No. 17 – Summer 1984 **The Quarterly for BBC Engineering Staff** Please circulate

Digital TV Sound Looks Good

On 24 May Research Department engineers carried out what is believed to be the first 'all-digital' transmission of stereo television sound, using the Crystal Palace transmitter after closedown. They are now confident that a digital system will best fulfil the requirement for stereo with television from terrestrial transmitters.

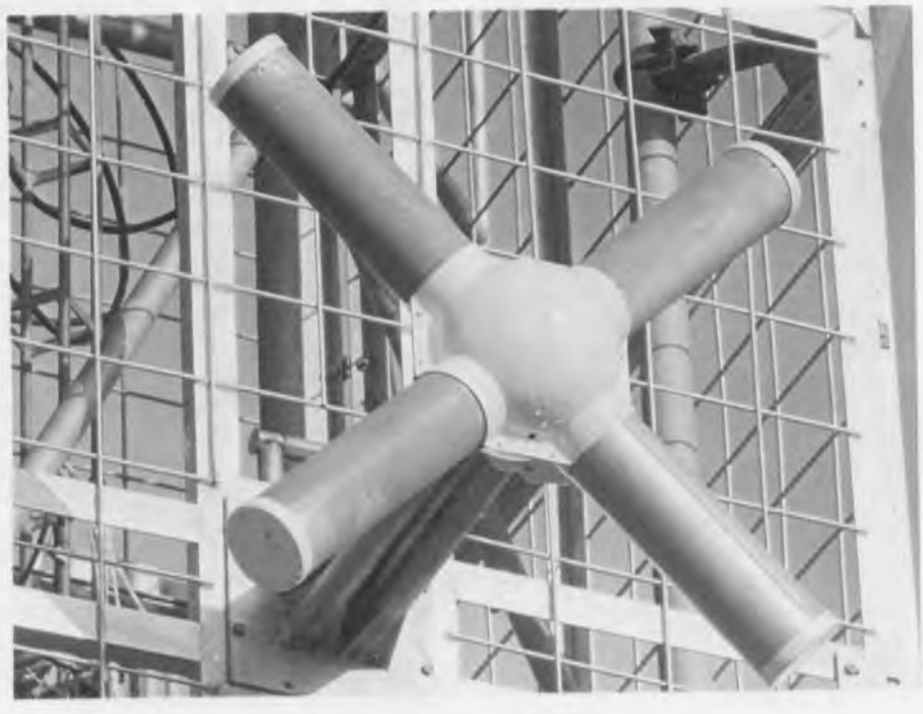
The programme consisted of a conventional (analogue) video recording of a pop concert recently featured as a simultaneous stereo broadcast on BBC television and BBC radio. The associated digital recording of the sound signals was replayed into the digital stereo transmission system without conversion to analogue form.

The equipment included a sampling-rate changer provided by Studer for converting from 44.1 to 32 kHz and a software-controlled processor for altering the pre-emphasis characteristic from that used in the recorder to the one required for transmission.

These tests are the latest in a series which began at Wenvoe (see Eng Inf No 15). That test confirmed the ruggedness of digital stereo tv sound in areas of difficult reception. Compatibility trials from Crystal Palace in March this year then confirmed that no significant interference would be caused to sound or vision reception on existing receivers.

In consultation with the Home Office, discussions with the IBA and industry are well under way with a view to the early establishment of an agreed UK specification. It is hoped that further tests can be arranged.

TCPD Special Feature



A typical mixed (circular) polarised vhf aerial under test

VHF Radio Re-Engineered

The BBC's VHF Radio Services were planned in the late 1940's/ early 1950's and assumed the use of mains-powered mono receivers connected to aerials mounted 10 m above ground level. The horizontally polarised mode of transmission was chosen, because horizontally mounted domestic receiving aerials would reduce the risk of ignition interference, and minimise multipath distortion. By 1966 a network of eighty-two transmitting stations was providing three monophonic networks to an estimated 99.3% of the population.

The introduction of stereo in 1966 meant that, for a given signal-to-noise ratio in the listeners mono receiver, it would be necessary to increase the field strength from the transmitters to achieve the same ratio in a stereo receiver. Clearly this was impractical, so the effective service area covered by the transmitters was re-defined, (from 48 dB to 54 dB relative to 1 μV/m) leaving a requirement for low power relay transmitters to fill in the gaps thus created.

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Editorial

In this edition of Eng Inf, we break with previous tradition, and turn the spotlight on one department, almost exclusively.

Of course, most engineers are well acquainted with the excellent work of Transmitter Capital Projects Department whose range of activities cover the frequency spectrum from 50 Hz high-voltage main installations, to satellite receiving equipment in the 5 GHz band.

Besides the installation of uhf television relay transmitters, which open at the rate of one every four days, TCPD are also responsible for the re-engineering of the vhf band, where they are converting stations to mixed-polarisation for the benefit of car and portable radio listeners, and building new relay stations to fill in the gaps in overall cover.

It may come as a surprise to learn that TCPD engineers are also involved in many other activities. From the provision of shf vision link equipment and mobile relay towers for Television OBs, to new aerials and transmitters, or should I call them senders, for External Services. High power mains installations in studio centres are also the responsibility of TCPD, as are the most cost effective ways of using the electricity supplied, and thus helping to reduce the Corporation's huge electricity bills.

Thanks are due to the many TCPD engineers who have contributed to this edition of Eng Inf and commiserations to those whose efforts were not published because of lack of space.

BBC Engineering at IBC 84. The 1984 IBC will be held, once again, in Brighton in September. BBC engineers will be playing a major part in the conference, presenting eighteen papers ranging from digital topics to DBS. In the accompanying exhibition, much of the hardware associated with the papers will be on display for visitors to evaluate.

If you are visiting IBC, why not drop in to the exhibition, where you will find a welcome on the BBC stand on the lower ground floor (Stand number L10). For those unable to attend, there will be a full report of the exhibition in the next edition of Eng Inf.

Alan Lafferty

C.O.E.R. Retires

Duncan MacEwan, Controller Operations and Engineering, Radio, retired from the BBC on 25th June after a career spent almost equally in radio and television.

Duncan joined the Corporation as a probationary engineer in December 1947, and became one of the founder members of the Scottish/North television outside broadcast unit before moving to ETD where he worked as senior lecturer establishing the new Technical Operations section in 1956. He was promoted to EiC Television, Birmingham in 1960 and then Regional Engineer, Northern Ireland in the following year. In 1969 he was appointed Chief Engineer, Regions, and in 1971, Chief Engineer Radio Broadcasting. In 1983 he became the first holder of his present post.

His period as Chief Engineer, Radio, saw significant advances in BBC Radio. The 13-Channel pcm system was established to distribute high quality stereo signals to the vhf transmitters. The period heralded also the expansion of Local Radio to cover most of the main areas of population in England and development of the radio services in the National Regions. More recently Duncan oversaw two major refurbishment programmes, namely the replacement of the Radio OB fleet with vehicles containing innovations, including greatly improved stereo facilities, and a similar refurbishment and modernisation programme in radio studios.

Duncan was recently the recipient of a Sony award for technical excellence and achievement for a broadcast via satellite of "A Concert from Seoul" a concert of traditional Korean music.

He has been succeeded in the post by Bill Dennay, previously CEXB.

Bill joined the BBC in 1956 at Daventry as a probationary Technical Assistant and served as Technical Assistant and Engineer at several radio and television transmitting stations. He then moved to ETD where he was a member of the lecturing staff from 1961 to 1973.

In 1973 he moved to Transmitter Group headquarters and after periods as Head of Operations and Head of Engineering was appointed Assistant Chief Engineer, Transmitters in 1978.

In 1979 he was promoted to Chief Engineer, External Broadcasting and had responsibility for many important advances in External Services engineering. He was much involved in the discussions between the BBC and the Government to improve the audibility of the External Services transmissions, the outcome of which was a major equipment investment of over £100 million. Significant features of this were the replacement of UK-based World War II transmitters with modern high power units, additional relay stations at Hong Kong and in the Seychelles, and the provision of satellite feeds of radio programmes to overseas relay stations. Also included was the important continuation of the refurbishment of the studios at Bush House.

More recently he saw the final plans produced for the major modernisation of the Monitoring Station at Caversham/Crowsley Park.

Transmitters Opened

The following uhf transmitters have opened since April:

Blackburn	Lancashire
Chepstow	Gwent
Draperstown	C. Londonderry
Garelochhead	Strathclyde
Gorey	Jersey C.I.
Hamstreet	Kent
Hartington	Derby
Lowther Valley	Cumbria
Newport Bay	Dyfed
New Radnor	Powys
Pooley Bridge	Cumbria
Totnes	Devon

Change of Programme Source to East Midlands opt-out:

Stanton Moor
Bolehill
Matlock
Ashford-in-the-Water

The following vhf transmitters have opened or changed:

Guildford	Surrey
Swingate (mixed pol'n)	Kent

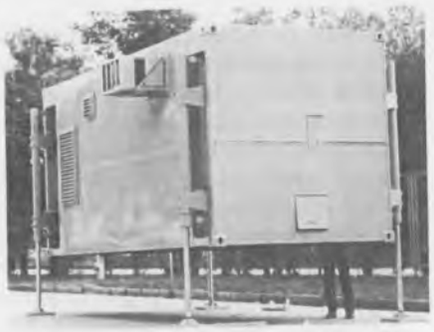
The following local radio transmitters have opened or changed:

Clipstone	R. Nottingham
Geddington	R. Northampton
Swingate	R. Kent

Main Station Change

Main Station Section have produced a comprehensive plan, see TCPD Report No 84/02, recommending complete re-engineering of the uhf main station network over the next fifteen years.

This involves the complete replacement of existing plant, some of which uses the multiplex system of operation with new parallel operated transmitters. For non-transmitter engineers it should be explained that the multiplex system normally uses two klystrons in the transmitter, one for sound and one for the vision signal. Should one klystron fail, the remaining klystron carries both sound and vision signals via modified circuits. In parallel operated transmitters there are four klystrons, two for sound, and two for vision, forming two halves of the whole transmitter. Should one



One of the containerised transmitters

half fail, the other half carries the entire output.

Although operationally advantageous, parallel operation is not the cheapest solution either in terms of capital outlay or operating expenditure. Hence, in order to enable this type of transmitter to be funded within foreseeable budget and revenue provision, there will be a greater need to rely upon new technology to obtain cost effective solutions.

It is therefore envisaged that at high power stations pulsed-beam klystron transmitters will be employed, whereas at smaller sites, tetrode equipment may be used.

Schemes have already been approved for replacing the BBC 1 and BBC 2 transmitters at Sutton Coldfield and the BBC 2 transmitter at Winter Hill. Both projects are due for completion within the next twelve months, by which time it is anticipated that approval will have been obtained to re-engineer Pontop Pike.

In most cases, the existing uhf transmitter accommodation will be re-used after the necessary building alterations have been carried out.

For this to be implemented on a satisfactory basis, it will be necessary to maintain services throughout the six month installation period using transportable transmitters.

Two 20 kW containerised transmitters manufactured by Siemens have been ordered for this application and they will each be coupled with a 10 kW emergency transmitter to provide back-up facilities.

Stereo to Channel Islands Not Easy

Much time has been spent over the last few years in considering how stereo radio programmes might best be carried to the Channel Islands for the transmitters at Les Platons.

Submarine cables are unsuitable for stereo signals, and the alternative of an SHF radio link via France is expensive and complicated.

After extensive tests it has been concluded that the most cost effective way of feeding the Channel Islands is by conventional rebroadcast receivers. These have been used for over 20 years for mono, but for stereo an extra 18 dB of signal level is required in order to achieve the same signal-to-noise ratio. Stereo signals are also more susceptible to adjacent channel interference.

The nearest reception point to the mainland is Alderney. The signals received here over the 100 mile sea path are sent to Fremont Point on Jersey using PCM on the tv links over video circuits, using equipment made by GT & E and then by local Telecom lines to Les Platons.

Satisfactory stereo reception has been achieved by using a diversity switch, operated by receiver agc, which selects the receiver with the highest signal from either North Hessary Tor or Rowridge. This results in excellent path and frequency diversity. To avoid chatter when the diversity switch operates, hysteresis and variable time-constant circuits are used. Triple 6-element yagi aerials are mounted low on the mast at Alderney to avoid ground reflections which cause frequent and deep fades during anticyclonic conditions.

The average receiver input is about 800 μV. The Rowridge aerial is panned 15 degrees off the direct bearing to reduce adjacent channel interference on R4. An additional aerial has been located in a position further down the hill where it is well screened from the French coast.

A miniature helical IF filter has also been designed to improve the selectivity of the RC5/9 receivers, because of the adjacent channel problems. One unexpected source of interference was a harmonic of the PCM 2048 kbit stream which caused a "burble" on R4.

To reduce the subjective annoyance caused by switching between sources with different noise levels, the CD3/23 stereo decoder was modified to provide a "blend" facility. The left and right channels are progressively mixed during fades below 200 uV ensuring that noise is kept above 50 dB4W even for signals as low as 15 uV. This is, of course, at the expense of stereo separation. Deep fades, however, seldom last for more than a minute and rarely occur more than four times a month because of the diversity arrangement adopted.

The Rowridge aerial is due to be replaced in 1986, and the new aerial will have a polar diagram shaped to minimise interference towards France. This will reduce the signal level in the direction of Alderney by 8 dB. However, it is hoped to recover 3 dB by using cross-polarised aerials. A further 5 dB may be obtained because the new aerial will be 30 m higher than at present, thereby providing extra path-clearance above a hill which is a mile from Rowridge in the direction of Alderney.

The new system has been on engineering test since before Christmas and is expected to enter permanent service shortly.

* * *

Stereo OB Link Equipment

For four years Communications Section, TCPD have been negotiating with the Home Office for the use of spectrum in the 1500 MHz band. This spectrum is required for the point-to-point transmission of high quality stereo signals.

These negotiations reached a successful conclusion in October 1982, since when Communications Section have published an equipment specification for a digital radio link. When used together with two-channel 676 kbit/s NICAM equipment this will provide high quality links for both permanent circuit and OB use.

Contracts have been placed for eight sets of equipment to provide feeds from Local Radio Studios to their respective vhf transmitters and for four OB links.

The equipment has been ordered from Continental Microwave Limited who have been issued with a licence to incorporate a Designs Department 676 kbit/s modem into their 1500 MHz radio link systems.

The OB equipment is expected to go into service in August 1984 and the first fixed link in September 1984.

VHF Radio

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But of even greater significance has been the invention and availability of the transistor. This has resulted in the proliferation of portable and car radios, which apart from using aerials closer to the ground (where the field strengths of horizontally polarised transmissions decrease more rapidly than vertically polarised transmissions), require aerials which continue to provide satisfactory reception when these receivers are moved around.

By the late 1970's it was estimated that only 80% - 90% of the population would be able to enjoy satisfactory indoor reception with portable receivers, and 97% stereo reception using outdoor aerials. In addition the coverage for car radios would be even less satisfactory.

It was decided, therefore, to add a vertical component equal in power to the horizontally polarised signal radiated by the existing stations, which would be satisfactorily received by a vertical whip aerial with its omni-directional receiving characteristic in the horizontal plane; and to construct a number of new transmitting stations to cover areas where there is low field strength from the existing transmitters.

To minimise costs at some of the later vhf sites employing relatively modern equipment it has been possible to double the aerial apertures and to achieve the desired circularly polarised transmissions, thus avoiding the need to re-engineer the transmitters. The relative staff effort involved and the demands on industry taken over the period as a whole are other factors which have had to be taken into account in arriving at what is believed to be the optimum plan. At sites requiring new masts the work is often complicated by the need to provide new uhf aerials, as at Sutton Coldfield and Wenvoe.

All solid-state transmitter equipment, designed by Designs Department, to specifications issued by TCPD is used for stations requiring powers up to 4 kW. For higher power stations requiring up to 40 kW per programme, the same drive equipment is used to feed valve amplifiers.

The aerial systems for Network Radio are all capable of handling at least five programmes with frequencies anywhere in the range 88 MHz - 108 MHz, and those for Local Radio are capable of carrying two programmes at the appropriate power level.

Re-engineered vhf services have already commenced from Wrotham and Sutton Coldfield and are scheduled to start from Holme Moss in September 1984, whilst work is under way at a number of other high power stations. On the low power front, re-engineering has been completed at eleven sites and new services have commenced from twenty-six sites, the great majority being existing uhf television sites.

In addition to the above, existing Local Radio transmitters have been converted to stereo operation, new stations opened and the coverage of other stations increased to provide county coverage.

By implementing such a plan it was anticipated that virtual national population coverage for all classes of reception would be achieved. However, the use of extra frequencies would be necessary. There were also plans for additional National and Local Radio Services. Fortunately these requirements came immediately prior to international discussions to extend the frequency band allocated to vhf broadcasting to cover the range 88 - 108 MHz and at a time when the existing transmitting equipment was nearing the end of its useful life.

Final international agreement to frequency allocations for five National and two Local Radio Services is confidently expected later this year, although some of the frequencies will not be available until 1996, and some of the allocations are not those which would have been chosen by the BBC as the optimum for listener convenience, technical elegance or minimising capital expenditure.

The plan adopted in 1979 envisaged an expenditure of £60 M - £70 M over a ten year period to 1989, but subsequent budget constraints and the slow clearance of the upper part of the frequency band seem likely to extend the period.

The basis of the detailed plan of work evolved by TCPD is to re-engineer stations in descending order of population coverage so that the capital expenditure will maximise the benefit to the public.

However, there are a number of constraints which would make it economic madness to re-engineer strictly in descending order of population. Band II aerials designed to produce signals of mixed polarisation, with the components usually phased to provide circular polarisation for optimum car radio reception, impose considerably higher wind-loading on structures than do corresponding aerials for horizontal polarisation. Thus, at some sites, only by waiting for the cessation and removal of 405-line tv aerials could the requirement for a new mast and/or new building accommodation be avoided. In some areas negotiation with the IBA will result in the closure of BBC "vhf only" sites, with the re-engineering of the BBC services on IBA sites.

Regional Links

Engineers working in Communications Section of TCPD have recently completed the last of a batch of four Radio Link Vehicles which will be used by the Regions on Television outside broadcasts.

The vehicles, which are built on Dodge 11 ton chassis, provide facilities for the setting up, monitoring and testing of sound and vision links and include mains and standby battery supplies.

New communications link vehicle

The vision system includes bay mounted shelves to house the microwave link control units, a routing and monitoring matrix, equalisers, monitors, with provision to install send and receive test equipment. Four link tripods can be secured to the vehicle roof. Jacks fitted to the corners of the body help to provide a stable working platform. An off-air check receiver is also provided, and its aerial is fixed to a small pneumatic mast installed at the front of the technical body.

The sound facilities include provision to house Designs Department music links, 5-channel multiplex, and sound-in-syncs encoders and decoders. The equipment can be interconnected and monitored using a matrix and an ME2/5 provides measuring facilities. Communication facilities provided include a radio telephone and a 4-line EMX panel.

A 3.5 kVA air-cooled petrol generator is located in one of the vehicle's lockers. This will operate all of the technical equipment and lighting and in most instances, a limited general purpose supply, for approximately seventeen hours before refuelling. All of the essential technical equipment and emergency lighting can be powered off the standby battery systems, with a capacity of 110 ampere hours at both +24 v and -36 v. An inverter working off the 24 v battery provides a mains supply for equipment not designed for battery operation.

Limited welfare facilities are provided. A small fixed fan heater can be used when mains are available, but otherwise a Webasto heater, which uses the vehicle's fuel and battery supply, will be employed. A pumped and filtered cold water supply is fitted and a mains operated water heater is also plumbed through to the sink. A small mains operated cooker, provides limited cooking facilities and a heated cupboard is provided to assist in the drying out of wet clothes.

The Project Engineer for these vehicles was John Levett, assisted by Peter Brake and although most of the wiring was installed by Pye TVT, Vaughan Rees, Harry Mountford and Jim Whitcombe all assisted in completing the installation.

Monitoring Satellites

A satellite receiving system has been provided by Communications Section of TCPD for the BBC monitoring service based at Caversham. The installation at Crowsley Park consists of a 4 m diameter dish with equipment operating on the 4 GHz band in order to monitor the Russian 'Gorizont' series tv satellites.

The electronic equipment, manufactured by NEC, consists of a 4 GHz/1 GHz down-convertor mounted at the dish focus, and a tv vision and sound receiver in the building, the two being interconnected by coaxial cable. Gorizont carries Moscow television for distribution to, amongst other places, Cuba and Siberia. Consequently an Atlantic equatorial satellite at 14° W is used and this can easily be received in this country. Excellent tv pictures are available at Crowsley Park with unweighted signal/noise ratio of about 43 dB. Another Gorizont satellite is positioned over the Indian Ocean at 53° E and the Crowsley Park dish has recently been used to gather data from this satellite although this necessitates pointing only about 5° above the horizon with consequent degradation in signal/noise.

Staff from Communications Dept, and Cavesham inspect the completed satellite installation

The NEC down-converter at the dish includes a multistage FET pre-amplifier giving an overall noise figure better than 2 dB. The tv receiver has the capability of selecting up to 20 separate channels which can be programmed on a P-ROM. Transmission of the SECAM system tv is by frequency modulation, with subcarriers at 7.0 and 7.5 MHz for sound channels. These are used for tv sound and Moscow radio respectively. The Crowsley Park installation was completed and handed over to External Services in April, 1983.

How the Stations Were Built

One of the prime functions of TCPD, in collaboration with ACED, is to implement the technical recommendations of Research Department, for new transmitters, in the most economic way.

The priority of the various stations has been largely determined by cost effectiveness, that is cost per head of population served. This translates in practice to the construction of progressively lower powered relay stations serving smaller and smaller communities.

Thus the first relay stations to be constructed typically radiated an erp of 10 kW, derived from klystron amplifiers producing 1 kW vision power and the associated sound carrier, and employed relatively large quasiomnidirectional aerials mounted on 45 m towers. Twenty stations of this type have been commissioned, serving on average 57,000 people, but with individual coverages ranging from 7,000 to 260,000.

The next generation of relay stations employed travelling wave tube (TWT) capable of producing 200 W of rf vision power and the associated sound carrier. A total of fifty were constructed, with some serving in excess of 50,000 people, but averaging 21,000.

These were followed by relay stations employing 50 W TWTs and valves, and solid state equipment of 50, 25, 10 and 2W vision output powers, in progressively larger numbers.

As powers, and associated accommodation, were reduced so was the complexity and size of aerial systems and their support structures. Some of these are no more than 14 m wooden poles. The lowest powered stations will serve communities of down to 200 people and cost up to about £100 per head served.

The reliability of equipment tends to be inversely proportional to output power. The higher powered stations serve the largest number of viewers, consequently standby equipment, usually of lower power, with automatic changeover is fitted at the higher powered stations. However the effective use of systems with standby equipment necessitates automatic monitoring equipment to advise the state of the system, which itself adds to the maintenance load.

Stations fitted with solid state equipment of 50 W and lower power do not usually have any standby equipment. Solid state equipment is inherently more reliable and, for uhf, largely of technological necessity, is designed so that reduced output power rather than total failure is the most likely mode of failure. Dealer contacts and the public are relied on to report faults.

It is worth noting that failure of the public electricity supply now accounts for nearly 50% of all shutdowns.

Currently the mean time between shutdown due to transposer faults is about 3½ years and the average duration of shutdowns due to this cause about 4 hours. Clearly to improve on these figures, either by equipment or power supply improvements, would involve very substantial expenditure for little return.

The early stations, that is the higher powered ones, employed buildings with three principle areas: an area for the BBC equipment, an area for the IBA equipment, and an area for shared equipment and toilet facilities.

Later stations with lower power equipment of increasing reliability utilize a single room shared by both Broadcasting Authorities. The earliest 10 W equipments were housed in traditional buildings with a floor size of 3 m x 2.4 m. Subsequently pre-wired grp or metal cubicles of sizes gradually reducing to a floor size of 1.1 m x 1.1 m have been used as the size, reliability, design and maintenance philosophy has evolved.

At the time the 10 kW erp stations were being constructed and it was appreciated that the larger number of lower power stations invited standardisation of transposer equipment capable of operation for any channel with minimal adjustment. These aims were only partially achieved at first as they were ahead of available technology. In later designs it was found possible to separate the equipment into channels determining passive items, and wideband active modules covering the whole of the uhf bands. This meant that spares holdings could be reduced, modular maintenance was a reality, which in turn meant that times on site were reduced, making the use of smaller and cheaper accommodation a logical step.

The very latest equipment, BBC designed, and developed from specifications issued by TCPD, (and now being made under licence for the IBA), utilises only three types of active modules with built-in fault indication lamps. The configuration of the equipment is such that from a knowledge of the number of services which have failed it is possible to determine with a very high degree of certainty which type of active module is required before leaving base to restore service(s).

In parallel with transposer developments, standardised building blocks for aerial systems and support structures have been developed.

Costs in real terms have fallen over the years, due not only to improved equipment, but also by employing prefabricated techniques to minimise on-site installation and commissioning time.

Contractors were employed to install the technical equipment at the 10 kW erp stations and some of the early 200 W and 50 W TWT stations, but subsequently this was progressively taken over by TCPD staff so that none of the solid state equipments have been installed by contractors.

In parallel with this trend, TCPD staff undertook a larger proportion of the site work associated with aerials and aerial support structure erection. In recent years the only contract labour employed on site has been to construct access tracks, install tower foundations, and carry out site works such as fencing.

The final phase of the uhf relay station construction programme, consisting mainly of 2 W stations, will be carried out almost exclusively by TCPD staff, with ACED involvement being limited to sites involving special requirements.

* * *

Power Control a Gem

Automatic control of power equipment by microprocessor based systems is currently being introduced into two areas of the BBC's engineering activities:

* High power mf transmitting stations (Stagshaw, Westerglen and Moorside Edge).

* Broadcasting House (maintained power supplies).

An investigation of the market led to the conclusion that a general purpose industrial controller - as used in the process plant industry - would be the most suitable. This decision was reached on the basis that such equipment is available as a complete integrated package specifically designed to work in an electrically noisy environment.

The GEC 'GEM 80' system was finally chosen as it had the following additional advantages:

* Used by major customers with rigorous quality assurance requirements.

* Reliability statistics based on a reasonably large number of installed systems.

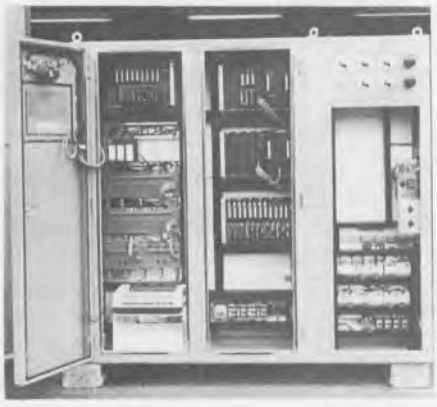
* Highly 'user friendly' control language.

In Broadcasting House the GEM 80 controls the duplicated automatic standby plant sets. This involves complete starting and circuit breaker switching sequences on 'mains failure'. It includes the control of automatic synchronising and load sharing of both sets. The system also provides operator initiated automatic test routines during which both sets are synchronised with each other and the London Electricity Board mains supply.

A VDU is used for operator information on alarms and system status, together with a printer for data logging.

GEM 80 systems are also being installed at Stagshaw, Westerglen and Moorside Edge transmitting stations to provide automatic selection of duplicate mains supplies and the standby plant, automatic periodic testing of the standby plant and energy consumption monitoring.

It is expected that all four systems will be operational by the summer of this year. Future systems are planned for Droitwich, Burghead and Start Point transmitting stations and at a number of high power vhf transmitting stations starting with Black Hill. It is hoped to include mains auto-synchronising on future systems which will enable the standby generator plant to be fully automatically tested without disconnection of the mains supply and make possible savings in electricity maximum demand charges without need to shed load.



The GEM 80 equipment

TCPD Work on Ascension Island

In 1966 the Ministry of Public Building and Works (MPBW), later renamed the Property Services Agency (PSA) of the Department of the Environment, built a 6.3 MW diesel generating power station at English Bay on Ascension Island. Seven 900 kW 11 kV generators and de-salination plant with the capacity to produce nearly 60,000 gallons of water per day were installed. Most of the station's electrical output was needed for the nearby BBC HF Relay Station. De-salinated water is piped around the UK-occupied part of the island.

Responsibility for operating the power station was passed to the BBC in 1978 when PSA withdrew from Ascension Island and in 1979, the decision was taken to start a plant replacement programme. The first phase of the project began in 1982 and represented a major workload for TCPD's Power Systems Section.

Two new Allen 12 cylinder 1.36 MW sets were installed in 1983. The first replaced an existing Ruston 16 cylinder naturally aspirated 900 kW set, the second being located on an adjacent, and until then 'spare' base. The new

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The RAF base on Ascension Island

Testar

TCPD Power Systems Section has introduced a Hewlett Packard HP250 mini-computer to the task of monitoring electricity usage at transmitting stations. The system, developed with programming effort from the Small Systems Unit, is known as TESTAR (Transmitter Electricity Supply: Tariff Analysis and Records) and may well point the way ahead for energy management throughout the Corporation.

By late 1981 the existing manual records system was hard pressed to cope with the sheer influx of data, let alone provide a proper basis for energy management. Although price inflation had abated, the Area Electricity Boards were now offering a wider range of sophisticated tariffs with potential savings for the energy-conscious consumer.

The system needed i) to hold details of each site's general characteristics and power supply; ii) to record consumption and cost data from electricity bills; and iii) to improve our analysis of this information and engage in regular tariff reviews. Services of this sort are available - in whole or part - from various 'tariff consultants' and software houses. Investigation showed, however, that an in-house computer system would give both more control and more benefit.

Possible micro and mainframe solutions were investigated, but TCPD decided on the HP250 equipped with a 16 megabyte 'Winchester' disk and a dot-matrix printer. This self-contained dedicated machine gives immediate access to the whole database and, with a maximum of four extra terminals, allows for future expansion.

The database program (RECORDS) is written in HP Basic. For each transmitting station it accommodates a comprehensive 'site profile' and seven years' accounts data. A range of pre-specified prints (Sites Directory, year-on-year Progress Comparison etc) help identify stations for closer investigation and a high-level enquiry package (QUERY) allows interrogation of the database on more ad-hoc terms.

RECORDS is complemented by MODELS, a flexible mathematical modelling program which can mimic the charging components of more than 100 tariffs offered by the 19 UK Area Boards. It is used to predict the effects of tariff changes, price rises or changes in consumption.

Energy management involves more than the scrutiny of statistics from afar. Test equipment (such as the Crest energy monitor recently acquired by TCPD) and micro-processor control systems at some premises have a part to play. At certain large transmitting stations the BBC must also consider Load Management tariffs which offer considerable savings - in return for very occasional load-reductions.

An Energy Management Working Group, including BBC Consultancy staff, has recently examined the desirability of introducing a formal energy management system in the BBC. TESTAR is being considered as the basis of a larger system to help control and monitor the BBC's energy usage. The Corporation currently spends about £20M a year on electricity, oil and gas supplies.

The TESTAR computer terminal

Ascension Island

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sets are turbo-charged and intercooled giving significant fuel savings. Heat recovery is by a closed-loop engine jacket-water exchanger and by an exhaust-gas boiler producing steam at up to 150 psi, for use in the desalination process.

To meet the needs of the Ministry of Defence in the aftermath of the Falklands War, a new 600 man RAF camp was constructed during 1983 and the BBC were asked to provide an electricity supply to the site. This involved constructing 9 km of new 11 kV overhead line. Most of the line is of open wire construction supported by steel poles concreted into the lava. Explosives were used to construct the pole and stay holes in the difficult areas. Royal Naval helicopters were made available to position poles in prepared holes in difficult access areas, although in the event they were not needed.

Planning for the RAF camp was based on an eventual maximum demand of 1.3 MW. To meet this requirement, a third 1.36 MW generator is being installed, and is planned to come into service in August this year.

Before installing the set, special attention was given to refurbishing the old engine foundation before re-use. A drilling survey was carried out on the underlying basalt rock which was found to be heavily faulted and to contain many voids. The new set weighs 38 tonnes and requires a very stiff base.

To avoid the possibility of foundation deflection due to rock movement it was decided to construct 18 re-inforced "mini-piles" of 150 mm diameter which were drilled through the base and 5 m down into the rock.

Later this year feasibility studies will be carried out prior to completing re-engineering the whole site, including the water production plant.

Skelton

Automated

As part of an ongoing automation programme, a new control system has been installed at External Services hf transmitter site at Skelton in Cumbria, by TCPD using Designs Department as the main contractor. The system will control and monitor the ten 250 kW transmitters of 1960's vintage at Skelton 'A' and the twelve wartime transmitters at Skelton 'B' about 1 mile away.

All routine switching is performed automatically, including selection of aerials, aerial slew angle, programme source, and transmitter on/off and standby switching. Frequency changing must still be accomplished manually because of transmitter limitations, but the system provides prompts when intervention is required, and checks that the correct frequency has been set up. All switching operations are checked and alarm messages displayed when appropriate, on monitors conveniently located round the building. The control system comprises, in total, about 25 Zeus micro-computers. One computer is dedicated to each transmitter and contains in its memory the entire 6 months switching schedule.

Schedules are entered and the system interrogated by means of a keyboard and screen comprising part of an "intelligent VDU" station. Direct control from the keyboard is also possible. For security, schedules are also stored on magnetic discs.

The computers communicate with the VDUs via a secure data hub, thus operating in a "distributed intelligence" configuration. This means that a computer failure is unlikely to affect more than one transmitter.

The computers provide control signals to an extensive interface and switching system, designed by TCPD. This also provides interlocking for the transmitters and an ergonomically designed manual intervention and monitoring facility.

A number of novel features have been incorporated, including: an optical fibre data link to one of the VDUs, because of the probability of RF interference; a rubidium frequency standard for the transmitter drives, ensuring that Skelton transmissions are accurate to better than one part in 10 to the 11; and a "modulation analyser", experience with which has led to the design of an automatic test system for transmitters, which will be incorporated into future installations.

The remote control of Skelton 'B' via land lines and modems has also provided valuable experience towards the possibility of direct control from the studio centre. This part of the system is expected to become fully operational later in the year.

Bob Hammond, TCPD, (back to camera), discusses the micro-processor control system in Skelton 'A', with Chris Garlick (Tx Dept)

* * *

Power at TVC

Power Systems Section of TCPD also contributes to many projects related to programme production facilities.

At Television Centre, for example, it has always been responsible for the design, procurement and installation of major power equipment. Its current projects are the reinforcement of production lighting supplies to Television News, provision of a 600 kW standby generator to replace those existing (trebling the stand-by capacity), and the provision of a new substation and reorganisation of the intake switchboard to meet the increased demands of the Stage V development.

All transformers used at TVC to date (which convert the 11 kV supply taken from the London Electricity Board to a usable 415/240 volts) have been of the air insulated open winding type. This type of transformer was selected to avoid fire risks which might be associated with the more usual oil insulated transformers. This allowed the voltage transformation to be carried out close to the heavy loads (the production lighting supplies to the eight main and five presentation/news studios). A disadvantage of the insulation material used in most of the older dry-type transformers is that it is hygroscopic and attracts consider-

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A typical 33 kV/11 kV substation

Rampisham Project

In 1979 the Government approved a capital programme to improve the audibility of External Services, in particular those to central and eastern Europe, the USSR and the Middle East. This programme included the replacement, with modern high-power transmitters, of the Skelton B station which was originally built in 1941 and still operates the original war-time transmitters. For propagational reasons a site in the south of England at Henstridge was chosen, but due to serious objections raised by the Ministry of Defence our planning application had to be withdrawn. It was therefore decided to install the new high-power transmitters at the existing Rampisham transmitting station.

Before the new transmitters can be installed in the existing building at Rampisham, it is necessary to remove the existing 250 kW hf transmitters and these have been relocated at Skelton A. The project requires careful planning by TCPD to ensure that there will be a minimum of disruption to External Services operational schedules during the work.

Eight 500 kW hf transmitters will be provided, four supplied by AEG - Telefunken and four by Marconi. The transmitters are the latest generation, high efficiency PDM type with fully automatic tuning and wave-changing facilities. The AEG transmitters employ a frequency-follow control system and the Marconi transmitters a pre-set control system. Waste heat from the transmitters will be recovered, and used to heat the building. Provision is also being made to utilise heat for horticultural purposes provided that a suitable tenant can be found. A 750 kW test load will be provided for commissioning and maintenance purposes.

Thirty-four wideband aerials will be provided, each spanning an octave and equipped with automatic slewing facilities. The first of nine aerials to a TCPD design will be erected by Marconi. The second group of eleven aerials will be supplied by TCI. The aerials will be fed by screened feeders, also designed by TCPD and having a total length of twenty kilometres. A matrix switching station will be provided to enable any aerial to be powered from any transmitter. Thirty-four towers ranging in height from 50 m - 105 m will support the aerial curtains and reflector screens. A new type hydropneumatic fuse will protect the structures by extending the aerial halyards during conditions of excessive wind and ice loadings.

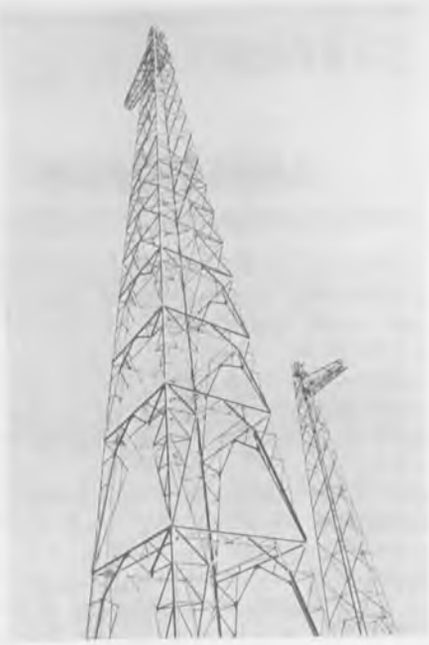
The control system, based on the Designs Department distributed 'Zeus' equipment will provide comprehensive automation facilities. It will perform all the scheduled operational activities without supervision and provide a supervisory and reporting function for several 'house keeping' tasks (such as power equipment status). There will be capacity within the system for further developments which may include control via data link from another centre.

The major expansion of transmitter facilities at Rampisham has inevitably involved considerable reinforcement of the incoming electricity supply network from the local Electricity Board, as well as the on-site distribution. The basic station requirements for the electricity supply are a duplicate full capacity 11 kV supply, a supply capacity of 10 MVA, with a low supply source impedance.

In order to meet these requirements, two 33 kV supplies have been provided by the Southern Electricity Board derived from separate grid supply points. The separation in supply points using different routes to the site provides high security against a total supply failure. Two BBC owned transformers convert both 33 kV supplies to 11 kV and feed this to an 11 kV switchboard for distribution to the transmitters. The 33/11 kV transformers are specially designed low impedance units and are connected in parallel at the 11 kV switchboard in order to meet the source impedance requirement of the 500 kW transmitters.

Since two separate grid points are being paralleled at 11 kV (a most unusual arrangement) a computer load flow study was used by TCPD to predict the possible true and reactive power transfer through the two BBC transformers.

A new substation has been constructed adjacent to the transmitter building and this houses two Electricity Board 33 kV switches and the BBC equipment comprising two 10 KVA transformers and associated tap changers, and neutral earthing equipment.



The new 50 m and 95 m towers at Rampisham

The substation was fully commissioned by TCPD Power Systems in April of this year.

The overall project was started in 1982 and to date four transmitters have been installed and are being commissioned, seven towers have been erected and HV electricity supplies are complete. Project completion is scheduled for 1986. at a total estimated cost of £22 million and will represent the largest individual project carried out by Transmitter Capital Projects Department.

War-time TX replaced

TCPD are currently re-engineering the Droitwich transmitting station and part of this work involves replacing the low frequency (lf) transmitters which are of world war two vintage. The new transmitters, which will be operated in parallel to achieve the necessary redundancy, will be capable of working 24 hours a day. This is required by the Radio Teleswitching and Standard Frequency services, which they are specified to carry, in addition to Radio Four and External Services programmes.

The new transmitters, which represent the 'state of the art' in high power transmitter technology, use a single tetrode valve in the

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Radio Bristol Tests

During April this year listeners to the mf service of Radio Bristol have been subjected to a special form of signal processing which is part of an experiment being conducted by Research Department in association with Radio Broadcasting and TCPD, who provided the special transmitter equipment.

The object of the experiment, results of which are still being analysed, was to see if listeners could detect any subjective degradation of various types of programme material when the carrier amplitude was compressed inversely as the programme volume increased.

The overall effect of compression at the transmitter and expansion due to receiver automatic gain control (agc) action is to maintain the listeners loudspeaker at the same volume he would receive if Dynamic Carrier Control (DCC) were not employed.

Exactly the same effect would also have been achieved by simply reducing transmitter output power, but the subtlety is that if this had been done by only, say, 3 dB the listeners agc would have increased the receiver sensitivity by 3 dB and consequently any noise or interference would also increase by the same degree.

With DCC, the full carrier level is transmitted during quiet passages of programme, ensuring that the signal-to-noise ratio is unspoiled. When loud passages are transmitted, the carrier level is automatically reduced, but the corresponding increase in receiver noise is masked by the greater volume. With 3 dB of Carrier Control, that is with a carrier amplitude reduction of 3 dB at 100% modulation the average power saving with a constant efficiency transmitter is of the order of 15 to 20%, depending on the type of programme material. To save this amount by simple power reduction would have resulted in a 1.5 or 2 dB increase in listeners' noise or interference.

The equipment used at Bristol consisted of a 5 kW linear amplifier driven by a low power Pulse Duration Modulated (PDM) transmitter. The PDM system was chosen because it is very easy to independently control the modulation index and carrier level by simple addition of audio and dc signals in the modulator.

The basic parameters of the system required by Research Department were:

a) The modulation index should be directly proportional to programme volume regardless of carrier level within a tolerance of ½ dB.
b) The Carrier Control signal should be derived from a peak programme detector with fast attack and 220 mS release time-constants.
c) The audio signal should be delayed by 220 mS relative to the Carrier Control signal to prevent transient overmodulation.
d) The transient response at the Carrier Control port of the transmitter should be appropriate for the detector attack time.
e) To maintain similar dispersion characteristics during processed and normal transmissions the delay-line should always be in the signal path.

A processor meeting these requirements was made by adopting a standard BBC delay-line type limiter (AM6/18) and using the side-chain control signal to influence carrier and audio levels in appropriate ratios. All of this equipment and test gear was installed in a 10 metre standard I.S.O. shipping container at Droitwich and moved on a trailer to Bristol where it was parked outside the Radio Bristol (Mangotsfield) transmitting station. The rf output, audio and power cables were connected into the station and during test transmissions the container equipment was substituted on a no-break basis for the normal Radio Bristoi transmitter.

Apart from the simple power saving aspect of Dynamic Carrier Control there are other engineering advantages, such as:

a) A transmitter can be adjusted to provide constant load on its power supply. This can improve line regulation or reduce the mechanical inertia and low reactance requirements for standby generators.
b) A transmitter of given power rating can be adjusted to give a higher carrier power without exceeding component ratings.
c) For a given carrier power the rating of aerial matching components and transmission lines can be reduced.
d) In the case of linear amplifiers the average efficiency can be improved, offering an additional power saving.

Droitwich

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output stage which is operated in switched mode (class 'D') to achieve a high power conversion efficiency. This tetrode is modulated by a Pulse Duration Modulator (PDM) employing Marconi's Pulsam system. The conversion efficiency including losses in auxiliary cooling plant will be over 70%, from supply mains to aerial, compared to about 30% for the old transmitters. Waste heat from the valves is removed in a closed vapour cooling system which uses only a few litres of water.

The Pulsam modulator is a special version of that used by Marconi on their new 500 kW short wave transmitter and most of the novel features of the transmitter are associated with this modulator.

Because of the high efficiency of the transmitter it has been necessary to re-design the aerial at Droitwich to increase the inherent damping and retain the radiated bandwidth at present achieved with the less efficient transmitters.

To assess what improvement would be necessary, a working scale model of the whole transmitter to aerial system was produced by the manufacturer as part of the development programme. This resulted in aerial changes which are being made by TCPD without significantly altering the static and wind loads imposed on the two 152 m masts which support the aerial. These changes will also improve the radiation efficiency of the aerial.

The large percentage bandwidth associated with lf broadcasting still results in appreciable aerial impedance variation over the channel. These variations are made symmetrical about the carrier frequency by a phasing network inserted in the aerial feeder. This prevents dissimilar power and phase relationships between the two sidebands with otherwise consequent distortion at the listeners receiver.

DBS Transponder Tested

A major experimental trial of the new C-MAC/packet transmission standard for DBS has been conducted at Research Department, using hardware to simulate the complete DBS signal chain. This standard, developed by the EBU from the earlier IBA proposals, was initially tested at BBC Research Department and at EBU Headquarters, in Geneva, during 1983, to establish the performance attainable. However, this earlier work used a simplified version of the signal chain which was not a thorough DBS simulation. The recent tests have provided the first practical proof that the standard is suitable for DBS, and this consolidates the results of theoretical modelling carried out by the European Space Agency as part of their EBU studies.

A Research Department report will shortly be published, detailing the results of this comprehensive series of tests, and presentations will be made at the 1984 International Broadcasting Convention in Brighton. The work was performed in collaboration with British Aerospace, Dynamics Group and with the assistance of Television OBs (Comms. Group), Designs and Transmitter Departments.

The experimental set-up was highly complex, incorporating the BBC Transportable Satellite Earth Station, to simulate the satellite feeder-link earth station and the DBS receiver, and a "breadboard" satellite transponder constructed by British Aerospace (BAe). This transponder was fully representative of the communications payload of a DBS satellite, and contained microwave filters with a similar, tight specification to those which will be required for DBS. The transponder also employed Travelling-Wave Tube (TWT) amplifiers similar to their DBS counterparts except for their output power. In order to permit the wide range of tests to be completed within the relatively short time available, a semi-automated, computer-controlled measurement and recording system was employed, and this proved invaluable.

The objectives of the tests were to measure the quality of the MAC vision signal and the data signal in a nominally undistorted channel, to measure the sensitivity of these signals to channel degradations, and to examine the effects of interference and noise. One of the main points of the investigation was to determine the effect of the transponder filters, and other frequency response distortions, in the presence of non-linear amplification by the TWT amplifiers. By adding controlled amounts of distortion in the signal chain, useful information was obtained on the sensitivity of the C-MAC signal. Another important consideration was interference to and from other satellite services, particularly in the feeder-link, and this was simulated by duplicating the appropriate parts of the system.

The results show that the picture and data quality after transmission through the simulated DBS chain were good, with little sensitivity to likely channel impairments. However, C-MAC could cause interference to other DBS services because of "spectrum-spreading" of the data signal caused by non-linear amplification, unless sufficient attention is paid to the specification of the feeder-link station and the filters for the operational satellite. Nevertheless, these tests have shown that the C-MAC/packet system is technically suitable as a transmission standard for future DBS services.

Pete Shelswell (foreground) and Chris Gandy (right) of Research Department discuss spectrum-spreading of the C-MAC signal with Cliff Barber (BAe) whilst his colleague Roger Jayes (background) controls the measurement and recording system. The photograph also shows part of the experimental set-up, with the BBC Transportable Satellite Earth Station (top left) and the BAe satellite transponder laid out on its "breadboard" (bottom left)

Power Systems Work

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able dust from convection currents. A fully epoxy resin encapsulated winding is being introduced for the first time to reduce maintenance and the risk of flashover on the re-engineered Television News supply.

At Wales Farm Road the Section has been responsible for specifying the equipment for a new substation for the Scenery Construction facilities.

Every Local Radio Station is equipped with a small diesel standby alternator to provide sufficient energy to fully operate two cubicles under mains failure conditions.

A further ongoing role of Power Systems is the gradual replacement of the BBC's fleet of trailer and vehicle mounted generators. These are used for outside broadcast or television film work, powering single or multi-camera mobile control rooms or just production lighting.

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