ENG INF

SUMMER 1989 No. 37

# NEW SATELLITE LINK FOR RADIO OBs

Radio OBs, based at Concord Road in West London, has taken delivery of a new satellite link system. It operates in conjunction with Eutelsat 1, Flight 2, positioned at 7° east over the equator, and was provided in record time by Transmission Engineering Department, based at Warwick.

The transportable up-link enables a stereo circuit of the highest quality to be achieved from anywhere in the UK — provided it can 'see' Eutelsat 1. The satellite signals are received via a 3 m dish antenna, sited on the roof of Broadcasting House in London, from where they can readily be routed to any of the four radio networks.

The new equipment was first used live on Sunday 4 June, when it provided the circuit back to Broadcasting House for the Morning Service from Rodborough, near Stroud. It has also been used successfully at Glyndebourne, for a live opera on Radio 3, and is currently accompanying the Radio 1 RoadShow around the coast of Britain on its summer tour.

Starting on page 16, Simon Shute (G M Ops & Eng, Radio) explains why the new link has been acquired and Nigel Adams, of Transmission Engineering Department, describes the technicalities of the system.

## RESEARCH DEPARTMENT A SPECIAL FEATURE BEGINS ON PAGE 7

*A visitor's first glimpse of the mansion at Research Department, Kingswood Warren. Fortunately, most of the trees along the driveway survived the big storm of October 1987 but a hundred and twenty-three others were blown down and many more disfigured.*

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# ENG INF

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The closing date for stories to be included in our autumn issue (No. 38) is 25 August.

Mike Meyer


# LETTER

Sir

Can I appeal through your columns to those who order components from outside the BBC — please make sure that the correct delivery address is known to the supplier. Many parcels arrive simply addressed to 'BBC, Broadcasting House, London W1'.

Post Room sends them to EID — where else! — and it can take a considerable effort to trace the proper destination. This month's detective work led to destinations in Tel OBs, Kendal Avenue, and at a Midlands local radio station!

So please give your full name and BBC address when ordering components from outside suppliers.

By the way, EID still has an electric motor which arrived nine months ago! The manufacturer knows we have it but nobody has claimed it yet. Any takers?

Charles Hope, EID

# TELEVISION PB

The Summer 1989 edition of the pocket booklet 'BBC Television Transmitting Stations' is now available from EID. Please telephone LBH 5040 to order your free copy(ies).

# CODED EQUIPMENT REGISTER 1988 ISSUE

By the time this issue of 'Eng Inf' lands on your desk, you should also have received the 1988 edition of the **Coded Equipment Register** (CER), which has replaced Registered Designs and Coded Equipment (RD&CE), Part I — commonly known as the 'silver book'.

The 1988 edition differs from previous issues in a number of ways. The most significant is that it includes only those codes which have been taken out during the last twelve months. Therefore, it is essential that you retain your 1987 volume, if you want to refer to equipment which is over a year old!

As well as containing the usual information on new designs, the 1988 edition of CER also includes an addendum to the Technical Document Cross-Reference (previously published separately), and information on the availability of licensed equipment. This latter section has previously been included towards the back of D&ED's **Engineering Components Catalogue.**

As a result of this combination of documents, and the added complication of changes to job titles and addresses, I have had to completely revise the mailing list for this edition of the Register. Therefore, if you have not received a copy, but you used to get either RD&CE or the Cross-Reference (or both), then please let me know so that I can send you one of my limited supply of spare copies, and amend my list for next time. However, do note that many areas are serviced by a departmental distribution point, so please check with them first.

Peter Jefferson
Liaison Engineer, D&ED
Tel: AH 375

# 'ENGINEERING INFORMATION' ON CEEFAX

EID's 'Engineering Information' page on Ceefax has been transferred from BBC 1 (page 195) to BBC 2 (page 297).

The move results from a plan to relaunch Ceefax in the autumn, when 'Engineering Information' will again be moved, this time to a more permanent page yet to be announced.

According to Graham Norwood, Editor Ceefax: 'The aim in re-launching Ceefax is to provide it with a bigger output and faster access time'.

'Ceefax now comes under the News and Current Affairs directorate and the new-look output will more accurately reflect the parent department.'

# TRANSMITTER NEWS

The following stations opened between 1 April and 30 June:

**Television**

| | |
|---|---|
| Branscombe | Devon |
| Bronwydd Arms | Dyfed |
| Charmouth | Dorset |
| Chudleigh | Devon |
| Cynwyl Elfed | Dyfed |
| Far Highfield | Lancashire |
| Pen-y-Banc | Clwyd |

**FM Radio**

| | |
|---|---|
| Kirkconnel | Dumfries & Galloway |

# ACROSS THE CHANNEL — bit by bit!

The end of July should see the commissioning of a unique PCM programme link to the Channel Isles and the realisation of several years test and development work involving several BBC departments. The link forms a spur from the BBC's main 8 Mbit radio distribution network on the mainland and has the capacity to convey 12 high-quality audio channels and Radio Data information to Les Platons on Jersey, the BBC's main FM station for the Islands.

The propagation path across the English Channel is too long and unreliable for a microwave link so use has been made of the existing television receiving capability on Alderney, the nearest of the Channel Isles. Here, tv pictures are already received off-air from Stockland Hill, for onward distribution to Fremont Point on Jersey, the Islands' main tv station. What makes the new audio link unique is that it uses carrier frequencies on uhf channel 30, interleaved with the existing tv transmissions radiated from Stockland Hill (channels 23, 26, 29 and 33).

The link employs two uhf carriers within the channel 30 frequency allocation, each modulated by a 2 Mbit NICAM bitstream. The 'Tamed FM' (TFM) method of modulation is used — a form of phase shift modulation that produces a very well-controlled frequency spectrum.

Some of the more remarkable technical aspects of the link are:

(a) the receiving system on Alderney will produce a decodable bitstream from an input carrier level of -92 dBm (0.6 pW!) in the presence of adjacent Channel 29 signals at a level 30 dB higher.

(b) the level of carrier received at Alderney can vary from -95 dBm to -45 dBm, requiring a receiver agc loop with 50 dB of dynamic range.

(c) the system should produce decodable audio, ie six high quality stereo channels, for 99.5% of the time over a distance of 136 km — from only 10 W of transmitter power.

(d) The erp in the direction of Alderney is 250 W; the tv services from Stockland Hill have an erp of 250 kW!

(e) the receiving site on Alderney employs a 9 m dish aerial which exhibits a gain of around 30 dB.

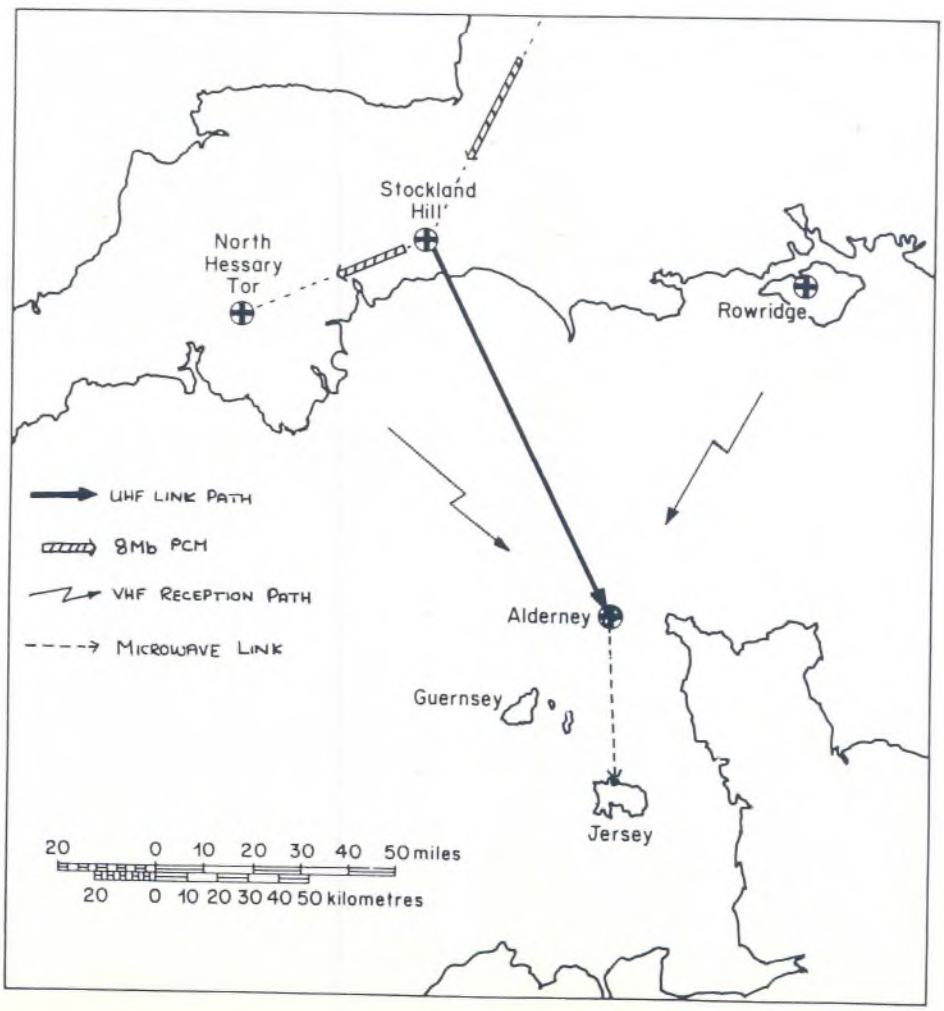
## BACKGROUND TO THE LINK

### New Frequency Plans

Network FM in the Channel Isles has, in the past, relied on off-air reception at Alderney of either Rowridge or North Hessary Tor. A 'diversity' reception system selected whichever station provided the better signal quality at any given moment and sent the chosen signals via microwave link to Les Platons for re-broadcasting.

In 1984, a new international frequency plan was drawn up in Geneva which required the BBC to radiate some 8 dB less from Rowridge in the direction of France; this would be achieved by re-engineering its aerial system. However, its signal strength at Alderney would also be reduced by about 8 dB, rendering it unsuitable for re-broadcast purposes. Thus, an alternative arrangement would need to be found.

Satellite links, submarine cables, etc would be very expensive, so it was decided to carry out propagation studies involving Stockland Hill, which was already a repeater site for the pcm network feeding North Hessary Tor.



# — CHANNEL ISLES: new pcm link —

## Reliability Tests

To check that an in-band tv link would be feasible, Research Department performed a study to find suitable uhf frequencies which would minimise interference to other transmissions, yet provide a rugged system for carrying pcm signals to Alderney. The most likely causes of link problems would be a combination of deep signal fades, multipath propagation and interference from existing tv transmissions.

A complex reliability calculation was needed but, fortunately, useful propagation statistics were already available from the time that the tv re-broadcast arrangement on Alderney was first installed. The results of this earlier study indicated that a link based on channel 30 should be acceptable for the required 99.5% of the time.

Using the combined efforts of Research Department, Designs Department and TCPD (as they were then called), a prototype link on channel 30 was installed in June 1986. Computer-based data loggers were installed to monitor both ends and the link was left to transmit a string of simple data for a period of two and a half years.

A wide range of weather and tidal conditions were encountered during this period but the data, when analysed at Research Department, proved that the required 99.5% reliability had been achieved. It was then up to TED (formerly TCPD) to write the specification and procure a workable final realisation of the link.

## The Equipment

Most of the required frequency conversion and amplification was fairly familiar to uhf transposer engineering, so Continental Microwave Ltd (CML) were approached to see if they could build such a link. Despite some of the rather stringent requirements of TED's spec, CML were confident that they could produce a system and a contract was placed with them to build the apparatus bays. These were to include a hybrid of CML transposer equipment, D&ED TFM equipment and TED control and changeover equipment.

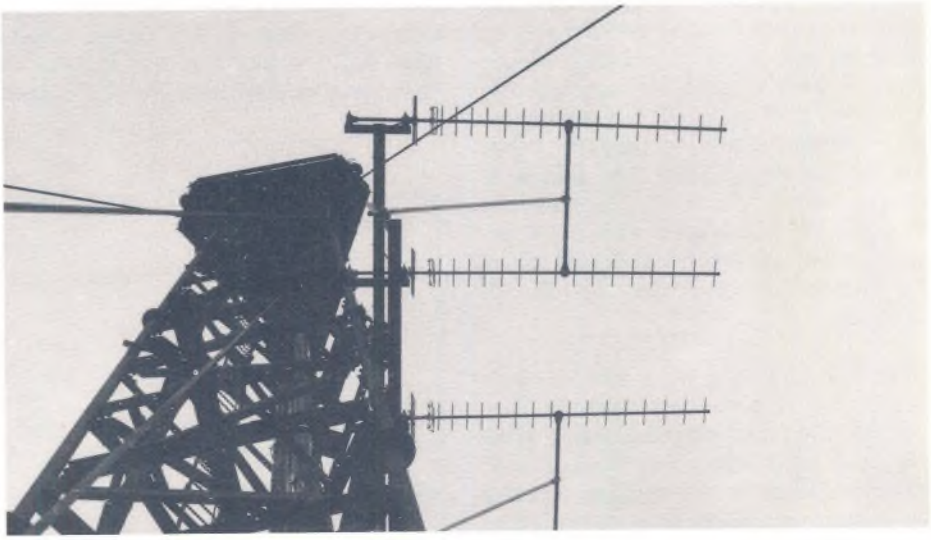
By this stage the project was beginning to become a race against time. In addition to pressures created by the new frequency plan mentioned above, it was necessary to get the link into service before Rowridge could be re-engineered for Radio 1 FM. The required TFM equipment was still under final development at D&ED and so, to meet the short timescale, the equipment for the link was produced 'in-house' at D&ED rather than going out to manufacture.

NICAM decoders would be required in the Channel Isles but, at this stage, it would have been impractical to manufacture more Mk 1 NICAM equipment. Thus, it was decided that the link would be the first application for the newly developed and much improved Mk 2 NICAM decoder. This would require the production of a new bay, the specification of which TED had already produced in order to meet the requirements of re-engineering the pcm network.

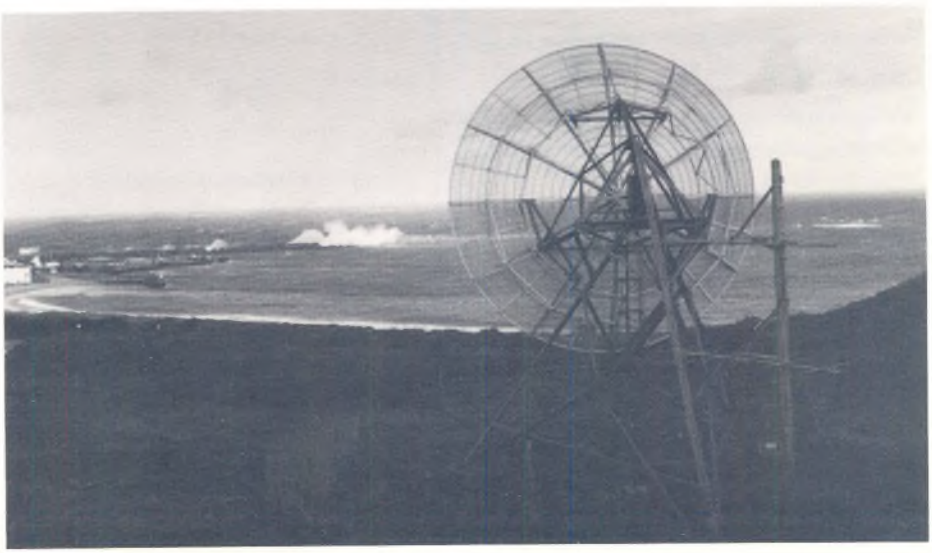
At the time of writing (late June), the link is almost a working reality. It has been seen to work in the factory (with the English Channel simulated by up to 130 dB of attenuation!) and is now installed at Stockland Hill and Alderney — transmitting network bitstream under test. It will provide the Channel Isles with digital stereo feeds of Radios 2, 3 and 4 (and Radio 1 in the future) as well as the Radio Data information that is carried by the pcm network.

The project represents the culmination of four years work by many people from various departments. They include: David Russell and Peter Gooderham of TED; Geoff Phillips and Mark Maddocks of RD; Bill Murray and Chris Newey of D&ED; Mike Nightingale of TOD and many more RD, D&ED, TED and TOD staff too numerous to mention.

Keith Hayler, Project Leader
Transmission Engineering Department



*The transmitting array at Stockland Hill*



*The 9 m receiving dish on Alderney*

# IN BRIEF...

## TELEVISION CENTRE

### NC2 reopens in stereo

Network Control 2 (NC2) at Television Centre re-entered service on Saturday 1 July. The area is now able to handle and monitor progammes in stereo, all audio through the network being in either stereo or split-mono, depending on its source. Because so much had to be moved to facilitate the removal of asbestos, the opportunity was taken to rationalise the sound and vision bays and also to move the Main Distribution Frame (MDF). The original PO-type solder blocks in the MDF have now been replaced by Krone types.

While the area was out of service, other work included the installation of: a VHS recorder to automatically record presentation junctions; a U-matic VTR as standby/filler to cover under-runs and breakdowns, and a CD player in the continuity studio to complement the existing record player.

The work was carried out by Central Systems Section of P&ID Tel, project-led by Bob Walters, while Roy Bertram, the System Engineer with PresFax, represented TV Network department.

### Four new stereo VT cubicles

P&ID Tel has converted four VT cubicles to stereo, at Television Centre. This is an interim measure as stereo will become the norm when Tel Recording moves to the new Stage 5 block at TVC in 1991.

These four cubicles have been devised such that they can be mono or stereo at the flick of a (single) switch. The work included adding extra monitoring and audio mixing facilities within the cubicles, while it was also necessary to completely reappraise the lines to and from the four cubicles and within the VT area generally.

Compatibility and reverse compatibility were considered essential. A cubicle in stereo mode must provide a mono signal to those destinations expecting mono; conversely, a cubicle in mono mode must provide split-mono to an area expecting to receive a stereo signal.

Each cubicle was scheduled to be out of service for four weeks and this included time for removing or sealing any asbestos found — the result of ageing LDR floor tiles.

The work was carried out by Recording and Film Section of P&ID Tel. Lawford Thomas undertook the lines conversion work while Tony Anstis was responsible for the cubicles.

## CARDIFF

### Improved Post-Production Facilities

With the acquisition of a new building opposite BH Llandaff, BBC Wales is taking the opportunity to improve its post-production facilities. The two dubbing theatres currently sited two miles away at Gabalfa are to be replaced with three new areas — one each for video, film and PSC.

Film dubbing facilities had to be retained throughout which meant that the PSC area (the first to be completed) had to do this work temporarily. Recently, the Film Dubbing Theatre has been offered for acceptance which means that the PSC suite should soon be released for its intended purpose. The video dubbing area will be completed in the next few weeks.

To ensure flexibility, the video and film dubbing theatres have been designed to work with either of the two media. To this end, the Video area has been fitted with a DXC3000 camera and an Albrecht PB 42 projector. The Film area, on the other hand, has been fitted with a choice of monitoring: projected picture or a 32" video monitor fed from a DXC 101 camera fitted to an Albrecht PB 51 projector.

Although film might be considered an established technology, there have been a number of developments incorporated in this project. For example, the old Mag-Link equipment has been replaced with new Timeline Lynx synchronisers, permitting the use of standard timecode and hence synchronisation between film and VT. Also an S-VHS machine is being tested for video replay, during the audio dubbing process.

The project is being led by Roy Clarke with assistance from Alan Riley and Pete Traill, all from Recording and Film Section of P&ID Tel.

### New Lens Adaptor

In Cardiff, the Mechanical Workshop in conjunction with Electronic Services has designed and manufactured an adaptor which enables the Schneider TV80 lens to be fitted to the Thompson 1624 lightweight OB camera.

It consists primarily of a box section, cast aluminium, beam which has to be machined to take the camera wedge plate, the lens being held by large thumb wheel screws and a safety locking bayonet. The lens requires that a power feed be taken from the 1624 camera and a package of electronics was designed and is contained in the box on the side.

To help achieve compatibility between different camera/lens combinations, and to compensate for large temperature differences encountered in OB situations, the camera mounting shoe is sprung loaded.

For further details please contact: Bill Thornton, Mechanical Maintenance Manager, Room E0105 BH Llandaff (Ext 2301/2248) or Geoff Claxton, Electronic Maintenance Supervisor, Room GO63 BH Llandaff (Ext 2302).

# SUNSPOTS AND MAGNETIC STORMS

While the last edition of 'Eng Inf' was being prepared, the 'largest magnetic storm for forty years' was taking place. That description was applied by two members of the Geomagnetism Research Group of the British Geological Survey, writing in the May 1989 issue of 'Radio Communication' (the magazine of the Radio Society of Great Britain). Its effects were certainly noticed by engineers at the BBC's Receiving Station at Crowsley Park, by the language monitors at BBC Monitoring (at nearby Caversham Park), by listeners to BBC World Service transmissions — indeed, by anyone, anywhere, trying to receive HF signals.

The cause of the problem was the sun and, in particular, a large group of sunspots which produced numerous large flares. These, in turn, temporarily modified the magnetic fields around the sun and the earth, and thereby altered the density and effective heights of the various layers of the ionosphere by which HF broadcasts are propagated. Sunspots and associated flares are by no means unusual, but the size and intensity of this phenomenon was rather greater than usual.

This group of sunspots covered approximately 2500 millionths of the area of the sun's hemisphere and is the largest observed so far during the current eleven-year cycle. It is comparable with the largest observed in the three previous cycles but is still small compared with the largest observed this century. That was in 1947 and exceeded 6100 millionths; there were four other large groups in the same cycle, each between 4500 and 5200 millionths.

Solar flares emit radio energy over a wide spectrum, resulting in periodic problems with HF reception. We had a foretaste in February of things to come in March. This same group of spots and flares was active around 10 February, producing a number of sudden ionospheric disturbances (SIDs) and unsettled reception conditions. On its re-appearance in March, the group had doubled in size and was much more active.

For several days, two or three very noticeable SIDs per day were observed (along with several smaller ones) and reception conditions deteriorated appreciably — the highest received frequencies at Crowsley Park were 50% or more below normal, for a period of 22 hours, and up to 20% lower than normal for 56 hours. A visible effect was an aurora observed in southern England on 13 March, between 2130 and 2400 UTC.

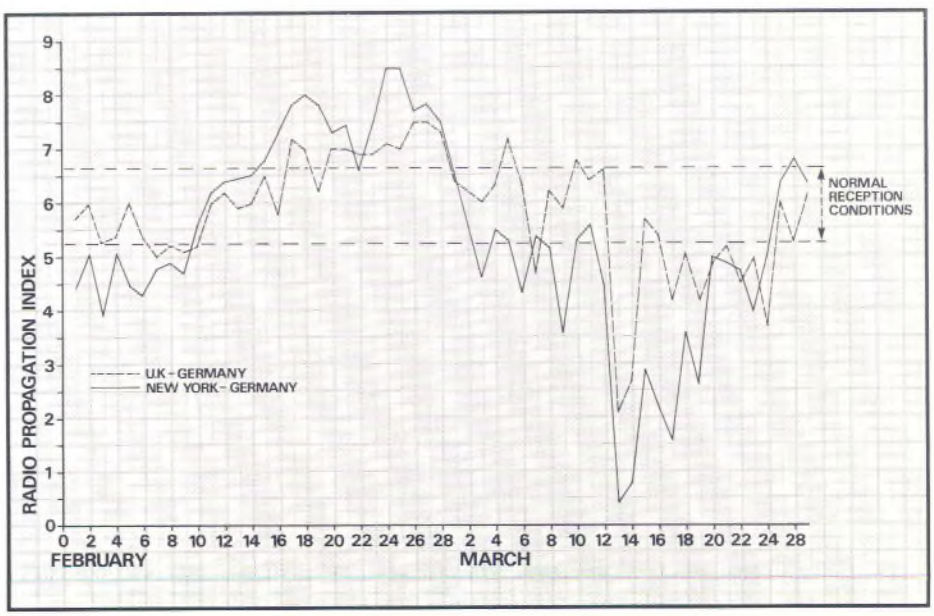
Confirmation of the extent of the storm (as if it were needed!) came over the next few days from the Rutherford Appleton Laboratory at Didcot, Oxfordshire, which had collected data from observatories in Europe, the States and elsewhere. Two samples of the Radio Propagation Index, for circuits from the UK to Germany and from New York to Germany, are shown in the accompanying graph. These show the classic pre-storm enhancement taking place towards the end of February, followed by a sharp drop at the time of the storm.

The Average Antipodal A-Index, which indicates unbalance in the earth's magnetic field, usually has an average daily value of 25 to 30, rising to perhaps 100 during normal storms. The peak values during a normal storm rarely exceed 200, measured over 3-hour periods. On 13 March, the daily average was 355 and on the following day, 211 with maxima of 729 in two consecutive 3-hour periods.

The writers of the article in 'Radio Communication', mentioned above, referred to other more down-to-earth effects: 'Rapid changes in the geomagnetic field during the storm induced voltages in power lines, trans-oceanic cables and telephone and cable networks. In Quebec, Canada, the electricity supply grid tripped, blacking out large areas of the province... In the North Sea, instruments used to steer drill-heads experienced swings in compass readings of up to 12 degrees'.

Although this particular group of sunspots has now disappeared, others will no doubt take its place. As we head for the maximum of the current solar cycle, due next year, and into the long decline that follows, past experience suggests that more storms are in prospect for the next three years or so. Indeed, at the time of writing (mid-June), a number of SIDs have already been observed at Crowsley Park, caused by another large group of sunspots.

Don Cox, Shift Supervisor
Receiving Station, Crowsley Park




*Variations in the Radio Propagation Index during February and March, 1989*

# RESEARCH DEPARTMENT

## By Ted Hartwell, Research Author

Readers who have visited Research Department may have had a feeling of envy as they entered the well kept grounds, drove up to the front door and then stepped into the main entrance hall with its high decorative ceiling and intricate carved wood panelling. I think most of us who work here — and some have been here many years — never lose our appreciation of working in such pleasant surroundings.

Research Department is located at Kingswood Warren, just off the busy A217 at Tadworth, Surrey. Set amid the homes of the affluent, the Department occupies about thirty acres of parkland. The main building, 'A' Block, is a Tudor-style mansion built in the 1830s and which has seen some notable owners in its time. These include Joseph Rank, founder of the milling empire, and Sir Cosmo Bonsor, a brewer and railway magnate who had a great hand in the extension of the local railway line from Tadworth to Tattenham Corner, to cater for the Derby Day crowds.

The BBC purchased Kingswood Warren in 1948, in a very dilapidated state as it had been neglected during the war and unoccupied since. After essential renovations, staff started moving in from their previous headquarters at Nightingale Square in Balham and from Bagley Croft, at South Hinksey near Oxford, where many staff had been evacuated following a narrow escape from a V1 flying-bomb which fell too close for comfort!

H L Kirke, who had been appointed Senior Development Engineer by John Reith in 1924 when the BBC was not yet a Corporation, became the first Head of Research Department when it was formally instituted in 1930. This followed the amalgamation of the original Research and Development Sections of Savoy Hill days. First located at Avenue House in Clapham, the new Research Department moved twice during the thirties, first to Nightingale Lane, Balham, and then to nearby Nightingale Square.

*A sketch of the mansion as it appeared about five years after it was built.*

In February 1949, Kirke moved to Kingswood Warren which then became the Department's official headquarters. In 1950, a new research block — 'B' Block — was completed and in 1961 an extension to the mansion was added enabling the last staff, Acoustics Section, to move to 'KW' from Nightingale Square.

It is against this background that the creative work of the Department continues. The remainder of this article gives a brief description of the various units within the Department together with examples of current activities at KW. Some of these may benefit listeners and viewers either immediately or in the very near future while others may not come into fruition until the late 1990s or even the next century.

## STRUCTURE

The current Head of Research Department is Dr Bruce Moffat, who reports to Deputy Director of Engineering, Charles Sandbank.

The Department consists basically of a research branch and a technical services/administrative branch, the total staff of 215 being divided approximately equally between the two. The research branch is divided into three Groups — Radio Frequency, Transmission, and Studio — and each of these has a number of Sections which are further subdivided for specific projects.

Colin Smith holds the post of Research Executive and is responsible to Bruce Moffat for Technical Services and Administration. He is supported by three managers: Head of Technical Services, Jim Pike; Administration and House Services Manager, Terry Leyland, and Computer Manager, Rex Lee. Colin also looks after financial matters and, in the absence of an on-station Personnel Officer, acts as the first reference point for Personnel matters.

The present structure of the Department is shown in the diagram overleaf.

# RESEARCH

As mentioned earlier, this branch comprises three Groups — Radio Frequency, Transmission and Studios.

## RADIO FREQUENCY GROUP

Headed by Dr Paul Ratliff, this Group is primarily concerned with radio frequency research and planning for the BBC's network of broadcast transmitters and its many links spanning radio cameras to satellite news gathering. It is divided into two Sections: Transmitters and Propagation, and Service Planning, many of whose members also get involved in national and international negotiations on frequencies and technical standards.

### Transmitters and Propagation

Peter Shelswell heads this Section which knows few bounds; it is currently concerned with antennas and propagation, SHF communication systems, satellite broadcasting systems and planning, transmitters and modulation systems, and RF hazards. The work covers the spectrum from LF to SHF but the Section has set its sights even higher on EHF.

### Service Planning

This Section is concerned with the coverage and planning of the transmitter networks that convey the BBC's output to viewers throughout the country and to listeners both at home and overseas. Headed by Bert Black, it is subdivided into five units dealing respectively with Television, Radio, Ancillary Services, Special Studies and Planning Resources. Many of its staff are engaged in travelling all over the country carrying out surveys and field strength measurements at existing and proposed transmitter sites.

The Section has built up a number of extensive databases and developed a major investment in propagation prediction programs, stored on the central VAX 11/750 computer. These aid in selecting the most suitable transmitter sites and technical characteristics, and in predicting service coverage.

## TRANSMISSION GROUP

An important part of broadcasting engineering is evolving methods of sending television and sound signals from studios to transmitters, from mobile locations to studios and within studio centres themselves. Methods of data broadcasting, the study of modulation systems, and the special advantages of optical fibres in the transmission of digital audio and video signals, are typical of the kind of research undertaken by Transmission Group under Howard Jones. The Group comprises three Sections: Baseband Systems, Carrier Systems and Data Systems and examples of the work of each are given below.

### Baseband Systems

Digital TV transmission, high definition television, video and audio bit-rate reduction, and optical transmission

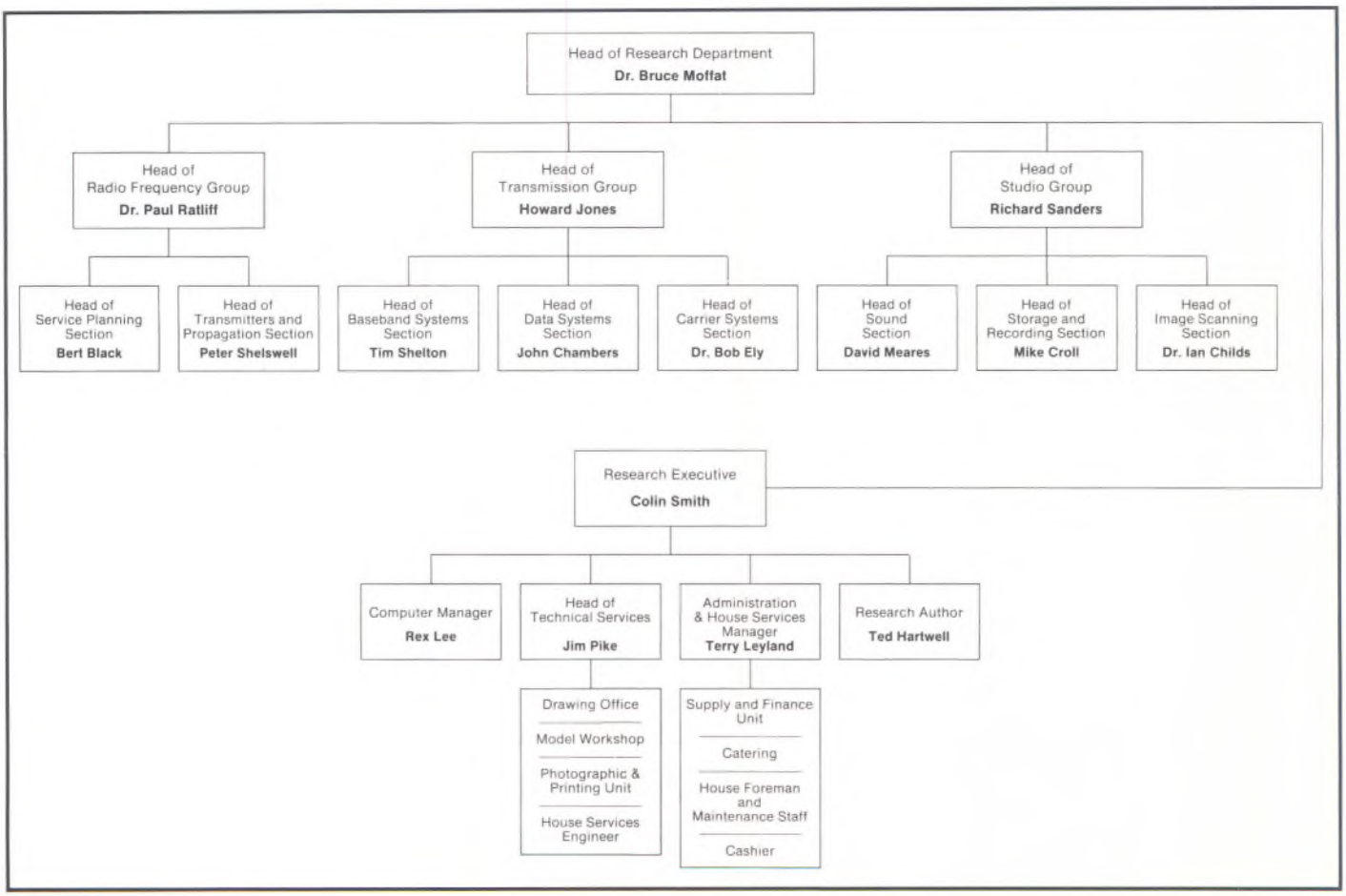



*Chart showing the present structure and senior staff at Research Department*

and routeing are some of the specialities of this Section headed by Tim Shelton. Participation in Eureka and RACE projects is a major aspect of the Section's work (as described later under 'Collaborative Research Projects').

### Carrier Systems

Conditional Access television and RDS are BBC buzzwords at the moment. Work on these, together with work on advanced modulation and coding, and digital stereo sound with terrestrial television (NICAM 728), are examples of the work currently being undertaken by engineers in this Section, under their head, Dr Bob Ely.

### Data Systems

Ceefax has been around for so long now that one may be forgiven for not being aware that continual improvements are being made to the teletext system. This, together with development of associated data systems, such as Datacast, and development of the Department's computer image-processing facilities, is the speciality of this Section under the direction of John Chambers.

***Microwave Antenna Range***

*Flat-plate antennas are being investigated as less obtrusive and more convenient alternatives to parabolic-dish antennas, for both DBS reception and microwave link use. Engineers Mark Maddocks and Chris Gandy are shown here conducting tests on a flate-plate antenna sub-array, using the Department's SHF measuring range which comprises a 90m line-of-sight path from the roof of the mansion to the measurement building across the open field.*

## STUDIO GROUP

Studio Group is concerned with those aspects of research affecting the programme origination end of the broadcasting chain. Example are: outside broadcast control vehicles and studios at local, regional and network production centres, including those for the World Service. Richard Sanders heads the Group which comprises three Sections: Image Scanning, Sound and Storage & Recording.

The Group has been exceptionally busy on the Eureka 95 HDTV project over the last year (see 'Collaborative Research Projects'). It acquired an old CMCR from Wales and converted it to HDTV, equipping it with camera and mixing facilities as well as digital video and audio recording and editing equipment. Special BBC recordings were made to the proposed 1250-line HDTV standard and successfully demonstrated in the Eureka pavilion at IBC 88 in Brighton and to President Mitterand in Paris.

### Image Scanning

Dr Ian Childs heads this Section which deals with picture origination and signal processing equipment such as television cameras, telecines and display devices.

The Section did a considerable amount of the original work on the line-array telecine which is now marketed by Rank Cintel. More recently it has been, and still is, heavily involved with work on HDTV systems.

### Sound

Studio acoustics, loudspeakers and audio signal processing are the main topics of research for this Section headed by David Meares.

Readers who have listened to programme output on LS3/5s, LS5/8s or LS5/9s owe a lot to the electro-acoustic experts, past and present, of this Section.

### Storage and Recording

Under its head, Mike Croll, this Section is primarily concerned with magnetic recording media and technology, digital record/replay processing and picture storage systems. It too has been greatly engaged in HDTV.

## RESEARCH PROJECTS

Here in more detail are some of the important research projects currently being undertaken in the Department.

### Two-channel Digital Sound with Terrestrial Television

The European system, now known as NICAM 728, is based on work done mainly in Baseband and Carrier Systems Sections over the past twenty years; Transmitters and Propagation Section also contributed important ideas. Last year, a full NICAM 728 specification was published jointly by the BBC, the IBA and BREMA.

At present, experimental stereo broadcasts are being made on BBC1 and BBC2 from Crystal Palace only. However, a programme of transmitter refurbishment is currently being undertaken by our colleagues in Transmission Engineering Department. The aim is to provide 70% coverage of the UK population by 1991, when a full service will begin.

Many other countries have adopted or are considering the NICAM 728

system for their own use, including Sweden, Finland, Denmark, France, Spain, New Zealand, Yugoslavia and the People's Republic of China.

## Radio Data System (RDS)

The BBC RDS service, another production of Carrier Systems Section, was publicly launched at the BBC Radio Show in Earls Court last November. RDS is the system in which an additional subcarrier is added to BBC FM broadcasts to enable the transmission of data to 'intelligent' receivers.

Two of the main purposes of RDS are to enable drivers to have their receiver automatically retuned to the strongest transmitter radiating the selected programme, as they move from area to area, and to provide them with travel information relevant to the area in which they are driving. Ways of enhancing this latter feature are being studied by the BBC within the EEC's DRIVE programme (Dedicated Road Infrastructure for Vehicle safety in Europe).

It is hoped that receiver manufacturers will soon make RDS receivers more readily available to the public and will eventually show interest in a receiver with BBC badging.

## Conditional Access Television

Carrier Systems and Data Systems Sections are busily working on Conditional Access Television, which will enable the BBC to transmit enciphered vision, sound and data signals to authorised subscribers only. The BBC, in conjunction with British Medical Television, is currently operating a two-year broadcast-to-VCR 'downloading' experiment, during the night. The recent White Paper on Broadcasting envisaged the extension of such services.

Whilst the viability of replacing the licence fee with a subscription-funded public service is still open to question, the BBC is anxious to expand its conditional access services. This includes the possibility of a subscription HDTV service in the latter part of the nineties.

## Digital Video Recording

The Department now has four Sony D1, digital component, video tape recorders which Storage and Recording Section is using mainly ganged for HDTV. The four recorders were successfully used in the Eureka 95 HDTV demonstrations at IBC 88 and elsewhere.

Special multiplexing equipment has been designed by the Section to enable the four machines to record and play back the 1250-line, 50-field, 2:1 interlaced HDTV signal. It enables each recorder to copy and edit one quarter of the picture information at a time, without any significant generation loss.

The source HDTV picture first is demultiplexed such that successive groups of four pixels, from the even lines, are alternately recorded on machines A and B. Similar groups of pixels from the odd lines are alternately recorded on machines C and D.

This interleaved format allows a valid 625-line picture to be viewed from any of the four recorders, albeit at reduced resolution. It also means that this signal can be distributed within a studio using a normal 625-line routeing system to provide a 'confidence' picture for other studio staff.

On playback, the alternate groups of pixels and lines from the two pairs of machines are then multiplexed to restore the HDTV picture.

## Computer Image Processing

The study of different television systems nowadays is generally easier to do by computer simulation than by building dedicated hardware that may lead to no satisfactory result. Data Systems Section in conjunction with Computer Manager is engaged in developing the Department's computer image processing facilities which allow such study. Digital and analogue television signals, in both component and composite form, as well as audio signals can be processed using this equipment.

At present, the semiconductor storage capacity of the processor can accommodate either 5.6 seconds of 625-line television signals, digitally encoded according to CCIR Rec 601 or, with the aid of a multiplexer now being prepared, 2.4 seconds of RGB HDTV signals, sampled at 72 MHz. Interfaces are being provided to enable transfer to D1-standard digital video recorders.

A two-fold improvement in processing time has been achieved by using a Meiko transputer array. Work continues towards running many transputer processors in parallel and a ten-fold speed increase, at least, is envisaged.

***HDTV Mobile Laboratory***

*A view of the Production Control area inside the refurbished redundant OB vehicle, now equipped as a mobile HDTV production facility/laboratory. The vehicle was successfully demonstrated at IBC 88 as part of the Eureka 95 display and has been used for some notable OB events since, including this year's FA Cup Final at Wembley. Alastair Bruce is pictured controlling the four D1 digital VTRs, used in combination to record and reproduce HDTV pictures.*

## Digital Audio Editing

Editing staff in Network Radio and News & Current Affairs are building up their experience of using digital audio editing equipment, originated by engineers in Sound Section. The equipment enables editors to make complex edits quickly; some of these edits would be very difficult or excessively time-consuming in the analogue domain. Further development continues and a collaborative deal with a commercial manufacturer promises further enhancement of digital audio editing.

## Studio Acoustics

Sound Section provides a continuing advisory service to the output directorates on all aspects of acoustics. Much research goes into predicting how new studios, for example the new theatre in Television Centre Stage 5 development, will behave when completed. This calls for close cooperation with Architectural and Civil Engineering Department as well as with colleagues in programme making and resource operations.

The past year has seen the culmination of a major acoustic project at Research Department itself, with the completion of the Acoustic Transmission Suite. This is a purpose-built laboratory, principally for the measurement of sound insulation. It comprises a source room and a receive room, between which studio partitions, windows, etc, may be erected and their transmission properties measured. Each room can be independently used as an ISO standard reverberation room, when not being used for transmission measurements.

## Outside Broadcast Links

Transmitters and Propagation Section has been busy on two OB fronts; firstly on a helicopter-tracking radio-camera link, known as Helitrak, and secondly on the design of radio-camera antennas for backpack use, at 2.5 and 12 GHz.

In the Helitrak system, television signals from a helicopter are tracked automatically by means of a receiving dish mounted on a tripod. The television signal itself is used to control the servos driving the tracking mechanism, so that the dish always points at the helicopter. This was successfully used experimentally at the Boat Race in April.

The 2.5 GHz radio-camera antenna is an omnidirectional, circularly-polarised, type which has excellent multipath immunity and has been used very successfully at several major sports events. At the time of the Seoul Olympic Games, it became apparent that only 12 GHz radio cameras would be available to the BBC. As a switched six-horn type antenna was only in its early development stage, it was necessary to come up with an alternative solution very promptly.

In the event, a ring of cross slots choked and fed by a circular waveguide was produced just in time and proved highly successful. Whilst the existing designs are being exploited commercially, work continues on the switched-horn system, which is expected to give even more dependable performance at an economic price.

# COLLABORATIVE RESEARCH PROJECTS

Although the Department's prime function is dedicated to serving its customers in the programme and transmission departments, a great deal of work is now undertaken in collaborative projects with partners in Industry at home and abroad. Such collaboration yields valuable income to the BBC and is sometimes undertaken in conjunction with Design and Equipment Department and BBC Enterprises.

Many pieces of equipment originating from Research Department designs are now manufactured under licence. One example is the Rank Cintel Slide File/Art File family.

## Eureka HDTV

Undoubtedly the most significant work the Department has been engaged in during the past year is in connection with the Eureka 95 MAC-compatible High Definition Television project, the highlight of which was the HDTV demonstrations at IBC 88 in Brighton, last September. This project, being undertaken with British and European partners, is aiming to achieve a working European HDTV system by the early nineties.

Research Department played a key role in the infrastructure and programming of the IBC 88 demonstrations themselves and one of our bandwidth-reduction algorithms with Digitally Assisted Television (DATV) was chosen for the HD-MAC compatible system. Many sections of the Department were engaged in achieving this highlight, but particularly Image Scanning and Storage & Recording, along with the Model Shop. Many staff will continue to be involved on this project throughout the coming year.

## Eureka DAB

Another Eureka project (No 147) in which we are involved has shown substantial progress towards Digital Audio Broadcasting (DAB). This has shown that not only digital audio quality but also about four times the spectrum efficiency of FM can be obtained; such a goal is highly desirable in the age of Compact Disc. The RF work is undertaken by Transmitters & Propagation and Service Planning Sections, and the audio work by Baseband Systems Section.

## RACE

The Department participates in several RACE projects — **R**esearch and development of **A**dvanced **C**ommunications-technologies in **E**urope. The one which the Department leads (Project No 1036) is that to develop a WTDM Broadband Customer Premises Network, this work being done by Baseband Systems Section.

WTDM is a combination of optical wavelength division multiplexing (WDM) and electrical time division multiplexing (TDM). It is a system using electro-optic technology to enable the routeing and switching of digital audio and video signals in future all-digital studio centres.

The WTDM system under consideration uses a 'standards independent core' based on the synchronous multiplexing hierarchy recently specified by

the CCITT. Blocks of data will be assembled at multiplexes of 155 Mbit/s and a 2.5 Gbit/s multiplex will be conveyed at each of sixteen wavelengths. The system is compatible with HDTV. A demonstration showing the principles of WTDM on optical fibres was given on the BBC stand at IBC 88 and attracted wide interest.

Although not led by RD, the RACE HIVITS Project (No. 1018) demands even more effort than WTDM; it is aimed at video and audio bit-rate reduction and is pursued by Baseband Systems Section.

### Frequency Planning

Research Department has also undertaken frequency planning work for the Department of Trade and Industry and the Home Office: (i) in connection with additional television services — the so-called Fifth and Sixth Channels — in the VHF and UHF bands, and (ii) in connection with Band II Community Radio frequencies, particularly difficult in the London area.

## MISCELLANEOUS RESEARCH ACTIVITIES

A few activities not covered in the previous sections are nevertheless important aspects of Research work — Representation, Patents and RD Reports.

### Representation

Much time is devoted to work on International Standardisation and many of the Department's senior engineers represent the BBC, and sometimes the UK, on national and international committees such as those within the EBU, AES and ITU (WARCs, CCIR and CCITT). This often necessitates trips abroad and whilst it does interrupt the normal work of the Department to some extent, it enables BBC Engineering to continue to be seen at the forefront of broadcasting engineering advancement.

### Patents

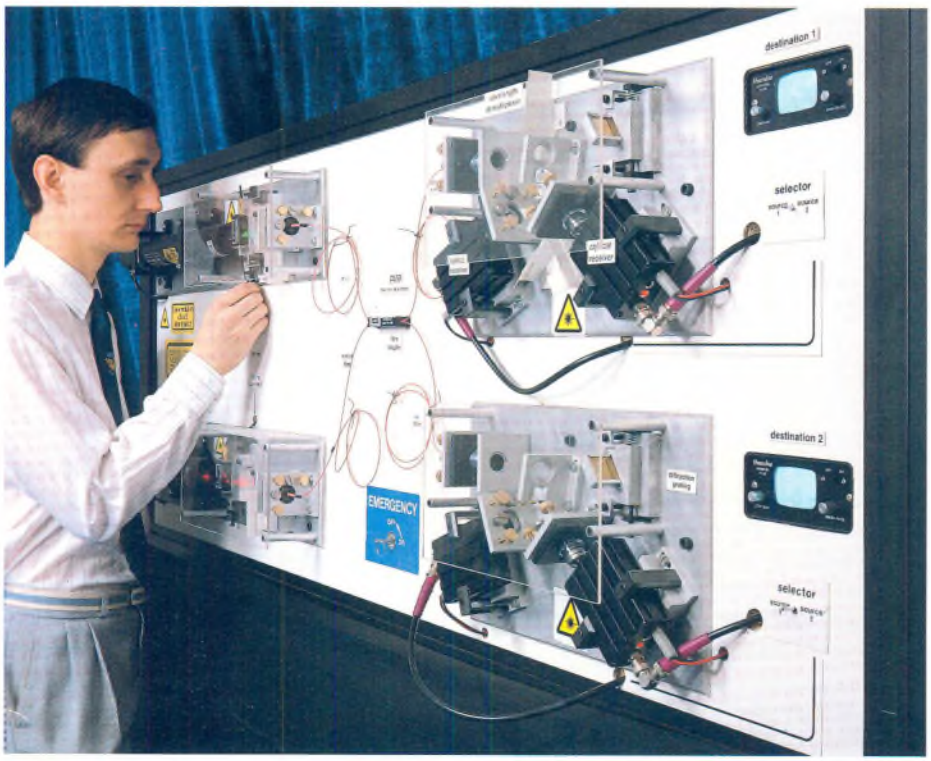
Research Department engineers are encouraged to patent their ideas and over the last ten years approximately twenty patent applications a year have been submitted. Of these, a rising average of thirteen are granted annually.

### Research Department Reports

Research Department Reports are written and produced to a high standard and are widely accepted as being of an authoritative nature.

The first RD report was published in 1933. Today, about 20 are published annually and distributed to research and industrial organisations, academic establishments and libraries throughout the world. Virtually all RD Reports are non-confidential and copies may be requested by contacting Mrs Anne Bennett on KW Extension 303.

In addition to the formal Research Reports and the confidential Annual Report, the Department publishes an annual illustrated Research Review covering the work of the previous year. This is widely circulated both within and outside the BBC. Hundreds of Technical Memoranda, Acoustic Surveys and Service Planning Notes are also produced but they have a limited distribution; a few dozen papers are published externally in journals and conference proceedings.




***WDM Demonstration Equipment***

*A model to demonstrate WDM principles used in the WTDM RACE Project 1036 was shown at IBC 88 in September. John Zubrzycki is shown here adjusting a green laser, which transmits one video signal, while a red laser below transmits a second video signal. An optical fibre from each takes the separate signals to a small fibre coupler in the centre of the panel where they are combined, i.e. wavelength-division-multiplexed.*

*The multiplexed signals then continue through more optical fibre to each of two wavelength demultiplexers shown on the right. A diffraction grating in each separates the beams and directs them towards photodetectors which enable the separately recovered signals to be displayed on the two mini-monitors at the extreme right; destination control is implemented using a switch located below each monitor.*

*The model is also being demonstrated at P&ID Tel Seminars at Wood Norton*

## RECRUITMENT AND TRAINING

A continuing intake of new talent is an essential ingredient for the healthy future of the Department's research work and each year a number of new graduate recruits join us.

Graduate Trainees are recruited at around age 21-22. They spend an eighteen-month training period, including a residential course at Wood Norton, gaining experience in different research sections before expecting to be promoted to the post of Research Assistant. Graduates who have done some post-graduate research are recruited directly as Research Assistants at around age 24-26. The Department also offers Sponsored Studentships as well as mid-course Industrial, Vacation and Pre-university Traineeships.

Numerous internal and external training courses are undertaken by staff at various stages of their career.

## QUEEN's AWARDS

The Department has received four Queen's Awards for Technological Innovation: in 1969, 1974, 1983 and 1987. These were for its work on the Field Store Standards Converter (with Designs Department), Sound-in-Syncs (with Designs Department), teletext (with the IBA) and LF Radio teleswitching (with the Electricity Supply Industry) respectively.





# TECH SERVICES and ADMIN

As mentioned earlier, Colin Smith — the Research Executive — heads this branch of the Department. It comprises three main sections: Technical Services, Computing Facilities and Admin & House Services.

## TECHNICAL SERVICES

This section comprises nearly 50 staff headed by Jim Pike and is divided into the following units:

### Drawing Office

The Drawing Office has eight draughtsmen and three drawing office assistants headed by Harry Willard. All the draughtsmen are trained in the use of and have access to CAD facilities. These are used mainly to prepare drawings and computer data for printed circuit boards which are generally manufactured in-house, in the Model Workshop.

The Drawing Office assistants work mainly on the production of circuit diagrams, graphs, histograms, maps, etc, for Research Department Reports, Technical Memoranda, and published papers. They also prepare antenna radiation patterns and transmitter coverage maps for Service Planning Section and artwork for lectures and demonstrations.

### Photography and Printing

David Jones heads this unit which employs three photographers, a specialist typist who operates the Department's in-house phototypesetter, and four print room staff. The unit is kept busy throughout the year undertaking various photographic assignments and typesetting, printing, collating and binding the Department's output documents.

### Model Workshop

The Model Workshop is housed in what was originally the stable block and which was occupied by Canadian troops and later the Home Guard during the second world war. It has nineteen staff and is comprehensively equipped to provide a full supporting role to engineers in the manufacture of not only prototype, but occasionally service equipment as well. When there has been spare capacity, the Workshop has been able to make items for other BBC departments.

### House Services Engineering

House Services Engineer, Eddie Cole, is responsible for the essential services, for new building work and for the major maintenance of the premises; health and safety precautions are of special concern to him. He has recently been heavily involved with ACED and outside contractors in the construction of the Acoustic Transmission Suite mentioned earlier.

## COMPUTING FACILITIES

Rex Lee, Computer Manager, is in charge of the Department's central computing facilities. These comprise a VAX 11/750 minicomputer, a number of MicroVAXs and peripherals, networked in a multi-user environment. In addition, a powerful picture-processing system is being developed in conjunction with Data Systems Section using a Meiko parallel-processing computer which exploits transputers.

Apart from the central computing facilities, each Section has one or more software laboratories equipped with terminals which can access the central facilities over a low-speed Multilink network. Additionally, there is an ever-growing number of workstations and stand-alone microcomputers used for solving engineering problems, software development, experiment control and data logging, report writing, etc.

## ADMIN AND HOUSE SERVICES

No department can run without the support of its administrative staff and Research Department is no exception. Much of the work is often unnoticed or taken for granted, but would be quickly missed if it were not done. Terry Leyland

is in charge of this section which includes Supply and Finance, Catering, premises maintenance, Telephonists and Cashier. He is also responsible for providing secretarial staff and is the Department's safety representative and Library liaison manager.

### Supply and Finance Unit

Peter Bing heads this unit comprising the Stores, for the ordering, invoicing and supply of technical and general items, and the Accounts and Allowances offices. The unit also handles the interchange of management information to and from KW and Engineering Accounts via EMIAS at Sulgrave House.

## LIBRARY

This is one of a number of library and information units forming part of BBC Data and is the BBC's principal engineering library. Its use is not restricted to Research Department and anyone within the BBC may make use of its services.

There is a comprehensive collection of books, reports and periodicals in the fields of radio and television engineering, communications, electronics and computing, and access to other BBC and non-BBC libraries is offered as part of the service, as is in-depth literature searching.

At the moment an important task for Angela Goldfinch, the Subject Specialist in charge of the Library, is compiling a database of the many Research Department Reports and Technical Memoranda issued annually and dating back many years. This will enable engineers to locate relevant reports on a given subject quickly.

Anyone requiring more information about the Library's services should contact Angela Goldfinch on KW Extension 205.

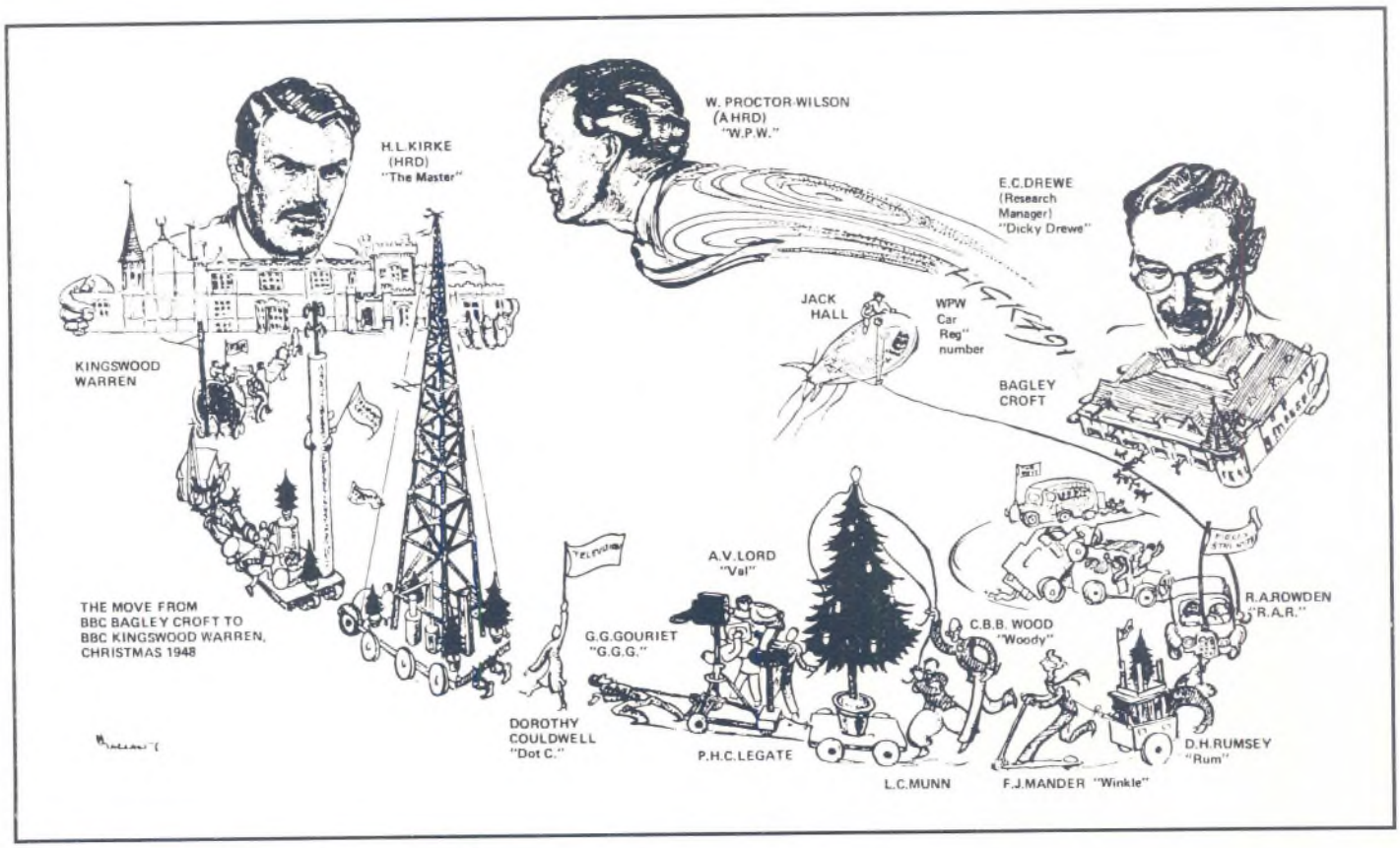
## BBC CLUB

There is an active Group of the BBC Club here and, because Kingswood Warren is blessed in having superb grounds (an essential laboratory as well, of course), staff can participate in a multitude of activities during the lunch break or 'after hours'. Croquet is perhaps the most unusual activity but putting, archery, tennis, badminton and several others are also practised. For those of a more energetic nature, the Horticultural Section's allotments often need digging, planting, weeding, etc.

## CODA

Research Department is always looking for engineers with appropriate qualifications/experience, especially Laboratory Engineers, who make prototype equipment and who generally provide support to research teams. Any engineer interested in coming to work at Kingswood Warren should get in touch with Colin Smith on KW Extension 224.

A two-page leaflet has been produced which gives a brief history of Research Department: copies can be obtained from the Research Author in Room A120, Kingswood Warren (Tel: 207). Anyone wishing to delve deeper into the history of the Department should refer to 'BBC Engineering, 1922-1972' by Edward Pawley.




*This cartoon was drawn at the time by talented draughtswoman Margaret Gallant. It illustrates some of the Department's personalities, including two subsequent HRDs, involved in the move from Bagley Croft, near Oxford, to Kingswood Warren in December 1948.*

# WOOD NORTON — new audio facilities

Part of the commitment of the Audio Operations Unit at Wood Norton is to provide training for Studio Managers and Audio Assistants, both in London and the Regions. In support of this commitment, an MBI Broadcast Systems, Series 24D sound desk was installed in Studio 8, shortly after Easter. Many of you will remember the Studio 8 area as the old 8-track recording studio in Wood Norton Hall, previously called 'Studio 1'.

*L to R: Lecturers Steve Jones, Lloyd Silverstone and Jill Diver with the MBI desk*

Nowadays, the trend is towards buying off-the-shelf equipment and the MBI desk is a splendid example of how to arrive at a complete installation, by buying a series of slot-in modules to provide the facilities required. Our final complement consists of:

— 4 mono microphone/line level modules

— 8 stereo line input modules

— 1 stereo outside source module

— 1 telephone control and balance unit

— 4 stereo group modules

— 1 stereo main output module

With the move toward single-operator sound desks in many areas (such as the recent MBI installations in London BH Studios 5C, 5D and 5E and also the announcer-operated continuities at BH Glasgow, serving Radio Scotland), it was decided that the equipment should be arranged so that it is easy to operate from the centre of the wrap-round mixing console. To aid this, all the replay sources have a remote Start and Stop facility, from either buttons on the desk or via fader Start options.

The channel inputs are configured for quick and easy use, all being normalled to the various replay sources which include two Technics SLP 1200B CD players, two EMT 938 gramophone decks, a Sonifex $\frac{1}{4}$ inch cartridge machine, three Studer A810 $\frac{1}{4}$ inch tape machines and up to four studio microphones. However, for those occasions when there is the requirement for an extra person to play in tapes and swing in discs, the facility of over-plugging the EMTs with stand-alone RP 2/9 type gramophone decks is also available.

Without going into too much detail, other extras include a Yamaha SPX 90 artificial reverberation unit, two Rane PE 15 parametric equalisation units and a Gemini Easyrider compressor/limiter, all mounted in a plinth situated to the left of the desk. This, we felt, was a better solution to mounting the effects units than a rack above the meter hood, which can be quite a stretch when seated and also ruins the eye contact with the Studio Presenter. The effects units fixed in the plinth are therefore within easy reach of the operator. The inputs and outputs of these devices are available on a jackfield just underneath the EMT 938 gramophone decks.

As very little plugging of sources is required, the main jackfield bay is at the back of the cubicle, out of the way of the Operators and the Producer. The only piece of equipment in the bay that is used on a regular basis is a German-made ASC three-head cassette machine, capable of being fully remote-controlled from the mixing console.

With about 21 sq metres of floor area in the studio, the installation is very versatile and will be used for operational training in many programme types and styles. These will range from simple editing sessions to disc and tape compilation programmes, or even small drama productions if the need is there.

Already the indications are that this is going to be a very popular area for the many Audio courses that pass through Wood Norton, at both introductory and qualifying levels.

May I express my thanks to Chris Tunstill and John Fabrizi at Wood Norton, who did the local wiring installation in a very short time, and also to the installation engineers at MBI for providing a desk that slotted together with very few hassles and headaches.

Steve Jones, Lecturer
Audio Operations, ETD

# RADIO OBs — new satellite link

**As featured on page 1, Radio OBs has taken delivery of a new satellite link system. Here, Simon Shute describes the advantages of the new system and Nigel Adams outlines how it works:**


*The transportable up-link, as rigged for tests at Concord Road in mid-June. In normal use, the dish aerial and associated equipment will sit on the tailgate of the OB vehicle shown.*

A dream of several years standing has been realised with the successful commissioning of the transportable satellite up-link for Radio OBs.

Ever since satellite technology stopped being the exclusive preserve of the world's telecommunication authorities, with their massive 30 m dish aerials, the prospect of arriving on site, pointing a dish skywards, and immediately receiving a perfect stereo signal in BH control room has seemed tantalisingly possible. At last, thanks to the efforts of many people in several BBC Engineering departments, all the technical and administrative difficulties have been overcome, and the dream is as near a reality as we could have reasonably expected.

The use of a satellite link for OBs may not seem very new. The radio situation is however significantly different from television in a number of ways.

(i) The much smaller bandwidth required means that satellite capacity is much cheaper than for TV. The costs of setting up terrestrial links are much the same for either.

(ii) There is no straightforward way of setting up stereo OBs for Radio. Various techniques have been used over the years, all of which have had their disadvantages.

(iii) The system we have now installed uses a receiving dish on BH itself, thus avoiding the need for any terrestrial circuits. This, in turn, further reduces the costs.

Radio expects to use the new satellite system as the first choice for the provision of a stereo OB circuit. It is planned to use it on average three times a week, rather than for the occasional 'special' which would be the case with Television.

Simon Shute
General Manager
Ops and Eng, Radio

*Broadcasting House with the 3 m receiving dish top right, next to a 1.8 m experimental dish.*

## How it works

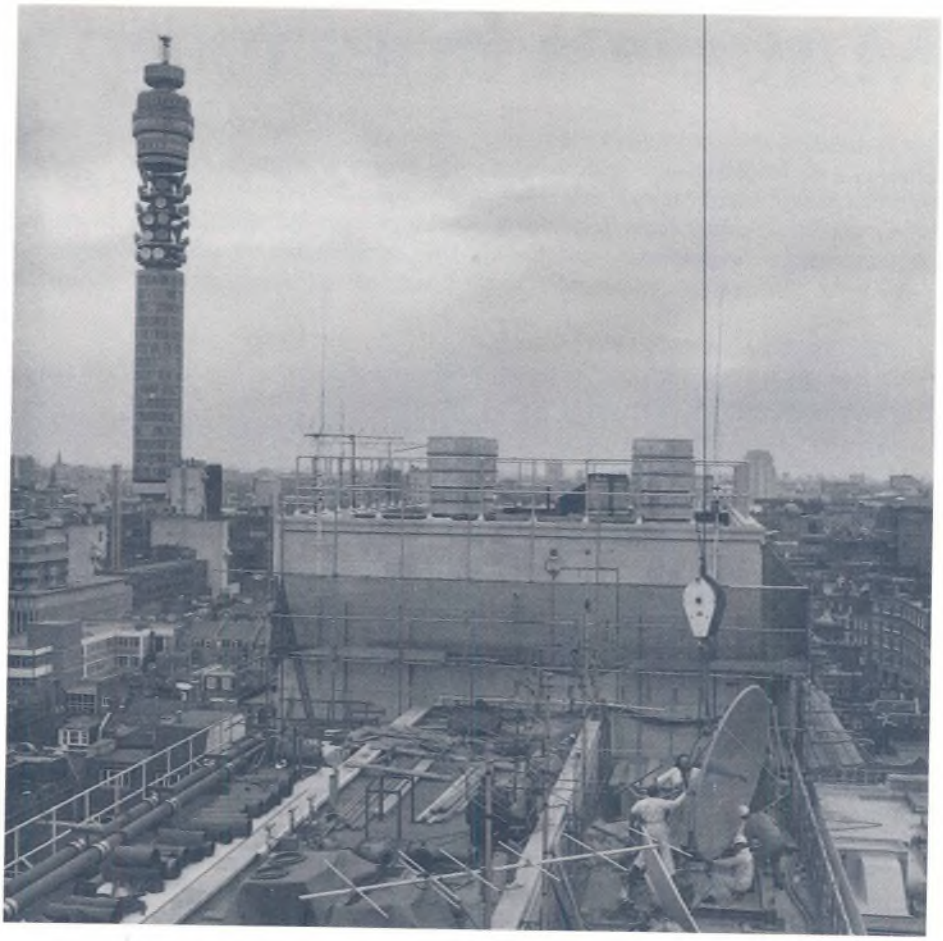
At an OB site, the stereo signals are digitally coded to the DS1 standard, recommended by the EBU, which comprises a bitstream at 1024 kbit/s. A digital modulator then converts the DS1 signal to a 2048 kbit/s QPSK signal, on a carrier frequency of 70 MHz. This in turn is upconverted to the final output frequency of 14.5 GHz and amplified to provide 300 watts of rf power into a 1.9 m dish antenna (eirp = 70.5 dBW).

The down-link signal from the satellite, at 11.1 GHz, is received on a 3 m dish aerial at Broadcasting House. A low noise converter, mounted at the receive antenna, amplifies and converts the incoming signal to 1.1 GHz which is then carried by co-axial cable to the first floor Apparatus Room, to be converted to a 70 MHz signal. Finally the 2048 kbit/s QPSK signal is demodulated to a 1024 kbit/s bitstream, from which the DS1 decoder produces the stereo audio signal.

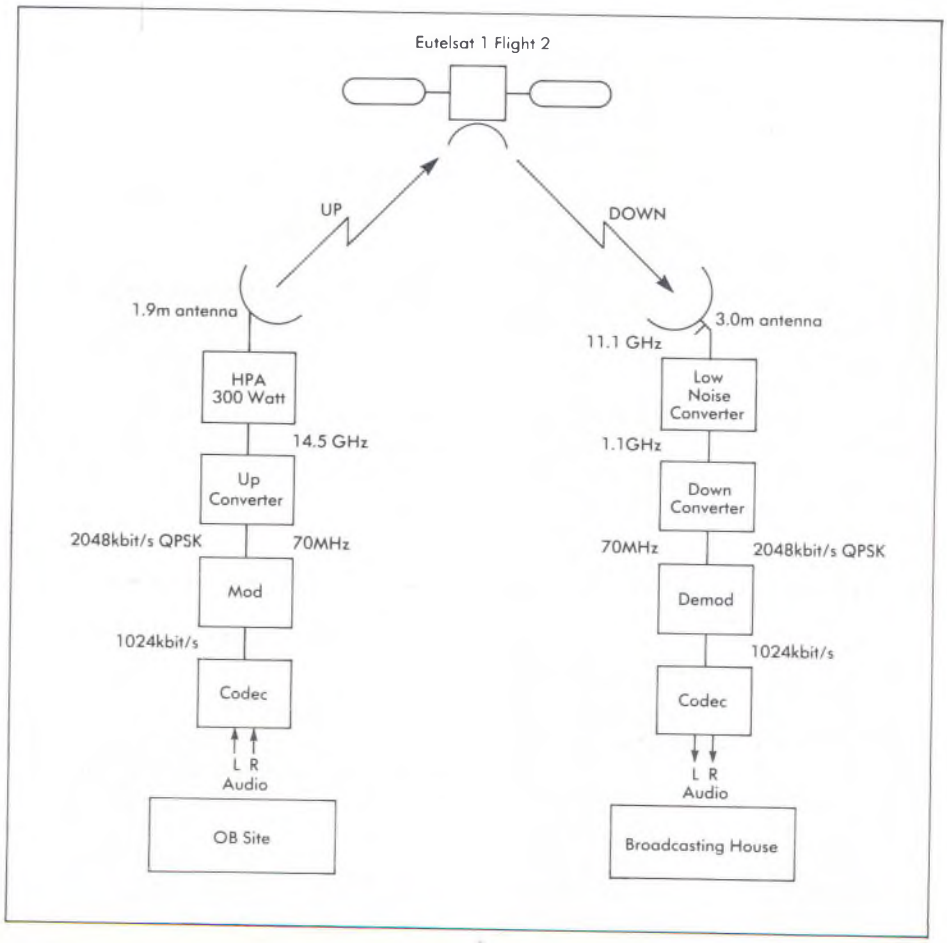
The doubling of the bit-rate from 1024 to 2048 kbit/s, for transmission through the satellite link, allows the decoder to provide a considerable amount of error correction on the received bitstream. Thus, the system is able to operate at very low carrier-to-noise ratios. It is also capable of carrying a Nicam 676 kbit/s signal, as an alternative to the DS1 system.

The system was selected by Transmission Engineering Department and consists of various units from different manufacturers, too many to list here. However, the main equipment — the up-link terminal — is a Mantis 1900, supplied by Advent Communications of Chesham, Bucks, who also supplied and supervised the installation of the 3 m dish at Broadcasting House.

Nigel Adams, Project Leader
Transmission Engineering Department



*A giant mobile crane lowers the 3 m dish onto the roof of BH.*




*Block diagram of the satellite link.*

# MAC — a brief recap

Many by now will be familiar with the MAC signal, its background and future role in satellite broadcasting. For those who are not, the following brief summary might be helpful.

## Background

The 1977 World Administrative Radio Conference (WARC) set a channel bandwidth of 27 MHz for direct broadcasting by satellite (DBS). Although their considerations were based on the use of the established PAL and SECAM systems for colour television, DBS clearly provided the opportunity to introduce a new system which could offer improved quality. Alternatives to PAL and SECAM were permitted by WARC 77 — provided they produced no greater problems of co-channel and adjacent channel interference than the established encoding systems.

In 1982, the Part Committee in the UK adopted the Multiplexed Analogue Component (MAC) system for British DBS. Pioneered by the IBA, MAC time-compresses the analogue colour-difference information and the luminance information, such that they can be transmitted in sequence on a television line. This time division multipex, by separating colour and brightness in the time domain, avoids the problems of cross colour and cross luminance, to which the PAL and SECAM systems are both prone. (PAL and SECAM combine the chrominance and luminance information by using a frequency division multiplex technique).

In the MAC system, time compression — achieved by sampling and storing the analogue signal at one rate and reading it out at a faster rate — increases the bandwidth of the signal. The overall bandwidth requirement is reduced however by exploiting the eye's lesser need for chrominance information, by transmitting components on alternate television lines of a conventionally scanned picture.

Time compressing the luminance information by a factor of 3:2 and the chrominance information by 3:1 was found, in terms of picture quality, to offer the best utilisation of the line period. This results in the luminance and chrominance components taking up about 34.7 and 17.3 µs of the 64 µs line period, respectively.

# C-MAC

Starting from MAC, the European Broadcasting Union (EBU) has developed the C-MAC packet system which, in addition to the vision signal, provides for a variety of digital sound and data services. The sound and data signals are integrated within the line period as shown in figure 1.

C-MAC uses an instantaneous data rate of 20.25 Mbit/s, giving an overall data rate of about 3 Mbit/s. In the absence of picture information, the whole line can be used to carry data and this gives an overall data rate of 20.125 Mbit/s.

It is often convenient to imagine the whole line being sampled at a rate of 20.25 MHz, dividing each line into 1296 samples of length 49.4 ns (totalling 64 µs). On waveform diagrams which describe the various C-MAC packet variants, the time axis is usually calibrated in terms of these notional samples.

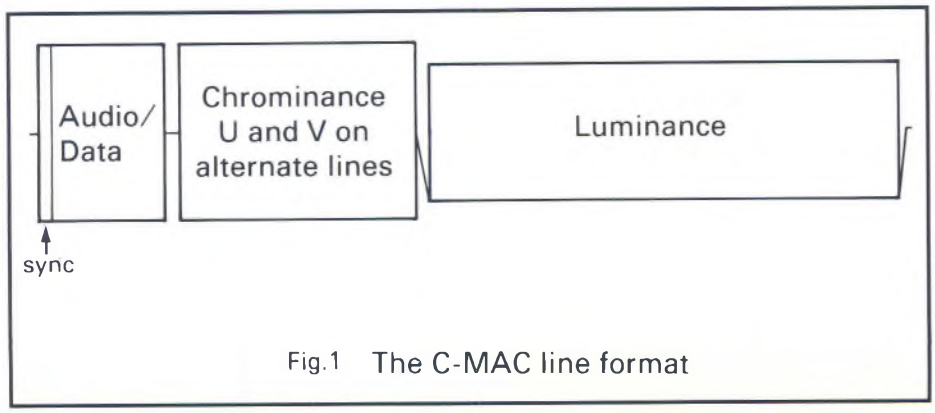



Fig.1 The C-MAC line format

The choice of 20.25 Mbit/s eases the conversion, in both directions, of C-MAC packet signals and those conforming to the studio digital video standard, CCIR Rec 601. (If 20.25 MHz is reduced by the compression ratios used by C-MAC for luminance and chrominance (ie 3:2 and 3:1), it gives 13.5 MHz and 6.75 MHz, which are the sampling rates specified by Rec 601 for the luminance and chrominance information).

In the C-MAC packet system, the carrier is modulated with an RF multiplex of the sound/data and vision information. During the sound/data period, 2-4 phase shift key modulation is used. (In this method, ones and zeros are represented by carrier phase shifts of +90° and −90°, respectively.) During the period when the luminance and chrominance information is being transmitted, frequency modulation of the carrier takes place.

C-MAC supports the equivalent of eight 15 kHz wide, high quality, sound channels but there is great flexibility in what sound or data services can be provided.

# D-MAC

D-MAC is a variant of the system in which the sound/data packet is 'duobinary' encoded (see next paragraph). The data signal is time-division-multiplexed at baseband with the compressed vision information and the whole signal is frequency-modulated on to the RF carrier. Thus a single FM demodulator can be used in the receiver to recover both the compressed vision and data signals.

Duobinary encoding makes use of three levels which may be designated +1, 0 and −1. All incoming zeros are encoded as the middle level (0) while incoming ones are represented either as the highest or lowest level (+1 or −1) as follows:

— Where there has been an even number of zeros between an incoming one and the previous one, it is represented by the same level (+1 or −1) as was used to encode the previous one.

– If the number of zeros between the ones is odd, the incoming one is represented by the opposite level.

An example is shown in figure 2.

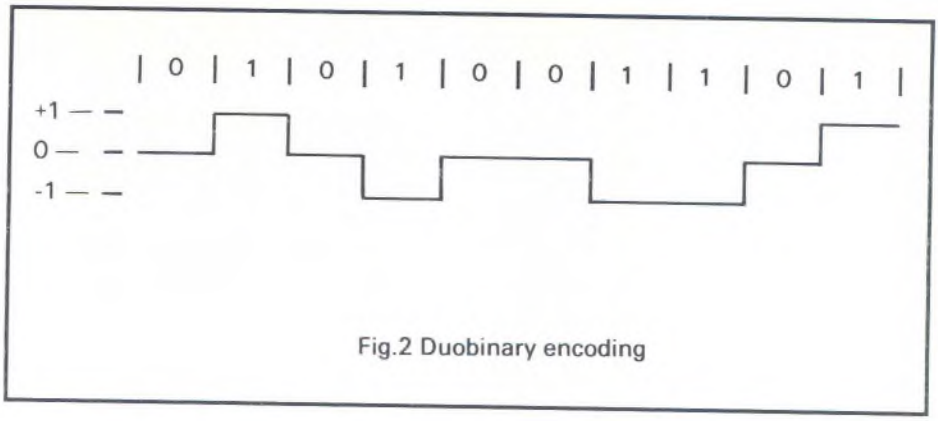


Fig.2 Duobinary encoding

While marginally less rugged than a straightforward binary system, duobinary encoding enables the bandwith requirement of the sound/data information to be reduced.

D-MAC also uses an instantaneous sound/data rate of 20.25 Mbit/s with a burst of data, 206 bits long, on each line.

Following a run-in bit, there is a six bit synchronisation word, whose function is to establish line synchronisation and to identify which of the two colour difference components is carried on that particular line.

The following 199 data bits are divided into two equal blocks of 99 bits plus one spare bit at the end. Dividing the active data on each line in this way generates two sub-frames of equal size when looking at a full picture. This structure eases conversion to D2-MAC, discussed in the next section.

Line 625 carries no picture component but carries 1296 bits of data including frame synchronisation data, time and date information, satellite position and data defining the overall configuration of the sound/data packet.

As with C-MAC, D-MAC has the data capacity to support eight high quality sound channels. A wide range of options exist on how data capacity can be used, including the possibility of teletext and other data systems as well as over-air addressing for conditional access systems. Full or half bandwidth, mono or stereo, sound channels can be supported using either linear or NICAM encoding. D-MAC is capable of supporting different expansion ratios, enabling pictures with a 16:9 ratio to be transmitted.

D-MAC will be used by British Satellite Broadcasting (BSB) on its DBS satellite, due to enter service next spring, and by the W H Smith channels which are scheduled to be transmitted by the Astra satellite in due course.

D-MAC also, most importantly, provides the evolutionary path to the compatible high definition television system being developed by the Eureka 95 project, to which the BBC is making a significant contribution.

# D2-MAC

Despite the saving introduced by duobinary encoding, the bandwith of D-MAC is still too high to be carried by many existing European cable systems. It has a vision bandwith of 8.5 MHz and, if transmitted by the standard AM vestigal sideband method, an RF channel bandwidth of 10.5 MHz is required.

To enable cable systems to carry DBS signals, a variant called D2-MAC was devised in which the sound/data packet uses a rate of 10.125 Mbit/s, ie half that of D-MAC. This of course reduces the system's capacity, providing the equivalent of only four high quality sound channels, but does enable the signal to be accommodated using an AM vestigal sideband on a channel with 7 MHz bandwidth.

The D2-MAC sound/data packet is similar to that of D-MAC but, following the run-in bit and synchronisation word, it has a single active data block on each line of 99 bits. Transcoding to D2-MAC from D-MAC can be achieved by discarding one of the two D-MAC sub-frames.

# A-MAC

This is an early variant of the system where the sound/data services are combined with the basic C-MAC picture information at baseband, using frequency-division-multiplexing. A digital data sub-carrier at 7.16 MHz is modulated with the sound/data information and is added to the C-MAC luminance and chrominance information which occupies about 6 MHz.

# B-MAC

B-MAC also adds the sound/data packet to the basic MAC picture information by means of a time division multiplex at baseband. However, a multi-level code is used for the sound/data packet which reduces the overall bandwidth requirement of the signal to about 6 MHz, at the cost of having a lower noise immunity for the sound/data packet.

The overall data rate is lower than with D-MAC. However, B-MAC is useful for satellite transmissions which are to be distributed terrestrially using conventional UHF transmitters, microwave video distribution systems (MVDS) or cable, without the need for transcoding prior to distribution. The system has found application in Canada and Australia.

# S-MAC

This is a studio-based variant of the system which was devised to enable Rec 601 digital component signals to be routed through an analogue distribution system. S-MAC multiplexes the Y, U and V components on each line and also maintains the sync-and-burst of the composite signal. The compression used by S-MAC results in the signal having a bandwidth in excess of 11 MHz.

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# N&CA — 3D graphics

The 3D Graphics operation at Television Centre is really getting underway now, as witnessed during our coverage of the Euro-elections in mid-June. Based on the BBC's exit poll and Euro results as they came in, the presenter, Peter Snow, was able to project how the Euro voting patterns, if repeated at a General Election, would affect our representation in the House of Commons.

Some of these graphics involved the computer construction, in three dimensions, of the interior of the House of Commons. These images were then used as a backing for real-time 2D graphics, constructed by the Computer Graphics Workshop, which illustrated party gains and losses by means of colour blocks above and below a horizontal line. The final sequence of 3D and 2D graphics was displayed in the studio on a two-screen projection system which Peter Snow used to illustrate the numbers of MPs to hypothetically gain seats in Parliament.

The entire 3D construction took place on the recently upgraded Cubicomp PictureMaker system. Specifically built for video animation, the system functions via three interactive modules:

— The BUILD module is used for the construction of models, the assignment of colours and textures, and the design of model lighting.

— The MOTION module takes the models from BUILD and allows motion to be applied, including linkage, colour and lighting changes, camera cuts and fades.

— The final module, called CLICK, takes the data produced by MOTION and 'renders' the frames of animation, controlling a single framing VTR.

Using pictorial reference only, the data required to form the model's shape was entered to produce a wire-frame description of the Commons' interior. To allow easy handling on the computer, the model was built in five separate sections.

The colours were then specified using a colour menu that allows selection of the surface colour, transparency and reflectivity. The process of 'rendering' then takes this colour information and adds it to the wire-frame to produce a 'solid' image of the model.

At this stage the lighting was assigned. The Cubicomp system allowed the use of conical-shaped lights to produce subtle downlighting effects on the walls of the interior.

The key to making the image work across the two screens was being able to adjust the perspective of the 3D image to be centred either on the right or left edge of the screen. This allowed the correct perspective to be seen when left and right halves of the image were combined in the two screen projection.

The majority of the project was completed in three days. The equipment has also recently been used on programmes such as Newsnight, Panorama and the Nine O'clock News (Budget graphics).

The Cubicomp PictureMaker system is based on an ordinary Compaq 386/16 Deskpro PC with Cubicomp's own 24-bit Video display, a 24-bit Video grab facility and VTR control boards. Tape control is via an RS-422 port which allows the control of up to 42 different VTRs.

The 3D area also has the only Aims EletroGiG animation system in the UK. Still under development, the system has fast ray-tracing software that produces superb quality images with a higher degree of realism than PictureMaker. It has already been used on 'The Money Programme' and 'On The Record'.

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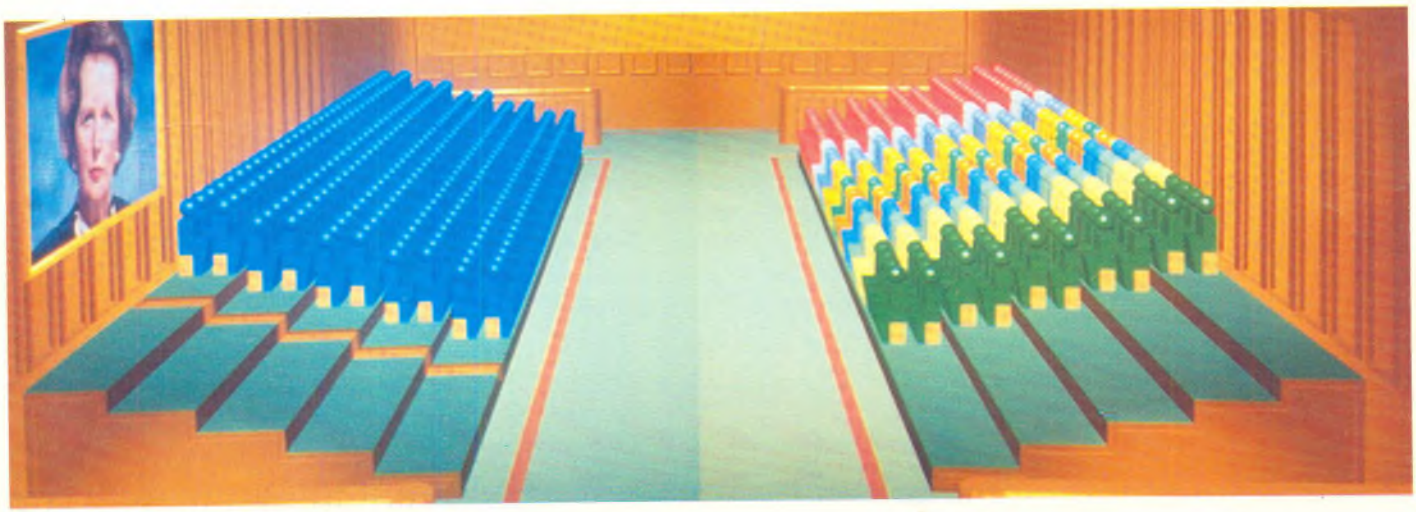

*A 3D representation of the House of Commons*