ENG INF

The quarterly for BBC engineering, technical and operational staff

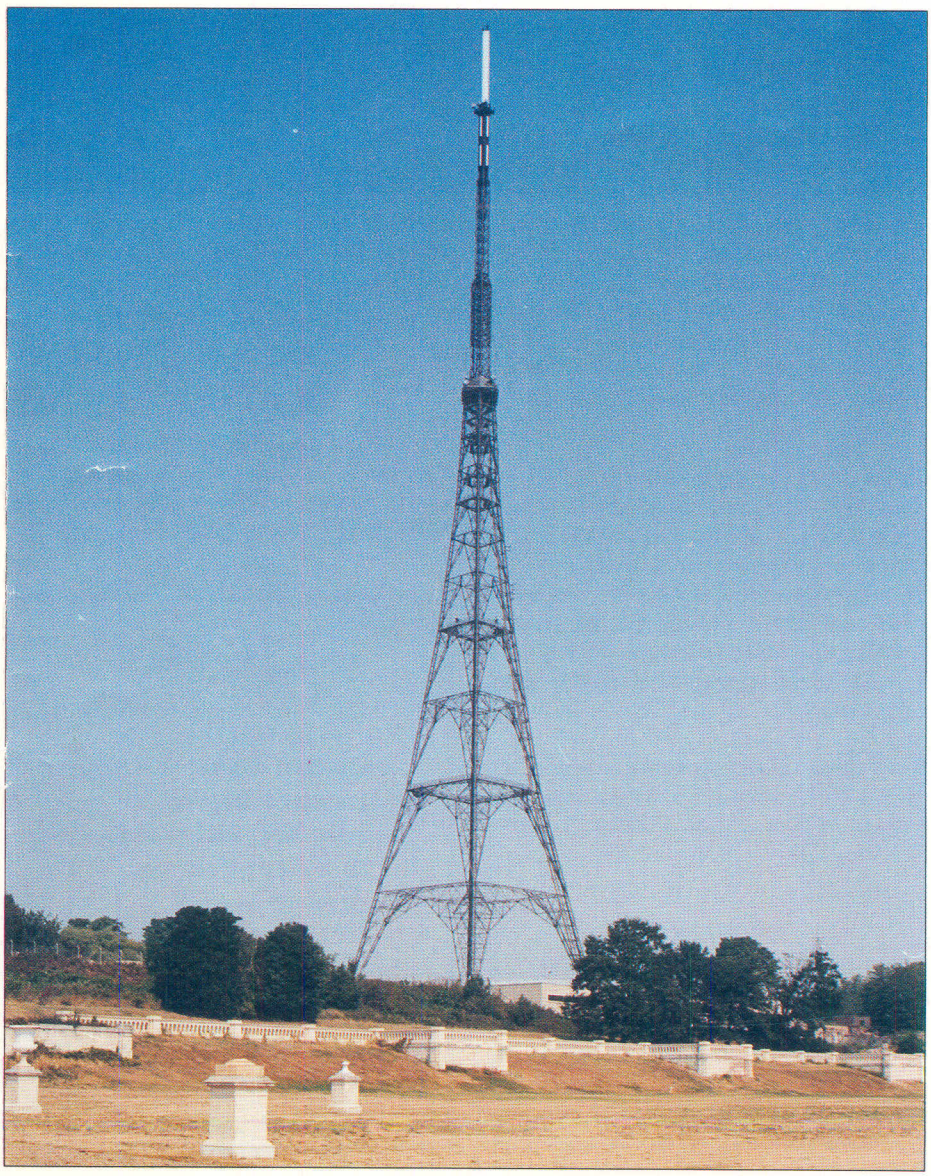
WINTER 1990/1 No. 43

STEREO TV SOUND

The Television service, in conjunction with Engineering Division, is getting ready for the autumn launch of Nicam stereo tv sound on BBC 1 and 2 — coinciding with the start of the autumn tv schedules.

Initially, ten main stations and some 380 relays will bring Nicam stereo sound within range of about 73% of the UK population. The remaining tv stations will be equipped as quickly as possible over the next few years.

More information, including a Nicam coverage map, is given on page 11.



John Flewitt, EID

Crystal Palace has been radiating Nicam engineering tests for the television industry since July 1986.

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ENG INF

Edited, designed and typeset by EID, Room 707A HWH.
Tel: LBH 4316

☆ ☆ ☆ ☆

Very many thanks to everyone who sent in texts for publication in ***Eng Inf*** during 1990. Without your help, we could not have published such a wide variety of interesting and, hopefully, very useful articles.

If you wish to contribute to our next issue (Spring 1991) please let me know your intentions as soon as possible. Your completed text should then reach me by Friday the 22nd of February.

Very best wishes for 1991 to all our readers.

Mike Meyer

TRANSMITTER NEWS

The following services opened or changed between 29th September and 14th December:

New TV relays

Aberbeeg	Gwent
Brighton Central	East Sussex
Bucknell	Shropshire
Coldean	East Sussex
Glenridding	Cumbria
Glenridding Link	Cumbria
Kenilworth	Warwickshire
Llanfach	Gwent
St Neot	Cornwall

Radio 1 on FM

Caterham	Surrey
Forfar	Tayside
Guildford	Surrey
High Wycombe	Bucks
Kenley	Gtr London
Meldrum	Grampian
Winter Hill	Lancashire

Radio 4 on FM

Meldrum	Grampian

Local Radio

Radio Solent began broadcasting in stereo on the 12th November, from its new studio centre in Southampton (see page 4).

LICENCE AGREEMENT

As reported in ***Eng Inf*** No 42, two distribution agreements have been put in place for the BBC AESIC digital audio interface device. One of the companies concerned — **Newbridge Microsystems** of Ontario, Canada — has now signed a second licence which allows them to manufacture and market the CO4/38 AESIC Evaluation Unit on a worldwide basis.

Further details on this agreement, or on any other aspects of licensing, can be sought from the Liaison Engineer on Avenue House ext 375.

Peter Jefferson
D&ED Liaison Engineer

PATENT APPLICATIONS

Three BBC Patent Applications have been published recently — GB 2 220 093, GB 2 220 094 and GB 2 229 889. The first two relate to an earlier BBC Patent (GB 2 124 807) which described the use of a shortened 'chain code', at a rate of one bit per frame, as a quick and efficient method of synchronising to a multiplex structure involving frames and super-frames (eg, television lines and pictures).

GB 2 220 093 and 4

Titled ***Data Synchronisation***, GB 2 220 093 describes the use of more than one bit per frame to give faster identification of the position within the super-frame. Provided that this number of bits is mutually prime to the length of the super-frame, the same chain code can be repeated that number of times without ambiguity, and the look-up table required to convert to the frame number is no more complex than in the one-bit case.

Titled ***Data Transmission***, GB 2 220 094 describes the use of two such shortened chain codes, both repeating at the super-frame rate. However, while one remains unchanged as the synchronisation reference, the relative phase of the second sequence is varied from time to time as a very rugged method of multi-level signalling.

Both these applications were published in late December 1989. The inventor is Adrian Robinson of Carrier Systems Section, RD.

GB 2 229 889

Titled ***Gallery Interleaving***, GB 2 229 889 describes a system whereby a video mixer is simulated for training purposes by a videodisc player, which normally replays only stills or sequences. In this application, a single videodisc contains the interleaved outputs of typically three cameras. Because the videodisc player can jump up to tens of pictures forward or backward during the interval between pictures, the interleaving can be arranged so that the replay can be switched between camera signals, as with a vision mixer. For convenience, each camera picture carries all three camera pictures inset at the bottom of the screen.

This application was published in early October 1990 and the inventors are Andy Finney and David Allen, formerly of the Interactive Television Unit at Elstree.

A copy of the full specification for each of these applications has been sent to the RD library at Kingswood Warren.

* TV TRANSMITTER * BOOKLET

The Autumn 1990 edition of ***BBC Television Transmitting Stations*** is now available from EID. Please telephone LBH 5040 to order your free copy.

IBC 90

We inadvertently omitted ***"Satellite links for radio programme contribution"*** from the list of BBC Technical Papers which appeared on page 17 of our previous issue.

Our apologies go to Simon Shute (G M Ops & Eng R) and Mark Maddocks (Research Department) who jointly delivered this paper at IBC 90.

ENGINEERING MANAGEMENT

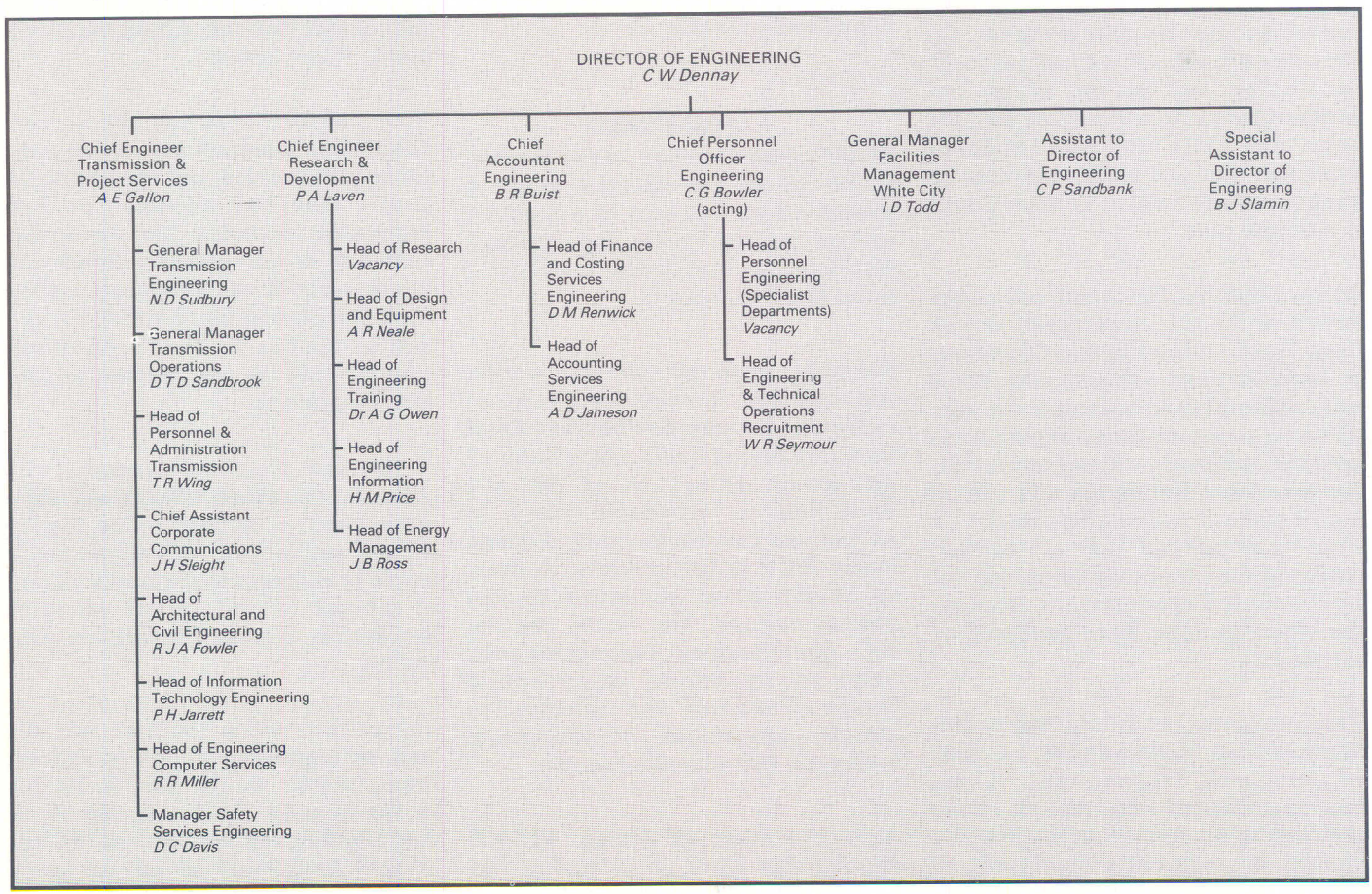
Structural changes

The management structure of Engineering Directorate has been reorganised from the 1st of January, 1991. While Bill Dennay continues as Director of Engineering, the following changes have taken place:

Charlie Sandbank has retired as Deputy Director of Engineering and has not been replaced in that post, which has now closed. However, he is continuing with the BBC as **Assistant to Director of Engineering**, representing the Corporation's interests in the EBU, EUREKA, RACE etc., The managerial responsibilities of the post of DDE have been taken on by two redesignated Chief Engineer posts.

Bert Gallon — formerly Chief Engineer Transmission — has taken on the additional management responsibilities of Architectural and Civil Engineering Department, Information Technology Engineering and Engineering Computer Services. He is now based in London, and acts as the Director of Engineering's deputy. The new post is titled **Chief Engineer Transmission and Project Services**.

Phil Laven — formerly Chief Engineer Information and Training — has taken on the additional management responsibilities of Research Department and Design & Equipment Department. The new post is titled **Chief Engineer Research and Development**.



Engineering Directorate — January 1991.

LOCAL RADIO

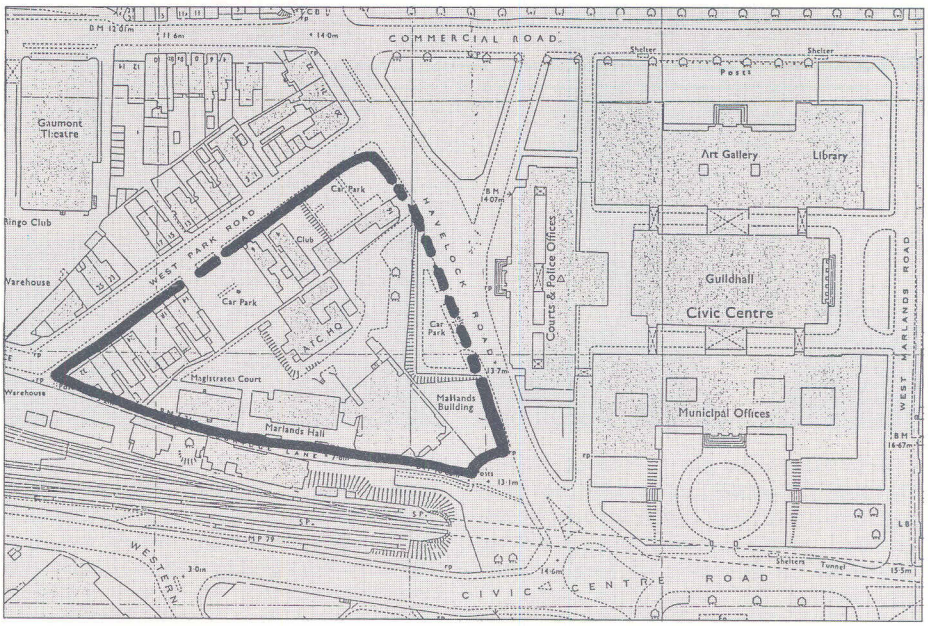
Solent's new studio premises

Radio Solent began broadcasting in November from a new studio centre in Southampton, transmitting its programmes in stereo for the first time. ACED's Acoustic Architect, Keith Rose, describes how the centre was designed and constructed, with particular reference to its acoustic environment.

Radio Solent is the first regional service to commence operations from the new site in the centre of Southampton. It will be joined later by the regional Television service for the area, thus consolidating Southampton's local radio and television activities in a new and up-to-date broadcasting centre.

Initial Surveys

A plan of the site, as surveyed in 1986, is shown on the right. At the outset there were some misgivings about the wisdom of building a studio complex for both Radio and Television on a sloping island site, encompassed on all sides by high noise levels. It was certainly one of the most challenging sites encountered in recent years by BBC acousticians.



Plan of the site as it was in 1986.

A few hundred metres south of the proposed site was the main Southampton railway station, with the lines and a rail tunnel running very close to the site. On the other two sides of the triangular site were major roads carrying all forms of heavy vehicles. In addition to this, the town hall clock opposite produced extremely loud and melodious tones on the quarter-hour and at 12 noon played a complete tune.

In April 1986, ACED carried out a noise survey of the site, in conjunction with Tony Woolf — then Engineer (Standards & Acoustics) Radio Engineering. While this confirmed that the necessary studio, airborne, sound insulation requirements could be achieved — with known BBC constructional techniques and careful use of planned noise buffer zones — it also recommended that a vibration survey of the site should be carried out by Research Department, to check on the vibration noise levels produced by the trains.

This was carried out in July 1986 by Bob Walker, Derek Mathers and W. J. Collins of Research Department. Their recommendations were that all Radio and Television studios on the new site should be resiliently mounted, to achieve the required internal BBC background noise levels necessary for broadcasting studios.

Layout Design

At the commencement of the project, Radio Solent was classified as an ***A station***, which consisted of a Studio 1 with an operations room, and a Studio 2 with cubicle. The design used Mk 2 Local Radio equipment.

Normally, when this type of A station was upgraded, it would have been re-configured to comprise Cubicles 1A and 1B with a shared studio, and a Studio 2 with cubicle. Thus, in March 1987, the West London Architects Group in ACED was commissioned by Andrew Dodd, RCP project manger, to draw up sketch plans produced by the station manager, Tim Neale, and the EiC, Andy Bocking. These plans were based on the proven square format layout of studios and cubicles, as already implemented in Nottingham, Liverpool, Bristol and Newcastle.

At a late stage of design, MDRB decided that when an A station was rebuilt, it should be replaced by a ***B station***, which did not have a Studio 2 and cubicle. This caused great consternation at Radio Solent.

As a mature station, there were established programmes which were either pre-recorded and used both the studio and the cubicle, or had particularly complex operations that needed to be set up well in advance of transmission. It was hard to see how this could be accomplished by two transmission cubicles, 1A and 1B, where one is on-air while the other is rehearsing the next programme.

A revised plan was successfully presented to the then MDRB, whereby a third cubicle would be provided, sharing the one studio area. This third cubicle would be equipped to the same standard as cubicles 1A and 1B but would be deployed as a News Preparation Area (NPA).

The next problem to solve was the best arrangement of the broadcast areas, which would also include a phone-in area. This was solved by Andy Bocking and Mike Jasinski (MELR South & West) who produced a hexagonal design for the studio complex. This

layout, shown below, was incorporated into the overall design by Paul Tharmasingam, the ACED architect responsible for the local radio aspects of the Southampton project.

The design offers good visual communication between areas, provides a studio with adequate floor area (approx 40 sq metres) and makes best use of the available space between the structural columns of the building.

Construction

In accordance with Research Departments recommendations, the ACED architectural team designed all five technical areas in a 'box within a box' construction, which is fully detailed in the recently-published BBC Guide to Acoustic Practice (see ***Eng Inf*** No 42). With this type of construction, the whole floor, walls and woodwool roof slab are resiliently supported on rubber anti-vibration pads which sit on top of upstands on the structural concrete slab.

These pads, carefully selected by ACED structural engineer, Peter Wilkins, are designed to ensure the studio structures have a natural resonant frequency in the order of 10 Hz (the studio loadings had to be accurately determined at the outset for this to be achieved). Each room is isolated from adjacent areas by the provision of structural breaks in the concrete floor slabs around the perimeter of each technical area.

Danny Reardon, Soton

The hexagonal studio.

Though deemed essential by structural engineers and building inspectors, cavity wall ties are an acoustic evil as they provide an acoustically-undesirable physical connection between adjacent areas. On this project, flexible wall ties were used to connect the two leaves of the cavity brick walls together. As the work proceeded, the void between the brick skins was filled with mineral wool to ensure that the cavities were kept free of mortar droppings. All this work was carried out under the careful supervision of the resident civil engineer, Danny Reardon, and Joe Kalinowski who was the job architect for the overall Southampton project.

Acoustic Treatment

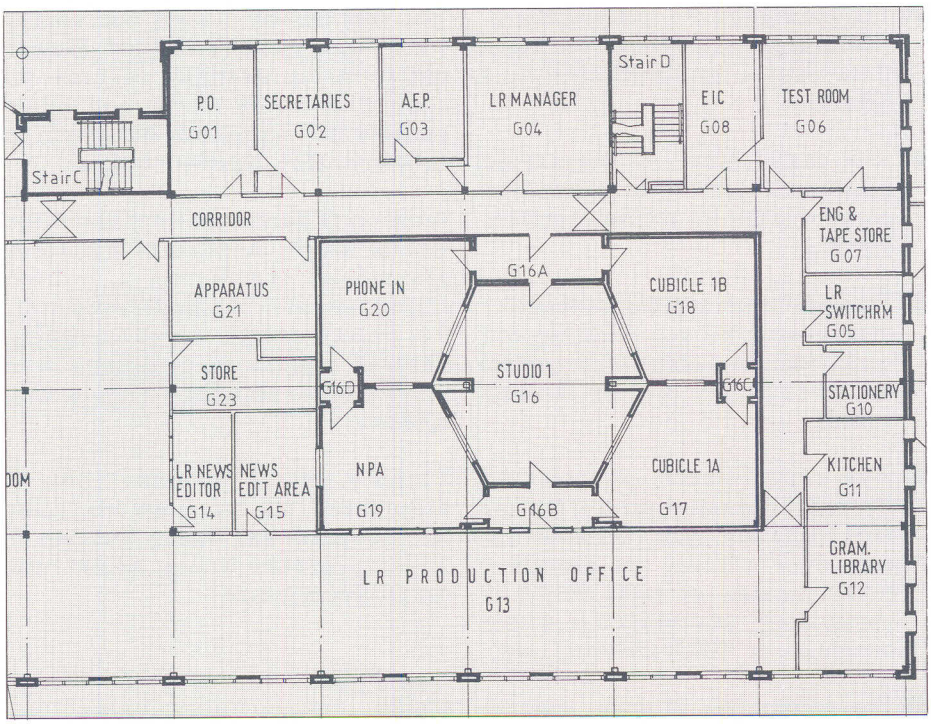
The requirement for four large observation windows between the studio and the adjacent areas, plus the need for two access doors, left little space on the walls for acoustic treatment. Thus, to reduce the possibility of flutter echoes, the side walls of the hexagon-shaped studio were designed to be at four differing angles. In addition to this, the double-glazed observation windows were angled in the vertical plane, on the studio side.

The remaining wall surfaces in the studio — those adjacent to the technical areas — were then covered with a mixture of modular absorbers and finished off with a stretched fabric finish. The overall choice of colours and finishes, in conjunction with Paul Tharmasingam's timber detailing around the observation windows, has produced a very pleasing internal design.

Acoustic tests on the 8th and 9th of November showed that the background noise levels comfortably met the specified noise criteria — only an occasional massive freight train could be felt, though not heard.

The walls which separate the main studio and the adjacent areas provide an average sound insulation of 60dB over the frequency range, 100Hz to 2,500Hz. The wall between the two self-op cubicles provides 62dB average insulation over the same frequency range.

Despite the large areas of glass, the reverberation time in the main studio averages 0.22 seconds over the frequency range 250Hz to 4,000Hz; other areas



Plan of the local radio area showing the hexagonal design.

have an average reverberation time of approximately 0.18 seconds.

Keith Rose
Acoustic Architect, ACED

Andrew Dodd of Radio Projects adds: Three mixing desks and the associated apparatus room were provided by MBI Broadcast Systems Limited to the Local Radio Mk 4 operational specification — popularly known as 'The Mk 4'. This was done under a supply and installation contract — the official term although it is commonly known as a 'turnkey contract'.

And so it proved to be: the key to the new Radio Solent studio complex was turned on, on Monday 12th November.

Danny Reardon, Soton

Cubicle 1B at Radio Solent.

NORTHERN IRELAND

Building Energy Management System

The NI Region has introduced a Building Energy Management System in the Belfast BH complex. It is described here by Fred Wylie.

The system was designed on the basis of a survey and report commissioned by the region and carried out in 1988 by Energy Management Section (EMS). (The philosophy and objectives of this section were described in ***Eng Inf*** No 41.)

The NI Region had already introduced procedures to make savings on the purchase of utility supplies (electricity, oil and water). The purpose of this article is to describe some of the practical steps subsequently taken, including the introduction of new equipment and procedures to make more efficient use of the utility supplies and in particular, electricity and heating oil. Some of the main parts of the scheme are:

- The installation of a pc-based Building Energy Management System to permit comprehensive monitoring of plant, utilities and environment. The system has executive control over chillers, air conditioning and boilers using time-switching, set point control and other relevant input information.
- The installation of micro modulation burners on boilers, controlled for maximum burn efficiency.
- The installation of a specialist microwave detector in the orchestral Studio 1 to control air conditioning and lighting.
- The installation of ultrasonic presence detectors in office and corridor areas to control domestic lighting.
- The installation of presence detectors in toilet areas to control lighting and additionally in gents toilets to control the flow of water used for flushing urinals.
- The replacement of existing fluorescent fittings with low energy, high frequency types. These are not only more efficient but provide a better quality of light which is particularly advantageous where computers or VDUs are being used.
- The automation of some external doors where frequent usage or the movement of goods meant that the original doors were left open with consequent heat loss.

The scheme will reduce our annual energy bills by some £60,000. Similar energy saving strategies will also be applied in a new studio and office building that is presently being built in Belfast for BBC Northern Ireland.

A unique feature in the financing of the scheme was the inclusion of a generous grant from the Northern Ireland Department of Economic Development. The Department was at that time giving financial support to companies who were earnestly pursuing Energy Saving schemes.

Trend Control Systems Ltd, of Manchester, was the main contractor for the system and Simon Wooden of Building Services Group, ACED, was the project manager.

Fred Wylie
MCES
Northern Ireland

LOUDSPEAKERS
The BBC collection

Graham Whitehead describes the range of BBC-designed loudspeakers, both past and present, used in programme balance and monitoring. The detail is brief but goes some way to explaining the reasons that the design came into being, and the applications for which they may have been designed. The current range is also described.

BBC loudspeakers are designed to provide a neutral sound which is consistent and repeatable: units can be supplied and maintained over a number of years without a change in performance.

Classification

BBC loudspeakers exist under four classifications:

LS1/-- loudspeaker assemblies, miscellaneous use.
LS2/-- chassis units.
LS3/-- loudspeaker assemblies, outside broadcast use.
LS4/-- loudspeaker assemblies, studio use.

Before these classifications came into use, loudspeakers were coded LSU/--. In future, only the LS1/--, LS2/--, and LS5/-- classifications are going to be used, ie OB and studio loudspeakers will be lumped together under the LS5/-- code. There are too many individual types to cover so, in this article, I shall confine myself to the more common types of monitor loudspeaker.

Cone Materials

The type of material used to form the cone of a loudspeaker has a marked effect on the overall sound and consistency of the loudspeaker. Over the years, a variety of materials has been used.

The original material was ***paper***, which was pulped, compressed, and formed. This offered only the minimum of control over the resultant sound quality, especially in the critical midrange area, and effort was made to find an alternative.

In the mid-sixties, partially as a result of development work at Kingswood Warren, ***Bextrene*** — a kind of polystyrene — started to be used. Its major advantage was the ease by which more consistent results could be obtained by vacuum forming. The resultant sound quality could be controlled, was more repeatable from one sample to the next, and the hf response was superior. However, it was necessary to coat Bextrene with a damping compound to remove colourations in the region of 1.5 to 2 kHz. This process has never successfully been automated. The dope was applied by hand and hence the manufacturer was at the mercy of the skill and dexterity of whoever was wielding the paintbrush!

The use of plastics — notably ***polypropylene*** — developed considerably during the 1970s, again with pioneering work at Research Department. Polypropylene offered similar improvements over paper as did Bextrene. It did not need to be coated however, as the material was inherently self-damping. Because of its lower density, polypropylene yields greater efficiency than Bextrene and hence greater sound levels are possible for the same power input. This is the material currently being used for our Grade 1 monitors.

Yesterday's monitors

LSU/10
This large assembly, in an oak cabinet, was designed just after the war for general studio use. Some may still be found in service in talkback or PA applications.

The following units were used:

— Parmeko 18-inch dual concentic woofer/horn tweeter
— Lorentz LPH65 tweeter (for extended hf)
— Modified Leak TL/12 valve amplifier: 12 watts

LS3/1
A grey-painted totally-enclosed assembly for OB use. HF units were mounted on a perforated sub-baffle in front of the lf unit, to enable accurate monitoring at close range.

The following units were used:

— Plessey 15-inch paper cone woofer
— 2 x Rola-Celestion HF1300 tweeters

LS3/1A
Similar to the LS3/1 but with the bass unit replaced by a Goodmans C129/15pr.

LS3/4, and B
An angled-front assembly for mounting close to the ceiling where space was at a premium, eg. OB vehicles or above vt machines. Beware! Some of these are still in service but the surround of the bass unit fails with age and the unit is obsolete. The old ones have a gold-coloured grille cloth. There are later, current types, with a black grille and the old may be modified into the new (see LS3/4C and LS5/11 on the next page, under "Today's monitors").

The following units were used:

— Spendor BC2/8, 203mm Bextrene cone woofer
— Rola-Celestion HF1300 tweeter

LS3/5
The predecessor to the LS3/5A. Superseded when the particular bass unit used became unreliable.

The following units were used:

— KEF B110, 110mm Bextrene cone woofer
— KEF T27 27mm Mylar dome tweeter

LS3/7
Similar in size to the LS3/1 and designed to replace it. Some are still in service for talkback, but none should now be used for monitoring. Max SPL at 1.5m: 104dB(A). Will become obsolete when repair stocks of drive units are exhausted.

The following units were used:

— Spendor 8-inch Bextrene cone woofer
— Son Audax HD12x9D25, 25mm fabric dome tweeter

The amplifier (AM8/15) is a modified Quad 303 where one channel drives the lf and one the hf, by the use of an electronic frequency-splitting and equalising network.

– LOUDSPEAKERS –

LS5/1, and A
The studio versions of the LS3/1 and A, designed to replace the LSU/10. The cabinets were larger than the LS3/1 and the tweeters were mounted above the woofer, rather than in front of it.

The following units were used:

— Plessey (LS5/1) or Goodmans C129/15pr (LS5/1A), 15-inch paper cone woofer
— 2 x Rola-Celestion HF1300 tweeters

LS5/2, and A
Television versions of the LS5/1 and A. A different enclosure shape was used to enable the unit to be suspended.

LS5/4
A version of the LS3/1A for Bush House.

LS5/5
A large freestanding assembly for studio monitoring, built into a grey-painted cabinet. Max SPL at 1.5m: 103dB(A).

The following units were used:

— 12-inch Bextrene cone woofer (LS2/1)
— 8-inch Bextrene cone midrange (LS2/2)
— Celestion HF 1400 tweeter
— modified Quad 50D power amplifier (AM8/11)
— pre-amp and equaliser (AM1/20)

LS5/5B
A version of the LS5/5 with a Spendor BC2/8 mkII midrange unit and finished in teak veneer.

LS5/6
A television version of the LS5/5. Mounted in a different enclosure shape for suspending.

Today's monitors

LS3/4C
A medium sized triangular-shaped assembly, for mounting on a ceiling or wall where space is at a premium. Used in television in CMCRs/MCRs or vt cubicles. Replaces the LS3/4 and LS3/4B, or may have been converted from one of the above. Max SPL at 1.5m: 101dB(A). About forty are in BBC service.

The following units are used:

— 8-inch Bextrene cone woofer (LS2/13)
— Son Audax HD13D34, 34mm fabric dome tweeter (LS2/12)

Requires a 50 watt amplifier.

LS3/5A
A small 'bookshelf' assembly for use in restricted areas, such as OB vehicles. Extensively used in Local Radio. Max SPL from a pair at 1.5m: 95dB(A). Over 3500 are in BBC service and over 100,000 have been sold commercially, worldwide. Made under licence by Swisstone (Rogers), Spendor and Harbeth.

The following units are used:

— KEF B110 SP1228, 110mm Bextrene cone woofer.
— Modified KEF T27 SP 1032, 27mm Mylar dome tweeter.
— KEF SP2128 crossover (FL6/38)

Requires a 25 watt amplifier.

LS5/8
A large floor-standing assembly for high-level, high quality studio monitoring. Replaces the LS5/1 and LS5/5. Max SPL at 1.5m: 116dB(A). Just under a thousand are in BBC service. Made under licence by Swisstone (Rogers).

The following units are used:

— Rogers 12-inch Polypropylene cone woofer.
— Son Audax HD13D34H, 34mm fabric dome tweeter (LS2/15)
— modified Quad 405 power amplifier (AM8/16)

The AM8/16 contains an equalising and frequency-splitting pre-amplifier. The woofer and tweeter are each driven from a separate amplifier channel.

LS5/8AL, and R
Similar to the LS5/8, but with the baffle angled in at 30 degrees for corner-mounting in vehicles. Left and right handed versions make up a pair. Special acoustic treatment is required due to the close proximity of the loudspeaker to the walls. Eight pairs are in BBC service.

LS5/9
A medium-size studio monitor for high-quality monitoring in areas where the LS5/8 would be too large. Designed to produce similar subjective sound balance to the LS5/8. Max SPL at 1.5m: 105dB(A). Over a thousand are in BBC service. Made under licence by Swisstone (Rogers) and Spendor.

The following units are used:

— 8-inch polypropylene cone woofer (LS2/14)
— Son Audax HD13D34H, 34mm fabric dome tweeter (LS2/15)
— crossover (Fl6/36)

Requires a 50 watt amplifier.

LS5/11
This is a modified LS3/4, intended to produce a similar subjective sound balance to the LS5/9. It uses the same units as the LS5/9, fitted to a modified LS3/4 baffle, although the crossover is modified. Max SPL at 1.5m: 106dB(A).

Requires a 50 watt amplifier.

Commercial Loudspeakers

For some applications, there is no suitable BBC-designed loudspeaker so we have to go to the commercial market-place. An example is high level monitoring of Rock music, where we have used a variety of types over the years. In general, though, it is preferable to stick to the LS-coded units as these undergo rather tighter quality control checks, at Avenue House, than is common commercially.

Supply And Repair

The LS3/5A, LS5/8 and LS5/9 are available from Design and Equipment Department, although new LS5/8s will be made to order only. No new LS3/4Cs will be made: requirements will be met by the LS5/11.

If repairs are required to any BBC loudspeaker, it should be returned to D&ED who holds the Reference units of each type.

If you require any further information on BBC loudspeakers, and their associated amplifiers, please contact me on Avenue House ext 311.

Graham Whitehead
Support Group, D&ED

MIDLANDS REGION

East Midlands Today

As we went to press, a 30-minute programme *East Midlands Today* was scheduled to be broadcast nightly –Monday to Friday – from Nottingham, starting in early January 1991. Bob Stacey and Andrew David describe the developments which have made this possible.

The East Midlands has had a television production facility in Nottingham which spans three decades. In recent times, the News and Current Affairs unit has provided a six minute sub-opt, and two or three main stories, in the Midlands Today programme from Birmingham.

The move from Willson House in May 1989 to the East Midlands Broadcasting Centre in York House (see ***Eng Inf*** No 38) gave the News & Current Affairs unit an opportunity to upgrade a large amount of the equipment which had seen dozens of years hard service in their old premises. The gallery, studio and technical area have been equipped with some of the latest technology, to enable the upgrade to half-hour capability with the start of the ***East Midlands Today*** programme.

Gallery and Studio

The existing cameras — at present three Sony DXC 3000s on Vinten peds — have been augmented by an additional camera for weather use. The studio lighting has been increased and the Lee Colortran manual desk has been replaced by a Rank Strand M24 155-channel memory desk.

The 16-channel, three-bank Grass Valley vision mixer has been retained but a new space for the production staff has been provided directly behind the vision mixer. This is for the producer, the production assistant and other members of the news team.

The monitoring and communications systems in the gallery have also been upgraded.

Traffic

East Midlands Today will be transmitted from a new Traffic area in conjuction with Edit Suite 1.

The Traffic area is able to perform multiple tasks simultaneously and has two Betacam SP recorders, a U-matic machine, an S-VHS player and a domestic VHS player/recorder. There is a full range of measuring and calibration equipment as well as monitoring and communications facilities. The system is controlled by a sophisticated switching matrix, allowing rapid communication between machines and any other designated area — both within the complex and throughout the BBC.

Edit Suites

A third edit suite has been provided to augment Edit Suites 1 and 2. Suite 1 is solely an editing area but Suites 2 and 3 can additionally transmit and receive material. All three suites are equipped with Betacam SP and U-matic machines.

Graphics

The Graphics area is situated next to Traffic and close to the three edit suites. It contains a rostrum camera, a Quantel Paintbox — Model VR with Presenter — and an Abekas A72 caption generator. These facilities now enable Nottingham to produce the sophisticated graphics which have become the norm on BBC news programmes from other regions.

Set and Image

A new set has been designed and constructed in-house, to replace the one which matched the Midlands Today set used in Birmingham over the previous three years. A new title sequence has been developed and the programme includes a weather sequence, presented by a dedicated weather person.

Staff

The new programme has required extra staff in most areas. The station now has an editor and two assistant editors while the compliment of journalistic staff has been increased with two reporters, two sport and leisure reporters, five or six regional journalists and a planning journalist.

The operations department, under an operations manager, now includes an operations supervisor, two senior operators, three operators, two operational engineers, three picture editors, an assistant editor and a graphic designer. The production staff include two assistant producers and six station assistants.

The programme and administrative jobs are serviced by the original team of dedicated production assistants and secretaries.

Bob Stacey
Operations Manager
Nottingham

Andrew David
Presenter
East Midlands Today

ON THE ROAD WITH EID

Our roving camera has captured these two shots of EID survey vehicles in far-flung places — Moscow and Dallas ...

Charles Hope, EID

Moscow: 7 km northeast of Kilmarnock, Strathclyde.

Charles Hope, EID

Dallas: 13 km southwest of Elgin, Grampian.

SCOTLAND
Edinburgh's Queen Street facilities

The Queen Street premises in Edinburgh were re-occupied by production and operational staff in early October. This saw the completion of a major refurbishment of the four Georgian houses, which started in 1988. Simon Cooke describes the updated technical facilities now available in the capital.

Broadcasting House, Queen Street, Edinburgh has been used by the BBC since 1930 and has been modified and developed in a piecemeal way. In recent years, up to the start of this project, work on the buildings was kept to a minimum because of the anticipated construction of a new Broadcasting Centre (when devolution for Scotland was high on the political agenda). That project was eventually cancelled in favour of a major refurbishment of the existing premises, which has now come to fruition. The works have included:—

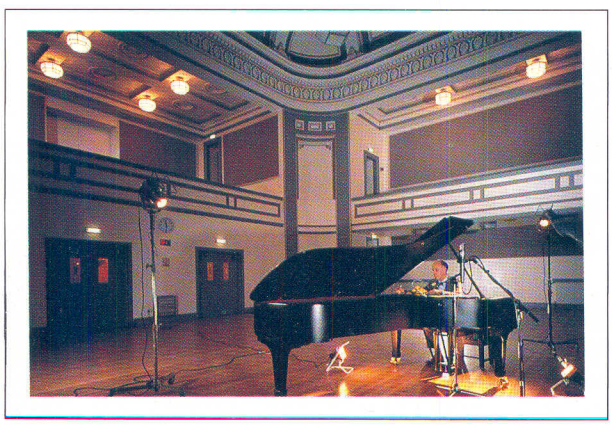
- Meeting current fire and building regulations
- Making good, extensive deterioration of the exterior and interior fabric, and the services
- Major modifications to improve the use of the internal space
- Providing studios, offices and support areas to meet present and planned broadcasting needs, and allowing additional rented accommodation in the Miller Building, Thistle Street, to be vacated

In order to consolidate the BBC's position in Queen Street, the purchase of No 5 was negotiated. The BBC now owns the freehold of all the properties (Nos 4, 4A, 5 and 6) which includes three mid-19th century halls at the rear, originally built for various religious and philosophical institutions. Numbers 4, 4A and 5 are Category A listed buildings while number 6 is Category B within an 'A' group.

There are just over a hundred staff based in Edinburgh and the plan for Queen Street provided for 560 sq metres of office accommodation and 981 sq metres of ancillary areas. The whole project was managed by Radio Projects. Roger Ackroyd was the Project Manager and the technical installation Project Leaders were Simon Cooke and Ken Clegg, assisted by Installation Supervisor, Rik Brooks. Television facilities were provided by local engineering staff.

Simon Cooke, RP

Ken Clegg at the Synclavier keyboard in Cubicle 2.



PRPO, Glasgow

Studio 1.

RADIO

Studio 1
This was retained in its existing form but refurbished by BBC Scotland staff as a valuable performance area for occasional use.

Cubicle 1
This is equipped with a 36-channel TAC Magnum desk with C-mix automation and is designed to work with Studio 1 for recording music and audience shows. However it can also work with the drama studio (Studio 2) via tielines, or as a multitrack re-mix area with a hired machine brought in.

Studio 2
This is a facility new to Edinburgh — a comprehensive radio drama production suite. The studio contains a range of acoustic environments, including some with variable acoustics.

Cubicle 2
Cubicle 2 is equipped with a 40-channel Amek Mozart desk, with Supertrue automation. Recording will normally be directly onto a New England Digital Direct to Disk system, which enables the recording of eight separate tracks of digital audio onto hard disk, with a backup on tape drives. The system also provides cues for a Synclavier 9600, which can be used to play in prerecorded sound effects or to create effects. This equipment can be synchronised using either SMPTE timecode or MIDI. The former is provided by a Motionwoker vital tape machine, thus removing the need to have a tape machine playing timecode to lock everything together.

The great advantage of the Direct to Disk/Synclavier system is that sound effects sequences may be assembled and edited in a fraction of the time it would have taken assembling them from disc and tape. The system also allows time slipping of tracks relative to each other with ease. This provides great savings in post-production time and the time that artists are required in the studio.

Studios 3 and 4
The old Studios 2 and 3 have been relocated and refurbished for talks, discussion, and general programmes.

They are both equipped with an MBI Series 24 desk, offering eight microphone inputs, six stereo repro inputs, two dedicated telephone channels and four full-facility

outside source channels. The cubicles also offer a full range of repro sources and outboard signal processing units.

Studio 5

This is equipped as a DJ/self-op facility. The desk is an MBI Series 24 which has been configured to allow the studio output to be sent directly to line, or to appear on the desk in Cubicle 3. In this configuration, the audio assistant in Cubicle 3 would have final control over Studio 5's presenter and guest mics, and the repro and misc sources.

Comprehensive talkback is provided throughout Studios 3, 4 and 5, both between each other and their outside sources. It is expected that the majority of live programming from Edinburgh will come from this area.

NCA & RCN Studio

These are small self-operated studios which non-BBC personnel use to contribute voice-pieces to Scottish and national News and Current Affairs programmes. They are provided with EP5/22 equipment.

News Studio

This facility is provided for the preparation of news packages, and for contributions to news programmes in Glasgow. It is equipped with a Clyde Beta series mixer with eight channels offering: two mic inputs; tape and cart — recording and replay — facilities; and telephone interviewing and simplified outside source facilities.

TELEVISION

A small television studio (45 sq metres) is situated in the basement, operated remotely from Glasgow.

The psc edit suite provides simple two-machine editing of tapes in either the U-matic or Betacam format. The edited tapes may then be played back to Glasgow for incorporating into programmes.

Two psc crews operate from Queen Street.

CENTRAL TECHNICAL AREA

The CTA, as expected, houses all the facilities that support the studio operations in the building, as well as providing data, ringmain and rf distribution circuits to the office areas. Installation of the equipment here was carried out by Elliott Brothers (Audio Systems) Ltd, with the exception of the tv equipment which was carried out by Edinburgh engineering staff.

Simon Cooke
Radio Projects

NICAM STEREO
BBC Service to begin this year

As reported on page 1, ten main stations and around 380 relays will be ready to broadcast Nicam stereo sound on BBC 1 & 2 by this autumn. The ten stations will be:

Belmont	North
Black Hill	Scotland
Crystal Palace	South & East
Emley Moor	North
Mendip	South & West
Pontop Pike	North
Sandy Heath	South & East
Sutton Coldfield	Midlands
Wenvoe	Wales/S & W
Winter Hill	North

Other main stations, not listed, will be equipped for Nicam stereo sound over the next few years as fast as resources will allow.

Crystal Palace and its relays are already broadcasting engineering tests on the Nicam carrier (6.552 MHz above the vision carrier). These tests consists of normal programme sound — originated in stereo or mono — which may be liable to interruptions. The other listed stations, and their relays, will also radiate Nicam test transmissions in advance of the autumn service date — as and when engineering work has been completed during the summer.

Nicam receiving equipment is now widely available in the shops. A recent survey indicated about 100 different tv designs and some 30 vcr models. In late October 1990, about 500,000 Nicam units had been sold and this figure was expected to increase to around 750,000 units by the end of 1990.

Gross Nicam coverage this autumn from the ten main stations listed above, and their relays.

ENGINEERING RECRUITMENT
The way forward

John Reymond describes a new recruitment strategy, which takes account of the diminishing number of school leavers, and also describes Recruitment's new computer system for the 90s.

There will be 25% less 17 to 19 year olds leaving school in five years from now; one million less will be joining the workforce. Indeed, those who will graduate at the lowest point of the demographic trough (in the mid-90s) have already commenced their A-level studies.

Against this background and with a desire to further advance equal opportunities for all, irrespective of ethnic origin, gender, disability and age, Engineering and Technical Operations Recruitment is introducing a new recruitment strategy. It comprises three key elements:

— Market Development

— Objective Assessment

— Collaboration

Each element is vital to the success of the total strategy, which has been designed to ensure the continued supply of high calibre engineering and operational staff for the BBC in the lean years ahead.

Market Development

Market Development is a series of actions and initiatives being undertaken to raise the awareness of the BBC as an equal opportunities employer.

Educational establishments — at all levels — will continue to supply part of our recruitment needs. Thus we need to convince lecturers, teachers, parents and careers advisers that the BBC does have real and attainable jobs for their charges. It also needs to be understood that, as the number of school leavers fall, the number entering higher and further education will remain static or even increase. In percentage terms, therefore, the output of the universities and colleges will increase compared with the number of available school leavers.

This has led to the concept of Undergraduate Clubs, whereby we can capitalise on the BBC presence in key cities — often immediately adjacent to the local university or polytechnic. Already under way are links between BBC Manchester and Manchester University, UMIST and the local polytechnic. Likewise, in London, World Service is linked to nearby Kings College. These Clubs, the pilots for many, provide an insight for the students into our industry and show, at first hand, the challenge, diversity, friendliness and team spirit of work in the BBC.

In parallel with this work is the promotion of opportunities in the BBC at careers and other public events. Over a hundred events are being attended this autumn and winter, and not just in schools and colleges. We will also attend special events for Women Returners To Work, outreach events around White City, and events organised through the links we have established with the COMPACTS (the partnerships between employees and schools), the Women's Engineering Society, and SATRO (Science and Technology Regional Organisation) which is a network of some forty independent regional centres operating under the Standing Conference on Schools' Science and Technology.

A major event in January, 1991, is the Association for Science Education's annual conference in Birmingham, held jointly at the University and Pebble Mill. In conjunction with Educational Broadcasting, we are participating to influence as many of the science teachers as possible and make them aware of the opportunities we can offer their students.

Objective Assessment

This is a method by which the suitability of each applicant — irrespective of their background and, to a major extent, their paper educational attainment — can accurately be assessed. The process is different from the historic, subjective, system of shortlisting and interviewing by panel.

The development of Objective Assessment for a specific job commences with the commitment from senior management to collaborate with our team of consultant psychologists. Through a process of structured interviews with staff in the recruitment categories, the consultant produces a detailed analysis of the tasks performed. From this initial research and through a follow-up questionnaire to all related staff, in all grades up to and including senior management, the relative importance of each task can be derived. This is then used to determine the key abilities required by a person to perform successfully in the job.

Objective Assessment has been tested in a number of different ways to develop each stage of the total system. It has been used to recruit two new recruitment officers, both of whom have proved very successful despite not having what was historically thought to be the essential background.

Initial work has been undertaken in Television Studio Operations on camera operators, in Radio on studio managers and — where the work is most advanced — on Transmission engineers. This wide spectrum of jobs is enabling us to gain the greatest diversity of experience and is helping to develop a set of core attributes applicable to each category of recruit.

The next intake of engineers for Transmission will be recruited using Objective Assessment and the selection process commences in January, 1991. The assessment questions have been set in a transmission context and have been specifically designed to measure the required attributes. However, they have been developed to ensure that specific job-related knowledge is not a prerequisite. Validation testing has been carried out with groups of students to ensure that they are totally fair, and against staff doing the job to give a calibration against known job performance.

All those who apply will be seen at the first assessment which eliminates the subjective stage of shortlisting. However, applicants are invited to pre-select themselves by means of a comprehensive information pack sent out in response to their initial enquiry. This pack contains details of the tests, an explanation of the

system and a timetable of the selection procedure so that all who then choose to apply know exactly what they will undertake and when.

The Objective Assessments are carried out in groups, whose size is determined by the number of applicants. This ensures that the increased number of candidates being assessed can be processed speedily against the declared timetable. This timetable forms part of a 'contract' between the BBC and the applicant — not only will applicants be seen if they apply but, if they are successful, their recruitment timetable through to a job will be as set out in the initial information pack.

Following this first assessment there will be a counselling session which does not form part of the selection process but is to ensure that applicants see the friendly human face of the BBC. It also gives them a chance to discuss their interests and job preferences which, in turn, enables Recruitment to offer the best advice on career choices within the BBC.

Collaboration

Collaboration between Recruitment and its client departments is vital. It ensures the support of senior line management in developing the Objective Assessment system and, subsequently, the continual updating of these assessments. Similarly, collaboration is necessary to reach and develop all parts of the recruitment market. Initiatives need to be developed corporation-wide and not just on an insular directorate basis; the sum of the directorates working together with Recruitment is far greater than the impact each can have alone.

The client department becomes the 'owner' of the Objective Assessments, although the initial stages of first assessment and counselling, as well as the administrative aspects, are normally delegated to Recruitment. The second stage, which is judgemental and concerns final selection, is carried out by the client department with support from Recruitment.

Computer System

The present administration system in Recruitment is manual, with a limited amount of computer and word processor assistance. It is labour intensive and no matter how carefully each person operates, it is inevitably prone to human failings.

For a number of years Engineering and Technical Operations Recruitment has been seeking a computer system to handle the administration of over 25,000 enquiries and the consequent correspondence each year. It was soon confirmed that, despite claims to the contrary, no off-the-shelf system contained the features we required and indeed none was flexible enough to customise to our needs. Consequently a detailed specification was developed and evolved through a number of stages of development.

A decision was taken to go out to tender, specifying directorate-preferred Unisys BTOS hardware. SAM Systems of Manchester, known for their specialised communications software, was eventually selected to produce a bespoke system to our detailed specification. To handle the volume of applicants with a rapid under-four-seconds response to any enquiry, a Unisys B39-5 (with an initial 320 MB of hard disk) was chosen, with ten B28s as terminals on the cluster.

Bar Codes

The philosophy of the system is different from any other known system in that each enquirer or applicant will be identified by a unique bar-coded number. This bar code will be pre-printed on the application forms which are sent out with every Recruitment information pack. When an enquiry is received, either by letter or telephone, the name and address of the enquirer will be logged, an address label will be printed automatically, and the bar code read. From then on, the name of the enquirer/applicant and the unique bar code number will be linked and held in memory.

On every subsequent return of the applicant's papers, the system will automatically bring up the record of that person immediately the bar code is read. A further unique feature is that the record will be displayed exactly at the point at which the next decision needs to be entered. This will speed up the operation compared with commercial systems where numerous combinations of keystrokes are required to get to the required screen and to the appropriate point on that screen. Every keystroke saved improves the efficiency of the total system.

Each category of staff, or area of employment, tends to follow a slightly different recruitment pattern. Indeed, during the transition period — as recruitment moves away from shortlisting and preliminary interviewing to Objective Assessments — there may be several different recruitment paths an individual could follow. This complexity of detail is elegantly stored for each individual by means of a 'key' carried by the bar code. Thus, whenever a particular decision point is interrogated, the appropriate next action for that applicant is automatically brought up on the screen. When required, however, this 'suggested' action can easily be overridden by the operator.

An important feature of the design is that any item of information known about the candidate should only require to be entered once. From then on, that information is held and used whenever

One of the screen displays under development.

necessary. Thus, searches of the database for current applicants fulfilling specified criteria can be run. If, for example, an urgent requirement is received for an engineer or operator to work at a regional centre, then a search of the database can identify those living, as indicated by their postcode, in the catchment area of that centre. The person can then be transferred from their current recruitment path (or 'conveyor belt') to a different track leading to this alternative position.

The bar code can also be used to identify batches of forms which have been sent to specific events such as Careers Fairs, etc. This is extremely useful as it will allow us to retrospectively assess the recruitment value of particular events.

A further useful feature is the ability to store a 'special interest' flag which registers on the screen every time that individual's record is accessed. Thus, an existing member of staff can reliably be kept up to date on the progress of an applicant of special interest, such as an acquaintance or a potential applicant met at a careers event.

The system in development already exceeds the ability of off-the-shelf systems, in terms of the level of automation of correspondence and its sophistication in handling the statistics required for equal opportunities monitoring. When fully developed, the computer system will provide a very flexible aid to Recruitment operations in the 1990s.

A future development being discussed is the use of outworkers to handle the basic data entry via remote terminals, either stand-alone or connected to the cluster via a modem. This approach will lead to further clerical staff savings and provide greater flexibility in the handling of workload peaks, by employing outworkers on a piecework basis.

If any readers would like further information on either the Recruitment strategy or the computerised administration system, please contact either Roy Seymour (H.Eng.T.O.R.) on LBH 5726, or myself on LBH 4754.

John Reymond
A.H.Eng.T.O.R.

ENGINEERING TRAINING

First blind trainee

Ian Snowdon is totally blind and recently completed an *Introduction to Radio Operations* course at Wood Norton, together with a group of fifteen trainee Studio Managers. His progress is described here by Malcolm Nelson.

Ian's training was a 'first' for the Audio Operations training unit. Although he'd studied audio topics in his spare time, he'd had very little practical experience. During a temporary job at BH Belfast, he'd expressed an interest in working in radio and Betty Pollock (Senior Personnel Officer, Northern Ireland) arranged funding for his training at Wood Norton from Ronald Neil (Managing Director, Regional Broadcasting).

Ian with his tutor, Jill Diver.

With one of Wood Norton's audio lecturers, Jill Diver, acting as his personal tutor, Ian mastered many of the practical skills needed to work in radio — setting up microphones, operating a variety of sound desks, playing-in recorded inserts from disc, tape or CD, and editing tapes.

Conor McBrierty (Belfast Audio Supervisor, on attachment to Wood Norton) helped Ian solve some of the practical problems by marking key controls with braille. Conor also collaborated with Wood Norton staff to develop a device to help Ian locate editing points on tape and to make accurate cuts and splices. This involved modifying a CAT automatic tape splicer for Ian's use.

An optical sensor, based on a bar code reader, was mounted on the tape splicer to help Ian locate white chinagraph marks made on the black backing of Type 200 audio tape. This allowed him to mark his edit points in the usual manner and locate them accurately in the cutting blades of the CAT. The device emitted a bleep to indicate that the white mark was in place and could have its sensitivity adjusted — high sensitivity to locate the edit point approximately, fine-tuning to pinpoint the correct position. Using the CAT also simplified the procedure of placing the splicing tape parallel to the sides of the tape to be joined.

By the end of the course, Ian proved himself capable of recording and editing a short feature programme entirely on his own. During his eight week training period, he also studied the technical aspects of sound and acoustics, and electricity and magnetism — taking notes with an audio cassette recorder and transcribing them into braille or on to a personal computer with speech synthesiser.

Without doubt, Ian enjoyed and responded to the challenge of his training and now hopes to follow it up with an attachment to an operational department somewhere in the BBC.

Following on from this first successful venture, Studio Operations, Radio has recruited a trainee Studio Manager who is blind and she has now started her training at Wood Norton.

Malcolm Nelson
Training Manager
Audio Operations

RESEARCH DEPARTMENT
Programmable gate arrays

Richard Evans describes a family of programmable gate arrays which is finding applications in logic design at Kingswood Warren.

The past eighteen months have seen a change in the way many engineers at Research Department implement digital circuitry. Whereas in the past, TTL and CMOS integrated circuits were used, with perhaps some small programmable devices such as programmable logic arrays (PLAs), we are now seeing the introduction of highly complex arrays of undefined logic in a single device — what is generally termed ***Programmable Gate Arrays*** (PGAs). Accompanying computer-aided design packages are used to optimise the circuitry for the chosen architecture, allowing the designer to concentrate more on the circuit function and less on the implementation.

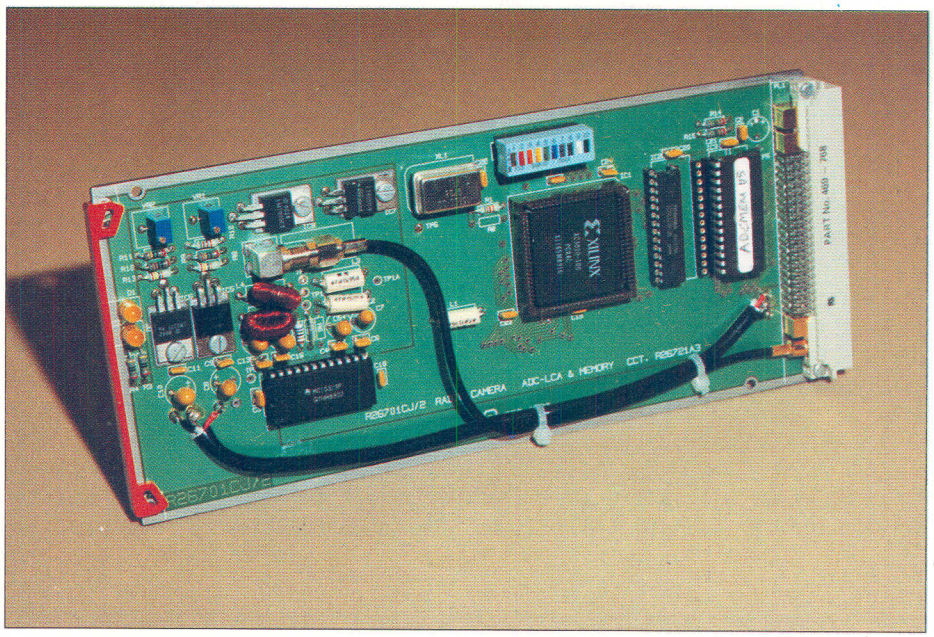
Unlike semi-custom mask-programmed ICs — which are aimed at producing several thousand identical devices — programmable gate array technology is suitable for one-offs or when developing a system. Every stage is effected in-house, which ensures a fast turnaround time for both initial design and subsequent modifications.

Competing Companies

There are several competing families of PGA currently on the market, all offering different programming characteristics and internal architectures. For example: the Plus Logic system — MAX-EPLDs — from Altera; Action Logic devices from Actel; and the system which many have chosen at Research Department — ***Logic Cell Arrays*** (LCAs) from Xilinx. It is this family of devices which are described here.

What is an LCA?

An Xilinx LCA is a small logic device (about 30mm square) containing a matrix of configurable logic blocks (CLBs) surrounded by input/output blocks connected to the external pins. A system of programmable interconnections links the blocks together, creating logic networks. Each CLB consists of a combinational logic section to implement the gates, along with storage registers to provide latches or flip-flops. Each I/O block can be configured as an input, as an output, or as a bidirectional pin with tristate output.



Research Department

A Radio-Camera circuit board featuring an Xilinx logic cell array.

The data required to define the functions of the logic and I/O blocks, and the routeing of the interconnections, is usually held inside a neighbouring eprom (though floppy disk and microprocessor can also be used). Immediately after power-up, the LCA automatically reads in data from this eprom, the time required being only a few milliseconds. The device is then programmed for as long as it remains powered. This approach means that to change the function of the device, all that is required is to reprogram the eprom.

The Design Process

The LCA design software runs on an IBM pc (or compatible) or workstation, and follows a set sequence.

Firstly, a schematic capture system is used to create a hierarchical circuit on the pc, usually from a combination of individual gates and 'macros' — a macro being a ready-designed sub-circuit such as an 8-bit counter or multiplexer. Alternatively, for those more used to connecting TTL packages together, a library of TTL device equivalents is also available.

Once the designer is satisfied with the circuit, it is checked by the software to minimise the logic and tie up any loose ends, then converted to an LCA design. The Automatic Place and Route program then allocates each part of the circuit to the configurable logic blocks within the LCA, in such a way that signal path lengths (and hence delays) are minimised. This is the computationally-intensive part of the process, where the pc is left to optimise the placement, and may take over one hour depending on the spare capacity of the device. Having completed the LCA design, an eprom can then be programmed with the configuration data.

In the event of a fault in the design, the engineer has two options: for small changes such as adding an extra inverter, LCA design itself can be edited and another eprom blown. This will only take a few minutes. For larger modifications or errors, the circuit diagram must be changed and the LCA redesigned which will take considerably longer.

One of the most important aspects of device performance is speed or propagation delay. This varies greatly — depending on the signal's physical path length inside the LCA, the speed grade of the device itself, and the method of interconnecting the blocks — but generally internal delays can be reduced

to the order of a few nanoseconds. Clock signals are specially catered for with their own clock networks and any specific network can be labelled as critical during the design entry stage, which ensures that they receive preferential treatment during the automatic placement stage. The manufacturers recommend that, generally, clock frequencies of up to 40% of the device's quoted speed can be used.

Variations

There are numerous variations available. Device complexity ranges from two thousand to nine thousand gates (for the commonly used 3000 series). Package variations are: pin grid array; plastic leaded chip carrier (PLCC), and ceramic flat-pack. There are also variations in the speed of devices which greatly affects their cost.

As an example, a typical LCA is the XC3020-70 PC84C. It is a 70 MHz 2000 gate device in an 84-pin PLCC package with eighty usable I/O pins. It requires a 2k eprom for configuration data and costs about £23.

The Pros and Cons

Using PGAs, a board-full of logic can be compressed into one chip which uses less power, generates less noise, is more reliable, gives greater gate-packing density, and can allow simpler printed circuit layouts. Also, modifications are easy; they become an integral part of the finished design and do not compromise its reliability.

Inevitably some time needs to be spent learning to use the system but this is quickly achieved, especially if the user has some experience of schematic capture packages. A finished design can be difficult to debug, since so many of the signals are hidden inside, but spare pins can be used to give access to critical signals. A complete software package which can produce a working chip costs about £2,600.

Some recent applications for LCAs include a digital video interface running at 27 MHz, an AES audio matrix controller, a video sampling controller and a transputer interface. The Xilinx system has become popular at Kingswood because it is a general-purpose approach to logic design. If speed of circuit operation is the most important requirement, large programmable array devices may not be the correct choice as there are faster devices available. However these will not have the flexibility provided by LCAs. A new family of 4000 series LCAs is now being launched and these will be even more powerful.

Richard Evans
Tx & P Section
Research Department

NORTHERN IRELAND

New PABX system

A new digital PABX system became operational at BH Belfast in early September, 1990. Fred Wylie describes the new system.

The new GPT ISDX system in Belfast is 1000-line capable and replaces the old 400-line Strowger PABX 3, offering all the advanced features of a modern digital telephone exchange. It will also interface quite readily with the BBC Digital Communications Network due to be commissioned soon and this will offer significant advantages to users throughout the BBC.

British Telecom has developed a very extensive digital communications system throughout Northern Ireland and the BBC was able to take full advantage of this for the new PABX installation. Two 30-channel private DASS (Digital Access Signalling System) links connect the PABX to the public service telephone network, using fibre optic cable. These DASS links, believed to be the first of their kind in Northern Ireland, again offer all the advantages of Multiline Digital Access with fast call setup and improved quality of voice transmission. However, the immediate advantage is DDI (direct dialling in) which is available across all of the 1000 number range offered by BT.

A new 'modern look' operators room is fitted out with three full colour display terminals and keyboards. The supervisor's terminal can also be used to alter trunk access capability and the class of service, direct from the keyboard.

The regional staff extension directory is held in the PABX memory, thus allowing the operators to forward calls with minimum delay. Most extensions have been supplied with modern phones giving number storage, call forwarding, call pick-up and many other features. Some departments, such as Sport, Religion and Agriculture, have been given pilot numbers where general incoming calls can be answered by any extension within that department or group of phones. The widespread use of feature phones has meant the replacement of many 'old' key and lamp systems — for so long part of the large office setup.

The provision of a comprehensive Call Logger System gives the ability to analyse call traffic and with 'least cost routeing' part of the intelligence of the PABX itself, it is hoped financial savings will be made.

Mercury Communications was the main contractor for the scheme which included the wiring of new phone sockets. Mike Shore, of Telecom Section, Transmission Department, was the project manager.

Fred Wylie
MCESNI

OPTICAL TV ROUTEING
Update on RACE Project 1036

Research Department is leading an ambitious international project – RACE Project 1036 – to develop an optical fibre routeing system for television studios. Supported with funds from the EC's Framework programme, the project is now just over half way through its five-year plan.

Andrew Oliphant describes the progress so far.

The formation of the project — which started work in January 1988 — was described in ***Eng Inf*** No 32 while Howard Jones' article on 'Digital Television' in ***Eng Inf*** No 42 gave some of the background to the development. So in this article I will concentrate on the technical progress that has been made.

Outline of the system

The system is known as the WTDM system because it combines signals by optical wavelength-division-multiplexing (WDM) and electrical time-division-multiplexing (TDM). It is based on a number of Local Routeing Centres (LRCs), each serving a number of sources and destinations, as shown in Fig 1.

At every LRC, each source signal is placed in its own identifiable time-slot in a 2.5 Gbit/s electrical multiplex. This signal modulates a semiconductor laser to produce an optical signal at a very closely-controlled wavelength between 1500 nm and 1560 nm in the infra-red region of the spectrum, where optical fibres have low attenuation.

Each LRC is allocated a different wavelength — there could be up to sixteen, spaced 4 nm apart. Single-mode optical fibres bring signals from all the LRCs to a star coupler which combines them to give a WDM signal and distributes the combined signal to all the LRCs, where any signal can be selected by optical and electrical demultiplexing. The signal path through the system is shown in Fig 2.

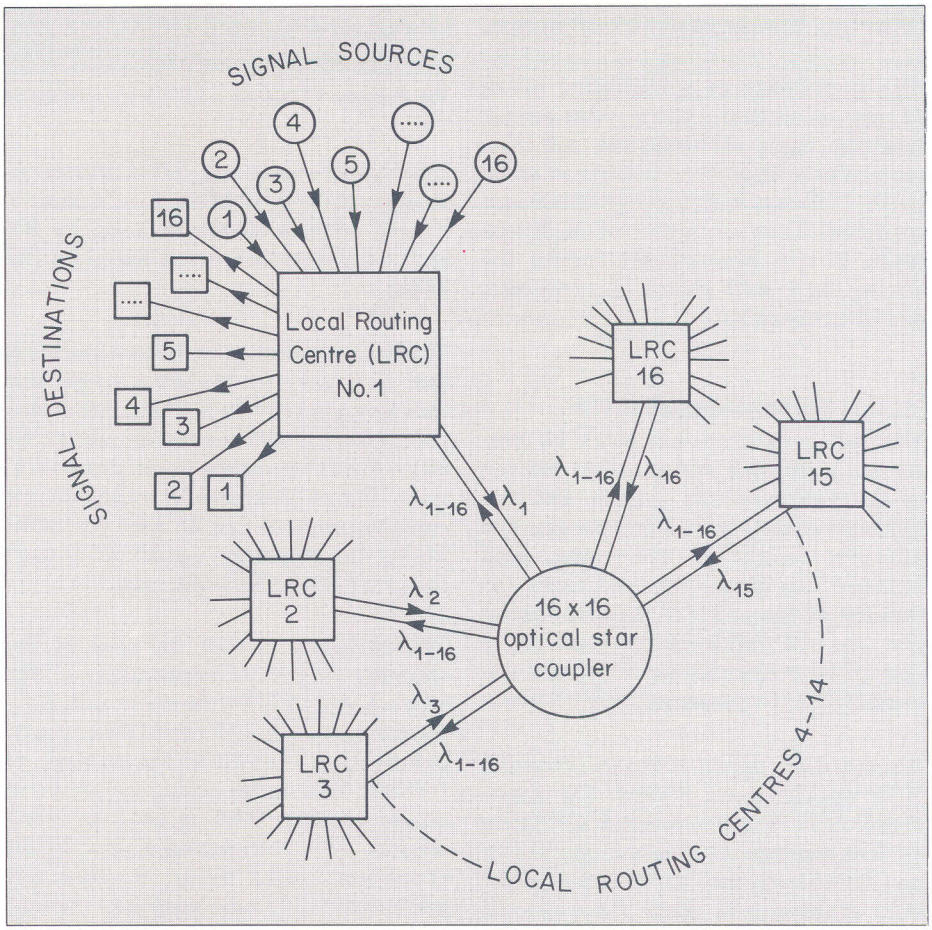


Fig 1: WTDM routeing system.

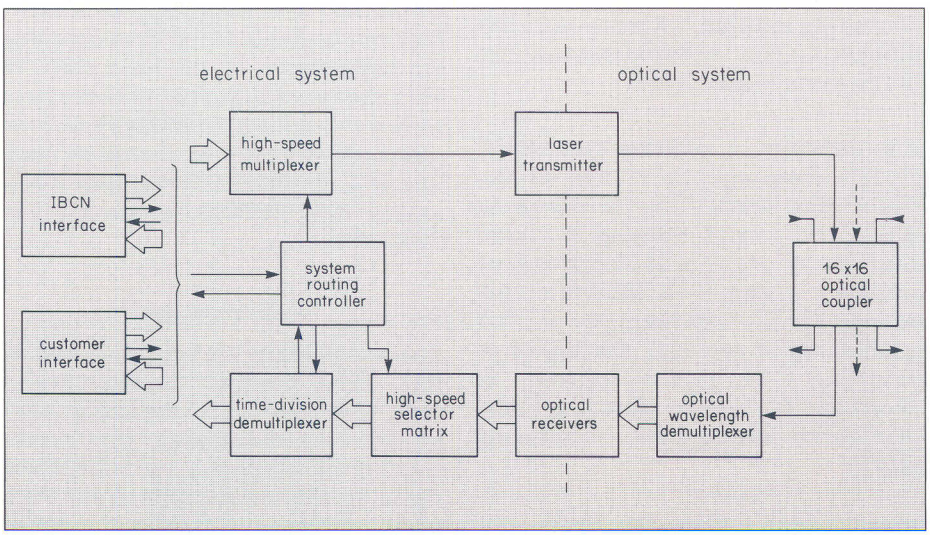


Fig 2: signal path through the WTDM system.

A system like this gives all the essential features of a television routeing system — availability of any source at any or all destinations, non-blocking selection, and setting up new connections without affecting those already set up — without the need for central switching.

A multiplexed optical fibre signal routeing system has a number of practical advantages over a conventional system with a central switcher. Because many signals are combined on

one fibre, many fewer cables are needed, and optical fibres are much less bulky than coaxial cables. There is no electrical connection between remote areas, eliminating the problems of earthing and mains hum. Optical transmission over the distances found in a studio centre is virtually lossless, so no cable equalisation is needed. Optical fibre transmission does not suffer from cross-talk, and optical fibre does not cause or suffer from electromagnetic interference.

The availability of a multiplex of all sources at all destinations, with source selection at the destinations, will be a particularly important feature in areas (such as News) where programmes are compiled from a number of incoming feeds. It will dramatically reduce the wiring and will eliminate complex circuit booking lists.

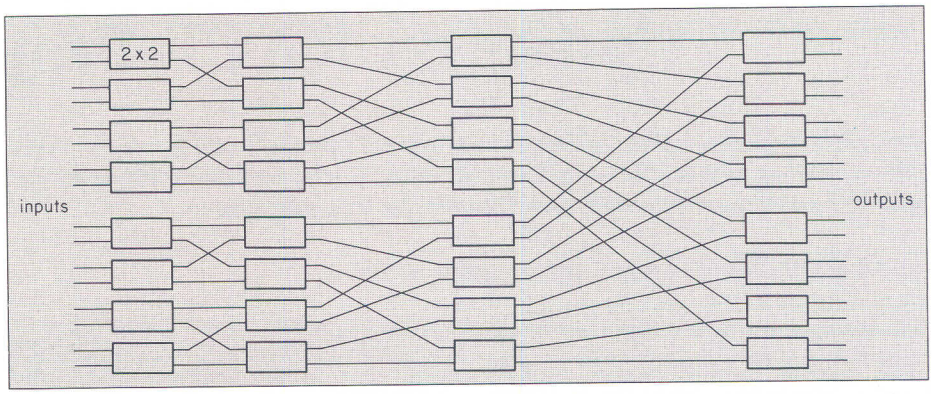


Fig 3: a 16 x 16 coupler made from a network of 2 x 2 couplers.

System Specification

The consortium started work by preparing a detailed specification for the performance of the system and for methods of testing its components. The aim was to specify everything, with realistic manufacturing tolerances, so that the performance of the demonstration test bed that would be built at the end of the project would be representative of the performance of a real network.

An important aspect of the specification is the optical power budget. The allowable loss is calculated by subtracting the minimum power that the optical receiver can detect from the output power of the laser transmitters. Then the expected losses of all the components of the system are added up. The largest item is the 12 dB loss of the star coupler because it is splitting the available power sixteen ways. However, allowances also have to be made for the losses of the other components and for such things as ageing of the lasers, connectors and splices (the loss of the fibre, at 0.3 dB/km, comes a long way down the list). After a bit of horse-trading between partners responsible for different components, the budget showed a healthy margin of about 4.5 dB.

Electrical Multiplex

An early decision in the project was to base the electrical multiplexing on the synchronous digital hierarchy (SDH) recommended by the CCITT (the body that recommends systems for international telecoms, as the CCIR does for radiocommunication). SDH will eventually replace the 2 Mbit/s — 34 Mbit/s — 140 Mbit/s hierarchy used by BT with a universal hierarchy based on 155 Mbit/s.

The main advantage of the new system is that it is easy to extract a single low bit-rate signal from a high bit-rate multiplex, whereas with the present hierarchy this requires a number of complex operations. Use of SDH should mean that the same equipment can be used for combining broadcasters' signals as is used for combining telephone calls.

The corollary is that the core of the routeing system is independent of the video and audio standards in use. So a digital system based on SDH is particularly well adapted to the mixture of formats that is becoming common in studio centres. PAL is used in many studios, with both analogue and digital recorders; some areas, particularly news, have to handle analogue components; and some areas, particularly graphics, need to use digital components. These different formats have quite different requirements for routeing, making interconnections difficult without multiple transcodings which erode picture quality.

The difficulty of routeing component signals transparently is one of the factors that is inhibiting the change to digital component working in studio centres. A standards-independent routeing system will facilitate this change (which will improve picture quality), while retaining the means of routeing PAL signals as long as necessary. It will also allow the introduction of new formats — including HDTV.

The electrical multiplexing and demultiplexing requires a number of special-purpose ICs. Most of these operate at 155 Mbit/s and are being designed by Alcatel Standard Electrica in Madrid; some of them have already been fabricated. However one pair of ICs has to combine sixteen 155 Mbit/s signals up to 2.5 Gbit/s and then split them again. These two circuits are being designed by SGS-Thomson in Grenoble and the first major setback occurred earlier this year when the first samples failed to reach their designed speed, although they showed the correct functions at a lower speed. However, they are now being redesigned to use a much faster process that has recently become available; this redesign should not delay the project much as an iteration of these ICs had been foreseen in the project plan.

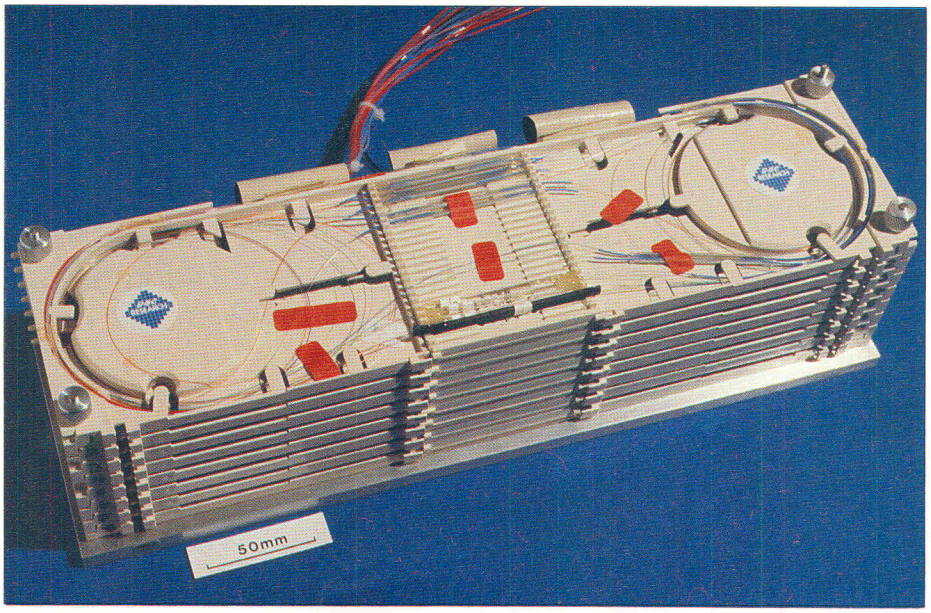
Laser Transmitters

To be useful for wavelength multiplexing with a wavelength spacing of 4 nm, the laser transmitters must emit a single closely-controlled wavelength. The transmitters are being made by STC Optical Devices in Paignton. They use distributed feedback (DFB) laser diodes, which contain a diffraction grating to define their wavelength very accurately; they can be finely tuned by controlling the temperature of the laser chip. In tests, the laser transmitter modules have shown a wavelength stability of ±0.2 nm compared with a specification of ±0.7 nm. The first complete 2.5 Gbit/s laser transmitters were delivered to the BBC in September.

Star Coupler

Two technologies are being followed by GEC Hirst Research for this component, which carries out the functions of multiplexing the sixteen wavelengths together and of splitting the multiplexed signal so that a sixteenth of the total power goes back to each local routeing centre.

A complete sixteen-way star coupler has been made from a network of 2 x 2 fibre couplers, as shown in Fig 3; if you follow the paths through the network, you will find that each input is connected to every output. The 2 x 2 couplers are made by stripping the cladding off lengths of fibre, twisting them together, and pulling gently over a gas flame until monitor photodetectors show that exactly 50% of the light going into one arm is coming out of each of the opposite arms. The thirty-two 2 x 2 couplers needed are spliced together and have been mounted in the box shown in the photograph on the right. This is believed to be the largest wavelength-flattened star coupler ever made (ie, a coupler with an even loss over a range of wavelengths). Tests have shown that more than 75% of routes through the coupler have an excess loss (over the 16-way division loss of 12 dB) of less than 1.2 dB; the maximum excess loss is 2.3 dB.



Research Department

A 16x 16 coupler in its protective case.

The other technology that is being followed is to make an integrated-optic star coupler by depositing optical waveguides on a silica wafer. This uses the same sort of techniques as are used in the fabrication of ICs and offers the possibility of cheap and repeatable fabrication of robust star couplers. 16 x 16 couplers have been made this year; they are among the most complex integrated-optic devices ever reported — the electron beam mask is shown in Fig 4. The first devices showed a high excess loss with large variations from path to path: this was traced to edge effects in the fabrication process, so larger wafers are to be used in future work.

Optical Demultiplexer

Each local routeing centre contains an optical demultiplexer to separate the sixteen optical wavelengths coming in from the star coupler. The wavelengths are separated by a diffraction grating and the sixteen beams are focused onto an array of output fibres leading to separate optical receivers (in a fibre-coupled demultiplexer) or onto an array of photodiodes (in a diode-coupled demultiplexer). Obviously the diode-coupled demultiplexer has the advantage that it integrates the first stage of the receiver, but its performance is limited by the performance of the integrated diode arrays — and they are not yet sensitive enough or fast enough for use in our system.

So we are working on both approaches: a fibre-coupled demultiplexer has been made by a specialist French company, Jobin-Yvon, (see the photograph overleaf) for use in the system test bed, and research on the diode-coupled demultiplexer is being carried out by STC Technology. Both companies have reported excellent results: an allowance of 5 dB had been made in the power budget for the demultiplexer, but the completed fibre-coupled demultiplexer has a loss of only about 2 dB; and prototype diode-coupled demultiplexers have shown excellent performance and offer the possibility of a very compact device for the future.

Optical Receivers

As mentioned above, the fibre-coupled demultiplexer requires separate optical receivers. These are being made by Thomson's Laboratoires Electroniques de Rennes. For high sensitivity, the receivers use an avalanche photodiode — a photodiode operated with a high reverse bias, close to breakdown; light falling on the device causes a controlled breakdown, increasing the photocurrent and giving a high gain in the same way as in a photomultiplier. The receivers include another stage of amplification, circuitry for regenerating the 2.5 Gbit/s clock, and a D-type flip-flop.

A prototype receiver with performance approaching the specification was

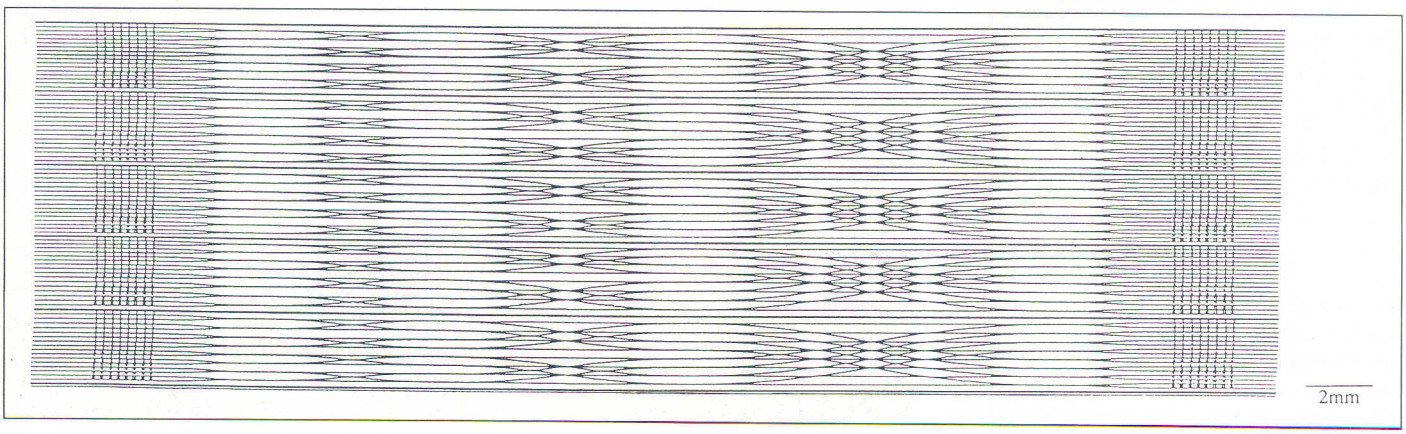
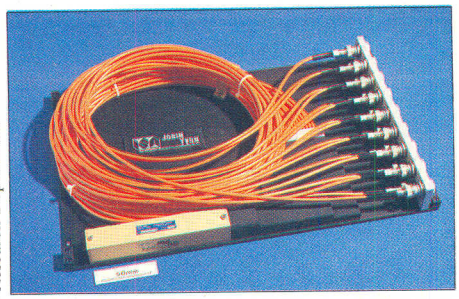
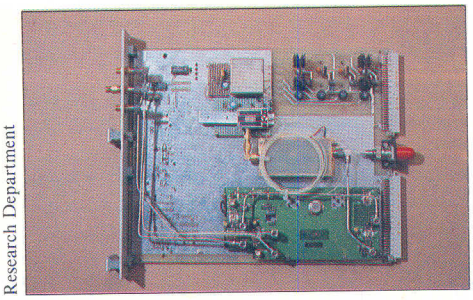


Fig 4: An election beam mask for the 16 x 16 planar coupler.



Research Department

Fibre-coupled demultiplexer mounted on a baseplate with the output fibres coiled up.



Research Department

Prototype optical receiver.

deliverd in September; production devices are expected by the end of the year.

Control

Each local routeing centre contains a control computer which sets up and releases connections at the request of the users. The control computers communicate with each other using a dedicated channel in the 2.5 Gbit/s multiplex. The controllers are being built and the control software written by the Research Neher Labs of the Netherlands PTT.

The software is written in Specification and Description Language (SDL), a language recommended by the CCITT for writing telecommunications control software, which is then machine translated to Pascal to produce executable code for the control computer. Simulations have shown that the control system can set up and release connections as specified: it can also recognise 'illegal' connections (for example, trying to connect a sound signal to a picture monitor) and give a warning.

Test Beds

The object of the RACE project is to produce test beds — partially populated WTDM systems that demonstrate all the critical aspects of the technology. A preliminary test bed will be assembled early in 1991. This will have four laser wavelengths — two close together and two at the extremes of the range — and will validate the optical aspects of the WTDM system. As more components are added, this will grow into the final test bed — with sixteen wavelengths, electrical multiplexing and demultiplexing, and control — so that we can demonstrate routeing of video and sound signals by the end of 1992.

However, a 'pre-preliminary' test bed has already been put together at Research Department by John Zubrzycki. It was demonstrated on the BBC stand at IBC and at a conference on broadband systems and networks at the IEE, in an exhibition organised by RACE Central Office (see the photograph below). This exhibit uses only two laser wavelengths, each carrying a single PAL video signal sampled at $4f_{sc}$ and multiplexed into an SDH container at 155 Mbit/s; the SDH interfaces were designed by Richard Marsden and Chris Newell.

The optical path from lasers to receivers is complete, using the components made by our partners for the 'real' test beds — this demonstration effectively answered a number of people who came up to us at IBC with questions like "Is wavelength multiplexing with so close a spacing really feasible?" Their next question was then usually "When will it be on the market?"

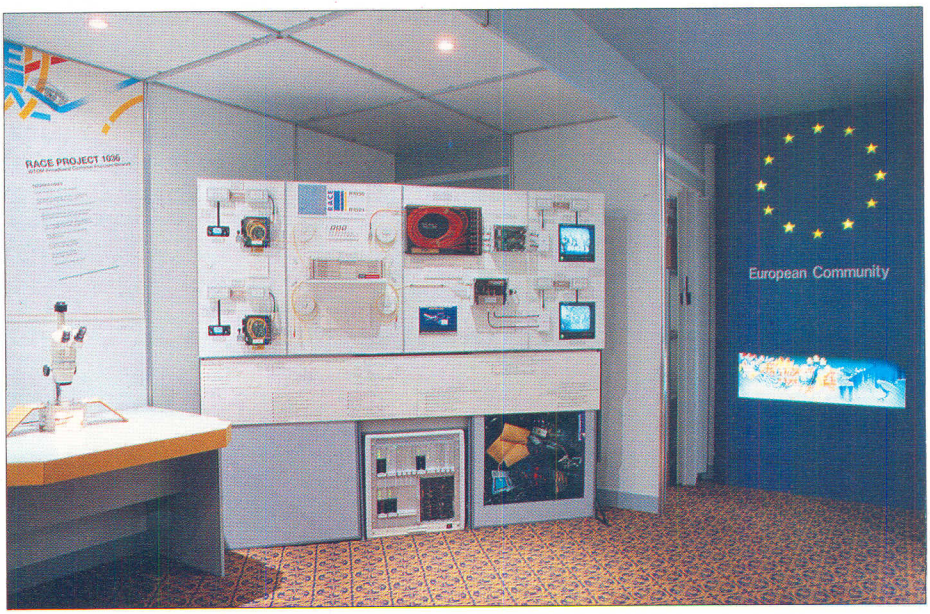
The Future

I hope I have said enough about the technical progress made by RACE Project 1036 to show that the project is now well on the way to proving the feasibility of the WTDM system. At this year's Technical Audit, the Auditors described it as "a fine example of a collaborative effort in Europe". The next step will be a trial installation. So our colleagues in Resource Development, Television are looking for a studio centre whose routeing system comes up for renewal a year or two after the end of the current project (1992), to allow some time for further development towards production.

One possibility that is being considered (using the normal cost and value criteria) is Cardiff, in 1994. In parallel with the trial installation we shall be trying to interest other potential users — beyond broadcasting — to ensure a large enough market to interest manufacturers.

The EC's RACE Programme is all about widening the scope of telecommunications towards an integrated broadband digital communications network carrying video and data as well as telephony. The BBC's RACE Project 1036 is contributing to that aim by developing a network that will allow telecommunications customers to integrate signals in their own premises — and thereby developing the sort of signal routeing equipment that we believe the BBC will need in the future. We are bringing broadcasting and telecommunications closer together, to the benefit of both.

Andrew Oliphant
Research Department



Research Department

The IBC exhibit at the IEE IBSN conference and exhibition.

D&ED Open Days '90

Design and Equipment Department staged its Open Days at Avenue House in late November, coinciding as usual with the annual Engineers' In Charge Conference. Peter Jefferson describes the new designs on show.

The event was held against the backdrop of wide-ranging changes within the Department, which are being introduced through 'Funding The Future'. As a result, fewer areas of the building were on display although a wide selection of new equipment designs were still shown. In addition, the opportunity was taken to introduce the new D&ED management structure, and to demonstrate a selection of the range of services which will be available to BBC Engineering.

As always happens in an IBC year, some of the equipment on display during Open Days — including all those from Audio Section — had also been shown at Brighton during September. These items (Network Clock, AESIC, Digital Headphones, Digital Audio Router, TARDIS, UHF Music Links, and RDS) were described in the Autumn edition of ***Eng Inf***, to which initial reference should be made for further information.

There now follows an outline description of the non-IBC exhibits which were shown during the Open Days.

VIDEO SECTION was showing a variety of items which demonstrate the broad range of its present areas of work: two **Video Monitoring DACs** which provide component and composite analogue outputs from an input of parallel digital video (to CCIR Rec 656); the **Teletext Data Combiner** which synchronises and combines the data from up to six composite video sources into a single signal, ready for insertion onto a video waveform; remotely-controlled **LoCo Equalisers** for the London Co-ax Network which allow path-length adjustments (up to 10 km in 0.5 km steps) to be made from Television Centre; and a **Chrominance Equaliser** which adjusts the chrominance gain according to the measured amplitude of the chrominance burst at the start of each video line.

RF SECTION has produced three items associated with the launch next autumn of the BBC's Nicam stereo tv service: two **UHF Transposer Linearity Correctors** for the Blue Streak and Silver Streak equipments are currently being sourced in quantity, to reduce the incidence of intermodulation products within the transposers, and a **Nicam Decoder** has been produced as a sub-unit for the UHF Transmitter Demodulator and Rebroadcast Receiver designs. The development of new **UHF Music Links**, and a **Band III Power Amplifier** for the VHF Music Links (designed in association with D&ED's Support Laboratory), is progressing; a quantity of **MF-FM Converters** is being produced for issue to schools around the country, to allow reception of the MF Radio 5 service on FM-only sets; and an **RDS Re-Processor** allows RDS data to be stripped off, and new data to be inserted, at FM relay stations.

CONTROL SECTION has been involved with providing new equipment and software for the current HF Automation projects on Cyprus and at Skelton, including an **Array Mimic**, which replaces the present matrix of LEDs — used to indicate the state of the array field — with an image on a colour monitor. The section has produced a **Man Safety Alarms Unit**, to provide safety monitoring of staff carrying out maintenance on unattended transmitter sites. Also, the current state of commercially-available **Speech Recognition** systems is being investigated, to see whether the technology might be applicable to certain areas of the BBC.

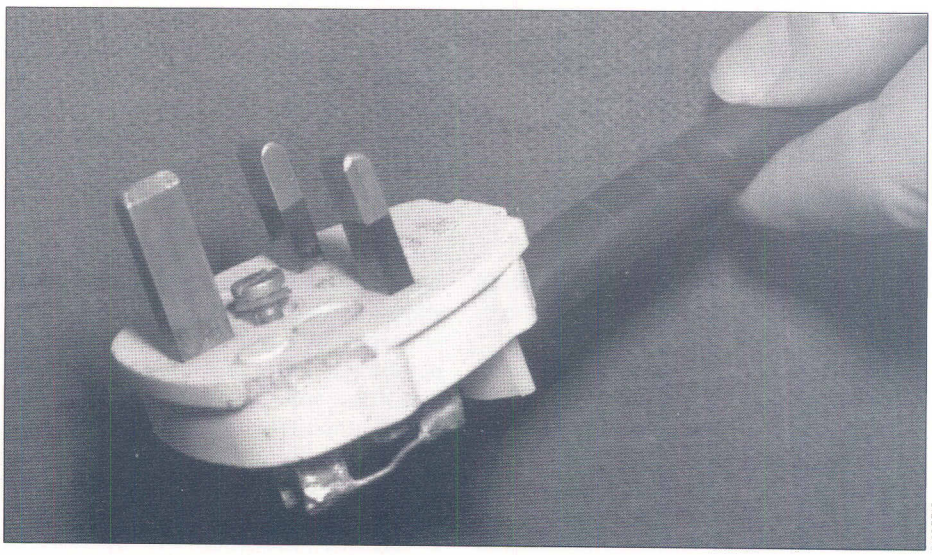
CENTRAL STORES mounted a display to illustrate some of the **Product Lines** which will continue to be available, following the reductions required as part of the reorganisation; these include a wide variety of cables and connectors, specialist tools, meters and relays, etc. Also shown were items from the **Eurocard Chassis System**, as were examples of both stock and non-stock **Corporate Stationery** (formerly available from Ware Stores).

STANDARDS SECTION showed the use of their **Semiconductor Database,** held on a set of CD-ROMs, which allow immediate access to information on over one million current and obsolete devices; this is just one example from the wide range of information which is available to the BBC from this section.

Information sheets for the majority of the items listed above are available from D&ED Liaison Unit (AH 375), should you require further details. A brochure for visitors to the Open Days was also prepared, and copies are also available from the same source; this gives broader details on the revised structure of Design and Equipment Department, as well as further information concerning recent areas of work undertaken by Design Group.

Peter Jefferson
Liaison Engineer
D&ED

SAFETY



MRM

MSS Eng nearly blew a fuse when this 'hard-wired' mains plug was sent to him. Are there any more out there he should know about?

LOCAL RADIO
Radio Car comms system

The Mk 5 Radio Car is about to enter service in Local Radio. Roger Palmer summarises the main technical features of this new design, and the associated base stations.

TED's Broadcast Communications Section (BCS) is responsible for the provision of radio cars and radio communication facilities for Local Radio.

Radio cars offer a cost-effective way of deploying local radio staff for the coverage of news items and other programme material. The cars are fitted with simple sound mixing facilities and a communications system to enable reporters to make live or prerecorded contributions. Communications with the studio centre are made via base stations (typically two per local radio station, located at the centre of the editorially-important areas).

As described in ***Eng Inf*** No 42, each station has been allocated a uhf frequency for programme contributions and a duplex pair of vhf frequencies for production co-ordination purposes. The incoming leg of the vhf link has an enhanced audio bandwidth, suitable for programme speech when the uhf link is out of range, and a BBC compander has been added to improve the noise performance. The main technical characteristics of both systems are summarised in the table above.

	VHF	UHF
Frequency Band	213/224MHz	446/455/469MHz
RF Bandwidth	12.5kHz	50kHz
Power ERP	25W	25W
Audio Freqency Response	150Hz - 6kHz	50Hz - 10kHz
Distortion	-34dB	-40dB
Signal to Noise	-40dBw	-50dBw

Technical characteristics of the vhf and uhf transmitters.

The Mk 5 Radio Car

The new Radio Car has been designed to be operated by presenters and reporters but, on a more complicated OB, an engineer will also be present.

The main facilities are:

- A pneumatic mast carrying the uhf antenna
- A vhf radio telephone with wideband link from the car to the studio centre.
- Switching to connect either a microphone, radio microphone or Uher tape recorder to either transmitter.
- Facilities to allow the contributor and reporter to listen to off-air cue feeds and, if necessary, the studio via the radio telephone.
- A radio microphone to enable the reporter to work remotely from the car.
- Connections to allow an engineer to mount a mixer in the car and monitor and mix all of the above.

The Mk 5 car, based on a Sierra estate, will eventually replace the still-current Mk 4 design, which is based on a Montego estate. Some of these have now done in excess of 100,000 miles, with equipment that was relocated from the Mk 3 Radio Car.

The Mk 5 vehicle differs from previous cars in that all the electronics are mounted in a small (11U) bay, mounted in the space left when the 1/3 portion of the split rear seat has been removed. (In previous designs, the various units were mounted in any available space in the car, thus making it difficult and expensive to remove and install in another vehicle.) The controls for all the equipment remain in the front as in previous designs. A block diagram of the audio feeds is shown in Fig 1.

Since the vehicle contains a 30ft mast, one of the main concerns in the design stage was that of safety, especially since it would be used by non-engineering personnel. Thus, there are many interlocks that will not allow the mast to be raised, unless the vehicle is parked with the handbrake on and the ignition off. Once the mast is raised, the engine cannot be started and, if the handbrake is released, the mast will be lowered automatically. Only when the mast is safely stowed can the engine be started.

A prototype vehicle was built and travelled around various local radio stations, so that feedback from the operators could be included into the design before a main scheme to replace the existing Montegos was started.

The Base Station

Basic Operation

A typical communications arrangement is shown in Fig 2. The uhf and vhf receivers are connected to the studios via high quality music circuits. A telephone-quality circuit (control line) connects the studios to the vhf transmitter, and the vhf receiver to the studios when the wide audio bandwidth option is not needed. Most stations use what is known as 4-wire ac signalling to key the uhf transmitter: dc signalling is in use in some areas but BT is slowly phasing out this option. The ac signalling tone is 800Hz and is filtered in the line linking unit, prior to transmission.

The vhf duplex system is fitted with Selcall, a selective calling system supplied as a standard option with most radiotelephones. A number of standards exist, but the one used in Local Radio is known as 'ZVEI' which is considered a reasonable compromise between signalling speed and robustness. Like other systems, Selcall uses fifteen tones to represent a 1045 matrix of codes.

A sequence of 5 tones is sent: Local Radio uses the first four to uniquely identify the station and the last digit to automatically select destinations within

the local radio station. This avoids the need for a base station control operator to handle incoming calls. A Selcall sequence is also used by studio staff to ascertain whether the radio car is in range: on reception of the code, the mobile automatically transponds with the station identity followed by a single acknowledgement tone code.

System Planning Considerations

Once the editorial imperatives have been defined, it is possible to identify possible base station sites — the most obvious being BBC transmitter sites. Predicted service area maps are obtained for each possible site, from Research Department, before a final decision is taken.

Although service area coverage is the prime factor which determines the location of a base station, compromises often have to be made. For example, the available capacity on existing sites may be limited, electromagnetic compatibility with existing installations may not be adequate, or environmental and planning considerations may compromise performance.

Another major problem that faces the system planner is interference from other installations on communal sites. There are four main categories of interference:

- Noise and spurious products, generated within transmitters, which occupy a broad bandwidth on both sides of the carrier frequency.
- Intermodulation products caused by inadequate isolation between the outputs of the various transmitters on site.
- Intermodulation products caused by nonlinear effects on the mast and antenna hardware — the 'rusty bolt effect'.
- Intermodulation products, and cross modulation and blocking effects in receiver systems, usually caused by large signals at their input.

Adequate filtering to eliminate these potential problems can usually be specified at the planning stage. However, on occasions, retrospective action has needed to be taken once the installation had been completed.

BCS's project engineer on Local Radio schemes is Peter Gooderham and the engineers are Gavin Robertson and Guy Stanbury.

Roger Palmer
Project Manager
Broadcast Systems, TED

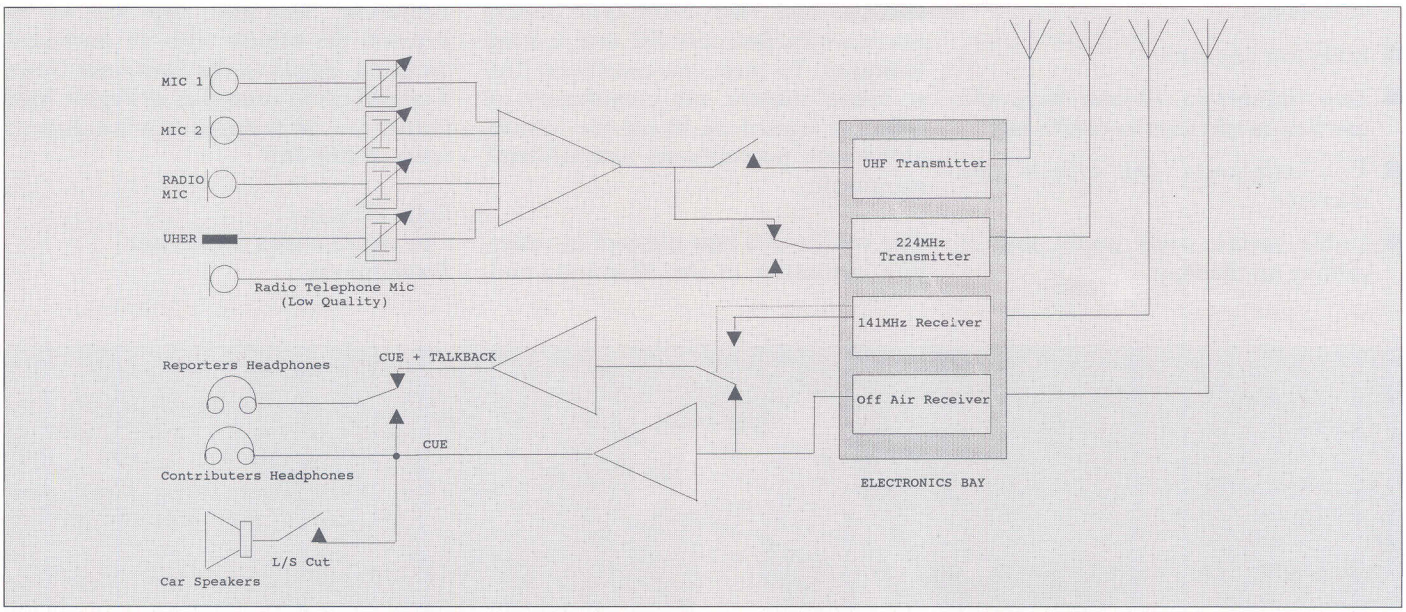


Fig 1: block diagram of the Radio Car audio feeds.

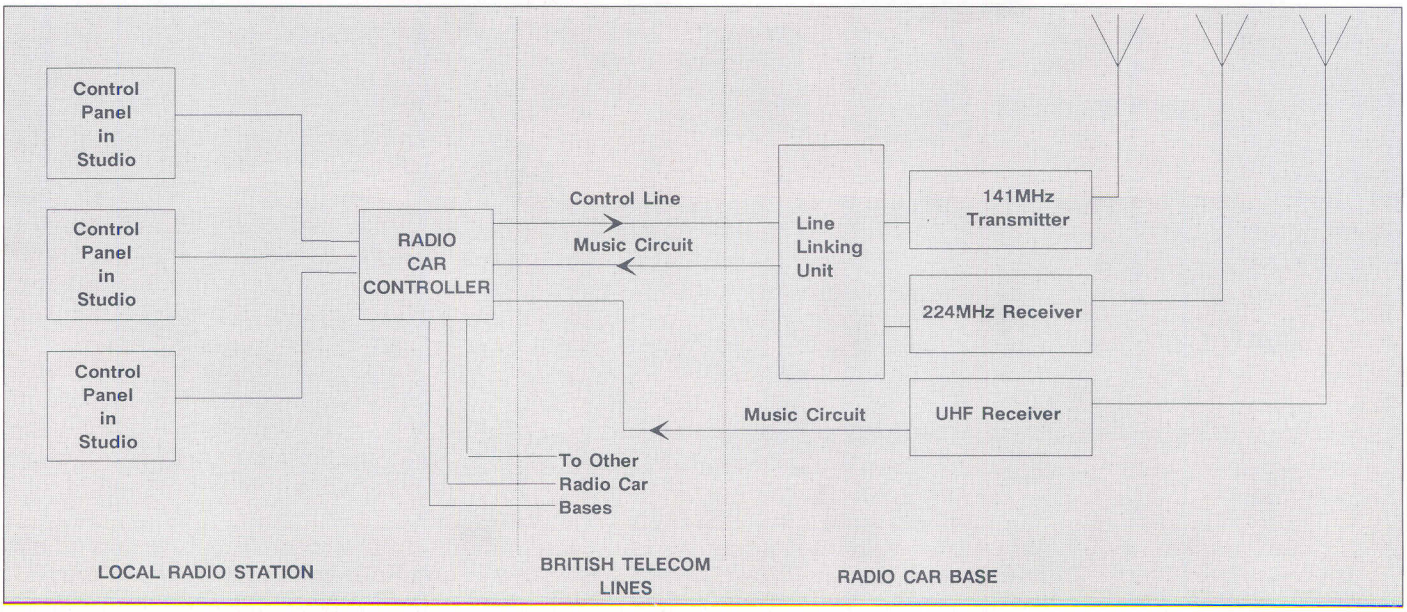


Fig 2: block diagram of the communications arrangement.

MIDLANDS REGION
Fast response News vehicle

Midlands Region recently took delivery of a fast response News vehicle, which is described here by John Deakin.

The new vehicle is based on a Land Rover 110 and was designed by TED at Warwick. It is similar to the News Land Rover operated by N&CA in London, except that it has not been stretched and raised (to keep the costs down).

The vehicle's basic equipment as delivered was as follows:—

- 3kVA alternator, driven from the vehicle power take-off, plus power distribution (12V & mains)
- 35 foot pneumatic mast and compressor
- Stabiliser equipment
- Two half-height 19-inch bays and one half-height narrow-width bay
- Two cellphones, one with a data interface
- Cable termination panel and rf cabling up the mast

As the Midlands vehicle is quite compact, it carries less technical equipment than the larger London version. In the 19-inch bays are: a b&w monitor, a colour monitor, a video cable trimmer, an oscilloscope, an off-air receiver, an audio and video jackfield, an audio monitoring panel, a time-base corrector and a DA rack. The Comms RT, scanning receiver and data interface have been accommodated in the narrow-width bay.

Installed elsewhere is a talkback base station, and two ENG tape replay machines (a Betacam SP and a Sony U-matic). To meet the essentially 'fast response' feature, the complement of cables is stowed on board the vehicle, along with microphones and talkback equipment.

The vehicle is a new concept in radio-link operation in the Midlands and, hence, is very much subject to a learning experience. It was originally intended that only one engineer would operate the vehicle and, for tape replay and simple pieces down the line, this generally holds. However, two operators may be required in more complex situations, such as live two-ways, where good communication is needed between a remote crew, the vehicle and base.

The Land Rover is already making a major contribution to the successful Midlands News and Current Affairs operation. The next step will be to provide the vehicle with an on-board terminal, linked to the Electronic News System (ENS) computer at Pebble Mill (which will be featured in a subsequent issue of ***Eng Inf***).

John Deakin
Communications Supervisor
Birmingham

NCA Publicity, Pebble Mill

The Midlands fast response News Rover at Pebble Mill.

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