THE ROYAL GREENWICH OBSERVATORY TO 1990

ABBREVIATIONS

AAT – Anglo-Australian Telescope
ASR – Astronomy Space & Radio
CATC – Carlsberg Automatic Transit Circle
CCD – Charge Coupled Device
CUO – Copenhagen University Observatory
DIAS – Dublin Institute for Advanced Studies
ESA – European Space Agency
IAC – Instituto de Astrofisica de Canarias
INT – Isaac Newton Telescope
IPCS – Image Photon Counting System
IRAS – Infra Red Astronomical Satellite
NBST – National Board of Science and Technology (of Ireland)
NERC – Natural Environment Research Council
PDS – Photometric Data System (Perkin-Elmer)
RAL – Rutherford Appleton Laboratory
RAS – Royal Academy of Sciences (of Sweden)
RGO – Royal Greenwich Observatory
ROE – Royal Observatory Edinburgh
SAAO – South African Astronomical Observatory
SERC – Science & Engineering Research Council
SLR – Satellite Laser Ranging
UKIRT – United Kingdom Infra Red Telescope
UKOT – United Kingdom Optical Telescopes
VLBI – Very Long Baseline Interferometry
WHT – William Herschel Telescope
ZWO – Zuiver Wetenschappelijk Onderzock

ROYAL GREENWICH OBSERVATORY
SCIENCE & ENGINEERING RESEARCH COUNCIL
HERSTMONCEUX CASTLE
HAILSHAM
EAST SUSSEX BN27 1RP

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COVER PICTURE *The 2.5m Isaac Newton Telescope dome and building at the Roque de los Muchachos Observatory on the island of La Palma in the Canaries.*

THE RGO TO 1990

In the Spring of 1984 astronomers from universities and polytechnics will begin scheduled observing at the new Observatory on La Palma using the fully re-commissioned 2.5 metre telescope and the new 1.0 metre telescope with their first suite of instruments in place. The construction of the 4.2 metre telescope is well underway and it will be brought into operation alongside the others by mid-1987. Work on its instrumentation has already begun, mostly in close partnerships between RGO and university groups, as with the other two telescopes.

The prospective user community consists of over 300 research workers in the UK, the Netherlands, the Republic of Ireland, and Spain and is likely to increase substantially in the future. All the telescopes are being equipped to allow full remote operation from the UK which will greatly increase the efficiency of observing.

Just as the provision of the present telescope facilities required much planning and design work in the past, we have now to plan for the UK's future in ground-based astronomy. The UK is at the forefront of research in astronomy; coupled with the facts that ground-based observing is not very expensive per astronomer, and that astronomy enjoys a much wider public interest than most other subjects, it is inconceivable that the UK will opt out of the next generation of telescopes. In collaboration with universities and polytechnics, and with overseas partners, the RGO is ready to play its part.

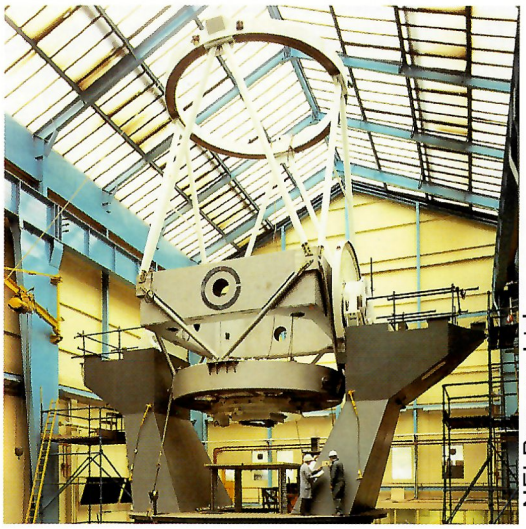
The astronomy community is generally familiar with progress on the procurement of the individual telescopes, but there is no wide understanding of RGO's role once the operational phase is fully established. Similarly, within SERC the Forward Look discussions normally concentrate on the near years and, as a result, there is insufficient discussion of the RGO's role in the medium-term. This document attempts to improve the situation by providing a panoramic view of the main activities of the RGO, looking ahead to 1990. I welcome comments and suggestions on the programme illustrated here, particularly from prospective users of the La Palma telescopes.

Alec Boksenberg

A. BOKSENBERG FRS
DIRECTOR

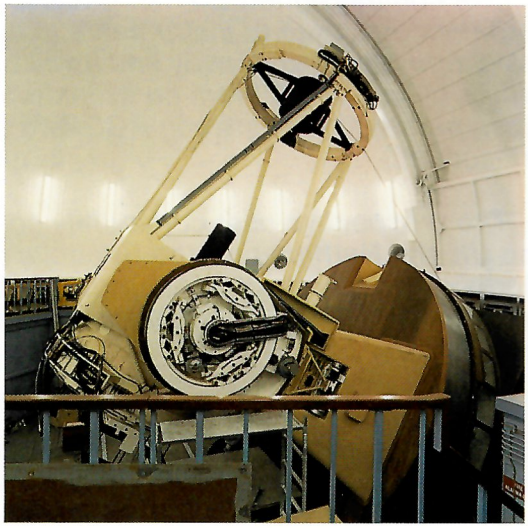
THE RGO

The RGO is a broadly-based national observatory with responsibilities in the areas of astronomy, geodesy and navigation. In astronomy, its prime task is the procurement and operation of four telescopes in a new large astronomical observatory on the island of La Palma in the Canaries; one of the world's very best sites. The major facility will be the 4.2 metre aperture William Herschel Telescope with a wide range of sophisticated common-user instruments and detectors at its four focal stations. The observing time on the three larger telescopes will be allocated, on the basis of scientific merit, to astronomers who will come generally from universities and institutes in the United Kingdom, the Netherlands, the Republic of Ireland, and Spain.

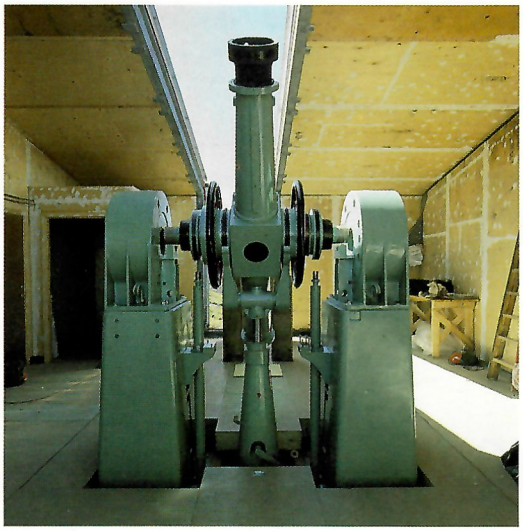


NEI Parsons Ltd

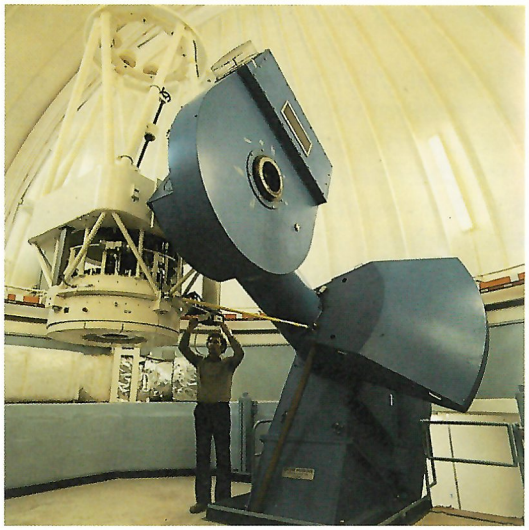
The 4.2m William Herschel Telescope. At f/2.5 with an altazimuth mounting, this is a compact, very high precision optical telescope with prime, Cassegrain and two Nasmyth foci.



The 2.5m Isaac Newton Telescope in a building which is the scientific centre for the UK telescopes on the mountain Observatory. It has prime, Cassegrain and coudé foci.



The 1.0m telescope is specially designed for high precision astrometry though it has a second Cassegrain focus instrumented for spectroscopy, photometry and other applications.



The Anglo-Danish Carlsberg Automatic Transit Circle. This instrument, together with the 1.0m telescope and ESA Hipparcos satellite, will provide fundamental positional data which will underpin the space and ground-based astronomy of the next decades.

La Palma

The Roque de los Muchachos Observatory, at an altitude of 2,369 metres, will be provided with roads, site services and hostel accommodation by the Spanish Government as part of an international agreement between the UK, Spain, Denmark and Sweden. The UK will provide three major optical telescopes, having a total of nine fully-instrumented focal stations, with the Netherlands and the Republic of Ireland as scientific partners. The fourth telescope, an automatic transit circle, will be operated through an agreement between the UK, Denmark and Spain. In addition to the telescopes, there will be computers for on-line data analysis, electronic and mechanical engineering workshops for the maintenance of the telescopes and instrumentation, and a library. A sea-level office will provide administrative support for the resident staff, visiting astronomers and the shipment of equipment.

HERSTMONCEUX

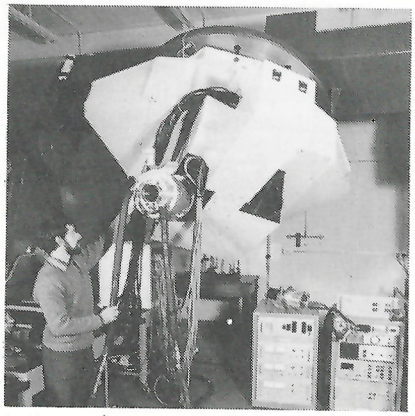
Herstmonceux Castle

The Herstmonceux home of the RGO has comprehensive engineering and electronic workshops which, in collaboration with universities, are responsible for developing and constructing most of the common-user instruments for the Observatory. They are housed in a complex of modern buildings on the western side of the site, together with computing facilities including the RGO STARLINK node, administration and stores. There is also accommodation here for a large data-bank project to provide for the storage and retrieval of all the data, both digital and analogue, from the telescopes on La Palma as well as other observatories in which the UK is involved. Associated with this are the measuring machines which are needed to exploit the photographic plate material.

Before the end of this decade, a large fraction of the observations from La Palma and the AAT will be performed remotely, without the astronomer having to make frequent overseas journeys. The Astronomy Centre in the Castle will house the remote observing centre itself together with adequate computing facilities for on-line data analysis, and quiet day and night accommodation for the high throughput of visiting observers. The scientific excitement generated by access to world-class telescopes, together with conferences and workshops taking place in an attractive environment, will combine to make this a unique scientific centre which is available to the whole of the SERC.

In addition to its astronomy activities centred around the observatory on La Palma, the RGO contributes to the sciences of geodesy, geophysics and navigation. This includes satellite tracking, with the Hewitt camera operated by the University of Aston, satellite laser ranging in collaboration with the University of Hull, the Nautical Almanac Office and the Greenwich Time Service. These functions are partially or wholly funded by agencies other than SERC.

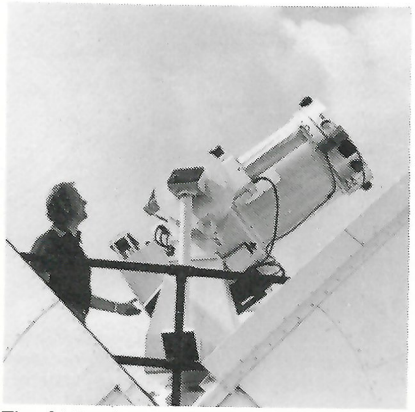
The West Building



Instrumentation for the 2.5m telescope

PDS Microddensitometer

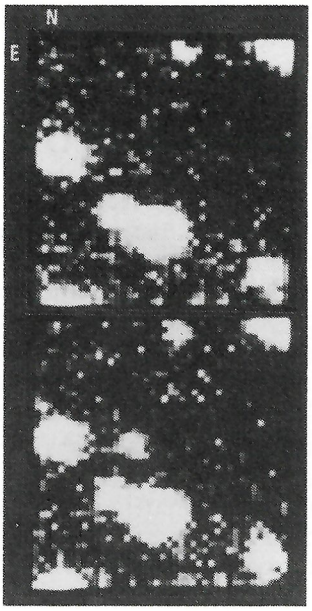
The Conference room



The SLR telescope

Public exhibition

THE CONTEXT

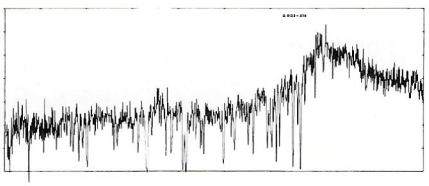


Two optical images of the field of the Vela pulsar obtained with the IPCS on the AAT at different phases in its 89 ms period. The pulsar (just to the left of centre) is 'off' in the top picture and 'on' in the bottom.

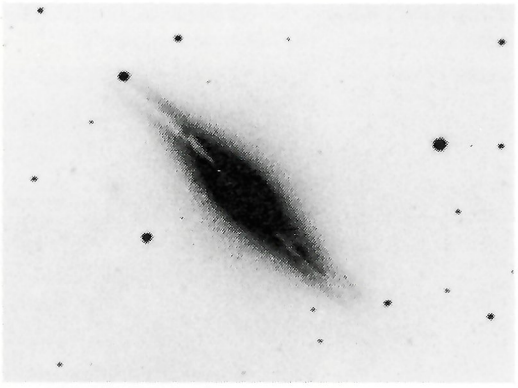
The UK is actively involved in a very wide range of scientific research but in astronomy, both theoretical and observational, it has the status of a world leader. Major advances in recent years have come from British astronomers, including the optical identification of the Vela pulsar, the recognition of the Seyfert galaxies as a new class of X-ray sources, the identification of the origin of the absorption lines in quasar spectra, and the measurement of the mass of the black-hole in the nucleus of NGC 4151, as well as the new developments in instrumentation which have made such discoveries possible.

The next ten years will see a major surge in the demand for time on ground-based telescopes. There will be two stimuli in addition to the development of current mainstream programmes and new instruments. Firstly, there is a growing recognition that significant advances in observational cosmology are going to require large scale observing programmes to build up sufficient statistics to answer questions such as the nature of the formation and evolution of the galaxies. Secondly, Space Telescope, IRAS and the new X-ray satellites will continue to identify new classes of object which will then have to be examined in the widest possible range of wavelengths, with the optical band being of the most fundamental importance (eg. for the measurement of position, redshift, abundances and dynamical state). In addition, the new space experiments, which carry much higher precision instruments than the early survey devices, will demand a level of fundamental support from traditional astronomical disciplines such as astrometry, that is only just being appreciated.

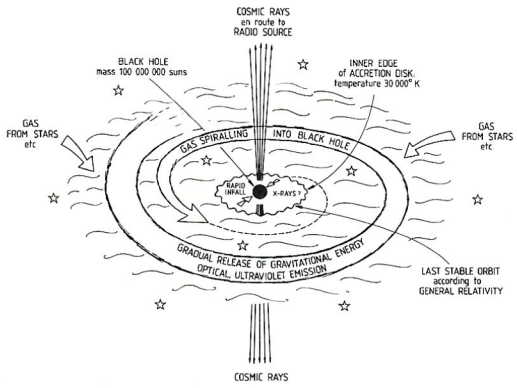
By 1987, UK astronomers will be well placed with a significant proportion of the observing time on the AAT (3.9m), at the SAAO (1.9m and 1.0m telescopes) and the UK Schmidt Telescope in the Southern Hemisphere, and in the Northern Hemisphere with the La Palma telescopes (4.2m, 2.5m, 1.0m), UKIRT (3.8m), the Millimetre Telescope, the radio telescopes at Cambridge and the MERLIN radio interferometer with its connections to the European VLBI network. All these facilities will be complemented by the image and data processing network, STARLINK, and the photographic plate measuring machines.



Observations of absorption lines in the optical spectra of high redshift quasars have made possible the study of the evolution of the gaseous medium in and between the galaxies over the major part of the age of the Universe.



The Seyfert galaxy IC 4329A.
Work in Britain and Australia led to the identification of the Seyfert galaxies as a major new class of X-ray sources.

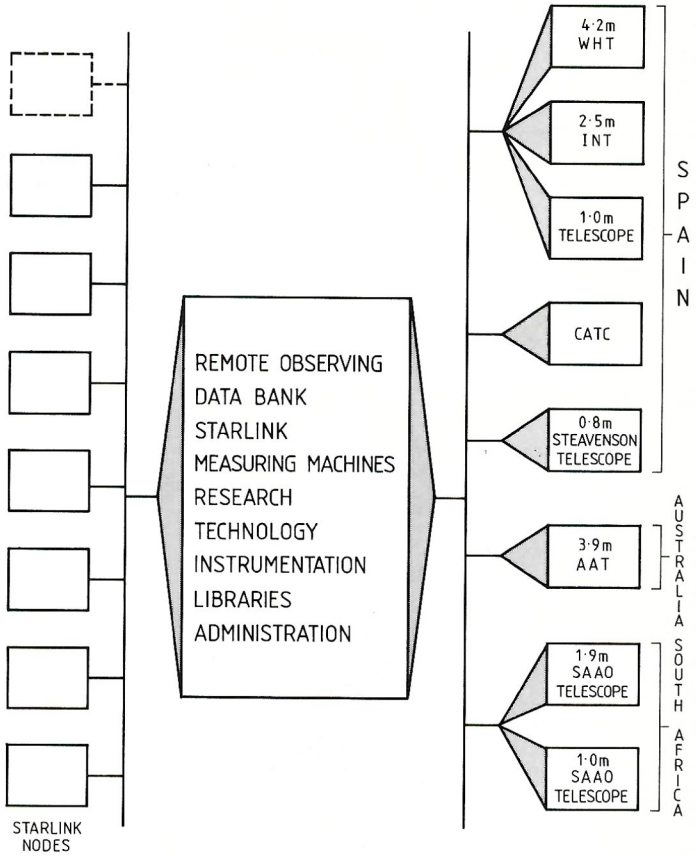


The Lynden-Bell model of a black hole in the nucleus of a galaxy. Observations of the variability with time of emission lines in the spectrum of NGC 4151 have given an estimate of a hundred million solar masses for the black hole in its nucleus.

RGO'S COMMON-USER SERVICE

Once the William Herschel Telescope is commissioned, the role of the RGO will be, in general terms, to provide a world class *common-user* service on those telescopes for which it is responsible. That is, a service equally accessible for the specialist on that particular telescope and instrument and for the astronomer perhaps more used to observation at different wavelengths or indeed new to observing. It will provide a comprehensive data-bank service with digital and analogue data from telescopes around the world and particularly from those on La Palma; with this will go computing facilities, measuring machines and libraries and the support necessary for observation preparation and data analysis. It will maintain and develop the La Palma telescopes and common-user instruments and also act as a coordinating focus for the provision of similar instruments for all telescopes to which UK astronomers have regular access. As an integral part of these activities, the RGO's staff will carry out scientific research with the dual purpose of ensuring the excellence of the service it provides and of carrying out those longer-term programmes which are vital for the scientific exploitation of the facilities but are less suitable for university-based astronomers to take on (eg. astrometry and large scale surveys). All this it will do using the minimum necessary resources but be ready to undertake whatever new programmes the ASR Board allocates.

The RGO is responsible for providing a common-user service at Herstmonceux and at the observatories on Spanish soil. In addition it provides common-user instruments to observatories in Australia and South Africa.

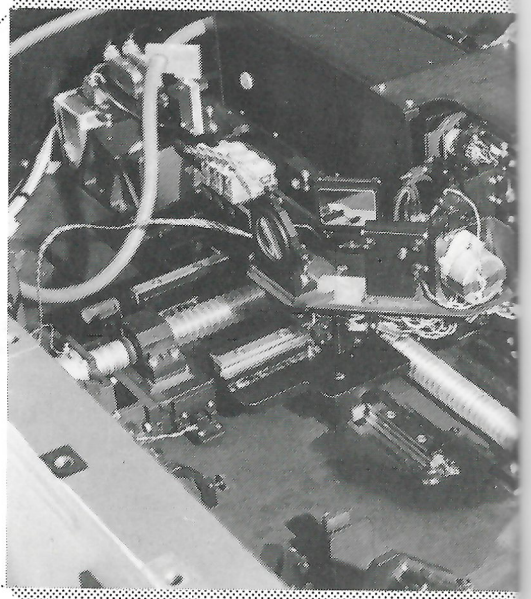


Gatwick airport, *one hour's drive from the RGO, is the origin of the largest number of low-cost charter flights to the Canary Islands. It is also now a major centre for world-wide travel.*

RGO

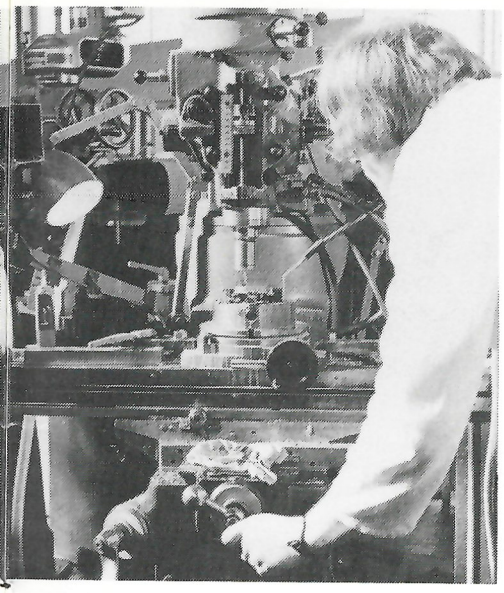
A reasonable measure of the scale of effort required to instrument and operate a telescope is the number of focal stations available to the observer. This is analogous to the number of beam lines or experiment stations on a particle accelerator. The three UK optical telescopes on La Palma have a total of nine focal stations each of which is instrumented sometimes, indeed, with a choice of alternative comon-user devices.

In addition to the La Palma telescopes, the RGO is responsible for operating the 0.8, Steavenson Telescope in the Sierra Nevada and has provided a major part of the suite of common-user instruments on the AAT and at the SAAO.



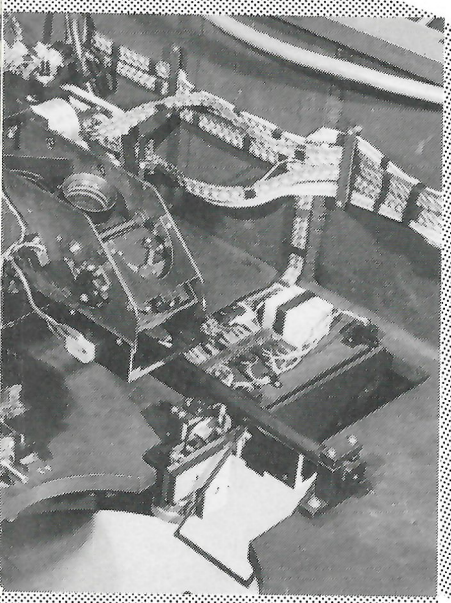
STEAVENSON TELESCOPE

UKOT LA PALMA

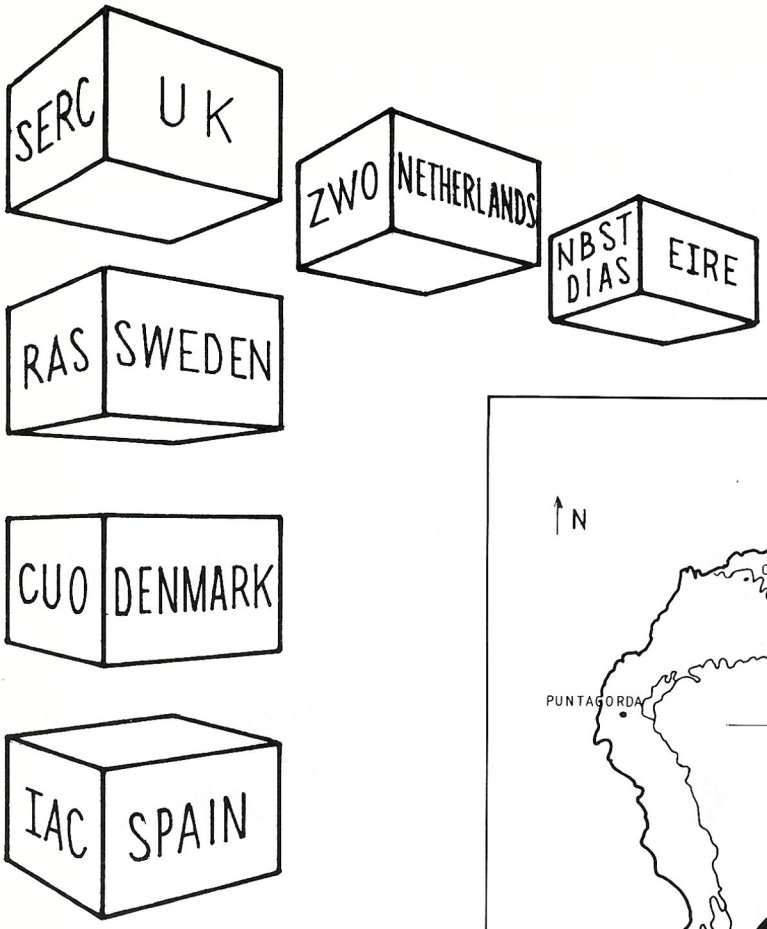


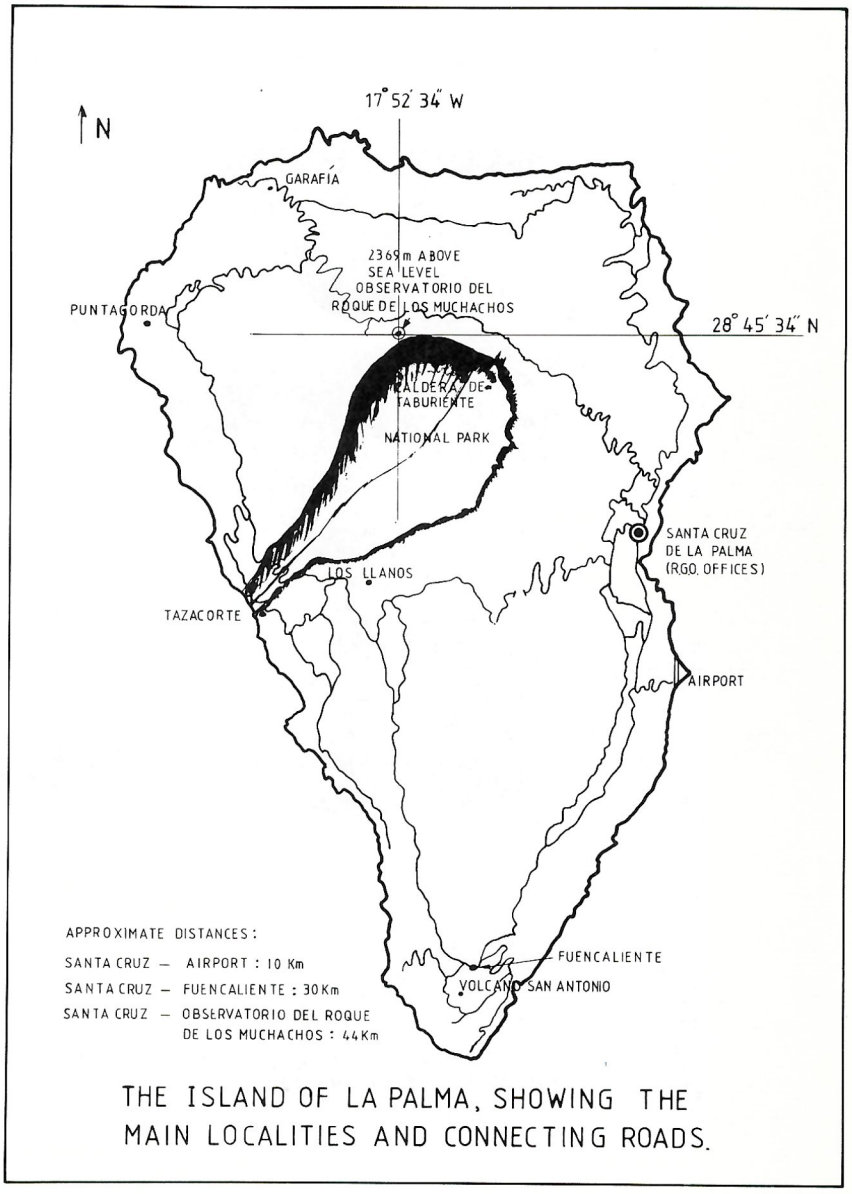
THE COMMON USER PROGRAMME

OTHER PROGRAMMES



ROQUE DE LOS MUCHACHOS OBSERVATORY





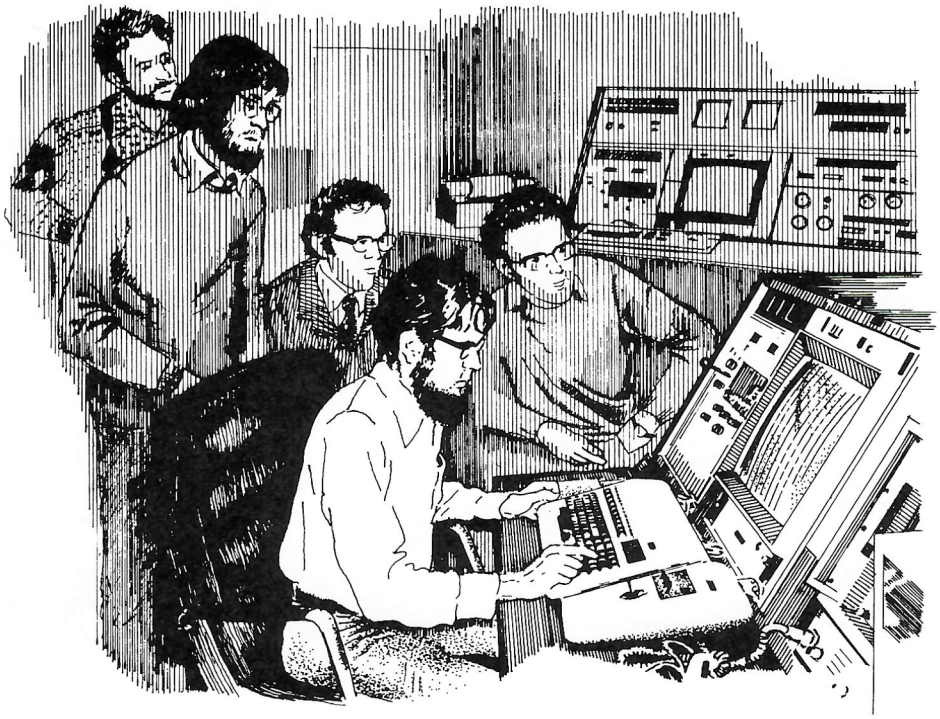
THE ISLAND OF LA PALMA, SHOWING THE MAIN LOCALITIES AND CONNECTING ROADS.

The RGO team on La Palma will have the responsibility for the security and maintenance of the telescopes and buildings and for rapid, first-aid, maintenance of the instruments, computers and telecommunications equipment. Any major repairs and modifications will need the facilities at Herstmonceux.

There will be support for those visiting astronomers whose requirements cannot be met remotely and for those collaborating in the international teams particularly with Spanish astronomers. There will be electronic and mechanical workshops, photographic facilities and darkrooms, astronomical catalogues and charts and a scientific and technical library. Most of this will be housed in the INT building. At sea-level there will be reception facilities and vehicles for visitors. Administrative staff will handle customs clearances, travel, freight shipping, etc. Many such staff will be local Spanish employees.

The Roque de los Muchachos Observatory is operated within the terms of an international agreement between Spain, the UK, Denmark and Sweden. This photograph, taken from the East, shows, from right to left, the 2.5m INT building, the 1.0m telescope and the two Swedish telescopes.

REMOTE OPERATION OF THE TELESCOPES

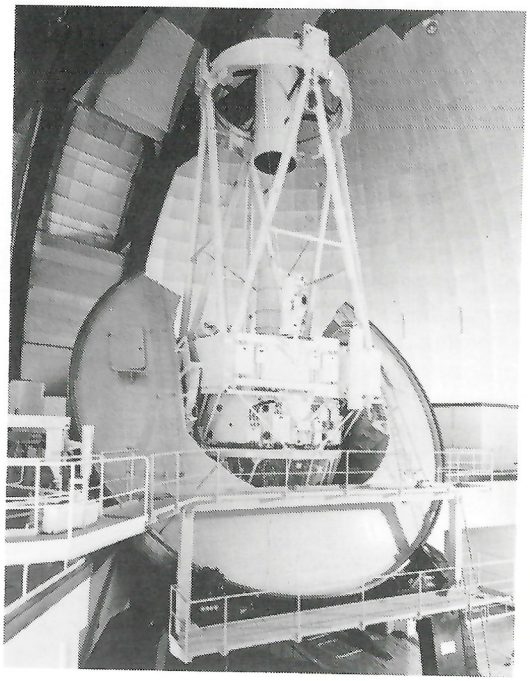


The successful remote operation of a telescope-instrument-detector system has already been experienced by the many astronomers who have used the International Ultraviolet Explorer satellite. Such a form of operation is clearly necessary for an observatory in space but there are also many advantages to the remote operation of ground-based telescopes. This has stimulated regular remote use of some telescopes in the US and a number of experiments from ROE, RGO and RAL to overseas sites (Hawaii, Kitt Peak and Siding Spring).

During 1984, the RGO will begin the first phase of remote operation of telescopes on La Palma. Shortly thereafter, a full scale remote observing facility will be provided in the Castle, giving significant advantages in cost and the flexibility of scheduling. The STARLINK computer network will be of great value for 'eavesdropping' on the observing process and for allowing the observer to share quick-look data with remote collaborators. The inexperienced user, or the astronomer from another wavelength region, will be assisted by 'hand-holding' astronomers that are familiar with the instruments and able to advise on their optimum use. The centre will also provide the facilities the astronomer needs to prepare for the observing run and sufficient data-reduction capabilities to make on-line decisions about the progress of the observing programme.

Allocations of time to a consortium of astronomers could then result in their sending just one or two of their number to the remote observation centre and using STARLINK as a secondary communications network. It implies that the observer will have to remain at the centre for a period of time for setting up, observing and preliminary data reduction and will need accommodation on the site which is quiet during both day and night.

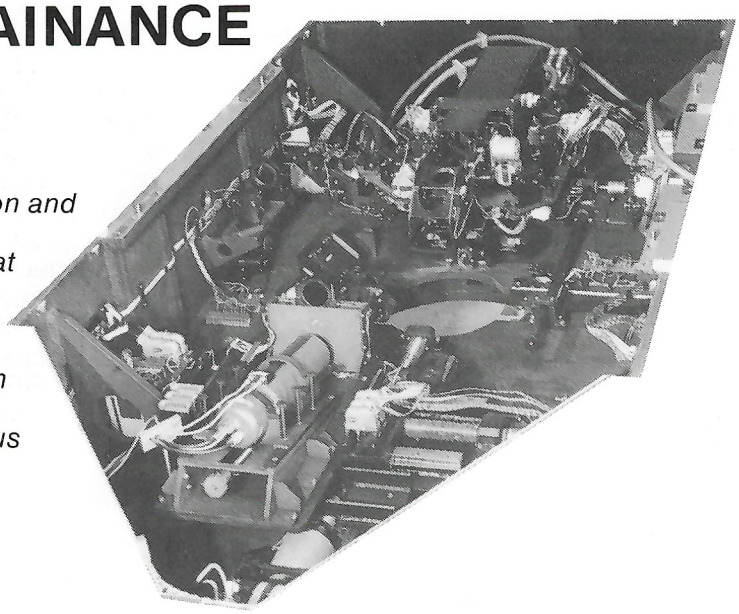
From 1987 onwards, with at least three major telescopes being operated remotely from Herstmonceux, it is expected that visiting observers will spend between 2000 and 5000 visitor-nights per year at the centre. Although, in the first instance, the observation centre will be set up to operate the telescopes on La Palma, sufficient provision is made in the plans for the use of other telescopes around the world, the prime example being the AAT. Since the SERC telescopes are at widely different longitudes, there will be the necessary 24 hour support.



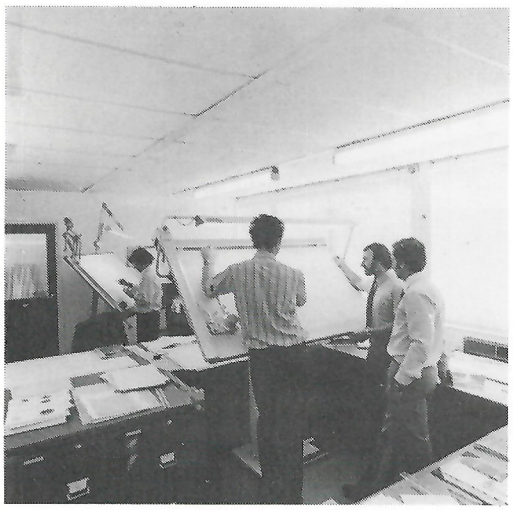
New instrumentation on the AAT is being designed to allow remote observing.

The remote observation centre will be housed in the Castle. Observing preparation facilities, access to computers, office space and quiet accommodation will also be provided here.

INSTRUMENT AND TELESCOPE DEVELOPMENT TESTING AND MAINTAINANCE



The interior of the Acquisition and Guiding unit for the 2.5m telescope. This is mounted at the Cassegrain focus before the instrument and provides a sensitive integrating television system for viewing the sky, an autoguider, filters and various calibration sources.



Much of the instrumentation for the La Palma telescopes, the AAT and those at the SAAO is designed and manufactured at the RGO where there are design offices and mechanical and electronic workshops. The RGO optics group designs optical systems for a very wide range of space and ground-based instruments.

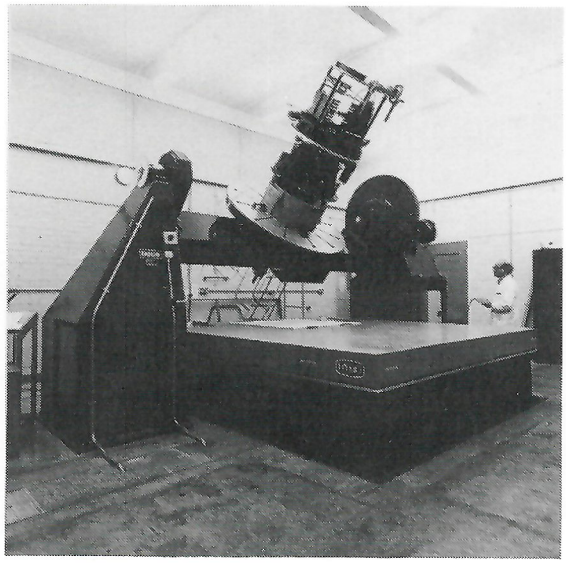
The common-user instruments and detectors already constructed for the 1.0m and 2.5m telescopes and those in the planning and construction phases for the 4.2m telescope will be competitive with ground-based instrumentation anywhere else in the world. The definition, development and maintenance of these systems are the responsibility of project groups at the RGO which include engineers and experienced observational astronomers from universities and the RGO.

Developments in detector technology can still make large incremental improvements in the performance of telescopes and it is vital that active groups are participating in and driving this development, and are able to exploit any improvements on the shortest timescale. Software developments can also make a big impact on the efficiency of use of an instrument, for example the recent development of spectrograph slit scanning to provide area spectroscopy (ASPECT) on the RGO spectrograph with IPCS at the AAT, and so the software group will play a vital role in keeping the La Palma telescopes in the forefront.

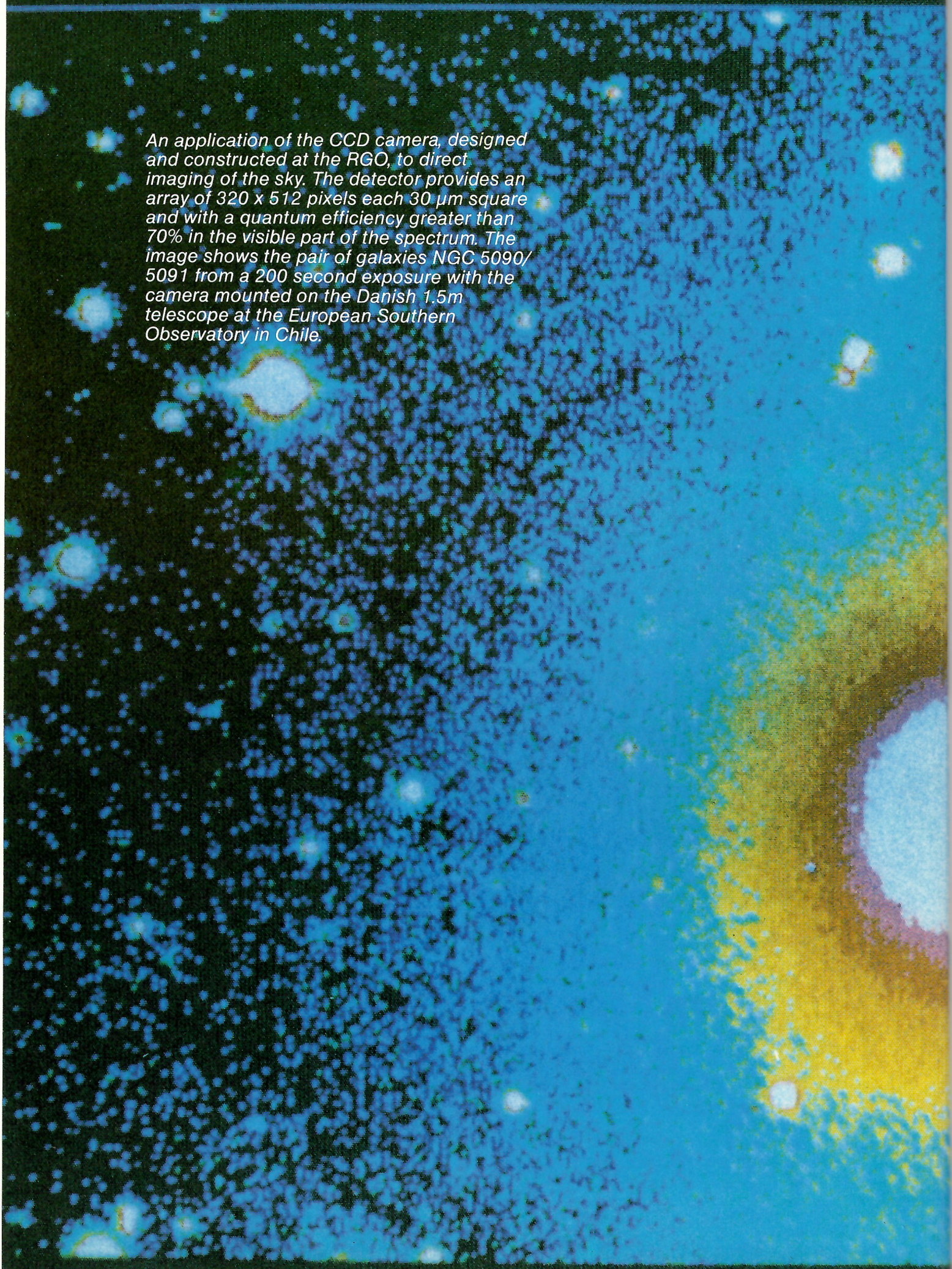
After the present procurement phase, culminating in 1987, there will be a continuing need for the development both of new and existing devices. This may range from new detector systems, through the interferometric linking of two

or more telescopes on La Palma to give very high angular resolution, to the design of a new, innovative and very large telescope. The experience of the RGO in telescope and instrument development and optical design is already very wide (extending, for example, to the AAT and its instrumentation) and it will be a natural focus for new initiatives. For a common-user instrument, this may mean either playing the primary role or forming a collaboration with a university group: existing examples are the collaboration with Imperial College of Science and Technology to produce the highly successful TAURUS imaging Fabry-Perot interfermoter and the collaboration with Durham University to produce the novel and highly efficient Faint Object Spectrograph.

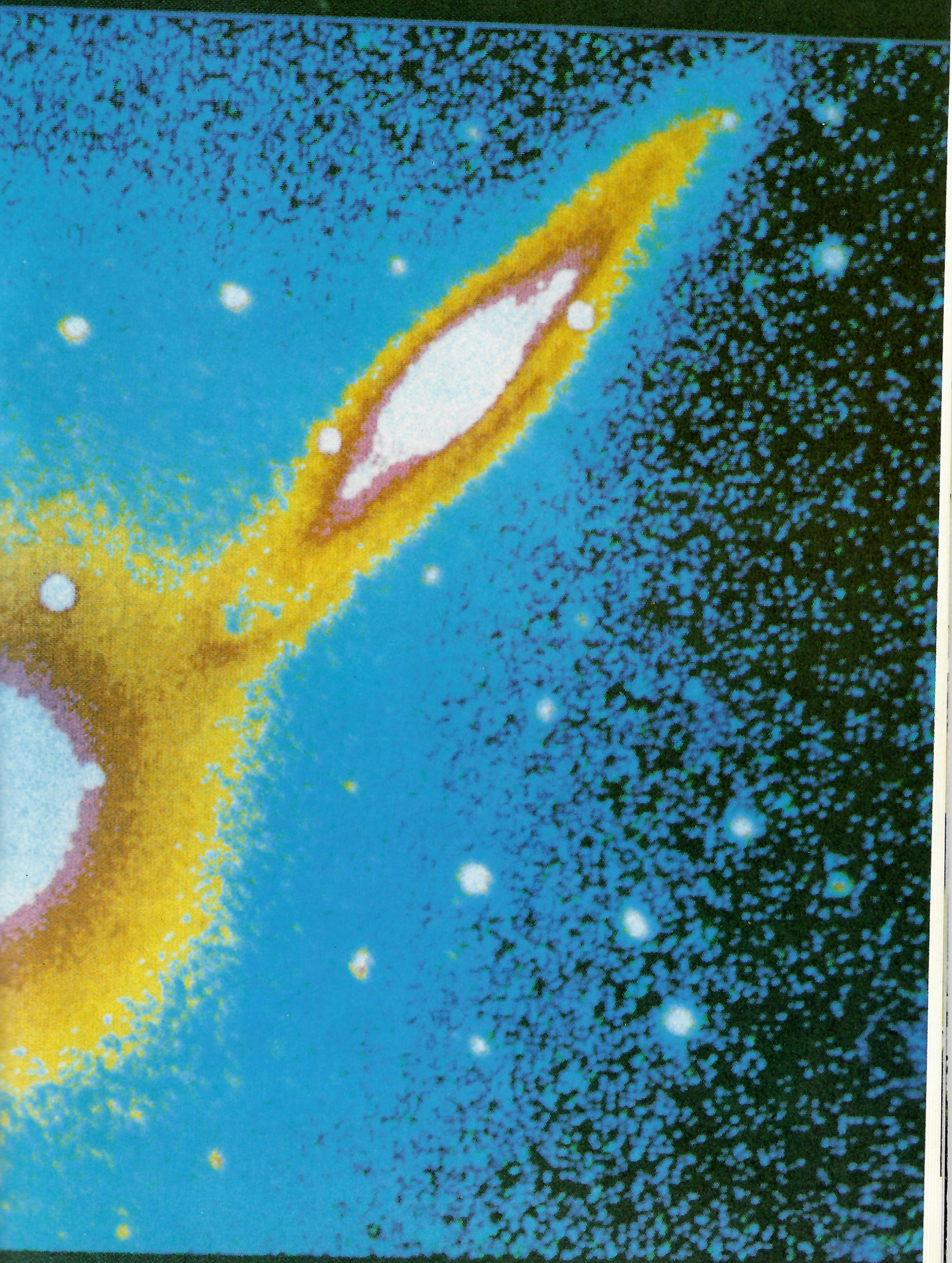
When a new instrument finally arrives at La Palma, it must be sufficiently well tested, and its performance understood, that it will result in the efficient production of reliable data as soon as it is put on the telescope; this is true for special (university produced) instruments as well as new common-user devices. The RGO will provide an instrument test facility at Herstmonceux which will include a telescope simulator and a copy of the instrumentation computer. It will also have the resources to produce technical and user manuals and provide training in maintenance and use. Additionally, the telescopes of the Equatorial Group will provide for observing trials of prototype instruments developed in universities.



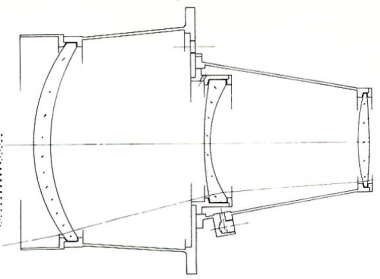
A telescope simulator at the RGO allows full attitude testing of instruments destined for the moving focal stations of telescopes. Here the camera with automatic plate and filter changer for the prime focus of the 2.5m INT is being tested before shipment to La Palma.



An application of the CCD camera, designed and constructed at the RGO, to direct imaging of the sky. The detector provides an array of 320 x 512 pixels each 30 μm square and with a quantum efficiency greater than 70% in the visible part of the spectrum. The image shows the pair of galaxies NGC 5090/5091 from a 200 second exposure with the camera mounted on the Danish 1.5m telescope at the European Southern Observatory in Chile.

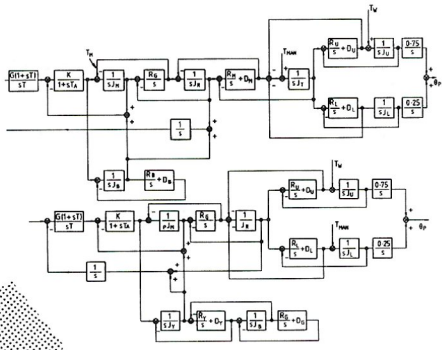


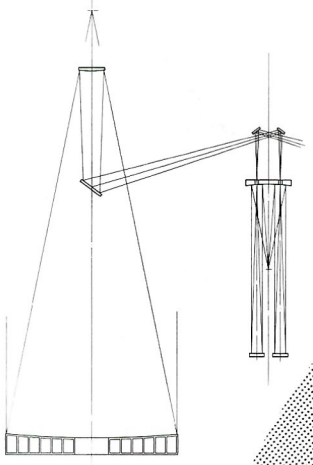
ENGINEERING TECHNIQUES



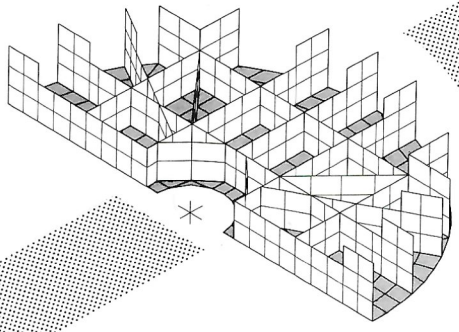
OPTICAL DESIGN

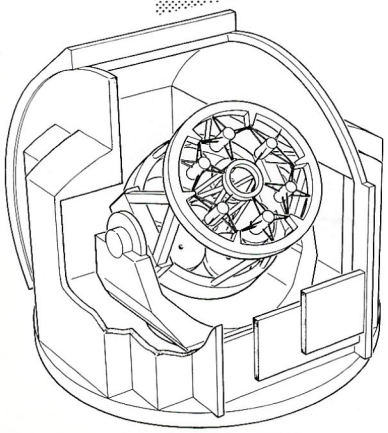
ELECTRONIC

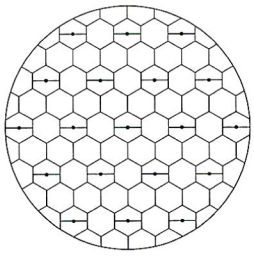


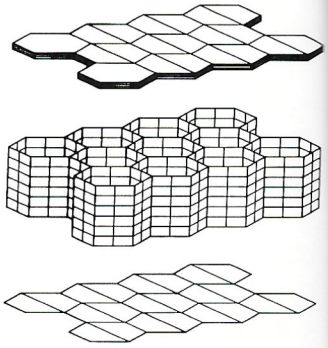


STRUCTURAL ANALYSIS

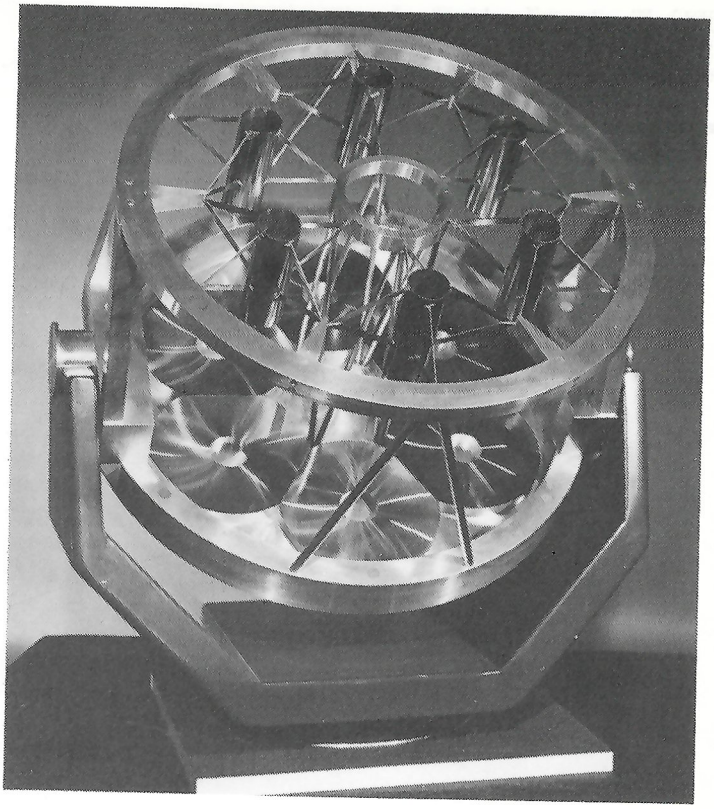


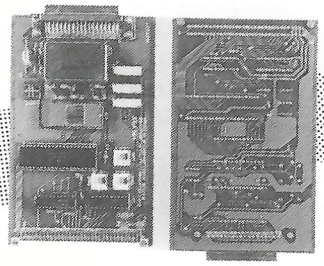


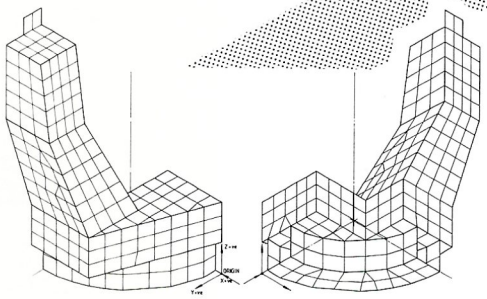


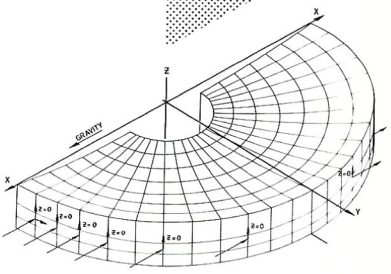


CONCEPT

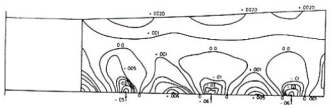


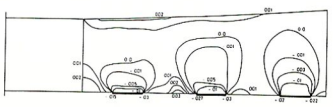






An optical telescope begins with the definition of the scientific communications' requirements and the production of a conceptual design. Many disciplines of science and technology such as optical, structural analysis, servo-control systems, electronics and computer science are then required to develop the concept into the final design of the telescope.





MIRROR DEVELOPMENT AND DESIGN

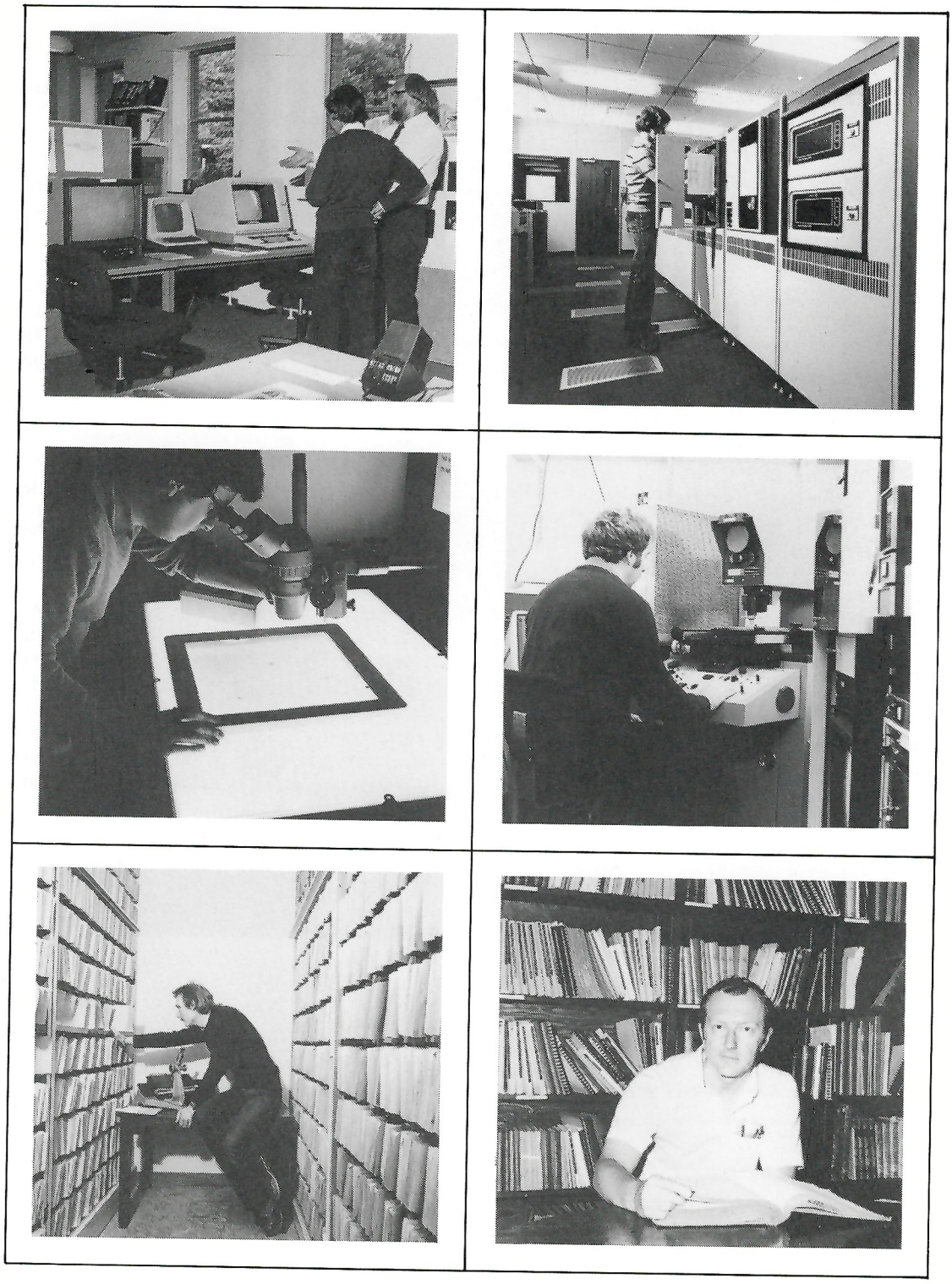
UK BASED ASTRONOMICAL SUPPORT

Associated with the primary process of observing are the vital requirements of data reduction facilities and of a properly organized data bank, both for analogue (plates) and digital data. Apart from some on-line data reduction which may take place on the instrument computers at the telescopes, STARLINK provides the means for the astronomer to make sense of the data, and access to this network will be available from RGO and in particular from the vicinity of the remote observation centre. We expect this very close association between observing and data reduction to be a major stimulus to the production of new computer software and intend to exploit this opportunity by having applications programmers working in the same physical environment as the observers, the resident astronomers and the operations staff.

The birth of a new observatory is the appropriate time to consider the right way to set up a data bank and to provide a convenient means of access for the whole community. Plans are well in hand, in collaboration with the Dutch astronomers, to provide a complete system of data logging at the telescopes, production of an archive of digital data, of associated engineering and meteorological information and the data-base system which is required to retrieve the material. Although this system is being implemented for the telescopes on La Palma, it will be extended to handle data from other telescopes and from satellites. This digital archive, together with the plate library, will become a unique research resource.

A plate archive of considerable scientific value already exists at Herstmonceux and new material will be added as the La Palma telescopes become operational. Information about the plate material, particularly detailed for the new plates, will be accessible through the computer data-base system. The support facilities to exploit these analogue data include devices ranging from simple eyepieces and microscopes to sophisticated measuring machines such as microdensitometers.

The RGO has a first-rate research library of current material. It also has scientific and library archives, spanning more than three hundred years, which provide a rich source of unique historical material on the development of astronomy, geodesy and timekeeping in the UK and overseas. These include long series of photographic plates and of unpublished data, and they are complemented by the books in the Airy Collection and in the main library. It is generally recognised that the RGO should continue to be a place of deposit under the Public Records Act, and therefore has a legal obligation to conserve this material and to make it accessible to the public for study under appropriate conditions.



Support for the observational astronomer includes an interactive computing facility for data analysis, a data bank with convenient access and retrieval, photographic plate viewing and measuring machines and a research library containing material stretching back over three hundred years.

Research Astronomy

and the Interaction with the Universities

Fully integrated with the observatory activities at the RGO is a group of world-class research astronomers who, by a balance of project responsibility and research activity, ensure that the facilities are geared to the requirements of the user rather than solely to the desires of the provider. They also carry a fund of observational experience with the instrumentation which will be passed on to visiting observers, both at Herstmonceux and on La Palma, through 'hand-holding' duties during the actual observing. Past experience at many observatories has shown that this often has the additional benefit of engendering fruitful new scientific collaborations.

Such collaborations are just one of the ways in which the RGO interacts with the university and polytechnic community in this country, with our scientific partners and with astronomers world-wide. The RGO has a particularly close relationship with the University of Sussex near Brighton, just over twenty miles away. Observatory staff hold visiting appointments: two Professorships, two Readerships and four Lectureships. M.Sc. and P.Dhil students writing observational theses usually work with a supervisor at Herstmonceux; there have been over eighty such students over the last fifteen years and many of them have gone on to make prominent contributions to astronomy. There is a series of joint seminars held at both sites. A series of research fellowships, held by astronomers carrying out observational programmes of interest to both groups, have been particularly successful and productive. Since the AAT was commissioned in 1974/75, more than half of the UK fellows at the telescope have been D.Phils and Fellows from Sussex.

The research interests of the staff astronomers, research associates and students are wide ranging and parallel those of observational astronomers in institutes the world over. At a national observatory they are, however, in a position to carry out some longer term programmes which, for reasons of continuity and time-scale, are more difficult for university astronomers to contemplate. In consequence, a fraction of the RGO's research effort is devoted to large-scale survey programmes, astrometry and the maintenance of the stellar reference frame. These programmes provide data which are fundamental to many programmes in space and ground-based astronomy and astrophysics. In addition, and in their own right, they allow a detailed study of the origin and evolution of our own Galaxy, complementing the studies of faint galaxies at large redshifts, and, through astrometric distance measurements, consolidate the first stages in the determination of the cosmological distance scale.

THE CONFERENCE CENTRE

A very fine feature of the RGO is the conference centre in the Castle which can accommodate meetings from small workshops up to full conferences. These are particularly important in providing the necessary end-point after the sequence of observing, data reduction and analysis: the real interpretation and understanding of the results. The environment is extremely attractive and popular with visitors. As well as regular series of astronomical meetings, this facility is available for use by SERC as a whole.

The links which are generated with university astronomers both here and abroad are an important consequence of having a strong team of research astronomers at the RGO. Such links precipitate scientifically productive visitor programmes, lively conferences and workshops and a close contact with technical and scientific developments elsewhere. They often also lead to longer lasting research and instrumental collaborations and to mutually beneficial exchanges of astronomers between institutions.

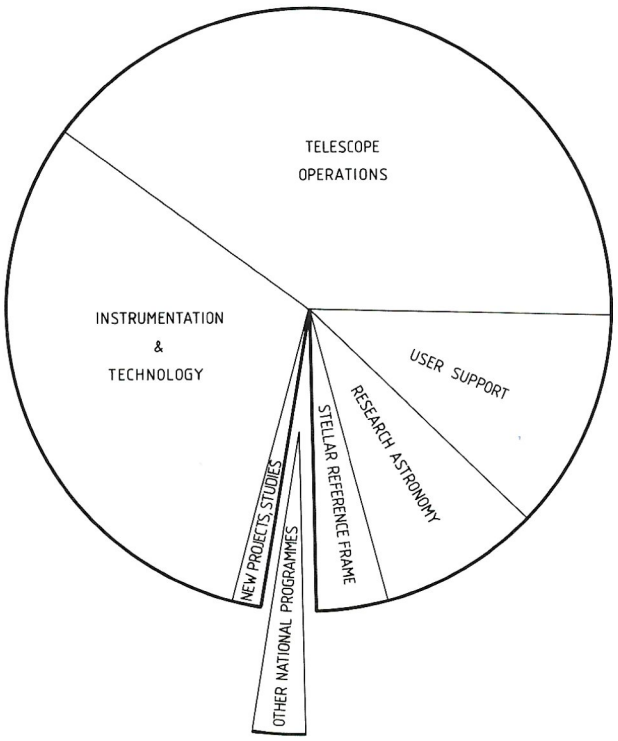
RGO Workshops in 1982/83

1982	7/ 8 July	— Remote Operation of Telescopes
	12/15 Sept.	— The Intimate Environment of Seyfert Galaxies
	24/26 Nov.	— Design of a Very Large Optical Infrared Telescope
1983	5/ 7 Jan.	— Satellite Laser Ranger Data
	8/10 Feb.	— Applications of Low Resolution Spectroscopy to Cosmology
	6/ 7 April	— Ionization Mechanisms in Galactic Emission Line Nuclei
	18/22 April	— Faint Object Camera for the Space Telescope
	4/ 5 May	— Calibration of Stellar Luminosities from Astrometric Data
	28/29 June	— Herstmonceux Conference — Observational Cosmology
	11/15 Sept.	— Meeting of STARLAB Direct Imaging & Spectrograph Sub-Committees
	15/17 Sept.	— Dynamical Problems in the Solar System
	10 Nov.	— High Resolution Imaging for La Palma

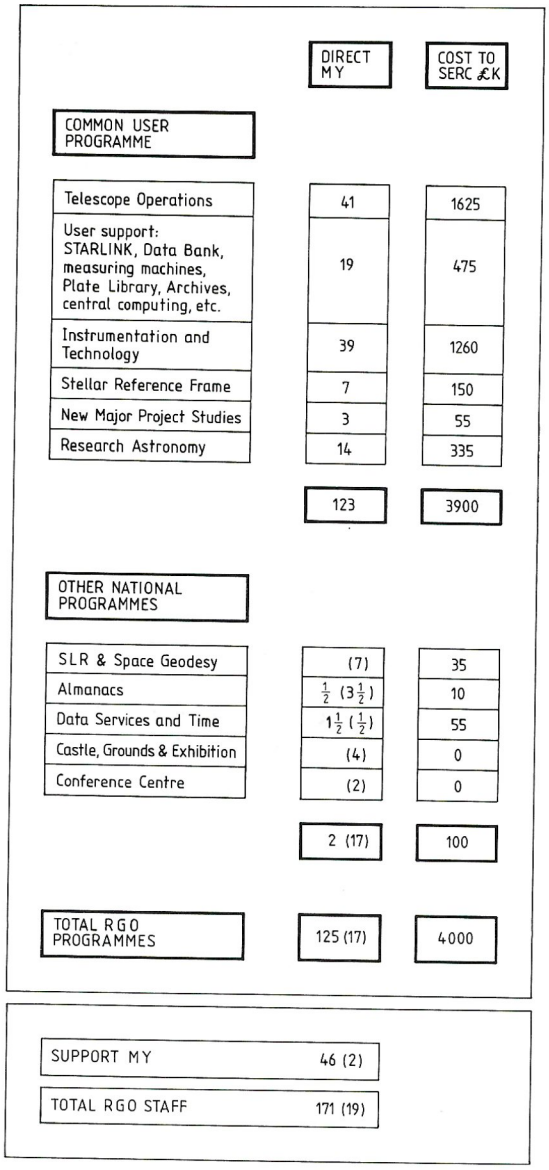
MANPOWER AND FINANCE

The total resources devoted to the programme outlined in this document will be larger than the RGO's own contribution. For example: there will be an involvement by University astronomers in the common-user programme; the Netherlands will be providing 20% of the staff required for operating, maintaining and developing the La Palma telescopes and instruments; much of the cost of the other national programmes will be met by customers. The SLR and Space Geodesy programme has been included on the assumption that there will be a substantial financial contribution from other interested bodies.

The RGO's own contribution of resources will be set by SERC's Astronomy Space and Radio Board in conjunction with international partners, and firm figures ahead to 1990 cannot be provided now. The figures opposite are the RGO's best estmate of what would be the minimum viable resources needed to sustain its part of the programme. The estimated manpower is considerably (20%) less than the 1983 strength, but should just be adequate if the research community at home and abroad contribute fully, particularly in taking on more of the instrument development than they have hitherto.



The diagram illustrates the distribution of SERC's financial contribution to the RGO programme, taken from the estimates in Column 3 opposite. Is therefore shows the net contribution after receipts.



	DIRECT MY	COST TO SERC £K
COMMON USER PROGRAMME		
Telescope Operations	41	1625
User support: STARLINK, Data Bank, measuring machines, Plate Library, Archives, central computing, etc.	19	475
Instrumentation and Technology	39	1260
Stellar Reference Frame	7	150
New Major Project Studies	3	55
Research Astronomy	14	335
	123	3900
OTHER NATIONAL PROGRAMMES		
SLR & Space Geodesy	(7)	35
Almanacs	$\frac{1}{2}$ ($3\frac{1}{2}$)	10
Data Services and Time	$1\frac{1}{2}$ ($\frac{1}{2}$)	55
Castle, Grounds & Exhibition	(4)	0
Conference Centre	(2)	0
	2 (17)	100
TOTAL RGO PROGRAMMES	125 (17)	4000

SUPPORT MY	46 (2)
TOTAL RGO STAFF	171 (19)

Column 1 shows the projected programme of the RGO in 1990.

Column 2 shows the effort in man years (MY) directly attributed to each programme, with the component of effort fully covered by receipts shown in parenthesis.

Column 3 shows the total net cost to SERC (October 1983 prices) of each programme. The cost includes salaries and wages, recurrent and capital expenditure, and an appropriate share of the cost of support manpower (shown at the foot of the table) and other overhead charges. Apart from the receipt from the Netherlands in respect of Telescope Operations, Instrumentation and Technology which is credited direct to the ASR Board, all other receipts have been credited to the appropriate programme. Income from visitors will cover the cost of maintenance and support for Castle, Grounds and Exhibition. The Conference Centre will be operated on a break-even basis.

OTHER PROGRAMMES

The RGO will continue to devote a small fraction of its resources to the study of the dynamics of the solar system and to the application of astronomy to geodesy, navigation and civil life. The main emphasis of these activities will, however, be in the field of "Space Geodesy"; on the determination of the orbits of artificial satellites by making and analysing observations of very high precision. The purpose is to improve knowledge of the gravity field and rotation of the Earth and to provide data that will be used by geoscientists to study the dynamics of the crust and interior of the Earth, of the oceans and of the atmosphere. This work will be carried out in close collaboration with scientists in universities, polytechnics, and other research establishments such as the Institute of Oceanographic Sciences and the Royal Aircraft Establishment. The current facilities, such as the Hewitt camera (now operated by the University of Aston) and the Satellite Laser Ranging system, may be extended to meet the requirements of the geoscience community, which is expected to increase its use of the RGO's conference facilities for technical meetings and summer schools.

The research in space geodesy will have application in the practical tasks of navigation and surveying. Moreover this work requires expertise in celestial mechanics and numerical analysis and involves high-precision measurements of time-epoch and of time-interval. It will therefore be fully integrated with the work that is now carried out at RGO in H.M. Nautical Almanac Office and in the Time Department. There will be a continuing need for the publication of almanacs for astronomy, navigation and surveying and, though the fundamental work in astronomy, geodesy and geophysics will be funded by SERC and NERC, it is expected that Government Departments will meet the costs of providing the publications and data relevant to their own interests.

The RGO will be expected to provide astronomical information and data for use by publishers of newspapers, diaries and books, by the legal profession and by the general public. This work will be carried out efficiently as a byproduct of the basic work for the almanacs and the costs will be recovered from charges.

SPACE GEODESY

The RGO will operate a high-precision satellite laser ranging system for use in the determination of selected satellite orbits. It will be the UK centre for the exchange of SLR data with other countries, will distribute such data on request to research workers in the UK, and will collaborate with them in the analysis and interpretation of the data. It will also participate in the development and operation of a mobile SLR system if this is funded by the UK alone or in partnership with, say, Australia.

Two Hewitt satellite-tracking cameras will be operating, one at Herstmonceux for which RGO has responsibility, and the other at Siding Spring in Australia. These will observe satellites with a wide variety of orbital parameters in order to obtain more accurate information about, for example, the upper atmosphere and the gravity field of the Earth. A prediction service for other observers will be provided as a byproduct and the observational data will be distributed to interested research groups.

DYNAMICAL ASTRONOMY

The new ephemerides that have been developed recently in the USA for the Moon and planets will provide the basis of the published ephemerides for the rest of this century. But observations from ground-based telescopes and spacecraft will still be needed to improve the theories of the motions of natural satellites and of some asteroids.

These studeis will be complementary to the work on the orbits of artificial satellites and will allow a gradual improvement in the formulae and data that are provided for astronomers in the Astronomical Almanac (which will continue to be published in cooperation with the US Naval Observatory) and in other ways. This work will also assist the determination of the relationships between the celestial reference frames, derived from observations of the stars and radio sources, and the dynamical reference frames associated with the solar system and the Earth.

NAVIGATION AND CIVIL ASTRONOMY

The RGO will contribute to the development and practice of navigation and surveying in several ways. Astronomical methods of positioning will still be in wide use and it will still be necessary to publish the Nautical Almanac, but it is likely that the form of tabulation will have been changed considerably to take account of the availability of small but powerful calculators. The navigator and the surveyor will still need to use astronomical methods of positioning, the Nautical Almanac, and Universal Time. The RGO will contribute (through the SLR activities) to the international service for Earth-rotation. It will also obtain precise time checks from radio signals (which may be broadcast by satellites) and these will be monitored automatically by the RGO against the local atomic-timescale that will be generated for use with the satellite laser ranging system and as a contribution to the national time scale formed by the National Physical Laboratory. Even the satellite navigation systems will make use of the fundamental data on the gravity field and rotation of the Earth to which the RGO will contribute.

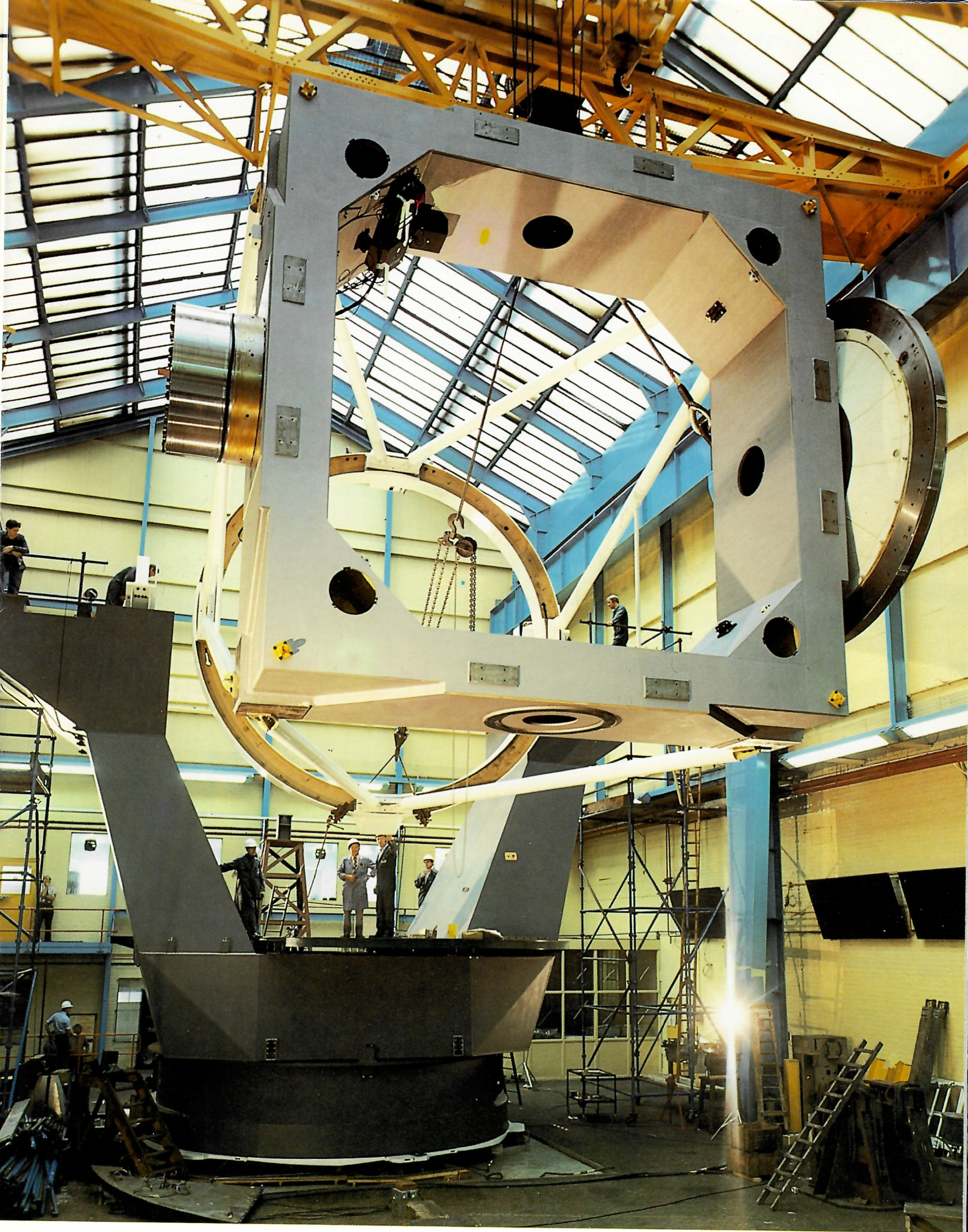
It is appropriate too that the RGO should continue to be the primary source of astronomical data for public life. Such data are published in a large number of periodicals but special computations of, for example, lighting-up time are made for individual places. By tradition the RGO disseminates information about public holidays since there is no single government department that accepts this responsibility. Many requests for information about astronomical phenomena are directed to the RGO which is recognised throughout the UK and many other countries as the authority on such matters.

The 4.2 metre WILLIAM HERSCHEL TELESCOPE, is now at an advanced stage of construction and assembly at the works of Grubb-Parsons in Newcastle. It is to be installed at the Roque de los Muchachos Observatory on La Palma in the Canary Islands.

This telescope, which will be the third largest single mirror optical telescope in the world after the Russian 6 metre and the Mt. Palomar 5 metre in the USA, weighs 190 tonnes and stands 18 metres (60 feet) high. It is supported in an altazimuth form of mounting, which has significant mechanical advantages over the more usual equatorial mounting. Precise movement of the telescope simultaneously about both axes will be achieved by a servo-controlled drive system being designed and constructed by Marconi Radar Systems Ltd. The drive system will in turn be commanded by a control console and computer designed and procured by the RGO.

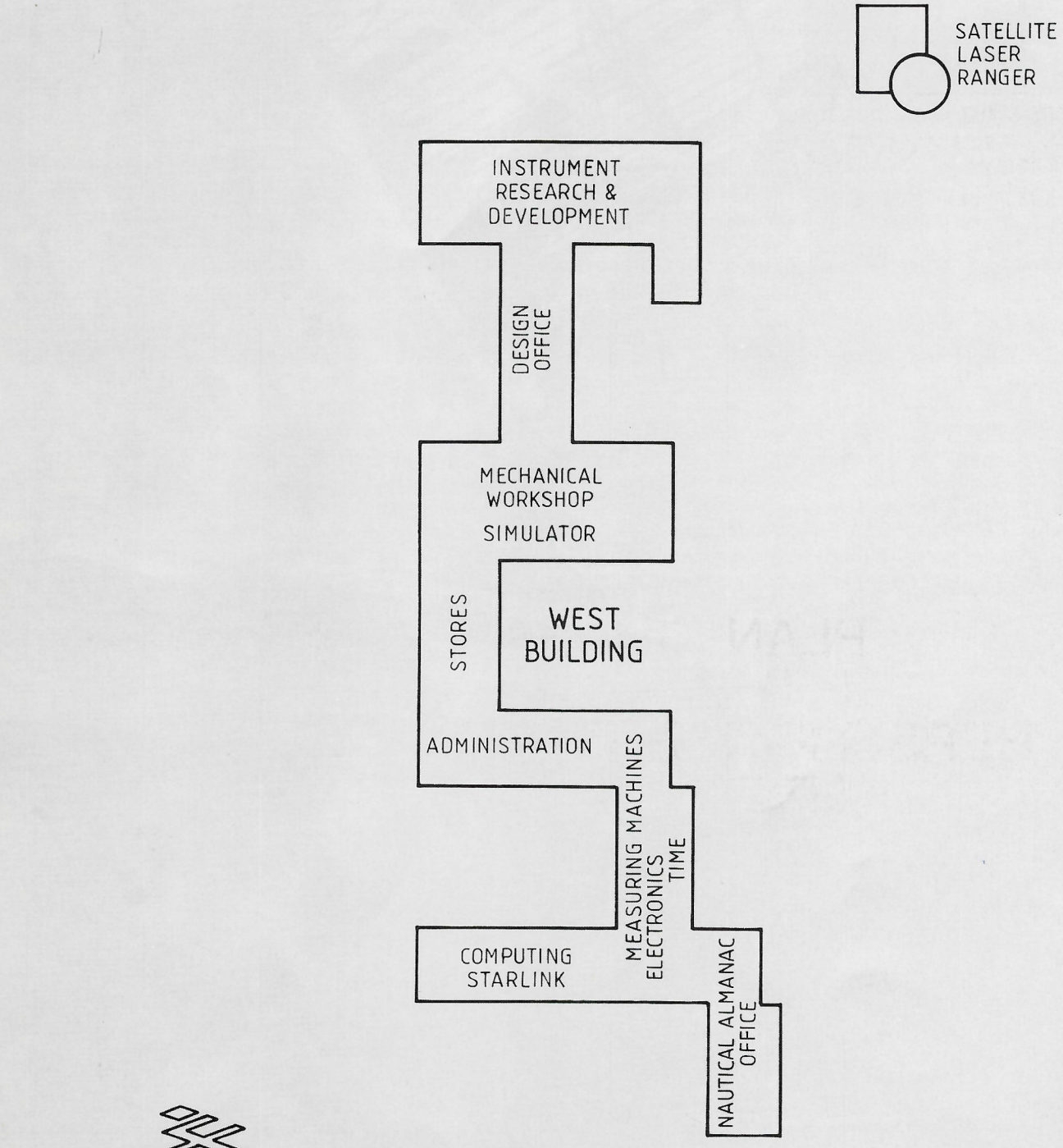
The 4.2 metre (14 feet) diameter primary mirror weighing 6 tonnes, is made of zero-expansion glass-ceramic material and is now approaching its desired parabolic form on Grubb-Parsons' optical polishing machine. The surface accuracy of this mirror is required to be better than one-tenth of a wavelength of light. In order to achieve this Grubb-Parsons are using a wavefront shearing interferometer with a Reticon detector and microcomputer system to assess optical performance and guide the polishing process.

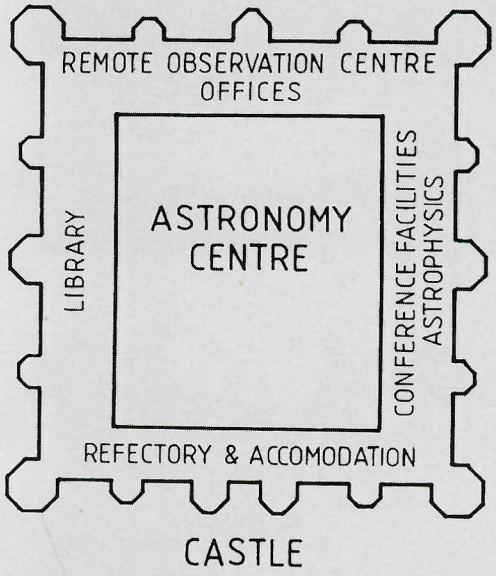
RGO engineers and scientists first began design work on the telescope in 1975 and after receiving financial approval placed contracts for manufacturers in 1981. They will be engaged in testing the telescope during the first half of 1984 before it is dismantled and shipped to La Palma for erection in 1985, in the building now under construction there. RGO expect to complete commissioning and bring the telescope into operation in 1987.

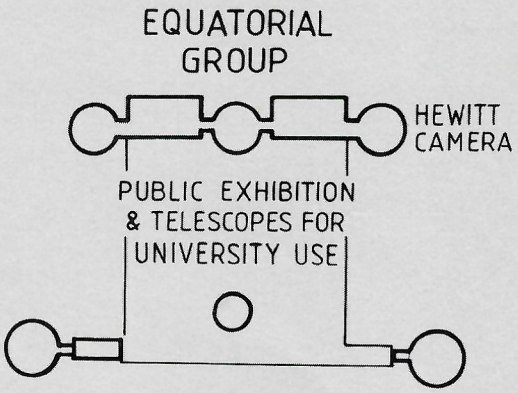


NEI Parsons Ltd

THE 4.2 METRE WILLIAM HERSCHEL TELESCOPE during assembly by Grubb-Parsons in Newcastle-upon-Tyne.


SATELLITE
LASER
RANGER
INSTRUMENT
RESEARCH &
DEVELOPMENT
DESIGN
OFFICE
MECHANICAL
WORKSHOP
SIMULATOR
STORES
WEST
BUILDING
ADMINISTRATION
MEASURING MACHINES
ELECTRONICS
TIME
COMPUTING
STARLINK
NAUTICAL ALMANAC
OFFICE
SUSSEX
UNIVERSITY
(20 MILES FROM RGO)





PLAN OF THE HERSTMONCEUX SITE

The optical components of the Faint Object Spectrograph for the 2.5m INT. This is a collaboration between the RGO and the University of Durham to build a highly efficient CCD spectrograph optimised for the study of faint, very distant galaxies.