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A record of BBC technical experience and developments
in radio and television broadcasting

Contents

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Errata
The undermentioned errors are regretted:
Page 5. 2.2.3, line 6, 'Ford Estate saloon' should read 'Ford
Escort saloon'.
Page 11, column one, the section beginning 'The results are
given in Table 8' to '. . . questionnaires completed by listeners
on reception in their homes' should appear on page 12 at the
end of section 5.6, paragraph one.

The cover photograph shows an operator typing a demon-
stration caption on the ANCHOR electronic character
generator, which is described in this issue.

The major contributions are preceded by individual lists of
contents.

Editorial

The External Services of the BBC

The publication in this issue of an article on the use of single-sideband transmission for programme feeds to overseas transmitters marks a convenient moment to review the history of BBC External Broadcasting which started as the BBC Empire Service over forty years ago and has undergone a number of major changes since its inception.

The BBC was one of the first broadcasting authorities to realise the possibilities of long-distance broadcasting by short waves and in 1927 started a service to the British Empire, using a transmitter at Chelmsford, working initially on 12·5 MHz and later on 11·75 MHz. This service proved very popular but indicated the desirability of using directional transmitting aerials and of broadcasting simultaneously on different short wavebands to overcome short-term variations in transmission via the ionosphere. In 1932 the 'Empire' station at Daventry was brought into operation, initially with two 15 kW transmitters. Vertically polarised directional aerials oriented towards five zones and suitable for winter and summer frequencies were installed initially. Tests showed that horizontal polarisation gave better results than vertical and that optimum results were obtained with a directional aerial consisting of four horizontal radiators stacked vertically at half-wavelength intervals. The height of the bottom radiator above ground was also found to be critical. As a result of these tests, a new aerial system was installed at Daventry and it proved so successful that it remained substantially unaltered for the next twenty years. The HRRS 4/4/1* array became the BBC's standard short-wave aerial. This phase of the overseas service lasted until 1939, during which time the number of transmitters was increased to eight.

From 1938 and throughout the war years the external services were required to change their policy. The Empire service was in English but it had now become necessary to counter enemy propaganda and this meant broadcasting to Europe in a number of languages, to the Middle East in Arabic, and to the Latin American countries in Spanish and Portuguese. A new studio complex was set up in the south-east wing of Bush House in London and powerful medium-wave and long-wave transmitters were built to put strong signals into Europe. A high average level of modulation was

* This is the code for an aerial array with a driven curtain consisting of sixteen half-wavelength radiators arranged in the vertical plane as four rows of four, the bottom row being one wavelength above the ground. A similar parallel curtain is used as a reflector. The letters signify that the array is horizontally polarised, has a reflector, is reversible, and is slewable.

essential to maintain intelligibility in spite of jamming, and sudden increases in modulation which might betray clandestine listeners had to be avoided. The number of short-wave transmitters at Daventry and other sites was increased to forty-two. Flexibility in the scheduling of operational frequencies for this large number of transmitters was helped by the development in early 1940 of a highly successful variable-frequency LC drive unit which adequately met the modest international carrier-frequency stability standards of the period and remained in active service for twenty years.

Many BBC engineers joined the armed forces and other services during the war and the operational needs of the Corporation were met by the recruitment of young people of both sexes, usually straight from school, together with some older people. After a minimum of essential training given at studio centres or transmitter stations, these new staff, with a small number of experienced staff to lead them, did excellent service throughout the war. They showed themselves capable of carrying out a large number of tasks, previously undertaken by qualified staff, and this highlighted the possibility of automatic operation which has since been introduced in a number of areas such as programme and aerial switching.

During the period 1949 to 1963, the communist powers used jamming in an attempt to prevent reception in their territories of programmes broadcast by the western democracies. Much ingenuity was displayed by BBC engineers in devising counter-measures: for example, the western powers sometimes combined all the available transmitters in a simultaneous 'barrage' directed towards a single country.

A significant event in 1950 was the inauguration of the BBC Far-Eastern relay station to serve South-East Asia. This greatly reduced the propagational difficulties encountered in direct transmissions from the UK to these areas. During the 1950s many of the British territories achieved self-government and a natural consequence of their newly acquired independence was a reduction in the extent to which they re-broadcast BBC programmes. During the same period, inexpensive transistor receivers became available; these had limited sensitivity and their wavelength ranges tended to favour the lower frequencies. Effective coverage thus required the establishment of powerful medium-wave and short-wave relay bases situated in or near the service areas.

Nearer home, medium-wave transmitters in Germany and in Austria became available in 1953 and were fed from the

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UK by landline to supplement the short-wave services. A few years later Central and Eastern Mediterranean relay stations were used to relay BBC programmes locally.

Since 1961 the main developments have been the replacement of the short-wave transmitters (some twenty-five years old) by more modern types with 100kW or 250kW output, the modernisation of the aerial arrays to carry higher power and have wider bandwidth, and the replacement of manual aerial switching by remotely controlled switching. More recently point-to-point feeds to the overseas relay stations using single-sideband short-wave transmission have been introduced. This is the method used for feeding the short-wave transmitters which were set up on Ascension Island in 1966 to improve reception of BBC programmes in Latin America and in West and South Africa. High-gain rhombic aerials are used to transmit and to receive the single-sideband signals so that a 30kW p.e.p.* transmitter can be used for this programme feed instead of a broadcasting transmitter rated at 250kW carrier power (1000kW p.e.p.).

Experience over three solar cycles has given the scheduling engineers a wealth of information on propagation and they are now able to predict the most suitable frequency for any path with accuracy. This, together with the establishment of relay stations, is increasing the audibility of BBC external broadcasting in many parts of the world, and the external services therefore enter the 'seventies well equipped to serve Britain's interests throughout the world by international broadcasting in a total of forty languages.

* Peak envelope power.

The Use of Single-sideband Transmissions for Programme Links to Overseas Relay Stations

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Contents

1 Introduction

In common with other broadcasting organisations the BBC makes use of overseas relay stations to reinforce h.f. broadcast transmissions direct from the country of origin. The proportion of BBC h.f. broadcasting carried by relay stations is currently about 40 per cent and is likely to increase in the future. Until quite recently these stations depended on broadcast reception from the United Kingdom for their programme feeds but in 1964 an s.s.b. point-to-point service was established for the relay station in South-East Asia using a converted broadcast transmitter at Daventry.

Practical experience with this equipment confirmed that an h.f. s.s.b. system could be used for broadcast quality circuits without losing any of the inherent advantages of s.s.b. transmission. A parallel increase in relay facilities led to a steady expansion of s.s.b. utilisation and by the end of 1969 three new transmitters in the United Kingdom were providing programme feeds to relay stations. The new transmitters are modified 30kW p.e.p. self-tuning communications equipments, their transmission characteristics being generally as described in the following sections.

Relay stations were equipped for s.s.b. reception well before the commencement of the first point-to-point service. This was because the ability to select either sideband of the received broadcast signal and thus reject adjacent channel interference is invaluable in the more congested broadcast bands, but the s.s.b. receivers also have the advantage that the demodulation process is more linear at high modulation levels and does not produce the objectionable audio distortion of an envelope detector with carrier-selective fading. The receivers currently provided are dual path diversity terminals used with UK-orientated aerial systems and no additional expenditure was required at these stations for point-to-point reception.

2 Benefits

From the point of view of the broadcasting engineer the advantages of s.s.b. programme feeds are both operational and economic. The main factors are:

(a) Flexibility. Point-to-point transmissions are not advertised to the general public as are broadcast services, so operating schedules can be changed at short notice to accommodate unforeseen interference or ionospheric variations. Schedules can exploit the rapid frequency-changing capabilities of the equipment without causing inconvenience to the listener, and can switch from one language, programme, or relay station to another as often as is expedient in planning a world-wide service.

(b) Aerials. More directional transmitting aerials designed for optimum reception at individual stations can be used. In h.f. broadcasting large territories frequently have to be covered from a single aerial.

(c) New facilities. Special devices or modes of transmission can be introduced to improve reception in abnormal ionospheric conditions.

(d) Spectrum conservation. In principle, system flexibility allows a smaller number of transmitters to be used for a given circuit reliability. Apart from the obvious financial implications an overall reduction in occupied bandwidth may sometimes be attained in addition to the inherent s.s.b. spectrum economy.

(e) Equipment cost. Since the primary functions of broadcast and s.s.b. transmitters are not the same, valid cost comparisons can only be made where they are justified by circumstances. Where comparison can be justified, however, an equivalent service would be provided by an s.s.b. transmitter at roughly one-third of the capital cost of the broadcast installation.

(f) Running cost. Operating costs of the s.s.b. equipment are also a fraction of those for the broadcast transmitter, a major factor here being that they require comparatively little operational effort due to their self-tuning capability. Power consumption and valve replacement cost are lower and maintenance requirements are reduced by the absence of high-level modulation equipment, lower peak r.f. voltages, and comparatively simple power supply and cooling systems.
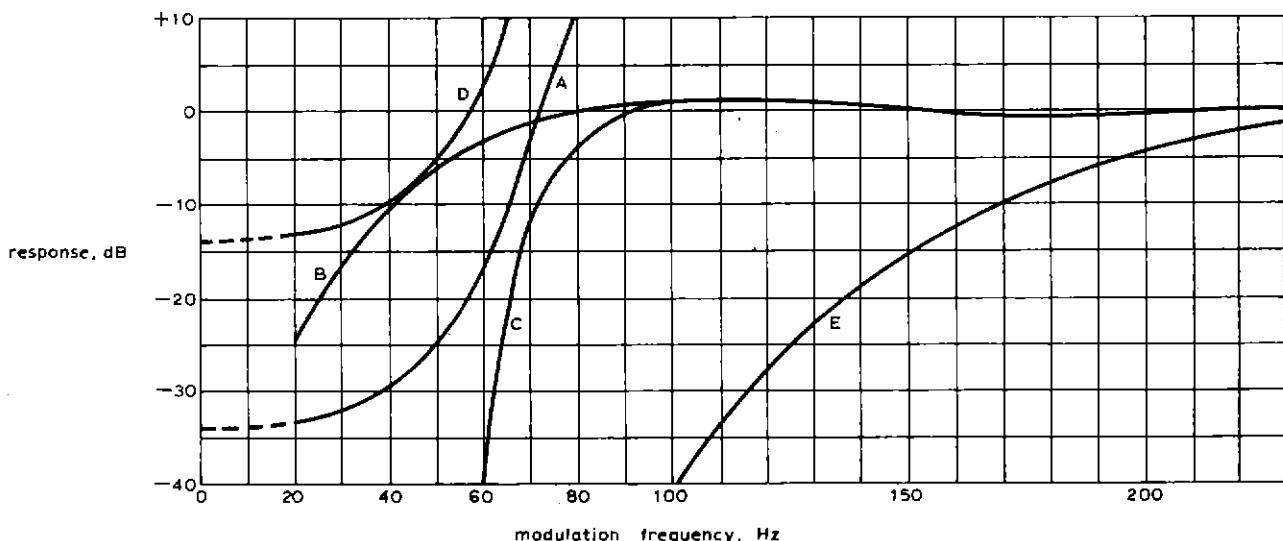
Fig. 1 Receiver carrier chain protection curves
A : 20 dB protection curve for − 16 dB carrier
B : Modulation frequency response without a.f. filter
C : Response with a.f. receiver protection filter

D : Protection curve for double-sideband full-carrier
signal
E : Response with typical communication-type
sideband filter

3   Performance Considerations

Modern developments in i.s.b. working have led to the availability of communications transmitters with stable performance characteristics and good modulation linearity. Synthesised* master oscillators provide for rapid frequency changing with excellent frequency stability. However, it should be remembered that good communications equipment is not necessarily suitable for carrying speech and music in programme circuits and a number of special factors have to be considered.

Communication systems are normally designed for an audio passband of 250 to 3000 Hz[1] and transmitter sideband filters for a baseband of 250 to 6000 Hz, so that two speech channels may be accommodated on each side of the carrier frequency. The significance of the low-frequency limit in relation to music is that transmission of fundamentals below middle C is fortuitous and a wider passband must be specified. Required band limits are determined by considerations of accepted practice in h.f. broadcasting, possible economic factors, international recommendations,[2] compatibility with direct broadcast reception from the United Kingdom, and the prospective operation of links in tandem, and these have led to a passband of 90 to 6000 Hz being specified for the BBC transmitters.[3] Since the lower frequency limit is normally determined by the sideband filter a special filter will be required.

Extension of the transmitted bandwidth can, however, have unfortunate results at the receiver. This is because the s.s.b. receivers used in programme circuits use the s.s.b. pilot carrier to operate their a.g.c. and a.f.c. systems, and in many cases for final demodulation, and it is necessary to protect the receiver carrier chain from interference from relatively high-level sideband components near to carrier frequency. The

* A synthesiser is a device which generates any single frequency from a closely spaced series (e.g. at 100 Hz intervals) within a specified range, all frequencies normally being derived from a single high-stability reference oscillator.

simplest method of protection is to provide a suitable high-pass audio filter at the transmitter input to supplement the sideband filter selectivity. The effect is illustrated in Fig. 1, in which the protection limit curve A is calculated from the carrier filter characteristic of a typical receiver design, assuming a transmitted carrier level 16 dB below p.e.p. and a carrier to interference ratio of 20 dB. Curves D and E show why no protection is required when receiving normal broadcast or s.s.b. signals.

At the other end of the passband additional audio filters are required to minimise out-of-band radiation. Continuous programme modulation is more likely to cause harmful adjacent channel interference than is the case with normal speech communication, particularly when audio pre-emphasis and volume compression are incorporated in the programme chain, and a sharp cut-off low-pass filter at the transmitter input provides the most convenient safeguard. In order to cover band allocations of less than 6 kHz two or more filters can be provided with appropriate cut-off frequencies and these can be switched into circuit automatically according to the channel in use.

Also associated with the low-frequency extension of the transmitted bandwidth is the effect on transmitter modulation linearity of close tone spacings such as occur naturally in music. While not significant in speech transmission it is desirable in programme circuits for the linearity to be maintained with frequency separations down to about 20 Hz, and the regulation of the power supplies to the class-B r.f. amplifiers in a communications transmitter is likely to produce a sharp rise in intermodulation distortion when the difference frequency is reduced below about 50 Hz. The effect of changing the h.t. supply impedance is shown in Fig. 2, curve A being the measured performance of a standard unit and curve B the result of adding an extra main h.t. smoothing capacitor. Further reduction was attained in this case by reducing the main grid bias supply impedance.

Communications circuits commonly work with the carrier
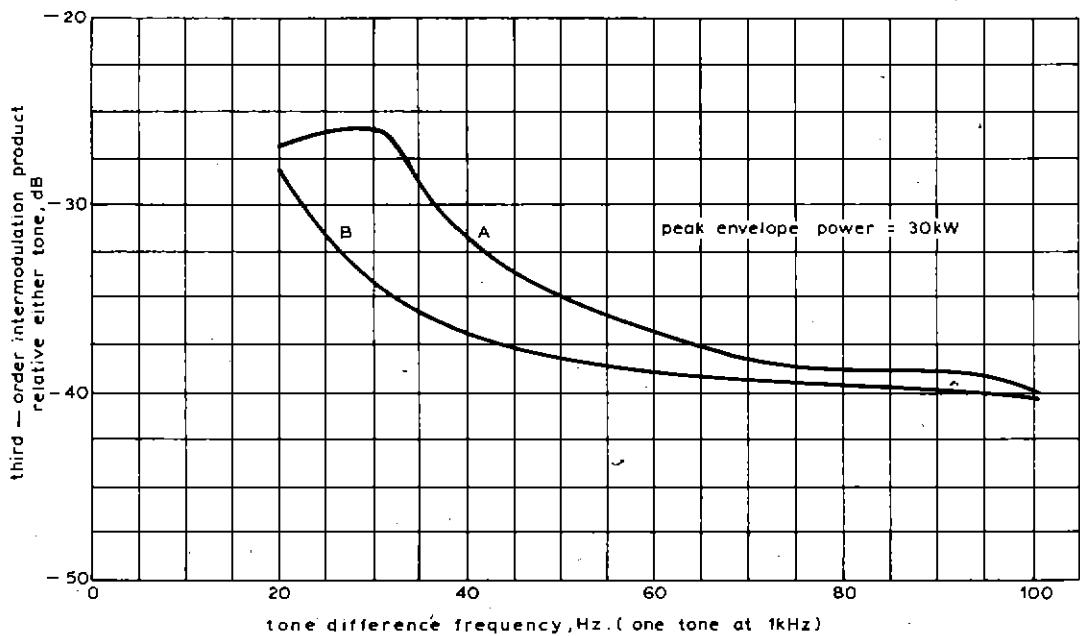
Fig. 2 Effect of supply impedance on distortion with close tone spacing

A : Performance of standard transmitter
B : With additional h.t. smoothing capacitor

completely suppressed at the s.s.b. transmitter while in the receiver an accurate locally-generated carrier is used for demodulation. Fading variations are sufficiently reduced by a combination of sideband a.g.c. and audio volume compressors, but the system has the disadvantage of introducing an indeterminate amount of unwanted compression into the circuit. This is avoided in programme circuits by using a reduced carrier system in which the pilot carrier operates fast-acting receiver a.g.c. to hold the circuit gain constant, and also provides the receiver with a frequency and phase reference for the sideband signals. The conventional carrier level of 16dB below p.e.p. has been found to be an effective compromise between receiver requirements (Fig. 1) and limitations of transmitter sideband power.

Necessary transmitter frequency stability is effectively determined by receiver requirements. Receivers with a.f.c. can follow quite large frequency excursions but the a.f.c. capture range is limited to the effective bandwidth of the carrier filter. Receivers without frequency compensation require the transmitter to remain within about 2Hz of nominal frequency in order that the accuracy of the musical scale can be retained, but this presents no difficulty with synthesiser techniques.

4 Monitoring

Programme circuits are essentially one-way systems in which repetition of missed items is not normally possible, and effective local monitoring of transmitted programme and carrier level is necessary to give immediate fault warning and thus minimise loss of service. Adequate carrier monitoring can be provided by an alarm relay energised from a sample of transmitter output, but more elaborate equipment is required to convert the sideband signals back to audio frequency for programme monitoring. While a suitable receiver could be

provided for s.s.b. monitoring, receivers with the necessary stability and performance are expensive and a better solution is to provide a second synthesiser to feed carrier frequency to an audio demodulator, the monitoring synthesiser then acting as a spare for the transmitter. A simplified scheme for a semi-attended installation is shown in Fig. 3; the audio comparator or 'automatic monitor' is used to detect major deficiencies in transmitter output and is backed up by routine loudspeaker checking for minor imperfections of audio quality.

An elaboration of this arrangement, shown in Fig. 4, allows a single synthesiser to act as spare for more than one transmitter in multiple installations. Here the overall monitoring is done in two stages, the audio signals being derived from the s.s.b. input to the synthesiser while a comparatively simple envelope comparator checks the operation of the rest of the system. Since there is no audio output which includes distortion in the linear amplifier circuits, the spare synthesiser is again used for routine quality checking by switching its audio demodulator to the appropriate transmitter. In both this case and the previous one the audio comparator may not be required when the transmitting station has existing facilities for transmitter monitoring.

The test equipment required for s.s.b. transmitters is more complex than for broadcasting installations. Means of checking the radiated spectrum and measuring in-band intermodulation products will normally be required if transmission standards are to be maintained and interference with low-level communication circuits in nearby channels avoided. The accepted method of doing this is to use an h.f. spectrum analyser in conjunction with a pair of audio-frequency tone generators,[1] and since the spectrum analyser is a relatively expensive item it is economic and practical to combine the equipment in a trolley-mounted unit with arrangements for connecting to test points on the transmitters.

Setting up and checking the transmitter self-tuning system
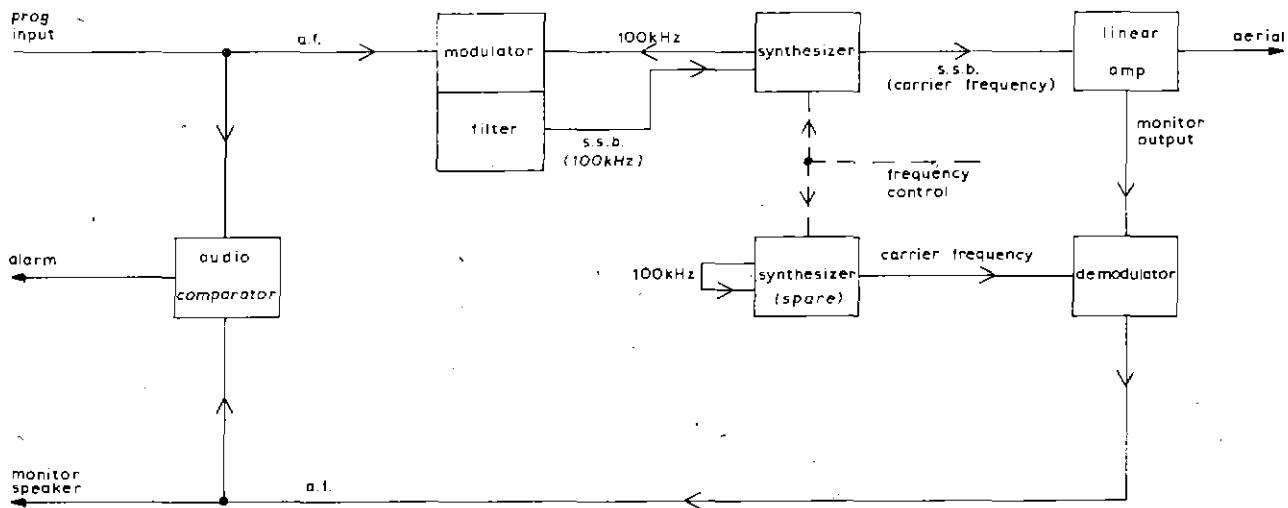
**Fig. 3** Monitoring with spare synthesiser
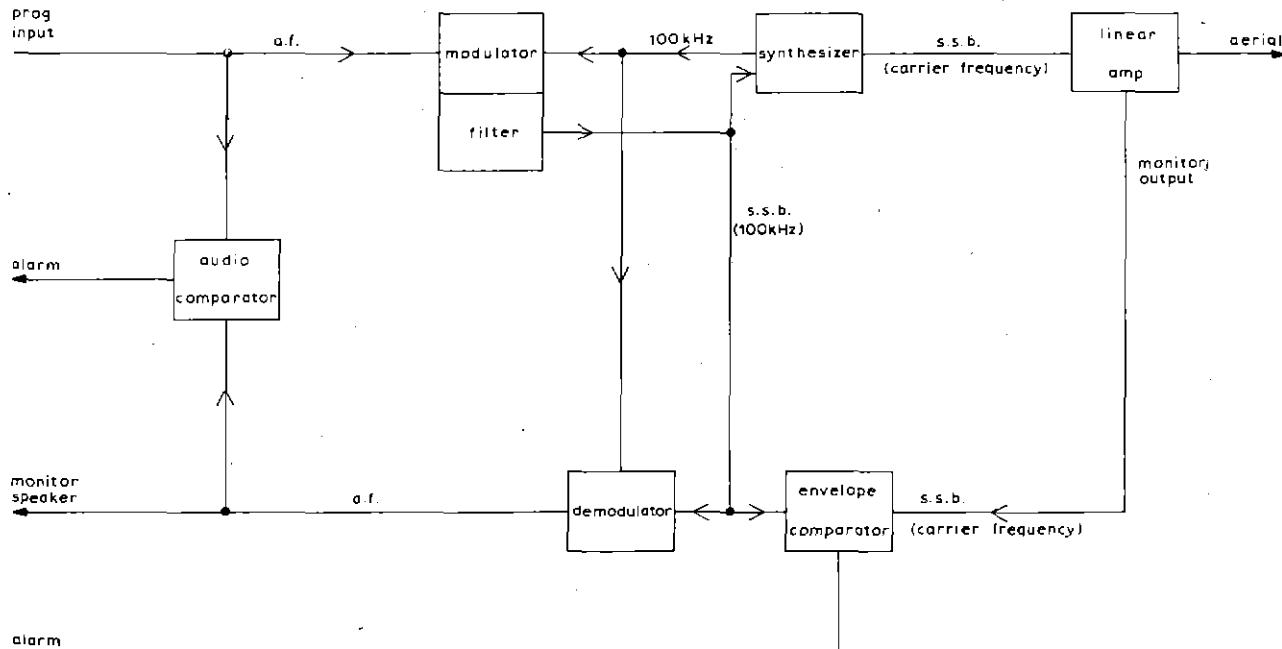
Fig. 4 Alternative monitoring system

while other co-sited transmitters are operating requires access to a non-radiating test load, which should preferably incorporate provision for calorimetric measurement of transmitter output power. A test load of suitable power rating can, of course, be shared by a number of transmitters.

5 Hazards

S.s.b. transmitters used in programme circuits are likely for economic reasons to be installed at existing broadcasting stations alongside transmitters of very much higher output power, and although the point-to-point and broadcast transmitters do not operate in precisely the same frequency bands, initial difficulties are likely to arise from spurious h.f. pickup, either through aerial cross-coupling or on the equipment

itself. Fortunately h.f. aerial systems are designed with considerable care to minimise coupling and consequent intractable intermodulation between transmitters, and the s.s.b. linear amplifiers are inherently less susceptible to this than are most broadcast transmitters. Trouble is most likely to occur in the self-tuning system and good design here is essential for it to function reliably in a hostile environment.

Direct induction into the equipment can result in damage or impaired performance in the low-level signal and control circuits. Special care is required during installation, therefore, to ensure that the integrity of cable and equipment screening is maintained and that test leads or other temporary connections do not inject harmful r.f. pickup into the equipment.

Safety requirements are generally similar in all high-power transmitters and effective means must be provided to exclude
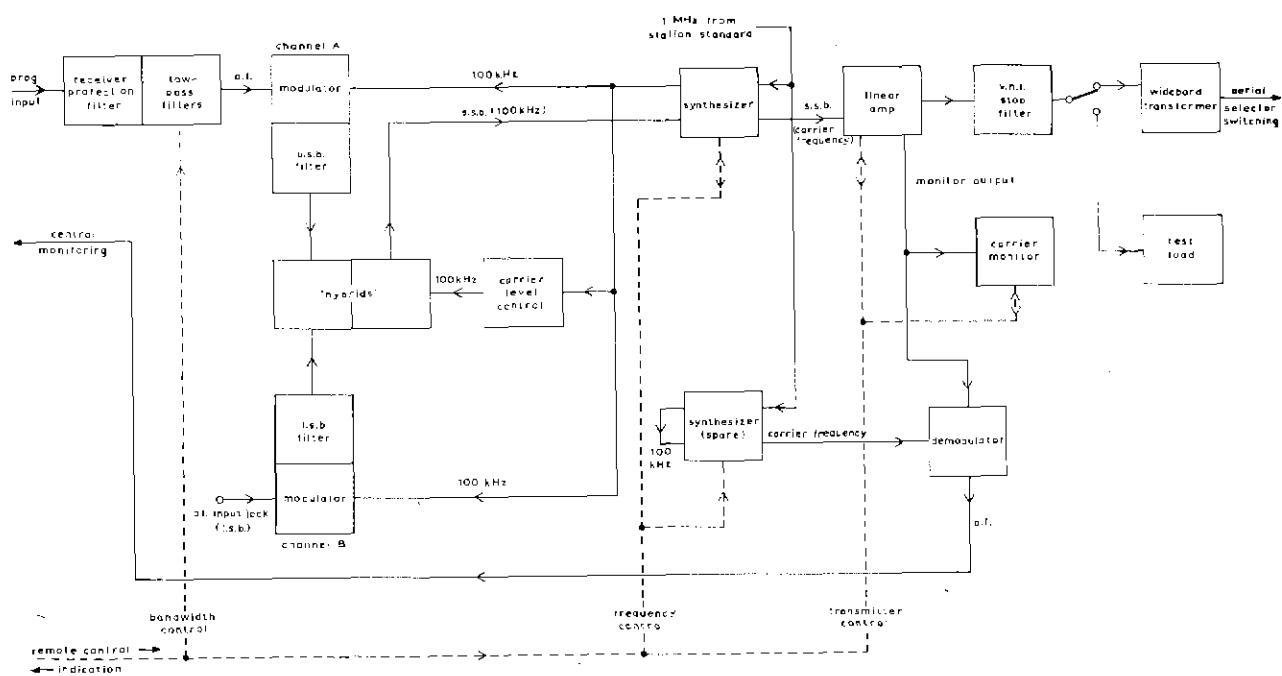
Fig. 5 S.s.b. programme link transmitter: signal paths

operational staff from high-voltage circuits and to protect equipment from consequential damage in fault conditions. Before commissioning a new type of transmitter at an existing station it is also necessary to ensure that its design is compatible with the established system of aerial and transmitter interlocks and safety procedures. One requirement at high-power transmitting stations is provision for convenient isolation of the transmitter from its aerial feeder, so that maintenance work can be done without hazard to staff or test equipment from r.f. power fed back through the aerial system.

6   System Description

It will be evident from the previous sections that given a good basic transmitter design the changes required for use in programme circuits are not of a fundamental nature, and can readily be incorporated during installation provided they are planned in advance. Although installations vary in detail, particularly in respect of control and monitoring arrangements, the elements of the transmitter signal path are as outlined in Fig. 5, which may be taken as typical for a station with centralised control and supervision of programme, transmitter, and aerial switching.

Audio input signals are band limited before being applied to the channel A (u.s.b.) modulator and the resulting sideband output from the extended range u.s.b. filter is combined with the 100 kHz carrier in the usual way, before being passed to the transmitter synthesiser for conversion to final frequency. The standard channel B modulator and l.s.b. filter, although not normally used, are retained for the sake of versatility.

Apart from the minor modification to maintain modulation linearity with closely spaced tones, the 30 kW self-tuning amplifier is a standard product which has been described elsewhere.[3] The v.h.f. output filter is a normal precaution in

the United Kingdom to prevent interference with television and other v.h.f. services by residual amplifier harmonics, and the wideband r.f. transformer is used to match the unbalanced transmitter output to the existing station aerial and feeder system.

A simple monitoring arrangement feeds demodulated signals back to the control centre for checking and sounds an alarm in the event of inadequate carrier level, the monitoring synthesiser being switched automatically to the correct frequency. The whole system is controlled remotely and no operator attendance is required at the transmitter.

7   Results

The BBC transmitters are in regular use in programme circuits to relay stations in Ascension Island, the Middle East and South-East Asia, and their overall performance has been most satisfactory. With full bandwidth operation the audio quality produced at receiver output compares favourably with that from broadcast transmissions and in normal ionospheric conditions is better than that obtainable from available cable circuits. The self-tuning and remote-control facilities are effective and provide flexibility of operation with a minimum of supervision and wavechange time.

Maintenance staff have remarked that communications equipment design is less amenable to rapid fault tracing than is generally the case with broadcasting equipment. However, the initial maintenance problems were less than had been anticipated, and current returns show the m.t.b.f. to be equal to that for the h.f. broadcast transmitters. Since two of the s.s.b. transmitters are relatively new a further improvement is expected in subsequent figures. Occasional malfunctions have been experienced with the self-tuning systems but these have generally been non-persistent or self-clearing and are not considered troublesome.

8 Conclusions

S.s.b. point-to-point circuits provide an economic means of sending programmes to distant broadcast relay stations, and given suitable frequency allocations and transmitter design the resulting relay quality is generally equal or superior to that obtained at realistic cost by other methods. The success of the s.s.b. programme links in a field where circuit reliability and audio quality are of prime importance reflects credit on all concerned in the provision and operation of the equipment and is likely to result in further demands for this type of system.

Foreseeable developments include completely automatic installations operated from time switches, and the provision of i.s.b. systems carrying two programmes simultaneously.

9 Acknowledgment

10 References

1. CCIR Rec. 348-1, 1966.
2. CCIR Rec. 297-1 and 338-1, 1966.
3. BBC Specification ES/41.
4. Stokes, V. O. 'Testing SSB Transmitters'. *Marconi Instrumentation*, Vol. 12, No. 4.
5. Stokes, V. O. and Barbone, W. V. 'Self-Tuned Linear Amplifier Transmitter', *Point to Point Telecommunications*, Vol. 8, No. 1, Oct. 1963.

The BBC Central Computer Complex

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1 Introduction

In the BBC's business of broadcasting, an essential element is the control of the use of resources such as money, equipment, artists, and staff; to assist in this control the BBC is using data-processing computers to an increasing extent. The main applications for computers in the BBC are at present:

Management Control
Engineering Research and Design Calculations
Audience Research
Programme Planning
Accountancy and Payroll
Storing and Forwarding of Teleprinter Messages including
　Telex.

To meet the increasing demand for computing capacity throughout the world, computers have been developing in size and complexity, and as a result, earlier machines have become obsolescent and progressively inadequate for meeting the more sophisticated demands. At the same time, the hardware necessary to do a specific job has been becoming less costly. At various points in time, therefore, decisions have had to be taken to change from one size and/or make of computer to another. These decisions have been made difficult because the various manufacturers' equipments and philosophies are in many cases not compatible.

Compatibility in this sense means the ability to run programs written in a language suitable for one machine on a different type of machine. Incompatibility may have stemmed originally from the way in which the electronics (the hardware) was designed but has continued into the field of computer languages and is now a software problem. BBC experience has confirmed that this is a major problem and one which is familiar to many organisations.

2 History

In 1962 a comparatively small machine (an Elliott 803) was installed in The Langham* to handle Audience Research returns and a few engineering problems. Later a simple system for scheduling studios was introduced for radio and by 1966 the total load had outgrown the capacity of the 803; it was replaced by an ICL 1909 computer which has since been extensively modified and enhanced to meet increasing demands. The 803 was transferred to Research Department and is still doing good service on engineering problems such as the predictions of field strengths from transmitter power and terrain information.

In parallel with this activity, by 1963 the problems of accounting for the BBC's income and expenditure were increasing. To avoid increasing the number of staff required to handle the mounting work load, an ICT (now ICL) 1500 computer was installed. In 1964 a second ICT 1500 was added and the pair were moved to a new location. These machines are now obsolescent: maintenance is becoming a problem and it is difficult to find operators willing to work on the machines for long because of the lack of career prospects.

3 Present Installation

As an interim measure an ICL 1901A was acquired in February 1970, and installed alongside the 1500s. The ICL 1901A consists of a processor with a core store of approximately 16000 words (of twenty-four bits each), a card reader operating at 600 cards per minute, a line printer operating at 600 lines per minute, four tape decks transferring data at 20000 characters per second, a twin magnetic disc unit holding 3·2 million six-bit characters, and an operator's console for controlling the programs. This has taken over part of the load from the 1500s and is assisting in developing new systems. It will be used for checking rewritten computer programs and will allow for certain routines to be handled within Finance Division. These routines are mainly concerned with ensuring

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* A former hotel near Broadcasting House, now used as BBC
　premises.
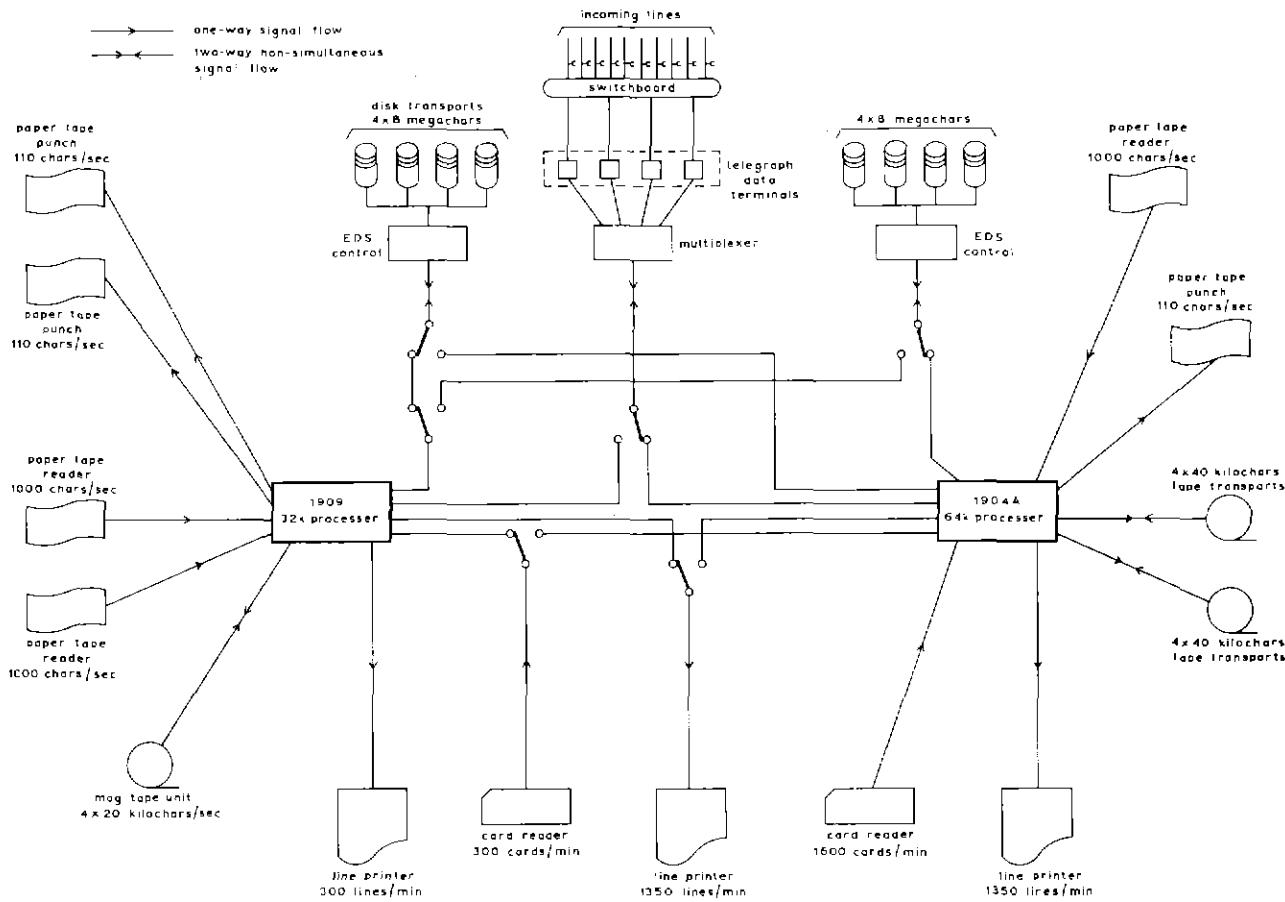
Fig. 1 Sulgrave House – Systems diagram of the computer complex

the validity of data that will be used in subsequent routines that call for more powerful computer facilities.

To cover the remainder of Finance Division's work and to meet the increasing demand for computer capacity from the rest of the corporation, a decision was made in July 1969 to acquire an ICL 1904A computer. This was installed at Shepherd's Bush together with the ICL 1909 (formerly in the Broadcasting House area) in a building known as Sulgrave House. The configuration of the equipment that is housed there is shown in Fig. 1.

A note of urgency was added to the situation by predictions based on known developments that the total computer capacity available within the BBC by mid-1970 would be seriously overloaded. It was necessary therefore to carry out the agreed plan as soon as possible and Sulgrave House was acquired in December 1969, the installation of the computer being scheduled for June 1970.

Data-processing computers with associated magnetic tapes and magnetic discs have stringent environmental requirements. Moreover, it is essential for efficiency that all the supporting equipment, offices, and staff should be available in areas adjacent to the computer. In all a floor area of 10000 sq. ft was required and to carry out the necessary building, wiring, and installation in the time set was a difficult operation.

The layout of the new computer area, which is shown in Fig. 2, has been carefully designed to facilitate the smooth flow of work between the various areas.

The complete installation comes from the ICL 1900 range

and consists of the type 1909 processor, with a core store of approximately 32000 words (of twenty-four bits each) and cycle time of two microseconds together with the necessary peripherals which include:

four exchangeable disc transports holding 8 million characters each,
four magnetic tape decks,
an eighty-column card reader (300 cards per minute),
two paper-tape readers (1000 characters per second),
two paper-tape punches (110 characters per second),
a slow line printer (300 lines per minute),
a fast line printer (1350 lines per minute), and
a multiplexer for handling teleprinter out-stations connected over Post Office lines.

The new equipment, which shares some of the peripherals on a switched basis with the 1909, consists of the 1904A processor with approximately 64000 words of core and a cycle time of 750 nanoseconds, together with four exchangeable disc transports,* two groups of four tape decks, an eighty-column card punch capable of operating at 1600 cards per minute, an additional paper-tape reader and punch, and another fast line printer (1350 lines per minute). Fig. 3 shows an operator at the control console of the 1904A computer, and Fig. 4 gives a general view of the computer room.

* These exchangeable disc transports will be traded in for five disc transports, each with a storage capacity of 30 million characters, in about eighteen months' time.
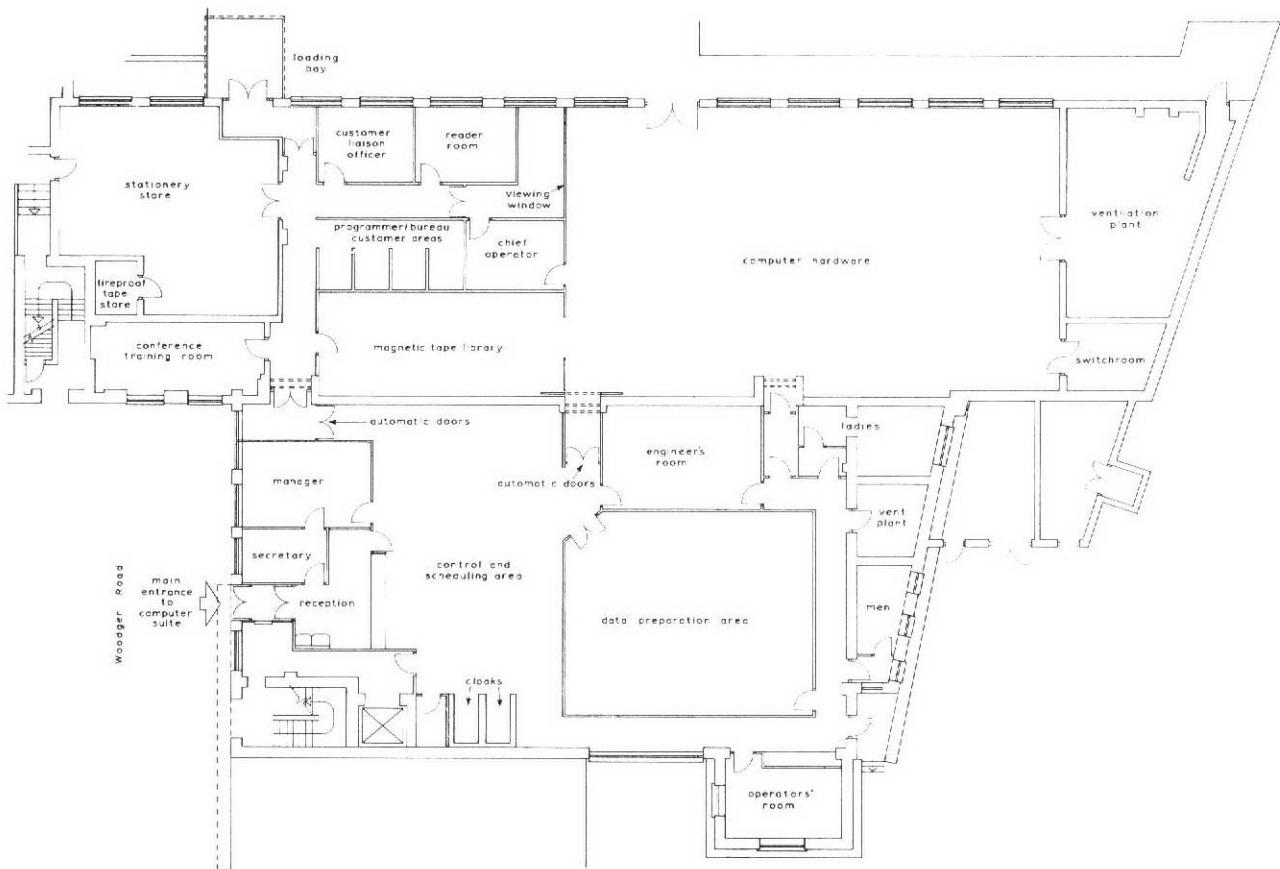
**Fig. 2** Layout of the computer area in Sulgrave House
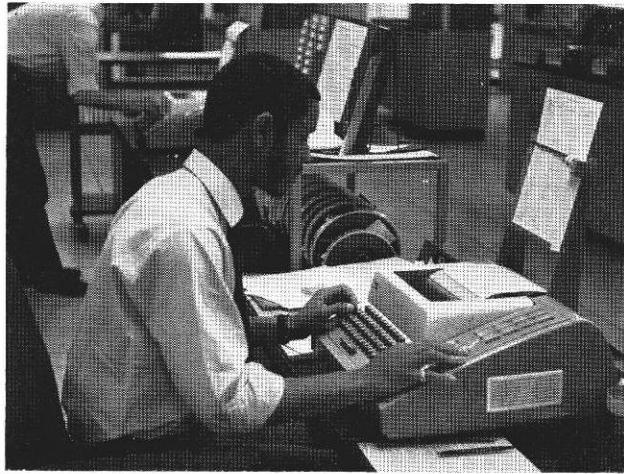
Fig. 3 An operator at the control console of the 1904A computer. The control console of the 1909 computer is in the background

4 Applications of Present Installation

The facilities provided by this new installation can be used for three main purposes:

(a) Management Control
(b) Stock Control
(c) Engineering.

4.1 Management Control

4.1.1 Television Management Information System

The Television Management Information System has been evolved to assist the Controllers of BBC-1 and BBC-2 and the Heads of various Output Departments in planning television programmes and in costing them against a budget.

The files of information for the transmission plans, programmes to be produced, loading and scheduling of resources against available facilities are all held on the central computer discs or magnetic tapes. The up-dating information is prepared on punched tape which is delivered physically to the computer centre and read on the paper-tape readers attached to the computer.

About six months before the start of a transmission year, Channel Controllers up-date the already existing broad transmission plans for that year. Programme Planning translate these plans into production plans and ensure that the plans are practical in relation to major resource availability, using a wealth of experience and past 'actuals' as basic yardsticks.

The effect of transmission plans on the programme stockpile (either existing or 'in the pipeline') is considered, proposals are made for replenishing the stockpile, and the total output required from Output Departments is calculated. There are, of course, numerous other calculations which are required to exercise Management Control. In general the procedure is as follows:

(1) Channel Controllers inform Heads of Output Departments of the quantities and types of programmes required as a result of which programme offers are made.

Fig. 4 General view of the computer room showing the control consoles (right), card readers (left), and tape decks in the background

(2) Output Departments prepare a Programme Budget Estimate (P.B.E.) for each programme or programme *strand* (i.e. series or similar grouping) offered.

(3) The P.B.E. indicates the most likely source requirements in unit terms and states the total cost of the programme proposal. This forms the basis of bartering between Channel Controllers and Output Departments.

(4) Programme Planning carries out a detailed analysis of all accepted P.B.E.s. The aim now is to use the computer to assist in comparing major resource demands on a weekly and daily basis against resource capacities to rearrange production plans in order to smooth out peak-demand periods and to prepare production schedules for Service and Engineering Departments, which will enable detailed resource scheduling and deployment to be carried out.

4.1.2   Radio Production Planning

In radio the aid of the computer has been enlisted for some years to assist in drawing up, on a day-to-day basis, schedules for transmitted programmes from information received in a random manner over a period of time in the Production Planning office. The computer is used to sort this information into suitable formats for the departments concerned. Further developments and greater sophistication are being actively considered.

4.1.3   Audience Research

Viewing and listening data obtained either from street interviews or special questionnaires are punched on to paper tape, sorted using the computer, and printed out in a variety of forms, either to indicate general trends in viewing and listening habits or to estimate the size of audiences for a given programme. The volume of returns dealt with has grown to $1\frac{1}{4}$ million per annum since the early days when the Elliott 803 was used.

4.1.4   Accountancy and Payroll

Finance Division is responsible for the overall accounting for the BBC's income (£81 million in 1969). To do this without an army of clerks, to get information quickly enough to be useful to management, and in order to satisfy artists, staff, and others requiring rapid payment, Finance Division has progressed through the various stages of using punched-card machines, ICL 1500 computers, and now the ICL 1900 range. This is the area in which the problems encountered in transferring from one type of machine to another have been most acute; they stem from technological developments which are reflected in the way systems are designed and the programs written. For instance, programs written in a language that can be understood by the ICL 1500 computer cannot be understood by the ICL 1900 range. The cost of rewriting these programs is a significant factor in the total cost of acquiring new computers and underlines the need for a common approach to computers within an organisation such as the BBC.

Data processing in Publications is currently in a transitional stage, from a mechanical punched-card system, to a computer system. The work load is being transferred during a period when both systems will operate in parallel. Six Mohawk

magnetic tape encoders have been installed recently which enables the computer input to be keyed direct on the magnetic tape, thus speeding up the reading of the input data.

Input is designed to give Management information over the whole spectrum of Publications Operations: cost and revenue in advertising; journal circulation figures for the Audit Bureau of Circulations; subscription information; stock recording with minimum holding levels; and Finance budgetary control – all are accommodated by daily or weekly batch-processing cycles.

Computer time for the period 1970–71 has been estimated at a total of 1192 hours, of which 942 hours is actual program-running time, the remaining 250 hours being set aside for systems development.

4.1.5   Capital Expenditure and Manpower Recording for Engineering Division

For some time engineering effort expended on installation and building work has been recorded against approved schemes and other jobs on a weekly basis, using the ICL 1909 computer. This information is being incorporated in a wider system for the better control of capital projects, a system that will stem from the capital budget through the carrying out and progressing of the work implied by that budget. The volume and complexity of the data, coupled with the need for reasonably rapid returns, require the speed and storage capacity of a computer.

4.2   Stock Control

CEMAST (the Control of Engineering Materials, their Acquisition, Storage, and Transport) is a stock-control system being introduced to assist in handling components, equipment, and material in Engineering Stores including the invoicing and associated ordering procedures.

Valve Store at Motspur Park has been operating a batch-processing system on a weekly basis for some time and is now using an on-line system (i.e. using teleprinters directly coupled over Post Office lines to the computer) for four hours per day. This is backed up by some batch processing overnight for non-urgent housekeeping purposes.

It is technically possible to extend this system to other Engineering and Technical Stores, using the same four hours per day, on a time-sharing basis and the benefits of such an extension are being assessed. A booklet on CEMAST is available from Technical Publications Section.

4.3   Engineering

The computer has been, and is being, used for many small engineering jobs involving calculations as opposed to jobs for assisting in the management of Engineering Division previously mentioned under 'Management Control'. Some engineering calculations can be done in a batch-processing mode, i.e. the data are handed in overnight to be run against an existing program and the result produced the next day. Other calculations, however, require a 'conversational' mode of working: the engineer sits at a teleprinter keyboard in 'conversation' with the computer and enters initially the program for the computer to follow and then the data against which the

calculations will be made. The answer then appears on the teleprinter for immediate assessment and a reappraisal of the problem by the engineer if necessary. Such a system is available for one hour per day for Designs Department.

5   Possible Future Developments

Computers are improving steadily in their speed of operation, in the complexity of the jobs that they can tackle, and in the quantity of data that can be stored.

Two major areas in which it is anticipated that the BBC will need to improve and expand its central data-processing capacity in the next few years are:

(a) in the amount of storage directly attached to the central processor, and

(b) in the facilities provided to user departments for putting data into and receiving information from the computer.

For the first requirement, the amount of data that can be packed on to magnetic oxide surfaces is increasing together with the speed at which the data can be written or read. An increase in the number of transports for holding magnetic-coated discs could meet the storage needs, although other technological devices may be imminent. Several hundreds of millions of six-bit characters can easily be stored on devices currently available.

To provide improved facilities to the user, typewriter-like keyboards associated with cathode-ray-tube displays and page printers local to the user are currently available. Teleprinters are, of course, widely used for projects such as CEMAST and the first cathode-ray-tube display in use in the BBC is operating on the Automatic Message Switching System.*

An improved relationship between man and machine is an obvious necessity but this is unfortunately the area which has been slowest to develop. Facilities for the direct reading of documents could, for some requirements, give a speedier and cheaper service. It may be possible, for instance, to introduce a document reader for scanning returns received by Audience Research. The speed at which these devices work would mean that there would be considerable spare capacity for other jobs, thus giving some encouragement to the introduction of this sort of technique.

6   Conclusion

The purpose of this article has been to cover the development in central data processing in the BBC. The new installation at Sulgrave House is a significant step forward and will give a better and more flexible service, together with the possibility of expansion for systems in development stages.

There are many other areas in the BBC into which computers may be introduced in the next few years for the better control of broadcasting plant and other process-control applications. Although some of these developments may appear to be totally unrelated to the central data-processing equipment described here it is essential that compatibility is maintained and much work will need to be done to achieve this.

The author would like to express sincere thanks to his many colleagues who have been responsible for the systems described.

* Described in BBC ENGINEERING, No. 83 (July 1970).

ANCHOR—an electronic character generator

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Summary: A new type of electronic character generator is described which produces an improved character shape over existing matrix type electronic character generators. Use is made of analogue waveforms to build the characters up from bars and curves and this gives a much more pleasing result.

The basic generator can be used with various pieces of peripheral equipment to provide a versatile caption generator.

Contents

1 Introduction

At present almost all television captions are produced by caption artists whose work is converted to a television signal by a studio camera or through a photographic process and slide scanner. However, the possibility of generating alpha numeric characters electronically and then typing the captions directly on to the television screen from a keyboard is very attractive so far as time saving and flexibility are concerned.

Electronic alpha numeric character generators are now quite widely used in the computer industry in video display units for rapidly presenting information from a computer. Various systems, including the standard television scanning system, are used at the cathode-ray tube to write the characters on to the screen. Some of the techniques used here have been applied to broadcast television although the requirements for broadcast captions are somewhat different from those of the computer display.

In television a large range of type founts are used with an almost infinitely variable number of character sizes. On the other hand the computer display generally has to present as much information as possible consistent with reasonable legibility. The characters therefore tend to be small with a fixed size and the shape sufficiently good for legibility only.

So far the only method used for generating characters for standard television type displays has been the dot matrix method. Here each character is built up from dots or squares in a fixed matrix. The dot matrix equipment at present used on some current-affairs programmes within the BBC uses a matrix of nine divisions in the horizontal direction by eleven in the vertical direction, corresponding to eleven lines on each field. The limitations on this type of equipment are such that the requirements for broadcast captions are far from being fulfilled. Character shape is very limited and on some characters good shape is impossible to achieve. Upper-case characters only of one size are generated and since each character occupies the same width, optimum character size and spacing cannot always be achieved.

Present developments in the matrix-type character generator are overcoming some of these limitations and should give better character shape, improved character spacing, and lower-case lettering.

The character generator described here, however, uses a completely different technique for building up the letters, since the original aim of the project was to produce characters which would be aesthetically acceptable when viewed on the home receiver.

2 The Generator
2.1 General

Each character is built up from straight bars and curves, all of equal thickness, which are joined together electronically to form the complete character. The component shapes may be divided up into three groups: vertical and horizontal bars, bars at an angle to the vertical, and curves. These are generated from repetitive square, sawtooth, and parabolic waveforms respectively, having the same repetition rate as each other and locked to the television synchronising waveforms. Each shape is generated over the whole screen area in a matrix of imaginary boxes so that the characters are available over the whole screen at any one time, rather than by generating the individual shapes as they are required for a set of characters in a given caption. It is in fact simpler to generate the characters continuously over the whole screen and then to select the particular character out of the 'page' by addressing each page from a data store. The synchronising pulse waveform is used to generate a set of master timing waveforms which define how many character 'boxes' appear on the screen. In the present case this is thirty-two across by seventeen rows down over the whole screen area, although the usable number is
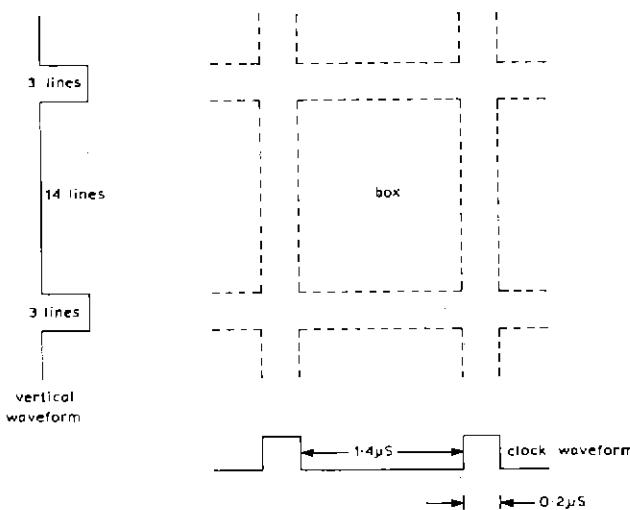
Fig. 1 Relationship of waveforms forming the character boxes

limited to twenty-five across by fourteen down to be within the safe viewing area. One of the master timing waveforms runs at forty times line rate (625 kHz) and determines the number of boxes across the screen and another runs at one-seventeenth line rate (slightly over 919 Hz) and sets the number of rows of characters per field. As the latter waveform does not run at an exact multiple of the field frequency, it must be reset at the start of each field. Fig. 1 shows the relationship of these two waveforms to the box.

All the other waveforms have the same frequency as one or other of these two master waveforms.

2.2 Characters with Horizontal and Vertical Bars

Each bar is generated by gating a pulse generated from the clock waveform of Fig. 1 with a vertical gating waveform which corresponds with the position and height of the bar in the box. The width and timing of the pulse also define the width and position of the bar in the horizontal direction. Use is made of quite simple monostable circuits in cascade to delay and form the pulse waveform, and gating of the pulses is carried out with standard integrated circuit logic gates. The bars, which are formed separately, are then added together in another logic gate to make the appropriate character. Fig. 2 shows the
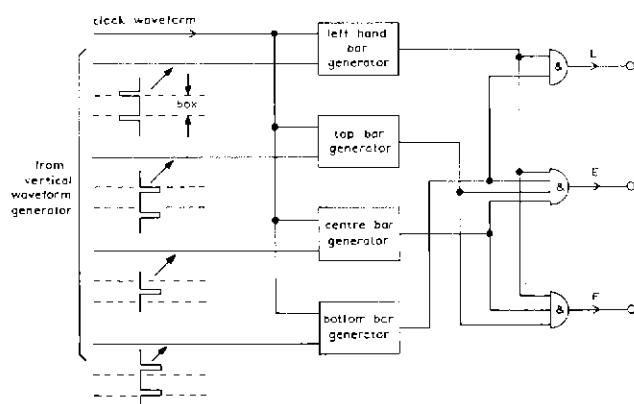
Fig. 2 Bar generation and gating arrangements for the letters L, E, and F

arrangement for generating the letters L, E, and F and illustrates the fact that many of the component bars and curves are common to a number of characters, which simplifies the circuitry considerably.

The waveforms at the three outputs in Fig. 2 are the video waveforms which would display a full screen of the letters L, E, or F. Further gating, controlled by a data store, then takes place to select single characters from the full screen so that words and captions may be built up as illustrated in Fig. 3.
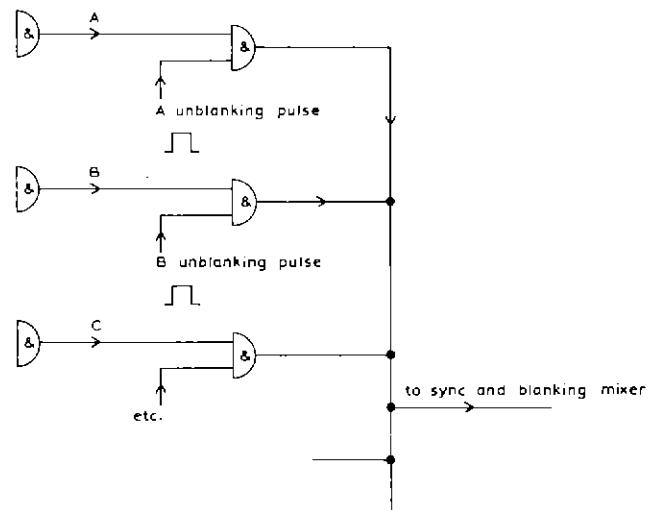
Fig. 3 Gating to select single characters

2.3 Characters with Sloping Bars

Rather different techniques are employed to generate the sloping bars although processing of the bars is similar to the above.

Each sloping bar is generated from two sawtooth waveforms, one running at the clock waveform rate and one at the vertical box repetition waveform rate. These two waveforms are connected to a differential level detector (see Fig. 4) which produces a step at the collector of TR2, at the instant when the two input waveforms sweep through the same potential. The positive-going edge of the output waveform is thus phase-modulated in time and follows a slanting line across the box. This edge drives a monostable circuit to produce a slanting bar. The position of the bar in the box is determined by the relative d.c. levels of the waveforms at the inputs of the level detector and the slope of the bar by the relative amplitudes of the two waveforms. By inverting one of the waveforms to the detector the opposite slope can be obtained. The vertical sawtooth waveform is 'interlaced', i.e. there is a half-line timing difference on alternate fields with respect to line rate pulses and this ensures that the diagonal bar has smooth interlaced edges.

The bars are then added together as required to form various characters.

2.4 Characters with Curved Components

Similar techniques are used to generate circles as are used for the sloping bars except that parabolic waveforms are employed. Two level detectors are required each receiving the same pair of parabolic waveforms but with an offset in the relative d.c. levels of the inputs to one of them. One of the
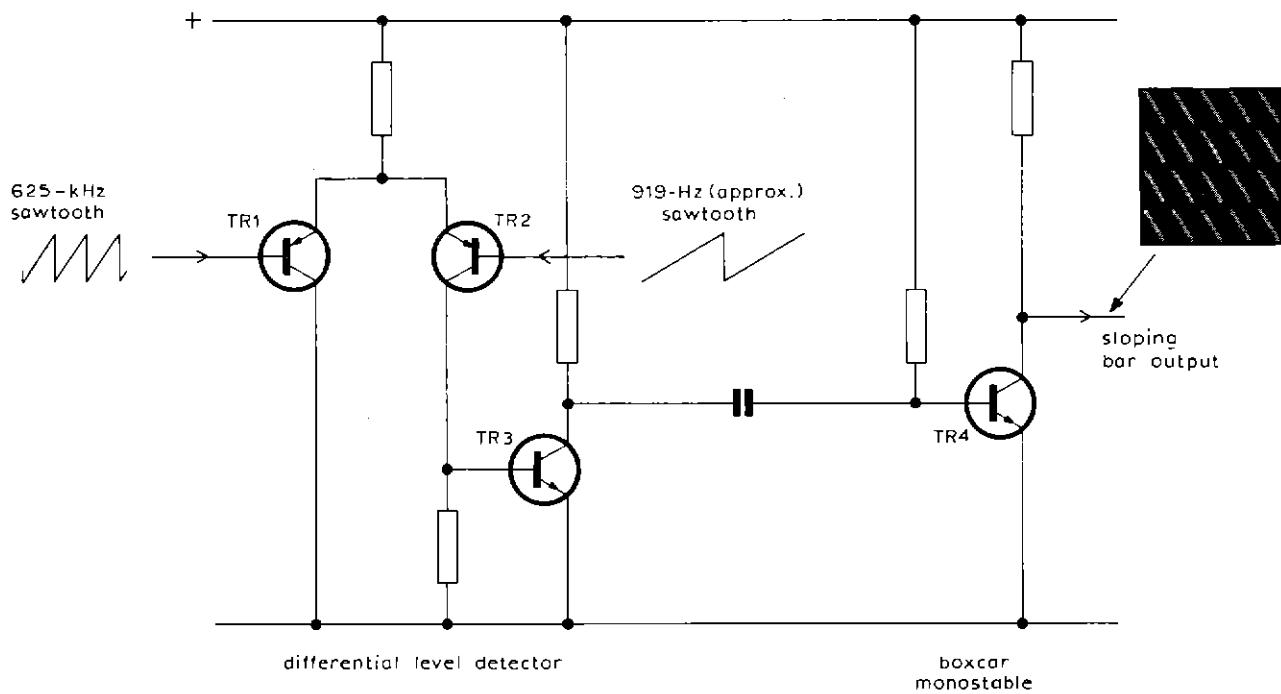
Fig. 4 Generation of sloping bars
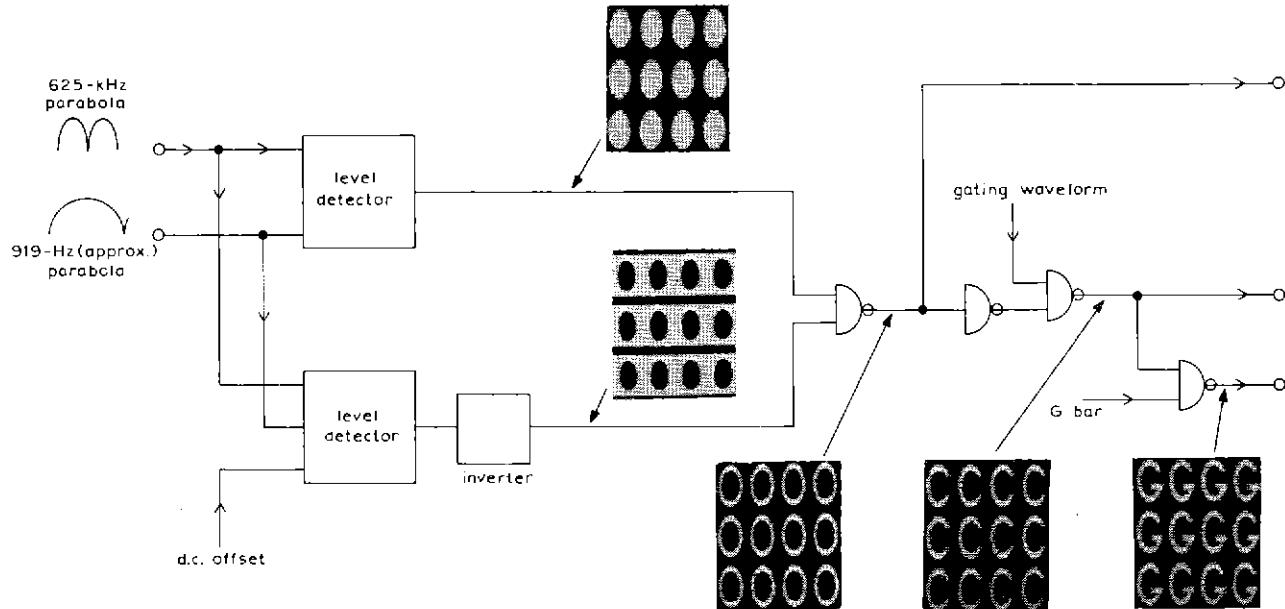
Fig. 5 Formation of characters with curved components

level detectors produces an output which appears as a series of white discs on the screen (see Fig. 5) and the other detector with the offset produces a series of smaller discs concentric with the larger circles. By inverting the smaller discs (making them black) and mixing them electronically in a DTL nand gate, the letter O is formed at the output of the gate. If the lower-frequency parabolic waveform were applied directly to the level detectors without any processing, the change in the instantaneous potential of this waveform during each line period would cause the pattern of lines forming each character to vary slightly at different positions along a row. To avoid this effect, and so to produce a tidier display when, say, a row

of zeros is set up, the 919 Hz waveform is sampled at the start of each line and the sampled value is held throughout the line period.

This forms the basis of other letters such as C, G, and Q by suitably gating and adding other straight bars.

A second series of characters using parabolic waveforms are 8, 3, S, etc., which require a double frequency parabola in the vertical direction so that two circles, one above the other, are formed in each character box. Similar techniques of gating out sections of the basic 8 are used to form the 3, S, and B.

The complete range of characters is shown in Fig. 6.

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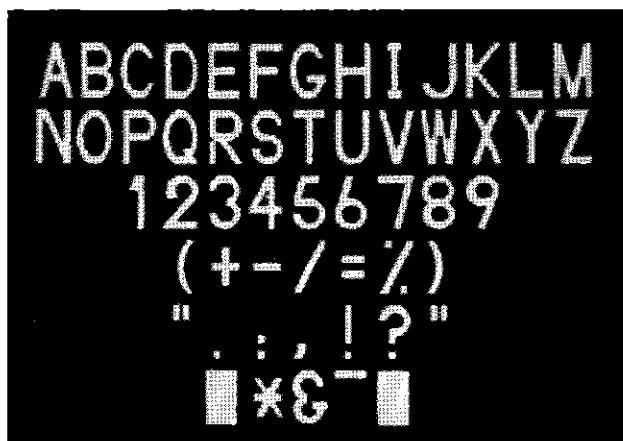
Fig. 6 Complete range of characters

2.5 Generating Captions

As stated above, each character is generated over the whole screen area, since the waveforms used are continuous throughout the picture period. There are about fifty outputs from the character generator (twenty-six capital letters, nine numbers, and various punctuation marks and other signs) and each output can be switched on or off by a control input. All the outputs are mixed together and pulses are fed into the control inputs which allow the characters to pass to the output. As an example, if the word AND is to be written on the screen a control pulse is sent to the A generator and allows one A to pass to the output at the position required. Similarly in the next box position a control pulse is sent to the N generator and so on for the whole word.

The control pulses are derived from a binary data store, which takes the form of recirculating twenty-five-bit MOS shift registers. Eight registers store enough information, using the standard eight-bit computer code, to display one
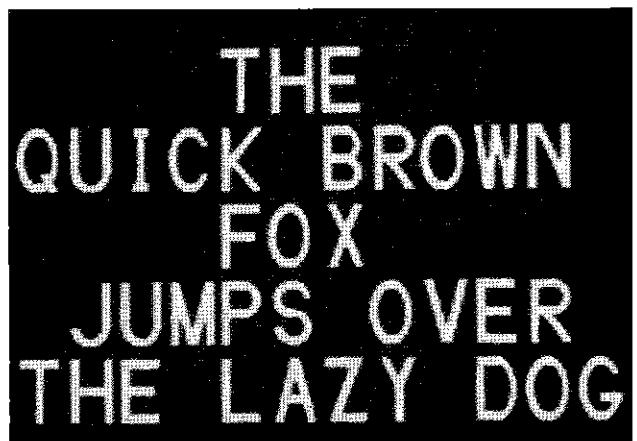
row of characters across the screen. The shift registers are clocked at 25 × line rate so that the data are circulating synchronously with television line rate. This means that the stored data can be used directly, after decoding, to feed the control inputs of the character generators (Fig. 7). To display a full screen of information fourteen rows of storage are required, giving a total of 112 (14 × 8) shift registers.

The store is addressed using standard computer control codes, for example STX (Start of Text) sets the address to the store to the top left-hand corner. By then feeding a character code to the store that character will be stored in the top left-hand corner. A cursor is displayed on the output picture which shows the address position to the store. The cursor may be moved vertically or horizontally without affecting the data already in the store and hence captions can be written, overwritten, or corrected by positioning the cursor using control codes and then feeding in the appropriate character code.

Whenever a character code is read into the store, the cursor automatically moves on to the next position ready for the next character.

3 Facilities

The simplest set-up is for the ANCHOR to be connected to a computer type keyboard which will generate the standard eight-bit code. Captions can then be typed directly on to the screen from the keyboard. However, in many cases the content and format of many of the captions required in a programme will be known in advance and it is therefore more convenient to record the codes for the captions at leisure before the programme and then read into the ANCHOR store from the storage medium when required. There are various methods of storing the codes and where only a few captions are required paper-tape storage is cheap and convenient.

Where access to a large number of stored captions is required some other form of storage is required and this could well be a magnetic disc, drum, or tape loop with a storage capacity of 1000 rows or more, or equivalent to at least seventy full-screen captions.

This type of electronic caption generator can provide interesting presentation effects, for example individual words may be flashed on and off to draw attention or alternatively
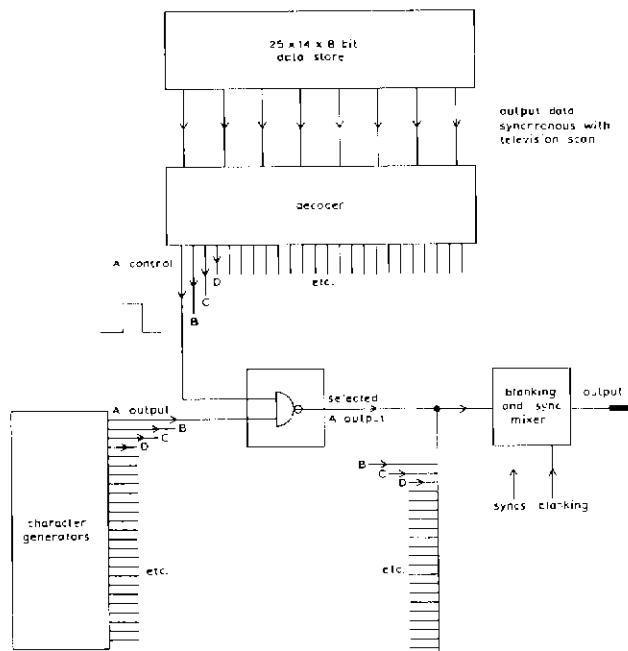
Fig. 7 Character selection from the data store

separately coloured using a colour synthesiser. Captions may be 'crawled' across the screen from right to left and also to give the effect of immediacy a caption may be revealed character by character and row by row giving a 'zip' effect.

Editing of captions may be facilitated by the ability to justify individual rows of the caption left or right.

4 Conclusions

ANCHOR has to some extent bridged the gap between the rather 'machine-made' matrix-type characters and captions produced by a caption artist. However, there is a long way to go before the electronic circuit could replace the caption artist. Correct spacing of the letters in a word is a big obstacle and even with new developments claiming proportional character spacing the ideal has not been achieved. The generation of different type faces is a possibility with matrix-type generators having a very fine matrix, although the cost would be prohibitive at the present state of the art. A range of character sizes presents a similar cost barrier.

However, despite these basic limitations ANCHOR with its clean, readable characters and various presentation facilities can provide a very useful production facility as was demonstrated in this year's General Election programme.

A Printed Panel Aerial for u.h.f. Relay Stations

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Research Department

Summary: A vertically polarised panel aerial has been designed in order to satisfy a variety of directional requirements at low-power u.h.f. relay stations. The aerial uses printed circuit techniques for cheapness and accuracy of reproduction.

Contents

1 Introduction

The majority of u.h.f. relay stations now in service utilise transmitting aerials having a cardioidal horizontal radiation pattern (h.r.p.).[1] At a few stations a more directional h.r.p. has been required and an aerial normally used for reception[2] has been adapted for transmission. As more low-power relay stations are required it is expected that the number of directional aerials will increase, partly to concentrate the available power where it is needed but more especially to minimise co-channel interference to other areas using the same channel allocations. The exact form of the directional requirement will vary from station to station so that it will be advantageous to use a basic aerial unit (panel), numbers of which may be assembled in different configurations.

The smallest aerials planned will have a vertical length of four wavelengths and, since it is normal practice to feed each half aerial separately to give reserve facilities, each panel should have a radiating length of two wavelengths.

It is also desirable that each panel should have a satisfactory impedance and radiation pattern over a wide band of frequencies, not only to permit four-channel operation but also to minimise the number of versions of the aerial required to cover the u.h.f. television bands.

2 Construction of Panel

The panel comprises two 'batwing' elements spaced approximately one wavelength from each other and about one-quarter
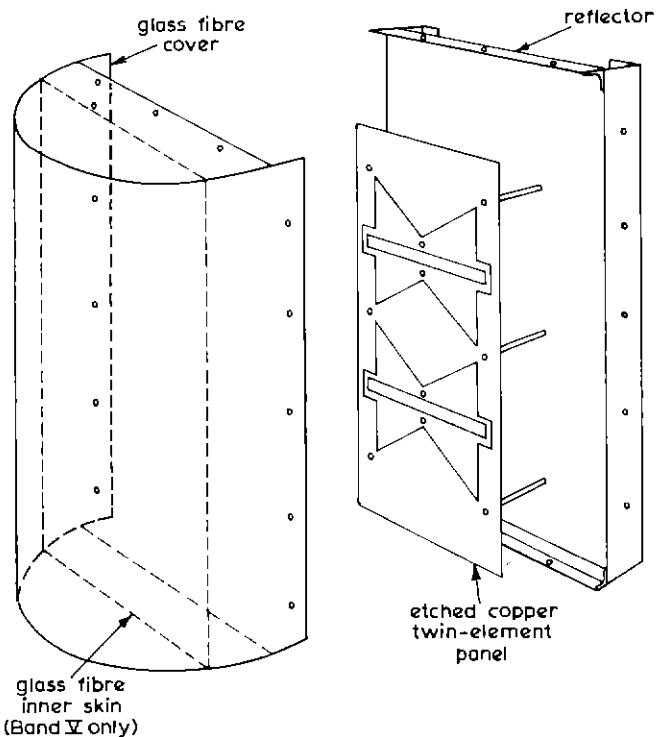
Fig. 1 Twin-element batwing aerial panel and cover.
The batwings are printed on the reverse side of the panel

wavelength from a reflecting screen (Fig. 1). Each radiating element is driven through a 100-ohm distribution feeder and a Pawsey stub balun and the distribution feeders are paralleled to give a 50-ohm input impedance. The 'batwing' elements and the associated feed connections are printed on 1·6mm ($\frac{1}{16}$ in.) glass-fibre laminate. Details of the feeding arrangement are shown in Fig. 2. The radiating elements are protected from the weather and from accidental mechanical damage by means of a glass-fibre cover. In the case of the Band V panel only, the electrical effect of the glass-fibre cover is reduced by means of an inner skin.

Two models of the panel were made, covering Band IV (470 MHz–582 MHz) and Band V (614 MHz–854 MHz) respectively.
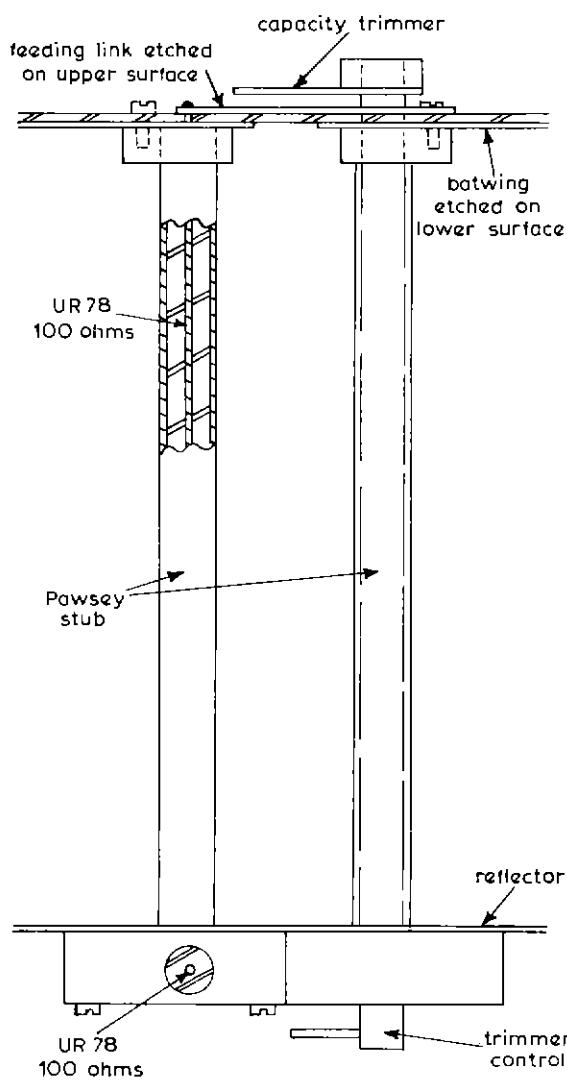
Fig. 2 Detail of feed arrangement

3 Admittance

At a typical station with a mean aerial height of about 36 m (120ft), the relative amplitude of radiated delayed signal (resulting from mismatch at the transmitting aerial) should be arranged to be less than −34dB.[3] Taking losses in the feeders and combining networks into account and allowing for 10dB reflection loss at the translator,* the maximum permissible reflection coefficient at the transmitting aerial is 10 per cent. The reflection coefficient achieved on the complete aerial will be dependent on the distribution transformers, the aerial panels, and whether the latter are driven in phase or phase quadrature etc. On the simpler arrangements of panels it may not be possible to use phase quadrature arrangements and it is therefore desirable that the reflection coefficient of a single panel should be appreciably less than 10 per cent. The level achieved was of the order of 6 per cent over the working

* It is hoped that a more typical figure may prove to be 15dB, but at the present time this is not assured.
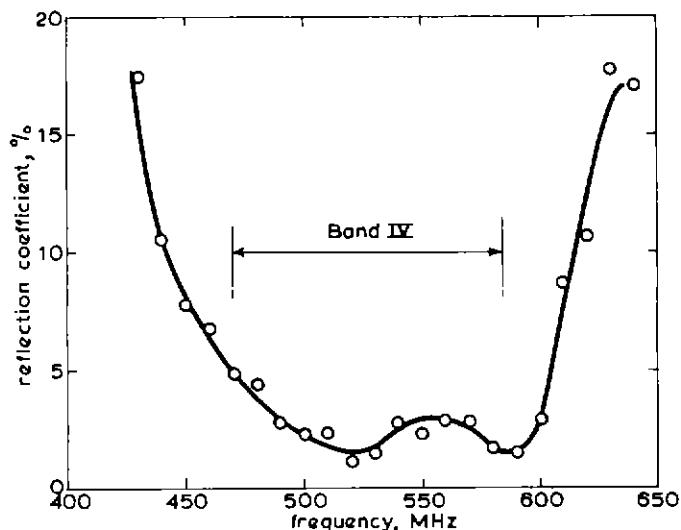
Fig. 3 Measured reflection coefficient of Band IV aerial panel
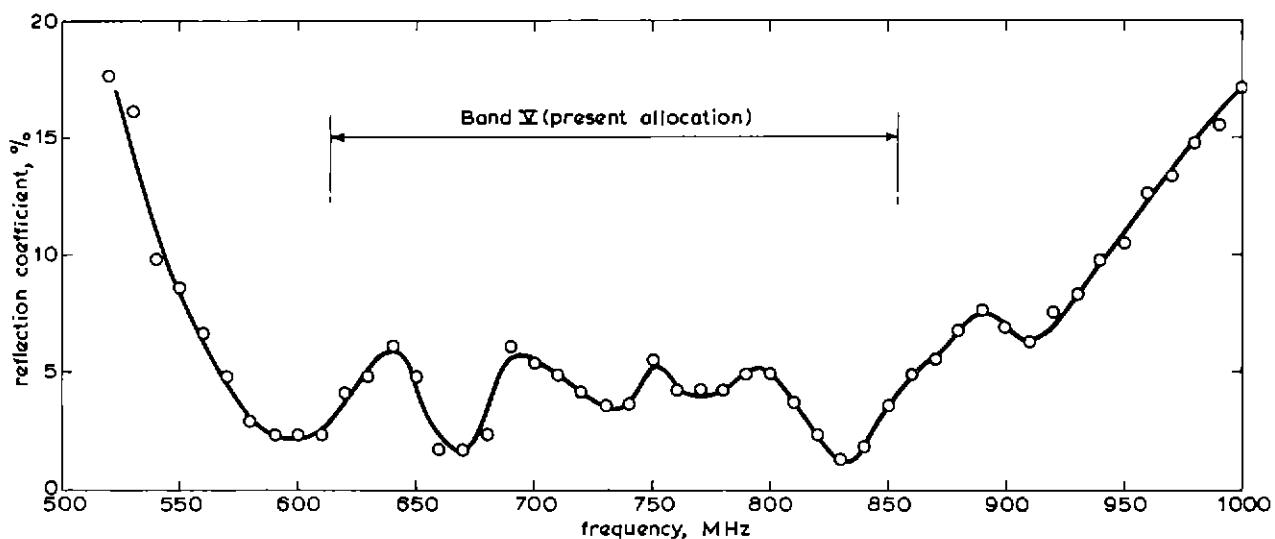
Fig. 4 Measured reflection coefficient of Band V aerial panel

frequency band for both panels. Figs. 3 and 4 give the variation of reflection coefficient as a function of frequency for the Band IV and Band V panels respectively.

4   Horizontal Radiation Patterns

The h.r.p.s of the Band IV and Band V panels are shown in Figs. 5 and 6 respectively. The beamwidth between half-power points lies in the range 55°-70° and this is sufficiently

wide to enable a single panel per tier to be used for many stations. Where the area to be served subtends a greater arc than this, combinations of two or more panels may be used. Figs. 7 and 8 show the h.r.p.s obtainable with two panels mounted at 90° and Figs. 9 and 10 the h.r.p.s with two panels mounted at 120°. Since these h.r.p.s are highly directional, there are arcs in the vicinity of the minima where unacceptable differences between channels may arise; these arcs are shown on each figure.
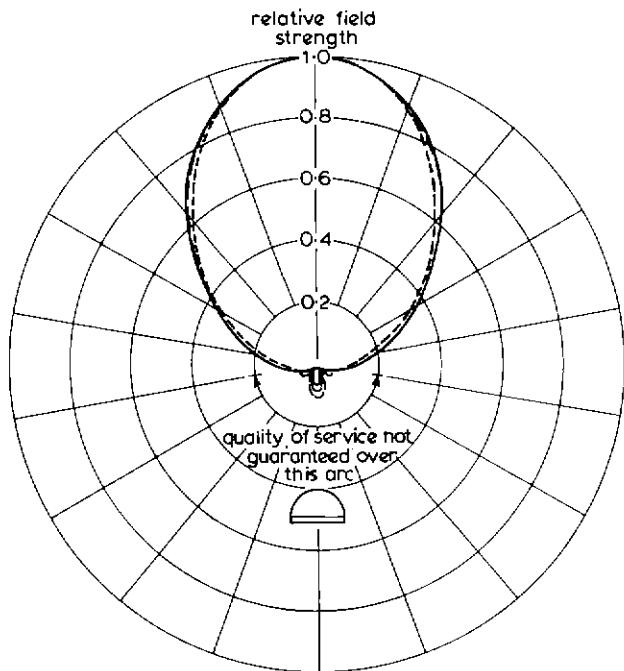
Fig. 5 H.r.p. of single Band IV aerial panel
------450MHz ————530MHz - - - - - - - 600MHz
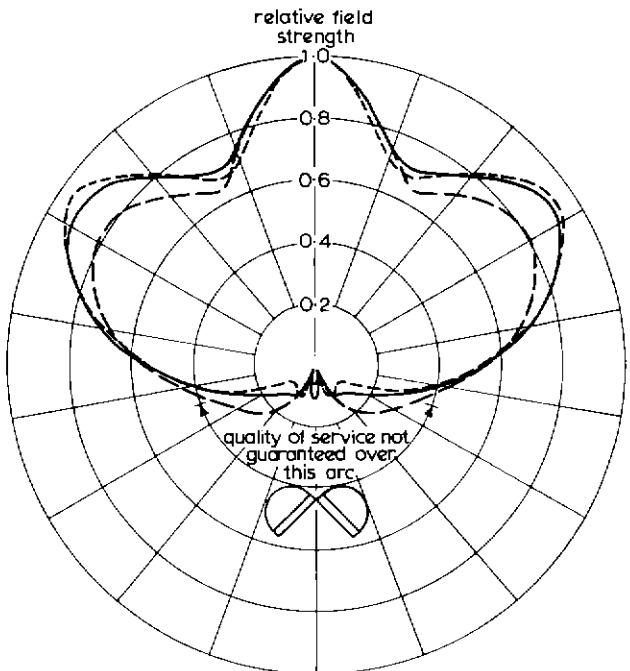
Fig. 7 H.r.p. of two Band IV aerial panels set at 90°
------450MHz ————530MHz - - - - - - - 600MHz
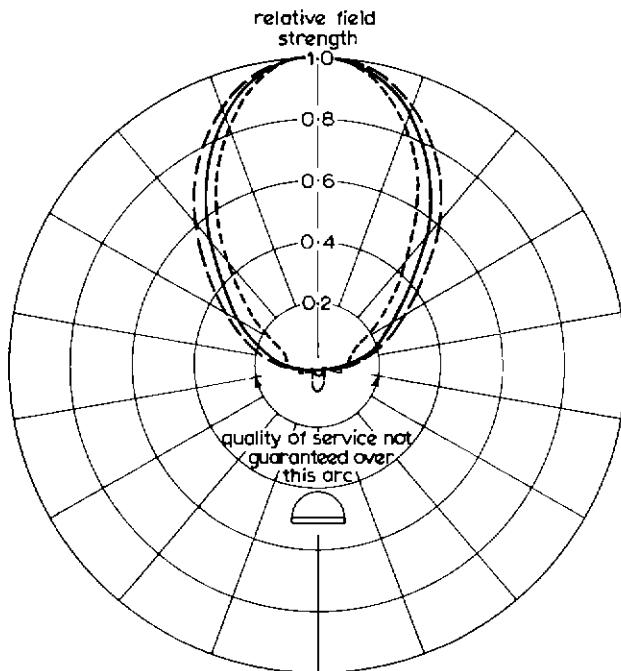
Fig. 6 H.r.p. of single Band V aerial panel
------600MHz ————750MHz - - - - - - - 860MHz
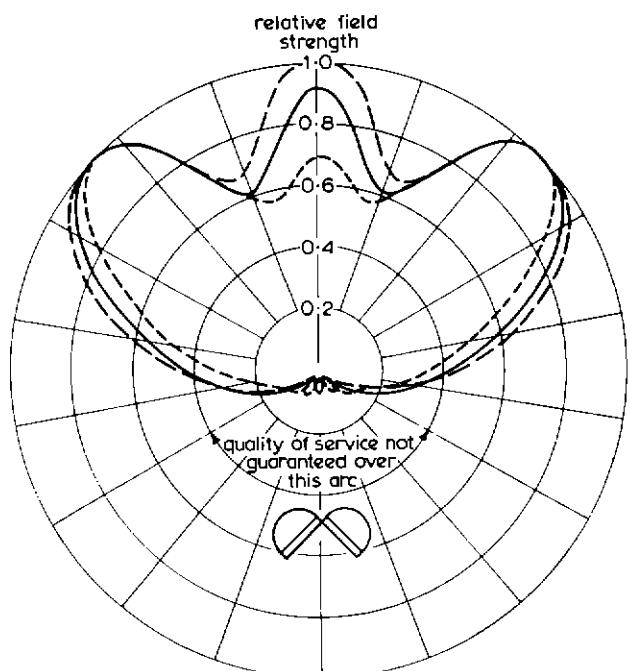
Fig. 8 H.r.p. of two Band V aerial panels set at 90°
------600MHz ————750MHz - - - - - - - 860MHz
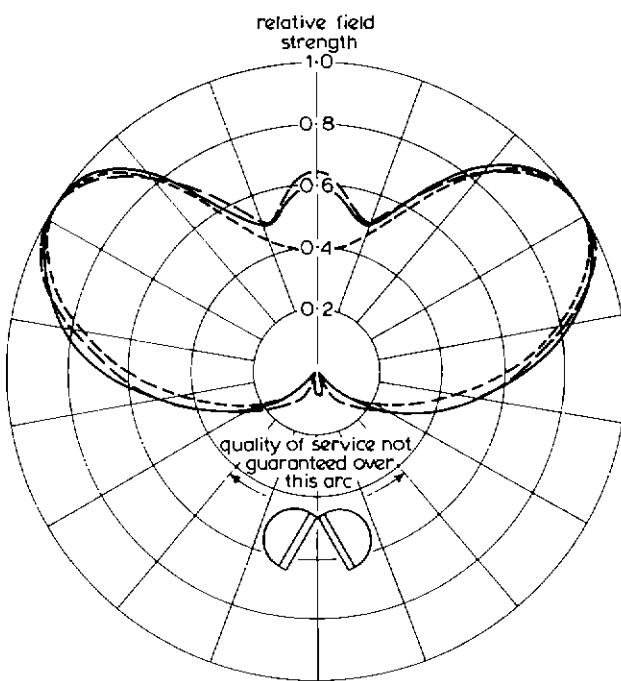
Fig. 9 H.r.p. of two Band IV aerial panels set at 120°
------450MHz ————530MHz --------600MHz

Fig. 10 H.r.p. of two Band V aerial panels set at 120°
------600MHz ————750MHz --------860MHz

Fig. 11 V.r.p. of single Band IV aerial panel
------450MHz ————530MHz --------600MHz
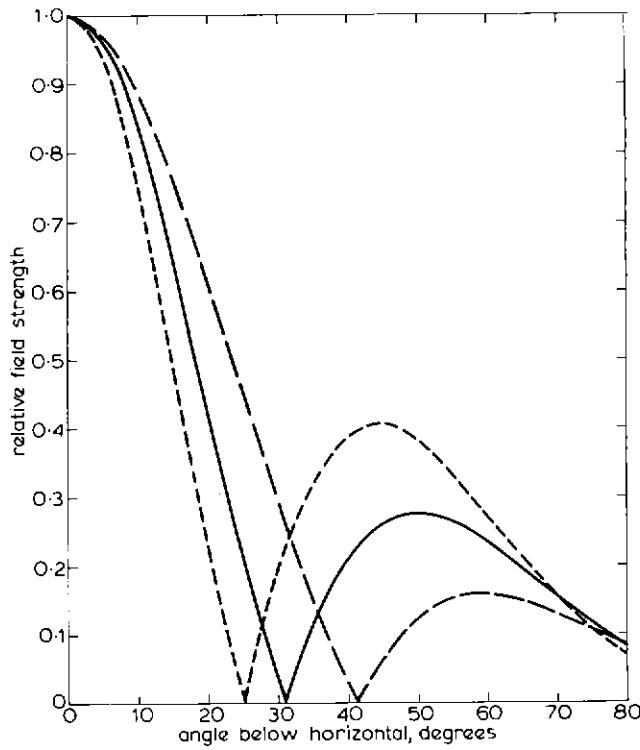
Fig. 12 V.r.p. of single Band V aerial panel
------600MHz ————750MHz --------860MHz

5   Vertical Radiation Patterns (v.r.p.s)

The v.r.p.s of the individual panels are shown in Figs. 11 and 12, and those of two panels stacked vertically (giving a vertical length of 4λ) are shown in Figs. 13 and 14.

At some stations it will be desirable to tilt the maximum of the v.r.p. below the horizontal. This could be effected by tilting the panels physically. However, provided that the angle of tilt is small (≤6°, say) it will probably be more convenient to tilt the beam electrically by retarding the phase of the feed to the lower panel.

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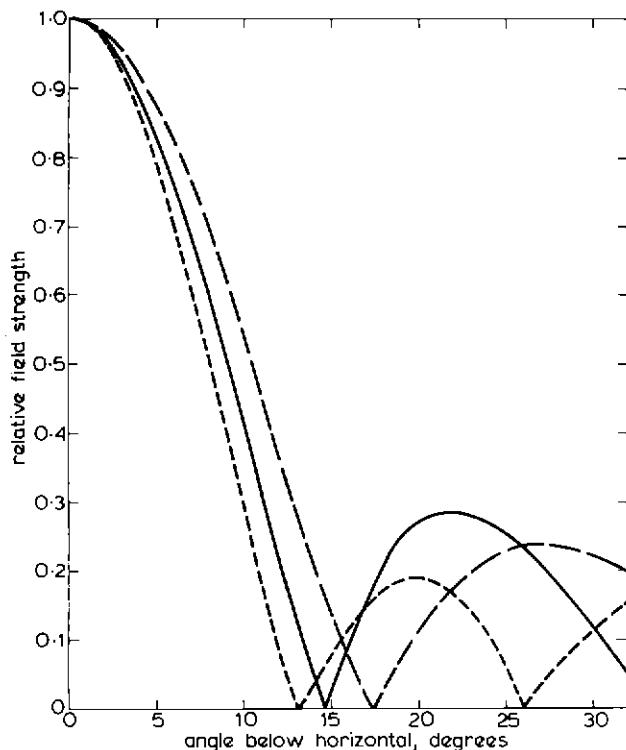
Fig. 13 V.r.p. of two stacked Band IV aerial panels
— — — — — 450 MHz ———————530 MHz - - - - - - - 600 MHz
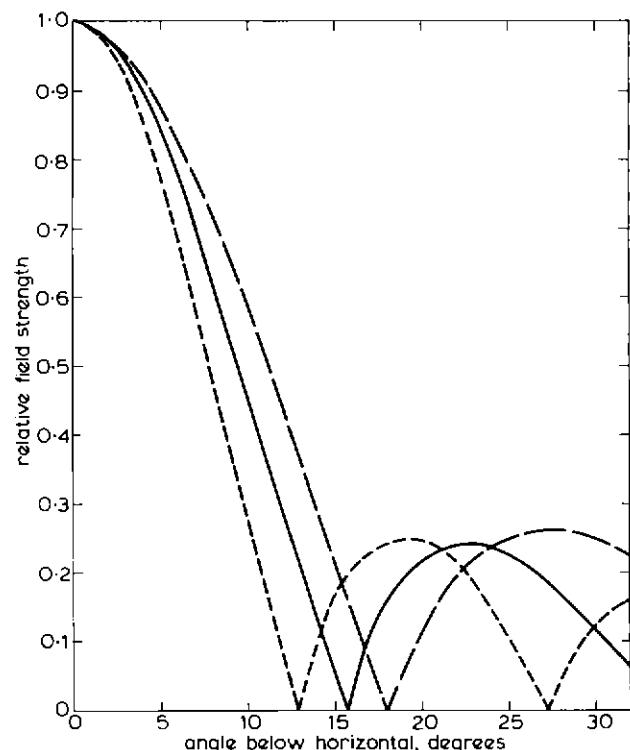
Fig. 14 V.r.p. of two stacked Band V aerial panels
— — — — — 600 MHz ——————750 MHz - - - - - - - 860 MHz

At a few stations it may be necessary to fill the first minimum of the two-stack v.r.p. Although this could be done by physically tilting the upper and lower panels in opposite directions, it may be more convenient to feed unequal powers to the half aerials.

It is probable that aerials of greater radiating length will be required for some stations but no special difficulties are expected.

6 Gain

Gains were deduced by integration of the radiation patterns taking into account losses in the UR78 distribution feeder. The gains of single panels in the direction of maximum radiation are given in Table 1, relative to a half-wave dipole. In practice, not less than two tiers of panels will be used. Gains of two tiers with arrangements of one or two panels in each tier are given in Table 2; they refer to the maximum of the h.r.p. and are relative to a half-wave dipole.

TABLE 1
Gain of Single Panel

Band IV Panel		Band V Panel	
450 MHz	9·6 dB	600 MHz	9·9 dB
530 MHz	9·7 dB	750 MHz	10·9 dB
600 MHz	10·3 dB	860 MHz	11·8 dB

7 Power Rating

The parts of the panel which seemed likely to determine the power rating were the printed connection at the drive point, the UR78 distribution feeders, and the input connector. The distribution feeders are rated at 195 W mean at 850 MHz for an ambient temperature of 40°C, giving a limit for one panel of 390 W mean. The input connector to the panel may be safely used up to about 400 W at 850 MHz. Thus, provided

TABLE 2
Gains of Arrangements of Two Tiers of Panels

Arrangement	Band IV Panels			Band V Panels		
	450 MHz	530 MHz	600 MHz	600 MHz	750 MHz	860 MHz
1 Panel per tier	12·8 dB	13·0 dB	13·3 dB	12·6 dB	13·7 dB	14·7 dB
2 Panels per tier, set at 90°	10·9 dB	10·7 dB	10·8 dB	10·1 dB	11·3 dB	12·4 dB
2 Panels per tier, set at 120°	10·0 dB	10·3 dB	10·5 dB	9·6 dB	10·9 dB	12·1 dB

the feed-point connection does not overheat, the Band V panel should have a power rating of 390 W mean at 850 MHz; the corresponding figure for the Band IV panel at 580 MHz is 490 W mean.

Power tests were carried out on one panel of each type. The Band IV panel was tested at a level of 600 W at a frequency of 545 MHz in an ambient temperature of 15°C and for a short period at 1 kW. The Band V panel was tested at a level of 300 W at a frequency of 750 MHz in an ambient temperature of 20°C, this being the highest power available. These tests confirmed that the power rating is determined by the distribution feeder.

The above limits indicate that an aerial comprising two or more panels will be well within rating when used with translator powers of 10 W and 50 W peak vision. Should it ever be desired to use an aerial comprising only two panels with powers of 200 W peak vision, this will still be possible, with full reserve facilities (i.e. capable of taking all the power in one panel under emergency conditions), provided feeder and network losses totalling 2·3 dB are present.

8 Conclusions

Two vertically polarised aerial panels have been designed, one for Band IV and one for Band V. The Band V version covers a frequency range of 1·55:1 with a reflection coefficient not exceeding 6 per cent. In the Band IV version some of the inherent bandwidth has been sacrificed in order to make the panel smaller, but the reflection coefficient does not exceed 5 per cent over the required frequency range.

By assembling numbers of the panels in various configurations, it will be possible to satisfy most directional aerial requirements at low-power u.h.f. relay stations.

9 References

1. A vertically polarised transmitting aerial for u.h.f, relay stations. BBC Research Department Report No. E-122, Serial No. 1966/74.
2. A u.h.f. trough aerial for rebroadcast reception. BBC Research Department Technical Memorandum No. RA-1019.
3. Specification of the impedance of transmitting aerials for monochrome and colour television signals. BBC Research Department Report No. E-115, Serial No. 1965/8.

Contributors to this issue
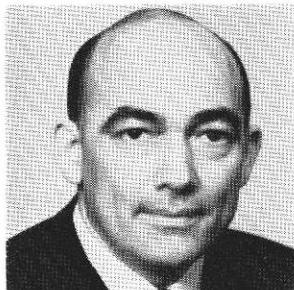
David Price, who has been with the BBC for twenty-five years, joined the Planning and Installation Department in 1955 and is now with the External Projects Unit. He has worked on most kinds of broadcasting equipment and has a particular interest in automatic systems and new techniques. He first became concerned with h.f. programme circuits in 1967, and is currently engaged on h.f. reception problems and the modernising of obsolescent transmitting equipment.

Ron Evens joined the BBC in 1941 as a youth-in-training at Bartley transmitting station. He was called up for the Royal Navy in 1945 and returned to the Transmitter Department in the BBC in 1948. In 1951 he transferred to Communications Department and from 1958 to 1960 spent two years installing and running a broadcasting service on medium and short waves in the British Solomon Islands Protectorate. Shortly after his return he joined Studio Planning and Installation Department and was responsible for developments in the central areas at Television Centre and Lime Grove and in Regional switching centres. He was seconded to CBS, New York, for six months to assist in their programme for the colorisation of television studios in the winter of 1965, and on his return became Computer and Automation Developments Engineer, dealing with a variety of aspects of data processing and process control for the Corporation.
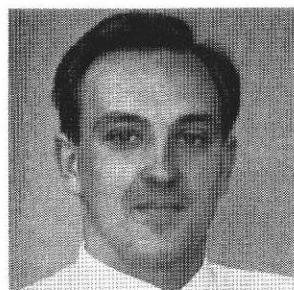
Ray Taylor joined the BBC in 1959 as a graduate apprentice after graduating from Imperial College in the same year. After eighteen months of the two-year apprenticeship he expressed interest in working in Designs Department and after a short spell in the television transmission section of Designs joined the television recording section where he now works as a senior engineer.

He was associated with the development and testing of the first colour video-tape recorders for the 625-line standard and more recently responsible for the design of vertical aperture correctors used in film recording and studio colour cameras.

Ron Spencer came to the BBC in 1961 after studying at Northampton and Regent Street Polytechnics and working for two years for Standard Telephones and Cables Ltd at Enfield. He joined Designs Department as a laboratory technician in the television recording section, where he has worked until the present time, being promoted engineer in 1969.

In addition to his work on electronic character generation, he has been concerned with the design of line store and field store standards converters.

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