machine Section, which occupied the hut on the west side of the South Courtyard, was responsible for the operation of the Hollerith punched-card machines (see section 2.2.6.4), which were used for calculations for the other three sections. My recollection is that Mr Carter also supervised the use of the National accounting machines (see section 2.2.6.3), but these were kept in the east hut as they were operated by the junior staff of all the sections. Mr G A Harding (also an EO) was the deputy head of the Machine Section.

The junior staff were Assistant Experimental Officers (AEO), who were usually qualified at Higher School Certificate level (now A-level), and Scientific Assistants (SA), most of whom were girls from the local grammar schools, who had General School Certificates (now GCSEs). (The grade title was, strictly, ‘Assistant (Scientific)’, but the name ‘Scientific Assistant’ was normally used.)

2.2.3 General aspects of work in the NAO

2.2.3.1 Training

All new recruits to the Office had to go through a basic training course in numerical calculation. Albert Carter, who was in charge of the Machine Section (see later), was the training officer. The exercises started with the writing of the digits 0 to 9 in unambiguous forms and included writing from left to right the answers to mental additions and subtractions of two numbers. We were soon to learn that checking columns of figures by forming the differences of successive values was to become a major part of our work and so speed and accuracy in this process were vital. [More details of the procedures that we used to guard against errors in our calculations are described in section 2.2.6.2.] We were also introduced to different types of calculating machines. I believe that almost all members of the staff had their own manually operated Brunsvigas, but there were also a few electromechanical calculators (Marchant and Friden). These had, for example, automatic multiplication and division and were faster for some jobs.

We were also all given training in proofreading. The Office was then producing many hundreds of pages of numerical data that were published in a variety of almanacs and publications. Not only did we have to ensure that the calculations were correct, but we had to endeavour to ensure that there were no errors in the published volumes. Our numbers were set in type by Monotype-keyboard operators, who, not unexpectedly, occasionally made mistakes; moreover, mistakes could be made in the correction of errors that had been found on the proofs and even in the later stages of the printing process. Each member of the staff of the Office was expected to do two hours proofreading each day. This stint was usually done at the beginning of the day so that the Office would be free from the noise of calculating machines and other distractions.

There was a great deal of cooperation between the staff of the four sections of the NAO. This was certainly true of proofreading, and every member of the staff was expected to share in this task. As a consequence, all of the senior staff were familiar with all the publications and could contribute ideas for their improvement. The tabulations in the navigational almanacs (ANA and AA) were derived from the fundamental ephemerides computed for the NA and the computational techniques were largely the same even though the output had different purposes and format. The most important common factor was that all calculations had to be thoroughly checked so that any mistakes in them would be discovered before the final results were published. From an external point of view, the navigational work of the NAO was probably of the greatest importance, but it depended on contributions from all sections of the NAO.

2.2.3.2 Formalities

As was customary at the time, both dress and forms of address in the Office were rather formal, although conditions in, say, a bank would have been even more formal. Jackets and ties were standard for the men, and the ladies and girls were all neatly dressed — slacks were not worn in the Office! Senior staff were always given their titles — Mr or Miss, as appropriate — or were referred to by their initials, which were normally used on written lists and messages. For example, Mr Sadler was otherwise known as D.H.S.. As far as I can recall, I never used ‘Walter’ or ‘Harold’ when talking to Mr Scott or Mr Richards. (I shall not normally use titles in this text and I will often use forenames for staff that I came to know well.) Similarly, the Astronomer Royal was always referred to as the A.R..

2.2.3.3 Services

Morning coffee was served at our desks by the young Scientific Assistants, who did much of the ‘routine’ work of the Office. Although their work was referred to as ‘routine’ they had to understand what they were doing and to be on guard against errors that could arise in many different ways. These SAs were all attractive girls who had reached at least School Certificate level in mathematics at school; almost all of them had been recruited locally from the High Schools in Eastbourne and Bexhill. These girls used to take turns to make and serve the morning coffee and afternoon tea. I think that they enjoyed the break and the chance to go around the Office.

Other services that I appreciated were provided by the Messenger, Mr Wenban, who had served in the Royal Navy. He came around regularly to bring and take ‘transits’, which could be incoming or outgoing letters, internal messages, packets of work or sets of proofs sent from one person to another. Some items, such as Office Notices or lists of recent acquisitions to the library, were sent on circulation to an appropriate list of staff. He also used to ensure that when we arrived in the morning our calendars had been changed to show the correct date — all our work and notes had to be dated — and that we had clean glasses and a carafe of fresh water.

2.2.3.4 Cooperation and attribution

The work of the Office depended for its success on the wholehearted cooperation of the staff; very few, if any, jobs were carried out completely by one person, or even by a small group of persons. In particular, proofreading was always spread around the Office so the proofs were read by persons who had not prepared either the basic data or the copy. This was particularly important for the explanatory pages, and comments by proofreaders could lead to changes in the presentation of the data as well as to improvements in the text. Similarly, proposals for new tabulations or new methods of computation were circulated for comment amongst all the senior members of the staff. Junior members of the staff could, and did, make suggestions for improvements, with the result that it would have been impossible to assign credit individually.

The prefaces for the almanacs and other publications of the Office were attributed to the Astronomer Royal and usually stated that the publication had "been prepared under the immediate supervision of the Superintendent of H. M. Nautical Almanac Office". A list of the staff of the NAO was given in the preface to the *Nautical Almanac*, but the other regular publications did not give the names of those concerned. Scientific papers were usually, but not always, attributed to one or two individuals. In general, however, the techniques developed in the Office and the results of investigations were described anonymously in the publications.

In later years the policy gradually changed for two reasons. Firstly, the use of computers meant that sections of the Office, or even individual members of the staff, were assigned tasks that they could complete with very little assistance from others. Secondly, promotion became dependent on interviews in a competitive environment, rather than on the consideration by non-interview boards of annual staff reports and of the recommendations by the Astronomer Royal.

2.2.4 The astronomical work of the NAO

2.2.4.1 The fundamental ephemerides

The term 'fundamental ephemerides' refers to the tables of daily values of the positions of the Sun and planets and of hourly values of the positions of the Moon that were published in the first part of the *Nautical Almanac*. These fundamental ephemerides and other data printed with them were used not only for the tabulations in the ANA and AA, but as the basis for astronomical and navigational almanacs and for other calculations, such as those for tidal predictions, in many countries of the world. This was one of the U.K. contributions to international arrangements for the sharing of work of both computing and publishing astronomical data for use in astronomy, navigation, surveying and daily life. The other major contributor was the Nautical Almanac Office of the U.S. Naval Observatory (USNO), in Washington, D.C.. France, Spain, U.S.S.R. and Germany made lesser contributions. USNO computed the data for the second half of the NA and so, in general, the numbers in the *American Ephemeris and Nautical Almanac* were the same as those in the British NA, although they were printed separately in different styles.

Sadler had played a major role in setting up these arrangements before and after World War 2, and he was to extend them even further during the next few years.

He has described these activities in detail in his *Personal History* of the NAO [denoted by SPH for time being] and so I shall not attempt to do so here.

The fundamental ephemerides were not computed a year at a time, but were computed for about 20 years at a time. The current almanacs were based on pre-war calculations and the NAO was engaged on computing the ephemerides of the Sun, Moon and (major) planets for the period 1960 to 1980. The theory of the motion of each of these bodies was represented by a thick volume of printed ‘Tables’ containing complex instructions on how the various tables in the volume had to be combined to give the final results. These tables were designed for manual use, but the new punched-card machines were used to carry out the enormous numbers of additions and other operations that were required.

The largest single job was, probably, that of the computation of the ephemeris of the Moon. This was based on a theory due to E. W. Brown and the tables that represented his theory were printed in a volume that measured about 35 x 25 x 10 cm. It was said that an expert who was thoroughly familiar with the process could calculate one position in about 12 hours of continuous effort — and it was necessary to calculate positions at intervals of 12 hours! L. J. Comrie had been the first to use to use punched-card machines for this computation.

My introduction to these techniques came when Mavis Gibson and I were given the task of planning and supervising the calculation on the punched-card machines of an ephemeris of values of the ‘nutation in longitude and obliquity’ for each day for 100 years from a new theory that had been developed by E. W. Woolard at U.S.N.O. This involved summing only about 90 terms, compared with about 1500 for the Moon; even so, it kept us busy for a lot of our time over a period of about one year. I later wrote a brief account of the ‘method of cyclic packs’ that we used as it differed in detail from the method described by Comrie. The account was published in the *Improved Lunar Ephemeris 1952-1959* and our values were printed later still in the first number of the new series of *Annals of the Royal Greenwich Observatory*.

I had very little to do with the computation of the fundamental ephemerides, and so I cannot be sure how the work was split between the staff concerned. My impression/recollection is that the work was planned by Porter, who was responsible for breaking the job down into many stages and for setting out the formulae to be evaluated. He needed to discuss his ideas with Carter and Harding, who had the job of carrying through each stage on the punched-card machines or on the National machines, and he was supported by Smith and Candy, who provided starting data and check values for each stage. The intermediate sets of values would be combined until the final values were obtained. These would then have to be checked to find any mistakes that had occurred in the computation of individual values and also to verify (hopefully) that the adopted procedures and formulae correctly represented the theory of each ephemeris. Each ephemeris would be evaluated from the appropriate Tables at the widest practicable interval and would then be subtabulated to the required interval; for example, from 40 days to 1 day for the outer planets and from 12 hours to 1 hour for the Moon.

These fundamental ephemerides were printed one year at a time to form what was known as the *Advanced Proofs of the First Part of the Nautical Almanac* and about 100 copies were distributed, without charge, about four years in advance of the year to which they referred, to almanac-producing agencies around the world. The ephemerides and other information for the Second Part were produced, using our data where appropriate, by the Nautical Almanac Office at the U S Naval Observatory. The US NAO sent us proofs, which were then used to prepare copy for use by our printer — then C. Tinling & Co. at Liverpool. At this time the *Nautical Almanac* and the equivalent *American Ephemeris* differed in typographical style and, to some extent, in content; for example, the ephemerides for lunar occultations were quite different. The other major almanacs produced by the French, Spanish and Russian ephemeris offices differed even more in style and content; in particular, the French used different theories for the ephemerides of the planets.

2.2.4.2 Planetary Co-ordinates

Apart from their publication in the NA and their use for the ANA and AA, the computed coordinates of the planets were also to be published to lower precision in the volume *Planetary Co-ordinates for the Years 1960-1980*, which was the successor to the previous volumes for 1900-1940 and 1940-1960. The main use of the volume was for the computation of predictions of the orbits of comets. Porter was the editor, while Candy and I were his assistants. My main task was to design the section of formulae on the various methods that were available for orbit computation. In addition we were to assist in the computations of the orbit of a fictitious comet, which we called NAO1, that would be used to exemplify the ways in which the volume could be used.

Porter had written the book *Comets and Meteor Streams* and was then Director of the Computing Section of the British Astronomical Association, some of whose members computed the orbits of comets.

At this time (1952/3), Professor Sam Herrick, from the University of California, was spending a sabbatical year at the Observatory in order to complete a book on celestial mechanics. He was accompanied by his wife and three children, and he was later joined by his graduate assistant, C G (Jeff) Hilton. He agreed that Jeff should spend part of his time on the computation of the orbit NAO1 by a method that Herrick had developed. (Jeff was based in my room, as Green had left to study at Imperial College, and we met again later in 1961 when I went to California.) As the ‘comet’ got further and further from the Sun, so our predicted coordinates differed more and more, but we could not find any mistakes that had caused this. We were relieved and surprised that our results came back together again when the comet returned to the Sun. Although I did not realize it at the time, this effect had been known to Norman Lockyer and later to Raymond Lyttleton, who used it in the ‘sandbank’ model of comets. The idea was that a comet was a diffuse cloud of particles when it was far from the Sun, but that the particles converged and collided when the comet approached the Sun, thus giving rise to the activity that is seen.

2.2.4.3 The lunar occultation programme

The Office was responsible for the international programme for the prediction of ‘lunar occultations’, that is of the times of disappearance and reappearance of stars at the limb of the Moon as it moves in its orbit around the rotating Earth. These are the times when the ‘lunar distances’ of the stars are zero and they depend on the geographical positions of the observers. The differences between the observed and predicted times could be used to give information about the variations in the rate of rotation of the Earth and about various other factors that affect the time, such as the very small errors in the lunar theory. I did not realize then that the observation of the rotation of the Earth would play such an important during the last decade of my career.

In order to encourage the making of observations of the times of the occultations, the predictions were distributed throughout the world. The predicted times depended on the positions of the observers and so it was necessary to calculate the times for about 80 positions, known as standard stations, around the world. The observers participating in the programme, who were mainly amateurs, could either use the times for the nearest station or make use of the data for two nearby stations to calculate better predictions. Some predictions were published in each of the principal national almanacs, while others were published in handbooks and magazines such as *Sky and Telescope*. Predictions for 10 stations in the British Commonwealth were published in the NA and in the *Handbook of the British Astronomical Association* (HBAA). During the 1920s and 1930s the BAA had played a major role in the prediction of lunar occultations, but then, largely through Comrie's initiatives, the NAO took on a major part of the work of an international programme.

The task of deciding which conjunctions of stars with the Moon (when they have the same right ascension) might lead to an occultation somewhere in the world was carried out in the US NAO, which also calculated appropriate data, known as 'occultation elements', from which predictions could be calculated. These elements were used in the NAO to set up the 'occultation machine', which simulated the star (by a small lamp), the Moon (by a lens) and the Earth (by a globe on which the standard stations were marked); it might be described as an analogue computer in which the result was shown by a dial. The 'shadow' of the Moon cast by the star was represented by a circular column of light which moved across the rotating globe as the lens was moved through the beam of light from the lamp. The outline of the disc of light on the globe marked the locus of positions from which the star would be seen at the limb of the Moon. The operator turned a handle to drive the lens, the globe and the dial, which showed the interval of time from the initial starting position at the time conjunction.

The machine showed for each listed conjunction the stations from which occultations would be visible and the times when the stations were on the edge of the disc could be read from the dial. The machine also showed the many conjunctions for which the track of the shadow would not pass over any place where an observer might be expected. The approximate times given by the machine were then used as the starting times for calculations to give the more accurate times for publication.

I believe that Miss Marion Rodgers (whose initials became MR^2) carried out much of the machine work with the assistance of other members of the Section.

In addition to making the predictions, the Office also collected, 'reduced' and then analysed the results of the observations, some of which were sent to the Office by the observers, while the rest were obtained by scanning astronomical journals and reports. The reduction process resulted in the difference in each time being expressed as a residual that corresponded to an error in the adopted value of the semi-diameter of the Moon. (Or, equivalently, as an error in the predicted lunar distance.) The residuals were then analysed annually by Miss McBain to find the corresponding average errors in the latitude and longitude of the Moon over the period of the observations used. The results were published in short papers in the *Astronomical Journal*; in effect two small numbers resulted from a very large effort in both calculation and observing. The programme was coordinated through Commission 17 of the International Astronomical Union (IAU).

(See section 2.2.7.2) Miss McBain was the secretary of the Commission for many years. It is no wonder that, at the time, Sadler questioned whether it was worthwhile [SPH, 13], but the programme justified itself in later years.

2.2.4.4 Apparent Places of Fundamental Stars

Until 1941, each of the national almanacs for astronomers and surveyors contained tables giving the apparent coordinates (or ‘places’), at an interval of 10 days, of a selection of bright stars. Such coordinates vary with time of year and from year to year and were used in determining time and geographical positions from astronomical observations. In 1938 the IAU adopted Comrie’s suggestion that there should be a single international volume that would contain such data for a much larger number of stars than could be published in any single almanac. The computation of the data was shared between several national ephemeris offices, while the volume itself was prepared by the NAO and published as the *Apparent Places of Fundamental Stars* (APFS). The explanation of the use of the volume was printed in French, German, Spanish and Russian as well as English. Sadler had to carry through the project and make the detailed arrangements by correspondence. Mr Richards then had the task of implementing the decisions. When I joined the Office, the arrangements were, I believe, working well, but the proofreading of the volume entailed a considerable amount of effort.

Richards, who reported to Miss McBain, was largely responsible for the tedious work of collating and checking the incoming material and then of preparing copy for the printer. I got on well with Richards; I found that he had a very large range of knowledge and appeared to be very competent. So I was rather surprised that he did not have greater responsibility; it was not until I read Sadler’s *Personal History* a few years ago that I realized that he had proved to be unreliable in earlier years. Before joining the NAO in 1931 he had served in the Colonial Survey in Tanganyika and prior to that he had been employed as a research student at the Norman Lockyer Observatory in Devon from February 1927 to April 1928.

2.2.5 The navigational and geodetic work of the NAO

2.2.5.1 The navigational almanacs and tables

From the point of the view of the Admiralty, the most important product of the NAO was the *Abridged Nautical Almanac* (ANA), which was produced for use in the Royal Navy but which also sold in large numbers for civilian use throughout the world. At the time, the profits from the sales of the ANA were retained by H. M. Stationery Office (HMSO) and were used to subsidise other publications. The *Air Almanac* (AA) was produced for the Royal Air Force and was also sold for civilian use, but in a much smaller market; the costs of production in the NAO were borne by the Admiralty. In addition, the Office produced auxiliary tables and diagrams for use in astronavigation. Most of these were published by HMSO, but some were produced to meet special requirements of the services.

The main computations for the daily pages of the almanacs largely depended on the interpolation, or ‘subtabulation’, of the fundamental ephemerides to a shorter interval of time. Initial lines of differences had first to be computed by using desk machines from the differences of the fundamental ephemerides. Then the required values were formed by building up from their differences by using National accounting machines (see section 2.2.6.3) or punched-card machines (see section 2.2.6.4). These machines printed out the results, but the sheets had to be cut up into strips, which were then pasted on to thin sheets of white card in order to prepare the printer's copy. Headings and other individual items of information, such as the phase of the Moon, had also to be included on the copy. The process was obviously prone to error and so the copy had to very carefully checked before it was sent to the printer.

Mr Scott, who had joined the NAO on 10 May 1926, was the Head of the Navigation Section. He was a small, quietly-spoken man, who was extremely methodical and reliable. We were expected to put away our work and leave our desks tidy at the end of each day, but Mr Scott was the only person, as far as I was aware, who always left his desk bare of papers. He not only supervised very carefully the regular work of the section, but he also contributed much to the development and implementation of new work and to the investigations that were carried out from time to time. I learnt later that he felt that Sadler had taken the credit for some of his work, but I am sure that this was not a fair comment, even though Sadler might have been given the credit for it as a consequence of the anonymous character of our work.

2.2.5.2 Unification of the Almanacs

In the autumn of 1951, shortly after my joining the NAO, Sadler went to Washington for discussions with Dr Gerald M. Clemence, who was the Director of the Nautical Almanac Office in the U. S. Naval Observatory. They both then went to Montreal for a meeting of Working Party 53 of the Air Standardization Coordinating Committee of the Air Forces of the U.K., the U.S.A., Canada, Australia and New Zealand. At this meeting Clemence and Sadler jointly proposed that the (U.K.) *Air Almanac* and the *American Air Almanac* should be unified so that the contents would be identical. The Almanacs would continue to be printed separately in the two countries and would have different styles of cover and binding, but they would have a common title. The U.S. Office would be responsible for the preparation of the daily pages, while our Office would be responsible for the preliminaries and the Explanation. This proposal was "enthusiastically approved" by WP 53. [SPH, 12]

Firm proposals for the unification of the almanacs for marine navigation took a further three years to develop; partly because there were initially greater differences between the two almanacs. In this case our Office was to be responsible for the production of the daily pages on a new card-controlled typewriter that was delivered in 1953. Several different designs for the daily pages were tried and eventually a layout with the data for 3 days in each opening was agreed; the basic idea for this layout was put forward by Clemence, but the fine details evolved as sample pages were prepared and criticised. The unification of the contents took place in the editions for 1958, but the titles were not changed until the editions for 1960. (See section 3.3.1.1)

2.2.5.3 Decca charts

The Office was still responsible for the computation of the data used in drawing the charts for the Decca Navigation System, which had been developed during the war (under the name of Gee) and which was now widely used in western Europe for position fixing for both military and civilian purposes. [SPH, 8] (In North America the corresponding system was known as Loran.) The system depended on the synchronised transmission of radio waves from a master station and three slave stations. The receiver was able to measure the difference in the travel times of the radio waves from the master and a slave; the points at which this time difference took any particular value must lie on a curve with the shape of a hyperbola. If the time differences were measured for two slaves it was then possible to fix the position of the receiver at the intersection of the two hyperbolae. The task was to compute data from which a complete series of such hyperbolae for an appropriate interval in the time-difference could be drawn on the charts for the area around the four radio beacons. The curves for the three combinations of master and slave were drawn in different colours.

The computations were complicated by the fact that it had been found that the effective speed of the transmissions was not the same over the whole area, but differed between land and sea and to a lesser extent depended on the nature of the terrain. It was also necessary to take into account the curvature of the Earth's surface. The staff of the Office had, however, had considerable experience of this work and had developed efficient techniques for use with the National machines. The requests for such computations came at irregular intervals as new 'chains' of stations were set up or as new charts were to be drawn for existing chains. When electronic computers became available the expertise was incorporated in a computer program and the work was done directly by the company.

2.2.5.4 The Star Almanac for Land Surveyors

The Army produced its own almanac for determining position and azimuth by astronomical techniques, but the Office was responsible for the preparation of *The Star Almanac for Land Surveyors* to meet the requirements of the surveyors in Commonwealth countries. [See SPH, 10] The design for the first issue for 1951 was so good that this little booklet sold very well and was only changed in minor respects in later years. The NAO in USNO did not produce any similar almanac as another publication for this purpose was produced by another government agency.

The bulk of the work of computation and copy preparation was carried out by Mr Barry, who reported to Miss McBain. He had been a non-commissioned officer in the Royal Artillery, and was a horseman with horse-drawn guns, before joining the NAO. He did not have any formal qualifications; he was graded as a Senior Scientific Assistant. He was always very respectful of the senior members of the Office and I got on well with him; he lived in Brighton and so I would often talk to him on the journey between the Castle and Pevensey Bay Halt.

2.2.6 Computational facilities and procedures

2.2.6.1 Computers and calculating machines

When I joined the NAO, 'computers' were people and were expected to be able to carry out the basic processes of arithmetic, to carry out repetitively a complicated sequence of operations starting from given data, and to produce intermediate and final results in appropriate formats. We had a variety of desk calculating machines that we could use for these processes and we had to choose the most appropriate machine(s) for the particular task and to design the procedures to make best use of the facilities provided by the machines available to us.

We also had a variety of foolscap and double foolscap ‘forms’ that we could use to record the results. These forms were printed on good-quality paper and each sheet normally had two holes punched in the top left-hand corner. We were also provided with special two-hole punches so that we could punch the holes in any covers or paper that had been supplied without them. A ‘Treasury tag’ passing through both holes was used to hold the sheets together; the current sheet was inserted on the top of the packet. I believe that this system was introduced by Comrie to reduce the risk of any sheet being lost from a packet of computations because of a tear at one hole, as sometimes happened in files of correspondence.

The forms had varying numbers of vertical rules, some thicker than others, to suit the number of columns and the number of figures in the numbers in each column. The number of lines on each sheet matched the number of lines (47 or 48) on a standard page of the Nautical Almanac — I found this annoying when I came to use the sheets for tables with 51 lines. Some of the forms had line numbers printed on them and some even had the symbols for the quantities and operations printed on them for very common jobs. Usually, however, we were expected to write the precepts on a separate sheet that could be placed alongside the current sheet so as to provide all the instructions required by a new computer and to act as a reminder to computers who had done the job previously. These sheets should have been tagged on the top of each packet when it was put into store, but unfortunately this was not always done.

The standard desk machine was the Brunsviga 20; this was a purely mechanical machine in which the computer turned a crank handle to multiply (or add, subtract or divide) one number by another. The digits of the multiplicand were specified by the positions of row of 12 setting levers. The digits position of the multiplier was determined by the relative position of the product register, which could be moved by the left hand, with respect to the multiplicand register. The machine could be used to multiply a 12-digit number by an 11-digit number to give a 20-digit product. (Leading figures were lost unless, as was usual, the full capacities of the multiplier and multiplicand were not used.) The main advantage of the machine was that it had a transfer facility so that the product could be transferred to the multiplicand register and then multiplied by another number, and so on. Most members of the staff had such a machine on their desks. Mr Barry was alone in having a Swedish ‘Facit’ mechanical calculator.

I have a Brunsviga 20 which I bought for a nominal amount just before the Observatory moved to Cambridge in 1990. I used it ‘for real’ in 1993/94 when I was developing examples for use in a simulation of the Babbage Difference Engine, which could add numbers with 31 digits. Most electronic calculators and normal arithmetical processors on electronic computers operate on numbers with only about 8 digits, while the Babbage machine was designed for 31-digit numbers.

For jobs involving a great deal of multiplication a Marchant electromechanical calculator was popular with the Assistants. This required the depression of numbered keys for setting numbers and carrying out multiplications, rather than the moving of levers and the turning of a crank handle; division was fully automatic. The Office also had a Friden calculator, but this was less popular because an input error could not be easily corrected.

All of these machines were noisy in operation, and so as a rule they were not used during the first two hours of each day when most members of the staff were doing their proofreading stint for the day.

2.2.6.2 Mistakes in computations

One major disadvantage of such desk machines was that the operator had to write down the results of each step of the calculation. (A step might involve more than one operation if, for example, the transfer facility could be used or if the required result could be accumulated in the product register.) Each intermediate result would be used again at least once and experience showed that the recording and resetting of such numbers were the points in the computation where mistakes were most likely to occur; such mistakes would then carry forward into the following steps of the computation.

In order to keep mistakes to a minimum it was a rule that all numbers should be written neatly in ink using a standard style for each of the figures. Moreover, when a mistake was found it was to be corrected by crossing through and by giving the new figure above it in red ink. Any consequential mistakes were to be found and corrected in the same way, unless the effects were so extensive that it was better to record the new results afresh. After the correction process had been completed the computer was expected to verify that the differences between the new and old results were consistent with the original mistake that had been made. Experience had shown that the process of correcting for a mistake was a more prolific source of mistakes than the original computation!

Whenever possible, checks were built into the procedures so that any mistakes would be discovered before a lot of further computation had been carried out. For example, many computations involved the use of printed tables to provide values of trigonometric functions, such as sin x and cos x once x had been calculated; the computer would verify that $\sin^2 x + \cos^2 x$ was equal to 1.0 before proceeding. In other cases, some quantities would be computed by two different methods and the results compared to ensure that they were in satisfactory agreement.

Most of the jobs involved the computation of one or more smoothly changing quantities (or functions), such as the celestial coordinates of a planet, at fixed intervals of time, say every 10 days. The differences of successive values could be calculated mentally and written down in the adjacent column (called the first difference); then the differences of this column could be formed in the same way (giving the second difference), and so on. If all the values (and all the differences) were correct it would be found that the numbers in the successive columns (or ‘orders’ of the differences) would become smaller and that successive numbers would oscillate in sign. If one or more of the function values, or of the differences, contained a mistake, then part of the table would start to diverge. With experience it was possible to determine the position and size of the mistake, and then, if necessary, to go back to the original work to find the cause and to correct the work. Very often the mistake would have been made in forming a difference, rather than in the original table! The method of differencing was fundamental to much of the proofreading done in the NAO and is described in *Interpolation and Allied Tables* (see section 2.2.7.4).

2.2.6.3 The National machines

The Office had two Class 3000 National Accounting machines, one of which had been specially modified so that it operated on sexagesimal numbers, i.e., it could be used for calculations in hours, minutes and seconds or in degrees, minutes and seconds. These machines could only be used for addition and subtraction, but they had special features that made them extremely useful for many jobs in the Office.

1. Each machine had 6 registers for 12-digit numbers.

2. The machine could carry out a sequence of operations in accordance with the 'instructions' given by a series of 'stops' on a metal bar.

3. At each stop the contents of a register, selected by the depression of a key by the operator, could be added to or subtracted from one or two of the other registers, selected by the coding on the stop.

4. The number in the selected register was printed on a wide sheet of paper.

One very important use of the National machines was for checking by differencing, but the major use was for 'subtabulation', that is for the systematic interpolation of a table of values to a smaller interval. The process involved the building up of a table of differences line by line from a high order of difference to form the next function value. The table was started from an initial line of differences that had been calculated from the original difference table. The method used was self-checking in that the original function values should be reproduced exactly. The arrangement of the stops on the bar and the sequence of operations to be carried out depended on the interpolation formula to be used and the ratio of the two intervals. All the information required to set up and operate the machine was written on a 'set-up' sheet, of which over a hundred were used. Bars with the appropriate set of stops were kept for the most commonly used processes. The operation of the National machines was largely carried out by the Assistants, who worked in two-hour stints. The machines were rather noisy in use.

The use of the National machines had been pioneered by Comrie, and further developed by Sadler and others in the 1930s and 1940s. Both the machines and the procedures were improved during this period. Most of the final batch of set-ups, which were written on preprinted forms, had been prepared by Carter and Harding. The technique depended for its success on the use of the 'method of bridging differences', about which more is given in the notes on the preparation of the booklet *Subtabulation* in 1956-1958 (see section 3.3.1.1).

It is of interest to note that Babbage designed his 'difference engines' to use the summation process, but they would have suffered from the grave disadvantage that they could only add, and not subtract. The computers of the day would have had to calculate the differences of the original function by hand. This would have been a very tedious and error-prone task with the very long numbers that Babbage had in mind. It seems that he was not aware of the possibility of checking by differencing or of using bridging differences in subtabulation.

2.2.6.4 The basic punched-card machines

During the 1930s and 1940s the Office, which was then based in Greenwich or Bath, used the punched-card machines of other Admiralty establishments and other organisations. Such arrangements would have been quite impracticable at Herstmonceux and so the Office hired a basic set of Hollerith punched-card machines, which were installed early in 1951 in the hut on the west side of the South Courtyard of the Castle.

These machines used cards with 80 columns and 12 rows and the holes that represented the digits were rectangular. (The extra two rows could be used for 10 and 11 in commercial accounting or for control purposes, such as to indicate negative numbers.) The machines were hired from, and maintained by, the British Tabulating Machine Company (BTMC); they were compatible with the Hollerith machines made by IBM in the USA, which were used in the U.S. Naval Observatory. Machines that used cards with round holes were made at the ‘Acc. & Tab’ factory near to my home in Croydon; at the time I did not realize that the name was short for ‘accounting and tabulating’.

The basic machines were a sorter, reproducer, collator and tabulator. As their names imply the sorter was used to sort cards into the sequence of the numbers in selected columns, while the reproducer was used to reproduce the numbers from selected columns of one set of cards into chosen columns of another set of cards; a common use was to make a duplicate copy of a worn set of cards so as to reduce the risk of misfeeds that would disrupt the operations. The collator could be used to compare the numbers on the cards in the two feeds and to use the result to direct the cards into appropriate hoppers. The functions of the tabulator were similar to those of the National machine, but the numbers were read from cards and the results could be punched on cards and/or printed. The printer had 120 [or 132?] printwheels so that the numbers could be spaced out; it could be used to produce printer’s copy that required only a small amount of additional effort to prepare it for dispatch to the printer.

All the machines except the sorter were controlled by the wiring on a ‘plugboard’. Most holes on the board would correspond to the columns on the input and output cards so that, for example, the number punched in one column of the input card could be directed to any chosen column of the output card by linking them by a wire with plugs on each end. Other holes corresponded to the operations to be carried out. The planning of the sequences of operations and the design of the wiring was a skilled task in which Carter and Harding, in particular, were experts. The task of making up a board from a wiring diagram took care and time, and so some boards were kept permanently wired for the standard jobs in frequent use. A loose wire could completely invalidate a run and so the checking at the start of a new run was critically important.

The machines were normally operated by the Assistants in the Machine Section; Audrey Nevell and Audrey Crisford can be seen on the photographs that we have, but Flip Restorick was the most experienced operator at the time. The cards had to be handled carefully to reduce the risk of misfeeds or, worse still, card jams, which would damage the cards so severely that they would have to replaced by repunching by hand, with the consequent risk of mistakes. Any such new card had to checked independently by another operator.

The punched cards were stored in metal trays, which were themselves stored in special racks. Each tray would hold about two thousand cards. Accidents in which cards were dropped were very rare, and every effort was made to ensure that cards were not misplaced. If necessary, the sorter could normally be used to restore the sequence of any set of cards since, with very rare exceptions, every card had a job number and a serial number. The sorter could also be used to count a set of cards so that, for example, it could be verified that none were missing.

The cards were normally buff-coloured, but they were available with different coloured stripes along the top edge; some cards were of a different colour throughout, and some had a corner cut off. Most cards were printed in a standard way so the column and value of any hole could easily be identified. For some purposes the cards were specially printed to show, for example, the significance of numbers in particular groups of columns. These different devices helped to reduce the risk of mistakes and to draw attention to any mistakes that were made.

The bulk of the work carried out on the punched-card installation was for the publications of the Office, but some work was done for other departments of the RGO.

The machines required frequent maintenance by BTMC engineers and Arthur Burton, a jovial man who smoked a pipe and lived in Brighton, served the Office well for many years.

2.2.6.5 The IBM 602A calculating punch

As a result of Sadler's visit to the USNO in 1949, the basic punched-card machines, which were made in the UK by BTMC, were supplemented by a new machine that was made by IBM in the USA, but supplied to BTMC under a reciprocal marketing agreement. This electromechanical machine could multiply and divide, as well as add and subtract, and so it increased greatly the scope of the work that could be carried out on the machines.

According to Porter in a paper for the BAA "the speed with which the machine works is high because the most ingenious methods have been adopted for performing many mechanical functions simultaneously in one cycle". [JBAA 61(7),185-189, with 2 plates] He quoted the time for a calculation of the form $a + bc$ as 2½ seconds, even when b had only 4 digits. Today, this would be regarded as incredibly slow! The machine was also controlled by the wiring on a plugboard, which in this case had nearly 1500 sockets. Porter used the word 'programme' to describe the sequence of the instructions that were represented by the wiring, which could be extremely complex and very difficult to test.

The programmes became more and more sophisticated as experience was gained in the use of the machine. I believe that the 602A proved to be very reliable and it proved to be a major asset until it was replaced by an electronic computer after over 8 years in service.

2.2.6.6 The IBM card-controlled typewriter

Another new machine, an IBM card-controlled typewriter completely revolutionised the work of the Office. Again, Sadler had seen one in use at USNO and had obtained approval to add it to the original order for the punched-card installation. Unfortunately, delivery was delayed because of a break between BTMC and IBM and did not take place until March 1953.

The typewriter was used to produce copy for the publications that was of such a high quality that it could be used directly in the production of photolithographic printing plate. This obviated the need for the printer to set up each page in loose type and for the detailed proofreading that was needed to eliminate the mistakes made by the printer before the final plate was produced. It did not, however, completely eliminate proofreading since it was still necessary to check that no mistakes had been made in the computation of the numbers or in the handling of the cards before or during the printing run. We also found that it was necessary to verify that the printer had not introduced any mistakes during his attempts to improve the quality of the printing by, for example, touching up a figure that appeared to be broken.

The typewriter could not produce the printed headings of various sizes for the pages and columns, nor could it print some of the special symbols, such as those for the phase of the Moon, that were required. Further, most of the pages for the regular publications used rules to separate the columns of figures and the different parts of the page, but it was found that the eye was very sensitive to the very small misalignments that were made if the typewriter was used to print these rules from short segments. The fixed headings and rules were therefore printed on large sheets of high-quality paper on which the numbers were printed by the typewriter. A special procedure had to be devised so that the operator could verify that the paper had been correctly loaded into the typewriter — otherwise the numbers would not be centrally placed within the rules throughout the page.

The special symbols, footnotes and other items that were not printed from the cards were then stuck on to make the final, complete page of copy. The extra pieces were stuck on using a special glue known as ‘Cow Gum’. This had the advantage over ordinary glues that any excess could be rubbed off once it had dried without leaving any mark on the paper; in fact, the operators found that an eraser could itself be built up from dried Cow Gum. The Cow Gum came in large tins and when the tins were open a vapour with a characteristic smell was given off. Several years later I used some of this Cow Gum myself and found that it made me dizzy unless I made sure that the room was well ventilated by an open window. I do not know if any of the Assistants suffered in the same way, and I wonder whether its use would now contravene the Health and Safety regulations.

The need for pre-printed forms meant that it was uneconomic to use the typewriter unless the publication contained a large number of pages of the same design. I believe that its first use was for the *Apparent Places of Fundamental Stars* and then for the daily pages of the *Abridged Nautical Almanac*. It was never used for the *Nautical Almanac and Astronomical Ephemeris* since most of the tabulations were of 8 pages or less. The pages were reduced in size by about 70 per cent before they were printed; this tended to make the final printing appear to be of higher quality than the originals.

Sadler states that the card-controlled typewriter was very unreliable, but I suspect that most of the staff of the Office greatly welcomed the reduction in the amount of proofreading that had to be done as the figures were printed correctly. The Office proofread these and other such pages (such as those for the *Air Almanac*, which were typed at USNO) by ‘eye’, with a combination of mental differencing and comparison with copy. On the other hand, at the USNO punch-operators were employed to punch all the data on the proofs and then these new cards were compared with those that had been used to prepare the copy. We were never convinced that this was the best method to use.

2.2.6.7 Thoughts of an electronic computer

When I was a postgraduate student at Imperial College, I attended lectures by K D Tocher and C Michelson on programming for an automatic electromechanical computer, ICCE (Imperial College Computing Engine), that they were building, using relays rather than electronic valves. [RGO 16, box 14, packet 1, supplement to NAO file 13P] My supervisor, Professor A T Price, had intended that I would use it for my research, but it soon became clear that it would not be finished in time and so I used desk calculating machines instead. In fact, the machine was never finished. Unfortunately, I later scrapped my lecture notes about this computer.

It seemed clear, however, that the Office ought to be looking ahead to the time when electronic computers would be available for use for the computations for the almanacs and especially for the computation of orbits by numerical integration. Accordingly, I spent a week in Cambridge in September 1954 attending a course on programming the EDSAC, which had been developed in the Mathematical Laboratory of the University. This used five-hole telex paper-tape for input and output. The programming system made much use of subroutines (I believe for the first time) and the course certainly influenced my approach later to programming for other computers.

I have a copy of the book (1951) that was issued for the course, but not of my notes. I am amazed that the word subroutine does not appear to be used in the book on programming for the IBM 650 that I used when I was seconded to USNO in 1957 to learn more about the programming and operation of electronic computers. (See section 3.3.1.2)

2.2.7 Other aspects of the work of the Office

2.2.7.1 Calendarial information

The Office was generally regarded as the UK authority for matters relating to the calendar and it used to issue a sheet giving the dates of the religious festivals, public holidays, eclipses and phases of the Moon for the use of diary and calendar publishers. It also distributed sheets giving the times of sunrise and sunset for London and other principal cities and it provided the Automobile Association and other organisations with lighting-up times for various places. This work was regarded as a public service and no charges were made. An article on the work was published in a Trade Union journal in an issue with Angela James on the cover. The Office also dealt with requests for such data for legal purposes, especially lighting-up times for road vehicles.

2.2.7.2 International Astronomical Union

The International Astronomical Union (IAU) played an important role in the work of the NAO as it provided the principal forum for discussions about cooperation in the production of astronomical almanacs and related activities. There were similar Unions for other areas of science and all were represented on the International Council of Scientific Unions. The IAU differed from the other Unions in that individual astronomers were admitted to membership and had voting rights during the plenary meetings at the triennial General Assemblies. In the other unions the voting was by the representatives of the National Committees of the countries that were affiliated to the Union. The IAU had about 30 Commissions for particular aspects of astronomy and membership of them was according to the interests of the individual astronomers.

Shortly after I joined the Office, Sadler asked me if I would like to attend the next General Assembly of the International Astronomical Union, which was to be held in Rome in the following year (1952). I would not be sent on duty, but he thought that I would get a young astronomer's grant towards the travel costs from the IAU. At the time I did not realize how important the IAU was to the work of the Office, nor how much my own career would be later affected by participation in its activities. Moreover, I was trying to save in readiness for my marriage and was concerned that the costs of staying in Rome would be high. I therefore declined the chance; I realize now that Sadler would have been disappointed at this decision. Patrick Wayman, who joined the RGO about one month after me, did accept the offer; when he returned he told me that he had lived very cheaply in a student hostel. Twenty-seven years later he became the General Secretary of the IAU.

Sadler became President of IAU Commission 4 on Ephemerides at the Rome assembly and he served for 6 years, so that he was responsible for organising the meetings of the Commission in 1955 and 1958, as well as other appropriate activities between meetings. (The title 'president' is a direct transcription from French; the word 'chairman' would really be more appropriate in English.) Some years later, the IAU decided that commission presidents should normally serve for only three years, presumably so that more persons would have the honour of the title. Unfortunately, some of the persons chosen did not have the ability, or the inclination, or the facilities to carry out the job effectively. On the other hand, a president with good ideas would develop them during the 3 years prior to the meeting at which he was chairman, would get them adopted by the commission, and might then find that the next chairman failed to carry them through.

At that time the meetings of Commission 4 were dominated by the affairs of the principal national ephemeris offices as it was necessary to get agreement on the basis of the ephemerides and on the sharing of the work between the offices. Sadler certainly made good use of his 6 years of office as many important decisions were taken during that time to follow up the proposals put forward by Sadler and Clemence at the 1952 Assembly. These proposals concerned both the basis of the ephemerides and the arrangements for the preparation and publication of the almanacs. The implementation of these changes will be discussed in some detail in later sections.

The principal changes in the ephemerides followed, firstly, from the recognition that the rate of rotation of the Earth is not constant (see section 2.2.7.3) and, secondly, from the availability in the USA of electronic computers that could calculate the orbits of the Moon and planets directly by numerical integration.

The changes in the arrangements for preparation and publication of the ephemerides followed mainly from the agreements between Sadler and Clemence with regard to the unification of the almanacs of the UK and USA. In addition, there was a steadily increasing use of English as the common language for astronomy, and this made separate national almanacs less necessary. (See section 3.3.1.1)

I did attend the next General Assembly, which was held in Dublin from 29 August to 5 September 1955. This was shorter than the usual 10 days from Tuesday to Thursday, but it was followed by a visit to Northern Ireland on 6-7 September. We stayed overnight in Belfast, and we also had a visit to the Armagh Observatory.

There were formal plenary sessions on the first and last days and commission meetings etc. on the intermediate days. I had no duties to perform and so, in addition to attending the meetings of direct concern to the work of the Office, I was able to attend meetings of more general interest. I recall that Gerard Kuiper was the dominant figure in Commission 16 on the Planets. This was the meeting at which Ambartsumian put forward ideas about high-energy processes in some galaxies — these seemed very far-fetched to me at the time.

In addition there were special events — some scientific and some social. On the Sunday most of the delegates went by special trains to Killarney or Connemara — I chose the former. My main recollection of the trip is that Donald Menzel and Fred Whipple were in the party, and that the former played his guitar on the train on the way back; but it is all very hazy!

2.2.7.3 Ephemeris time

One topic that that was to be of major interest to me during most of my career was the introduction and definition of what was at first called *Ephemeris Time* (ET). In the 1940s it had become clear that the *Universal Time* (UT), which was the basis of GMT for civil use and astronavigation, was no longer appropriate for use for most scientific and technical applications. (See also sections 2.3.5 and 2.6.1) UT used the mean solar day as its unit and this had been shown to vary as the rate of rotation of the Earth is not constant. Long-term changes were shown by studies of the motions of the Moon and planets, while short-term changes were shown by the quartz-crystal clocks that had superseded pendulum clocks. The clocks provided a continuous timescale that was regulated by the observations of the transits of stars over the meridian.

At an astronomical conference in 1950 it was agreed that a new timescale, to be known as ephemeris time and to be based on the revolution of the Earth around the Sun, should be introduced. Dr G M Clemence, the Director of the Nautical Almanac Office in the US Naval Observatory, was a prime mover in the proposal of the resolution that was to be considered at the IAU General Assembly in 1952. He and Professor Samuel Herrick from the University of California, visited our NAO on his way to the Assembly and I was invited to sit in on a discussion between them and Mr. Sadler. (Dr Porter and Miss McBain were probably also present.) I have a recollection that I asked why it was not possible to wait until atomic time (AT) would become available (as I had heard that atomic clocks were close to completion). The reply was, if my memory is correct, a dogmatic statement that time should continue to be defined by an astronomical phenomenon that would be permanent and not subject to changes in technology. Unfortunately, the definition of ET that was adopted in 1952 soon proved to be inadequate and ET was eventually superseded by AT for general use and by other timescales for the most precise astronomical applications.

2.2.7.4 Interpolation and Allied Tables

My first major job that involved interactions with persons in other organisations was to act as editor for a completely revised edition of *Interpolation and Allied Tables* (IAT). This had first been published in 1936 by reprinting pages from the Explanation to the *Nautical Almanac for 1937*. Comrie had previously published similar extracts from the NA under the title *Interpolation Tables*, but he included additional material, such as formulae for computing derivatives from differences, in the 1936 booklet. Its price was low, it sold well and it was reprinted several times, but after 15 years its notation was obsolete and new techniques were in use.

Sadler realized that the scope of the work of the Office was rather limited and so he sought the assistance of Dr E T Goodwin, who had worked under Sadler in the Admiralty Computing Service (ACS) and who was the Superintendent of the Mathematics Division of the National Physical Laboratory (NPL) at Teddington in Middlesex. Other former members of the NAO/ACS, including Dr. Leslie Fox and Fred. W J Olver, also worked in the Mathematics Division.

I do not recall now what progress had been made when in 1953 Goodwin suggested that the IAT could be incorporated into the introductory volume of a proposed new series of NPL Mathematical Tables. Sadler agreed to this, but we eventually realized that NPL staff were intending to produce a volume that was in the style of a textbook and that they wished to include many lengthy, general formulae of high precision. On the other hand, Sadler was looking for another small, cheap booklet that would contain collections of formulae and tables that could be used directly by the computer (then still considered to be a person). We came to an amicable agreement to produce separate publications that would be complementary. They would use the same notation, but our booklet would contain, for example, special cases of the general formulae given in the NPL volume.

Our booklet was published in 1956 for a price of “five shillings net”; it was reprinted with amendments in 1961 and several times later. The NPL volume was published in 1956, with the title *The use and construction of mathematical tables*.

Although I had taken a course in numerical analysis at Imperial College, I learnt a lot more while I was preparing IAT. It consisted of three parts: an introductory text with numerical examples; a set of interpolation tables covering a wide variety of situations; and a final part that was a mixture of formulae, short tables and text for various aspects of numerical analysis. The first two parts were fairly straightforward, although the proposals and drafts were modified considerably before they were approved. The third part was ‘hard work’, as the material had to fit within each page, being neither too long nor too short.

Sadler, like Comrie before him, was extremely ‘fussy’ about the typographical appearance of the text and tables so that there would be the minimum risk of error by the user. I even visited the printer, John Wright and Sons Ltd in Bristol, so that I could better appreciate the problems of the printer in setting up complex mathematical material. We designed the tables so that vertical and horizontal rules were not required to separate the columns and rows — we relied on the use of spacing and type style.

The preparation of the Companion Booklet on *Subtabulation* is described in section 3.3.1.1.

2.2.7.5 Visits by H.M.S. Dryad

The RGO, and hence the NAO, reported to the Admiralty through the Hydrographer of the Navy, but there was no direct link with the Director for Navigation. I do not recall seeing any correspondence with him about the changes in the ANA, for example, although I assume that the Hydrographer would have consulted him. Our only other contact with the Royal Navy was through the visits to the RGO by the officers attending the courses on navigation at H.M.S. Dryad, which was a shore establishment near Portsmouth.

These visits came towards the end of the initial land-based part of each course, about every six months from late 1953, and were arranged by the NAO. There were about ten officers in each course, and several of them were usually from other navies. At the RGO, they visited the NAO and the Chronometer Department, had lunch in the canteen, and spent the afternoon, until it was time for tea, visiting the other departments of the Observatory.

2.2.7.6 The NAO Library

As it had been separate from the RGO until 1949, the NAO had built up its own library, which was moved to occupy one room in the hut where we worked. It was mainly a specialist collection of textbooks, astronomical and navigational almanacs, star catalogues and mathematical tables that were related directly to the work of the Office. The 'standard' complete set of the *Nautical Almanac* from 1767 was kept in Sadler's office. We had a second copy of the Almanac for 1768 that was, surprisingly, freely available; I used to take it to lectures with examples of our current publications. In addition, there were runs of several major serials, such as the *Monthly Notices of the Royal Astronomical Society*, and many individual unbound reports and minor serials, which were stored in pigeon-holes in alphabetical order of the country of origin. The latter items were mainly sent to the NAO in exchange for our almanacs, which were distributed quite freely to many observatories and institutions around the world.

At first my main interest was in the textbooks since I had to make up for my lack of a formal education in astronomy. I was dismayed to find that the books were arranged in alphabetical order of the names of the authors within very broad classes, such as astronomy and mathematics. This meant that books on specialised topics could be scattered within a whole bay of books, and were not grouped together as I would have expected. The arrangement of the library was fine if you knew which book or paper you wanted, but it was poor if you were looking for information on a particular topic.

I had not been in the Office very long before I suggested that the books should be classified more finely so that the books on a particular topic would be together. The library was looked after by Miss Joan Perry, who was the secretary of the Office. I think that she was pleased to have someone to take an interest in the library and I persuaded her that we should classify the books according to the Universal Decimal Classification system (UDC). I had become familiar with UDC while I was a postgraduate at Imperial College, where I used the Science Museum Library (as IC did not have a major library of its own). Moreover, UDC was to be used in the RGO library, which was to be moved from Greenwich into the Great Hall of the Castle (see section 2.6.5). I assume that we obtained Sadler's approval before proceeding; I believe that I did most of the rearranging in the evenings as I was then living in the hostel. I soon found that the printed classification was not adequate for such a specialist collection and so I introduced new classes as seemed appropriate.

The Office received quite a large number of journals and other serial publications. Before being put in the library, each item was circulated to those persons who had expressed an interest in the series concerned. One person was designated as the reviewer and was expected to look for papers or other items of direct relevance to the work of the Office so that those concerned would not miss them. Details of these items were entered on index cards by Miss Perry and were then filed, again in very broad classes in a special scheme.

Again I considered that UDC should be used for classifying such papers so that it would be easier to find the cards for the references on a given subject. I therefore started my own subject catalogue on index cards. I soon found that I had to introduce even more new subjects into the classification scheme, which soon began to lose its ‘universal’ character in the classes of particular interest to the Office. I also soon began to realize that many papers deal with more than one topic, and so two or more cards may be required for one paper. Moreover, most topics may be looked at from different points of view and it is often very difficult to decide how best to represent this in the classification scheme. (As I was to discover later, UDC has many different ways of dealing with such situations, and so the code that represents the classification of a paper or book may be very complicated.) My index gradually expanded as time went on, and I eventually made it available in the Library, but no one else seemed to be interested in using it.

I suppose that I would have to admit that the time I spent preparing the index was greater than the time I saved in finding references, but I always felt that the effort of classifying the content of a paper and of making the card helped to reinforce my understanding and memory of the paper. (In later years I became involved officially in the revision of the UDC class for astronomy: c.1974, 1988-9, 1993-98.)

The Office used to send copies of its publications to a large number of institutions on the understanding that they would send us copies of their publications. This was common practice in astronomy (and allied sciences) and it provided a way by which the stronger institutions could help the astronomers who were working in institutions that would not have been able to afford to buy even the basic astronomical publications. Formally, the material received was supposed to be of equivalent value, but this was interpreted as applying to the totality of the exchange, not to the exchange with each institution. There was much that was irrelevant amongst the material that was received, but occasionally there were unexpected items that proved to be of great value, either at the time or later when a new task was started. Some of the irrelevant items were of great personal interest and could be borrowed for reading at home.

2.2.7.7 ‘Copies’

The Office had a system for the circulation of ‘Copies’, which was a very effective way of keeping the more senior members informed about many different aspects of the work. Each day Miss Perry would circulate a folder containing carbon copies of outgoing letters, together with the incoming letters to which they were replies. Each person on the circulation list was expected to glance through the file and to read carefully items of direct relevance to their work and to take appropriate action. We were expected to initial each letter to show that we had read it; we were also expected to draw attention to any errors that we noticed. Many of the letters were of a routine character, but, for example, the exchanges between Sadler and Clemence about proposals for changes in the almanacs were of great interest.

2.2.8 Participation in external organisations

2.2.8.1 Royal Astronomical Society

Sadler attended every possible meeting of the Royal Astronomical Society; they were held on the second Friday of each month from October to May in the Society’s rooms in Burlington House, Piccadilly. He had been one of the Secretaries of the Society from 1939 to 1947 and had continued to organise meetings during World War 2, even though the Office had been evacuated to Bath. He later served as its President from 1967 to 1969. Miss McBain and Dr Alan Hunter, also from the RGO but based at Greenwich, were the two Secretaries when I first went to the RAS, firstly, as Sadler's guest and then as a Junior Member.

There was no official connection between the RGO and the RAS, but members of the staff were encouraged to join, to attend its meetings and to participate in other activities. Consequently, it seems appropriate to include here a general account of the character of its meetings and other activities.

The meetings, which lasted from 4 pm to 6 pm precisely, were preceded by tea in the Library. They began with formal business, which included the reading of the minutes of the last meeting, the "list of candidates for suspension", and the "list of presents received". It was some time before I realized that the first list referred to persons whose application forms for membership were to be suspended in the library. The presents were almost invariably books that had been given to the library. Finally, the President requested that "all those Fellows who have paid their admission fee and first contribution, but who have not yet been formally admitted, are invited to step forward and sign the book". Those who did were then addressed by the President, who said "Dr XYZ, in the name of the Royal Astronomical Society, I admit you a Fellow thereof" and then shook their hands, at which point everyone else clapped. Only then could the reading of the scientific papers begin.

These formalities were gradually reduced and eventually omitted from the 'ordinary meetings' of the Society. The Society also introduced separate specialist discussions for astronomy and geophysics that started in the morning and continued until mid-afternoon. These made it more worthwhile for members to travel to London from a distance and to attend the ordinary meetings that followed.

Usually there were four or five presentations by astronomers whose papers had been accepted for publication in the *Monthly Notices* of the Society. Each presentation was followed by an opportunity for questions, some of which revealed strong differences of opinion. These question and answer periods were often the most interesting parts of the meeting and so it was frustrating when the President announced promptly at 6 pm that "the meeting is now adjourned until 195x Month Day". The reason for the abrupt closure was that most of the senior Fellows were members of the RAS Club, which met nearby for dinner, preceded by drinks, at 7 pm.

Sir Harold Spencer Jones was the Treasurer of the Society from 1946 to 1952. The Presidents served for only two years. The President in 1951-1953 was Herbert Dingle, of Imperial College, who was then a small white-haired man. He gave a controversial presidential address "On science and modern cosmology" in 1953; he questioned the accepted view of the "Twin Paradox" that arises from the theory of relativity when one twin who goes on a journey into space and returns to Earth to find that his brother has aged at a faster rate. Dingle was associated with the Norman Lockyer Observatory (NLO) at Sidmouth and actually wrote the chapters of *The Life and Work of Sir Norman Lockyer* that are ascribed to Lady Lockyer and his daughter, Winifred Lockyer. I made much use of this biography when, after my retirement from the RGO, I moved to Sidmouth and wrote and lectured about Sir Norman.

Another period of great controversy was when Martin Ryle was trying to use the statistics of the variation in the numbers of radio sources with diminishing apparent intensity to question the Steady State Theory of the Universe, which had been put forward by Bondi, Gold, Hoyle and Lyttleton. The meeting room was particularly crowded on such occasions, and latecomers would have to stand in the side-aisles, or even behind the raised seats at the back of the room. Eventually, the room became too small, and so the Society’s meetings moved , firstly, to a room on the upper floor of the Geological Society’s rooms and later to the Scientific Societies Lecture Theatre in Fortress House in Savile Row, about a quarter of a mile away. The meeting room in Burlington House was converted to make a smaller Fellows Room and offices for the Executive Secretary and other administrative staff.

(See sections 5.5.8.8 and 6.3.4.5 for later developments, including the periods when I served on the Council of the Society.)

Membership of the RAS Club was by invitation only and the maximum number of members was fixed. (I use the past tense, but I believe that these rules still apply.) Members were expected to attend regularly, and I suspect that this explained why Sadler would attend RAS meetings when there was nothing on the programme that was relevant to the work of the Office. Members were allowed to take a guest, and each was expected to make a short speech after he was toasted. Sadler took me as his guest on a few occasions, and he also asked me if I would like to be nominated for membership, but I declined. I enjoyed the dinners that I attended, especially as some of the guests were good after-dinner speakers and had interesting stories to tell. I did not feel, however, that I could justify either the expense or the time that would have been taken by regular attendance. I also felt some resentment that such a restricted-membership club should, as I saw it, effectively dominate the policy of the Society.

At the time, only male Fellows could be members of the Club and I suspect that only male guests were allowed. (I believe that these rules have since been relaxed.) A few of the wives of members of the Club used to meet separately for dinner and, some years later, I joined them on one occasion for dinner at Brown’s Hotel. (I forget the circumstances for this.) The men’s Club used to meet at the Athenaeum, but I recall that we had to go in by a side door. The Club would also meet when the Society held an out-of-town meeting and it appeared that the number of guests would usually be increased on such occasions. The Club also used to give members of the Council of the Society who were not members of the Club the opportunity to attend its dinners while they were in office, but I did not avail myself of this as far as I can recall.

I was a Junior Member of the Society for three years and then I was elected as a Fellow, and so entitled to write F.R.A.S. after my name. This acronym does not, however, imply that the person concerned has made a significant contribution to the advancement of astronomical knowledge. It does not even imply a professional role in astronomy. In fact Bye-Law 29 merely required that “a candidate for Fellowship must be proposed and recommended by at least three Fellows or Associates, one of whom must certify personal knowledge of the candidate’s suitability”. A person who supports astronomy financially may be deemed suitable; it almost appears that only astrologers are not welcome.

Many of the professional Fellows of the Society are not astronomers, but are geophysicists, whose work is more allied to astronomy than to classical geology. The RAS first produced a *Geophysical Supplement to the Monthly Notices ...* in 1922; this gradually expanded until it became a major source of income for the Society. It was renamed the *Geophysical Journal* in 1958, and later the *Geophysical Journal*

International. My personal interests tended towards geophysics, partly because of my earlier work on geomagnetism, but also because the variations in the rotation of the Earth, which were measured by astronomical techniques, had geophysical causes and consequences. (See especially section 6.3.4.4.)

2.2.8.2 Institute of Navigation

Sadler was also an enthusiastic member of the Institute of Navigation, of which he had been one of the leading founder members. At first he did a lot of the duties of an honorary secretary, but without the title. He was elected President in 1953 for a two-year term. In the same year he became chairman of a working party of the Institute on the "Accuracy of astronomical observations at sea". Mr Scott was also a member of the WP and did a large part of the basic work. (I wonder if George Harding took part in any way, as he had been to sea to gain experience in astronavigation.) The report of the working party was published in 1957.

I did not have much involvement in the work of the Navigation Section of the Office, although I did my share of the proofreading of the nautical and air almanacs and of some of the special publications. Consequently, I did not go to the meetings of the Institute regularly, . In fact, only a small fraction of the meetings and papers was related to astronavigation.

Bill Nicholson, who joined the NAO in 1954 after serving as a navigator in the RAF, naturally took a greater interest in the Institute and Sadler gave him, rather than me, the occasional special job that was related to navigation. Mr Scott, who was the Head of the Navigation Section, and who contributed to astronavigation in many different ways (including writing several papers that were published in the Journal of the Institute), was elected to the Fellowship in 1957. I became a member of the Institute in 1961 and was elected to the Fellowship in 1979.

2.3 The Solar and M&M Departments: solar/terrestrial relations

2.3.1 The building of the Solar Dome

The Solar Building, which was usually referred as the Solar Dome, was on the hill to the south-west of the Castle and was the first permanent building to be built for the RGO at Herstmonceux. Superficially, it consists of a small single-storey brick building, with a rotatable dome (made by Cooke) about 22 feet in diameter on it; access to the dome is by an external staircase. Much of the construction was actually under the ground as there was also a large cellar, accessible by a staircase from the room below the telescope, where spectrographic equipment could be used under constant temperature conditions. The massive concrete pier on which the telescope was placed extended down to bedrock.. The painted dome was made of wood and had an outer covering of zinc.

Construction at Herstmonceux was started in 1947/48; the Dome (and the Solar Department offices in the Castle) were completed in April 1949, by which time work on the cellar had been started. For reasons, which are now hard to understand, the Dome caused a furore in the House of Commons as it was claimed that it was an eyesore that was out of character with the Castle. Perhaps it was judged when it was still surrounded