Founded 1925

Incorporated
by Royal Charter 1961

To promote the advancement of radio, electronics and kindred subjects by the exchange of information in these branches of engineering

Volume 50 No. 10 October 1980

The Radio and Electronic Engineer

The Journal of the Institution of Electronic and Radio Engineers

A New Look at Old Ideas

PRESSURES of modern life on individuals in their professional and private lives have encouraged developments which have the declared purpose of enabling the average person to cope and prevent him (or her) from becoming totally submerged. On the domestic level we have so-called 'convenience foods', we have the super or hyper-market for selling these, our homes are (or could be) filled with automatic labour-saving equipment of all kinds, and leisure and entertainment are increasingly more and more packaged. Nevertheless, there are straws in the wind that indicate that the pendulum is starting to swing back, and while the 'simple life' does not and never will appeal to the majority, 'doing it yourself' may well be an essential factor in successfully meeting the problems of the second industrial revolution—which involves far more activities than are usually associated with industry.

The engineer in his professional work is surrounded by very similar dilemmas: automated measurement has many advantages, but it also has drawbacks, so too with automatic control and communication, and with computation and design aids. In all these instances a return to basic practice, founded on a firm grasp of principles, can often be the most satisfactory way to solve a problem. Far be it that this Journal should advocate Luddite obstruction or suggest that ability to prove the Binomial Theorem (for instance) should be demonstrated before embarking on a calculation. But there are occasions when too much technology can be counter-productive.

In recent years highly sophisticated methods have been introduced in information exchange and retrieval. The role of the abstracts journal is well-established and represents an essential tool in gathering a list of published papers and articles on a particular subject and assessing which of them justify study. Now S.D.I. (Selective Dissemination of Information), an extension of abstracts services, uses computer storage of bibliographical details to provide regularly lists of relevant papers according to an enquirer's 'profile' of interests. Other similar schemes have been developed in the UK and elsewhere covering particular areas of knowledge and often offering opportunities for retrieval of information 'laterally', i.e. from other disciplines, on the basis of well-chosen key words. Interrogation of the distant data bank makes use of international networks (e.g. EURONET) and the enquirer can satisfactorily interact with the computer to an extent which might well prove to be overwhelmingly expensive in time alone for the traditional methods of a library.

But having established the key role of advanced computer-based techniques in dealing with the enormous bank of published knowledge, we do urge that the engineer, of all professionals, should not scorn serendipity in his reading as a valuable source of information. The 'faculty of making fortunate discoveries by accident', as it has been defined, is met by browsing through as many general (and specialized) journals as time permits—perhaps at home by the fireside or in the train—and scanning contents lists and abstracts journals are not substitutes. By publishing general interest and specialized papers as well as news items in its two complementary publications, the Institution provides those members who are prepared to use serendipity with readily accessible potential sources for broadening their interests. Such 'fortunate accidental discoveries' may well on occasion provide an immediate lead to solving a difficult current problem.

F.W.S.

The 54th Annual Report of the Council of the Institution

For the year ending 31st March 1980

The Council is pleased to present the 54th Annual Report of the Institution—the 19th since its Incorporation by Royal Charter. The Annual General Meeting will be held on Thursday, 23rd October 1980, at the London School of Hygiene and Tropical Medicine, commencing at 6 p.m.

INTRODUCTION

THE two dominant themes in the Institution's 54th year have been the build-up of the great debate on the future role and structure of the engineering profession occasioned by the completion of the Finniston Inquiry and the publication of its Report, and the continuing struggle to maintain the financial strategy and services of the Institution from a fixed level of subscription income at a time of rapidly increasing cost inflation.

The essence of the Institution's primary contribution on the first of these two themes is covered in the Executive Committee section of this Report, whilst the follow-up response on the more contentious topic of the 'formation' of the electronic and radio engineers of the future is reported in more detail in the section devoted to the work of the Education and Training Committee. It is already clear that the latter material will be a major concern of Council in the coming year.

As to the second of the two dominant themes, Council is particularly pleased to be able to draw attention to the Finance section of the Executive Committee report in which the Honorary Treasurer summarizes the very considerable success achieved during the year under report. As will be seen from the Balance Sheet included in the Annual Accounts which accompany this Report the substantial surplus achieved in this most difficult inflationary year has done much to help clear the accumulated losses of earlier years and augurs well for the future. It also encouraged Council to maintain subscriptions at the level notified to members in October 1978 for a further year.

New ventures initiated during the year were the launching of the membership newspaper, *The Electronics Engineer*, and the extension of the Institution's major conference programme in co-operation with a commercial exhibition organizer. Both these very promising ventures are covered elsewhere in this Report.

But in the midst of all this successful and encouraging activity the Institution was plunged into sadness by the tragic death in August 1979 of Admiral of the Fleet the Earl Mountbatten of Burma, President of the Institution 1947–48 and its Charter President 1961–62.* In its debate on how best it should honour his memory and acknowledge permanently and tangibly the major debt of gratitude owed to him for his unique service to our profession from the very early days, Council considered many proposals. It was eventually decided to establish a 'Mountbatten Premium' to take its place alongside the existing major Premium commemorating Clerk Maxwell. It will be awarded annually for outstanding papers published in the Journal concerned with the application of electronic and radio engineering in the public interest.

EXECUTIVE COMMITTEE

The Profession. During the course of the year there was continuing discussion in other bodies and much speculation in the Press concerning the possible outcome of the Committee of Inquiry into the Engineering Profession, but the Executive Committee remained content to stand by its original evidence submitted to that Inquiry in 1978.† It was thus gratifying to find that when the Finniston Report‡ was published by the Secretary of State for Industry in January 1980 much of its content was compatible with the views expressed by the IERE, differing only in the main on how its recommendations should be implemented.§

With the publication of the Report, the Department of Industry invited comment by those bodies which might be affected by any changes which might arise therefrom. The Institution's response welcomed in principle the major proposals made by the Finniston Committee.¶ It was necessary, however, to express reservations regarding the implementation of some of the recommendations made in the Report, and fundamentally concerning the composition of the proposed Engineering Authority. While the setting-up of a statutory body to promote and strengthen the engineering dimension was supported, it was considered to be essential that some means be found to ensure that the several specialized engineering disciplines were always represented in its membership at both Board and working levels. In other words the engineering profession, in common with others, must be self-governing and seen to be so. Similar reservations were

* *The Radio and Electronic Engineer*, **49**, no. 10, p. 477 and pp. 480–2.
† *The Radio and Electronic Engineer*, **48**, no. 5, pp. 225–6, May 1978.
‡ 'Engineering Our Future'. HMSO Command Paper 7794.
§ *The Electronics Engineer*, no. 1, 24th January 1980.
¶ *The Radio and Electronic Engineer*, **50**, no. 5, pp. 197–8, May 1980.

expressed about other recommendations, notably in pleading that the expertise of the specialized professional engineering Institutions and, where appropriate, the Engineers Registration Board, should not be jettisoned. This would be of particular importance in the establishment of a statutory register, accreditation of engineering degree courses, assessment of individual applicants for registration, and the continuing 'formation' of engineers.

The Institution's reply was also at pains to support the view that a new statutory register of engineers must embrace the nation's current stock of engineers and those at present under training. In this context the overriding importance of avoiding any move to 'grade' these engineers according to their academic achievement alone was stressed.

The Institution's response to the Finniston Report having been published previously verbatim in the Journal, it should be sufficient here to confirm that the Executive Committee welcomed the contents as a whole, though in addition to the reservations summarized above, it was felt that disappointment should be expressed that little had been said about the root cause of the inadequate performance of British manufacturing industry, which was seen to lie in the low standard of industrial relations in many of its areas. And in this same context, regret was expressed that the Report failed to give adequate credit to those elements of the engineering profession where credit was manifestly due, for instance to engineers concerned with design and manufacture in the electronic equipment and system engineering business.

IERE Newspaper. Following the introduction of the new format of the Institution's Journal to include more items of general interest preceding the normal content of specialist papers, the Executive Committee continued to examine the often-expressed need to provide members with more comprehensive general news concerning the profession. Acceptance of the widely-held view that more should be done to meet this need, notwithstanding the constant necessity to guard against increasing expenditure, led to discussions with a specialist publishing house on the possibility of producing a separate newspaper. The publisher was confident that sufficient advertising could be obtained to make such a venture financially viable and, in conjunction with SERT, a mutually acceptable agreement was entered into to commence a fortnightly publication (*The Electronics Engineer*). The first issue appeared on 24th January 1980 and initial comment on the news coverage and the satisfactory spread and volume of advertising obtained at the outset of this new project has been favourable.

Scholarship Funding. The Executive Committee is very pleased to report that the Trustees' investment policy for the Leslie H. Paddle Scholarship Fund has been sufficiently successful for them to be in a position to provide resources to support one post-graduate scholarship early in the coming financial year. It was therefore decided in February 1980 to make an announcement to this effect in April 1980 for a scholarship tenable commencing this year. This scholarship is for post-graduate study or research which in the opinion of the Institution will further the art, science or practice of electronic or radio engineering.*

* *The Electronics Engineer*, no. 6, 3rd April 1980.

Benevolent Fund. During the year under review, work on the drawing-up of a Trust Deed for the Institution's Benevolent Fund has been completed and a meeting will be convened early in the coming year to approve its adoption. As a result of this work and as a consequence of the Trust Deed, the now substantial funds will be invested under the protection of the Official Custodian for Charities, leaving the day-to-day management, including all contact with the membership of the Institution for both further subscriptions and the granting of aid, to the Fund's management committee. Thus this important fund will in future enjoy the maximum legal protection of its assets whilst retaining the existing liberty of personal freedom of action for the management committee.

Overseas Affairs. There has been no major change in the overseas affairs of the Institution. The Hong Kong Section has continued to consolidate the splendid progress referred to in last year's Report, and the membership there is now over 750.

The new arrangements made for the administration of Institution membership in India have been shown to be entirely satisfactory; indeed the introduction of 'Accelerated Surface Post', referred to in detail elsewhere in this Report, for the despatch of Journals and newspapers direct to the Indian membership has resulted in an improved level of liaison between them and the London office.

Concerning the Institution's participation in the affairs of international organizations representing the wider engineering profession, all that need be said is that our strong support of, and deep involvement in, the affairs of EUREL has been maintained and that, through the Council of Engineering Institutions, the interests of the British electronic and radio engineer have been maintained in the Councils of FEANI and the CEC.†

Finance. It is with a modest sense of achievement that the Council is this year able to report a significant surplus of income over expenditure. Coming as it does after many years of deficit accounting, and during a period of continuously increasing inflation, this eminently satisfactory result reflects much credit on all concerned with the Institution's revenue-earning activities and on the continued efforts to effect economies exercised by the administrative staff.

In fact, the actual surplus for the year was considerably higher than the figure shown at the end of the income and expenditure account. The opportunity having presented itself, however, your Council thought it prudent to write off some £10,000 against old and slow-moving stocks of conference and other publications and long-standing debts of conference fees now virtually uncollectable, thus easing the position for future years when the situation may not be so favourable.

The total income for the year shows an increase of some £82,000 compared with last year. Whilst £39,000 of this is due to the increase in membership subscriptions and fees which came into effect this year, an even greater contribution resulted from the increase in publications sales and fees from colloquia and symposia—a most gratifying result.

On the expenditure side the total increase of all costs and expenses has, by the exercise of strict economy wherever possible, been kept to within 6% of last year's figure—in a year when inflation was running at over twice this figure. Even adding the 'write-off' already referred to, the increase is only just over 10%. Of particular note in this context is the item of

† EUREL—Convention of National Societies of Electrical Engineers of Western Europe.
FEANI—European Federation of National Engineering Societies.
CEC—Commonwealth Engineers Conference.

Administration expenses which accounts for practically half of the total expenditure and which is only 4% higher than last year. The nett result of this major management effort is a surplus of £36,456, which has the most important effect of reducing our General Fund adverse balance by the same amount.

It would be unrealistic to expect a similarly large surplus next year, when continuously rising inflation will inevitably take its toll on expenses and when it is unlikely that the same massive increase in income from symposia will be achieved. However, with the continued close attention to economy in all departments, which has been a significant factor in this year's results, your Council looks forward with confidence to another financially satisfactory year.

PROFESSIONAL ACTIVITIES COMMITTEE

Bearing in mind the comment made in this section of last year's Report concerning the prime importance of this aspect of the Institution's work, it was both interesting and encouraging to note that the subject was highlighted by the Finniston Committee as the key future role of the engineering Institutions. During the year under report the IERE emphasis on this task has been maintained, but with the available headquarters effort slanted towards the major conference activity rather than the one-day events in London. There were two reasons for this: first, the importance, both in timing and professional engineering terms, of the three conference subjects programmed for the year, and second, the continuation of the difficulties experienced last year by the organizing committees in the compilation of suitable programmes for some of the subjects thought to be in need of the one-day event exposure.

Conferences. During the year the Institution held three major conferences of its own and participated as primary learned society contributor to one further major event associated with an international exhibition:

'Television Measurements'	(May 1979, Commonwealth Institute, London)
'Video and Data Recording'	(July 1979, University of Southampton)
'Land Mobile Radio'	(September 1979, University of Lancaster)
'Automatic Testing '79'	(December 1979, Metropole Hotel, Brighton)

A total of 1,554 delegates attended these conferences and of these some 19% overall were from overseas locations—a substantial increase in international interest over previous years. An in-house exhibition was associated with the IERE conference on 'Video and Data Recording' at Southampton, whilst the 'ATE 79' joint conference was complementary to the major international exhibition of the same name. The full texts of all the papers presented at these conferences were published as bound volumes and are available on sale from, or through, the Institution's Publications Department.

London One-Day Events. As was mentioned earlier in this Report, less emphasis was given during the year ended 31st March 1980 to these one-day events, due primarily to programming difficulties encountered by organizing committees: indeed, six such events originally scheduled for this year were postponed for this reason to a future session. Six very satisfactory one-day events were held in London, however, and attracted a total of 356 delegates. This was much the same level of support as was experienced last year and, in the committee's view, more than justifies the continuation of this facet of the Institution's learned society programme.

Local Section Activity. The committee is once more pleased to report a very creditable level of professional activity in the sixteen Local Sections of the Institution in the UK, virtually all of which was organized and managed by the enthusiastic volunteer members who serve on the Local Section Committees. During the year under report, 138 meetings for the discussion of technical papers were held by these Sections in addition to meetings held jointly with other organizations to discuss matters of general concern to the profession arising from the activities of the Finniston Committee. Items from the technical programmes of the Sections which merit special mention in this Report are, once again, the Megaw Memorial Prize Lectures organized by the Northern Ireland Section, 'Microprocessing 79' held by the Yorkshire Section in May 1979, 'Microprocessors in Action'—a one-day conference held by the Bedfordshire/Hertfordshire Section in December 1979, and the lecture programme arranged by the Yorkshire Section in association with the Leeds Electronics Exhibition in July 1979.

Representative Activities. The Institution has continued throughout the year to be represented on a number of external technical organizations and committees. It has also continued its active support for the work of standardization through the efforts of those Institution members who served on the Technical Committees of the British Standards Institution. Details of all these appointments as at the close of the year are given in Appendices 6 and 7.

EDUCATION AND TRAINING COMMITTEE

Throughout the past year the Education and Training Committee has continued its regular task of co-ordinating activities connected with the Institution's involvement in the work of other committees in the educational field—the Chartered Engineer Section Board and its supporting Educational Qualifications Committee and Training and Experience Committee, the CNAA Board for Degrees in Electrical and Electronic Engineering, the Joint Committee for Higher Certificates and Diplomas in Electrical/Electronic Engineering, and Programme Committee A2 of the Technician Education Council. Additionally, and as a consequence of its status as a Standing Committee of Council, it has been deeply involved in the formulation of the Institution's views on the educational implications of the recommendations for 'engineering our future' embodied in the Finniston Report.

Where the Institution's relationship with CEI and its committees is concerned, the impression referred to in the previous Annual Report that the new Chartered Engineer Section Board was likely to take a broader view of the engineer than its predecessor, Standing Committee 'A', appears to have been justified. There are, however, still areas in which the Institution feels that attitudes are too rigid. The Committee had hoped that it would be possible to report an agreement that where degrees in Science were concerned, CEI would be prepared to delegate responsibility for the assessment of their suitability as academic qualifications for engineers to the interested individual Institutions. To date, however, there has been no progress and it may be necessary to reopen the discussion. It was also disappointing to find that the working group which was established to examine the functioning of the Mature Candidate scheme appears completely to have ignored the Committee's recommendation that attempts should be made to find alternatives to the present 'Thesis' and has merely made some changes to the regulations which seem unlikely to be of any great benefit to the persons concerned. On the credit side, it was gratifying to note that the working party appointed to consider the problem of the compulsory CEI Part 2 paper 'The Engineer in Society' had made recommendations to the Chartered Engineer Section Board which are completely in accord with this Institution's proposals. These recommendations have now been submitted to the other 15 Chartered bodies for comment and the Committee hopes that at least some of the proposals which the Institution made will meet with general acceptance.

Although the number of candidates sponsored by the IERE to sit the May 1979 CEI examination was the largest since 1974, the results were somewhat disappointing. The number of persons passing or completing the Part 2 examination totalled 46 (14 UK, 32 overseas), as compared with 51 in 1978. The slightly lower figure is attributable almost entirely to the fact that the proportion of students who passed all 5 technical subjects at the first attempt, but failed 'The Engineer in Society' paper, was higher than in the previous year. On the other hand, the number of pre-1974 graduate members of the IERE who were successful in passing the Academic Test and therefore now meet the academic requirements for transfer to the class of Member, was higher than in the previous year, reaching a total of 39 (33 UK, 6 overseas).

In their report on the May 1979 CEI Part 2 examination the examiners and moderators commented on the fact that the performance of UK candidates in 'The Engineer in Society' had slightly improved, but there had been a deterioration overseas. The report also pointed out that Academic Test candidates in general showed a better performance in that subject than candidates taking the whole examination. It was suggested that the reason for this might well be that they are more mature persons and so have more first-hand knowledge of the topics with which the paper is concerned. These comments by the examiners and moderators may have contributed considerably to the decision of the CEI working group on syllabus revision to recommend that 'The Engineer in Society' should be separated from the examination as a whole and sat at a later stage. The working group also recommended that all persons seeking registration as Chartered Engineers should be required to hold at least an 'O' level in the English language, but on the other hand should be permitted an indefinite number of attempts to pass 'The Engineer in Society' or a paper of similar nature set by their own Institutions. Reference was made in the previous Report to the much higher pass rate in 1978 in subject 365 (Control System Engineering). It is interesting to note that the improvement was more than maintained in 1979—the pass rate in this year rising to 56%. In view of this, the Institution will consider whether it should recommend to CEI that persons who failed the examination in this subject only during the period 1975–1977 should be given an opportunity to sit it again.

Where revision of the CEI Part 2 examination syllabus in Electrical/Electronic Engineering subjects is concerned, it is understood that the CEI working group on Part 2 syllabus revision will shortly be reporting to the Chartered Engineer Section Board, and that the various Institutions are likely to have an opportunity to comment on the recommended syllabus changes before the end of the year.

It remains difficult to secure exemption from the CEI Part 2 examination for holders of Open University degrees. At the time of writing the total number of successful applicants for exemption is still only 5, and in all cases the successful applicants held significant qualifications in addition to their Open University degrees. It is only fair to state, however, that the problem largely arises from the limited availability of suitable subjects for study at the higher levels of the Open University scheme.

In the academic field, the Committee received with satisfaction the news that the Schools' Council's 'N' and 'F' proposals had been shelved, if not completely abandoned, and that CEI's Standing Committee 'A' had recommended to the Chartered Engineer Section Board that the standard of the CEI Part 2 examination should not be raised to that of an honours degree. This means that since the CEI examination is the exemplifying standard, the Institutions will remain at liberty to admit holders of pass degrees into Corporate membership.

In the autumn of 1979 the Education and Training Committee commenced the task of revising the Institution's training regulations. It was appreciated that this would be a time-consuming task, since the training requirements of the electronics industry are so different from those of almost all others that problems were expected in convincing CEI that the traditional formula was totally inappropriate. Because of involvement in other matters, the Committee was not able to make any progress during the early months of 1980, but hopes to produce a statement of training policy, based on its interpretation of the requirements of the largest companies in the electronics industry, during the coming year, and to follow this with more detailed proposals when the general uncertainty arising from the debate on the Finniston recommendations on this issue is resolved.

The Committee's working group on the subject of interesting graduates in training for management has reported to the full Committee, which later referred the working group's recommendations to Council. Council, however, decided that more time needed to be given to consider the recommendations than could be provided in time for the Annual Report.

The recommendations of the Finniston Report were considered at three meetings in the first three months of 1980. The Committee made recommendations to Council regarding the nature of the Institution's response to the questions concerning the Finniston proposals raised by the Department of Industry, and then proceeded to consider the request from the Department of Education and Science for comment on the educational aspects of these proposals. The Institution is required to present its comments with respect to six principal themes to be discussed at a National Conference on Engineering Education and Training to take place in October 1980. The Committee formulated responses on behalf of Council on three of these themes which it saw as being most directly related to its own particular area of interest. In respect of Theme 1—'Attracting enough suitable young people, including a proportion of the most able, to a career in engineering', it accepted the Finniston Committee's analysis of what needed to be done at school level to awaken young people's interest in engineering as a possible career, and to ensure proper coverage of mathematics and physics, but noted that similar recommendations had been made repeatedly for many years without effect. It felt that before anything useful could be achieved it would be necessary to change the educational philosophy of Teachers' Training Colleges, which remain dedicated to the idea that education should be pursued solely for its own sake, not as a means to material ends. On Theme 2—'Basic formation (i.e. education and training up to qualification) of engineers', the Committee was firmly of the opinion that Finniston's proposals for two types of degree—a B.Eng. and M.Eng. with streaming after the first year—were unworkable, and if their implementation were attempted a number of undesirable consequences would inevitably follow. It therefore recommended that, in general, engineering undergraduates should initially follow a course leading to the award of B.Eng. and that those with the necessary ability and inclination should later undertake M.Eng. studies—which need not necessarily follow 'end-on' from their B.Eng. studies.

In respect of Theme 6—'Relationship with the Technician Support Base', the Committee welcomed the proposals for the establishment of a Higher Engineering Diploma to replace existing HNDs only because it felt that sooner or later the Joint Committees which administer HNDs will be wound up. Its welcome for the HED was, even so, accompanied by two provisos: the first that the creation of a new award of this standard was only justified if the academic standard of the proposed B.Eng. was no lower than that of a good current B.Sc.(Eng.), and the second that the proposed validation of the HED by CNAA should not lead to a concentration of HED courses in Polytechnics to the exclusion of those Technical Colleges which had offered HND courses previously. The IERE view on the three remaining themes, which all relate directly or indirectly to the future role of CEI and the Institutions in the field of accreditation and registration of engineers, is incorporated in the Council's wider reactions to Finniston, highlighted elsewhere in this Report.

MEMBERSHIP COMMITTEE

The state of the Institution's membership register at the end of the year under report is summarized in the customary manner at Table 1. From this it will be seen that whilst the hoped-for continuation of the rate of overall growth of membership indicated at the beginning of the year has not been achieved, the Institution has more than made good the membership losses sustained during the year. To achieve this result the Membership Committee met on fifteen occasions and considered 793 membership proposals: 531 for direct election, 158 for transfer and 104 for reinstatement. At the year end a further 130 proposals were being processed for the Committee's consideration.

The accelerated pressure of inflation on all classes of member, and the further loss of confidence in the value of continued membership on the part of many of the remaining Graduates who qualified as such before 31st December 1970 are thought to be the primary reasons for the poor nett gain in both corporate and non-corporate membership. Some of these first-mentioned losses are, of course, accounted for by the well-understood cost-cutting decision of chartered engineers in dual membership of CEI Institutions but it must be recorded with regret that the bulk of the 381 'removals' listed in the Table are accounted for by Bye-law 33 action taken against members who failed during the course of the year to maintain their subscriptions in the required timely manner. There is nothing fresh to be said at present about the continued disappointing loss of mature Graduate members but it is hoped that some changes in membership nomenclature now under consideration at the offices of Her Majesty's Privy Council at the behest of CEI may lead to a measure of greater public recognition of the professional merits of these members in the coming year.

Table 1. Institution Membership April 1979 to March 1980

	Membership at 1.4.79	Additions: Direct Elections	Additions: Reinstatements	Additions: Transfers	Total Additions	Deductions: Removals	Deductions: Deaths	Deductions: Resignations	Deductions: Transfers	Total Deductions	Nett Gain (+) or Loss (−)	Membership at 31.3.80
Honorary Fellows	11	—	—	—	—	—	1	—	—	1	−1	10
Fellows	737	5	2	19	26	2	6	1	—	9	+17	754
Members	7326	72	52	94	218	92	23	44	17	176	+42	7368
Total Corporate Membership	**8074**	**77**	**54**	**113**	**244**	**94**	**30**	**45**	**17**	**186**	**+58**	**8132**
Graduates	2809	40	27	30	97	139	2	59	86	286	−189	2620
Companions	18	—	—	—	—	—	—	—	—	—	—	18
Associates	324	11	5	1	17	14	1	6	5	26	−9	315
Associate Members	940	82	11	14	107	31	2	11	4	48	+59	999
Students	1126	318	8	—	326	103	—	28	46	177	+149	1275
Total Non-Corporate Membership	**5217**	**451**	**51**	**45**	**547**	**287**	**5**	**104**	**141**	**537**	**+10**	**5227**
Grand Total	**13291**	**528**	**105**	**158**	**791**	**381**	**35**	**149**	**158**	**723**	**+68**	**13359**

The substantial increase in Student membership shown in the Table is some measure of compensation for the heavy loss of Graduates, since recent experience indicates that the majority of these Student registrations arise from genuine interest in the Institution's affairs and lead, on qualification, to transfer to the higher grade of membership.

PAPERS COMMITTEE

The range of subjects covered in the 1979 volume of *The Radio and Electronic Engineer* is as diverse as ever, extending from papers on subjects as basic as a new type of cable to applications of microprocessors in measurement. Within this wide range, however, one theme seems to dominate, namely new techniques in communications whether guided or free space. In fact, whereas some years ago it was often observed by those rash enough to make predictions on *any* aspect of electronics that 'there is nothing new to come in radio', in the last year or two this cliché has been shown to be far from accurate.

A notable special issue of the Journal during 1979 was that arranged by Professor D. J. Harris as guest editor on 'The exploitation of frequencies between 100–1000 GHz'. This collection of nine papers by authors from universities, government research and industry, both in this country and overseas, dealt with one of the 'frontiers' of radio and electronics. At the end of the period under review, the Committee was planning four special issues to be published in 1980 and early in 1981.

The policy of broadening the interest of the Journal has been followed and nearly every issue during 1979 and in the early months of 1980 has contained at least one paper dealing with some aspect of electronic engineering in a manner which it is believed will be found attractive and interesting to all members in these days of increasing specialization. Certain of the general interest papers have dealt with subjects rather outside the mainstream of electronics, for instance, 'The relevance of science to engineering' by Professor D. W. Lewin, 'Total engineering: control during production development' by J. G. Cottrell, and 'Management in a competitive environment' by R. McLellan.

The inauguration during the last quarter of 1979/80 of a fortnightly newspaper, *The Electronics Engineer*, has facilitated the removal from *The Radio and Electronic Engineer* of certain regular, albeit ephemeral, items and thus enabled additional papers to be published while maintaining over a period the same total number of pages in the Journal. Because of the greater space available, the publishing delay of papers has been reduced and this must make the Journal increasingly attractive to authors wishing to publish results of their work in the form of full papers without long delay.

Assessment of Papers. The decisions reached on papers during the year indicate a significant increase in the ratio of acceptances to rejections. These figures, which as usual include conference papers recommended by the respective organizing committees for consideration for publication, are as follows (1978/79) details are given in parentheses):

Number of papers considered	142	(139)
Accepted for publication	77	(59)
Returned for revision	21	(21)
Rejected	44	(67)

Perhaps as a result of closer collaboration with the conference committees, in the above figures the proportion of conference papers accepted was higher than in previous years. With conference papers, the decision is a 'go/no-go' one; revision, which usually results in about 30–40% of papers subsequently returning in acceptable form, is not appropriate for reprints from conferences. Also noteworthy is the fact that the acceptance figure for papers invited for special issues is customarily close to the 100% mark especially if those for which the initial recommendations were for revision are included.

While from time to time an author of a rejected paper will understandably take issue with a Committee decision, such instances are very few compared with the number of authors who comment appreciatively on the constructive criticisms based on referees' reports which the Committee conveys to them. Refereeing is an unpaid task conscientiously undertaken by an extensive panel of members and the Committee would like to take the opportunity to thank those who have contributed in this way to maintaining the standard of the Journal. Referees will surely feel that their most satisfying reward is to see the eventual publication of a well-constructed paper on a useful piece of work, or, when a paper has had to be rejected, a more successful result for the author's next submission.

Premiums. As announced in the Journal* and referred to earlier in this Report, the Council decided that the Institution should commemorate Lord Mountbatten by the establishment of an annual Premium bearing his name. This Premium is to be awarded for the first time for an outstanding engineering paper published in 1979 and it complements the Clerk Maxwell Premium which now most appropriately recognizes an outstanding paper on scientific aspects of radio or electronics. Details of these and other Premiums to be awarded for 1979 are given in Appendix 8. Four of the twelve papers were first presented at four different conferences while three other papers were published in the special issue on millimetric and submillimetric wave exploitation.

INSTITUTION PUBLICATIONS

The Radio and Electronic Engineer. Financial considerations have been well to the forefront during the past year which inevitably has seen increases in both production and distribution costs of the Journal and other publications. As foreshadowed in the last Annual Report, a change of printer enabled new techniques and technologies to be applied which meant that the cost of printing throughout 1979 was held substantially at the same level despite increases in actual charges. The total number of pages published during 1979 was almost the same as in the previous year even though several pages of meetings information were omitted in the last quarter of the year and published in separate leaflets. The diversion of further material to the new fortnightly newspaper, *The Electronics Engineer*, should enable a more constant content of original papers and general interest papers to be published in the future.

Increasing postal charges have led to the examination of alternative means of distribution and a contract has been negotiated with the Post Office for favourable rates on the basis of postcode sorting for members in the UK and this has shown the hoped-for result of holding costs. Delays in overseas mail have always been the cause of considerable concern and several possibilities have been examined in this direction. From the beginning of 1980, all overseas members have received their journals by a modified scheme of air mail ('Accelerated Surface Post') and transit times are now seldom more than fourteen days. The additional cost is regarded as being well justified as it provides overseas members with prompt information on Institution affairs and on progress in their profession.

* *The Radio and Electronic Engineer*, **50**, no. 6, p. 273, June 1980.

Subscription rates for the Journal were increased at the beginning of 1980 by a modest amount to keep pace with increased costs and revenue from this source as well as from sales of back issues and reprints continues to help offset printing costs. Distribution is at present by surface mail but consideration is being given to the use of the ASP services to most parts of the world next year.

Journal circulation for the calendar year January to December 1969 was 13,507, this sworn statement being slightly below the average monthly circulation of the previous twelve months of 13,696.

During recent years appointments advertising has predominated in *The Radio and Electronic Engineer* and comparatively little advertising of products has been obtained. Now that *The Electronics Engineer* has been established to emphasize 'classified advertising' generally, new arrangements have been made for obtaining a reasonable amount of product advertising for the Journal and it is hoped that this will build up to help offset production costs.

The Electronics Engineer. Recent Annual Reports have referred to the Council's wish to provide members with a more up-to-date and complete service of news on matters both technical and non-technical than is practical with a monthly journal. At the beginning of 1980 the first issue was published of a fortnightly newspaper, *The Electronics Engineer*, which has the objective of bringing to all members throughout the world Institution news and announcements, details of meetings, conferences and other activities, news of the industry and appointment advertisements. The Society of Electronic and Radio Technicians participates in the venture and its members also receive *The Electronics Engineer*. It is considered that this 'vertical integration' of the electronic engineering profession as represented by its two leading specialized professional bodies is in the interests of those members, particularly by the opportunity it provides for companies and organizations who are seeking engineering personnel at all levels.

Local Section meetings can be publicized very cost-effectively through this new medium, first because the events are brought to the notice of a much wider circulation of members of both the IERE and SERT, and secondly, through the considerable saving on postal charges which would have to be incurred to send similar individual announcements to members of Sections.

The Council has welcomed the co-operation which has been received from the commercial publishing organization which is producing *The Electronics Engineer* and hopes that all members will support it whether by using it for advertising for staff or by responding to its advertisements of employment opportunities.

Conference Proceedings. Between April 1979 and March 1980 Conference Proceedings were produced for 'Television Measurements', 'Video and Data Recording', 'Land Mobile Radio', and 'The Electronic Office' (held in April 1980). An impressive total of 127 papers amounting to 1413 pages was contained in these four sets of proceedings and sales both in advance and subsequent to the conferences have provided useful revenue in support of the Institution's learned society role.

Association of Learned and Professional Society Publishers. IERE support of ALPSP, to which some 100 learned and professional bodies now belong, has continued. The Association gives publicity to the Institution's Journal and its other publications through its Directory and by participation in exhibitions overseas, and it is a valuable forum for the exchange of expertise on many and varied aspects of publishing.

LIBRARY AND INFORMATION SERVICES

The continuing steady demand on the Institution's Library and Information Services has usually been met speedily and, it is hoped, efficiently, either through its own resources at Gower Street or from libraries of other engineering institutions or the British Library at Boston Spa. And the operating costs of the library services have been held in check thanks to those members and other users who customarily refund the charges for photocopies and postage.

Pressure to increase capital expenditure as represented by the rising cost of books and journals has, however, called for careful consideration: it is clearly impracticable to acquire more than a very small proportion of the flood of new titles in electronics subjects and the criterion has had to continue to be the demand expected from members for a particular book. If it is assessed that these will be numerous in the foreseeable future, then the book will normally be brought—if not, an inter-library loan will be arranged. It is not always books on the newest developments that are requested and considerations in making the best use of limited funds require that the Library's shelves also contain a reasonable coverage of the basic subjects on which electronics and radio engineering must always rest. Members regularly using the Library understand and appreciate the Institution's problems and often draw the Librarian's attention to potentially useful accessions.

A further management review has confirmed this year that the size of the Library and the demands made upon it do not justify elaborate but impersonal information retrieval facilities. An efficient, personal service therefore continues to be the aim of this area of the Institution's work.

ACKNOWLEDGMENTS

To fulfil its objectives a professional Institution cannot begin to succeed unless the enthusiasm of a nucleus of its members is such that they are prepared to give unstintingly of their knowledge and experience to this end by serving on standing, specialist group and conference organizing committees, and by representing the Institution on many outside organizations. The IERE has always been fortunate in this respect and probably never more so than at present when so many members are forthcoming to voluntarily contribute to the advancement of the art, science and practice of radio or electronic engineering, as the Appendices to this Report illustrate. To all these members the Council of the Institution extends its gratitude, and at the same time acknowledges with thanks the support of those loyal members of the permanent staff who administer the internal affairs to provide the platform for and to implement the decisions of the contributing members.

INCOME AND EXPENDITURE ACCOUNT FOR THE YEAR ENDED 31st MARCH 1980

	1980		1979	
	£	£	£	£
INCOME (Note 2)				
Subscriptions		258,570		219,742
Entrance, Transfer and Exemption Fees		4,669		3,890
Sales:				
Institution Journal	34,765		30,026	
Other Publications and Colloquia	18,102		14,184	
		52,867		44,210
Fees Received—Symposia		79,012		46,187
Dividends and Interest Received		1,076		415
Total Income		396,194		314,444
Deduct:				
EXPENDITURE				
Cost of Publishing Journal				
Printing Costs	67,310		60,824	
Less: Advertising Receipts	6,253		5,970	
	61,057		54,854	
Postage	24,015		23,304	
Envelopes and Wrappers	2,454		1,320	
	87,526		79,478	
Direct Expenses relating to Symposia				
Printing of Papers	10,159		8,327	
Accommodation and Travel	25,621		16,187	
	35,780		24,514	
		123,306		103,992
		272,888		210,452
Deduct:				
Administration Expenses				
Salaries and National Insurance	111,546		101,626	
Superannuation Scheme	3,867		4,348	
Postage and Telephone	16,134		16,327	
Printing and Stationery	6,769		7,788	
Computer Service	5,293		7,627	
Travelling and Entertaining Expenses	1,169		542	
Council and Committee Expenses	3,429		3,353	
Delegates' Expenses	104		214	
Bank Charges and Differences on Exchange	4,550		5,442	
Audit Fees	2,100		1,500	
Miscellaneous Expenses	1,857		1,755	
Carried forward	156,818	272,888	150,522	210,452

The notes set out on pages 488 to 489 form an integral part of these accounts.

	1980		1979	
Brought forward	156,818	272,888	150,522	210,452
Establishment				
Rent, Rates and Insurance	37,164		34,106	
Lighting and Heating	1,703		1,583	
Office Expenses and Cleaning	6,197		6,909	
Repairs and Maintenance	1,010		1,045	
	46,074		43,643	
Divisions and Sections Operating Expenses				
Salaries, Printing, Stationery, Postage and Office Expenses	7,097		8,016	
Hire of Accommodation, Lectures and Meeting Expenses	6,493		3,674	
Travelling Expenses	1,666		502	
Indian Proceedings	—		1,002	
	15,256		13,194	
Subscriptions to the Council of Engineering Institutions	12,493		9,790	
Awards and Contributions to Other Institutions	1,162		919	
Depreciation (Note 4)				
Furniture, Fittings and Equipment	735		800	
Profit on Sale of Assets	—		(251)	
	735		549	
Total Expenditure		232,538		218,617
Excess of Income over Expenditure for the year before Exceptional Item		40,350		(8,165)
Exceptional Item (Note 3)		(3,894)		—
Excess of Income over Expenditure after Exceptional Item carried to General Fund		£36,456		£(8,165)

STATEMENT OF GENERAL FUND

	1980	1979
	£	£
Adverse Balance brought forward	(87,518)	(79,353)
Excess of Income over Expenditure for the Year	36,456	(8,165)
Adverse Balance at 31st March 1980	£(51,062)	£(87,518)

BALANCE SHEET AS AT 31st MARCH 1980

	1980		1979	
	£	£	£	£
Fixed Assets (Note 4)		66,984		65,117
Quoted Investments at Cost				
(Note 5).....................		4,328		4,328
(Market Value £4,703				
(1979 £4,988))				
Premises Fund Investments				
(Note 7).....................		40,501		32,829
Current Assets				
Stock of Institution's				
Publications (Note 6)......	31,787		17,748	
Income Tax recoverable......	32		39	
Sundry Debtors and				
Prepayments	29,154		28,572	
Balances at Bank and in				
Hand	5,549		4,725	
	66,522		51,084	
Less:				
Current Liabilities				
Sundry Creditors and				
Provisions.................	49,120		65,802	
Net Current Assets		17,402		(14,718)
		£129,215		£87,556
Represented by:				
Fund Balances				
General Fund—Adverse				
Balance		(51,062)		(87,518)
Premises Fund Account				
(Note 7)..................		40,501		32,829
		(10,561)		(54,689)
Deferred Revenue				
Subscriptions and				
Receipts in advance		48,992		39,369
Short Term Borrowings				
Bank Overdraft		90,784		102,876
		£129,215		£87,556

Signed

William Gosling (*President*)
S. R. Wilkins (*Honorary Treasurer*)
S. M. Davidson (*Secretary*)

STATEMENT OF SOURCE AND APPLICATION OF FUND FOR THE YEAR TO 31st MARCH 1980

	1980		1979	
	£	£	£	£
Source of Funds				
Excess of Income over				
Expenditure after				
Exceptional Item		36,456		(8,
Add:				
Items not giving rise to the				
movement of funds:				
Depreciation	735		800	
(Profit)/Loss on disposal				
of Investments and				
Fixed Assets	—		(251)	
		735		
		37,191		(7,
Other Sources:				
Proceeds from disposal of				
Investments and Fixed				
Assets...................	—		709	
Increase in Subscriptions				
received in advance	9,623		—	
Increase in Premises Fund				
receipts	7,672		7,069	
		17,295		7,
Total Source of Funds.......		54,486		
Application of Funds				
Purchase of Fixed Assets	2,602		4,242	
Decrease in Subscriptions				
received in advance........	—		14,115	
Amount set aside for				
Premises Fund				
Investment	7,672		7,069	
		(10,274)		(25,
		£44,212		£(25,
Represented by:				
Movement in Working Capital				
(Increase)/Decrease in Stocks	(14,039)		975	
(Increase)/Decrease in Tax				
recoverable................	7		173	
(Increase)/Decrease in				
Debtors	(582)		(2,636)	
Increase/(Decrease) in				
Current Liabilities.........	(16,682)		10,688	
		(31,296)		9,
Movement in Net Liquid Funds				
Increase/(Decrease) in				
Bank Overdraft	(12,092)		12,362	
(Increase)/Decrease in Bank				
and Cash Balances	(824)		3,702	
		(12,916)		16,
		£(44,212)		£25,

NOTES FORMING PART OF THE ACCOUNTS FOR THE YEAR ENDED 31st MARCH 1980

1. The accounting policies adopted by the Institution are disclosed, where appropriate, in the notes below.

2. **Income**

The accounting policies adopted by the Institution for treatment of Income are summarized as follows:

(i) *Subscriptions:* This represents amounts received by the Institution in respect of the subscription year to 31st March 1980, together with any arrears of subscriptions collected in the period. Subscriptions received in advance carried forward as Deferred Revenue to future years.

(ii) *Journal and Publication Sales, Symposia Fees:* These represent amo receivable in respect of Symposia programmed for the year, and publications supplied during the year. Journal subscriptions receive advance are carried forward as Deferred Revenue to future years.

(iii) *Dividends and Interest received, Entrance, transfer and exemption fees:* T represent amounts actually received in the year.

3. Exceptional Item

Due to the current limited demand for certain of the Institution's publications, it has been considered necessary to reduce these items from cost to expected realizable value. This reduction is shown as an exceptional item.

4. Fixed Assets

The United Kingdom fixed assets of the Institution were revalued by the Secretary, acting on specialist advice, on the basis of market value at 31st December 1977. The surplus so arising was dealt with in the accounts for 1977/78. Subsequent to this revaluation, the Institution does not consider it necessary to provide depreciation on fixed assets other than those located overseas together with UK equipment.

Depreciation is calculated on UK equipment and overseas furniture and equipment at rates between 10% to 25% per annum of net book value.

	Furniture and Equipment £	*Library* £	*Total* £
Cost or Valuation			
As at 1st April 1979:			
at Cost	5,214	3,513	8,727
at Valuation	22,000	36,000	58,000
	27,214	39,513	66,727
Additions during the year at Cost	937	1,665	2,602
As at 31st March 1980	£28,151	£41,178	£69,329
at Cost	6,151	5,178	11,329
at Valuation	22,000	36,000	58,000
Depreciation			
As at 1st April 1979	1,610	—	1,610
Provision for the year	735	—	735
As at 31st March 1980	£2,345	—	£2,345
Net Book Values			
As at 31st March 1980	£25,806	£41,178	£66,984
As at 31st March 1979	£25,604	£39,513	£65,117

5. Investments

Quoted Investments

Nominal		*Cost* £
£1,000	$7\frac{3}{4}$% Barnet Corporation Loan 1982/84	982
£270	Inchcape & Co. Ltd.—$12\frac{1}{2}$% Unsecured Loan Stock 1982/83	99
£1,000	Islington Corporation—10% Redeemable Stock 1982/83	995
166	Muirhead Limited—25p Ordinary Shares	262
£1,000	Slough Corporation—$8\frac{3}{4}$% Redeemable Stock 1979/80	990
£521.20	Southern Rhodesia—6% Stock 1978/81	515
£500	Stock Exchange—$7\frac{1}{4}$% Mortgage Debenture Stock 1990/95	485
£1,220	$5\frac{1}{2}$% Treasury Stock 2008/12 (donated)	—
		£4,328

The Institution also has a residuary interest in a settlement consisting of freehold property which will be vested in the Institution at some future date. The Secretary estimates the value of this interest to be approximately £11,000 at 31st March 1980.

6. Stock of Institution's Publications

Stock of the Institution's publication is stated at the lower of cost and net realizable value.

7. Premises Fund

	1980 £	1979 £
Investments		
£28,000 City of Liverpool $10\frac{7}{8}$% Bond repayable 23rd April 1980	28,000	23,000
Balance at Bank	12,501	9,829
	£40,501	£32,829
Movement on Fund during year		
Balance 1st April 1979	32,829	25,760
Add:		
Receipts during year:		
Donations	1,233	1,684
Covenanted Subscriptions	3,937	4.142
Interest received on Investment	2,502	1,243
Balance 31st March 1980	£40,501	£32,829

8. Foreign Exchange

Fixed Assets located overseas have been converted to Sterling at the rate of exchange ruling when the asset was purchased.

Overseas remittances and receipts during the year have been converted into sterling at the current rates then ruling and the bank and cash balances held overseas at 31st March 1980 at the rate of exchange ruling at that date. Any resulting exchange differences have been included with Bank Charges in the Income and Expenditure Account.

AUDITORS' REPORT TO THE MEMBERS OF THE INSTITUTION OF ELECTRONIC AND RADIO ENGINEERS

We have examined the accounts set out on pages 487 to 489 which have been prepared under the historical cost convention as amended by the valuation of certain assets by the Secretary of the Institution as described in Note 4 to the Accounts.

In our opinion the accounts give, under the basis stated above, a true and fair view of the Institution's affairs at 31st March 1980 and of the surplus and source and application of funds for the year ended on that date, and comply with the Royal Charter and Bye-Laws of the Institution.

50 Bloomsbury Street, London WC1B 3QY

15th July 1980

GLADSTONE, JENKINS & CO.
Chartered Accountants

Appendix 1

Membership of the Council and its Committees as at 31st March 1980

COUNCIL OF THE INSTITUTION

President:

Professor W. Gosling, B.Sc. (*Fellow*)

Past Presidents:

P. A. Allaway, C.B.E., D.Tech. F.Eng (*Fellow*)
Professor W. A. Gambling, D.Sc., Ph.D., F.Eng. (*Fellow*)
D. W. Heightman (*Fellow*)

Vice Presidents:

H. E. Drew, C.B., C.G.I.A. (*Fellow*)
Professor J. R. James, B.Sc., Ph.D. (*Fellow*)
Brigadier R. W. A. Lonsdale, B.Sc. (*Fellow*)
P. K. Patwardhan, M.Sc., Ph.D. (*Fellow*)
J. Powell, T.D., M.Sc. (*Fellow*)
S. J. H. Stevens, B.Sc.(Eng). (*Fellow*)

Ordinary and ex-officio Members:

D. H. Andrews (*Member*) *
Colonel W. Barker (*Fellow*)
P. V. Betts (*Member*) *
C. S. den Brinker, M.Sc. (*Fellow*)
P. O. Byrne, B.Sc. (*Member*) *
Sir Robert Clayton, C.B.E., M.A., F.Eng., (*Fellow*)
J. A. Crimes (*Member*) *
P. W. Day (*Member*) *
I. D. Dodd, B.Sc. (*Fellow*) *
A. F. Dyson, Dip.El. (*Member*)
B. R. Evans, M.Sc. (*Member*) *
M. Gibson (*Member*) *
P. J. Hulse (*Associate Member*)
D. W. Iliffe (*Member*)
D. J. Kenner, B.Sc., M.Sc. (*Member*)
Henry J. Kroch, O.B.E. (*Companion*)
G. F. Lane Fox (*Member*) *
R. Larry (*Fellow*)
C. J. Lilly (*Member*)
B. Mann, M.Sc. (*Member*)
Professor C. W. Miller, D.Sc. (*Fellow*) *
W. D. Oxenham, M.A. (*Member*) *
A. D. Patterson, B.A. (*Memer*) *
P. A. S. Prance (*Member*) *
Major General H. E. Roper, C.B., B.Sc. (Eng.) (*Fellow*)
D. L. A. Smith, B.Sc.(Eng.) (*Fellow*)
T. Thomas (*Member*) *
K. R. Thrower (*Member*)
L. C. Walters, M.A. (*Member*) *
M. W. Wright, T.D. (*Associate*)

* Chairman of a Local Section in the UK

Honorary Treasurer:

S. R. Wilkins, (*Fellow*)

Seretary:

Sinclair M Davidson, C.B.E. (*Fellow*)

STANDING COMMITTEES OF THE COUNCIL

Executive Committee

Chairman:
Professor W. Gosling, B.Sc. (*Fellow*)

H. E. Drew, C. B., C.G.I.A. (*Fellow*)
Professor W. A. Gambling, D.Sc., Ph.D. F.Eng. (*Fellow*)
D. W. Heightman (*Fellow*)
Professor J. R. James, B.Sc., Ph.D. (*Fellow*)
Brigadier R. W. A. Lonsdale, B.Sc. (*Fellow*)
J. Powell, T.D., M.Sc. (*Fellow*)
Major-General H. E. Roper, C.B., B.Sc.(Eng.) ·*Fellow*)
D. L. A. Smith, B.Sc.(Eng.) (*Fellow*)
S. J. H. Stevens, B.Sc.(Eng.) (*Fellow*)
S. R. Wilkins (*Fellow*)

Education and Training Committee

Chairman:
D. L. A. Smith, B.Sc. (*Fellow*)

Brigadier G. D. Clarke (*Member*)
F. Goodall, B.Sc., Ph.D. (*Member*)
Commander A. H. Fraser, B.Sc.(Eng.), RN (*Member*)
P. J. Gallagher, Ph.D. (*Member*)
B. F. Gray, B.Sc. (*Fellow*)
R. W. S. Hewitt (*Fellow*)
G. P. Heywood, B.Sc. (*Graduate*)
C. H. G. Jones (*Member*)
A. J. Kenward, B.Sc. (*Member*)
Squadron Leader I. McKenzie, R.A.F. (*Member*)
P. J. Morley (*Member*)
Professor K. G. Nichols, B.Sc., M.Sc. (*Fellow*)
W. L. Price, O.B.E., Ph.D., M.S. (*Fellow*)
A. C. Shotton (*Fellow*)
A. Tranter, B.Sc.(Eng.) (*Member*)
Colonel J. Vevers, O.B.E. (*Fellow*)

Membership Committee

Chairman:
D. N. J. Cudlip (*Member*)

C. W. Brown, M.A. (*Member*)
D. A. Burgess (*Member*)
R. M. Clark (*Member*)
Wing Commander P. J. Dunlop, R.A.F. (Ret.) (*Fellow*)
J. W. Morris (*Member*)
G. H. Pegler (*Fellow*)
D. G. Roberts (*Member*)
R. S. Roberts (*Fellow*)
Group Captain J. M. Walker, R.A.F. (*Member*)
M. M. Zepler, M.A., Dip. El. (*Member*)

Professional Activities Committee

Chairman:
Brigadier R. Knowles, C.B.E. (*Fellow*)

Colonel W. Barker (*Fellow*)
Lieutenant Colonel F. G. Barnes, M.A., R. Sigs. (Ret) (*Member*)
K. Copeland (*Member*)
A. F. Dyson, Dip. El. (*Member*)
M. H. W. Gall, M.A. (*Fellow*)
L. Hale (*Member*)
J. R. Halsall, Dip. El. (*Fellow*)
A. Hann, B.Sc. (*Fellow*)
R. Larry (*Fellow*)
D. L. A. Smith, B.Sc. (*Fellow*)
W. E. Willison (*Fellow*)

Papers Committee

Chairman:
L. W. Barclay, B.Sc. (*Fellow*)

K. F. Baker, M.Sc. (*Member*)
J. Bilbrough (*Fellow*)
L. A. Bonvini (*Fellow*)
W. G. Burrows, Ph.D., D.I.C. (*Member*)
M. P. Circuit, Dip. El., B.Sc. (*Member*)
R. J. Cox, B.Sc. (*Member*
P. Denby (*Fellow*)
K. G. Freeman, B.Sc. (*Member*)
A. E. Hilling (*Member*)
R. M. B. Jackson (*Member*)
C. J. Lilly (*Member*)
Professor A. Pugh, B.Sc., Ph.D. (*Fellow*)
E. Robinson, B.Sc., Ph.D. (*Fellow*)
A. G. Wray, M.A. (*Fellow*)

Trustees of the Institution Benevolent Fund

Professor W. Gosling (*Fellow*) President
S. R. Wilkins (*Fellow*) Hon. Treasurer
S. M. Davidson, C.B.E. (*Fellow*) Secretary

GROUP COMMITTEES

Aerospace, Maritime and Military Systems

Chairman:
N. G. V. Anslow (*Member*)

Colonel W. Barker (*Fellow*)
A. Hann, B.Sc. (*Fellow*)
J. A. C. Kinnear (*Fellow*)
R. N. Lord, M.A. (*Member*)
R. B. Mitson, M.Sc. (*Member*)
Brigadier J. F. Blake, R. Sigs. (*Member*)
P. R. Hopkins (*Co-opted*)
C. H. Nicholson (*Fellow*)
Commander A. R. B. Norris (*Associate Member*)
R. M. Trim, O.B.E. (*Fellow*)

Automation and Control Systems

Chairman:
P. Atkinson, B.Sc.(Eng.) (*Member*

M. S. Birkin (*Member*)
A. E. Crawford (*Fellow*)
J. R. Halsall, Dip. El. (*Fellow*)
W. F. Hilton, D.Sc. (*Fellow*)
D. J. Kenner, B.Sc., M.Sc. (*Member*)
Brigadier R. Knowles, C.B.E. (*Fellow*)
B. Mann, M.Sc. (*Member*)
J. L. Patterson (*Member*)
Professor D. R. Towill, M.Sc. (*Fellow*)
Group Captain J. M. Walker, R.A.F. (*Member*)
Professor D. R. Wilson, B.Sc., Ph.D. (*Fellow*)

Communications

Chairman:
J. J. Jarrett (*Member*)

A. R. Bailey, M.Sc., Ph.D. (*Fellow*)

L. W. Barclay, B.Sc. (*Fellow*)
A. P. Clark, M.A., Ph.D. (*Fellow*)
Professor J. E. Flood, D.Sc., Ph.D. (*Fellow*)
L. W. Germany (*Fellow*)
Dr F. Goodall, M.Sc., Ph.D. (*Member*)
A. N. Heightman (*Fellow*)
G. R. Jessop (*Member*)
A. A. Kay (*Fellow*)
R. Larry (*Fellow*)
G. A. McKenzie (*Fellow*)
P. L. Mothersole (*Fellow*)
R. S. Roberts (*Fellow*)
R. E. C. B. Smith (*Member*)
K. R. Thrower (*Member*)
K. E. Ward (*Member*)
M. M. Zepler, M.A., Dip. El. (*Member*)

Components and Circuits

Chairman:
Professor A. Pugh, B.Sc. Ph.D. (*Fellow*)
K. F. Baker (*Member*)
C . Caine, B.Sc. (*Member*)
Professor D. S. Campbell, B.Sc., D.Sc., D.I.C. (*Fellow*)
Dr R. F. Mitchell, Ph.D. (*Co-opted*)
B. V. Northall, C.G.I.A. (*Member*)
J. K. Stevenson, B.Sc., Ph.D. (*Member*)

Computer

Chairman:
Colonel W. Baker (*Fellow*)

C. E. Dixon, B.A., Dip.El. (*Member*)
D. B. Everett, Ph.D. (*Fellow*)
P. L. Hawkes, B.Sc. (*Member*)
D. T. Law (*Member*)
Professor D. W. Lewin, D.Sc. (*Fellow*)
V. Maller, M.A. (*Member*)
Wing Commander D. G. L. Packer, B.Sc., D.U.S., R.A.F. (Ret.) (*Member*)
Major D. Pilgrim, B.Sc. (*Member*)
T. J. Stakemire (*Member*)
E. R. Tomlinson (*Member*)
S. E. Williamson, B.Sc., Ph.D. (*Member*)

Electronics Production Technology

Chairman:
L. Hale (*Member*)

J. W. Anstead (*Member*)
J. F. Burns (*Member*)
A. F. Dyson (*Member*)
D. M. Embrey (*Fellow*)
R. W. Hill (*Member*)
D. G. Horan (*Member*)
R. P. Marie (*Member*)
Professor D. R. Towill, D.Sc. (*Fellow*)

Measurements and Instruments

Chairman:
Professor P. B. Fellgett, M.A., PH.D. (*Fellow*)

A. E. Drake (*Co-opted*)
E. P. Fowler, M.A. (*Co-opted*)
M. H. W. Gall, M.A. (*Fellow*)
R. F. Monger (*Associate*)
J. K. Murray (*Associate*)
Professor P. A. Payne, Ph.D. (*Member*)
D. E. O'N. Waddington (*Fellow*)
P. C. F. Wolfendale (*Fellow*)

Medical and Biological Electronics

Chairman:
K. Copeland (*Member*)

R. Brennand (*Member*)
D. Groves (*Member*)
A. E. Hay (*Member*)
A. J. Huelin (*Member*)
L. R. Jenkins (*Co-opted*)
Professor P. A. Payne, PH.D. (*Member*)
L. W. Price, M.A. (*Member*)
J. R. Roberts, B.Sc., PH.D. (*Graduate*)
N. C. Scott, M.Sc., (*Member*)
H. J. Terry, B.A., Ph.D. (*Member*)

Microprocessor

Chairman:
Professor K. G. Nichols, M.Sc. (*Fellow*)

K. F. Baker, M.Sc. (*Member*)
C. E. Dixon, B.A. (*Member*)
P. R. Hopkin (*Member*)
D. G. Horan (*Member*)
B. Mann, M.Sc. (*Member*)
D. E. O'N Waddington (*Fellow*)
M. M. Zepler, M.A., Dip. El. (*Member*)

Appendix 2

Representatives of the Institution on the Board and Committees of the Council of Engineering Institution

Board

Professor W. Gosling, B.Sc., (*Fellow*)
Professor W. A. Gambling, Ph.D., D.Sc., F.Eng. (*Fellow*) (*Alternate*)

Standing Committee B

J. Powell, M.Sc. (*Fellow*)

Standing Committee C

S. J. H. Stevens (*Fellow*)

CEI-CSTI Joint Affairs Committee

To be appointed

Council for Environmental Science and Engineering

Professor H. M. Barlow, Ph.D., F.R.S., F.Eng. (*Fellow*)

British National Committee on Ocean Engineering

M. J. Tucker, B.Sc. (*Member*)

Committee on Health and Safety

Colonel F. R. Spragg, B.Sc. (*Fellow*)

Engineers Registration Board

Chartered Engineers Section Board
Group Captain J. M. Walker, R.A.F. (*Member*)

Committee on Training and Experience
D. L. A. Smith, B.Sc.(Eng.) (*Fellow*)

Technician Engineering Section Board, Supervisory Committee and Joint Membership Committee
K. J. Coppin, B.Sc. (*Member*)

Joint Qualifications Committee
Brigadier R. W. A. Lonsdale, B.Sc. (*Fellow*) Chairman

Appendix 3

Institution Representation at Universities, Polytechnics and Colleges

University of Aston in Birmingham

Convocation
Professor D. G. Tucker, D.Sc., Ph.D. (*Fellow*)

Barnsley College of Technology

Engineering Advisory Committee
To be appointed

University of Bradford

Court
P. J. Gallagher, M.Sc., Ph.D. (*Member*)

University of Nottingham

Court
Air Vice-Marshal S. M. Davidson, C.B.E. (*Fellow*)

Reading College of Technology
Board of Governors
Major-General Sir Leonard Atkinson, K.B.E., B.Sc. (*Past President*)

Southall College of Technology
Governing Body
B. S. Pover (*Member*)
Administrative Committee
A. G. Wray, M.A. (*Fellow*)

South East London College
Engineering Consultative Committee
J. I. Collings (*Fellow*)

East Ham Technical College
Electrical Engineering Advisory Committee
D. W. Bradfield, B.Sc. (*Member*)

Glasgow College of Technology
Advisory Board
R. D. Pittilo, B.Sc. (*Member*)

City of Gloucester College of Technology
Electrical Engineering Advisory Committee
H. V. Sims (*Fellow*)

Darlington College of Technology
Electrical Engineering and Science Advisory Committee
R. W. Blouet (*Member*)

Merton Technical College
Board of Governors
A. A. Kay (*Fellow*)

City of Nottingham Education Committee
Electrical Engineering Advisory Committee
F. W. Hopwood (*Member*)

Huddersfield Technical College
Engineering Advisory Committee
R. Barnes (*Member*)

Stannington College of Further Education, Sheffield
Electrical and Telecommunications Consultative Committee
P. A. Bennett (*Fellow*)

University of Surrey
Court
Sir Ieuan Maddock, C.B., O.B.E., D.Sc., F.R.S. (*Past President*)

Wakefield College of Technology and Arts
Engineering Advisory Committee
M. Holroyd, M.Sc. (*Member*)

University of Wales Institute of Science and Technology
Court
V. J. Phillips, Ph.D., B.Sc. (*Member*)

Watford College of Technology
Engineering Advisory Committee
F. P. Thomson, O.B.E. (*Member*)

Widnes Technical College
Electrical and Instrument Engineering Advisory Committee
D. Chalmers (*Fellow*)

Appendix 4

Representatives on Joint Committees for the Awards of National Certificates and Diplomas in Engineering

England and Wales

Higher National Certificates and Diplomas in Electrical and Electronic Engineering:

B. F. Gray, B.Sc. (*Fellow*) Chairman
D. L. A. Smith, B.Sc.(Eng) (*Fellow*)
A. Tranter, B.Sc. (*Member*)
D. Dick, D.I.C. (*Fellow*)

Scotland

National Certificates in Electrical and Electronic Engineering:

D. S. Gordon Ph.D., B.Sc. (*Member*)

Northern Ireland

Higher National Certificates in Electrical and Electronic Engineering:

Captain A. W. Allen, RN (Ret.) (*Member*)
J. A. C. Craig, B.Sc. (*Member*)

Appendix 5

Institution Representation on other Educational Bodies

City and Guilds of London Institute
Telecommunication Advisory Committee
B. F. Gray, B.Sc. (*Fellow*)
Joint Advisory Committee for Radio, Television and Electronics
W. B. K. Ellis, B.Sc. (*Member*)
Radio Amateur Examination Advisory Committee
R. G. D. Holmes (*Fellow*)
Advisory Committee on Communication of Technical Information
F. P. Thomson, O.B.E. (*Member*)

Council for National Academic Awards
Electrical and Electronic Engineering Board
C. S. den Brinker. M.Sc. (*Fellow*)

London and Home Countries Regional Advisory Council for Technological Education
Advisory Committee on Electrical and Electronic Engineering
K. J. Coppin, B.Sc. (*Member*)

North Western Advisory Council for Further Education
Specialist Advisory Committee for National Education
A. G. Brown. (*Member*)

Radio Television and Electronics Examination Board
Air Vice Marshall S. M. Davidson, C.B.E. (*Fellow*)
W. B. K. Ellis, B.Sc. (*Member*)
N. G. Green (*Member*)

Scottish Technical Education Council (ScoTEC) Course Committee A2
P. G. Wilks, B.Sc. (*Member*)

Technician Education Council (TEC)
Programme Committee A2
K. R. Thrower (*Member*)

Yorkshire Council for Further Education
Engineering County Advisory Committee
F. O. M. Bennewitz, M.Sc. (*Member*)

Welsh Joint Education Committee
Electrical and Electronic Engineering Courses Sub-Committee
I. D. Dodd, B.Sc. (*Member*)

Appendix 6

Members Appointed to Represent the Institution on External Bodies

EUREL (Convention of National Socieities of Electrical Engineers of Western Europe)
Professor W. Gosling, B.Sc. (*Fellow*)

British National Council for Non-Destructive Testing
A. Nemet, Dr. Ing. (*Fellow*)

British Nuclear Energy Society
R. J. Cox, B.Sc. (*Member*)

International Broadcasting Convention
Management Committee and Programme Committee
P. L. Mothersole (*Fellow*)
R. S. Roberts (*Fellow*)

National Council for Quality and Reliability
Brigadier R. Knowles, C.B.E. (*Fellow*)

National Electronics Council
Professor W. Gosling, B.Sc. (*Fellow*)

Watt Committee on Energy
M. S. Birkin (*Member*)

Parliamentary and Scientific Committee
P. A. Allaway, C.B.E., D.Tech., F.Eng. (*Fellow*)
Air Vice-Marshal S. M. Davidson, C.B.E. (*Fellow*)

British Electrotechnical Approvals Board
R. S. Roberts (*Fellow*)

Association of Learned and Professional Society Publishers
General Assembly and Council
F. W. Sharp (*Fellow*)

UK Automatic Control Council
P. Atkinson, B.Sc. (*Member*)
Colonel W. Barker (*Fellow*)
Professor D. R. Towill, M.Sc (*Fellow*)

UK Liaison Committee for Sciences Allied to Medicine and Biology
J. R. Roberts (*Graduate*)

Standing Committee of Kindred Societies
Major-General Sir Leonard Atkinson, K.B.E., B.Sc. (*Past President*)

Appendix 7

British Standards Institution Representatives

ECL/–	**Electronic Components Standards Committee**	Brig. R. Knowles C.B.E. (*Fellow*)
ECL/5	**Electronic Tubes**	G. R. Jessop, (*Member*)
ECL/5/2	**Electronic Tube Performance General**	G. R. Jessop, (*Member*)
ECL/5/8	**Electro-Optical Devices**	Prof. A. Pugh, B.Sc., Ph.D., (*Fellow*)
ECL/11	**Piezo-Electric Devices for Frequency Control and Selection**	E. Kentley, (*Fellow*)
ECL/12/5	**Microwave Semiconductor Devices**	R. R. Harman, (*Member*)
ECL/12/6	**Diodes, Transistors and Related Semiconductor Devices**	G. Hennessey, (*Member*)
EEL/–	**Electronic Equipment Standards Committee**	Brig. R. Knowles C.B.E. (*Fellow*)
EEL/8	**Electronic Measuring Instruments and Associated Equipment**	D. M. Styles, (*Member*)
EEL/8/7	**Electronic Instruments for Voltage Measurement**	D. L. A. Smith, B.Sc., (*Fellow*)
EEL/8/8	**Oscilloscopes**	D. M. Styles, (*Member*)
EEL/23	**Radio-Frequency Radiation-Induced Ignition and Detonation**	Col. F. R. Spragg, B.Sc., (*Fellow*) and D. M. Field, (*Member*)
EEL/24	**Electro-Acoustics**	S. Kelly, (*Fellow*)
EEL/24/1	**Audio Engineering**	S. Kelly, (*Fellow*) R. S. Roberts (*Fellow*)
EEL/24/2	**Measuring Devices**	W. V. Richings (*Fellow*)

EEL/24/3	**Ultrasonic Equipment**	W. V. Richings, (*Fellow*)
EEL/24/4	**Performance of High-Fidelity Audio Equipment**	R. S. Roberts, (*Fellow*)
EEL/25	**Radio Communication**	R. Larry, (*Fellow*)
EEL/25/1	**Radio Receiving Equipment**	R. S. Roberts, (*Fellow*)
EEL/25/4	**Aerials**	C. Hale (*Fellow*)
EEL/25/7	**Wired Distribution Systems**	P. Scadeng (*Fellow*)
EEL/25/8	**Reception of Sound and Television Broadcasting**	P. Scadeng (*Fellow*)
EPC/1	**Acoustics**	W. V. Richings, (*Fellow*)
GEL/1	**Terminology**	E. H. Jones, (*Fellow*)
GEL/1/1	**Fundamental Terminology**	E. H. Jones, (*Fellow*)
GEL/1/10	**General Heavy Electrical Terminology**	E. H. Jones, (*Fellow*)
GEL/1/20	**Magnetism Terminology**	E. H. Jones, (*Fellow*)
GEL/4	**Graphical Symbols for Electrical Engineering and Telecommunication**	R. A. Ganderton, (*Member*)
GEL/6	**Reliability and Maintainability**	Brig. R. Knowles C.B.E., (*Fellow*)
GEL/111	**Electromagnetic Interference**	M. A. Burchall, (*Fellow*)
MEE/10	**Engineering Drawing Practice**	D. J. Simmonds (*Member*) G. Taylor (*Member*)
MEE/158	**Mechanical Vibration and Shock**	W. V. Richings, (*Fellow*)
MEE/158/2	**Vibration and Shock Measuring Instruments and Testing Equipment**	W. V. Richings, (*Fellow*)
MEE/158/6	**Balancing, including Balancing Machines**	W. V. Richings, (*Fellow*)
NSS/5/6	**Audio-Aids (School Music)**	M. H. Evans, (*Member*)
DPS/4	**Magnetic Tape and Magnetic Disc Packs**	A. Pitter (*Member*)
PEL/50	**Static Power Converter Equipments**	M. A. Burchall, (*Fellow*)
QMS/3/4	**Maintenance**	Brig R. W. A. Lonsdale, B.Sc., (*Fellow*) and L. A. Bonvini, (*Fellow*)

Appendix 8

Award of Institution Premiums for 1979

MAIN PREMIUMS

LORD MOUNTBATTEN PREMIUM *Value* £100

'Superscreened cables'
E. P. Fowler (*Atomic Energy Establishment*)

CLERK MAXWELL PREMIUM *Value* £100

'Physical measurements in the 100–1000 GHz range'
M. J. Bangham, Dr J. R. Birch, Dr T. G. Blaney, Dr A. E. Costley, Dr J. E. Harries, Dr R. G. Jones and Dr N. W. B. Stone (*National Physical Laboratory*)

MARCONI PREMIUM *Value* £75

'Digital transmission of video and audio signals over an optical-fibre system'
N. H. C. Gilchrist (*British Broadcasting Corporation*)

HEINRICH HERTZ PREMIUM *Value* £75

'Real-time spectrum analysis using hardware Fourier chirp-Z transformations'
Dr R. Benjamin (*Government Communications Headquarters*)

SPECIALIZED TECHNICAL PREMIUMS

CHARLES BABBAGE PREMIUM *Value* £50

'Microprocessor implementation of tactical modems for data transmission over v.h.f. radios'
Dr B. H. Davies and T. R. Davies (*Royal Signals and Radar Establishment*)

LORD BRABAZON PREMIUM *Value* £50

'The detection of ice at sea by radar'
P. D. L. Williams (*Decca Radar*)

A. F. BULGIN PREMIUM *Value* £50

'Schottky diode receivers for operation in the 100–1000 GHz range'
Dr B. J. Clifton (*Massachusetts Institute of Technology*)

PAUL ADORIAN PREMIUM *Value* £50

'Atmospheric propogation in the frequency range 100–1000 GHz'
Dr R. J. Emery and A. M. Zavody (*Appleton Laboratory*)

P. PERRING THOMS PREMIUM *Value* £50

'Television measurements through psychophysics to subjective picture quality'
J. Allnatt (*Post Office Research Centre*)

SIR CHARLES WHEATSTONE PREMIUM *Value* £50

'Visual range monitors'
M. E. Judge (*Marconi Radar Systems*)

GENERAL PREMIUMS

ERIC ZEPLER PREMIUM *Value* £50

'The relevance of science to engineering'
Professor D. Lewin (*Brunel University*)

RESTRICTED PREMIUMS

SIR JAGDISH CHANDRA BOSE PREMIUM *Value* £50

'An amplitude-controlled adaptive delta sigma modulator'
Dr C. V. Chakravarthy (*Indian Institute of Technology, Kharagpur*)

Papers of sufficiently high standard were not published within the terms of the following Premiums and they are withheld:

Dr Norman Partridge Premium—Audio frequency engineering (Value £50)

Lord Rutherford Premium—Electronics associated with nuclear physics or nuclear engineering (Value £50)

J. Langham Thompson Premium—Theory or practice of systems or control engineering (Value £50)

Dr V. K. Zworykin Premium—Medical or biological electronics (Value £50)

Arthur Gay Premium—Production techniques in the electronics industry (Value £50)

Admiral Sir Henry Jackson Premium—History of radio or electronics (Value £50)

Leslie McMichael Premium—Management techniques associated with electronic engineering (Value £50)

Hugh Brennan Premium—Outstanding paper first read before any Local Section of the Institution and subsequently published in the Journal (Value £50)

IERE BENEVOLENT FUND

Annual Report of the Trustees for the period 1st April 1979 to 31st March 1980

During the course of the year under report work was completed on the preparation of a new definitive Trust Deed for the IERE Benevolent Fund. The main object of this work was to bring the purposes and procedures of the Fund formally into accord with the current membership and staff structure of the Institution, and to obtain maximum possible legal provision to ensure the continued independence of the Fund and protection of its assets in the foreseeable future. This new Trust Deed will be put to a Special General Meeting of the Fund for formal approval on 22nd May 1980.

As will be seen from the audited accounts of the Fund published with this report, demands on the resources of the Fund have been modest during the past year. No deserving applicant has been denied assistance during this period and the Trustees have continued to find that the most genuine needs are very often suffered by the most diffident applicants. It is therefore important that members who, at any time, get to know about a colleague in distress for any cause, ensure that details are sent to the Trustees without delay so that help can be brought to bear when need is greatest. The contacts engendered by Local Section activity can be most useful in this context.

Subscription income to the Fund continues at a minimal level, the main receipts during the year having been revenue from the Fund's wide range of investments. Whilst this has been more than adequate to meet the year's outgoings there are no grounds for complacency in this situation. Quite apart from the adverse effect of inflation on future usefulness of all revenue, it has to be remembered that electronic and radio engineering is still a relatively new profession. In view of this it could well be that the time will soon come when the demands on the Fund will rise quite quickly as the pioneers of the profession reach the age when assistance is most often needed. The Trustees must therefore maintain a position from which they can respond even more readily in the future than in the past, and members are earnestly requested to consider this, their own Benevolent Fund, when making up their charity subscription lists for the new year.

To sum up: a stable and financially successful year for the Fund has been marked by excellent progress in essential administrative work on the new Trust Deed for the future management and protection of the Fund. The Trustees' main concern now is the level of income for the future in the light of the pressures of inflation and the likelihood of greater calls on the Fund in the short term—a matter which they commend to the attention of the wider younger membership of the Institution.

ANNUAL ACCOUNTS OF THE INSTITUTION OF ELECTRONIC AND RADIO ENGINEERS BENEVOLENT FUND

INCOME AND EXPENDITURE ACCOUNT FOR THE YEAR ENDED 31st MARCH 1980

	1980 £	1980 £	1979 £	1979 £
INCOME				
Donations		564		667
Dividends and Interest Receivable		7,102		5,032
		7,666		5,699

	1980 £	1980 £	1979 £	1979 £
EXPENDITURE				
Legal and Professional Charges	1,065		75	
Grants and Donations	1,256		1,298	
Administrative Costs, Postage, Telephone and Stationery	250		250	
		2,571		1,623
		5,095		4,076
Add:				
Surplus on redemption and disposal of investments		378		—
Surplus for the year carried to Reserve Account		£5,473		£4,076

BALANCE SHEET AS AT 31st MARCH 1980

	1980 £	1980 £	1979 £	1979 £
ASSETS				
Investments at Cost		53,537		55,437
(Market Value at 31/3/80: £70,776 (1979 £76,783))				
Short Term Deposit		18,000		
Current Assets				
Bank Balances on Current Account	263		3,686	
Income Tax Repayment Claim	468		529	
Sundry Debtors	362		12	
Amount due from IERE	—		6,642	
		1,093		10,869
		72,630		66,306
Less:				
Current Liabilities				
Legal and Professional Charges Payable	976		150	
Amount due to IERE	25		—	
		1,001		150
		£71,629		£66,156
Represented by:				
Reserve Account—Balance 1st April 1979		66,156		62,080
Add:				
Surplus for the year		5,473		4,076
Balance at 31st March 1980		£71,629		£66,156

For Trustees
Signed
W. Gosling
S. R. Wilkins
S. M. Davidson

SCHEDULE OF INVESTMENTS AS AT 31st MARCH 1980

Nominal		*Co*
£100	Associated Electrical Industries Ltd.—6% Debenture Stock 1978/83	9
£1,000	Barnet Corporation—$7\frac{3}{4}\%$ Loan 1982/84	9
148	Bowater Paper Corporation Ltd.—Ordinary Stock	3
170	Burmah Oil Co. Ltd.—£1 Ordinary Shares	7
£2,206.59	Corporation of London—$6\frac{1}{2}\%$ Loan 1980/82	1,8
340	Courtaulds Ltd.—25p Ordinary Shares	5
£500	Courtaulds Ltd.—7% Debenture Stock 1982/87	4
750	Currys Ltd.—Ordinary 25p Shares	1,5
914	De La Rue Co. Ltd.—Ordinary Shares 25p	7
£210	E.M.I. Ltd.—$8\frac{1}{2}\%$ Convertible Unsecured Loan Stock 1981	21
373	English China Clays Ltd.—Ordinary Shares 25p	53
£4,853.99	$3\frac{1}{2}\%$ Funding Stock 1999/2004	1,37
£2,375.46	$5\frac{1}{4}\%$ Funding Stock 1978/80	2,00
£2,225	$5\frac{1}{2}\%$ Funding Stock 1982/84	1,99
£3,451.15	6% Funding Loan 1993	2,00
£2,250	$6\frac{1}{2}\%$ Funding Stock 1985/87	2,00
2,249	General Electric Co. Ltd.—25p Ordinary Shares	88
600	General Electric Co. Ltd.—Unsecured Capital Notes 1986	–
332	Grattan Warehouses Ltd.—25p Ordinary Shares	62
£2,188.43	Greater London Corporation—$9\frac{1}{2}\%$ Loan 1980/82	2,00
£200	The Great Universal Stores Ltd.—$5\frac{3}{8}\%$ Redeemable Unsecured Loan Stock	10
£300	The Great Universal Stores Ltd.—$8\frac{1}{4}\%$ Unsecured Loan Stock 1993/98	24
1,200	Henderson International Trust—now Vavasseur International Trust Units 5p	15
£150	ICI Ltd.—$7\frac{1}{4}\%$ Unsecured Loan Stock 1986/91	14
1,124	ICI Ltd.—£1 Ordinary Stock Units	3,33
£1,000	Islington Corporation—10% Redeemable Stock 1982/3	99
817	Lonhro Ltd.—25p Ordinary Shares	77
8,822	Marks & Spencer Ltd.—25p Ordinary Shares	5,47
1,250	Plessey Co. Ltd.—50p Ordinary Stock	1,47
187	Reed Group Ltd.—Ordinary Shares of £1	45
£35	Reed Group Ltd.—10% Unsecured Loan Stock 2004/09	3
2,000	Shell Transport & Trading Co. Ltd.—Ordinary Shares of 25p	3,14
£1,000	Slough Corporation—$8\frac{3}{4}\%$ Redeemable Stock 1979/80	99
200	Tanganyika Concessions Ltd.—50p Ordinary Shares	70
928	Thorn—7% Convertible Redeemable Second Cumulative Preference Shares	89
1,330	Transport Development Ltd.—25p Ordinary Shares	74
£1,225	Treasury Loan $7\frac{3}{4}\%$ 1985/88	99
£1,320	Treasury Loan $8\frac{3}{4}\%$ 1987/90	1,00
£1,990.69	Treasury Loan $8\frac{1}{2}\%$ 1980/82	2,00
£1,125	Treasury Loan 9% 1994	99
£3,850.67	Treasury Loan $9\frac{1}{4}\%$ 1983	3,50
£1,500	Treasury Loan 12% 1983	1,43
£2,180.01	Treasury Stock 13% 1990	2,20
796	Unicorn General Trust	12
750	Watts, Blake, Bearne & Co. Ltd.—Ordinary Shares 25p	43
500	Whitbread & Co. Ltd.—Ordinary 'A' Shares of 25p	29
		£53,53

AUDITORS REPORT TO THE TRUSTEES OF THE INSTITUTION OF ELECTRONIC AND RADIO ENGINEERS BENEVOLENT FUND

In our opinion the annexed accounts show a true and fair view of the Benevolent Fund's affairs at 31st March 1980 and of the surplus for the year ended o that date, and comply with the Rules thereof.

Signed:
GLADSTONE, JENKINS & CO
Chartered Accountant

50 Bloomsbury Street, London WC1B 3QY

25th September 1980

NOMINATIONS FOR ELECTION TO COUNCIL

In accordance with Bye-Law 43 the Council's nominations for election to the 1980–81 Council were notified to Corporate Members in the June issue of the Institution's Journal.

FOR ELECTION AS PRESIDENT

John Powell, T.D., M.Sc. F.I.E.E., F. Inst. P. (Fellow 1965, Member 1959, Graduate 1953, Student 1949, age 56) is Engineer-in-Chief of Cable and Wireless. After leaving school Mr Powell served for four years as a Radio Officer in the Merchant Service and at the end of 1946 joined Cable and Wireless. For the next ten years he held appointments at the company's stations in Gibraltar, Southern Rhodesia, Jerusalem, Transjordan and Cyprus, being appointed Engineer-in-Charge of the Cyprus Transmitting Station in 1951. In 1954 he was transferred to the development establishment in London where he worked mainly on error correcting multiplexers for radio teleprinter working. Following studies at the Polytechnic, Regent Street, he gained a London University B.Sc. general degree in Mathematics and Physics in 1955 and a year later a B.Sc. special degree in Physics. Between 1957 and 1961 he was seconded to the Post Office Research Station in Dollis Hill to work on submarine repeater development and during this period he undertook part-time study for an M.Sc. degree in Physics at the Northern Polytechnic, which he was awarded in 1959 for a dissertation on 'The theory of probes and their use in the study of ionised gases'. From 1961 to 1963 Mr Powell was Assistant Manager of the Development Laboratories and he was then appointed Head of the Transmission Section and also Project Controller for stages in the Commonwealth Telephone Cable, SEACOM. In 1965 he was promoted to Assistant Engineer-in-Chief and in 1972 became Head of Corporate Planning. Two years later he was appointed Chief Engineer (Record Systems) and following other Chief Engineer appointments he became Deputy Engineer-in-Chief; he took up his present post two years ago. Mr Powell held a Commission in the Territorial Army and Volunteer Reserve as a Lieutenant Colonel in the Royal Signals from 1958 to 1977, being awarded the T.D. in 1970.

Mr Powell has been involved in various aspects of the Institution's activities. During the fifties he assisted the Technical Committee in the preparation of its Report 'Recommended Methods of Expressing the Characteristics of A. C. Bridges' and he served on the Membership Committee from 1966–76, for three years as its Chairman. He has represented the Institution on Organizing Committees for international conferences and is currently on CEI Standing Committee B. He served on the Council from 1972–75 and as a Vice President from 1976–78 and from 1979–80 and he has been a member of the Executive Committee.

FOR RE-ELECTION AS VICE-PRESIDENTS

Harry Edward Drew, C.B., Hon. C.G.I.A. (Fellow 1948, Member 1944, age 70) is currently Chairman of Robert Stuart (London) (electroplaters) and a director of Export Packing Services (R&D) and of Quality Audit and Advisory Services; he is also an independent industrial consultant.*

Brigadier Robert William Allan Lonsdale, B.Sc., F.I.E.E. (Fellow 1971, Member 1953, age 53) is Director Quality Assurance (Technical) in the Ministry of Defence Procurement Executive.*

Samuel John Henry Stevens, B.Sc. (Eng.) (Fellow 1964, Member 1952, age 59) is Director of Aircraft Quality Assurance, Ministry of Defence Procurement Executive.*

Professor James Roderick James, B.Sc., Ph.D., F.I.E.E. (Fellow 1975, Member 1960, Graduate 1956, age 47) is Research Professor in Electronics in the Department of Electrical and Electronic Engineering at the Royal Military College of Science.†

Prabhakar Keshava Patwardhan, M.Sc., Ph.D., F.I.E.E., F. Inst. P. (Fellow 1969, Member 1959, Graduate 1952, age 52) is a Senior Scientist at the Bhabha Atomic Research Centre; he is the Institution's National Representative in India.†

* See also September 1978 Journal
† See also September 1979 Journal

H.E. Drew

R.W.A. Lonsdale

S.J.H. Stevens

J.R. James

P.K. Patwardhan

S. R. Wilkins

J. J. Jarrett

FOR RE-ELECTION AS HONORARY TREASURER

Sydney Rutherford Wilkins (Fellow 1942, Member 1935, Associate 1934, age 68) is Managing Director of Fleming Instruments Ltd. He was first elected Honorary Treasurer in 1973. (See Journal for September 1972.)

FOR ELECTION AS AN ORDINARY MEMBER OF COUNCIL

John James Jarrett (Member 1957, Graduate 1951, Student 1949, age 52) joined EMI Research Laboratories in 1945 and has continued with the company until the present, having been appointed Head of the Audio and Acoustics Department in 1977. Between 1945 and 1949 he studied at Southall Technical College for the Higher National Certificate with endorsements and in 1949 was promoted to Engineering status. Mr Jarrett's earlier work was concerned with television camera and studio equipment and for some 14 years he was with EMI Electronics working on various military projects and later was a member of a group working on pattern recognition. In 1970 he re-joined the central research laboratories as Head of the Television Department where the projects he was concerned with included single tube colour cameras and display equipment for computer tomography X-ray machines. He holds patents on a wide range of subjects.

John Jarrett has served on the Communications Group Committee since 1973 and on the Education and Training Committee from 1974 until 1976. He was also a member of the Organizing Committee for the 1977 conference on Digital Processing of Signals in Communications.

Contributors to this issue*

Robin Caine (Member 1970) received the degree of B.Sc. in physics from the University of Exeter in 1962. He then joined the BBC where he spent an initial period working in Television News on a wide variety of technical facilities. In 1964 he joined the Corporation's Research Department to work on the first all-electronic television standards converter, and he later transferred to the Engineering Designs Department. He spent the next few years designing u.h.f. equipment for television, but since 1975 he has concentrated on point-to-point transmission of high quality sound, with particular reference to p.c.m. systems. He is a member of the IERE Components and Circuits Group Committee.

* See also page 518.

Alan English studied at Harrow College of Technology and was awarded the H.N.C. in electrical engineering in 1968. He joined the Engineering Designs Department of the BBC in the same year, where initially he worked on the design of receivers for re-broadcast applications. Since then, he has concentrated on various forms of signal multiplexing, including the high-quality transmission of two video signals over the same circuit, data with sound, and more recently, time-division-multiplexed p.c.m. sound systems using companding and error-correcting techniques.

John O'Clarey studied electrical engineering at University College London, graduating with a B.Sc. degree in 1951. He joined the BBC in the same year, working first on point-to-point and re-broadcast television transmission. He is at present Head of the BBC's Designs Department's Transmission Section, which has been responsible for the design and development of various digital sound-programme transmission systems, including sound-in-syncs, and a 13-channel p.c.m. distribution system for sound programmes.

Company Profile

Growing with Racal

JOHN P. WILSON

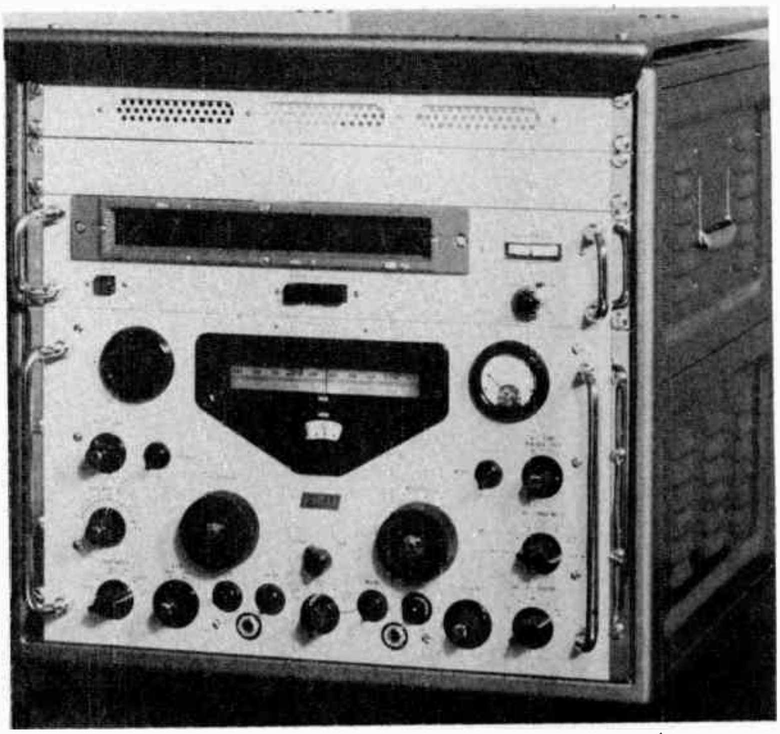


Fig. 1. The Racal RA17—Original h.f. communications receiver.

Previous subjects of 'Company profiles' published in the Journal have been relatively old-established organizations. Racal is still only about thirty years old but it is regarded both in the electronics industry and in the City as being one of the leaders by reason of its technological prowess and its commercial enterprise. This general interest article, prepared by a well-known freelance technical journalist for the company at the Institution's suggestion, describes how Racal achieved its present position and how it is building a sound structure for future expansion.

The Racal Electronics Group is a post-war phenomenon. No other British company in electronics has grown so fast or so profitably. It started buiness in 1950 with two partners, each pitching in £50 in cash and a lot of faith and enthusiasm. They were Ray Brown (now Sir Ray Brown) and the late G. Calder Cunningham.

The present chairman is Ernest T. Harrison who joined Racal in 1951 as secretary and chief accountant. He was a director by the time he was 32. Three years later he became deputy managing director. In 1966, when Ray Brown took an appointment as Head of Defence Sales at the Ministry of Defence, Ernest Harrison became chairman and managing director. Group sales in that year were £4 million. With the recent acquisition of Decca, 53-year old Ernest Harrison now heads a group of 20,000 people with sales in the coming year forecast at £500 million with profits approaching £100 million.

The remarkable performance of Racal has been achieved through good times and bad with only one year of checked performance (and that in the early days) over a span of 30 years. Otherwise it has been consistently upwards, taking employees along on the promotion ladder. Group deputy managing director David Elsbury joined Racal straight from his national service in the RAF as a line test engineer. Group technical director Geoff Lomer came from EMI as a development engineer. There are numerous examples of engineers making it to the top echelons.

Industry analysts, searching for the secret of Racal's success, comment on high returns on capital employed, of product and marketing strategy, the customer base of 150 countries insulating Racal from the effects of economic decline in any one geographical area. All true and reflecting imaginative but sound management, a necessity for success in any enterprise and not least in the competitive area of world electronics. But however sound the policies the simple fact remains that it is people who design the products, manufacture and test them, sell them, train customers and provide the service to sustain the product during its lifetime.

Of course there are many factors which contribute to a successful enterprise but they all depend on people and the Racal Group is a 'people company'. The structure of the Group, built upon comparatively small (by world standards) autonomous operating companies, each with its own management, product policy, local R & D, and marketing department, was no historical accident. It was a formula for growth of both the business and the people involved in the business, and time has proved that the formula works.

When a new market has been identified and Racal products have been established in that market it has been Group policy to spin off the activity into a separate Racal company giving the responsibility for management and further development of the business to the team responsible for the initial products and market development. Enterprise and initiative are thus rewarded and opportunity provided for demonstrating further initiatives.

In parallel with internal growth through establishing new product lines and spawning new companies, the Group has also sought growth by acquisition. This has mostly been through bright but comparatively small companies with complementary businesses, only too happy to expand within the more secure Racal environment with its management guidance and world-wide marketing contacts. An exception in size is Decca which itself has a number of separate operating divisions serving different markets and, although it is too early to forecast the eventual shape of Racal-Decca, the new acquisition clearly lends itself to the principle of self-motivating prosperous businesses in the Racal pattern.

Technological Milestones

Racal's business is communications with a central core in radio transmitters, receivers, transceivers, and systems. A number of peripheral activities support the mainstream equipment with antennas, magnetic recorders, acoustic accessories, encryption units, and test and measuring instruments. A little over ten years ago the radio business was supplemented by entry into the data communications market with high-speed modems, data terminals, multiplexers, and network control equipment. More recently still, Racal has entered the microwave market with components and systems and, with the acquisition of Decca, is now in marine radar, navigation aids, marine survey and electronic warfare, the latter being complementary to the fast-developing electronic warfare activities aready established in Racal.

Racal's start in business was virtually a two-man consultancy but a small manufacturing unit was soon set up taking in sub-contract work from other manufacturers and from the Ministry of Defence.

The company's first identifiable Racal product was a high-frequency communications receiver, the RA17, designed in the mid-50s around the triple-conversion drift-cancelling technique originated by Dr. Trevor Wadley, the technique eventually becoming known as the Wadley Loop. The idea had been canvassed round the established companies and rejected as being 'too difficult' to achieve in practice. Racal engineers undertook the project and with assistance from Admiralty engineers in the final stage of design solved the outstanding problem of internally generated spurious signals. The RA17 was the most successful general-purpose h.f. receiver of its generation with some 20,000 units sold throughout the world.

Two other notable achievements of the period were the first Racal digital counter/timer, and an unpublicized contract from the Ministry of Defence for the development and production of experimental single-sideband equipment, this providing Racal with early experience on a major new technique.

Building on the success of the RA17 the company soon developed a range of transmitters and, more important, became engaged in the development of frequency synthesizers.

In the 1960s Racal, in common with its competitors, experienced the trauma of the transition from electronic tubes to solid-state with varying results. A transistorized version of the RA17 receiver, for example, was only partially successful with the advantages of size, weight and heat dissipation offset by a degraded electrical performance. The later RA1770 series of h.f. receivers introduced in 1973 was a worthy successor and became another world leader, winning the Queen's Award for Technological Achievement.

The outstanding achievement of the 1960s was the Squadcal low-cost h.f. s.s.b. manpack for military use. It was designed for Third World armies and its essential qualities were simplicity of operation, reliability and ease of service. It was an engineering challenge in design, not so much in advanced circuits and concepts (although s.s.b. in such a set was quite new) as in value engineering, the whole set being assembled on a single large p.c.b. and packaged in a plastic case with metallized interior.

Squadcal was an instant success and was rapidly followed by Comcal with an extended frequency range and Syncal, a version in which a miniature frequency synthesizer replaced the discrete crystals of Squadcal and Comcal. These three manpacks were the spearhead which enabled Racal to penetrate an entirely new market and eventually to achieve near domination in tactical field radio with customers in over 130 countries.

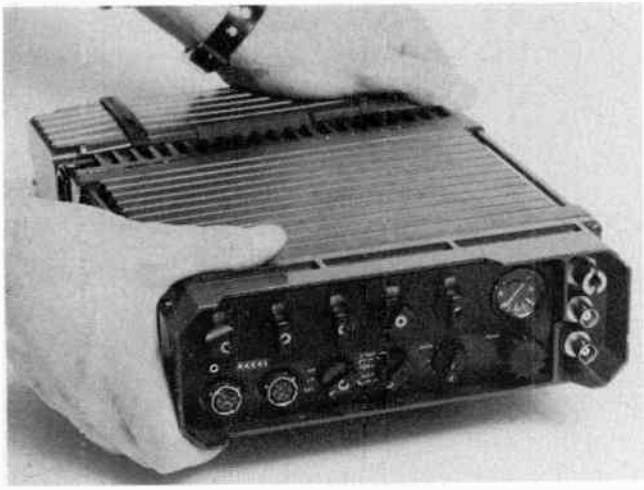
The 1960s also saw an imaginative move in setting up an operation in computer-aided design. This company, now Racal-Redac, had it first big success in the United States with Boeing and Raytheon as first customers. Racal-Redac c.a.d. systems are now used throughout the world by leading companies such as Decca, Ferranti, Rohde & Schwarz, Thomson-CSF, Sony and many others.

In 1969 the Controls and Communications group of companies merged with Racal, bringing in British Communications Corporation (BCC) who were already well advanced in the design of the v.h.f. sets in the Clansman series for the British Army. Thus, as well as Racal's own private venture manpack projects the company was now also involved in a major MOD manpack project. Racal's Clansman sales to the British Army and overseas customers are now well in excess of £100 million. The original Clansman models were added to by Racal and some modified for vehicular use. A notable achievement was research in co-siting techniques which enabled sets in close proximity (e.g. in the same vehicle) to work on nearby frequencies without mutual interference.

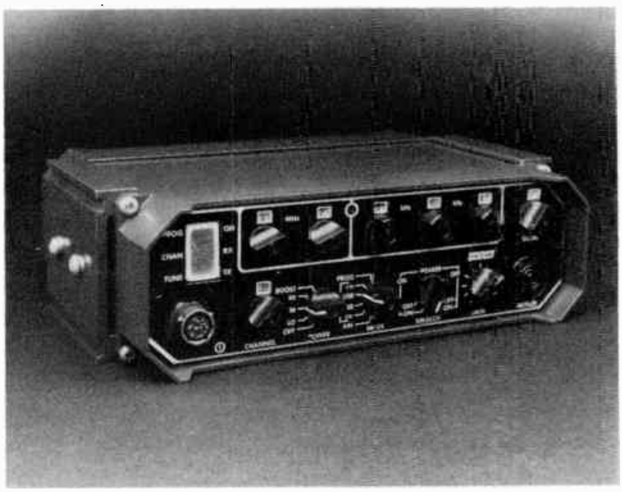
The 1970s saw the most dramatic technological growth in Racal's history. The new generation of h.f. receivers, the 1770 series already mentioned, were matched by a new generation of all-solid-state transmitters in 500 watt and 1 kW versions and a new remote control system, SCORE (Serial Control of Racal Equipment). By now, Racal was firmly in the big systems business and SCORE enabled groups of transmitters and receivers to be sited hundreds of miles away from the control centre and yet be tuned and adjusted, including switching antenna systems, over ordinary telephone lines. In a large radio surveillance centre, for example, all the receivers can be sited in an electromagnetically 'quiet' area with operators in an urban centre. With computer assistance each operator can supervise several receivers as many of the routine tasks can be automated.

Data communications was the fastest growing Racal activity in the 1970s. It started in 1969 with the formation of a 50/50 marketing company with Milgo Corporation in the United States with Racal acquiring Milgo in 1977 and another US

Fig. 2. The new Racal RA 1792 h.f. communications receiver.



(a) PRM 4031 manpack.



(b) VRM 4145 vehicle mounting.

Fig. 3. Racal–Tacticom's h.f. transceivers for military mobile communications.

company, Vadic Corporation, in 1978. Other companies have since been added to what is now called the Racal Data Communications Group to make it a world leader in the supply of data modems, both high and low speed, and ancillary equipment for data communications networks.

Racal-Datacom was established in 1974 as a specialist company in communications security equipment based originally on Comguard, a Racal development which provided time division encryption of voice signals. The product range has since been greatly enlarged with Racal-Datacom now recognized as a leading company in its field. The fundamental research on Comguard was undertaken in the Racal Advanced Development Division and once the product was proved commercially viable the new company was formed and is a good example of the Racal tradition of generating a new business and then giving young managers and engineers the opportunity to grow.

The necessarily brief review of developments outlined above brings out two important aspects. First, on the business side Racal has shown more than average ability in spotting market opportunities and reacting quickly to them. The growth figures year after year offer convincing proof of this. Second, that the technologies employed are matched accurately to applications. The customer who needs a comparatively simple solution to his problem is served equally as well as the one who demands the last word in sophistication.

The distinctive trend of the last decade has been towards the design and supply of systems. In radio communications, for example, Racal is unique in being able to supply practically all the elements in a large system from its own resources. The receivers, transmitters, antennas, remote control, recorders, encryption, modems, audio ancillaries can all be procured from companies in the Group.

Research and Development

Product development is by engineering teams at the individual companies. Local, as distinct from centralized, R & D keeps engineers in direct touch with new market demands arising from customers in their particular business or from the associated marketing team. Day-to-day contact with marketing men and the production unit gives engineers a 'feel' for the tasks in hand while also enhancing the 'family' atmosphere and providing the local autonomy which encourages self-reliance and initiative.

It was found in the early 1970s that with the great expansion programme and many new technologies on the horizon (e.g. microprocessors, v.l.s.i., s.a.w. devices etc.) it would be necessary to set-up a 'think tank' to examine in depth all aspects of new technology and how it might be profitably applied to new products. Thus, Racal's Advanced Development Division was established to undertake this type of work which would benefit the whole group and also undertake certain specific design projects for the operating companies. An ancillary operation was in microelectronics design and fabrication for producing in-house special circuits which would provide Racal products with a technological lead.

Racal Microelectronic Systems Limited has since been spun off as a separate company in its own right and last February Racal Research Limited was formed with its nucleus taken from the old Advanced Development Division.

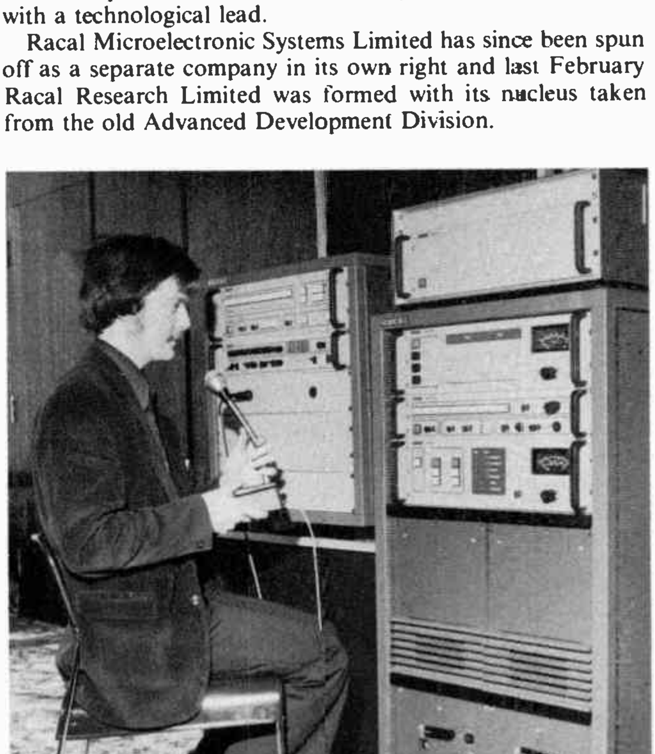


Fig. 4. System 10—low-cost 10-channel radio communications system.

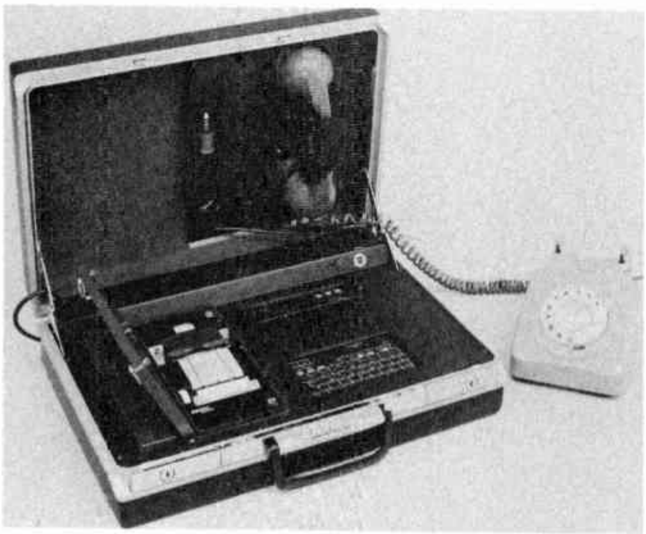


Fig. 5. Racal–Datacom briefcase teleprinter.

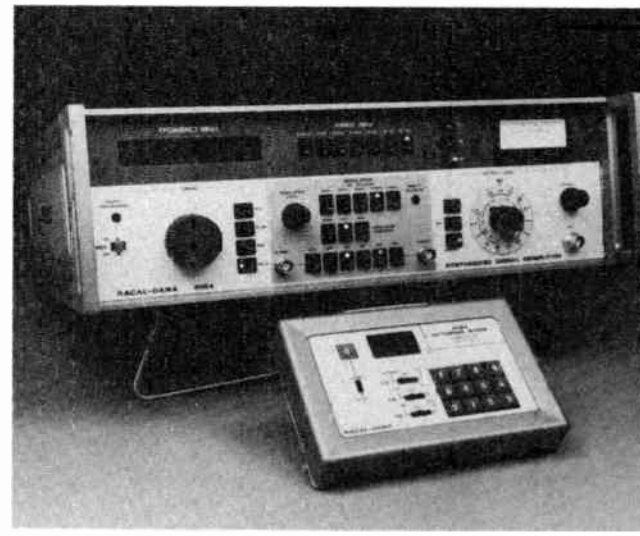


Fig. 6. Racal–Dana synthesized signal generator.

The present R & D structure is that overall co-ordination is through the Group Technical Director who provides general guidance and, through regular reports and meetings, ensures that there is adequate cross-fertilization of ideas and technologies while minimizing unnecessary duplication of effort. Racal Research and Racal Microelectronic Systems provide a service available to all the companies, and each operating company has its own development teams under the leadership of the local technical director.

Racal currently employs some 1100 people on design and development in the United Kingdom, excluding a large number in newly-acquired Decca. Their distribution varies with the type of business. Racal (Slough) engaged on highly classified advanced projects, mainly for the Ministry of Defence, employs a much higher proportion of qualified scientists and engineers than, for example, Racal-BPL producing panel meters. The largest group in numbers is in the strategic radio communications companies (products and systems) which together employ 128 QSEs plus 144 technician grades. The highest concentration is in Racal Research which currently employs 37 QSEs and three techician grades. Another area with a high proportion of QSEs is Racal-Redac in computer-aided design which has 60 QSEs and 15 technicians.

In graduate recruitment Racal expects to have an intake approaching 250 during the current year although a proportion of these will be of disciplines other than engineering. Fifty-six students reading electronic engineering and computer sciences are currently being sponsored by Racal at British universities. In addition, Racal will recruit some 100 craft apprentices during this year some of whom may well achieve graduate status in the years ahead.

The Outlook

The Racal group is exceptionally strong in the fastest-growing of all world industries, communications. The capability of the Group now extends over the whole electromagnetic spectrum from v.l.f. to microwaves and into infra-red and fibre-optic technology.

The mainstream civil and military radio and data communications business will expand strongly during the present decade and will be supplemented by rapid growth in electronic warfare systems. In the latter field Racal has recently developed direction-finding and jamming equipment and is at an advanced stage of development in a tactical frequency-hopping radio named Jaguar-V (Jamming Guarded Radio VHF). This very advanced equipment is expected to be the first of its type in service anywhere in the world. Another important growth area is in electronic simulators for which a separate company was formed last year.

In the broad field of technology it is worth noting that of 66 new equipments on display at the exhibition in London last October no less than 45 were microprocessor-based.

The acquisition of Decca has strengthened the product lines, the customer base and the design and engineering skills of the Group. The 'third force' in British electronics is now a reality with the only limit to further rapid growth being the quality and number of engineers the Group is able to recruit.

UDC 621.397.7.(41–4): 681.327.67
Indexing Terms: Television networks, Television applications, Alphanumeric display, Reception quality.

The measurement of Teletext performance over the United Kingdom television network

L. A. SHERRY, T. Eng. (CEI), F.S.E.R.T.*

and

R. C. HILLS, B.Sc.(Eng.) Hons, C.Eng., F.I.E.E., F.I.E.R.E.*

SUMMARY

This paper summarizes the results of extensive Teletext field trials conducted in the UK between March 1976 and March 1978.

Consideration is given to the Teletext performance of the u.h.f. television network, the extent of reception in the homes of viewers and the performance of Teletext decoders.

The results indicate that the service will be predominantly field strength limited provided viewers use well-installed outdoor aerials.

It is suggested that data regeneration may be used to advantage to ensure the highest possible standards of radiated performance from certain stations. This is because, to a large extent, transmitter group delay errors become more significant for Teletext than for television.

The paper concludes that an adequate Teletext service is available to a high percentage of the existing television audience, provided production receivers have a decoding threshold approaching 25% eyeheight. However, it is noted that many current production receivers fall considerably short of this performance.

* *Independent Broadcasting Authority, Crawley Court, Winchester, Hants SO21 2QA.*

Glossary of Terms

Teletext The generic name for the UK information broadcasting system in which pages of text and graphical symbols are transmitted in coded form on otherwise unused television lines during the frame interval.

ORACLE The name given to the Teletext service of Independent Television.

CEEFAX The name given to the Teletext service of the BBC.

Relay station A non-demodulating repeater station employing frequency transposition techniques with output powers up to 1 kW which derives its composite input signal by off-air reception of a parent station.

Rebroadcast link (*RBL*) A conventional baseband transmitter which derives its video and audio input signals by off-air reception of a parent transmitter.

Eyeheight In a noise-free data signal the eyeheight reflects the smallest difference which may exist between any 'zero' pulse and any 'one' pulse over all signal sampling positions. It is expressed as a proportion of the basic amplitude.
(Eyeheight values quoted in this paper were made before this definition was agreed upon and include reductions due to noise. See Appendix 1.)

Eyewidth In a noise-free data signal the eyewidth is the interval over which true data results from a comparison of the signal with a specific decision level. It is expressed as a proportion of the bit period.

Decoding margin In a non-return to zero (NRZ) data signal the decoding margin reflects the greatest difference which may exist between extreme logical decision levels for a given bit error rate, when the signal samples are referred to the run in timing and are equally spaced at the data rate. It is expressed as a proportion of a specified basic amplitude.

Decoding threshold This term relates to a terminal which accepts an input data signal and which provides output characters primarily intended for display. For a given degradation of a particular input signal, the decoding threshold is the smallest acceptable decoding margin of the input signal, for a defined character failure rate.

Clock cracker A one-page sequence of characters designed to test clock extraction circuits. Alternate ÷ and □ characters are transmitted which produce a data stream with minimum transitions and maximum one bits.

Data bridge Equipment used asynchronously to transfer Teletext data from one video circuit to another. Usually used in conjunction with an interval test signal inserter.

Data regenerator Equipment used to decode a distorted data signal and re-insert it on the same video circuit.

0033–7722/80/090503+16 £1.50/0

1 Introduction

Three services of television are presently available to over 98% of the population of the United Kingdom. Two of these are provided by the BBC (BBC–1 and BBC–2) and the third by Independent Television (ITV–1). A fourth service is in course of engineering development and will also be provided from the Independent sector. The organization and provision of the networking and transmission facilities both for ITV–1 and for the future channel are the responsibility of the Independent Broadcasting Authority. The present three services are transmitted on u.h.f. and in colour using the 625-line standard to CCIR System I parameters and PAL coding and are regarded as the principal services to all areas of the country. Two services (BBC–1 and ITV–1) are also available on v.h.f. with the obsolete 405-line monochrome standard but this is due to be phased out between now and 1986.

The siting and frequency allocation for all 51 of the main transmitters for this national u.h.f. network was based on the work of the Stockholm 1961 Conference[1] and provides for four u.h.f. channels to be assigned at each transmitter site. The arrangement of these allocations is such as to minimize co-channel interference in any particular area. Programme signals are routed to certain of these transmitters by baseband links (cable or microwave radio). The remainder rely upon direct reception of a parent transmitter and full demodulation to baseband. In addition, and to complete the coverage, there are a very large number of non-demodulating relay stations employing frequency transposition techniques. These stations all rely by definition upon reception of a parent station for their input signal: the parent may be either a main station as described, or another relay station. This network of main and dependent stations is such that in a number of cases there may arise cascaded chains of stations up to five or six in number, all relying upon reception of the up-stream station for their signal, and reflecting the accumulated distortions of the signal both by reason of equipment performance and propagation variations on the earlier links in the chain.

Programme signals for both BBC services are, apart from occasional regional variations, originated in London and distributed to the main transmitters through a British Telecommunications network which is essentially static in its connection.

The Independent Television network is complicated by the need to have a full regional broadcasting system and, at the same time, allow any one of 15 regional Programme Companies to export their programme to other parts of the network. The concept is highly flexible and the import and export of programmes and advertisements on the network is changed minute by minute by an elaborate network switching system operated by British Telecommunications.

2 The Teletext Service

In June 1975, a pilot service of data broadcasting was started in the UK which became known as Teletext. The system uses spare lines in the vertical blanking interval of the normal composite television video waveform to convey data which can be displayed, optionally with the normal picture, on a specially adapted domestic receiver.

Broadcast Teletext is currently available on the 625-line colour services of Independent Television (ITV–1) and the BBC (BBC–1 and BBC–2). Within Independent Television the service is known as ORACLE (an acronym for *O*ptional *R*eception of *A*nnouncements by *C*oded *L*ine *E*lectronics). The corresponding BBC service is called CEEFAX (See Facts). The technical standards of all three services are identical.

The data is carried as a serial stream with appropriate parity and error correction. It is arranged so that each television line (64 μs) carries data equivalent to one line of text on the television receiver display: each line of data is preceeded by a series of clock run-in pulses to enable the decoding circuitry to phase lock to the incoming data. Two such lines of data accompany each field of the television picture signal, using CCIR lines 17(330) and 18(331) on odd and even fields. These requirements impose restrictions upon the choice of bit rate which may be used. A bit rate of 6·9375 Mbit/s was proposed in the initial draft 'Specification of Standards for Information Transmission by Digitally Coded Signals in the Field Blanking Interval of 625 Line Television Systems', published jointly by BBC, IBA and BREMA in October 1974. Before this bit rate could be agreed for the final specification, it was considered necessary to know what percentage of the existing television audience would be able to receive an adequate Teletext service without placing new and onerous requirements on the maintenance of technical performance of the existing broadcast networks. It was also considered necessary to know if existing television waveform testing would be sufficient to ensure adequate quality of the Teletext data stream or if new tests would be necessary to monitor the performance of the distribution and transmitter networks. It must be borne in mind that the performance of the transmission equipment installed in the period 1965–1973 to provide the u.h.f. colour services was specified in terms of conventional television waveform tests. Early monochrome tests were retained and others were developed specifically to measure distortions on the chrominance signal. Similar tests have been used to maintain an acceptable quality of the radiated picture signal under operational conditions. It was not until 1973, when the very first experimental broadcast Teletext transmissions were made, that the response of this transmission equipment to a data stream with a bit-rate in excess of the system video bandwidth (5·5 MHz) became of interest.

3 Programme of Field Trials

In February 1976, by which time Teletext signals were regularly available on all three services, a series of field trials was initiated to provide answers to these questions and by May 1976 sufficient data had been collected and analysed to enable the Authority to confirm with a high degree of confidence that the proposed bit rate would be acceptable. However, the early results raised further questions and the field trial work was extended to cover other areas and was completed in March 1978.

During this period some 25,000 Teletext and related television parameters were measured and analysed. The work included a detailed assessment of the response of the u.h.f. television network to transmission of Teletext data, followed by tests and measurements in viewers' homes in various parts of the country. These tests have included measurements of u.h.f., v.h.f. and h.f. distribution systems and dedicated aerial installations.

A full vehicle-based survey was made in two relay station service areas. This work has established a correlation between field strength and Teletext reception and it has enabled a comparison to be made between the Teletext performance of the medium-gain aerial system used and the performance of the average domestic aerial installations of the earlier tests.

A further activity, which has continued in parallel with the field trials, has been the investigating of specific complaints of unsatisfactory Teletext reception. This has led to decoding margin tests being made on several commercial receivers. Although the tests do not present a comprehensive survey of the current decoder market, they are reported in order to indicate the standard of performance of decoders which were available at the time of the field trials.

This paper summarizes the results of all the field trials and suggests areas where performance may be improved.

4 Measurement Techniques

At the outset it was decided to assess the quality of the ORACLE data stream by making classical eyeheight measurements, backed up by a subjective decoding test using a commercial decoder. A definition of eyeheight and methods of measurement are covered in Appendix 1.

Although there are now moves to introduce the concept of decoding margin as a practical measurement of data quality, throughout the field trials eyeheight was measured in the presence of noise and non-linearity.

Eyeheight measurement, which is made by displaying the Lissajous figure produced by the data stream and a sinewave sub-multiple of the clock frequency, proved difficult in practice. This is because the height of the displayed eye diagram depends not only upon the inter-symbol interference on the data stream but also upon the phase stability of the clock waveform. Since the clock waveform must be regenerated from the distorted data stream, its phase stability will depend upon the degree of degradation of the data stream and the ability of the clock recovery circuits to produce a waveform without phase jitter.

Accurate measurement of eyeheight using a Lissajous display was not possible in the field until a precision adjustable eyeheight source was developed in IBA laboratories. This equipment is known as DELPHI[2] which is an acronym for *D*efined *E*ye *L*oss with *P*recision *H*eld *I*ndications.

This precision source of degraded eyeheight was used to develop and calibrate suitable clock recovery circuits to be used for Lissajous eye diagram displays. Whilst this work was progressing, an alternative method of assessing the quality of the data stream had to be found to allow the field trials to proceed. During the early field trial work it was noted that there was often a correlation between the Lissajous eye diagram and the amplitude of that part of the data stream which was unaffected by overshoots. Whenever this correlation was poor it could be considerably improved by adjustment of the clock recovery circuits in the eyeheight measuring equipment. Based on this correlation, a method of assessing data quality by direct inspection of the data stream on an oscilloscope was used for the early field trials. When more reliable clock recovery circuits were developed, a very good correlation was obtained between Lissajous eyeheight and direct inspection of the data stream. The latter has become known as 'tramline' eyeheight. The method of measuring tramline eyeheight and its correlation with Lissajous eyeheight are described in Appendix 1.

In making any evaluation of the potential Teletext audience, a specification for the domestic decoder must be assumed, This performance can be specified in terms of the lowest input eyeheight which will give a defined character error rate. Eight character errors on first write of a page was chosen as the limit of acceptable decoding, which corresponds to approximately 1 in 10^3 bit errors and it was provisionally agreed with BREMA that production receivers should meet this decoding performance provided the eyeheight was in excess of 25% at the aerial input.

Subjective decoding tests were made at all field locations using a domestic decoder which would meet this specification. The decoder had a manual preset data slice level control which was optimized at each location on the channel with worst Teletext reception and was not readjusted when changing channels at that location.

Linear television waveform measurements were made at each location using conventional measuring techniques together with video signal/noise ratio or field strength.

A subjective assessment was made of picture quality and impairments due to:

noise	co-channel interference
ghosting	impulse interference

The vehicle-based surveys used a 10-element domestic Yagi aerial mounted on a 10 metre telescopic mast with 15 metres of solid dielectric domestic quality feeder. To simulate the range of aerial positioning available on a typical house chimney, restrictions were placed on aerial adjustments. Once a location was chosen, the aerial height was adjusted in the range 8–10 metres above ground level and panned to optimize picture reception. A lateral movement of ±0·5 metres at right angles and in line with the direction of propagation was allowed, but for practical reasons the tilt of the aerial was not adjusted.

The energy spectrum of the Teletext data signal used, for all except the London field trials, was Gaussian truncated at 5·8 MHz. For the field trials conducted in the London area it was more convenient to employ a truncated raised cosine energy spectrum. In practice these two energy spectra are very similar, and do not affect the validity of the results.

5 Transmission Survey Results

5.1 The Distribution Network

Although as explained earlier, the ITV–1 system is basically a regional one, at the present time the ORACLE service is only originated by the Programme Companies in London. A national service is then provided by the use of asynchronous data bridges installed in each region. These data bridges allow ORACLE data to be inserted on the transmitted signal when a Programme Company is providing a local programme by 'bridging' the data from its incoming network feed. Similarly, data may be bridged from an incoming network feed to an outgoing network feed when a regional Programme Company feeds the network.

The Teletext data signal therefore often follows a long and varied path from its source to the viewer's receiver and is subjected to many forms of distortion which have been quantified by the field trials. The performance of the ITV distribution network was quantified by measuring the quality of a Teletext data signal originating from London at the input of each of the regional IBA transmitter networks. The mean received eyeheight at 19 such locations was 82% with a standard deviation of 7%. Although data bridges were not operational when the measurements were made, the performance of a typical network can be deduced from the results. Figure 1 shows a typical configuration of the present distribution network and its eyeheight performance based on the measurements made.

In the network configuration shown, the ORACLE data originating from its source in London passes via the British Telecom network to the Programme Contractor providing the network programme source. The ORACLE data is bridged onto the network programme source at this stage and is distributed via the BT-network to the local studios in each region. A further data bridge is used to allow the local studio to bridge data on to its locally generated signals such as advertisements.

The distribution network presents no real problems to the transmission of Teletext data because, although the network constraints mean that the data signal may have to take a very indirect route to its ultimate destination, it is regenerated by each data bridge.

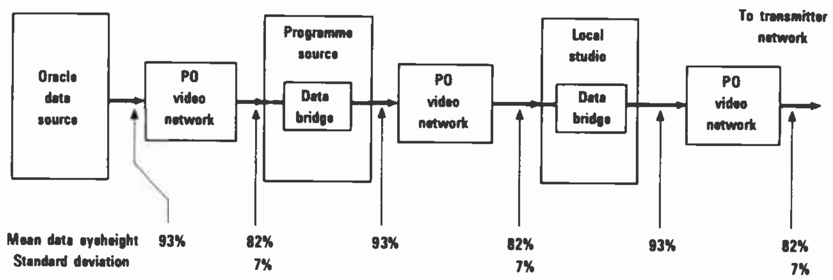


Fig. 1. Typical degradation in data quality on the ITV distribution network.

5.2 The Transmitter Network

To quantify the performance of the transmitter network in terms of Teletext signal degradation, three specialist teams made measurements of the quality of the data signal transmitted from 148 stations throughout the United Kingdom.[3] Nearly all main stations and high power relay stations were measured and a significant sample of measurements was obtained from the lower power relay stations serving populations of 10,000 viewers or less.

Although the transmitter network sometimes consists of up to four rebroadcast-link-fed transmitters in tandem and up to five transposers fed in tandem from a main transmitter, over 99% of the television audience receives its programmes from one of the transmitter configurations shown in Fig. 2. This Figure therefore summarizes the degradation in data quality found on the IBA transmitter network and the results are shown as histograms in Fig. 3.

No special checks or adjustments were made on the transmitter network prior to the measurements, so the results indicate the Teletext performance of a network, as found, maintained for adequate television performance.

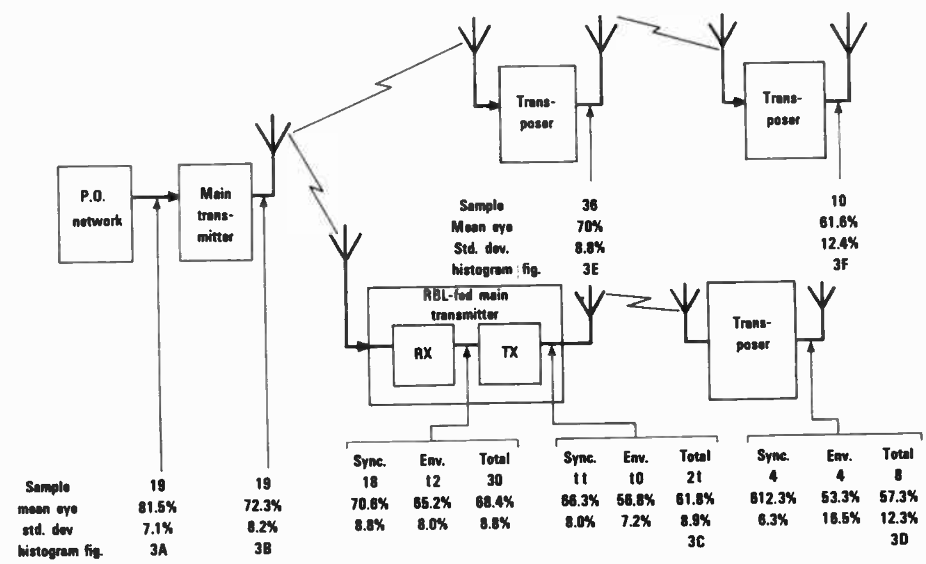


Fig. 2. Typical degradation in data quality on the IBA transmitter network.

Significant points to note from the results are:

Although the mean value of the transmitted eyeheight reduces as the number of tandem equipments is increased, generally the standard deviation or spread of results does not increase.

Rebroadcast stations, where the television signal is demodulated to baseband, produce a greater reduction in Teletext eyeheight than do transposer stations, where frequency conversion is achieved by use of an intermediate frequency. This is caused by the group delay problems associated with sound notches in RBL receivers and transmitters combining units. The common sound and vision conversion approach of a transposer does not involve such notches and therefore degrades Teletext eyeheight to a lesser extent.

The Teletext performance of rebroadcast stations, using receivers with envelope detectors, is significantly worse than similar stations using receivers with synchronous detection. This is not due in total to the theoretical difference in performance between envelope and synchronous detection.[4] The receivers with envelope detectors are an early version of the current IBA design and have an inferior group delay performance, particularly at high video frequencies which causes additional reduction in eyeheight.

The reduction in data eyeheight caused by transposers is quite low. An average reduction in eyeheight per transposer is about 4%. Figure 4 shows eyeheight measurement on a chain of five tandem transposers.

5.3 Problem Areas

Clearly the most significant loss of data quality occurs in re-broadcast link stations equipped with the early version of receiver with envelope detection. However, it was also noted during investigations that on some commercial receivers, signals which had passed through a rebroadcast receiver with an envelope detector were more difficult to decode than other signals with the same eyeheight. This happens because quadrature distortion produced by an envelope detector reduces the width of the eye diagram to a greater extent than its height. The reduced eyewidth makes more difficult the task of extracting a jitter-free clock signal within the decoder.

Figure 5 shows the eye shape of a received signal demodulated by receivers with both envelope and synchronous detectors. The former is characterized by a vertical asymmetry of the pattern and a consequent reduction in eyewidth when sliced at the half-amplitude level.

During analysis of results, an attempt was made to correlate poor Teletext data quality with measured linear waveform distortions such as $2T$ pulse K factor, pulse-to-bar ratio and chrominance luminance gain and delay. No such correlation was found. However, during subsequent investigations of transmitters with below average Teletext performance, it was generally found that the group delay characteristics were poor.

Transmitters with group delay errors which produced echoes close to the main $2T$ pulse produced poor Teletext eyeheight but a good $2T$ pulse K factor because the subjective effect of a very short term echo is quite acceptable on normal pictures.

5.4 Data Regeneration

Provided the Teletext bit-stream can be decoded correctly, its characteristics can be restored to those of the original source by regeneration. At the present time, regeneration of the bit-stream must be done at video and can therefore only be applied where the baseband signal is available, e.g. the input to a transmitter. It is capable of correcting errors produced by envelope receivers, but not those caused by group delay errors in the transmitter itself.

Regenerators are ideally suited to use on RBL-fed main stations. Here they are able to correct for:

quadrature distortion in the envelope RBL receiver,
disortion due to selective fading on the RBL path,
noise introduced by the RBL receiver,
group delay errors in the parent transmitter.

There is little advantage to be gained from using regenerators at main stations fed by cable or microwave link. The average eyeheight performance of all such IBA transmitters is 72% (see Fig. 2). Tests have shown that the average performance of a sample of 10 transmitters fed directly from data regenerators is of the same order but the standard deviation of the results is halved.

Data regeneration cannot be used at transposer stations because the signal is only converted to i.f. However, the need is not present to the same extent since eyeheight degradation occurs much less in transposers. This is because current transposers are broad-band to accommodate combined sound and vision working and, since they have no sound notches, they do not introduce group delay errors at high video frequencies.

High-power transposers of the future may separate sound and vision i.f. signals in the interests of efficiency. Such a design of equipment will need to be well specified in terms of Teletext, since the possibility of group delay error remains, but regeneration is not currently available.

6 Teletext Reception in Homes

6.1 Homes with Discrete and Communal Aerials

Four surveys of Teletext reception in viewers' homes have been made in various areas of the UK. The aim of the surveys was to calculate the potential Teletext

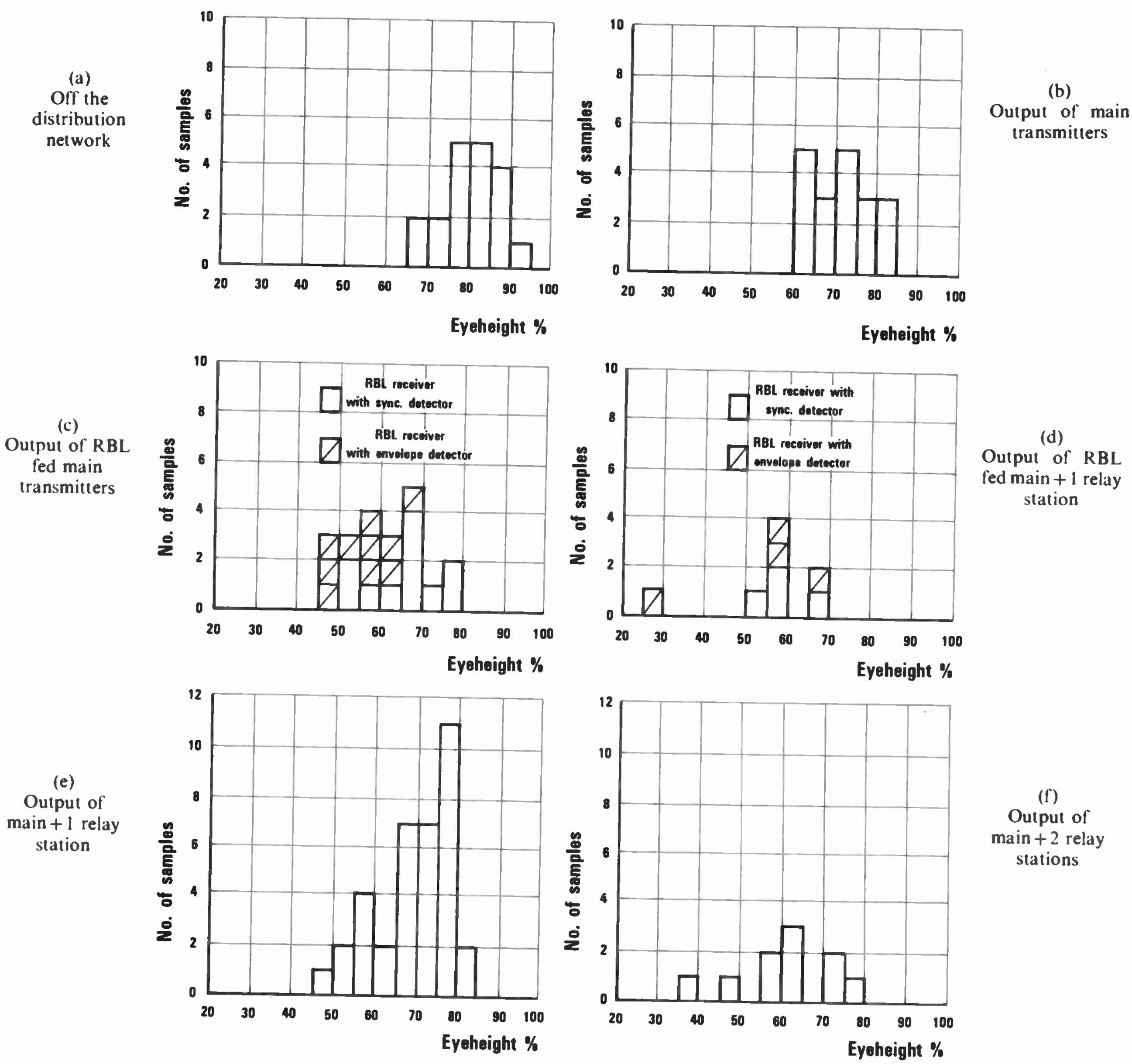


Fig. 3. Histograms of the distribution of eyeheight for various points in the transmission network

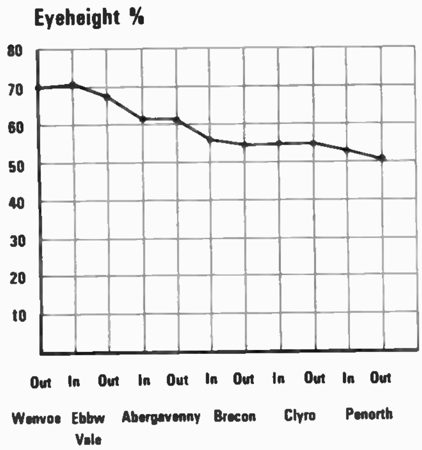


Fig. 4. Eyeheight degradation in 5 tandem transposers

audience and to find out how well the Teletext service performed using existing domestic aerial installations and to note any differences between urban and rural areas.

The areas chosen were:

Rural Hampshire in the immediate vicinity of IBA Engineering Headquarters at Crawley Court near Winchester. The population sample number was 29 consisting predominantly of IBA engineering staff.[3]

Central and surburban London. Here the population sample of 46 was mainly the homes of non-technical broadcasting staff in the area. 24% of the sample of London viewers live in apartments but the buildings are generally not very tall and in most cases would have less than 10 floors.[5]

South Wales. This location was chosen because it is a fairly well populated hilly area which is difficult to provide with a television service. It is an area of some 450 square miles served by 35 relay stations. The population sample of 42 homes was chosen from among local IBA staff and through television dealer contacts.[6]

The Yorkshire Dales. This area was chosen to further reinforce the experience of problems encountered in the South Wales valleys. The population sample of 58 homes came mainly from customers of a receiver rental company.[7]

(a)
(b)

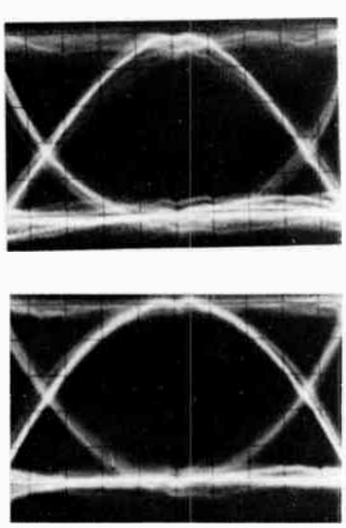


Fig. 5. Comparison of eye diagrams of envelope and synchronous detectors. (a) Asymmetrical eye diagram produced by envelope detection. Note the reduction in eye width at the half amplitude level. (b) Symmetrical eye diagram produced by synchronous detection

The tests in the homes of viewers were made in two parts. The first comprised the measurement of received eyeheight at the wall aerial socket using professional receiving equipment. The criterion used for prognosis of satisfactory Teletext reception was an eyeheight greater than 25%. The second involved making a subjective Teletext decoding test with a commercial integrated decoder to establish where signals could indeed be decoded. The tests were made on both IBA and BBC1 channels, togther with BBC2 if it was on-air at the time. This is possible because all three channels share the same transmiting site and receiving aerials.

The first series of tests in Hampshire proved very encouraging and, based on reception results in that area combined with the measured performance of the distribution and transmitter networks, it was calculated (using techniques described in Appendix 2) that some 97% of viewers throughout the UK could expect to receive an adequate Teletext service. Further tests in London suggested that the coverage in cities and urban areas was likely to be nearer 94%.

Problems were encountered in South Wales for two reasons. Firstly, there is a tendency among viewers in South Wales to try to receive additional programmes from stations beyond the particular local service area. This is because many programmes in this area are transmitted in the Welsh language and some viewers wish to have alternative source of programme in English. The receiving aerial is often optimized for the distant station and may even be of group or polarization unsuited to the local station.

The second problem came to light some time after the tests had been made, when it was discovered that the transmitting aerial of the parent station in the area had been faulty during the tests. For these reasons, the figure of 78% Teletext coverage for the area must be treated

Table 1

Summary of results of domestic teletext surveys

Survey Area	Homes Visited	Ratio of mean received to transmitted eyeheight	Standard deviation of received eyeheight	Eyeheights greater than 25%
Hampshire	29	0·85	16%	96%
London	46	0·84	18%	94%
South Wales	42	*	*	78%*
Yorkshire	49	0·85	17%	94%

* Transmitter aerial fault. See text

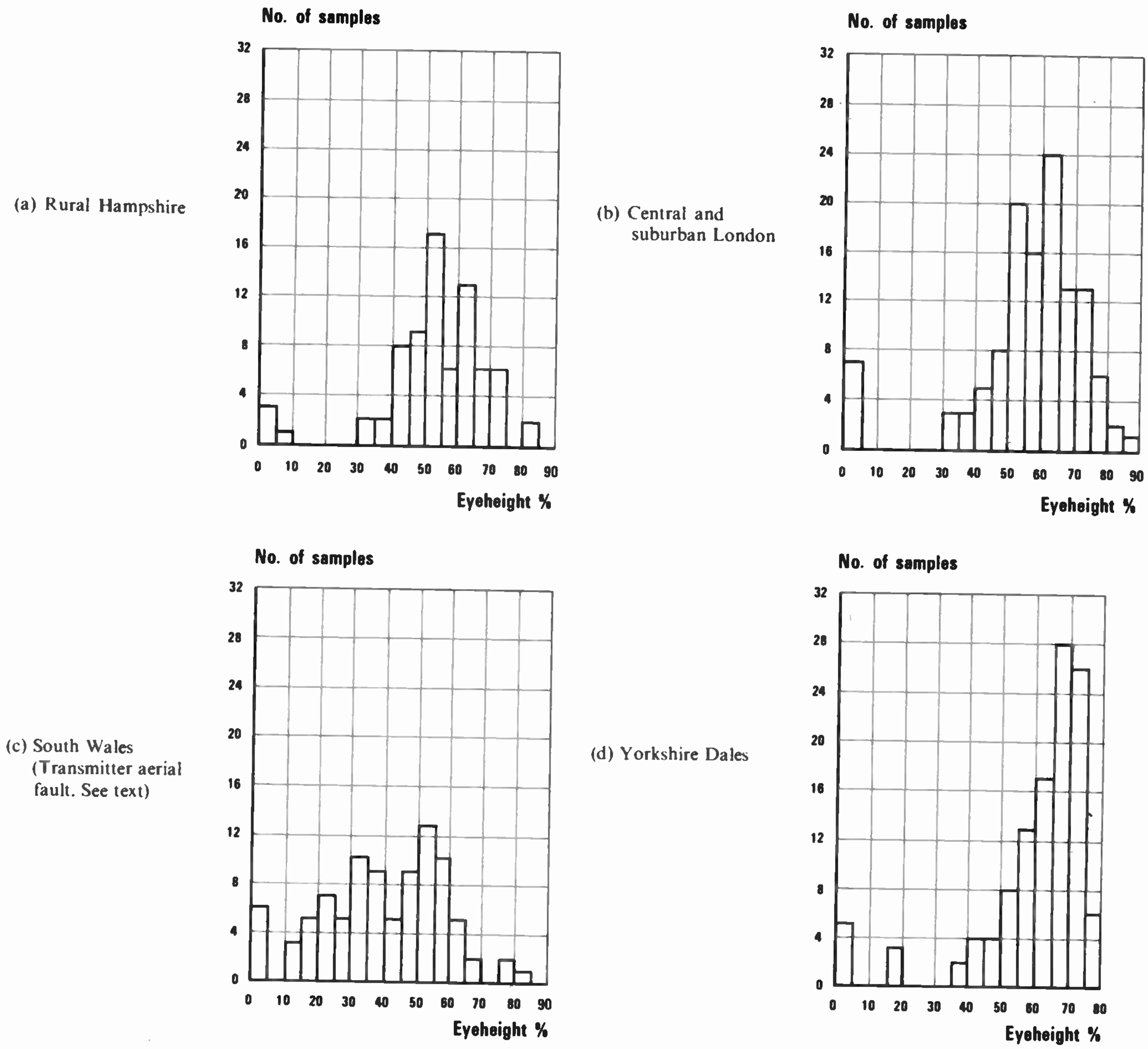


Fig. 6. Distribution of received eyeheight data measured in viewers homes (All 3 u.h.f. channels)

with considerable suspicion. Because of these problems, it was decided to conduct another survey in a similar area and the Yorkshire Dales were chosen. The results here were much more satisfactory with some 94% of the sample population able to receive a Teletext service.

In analysing the survey results, a constant has emerged which is common to all domestic survey results. It is the ratio of the mean received eyeheight in the service area, to the transmitted eyeheight. For existing domestic aerials this constant is about 0·85.

Table 1 shows a summary of the results of the domestic surveys and Fig. 6 shows the distribution of received eyeheight data for each area surveyed.

During the domestic surveys, Teletext reception was impossible at 19 locations. Some of these locations were excluded from the survey analysis because a set-top aerial was used, or in some cases an outdoor aerial of a wrong channel group. One viewer was using a v.h.f. Band III aerial for u.h.f. reception.

In a sample of television viewers taken at random, it is generally found that some 4% do not receive what can be regarded as adequate colour television pictures. However, it is interesting to look at the cause of the Teletext failure in each case. The failures have been classified into three causes, weak signal, reflections, or a combination of both. The pie diagram of Fig. 7 shows how these causes are distributed.

The pie diagram suggests that the most important consideration in Teletext reception is the need for adequate signal strength. Meteorological changes and

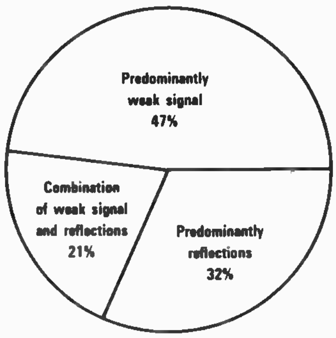


Fig. 7. Causes of Teletext failure with existing aerial installations

changes in ground reflections can affect u.h.f. propagation and in a multipath situation can produce various degrees of distortion of the video signal, and during the field trial it was noted that the value of eyeheight received off-air varied considerably with time due to changes in propagation conditions. However, since all the field measurements were done at fairly random time intervals and over a long period of time, it is considered that they will reflect the time variance of the eyeheight data. The calculation of potential Teletext audience will reflect this variance since some of the low eyeheight values recorded would have been due to adverse propagation conditions at the time of measurement.

A simple a.g.c. system may be used to advantage to maintain a constant chroma amplitude during varying propagation conditions but little can be done to maintain a constant eyeheight short of using broadband adaptive equalization circuits.[8]

6.2 Wired Distribution Systems

Surveys of wired distribution systems have not been extensive and the results have been varied. Since the number of households in the UK served by wired distribution cable systems is in the region of 2·6 million (12% of the population), they represent a considerable proportion of the total.

The results of the limited surveys indicate that, with well-maintained wired distribution systems, data eyeheights of greater than 25% can be expected at most subscriber outlets.[9]

U.h.f. and v.h.f. systems present few problems provided impedances are reasonably well matched. It is the h.f. distribution systems which have presented the majority of problems. These systems were found to have a rapid degradation of eyeheight with length of feeder route and h.f. to u.h.f. conversion produced considerable reduction in eyeheight in some cases. However, one h.f. distribution system was found to give Teletext performance quite on a par with discrete aerials when measured with a high performance h.f. demodulator and the received eyeheight data for this particular system is shown by the histogram of Fig. 8.

7 Mobile Vehicle Surveys

The surveys conducted in the homes of viewers indicate whether Teletext reception is possible with each existing aerial installation. Such tests are of limited objectivity for two reasons. Firstly, it is difficult to canvass viewers to obtain a random sample representative of any complete service area; secondly, the results are dependent on the quality of each viewer's domestic receiving installation. The latter factor precludes making a direct comparison of available picture quality and renders impossible the measuring of field strength.

To obtain more objective data on Teletext reception, vehicle-based surveys were made in two relay station service areas.[10] The first was a Band V transposer station (Abergavenny) in South Wales and the second a Band IV transposer (Hebden Bridge) in the Pennine foothills area of West Yorkshire. Measurements were made at random locations throughout these two areas at a density of approximately one location per square kilometre in the Band V service area and four per square kilometre, to obtain a significant sample, in a much smaller Band IV service area.

The object was to simulate as closely as possible a well installed domestic aerial at roof height and the installation described towards the end of Section 4 was used for the tests.

The results of the survey were very encouraging in that Teletext reception was possible at every location where the field strength exceeded the service area boundary contour value. Pockets of field strength below the boundary contour value do occur within the service area, due to local obstructions.

A scatter diagram of eyeheight and field strength for the Abergavenny survey is shown in Fig. 9.

The scatter diagram illustrates the fact that all eyeheights of less than 25% occurred when the field

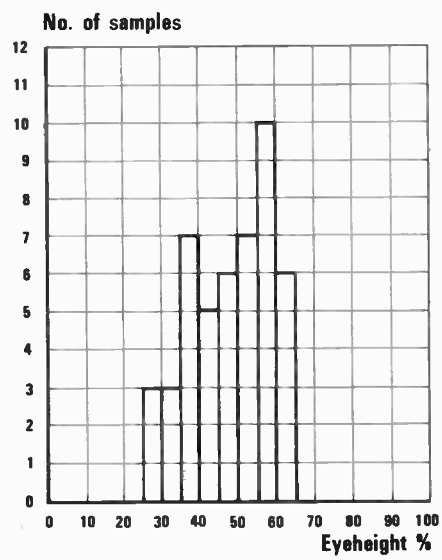


Fig. 8. Distribution of eyeheight data measured on an h.f. wired distribution system

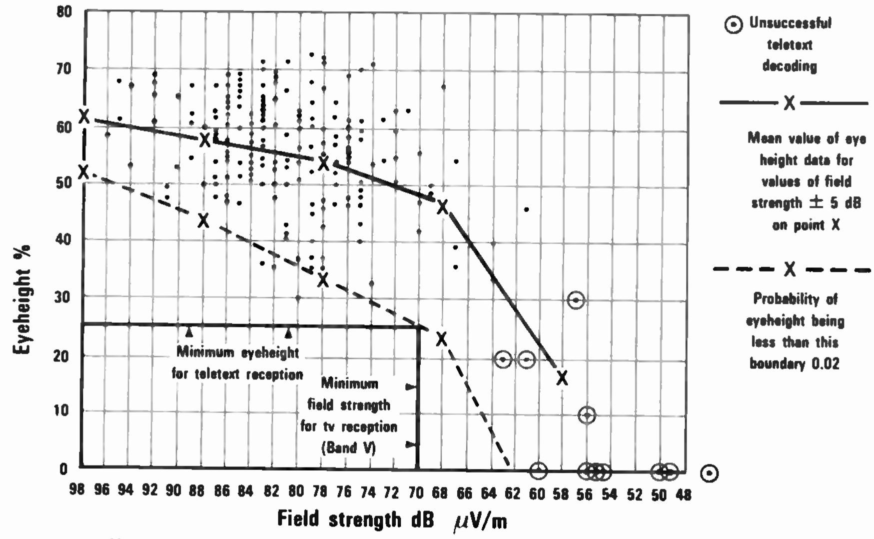


Fig. 9. Scatter diagram of measured field strength and eyeheight

strength was less than 70dBμV/m. The scatter diagram also shows that the eyeheight values drop quite sharply when the signal strength is weak.

The results of the vehicle survey are summarized in Table 2, so that they may be compared with the domestic survey results shown in Table 1.

Table 2

Summary of results of vehicle surveys

Survey Area	Locations Visited	Ratio of mean received to transmitted eyeheight	Standard deviation of received eyeheight	Eyeheights greater than 25%
Band V (Abergavenny)	88	0·90	13%	95%
Band IV (Hebden Bridge)	71	0·91	12%	99%

In comparison with Table 1, the ratio of mean received to transmitted eyeheight is improved from 0·85 to about 0·9 and the standard deviation reduced from 17% to about 13%. From these comparisons, it can be seen that a correctly-installed, medium-gain, outdoor aerial offers significant improvement in eyeheight reception over a typical domestic installation.

The very high percentage of eyeheight greater than 25% in the Band IV service area warrants further explanation. In planning this coverage area, a high level signal from a co-channel station was predicted in the service area for a significant percentage of time. The service area was therefore planned for a median field strength of 80 dBμV/m, instead of the normal 64 dBμV/m, to offer adequate protection against the interfering signal.

During the survey, the interfering signal strength was low. The fact that 99% of locations had eyeheights greater than 25% is attributed to the high median signal strength in the area which once again confirms that adequate signal strength is a prerequisite of good Teletext reception.

It is also interesting to compare the reason for Teletext failure during the vehicle-based survey with the reason for failure in viewers' homes (Fig. 7). If the failures are again classified into three causes, weak signal, reflections or a combination of both, the pie diagram of Fig. 10 can be constructed.

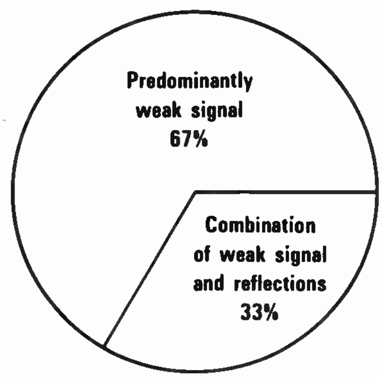


Fig. 10. Causes of Teletext failure with survey vehicle aerial

The pie diagram again shows that weak signals play a part in all Teletext failures when using the survey vehicle aerial installation. There was no instance where, with adequate signal strength, Teletext failed solely by reason of reflections. This reinforces the argument that an adequate signal strength is required for good Teletext reception.

During the vehicle surveys, tests were made to determine the effect of aerial panning on Teletext eyeheight. At several locations, the vehicle aerial was panned ± 50° off boresight (line of maximum signal strength) in 10° steps and the eyeheight measured. In all cases maximum eyeheight correlated with maximum signal strength, although in some cases eyeheight fell rapidly only 10° off boresight suggesting that optimum aerial alignment may be more critical for Teletext.

8 Teletext Decoder Performance

In addition to the Teletext field trials, IBA have investigated complaints of poor Teletext reception received from viewers, dealers and industry. As a result of these investigations, the performance of several commercial decoders has been checked and problem areas highlighted.

8.1 A.F.C. Action

The first problem occurred with the decoder used for the surveys when, in the London area, it was found that the correlation between eyeheight and decodability of the data stream was poor. It was found that tuning the receiver on picture did not necessarily ensure correct Teletext decoding. When tuning was optimized for Teletext decoding, much better results were obtained, although this did not degrade the picture quality. This indicates the need for a high-gain a.f.c. loop to provide repeatability in tuning.

8.2 Adaptive Slice Circuits

A further problem, on a different decoder, was caused by the adaptive slicing circuit. On this decoder it was found that the adaptive slice voltage varied by as much as 40% of the data amplitude throughout the duration of the data stream. This introduced decoding errors on all but the best quality data signal. A fixed slice level gave a much greater decoding margin.

8.3 Group Delay Errors

One complaint was investigated where signals which would decode perfectly on one receiver would not decode on another sample of the same receiver. This was traced to considerable spreads in the group delay performance of the i.f. amplifier. The problem occurred because the manufacturer only adjusted the i.f. amplifiers for amplitude-frequency response, which resulted in considerable spreads in group delay performance and hence spreads in Teletext performance.

8.4 Surface Wave Acoustic Filters

Some tests were made on a commercial receiver which used surface wave acoustic filters in its i.f. amplifier. This receiver produces very little reduction in eyeheight in its r.f. circuits and the overall performance is determined almost entirely by the performance of the Teletext decoder.

8.5 Reduced Eyewidth

A number of complaints were investigated of poor Teletext decoding in the service areas of transmitters fed from RBL receivers with envelope detectors. The reason for this was not discovered for some time because the eyeheight of the data stream was quite adequate for decoding. It was also noted that errors were occurring on only one type of decoder. On other types, decoding was error-free. The problem was eventually traced to reduction in eyewidth caused by the envelope RBL receivers (see Sect. 5.2). The decoder producing the errors was found to be especially sensitive to reduction in eyewidth and was unable to extract a good clock waveform from such a signal.

8.6 Decoding Threshold

The decoding threshold of a receiver has been defined as the eyeheight value at which significant decoding errors occur. As explained earlier, a level of 1 in 10^3 bit errors or approximately eight character errors or omissions per page on first write was chosen to be significant.

For a given Teletext receiver, the decoding threshold will vary depending upon the distortion which is reducing the eyeheight. For example, receivers with an i.f. 'roll-off' will perform better on signals with an h.f. boost than will those lacking such a 'roll-off', because of compensation effects.

The receiver used for the field survey tests had an average decoding threshold at the aerial socket of 25% eyeheight when tested with signals distorted by transmission systems. It failed at 35% eyeheight when tested with the more stringent IBA adjustable eyeheight source. Other receivers tested have failed at eyeheights as high as 70%. The majority of current receivers have eyeheight thresholds in the range 40–60%. Considerable improvements are required in certain areas of receiver and decoder design if the Teletext service is to be made available to a high percentage of the existing television audience. The trade association for the manufacturers of broadcast receiving equipment in the UK, BREMA, have given provisional acceptance to a target figure of 25% for future-generation receivers employing l.s.i. decoders. It is likely that such receivers will employ s.a.w. i.f. filters and synchronous detection.

8.7 The Effect of Receiver Decoding Threshold on the Potential Audience

By analysing all the received eyeheight data accumulated as a result of the field trials, it is possible to construct a curve to show the probability of receiving Teletext as a function of receiver decoding threshold.[11] Figure 11 shows a histogram of the total received eyeheight data measured.

The histogram has two important features. Firstly, the distribution is skewed. This is because the chance of

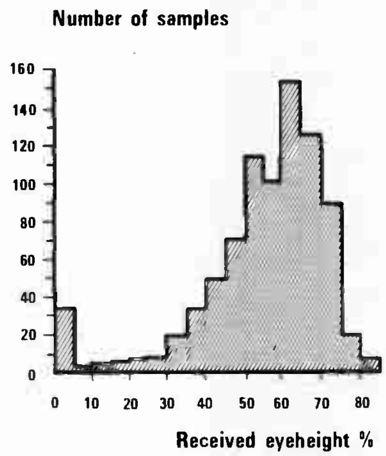


Fig. 11. Total received eye-height data measured by IBA

eyeheight reduction is greater than eyeheight increase in the reception path and receiving aerial installation. The second important feature of the distribution is the preponderance of zero eyeheight results. This accumulation of zero eyeheight results is caused by a limitation in the definition of eyeheight.

In theory, eyeheight may be less than zero (i.e. negative) but, in a practical measuring system, all such eyeheights are recorded as zero.

The zero eyeheight values come mainly from locations within the service area where the received signal strength is below the boundary contour value for that service area. For this reason, it is considered unlikely that improvements in transmitted eyeheight, within practical limits, will have any significant effect on the number of zero eyeheights found in a given service area.

If it is assumed that the histogram in Fig. 11 which is compiled from observed values, can be taken to represent the distribution of received eyeheight throughout the u.h.f. network, the probability of successful decoding may be plotted for a range of receiver decoding thresholds. This is an important factor so far as receiver design is concerned, since optimum performance where the decoding threshold approaches zero eyeheight is difficult to achieve and this curve can assist receiver manufacturers to set a realistic target figure.

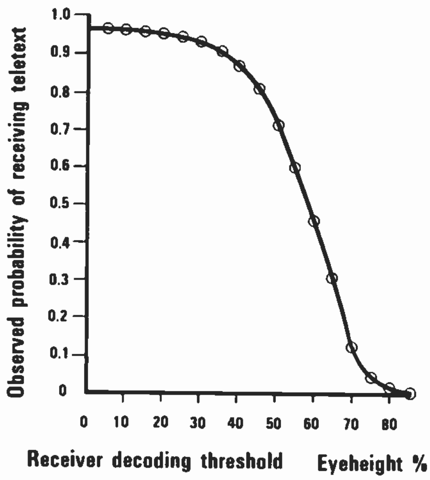


Fig. 12. Probability of receiving Teletext for given decoding threshold

The probability curve in Fig. 12 is constructed from received eyeheight data in Fig. 11 and illustrates the principle. Using an ideal receiver (i.e. one which decodes down to zero eyeheight) the probability of receiving Teletext is 0·96. This is because 4% of eyeheights measured were zero or negative and cannot be decoded without adaptive equalization. On the other hand, if a receiver is designed to operate satisfactorily at eyeheights of 25% or greater, then the probability of receiving Teletext falls to 0·95. This means that the service will be able to reach 99% of the audience which could be reached were they using perfect decoders.

Figure 12 shows also that, for receivers with a decoding threshold of 50% eyeheight, the probability of receiving Teletext is reduced to 0·73. This performance is typical of certain current production decoders.

9 Teletext Buzz on Sound

Certain television receivers have been found to produce an annoying buzz or crackle on the sound channel during transmission of Teletext data. Tests on receivers prone to buzz have revealed that:

In all cases this problem occurred on receivers with intercarrier sound circuits.

The buzz level is directly proportional to data amplitude and indirectly proportional to sound carrier amplitude.

Receivers with Teletext buzz are very sensitive to data amplitude. In round figures a 1 dB increase in data amplitude increases the buzz by the same amount as a 3 dB reduction in sound carrier amplitude.

In general, there is no relationship between overshoots on the data stream and buzz amplitude, provided that the overshoots are caused by group delay errors. However, overshoots caused by an enhanced h.f. response will increase the buzz level.

Sets prone to Teletext buzz can give far worse buzz under certain picture conditions, such as caption. However, the continuous nature of the data stream renders the subjective effect of Teletext buzz more annoying.

Teletext data with a Nyquist energy spectrum was found to cause many more complaints of buzz on sound than data with a raised cosine or Gaussian spectrum.

In the early days of the Independent Television field trials, complaints of buzz on sound reached epidemic proportions in some service areas. Certain makes of receiver were especially prone to buzz and some makes were found to be completely immune to the problem. A very strict control of the radiated Teletext data amplitude eliminated the majority of buzz complaints. Subsequently, in October 1976, the nominal radiated data amplitude was reduced from 71% to 66% of the picture amplitude, to introduce a working margin. Since that time, reported buzz complaints have been few and have been generally restricted to a particular set of one manufacturer. The set responds well to simple adjustments to cure the problem.

10 Conclusions

10.1 General

The extensive field trials of the UK Teletext system described in this report, have confirmed that an adequate service can be made available to a high percentage of the existing television audience, using the technical standards proposed originally in 1974.

10.2 Transmission Network Performance

The existing broadcast network is already capable of a high standard of performance without modification or significant increase in maintenance workload. Data regeneration may be used to advantage to ensure the highest possible transmission quality, particularly at rebroadcast stations with receivers employing envelope detection. To maintain consistent standards throughout the network, more attention will need to be paid to group delay performance than has been considered necessary for the television service.

10.3 Potential Audience

Provided that production receivers achieve a performance comparable with the receiver used for the field trials, some 95% of the existing television audience will be able to receive a Teletext service on their existing aerial systems. If such receivers can be made to meet the minimum 25% specification provisionally accepted by BREMA as a target figure, some further improvement in penetration can be expected. Vehicle surveys have shown that worthwhile improvements can also be gained over the average domestic aerial installation if a well-installed medium-gain, outdoor aerial is used.

10.4 Service Area Limitations

Vehicle surveys have shown that, with a well-installed outdoor aerial, the Teletext service is field-strength-limited. At each of those sites where Teletext could not be received, the field strength was below the boundary contour value for the particular service area. At no location, using the survey vehicle aerial, did Teletext fail due to reflections when, simultaneously, the field strength was adequate.

The domestic surveys show a somewhat different result in that the cause of failure, at 32% of the sites where Teletext could not be received, was reflection. This would indicate that existing domestic aerial installations are subject to more reflections than is the domestic aerial system used on the survey vehicle.

10.5 Decoder Performance

A decoding threshold of 25% eyeheight has been agreed to represent an acceptable compromise between performance and circuit production costs. This figure has been assumed when calculating the potential Teletext audience and subjective decoding tests on the receiver used for the field trials have demonstrated that this figure is realistic. However, many production receivers have decoding thresholds in the range 50%–60% eyeheight. Therefore, until the performance of production decoders approaches a 25% eyeheight threshold, Teletext service will be available to a less high percentage of television audience than that predicted by the survey.

11 Acknowledgments

The Authors wish to thank all IBA and ITCA staff who helped with the survey work. Thanks are due also to receiver manufacturers and associated industry for their co-operation in investigation of reception problems in the field and the Director of Engineering of IBA for permission to present this paper.

12 References

1 European VHF/UHF Broadcasting Conference. Stockholm 1961.
2 Mason, A., 'DELPHI, a versatile and controlled Teletext signal source'. International Broadcast Convention 1978, pp 253–257.
3 Sherry, L. A., 'An Assessment of Teletext Transmission over the UHF Television Network' — UKIBA Teletext Transmission Working Group Note 10.
4 Cominetti, M. and Stroppiana, M., 'Broadcasting of Data Signals inserted in the Field Blanking Interval of the Video Signal'. RAI-Radiotelevisione Italiana. Technical Report No. 74/4/E.
5 Sherry, L. A. and White, R., 'Independent Television Companies' Association/Independent Broadcasting Authority Joint Report on Teletext Reception in London'. UKIBA Teletext Transmission Working Group Note 26.
6 Sherry, L. A., 'Teletext Reception in South Wales'. UKIBA Internal Report.
7 Sherry, L. A., 'Domestic Teletext Reception in Yorkshire'. UKIBA Teletext Transmission Working Group Note 29.
8 Thedick H., 'Adaptive multipath equalization for tv broadcasting', *IEEE Trans on Consumer Electronics*, CE-23, no. 2, pp. 175–81, May 1977.
9 White, R., 'Teletext Reception in Wired Distribution Systems'. UKIBA Teletext Transmission Working Group Note 33.
10 Sherry, L. A., 'Teletext Reception in Relay Station Service Areas'. UKIBA Teletext Transmission Working Group Note 30.
11 Sherry, L. A., 'The Effect of Receiver Decoding Threshold on Potential Teletext Audience'. UKIBA Internal Report.
12 Hutt, P. R., 'Quality monitoring for a Teletext service', Conference on Television Measurements 1979, IERE Conference Proceedings No. 42, pp. 263–75.

13 Appendix 1: Measurement of eyeheight

The concept of eyeheight is derived from an analysis of the distortion of a single data pulse.[11] If such a pulse as shown in Fig. 13 has a maximum height $f(o)$ and a bar height produced by an infinite sequence of such pulses b then the eyeheight is defined as:

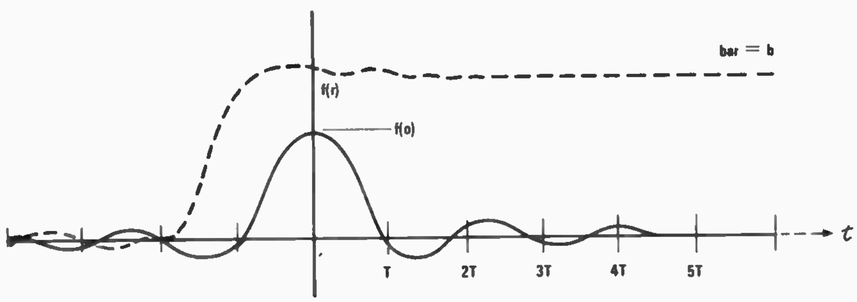


Fig. 13. A single data pulse

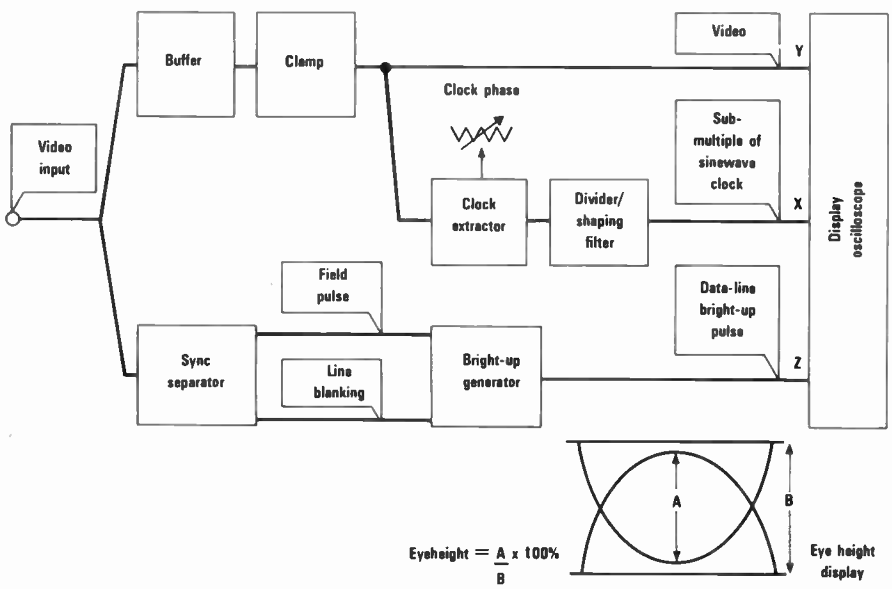


Fig. 14. Equipment used to produce Lissajous eyeheight display

$$h = \frac{f(o) - i}{b}$$

where

$$i = \sum_{k=-\infty}^{\infty}{}' \; |f(kt)|$$

and

$$b = \sum_{k=-\infty}^{\infty} f(t - kt)$$

$f(o)$ = maximum value of the pulse $f(t)$.

i = intersymbol interference component or a summation of the amplitude of the pulse lobes at the clocking instants.

b = Teletext bar height or the summation of an infinite sequence of single pulses.

$\sum'$ means that the summation excludes $f(0)$.

Many practical measurements have been made in the field using this technique with a specially-generated pulse and suitable oscilloscope graticule. Such a measurement is tedious because of the large number of individual amplitude measurements and the computations involved. Further it assumes a linear noise-free system which rarely occurs in practice.

If the data sequence is cut into T-wide lengths, with $f(o)$ or $f(kT)$ situated in the middle and these lengths are laid over one another, the resulting picture is called an eye diagram and the free area in the middle is the 'eye'.

An eye diagram may be displayed on an oscilloscope by producing a Lissajous figure with the data stream and a sub-multiple of the data clock. A data line bright up pulse is generated to exclude all television information and suitable equipment is shown in Fig. 14.

This method of measurement suffers a fundamental disadvantage, in that the reference data clock must be extracted from the distorted data stream. The clock extraction circuits must be capable of extracting a clock

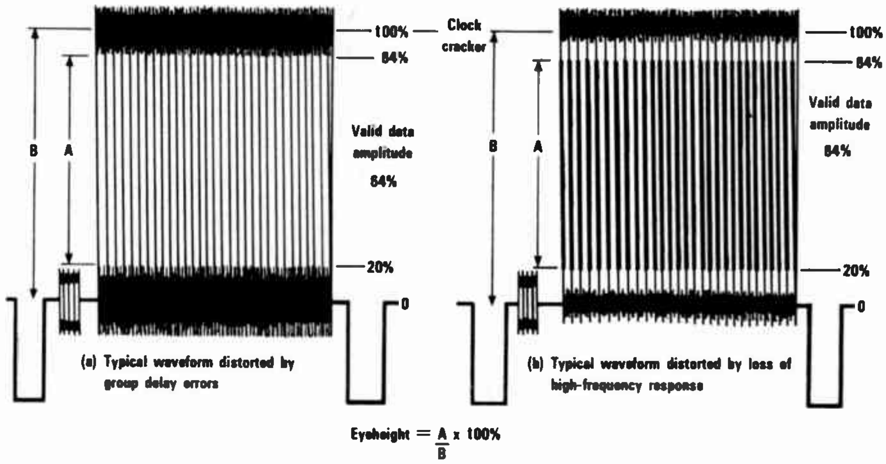


Fig. 15. Measurement of 'tramline' eyeheight

waveform from the data which is completely free from phase jitter otherwise this phase jitter of the x waveform will falsely reduce the height of the eye diagram. Extracting a jitter-free clock waveform from the data stream becomes more difficult as distortion of the data stream increases and therefore accuracy is decreased for low values of eyeheight. This method of measurement will include reductions in eyeheight produced by non-linearity and noise.

A method of measuring data quality by direct inspection of the data stream is shown in Fig. 15. In this method the data stream is inspected and a measurement is made of the valid data amplitude which is expressed as a percentage of the clock cracker amplitude. This valid data amplitude is defined as the undistorted area of the data stream where no cusps or inflections exist in the data transitions. To make this measurement it has been found advantageous to mask off the distorted area of data stream with a straight edge by moving it towards the centre of the data stream both up from black level and down from clock cracker until no inflections are visible. This is done because the worst-case cusp or inflection can occur anywhere along the active line and will move its position depending upon the data bits being transmitted. Since two imaginary parallel lines are brought together to define the valid data amplitude over the complete active line, the name 'tramline' eyeheight has been coined.

The measurement only gives information on the height of the corresponding eye diagram but says nothing about eyewidth. In practice it has been found that, with the exception of envelope detection distortion, eyewidth reduction is accompanied by a proportionate amount of eyeheight reduction.

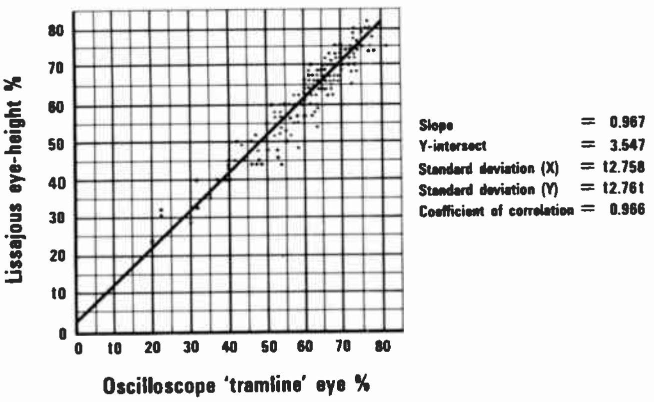


Fig. 16. Correlation between 'tramline' and Lissajous eyeheight

A correlation between eye heights measure by the Lissajous method and the tramline method is shown in Fig. 16. This correlation is sufficient to allow data quality to be assessed in the field on a routine basis using a television waveform monitor, thus eliminating the need for additional costly Teletext test equipment.

14 Appendix 2: Calculation of potential Teletext audience from distribution of received eyeheight

A sample of eyeheight measurements made in a television service area has a typical distribution as shown in Fig. 17. The distribution consists of two parts. The main body of the results forms an approximately normal distribution 'A' (sometimes skewed) and a number of zero eyeheight results 'B'.

It has been found empirically that plotting the distribution on an x axis where $x = \log(100 - h)$ removes the skew from the main distribution and so gives a better estimate of the mean value and standard deviation of the data.

The normally-distributed results are from locations in the service area where signal the strength is close to or greater than the minimum value specified for adequate television reception and from locations relatively free from multipath reception.

The zero eyeheight results come from locations in the service area where the signal strength is reduced by local obstructions to values lower than that specified for adequate television reception. In such locations, the eyeheight may in fact be negative, i.e. less than zero; but, in any practical measuring system, all eyeheights of less than zero appear to be zero when measured.

To calculate the potential audience from such a distribution the latter must be treated as two separate parts. For a given decoding threshold, which is a function of the Teletext receiver, a certain percentage of results from the normally distributed sample A will have an eyeheight below the decoder threshold and therefore will not provide a Teletext service.

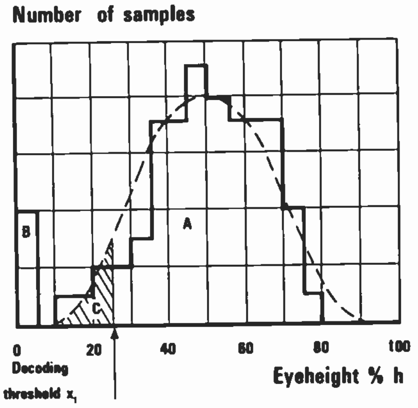


Fig. 17. Typical distribution of received eyeheight

The shaded area C of Fig. 17 represents the proportion of the total area under the normal distribution curve where the eyeheight is below the decoder threshold.

The zero eyeheight results do not form part of the normal distribution and must be calculated as a percentage of the total number of samples.

The total percentage of samples below the decoding threshold is the sum of the shaded area C (as a percentage of the total area A) and the zero eyeheight results B (as a percentage of the total sample A + B).

The shaded area C may be calculated as a percentage of the area under the normal distribution curve A from the mean value and standard deviation of the measured eyeheights excluding the zero results.

First, the decoding threshold must be expressed in terms of the number of standard deviations from the mean value of the distribution.

Let u = decoding threshold in terms of number of standard deviations from the mean

$\bar{x}$ = mean value of received eyeheight results excluding zero values

S = standard deviation of received eyeheight results excluding zero values

x_1 = decoding threshold eyeheight

E = fraction of normally-distributed sample below the decoding threshold.

Then

$$u = \frac{\bar{x} - x_1}{S} \qquad (1)$$

and

$$E = \frac{1}{\sqrt{2\pi}} \int_u^\alpha \exp(-x^2/2)\,\mathrm{d}x \qquad (2)$$

This function E for given values of u is given in normal probability tables. The total percentage of samples E below the decoding threshold is therefore:

$$E = \left(1 - \left(E + \frac{n_0}{n}\right)\right) \times 100 \qquad (1)$$

where n = total number of samples

n_0 = number of zero eyeheight samples.

The above calculations assume a fixed transmitted eyeheight. In practice the transmitted eyeheight from a given transmitter will vary with time due to equipment performance changes and propagation changes in rebroadcast transmitters. These effects are quantified in terms of mean value and standard deviation for the majority of IBA transmitter configurations.

Therefore, if the samples of received eyeheights are all from one transmitter and the transmitted eyeheight remains constant throughout the duration of the measurements, equation (1) must be modified in the following way:

$$u = \frac{\bar{x}a - x_1}{\sqrt{S^2 + S_1^2}} \qquad (4)$$

where a = ratio of mean received eyeheight to transmitted eyeheight

S_1 = standard deviation of a sample of transmitted eyeheights for a given equipment configuration

and $\bar{x}$ = mean value of a sample of transmitted eyeheights.

Using equation (4) to determine u assumes that variations in transmitted eyeheight over the range of values determined by the standard deviation will have no effect on the zero eyeheight results. This is a reasonable assumption since the zero eyeheight values are caused by very low signal strength.

If the samples of received eyeheights are taken from many different transmitters, it can be assumed that the variations in transmitted eyeheight will be reflected in the received eyeheight measurements, in which case equation (1) may be used to determine u.

Having determined u, the number of samples below the decoding threshold of the receiver, and hence the potential Teletext audience, can be calculated from equations (2) and (3).

Manuscript first received by the Institution on 10th April 1980 and in final form on 4th June 1980 (Paper No 1957/Comm 206)

The Authors

Raymond Hills (Fellow 1972, Member 1961) studied electrical engineering at Bristol University and received the degree of B.Sc.(Eng.) with honours in 1954. After a two-year graduate apprenticeship with the BBC, he joined the Aerial Unit of their Planning and Installation Department where, apart from a short secondment to Nigeria in 1957, he worked on the specification, design and installation of aerial and feeder systems for the domestic v.h.f./u.h.f. radio and television services and for the modernization of the short-wave stations of the Overseas Service. In 1967 Mr Hills joined the (then) Independent Television Authority as Head of Mast and Aerials Section in the Station Design and Construction Department. He was appointed Head of Department in 1969 and Chief Engineer (Transmitters) in 1973. He took up his present duties as Assistant Director of Engineering (Operations) in 1978, where he has responsibility for all aspects of the planning, construction and maintenance of the IBA's national network of television and local radio stations, together with the functions of technical training and safety.

Mr Hills has served on the Communications Group, Membership and Executive Committees as well as Conference Organizing committees, was a member of Council from 1968 to 1972 and a Vice President from 1976 to 1979.

Les Sherry is Head of the Electronic Maintenance Unit in the IBA. He joined the Authority in 1961 after serving an apprenticeship with the Post Office and subsequently obtained a Higher National Certificate in electrical engineering. He worked on several television transmitting stations before moving to the Maintenance Section at the Authority's headquarters near Winchester.

UDC 621.376.56:621.395.665.1:621.396.712

Indexing Terms: Radio broadcasting, Sound transmission, Digital techniques, Companding

NICAM 3: near-instantaneously companded digital transmission system for high-quality sound programmes

C. R. CAINE, B.Sc., C.Eng., M.I.E.R.E.,*
A. R. ENGLISH,*
and
J. W. H. O'CLAREY, B.Sc., C.Eng., M.I.E.E.*

SUMMARY

The paper describes a system, known as NICAM 3 (Near-Instantaneously Companded Audio Multiplex, Mark 3), which is being developed by the BBC for the transmission of sound programmes on digital circuits designed for multi-channel telephony.

Subjective tests which led to the choice of this system are referred to, and the system design, which is based on a compromise between efficiency and flexibility, is discussed in some detail.

Various applications are mentioned, the main one being for six channels in a dedicated bit-stream of 2048 kbit/s, but other arrangements are possible, including mixed telephony and sound-programme working.

* *Designs Department, British Broadcasting Corporation, Broadcasting House, London W1A 1AA.*

1 Introduction

Throughout the world, digital transmission is being used increasingly for telephony, with the result that analogue circuits will in time become scarce or even non-existent. For this reason, and also to obtain improved performance, work is being carried out by various organizations including the BBC, with the aim of using the new digital circuits for sound-programme transmission. The CCITT has recommended[1] several different bit-rates for international transmission, the primary and secondary rates favoured in Europe being 2048 kbit/s and 8448 kbit/s.

In order to make the most efficient use of the available bit-rate most of the systems currently being proposed use some form of companding, i.e. compression at the sending end and expansion at the receiving end of the digital circuit. In systems using companding the output noise depends on the signal level, the noise being least for the lowest signal levels, and highest when the signals reach their maximum levels. This may be acceptable owing to the masking effect of high-level signals, but the audibility, and hence the annoyance value, of this programme-modulated noise varies with the particular system, depending on such things as compression ratio and pre- and de-emphasis. Companding may be employed on both analogue and digital audio transmission systems, and the form of companding used may be either analogue or digital.

The BBC has had considerable experience of digital sound-programme transmission over the last 10 years.[2,3] Accordingly one aim for the new development was that the overall quality should be at least as good as that currently being obtained from a 13-bits-per-sample, linearly-encoded p.c.m. system, designed nearly a decade ago, and used since 1972 for the network distribution of radio sound-programmes. With this limitation the most efficient use of the available bit-rate has been sought, bearing in mind such things as error rates which may be expected on digital circuits, and the wish to keep the instrumentation reasonably simple.

2 Consideration of Companding Laws

Companding systems currently being proposed are either instantaneous or near-instantaneous.

2.1 Instantaneous Companding

In instantaneous companding each sample digital word from the analogue-to-digital converter is changed to another word with fewer bits. The transfer characteristic, representing the companded quantizing level as a function of the magnitude of the input signal, is a segmented straight-line graph, adjacent quantizing levels being equivalent to smaller signal level differences at low input levels than at high input levels.

0033–7722/80/100519+12 $1.50/0

2.1.1 *13-segment A-law*

An instantaneous companding law which is used for telephony is known as the A-law.[4] This has a segmented form which approximates to the curve defined by:

$$y = \frac{1+\ln(Ax)}{1+\ln A}, \quad \text{for } \frac{1}{A} \leqslant x \leqslant 1,$$

$$y = \frac{Ax}{1+\ln A}, \quad \text{for } 0 \leqslant x \leqslant \frac{1}{A}.$$

A value for A of 87·6 has been selected as optimum for telephony,[5] and the straight-line transfer characteristic approximation has thirteen segments, as shown in Fig. 1. The transfer characteristic is skew-symmetrical about zero, the positive quadrant only is shown here.† The finest discrimination, i.e. the difference between adjacent quantizing levels for very low signals, is equivalent to that which would be obtained with a linearly-coded n-bit system. For telephony, $n = 12$ is used, and hence 8 bits are actually transmitted, but for sound programme use, $n = 14$, which in at least one proposal, is reduced to 10 bits for transmission. It may be seen that in this case the highest level input signals are effectively coded to 8 bits per sample.

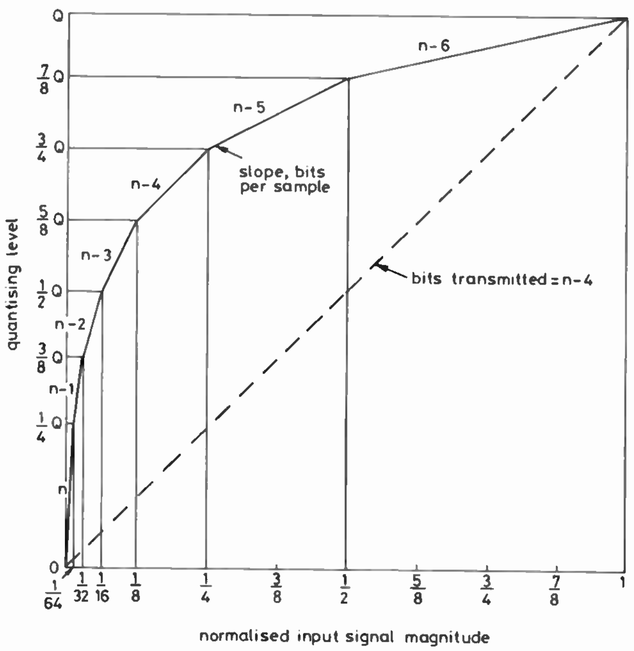


Fig. 1. 13-segment A-law.

2.1.2 *11-segment A-law*

Another approximation to the A-law curve has been proposed for sound-programme use. This has eleven segments with compression from 14 to 11 bits, and in this case the highest level signals are coded to a discrimination of 9 bits. The compression transfer characteristic is similar to that shown in Fig. 1, except that there are only six straight-line segments in each quadrant instead of seven. Also the quantizing level scale is divided into sevenths instead of eighths, the slope changing from n to $n-1$ at $\frac{2}{7}Q$ instead of $\frac{2}{8}Q$.

† The segment through zero is common to both the positive and negative quadrants.

2.2 Near-instantaneous Companding

In near-instantaneous companding blocks of 32 samples are examined to discover the maximum sample value in the block. The coding slope is set according to the amplitude of the maximum sample and all the samples in a block are coded to an accuracy determined by that largest sample value. For each block it is necessary to derive a scale factor word which is sent to the decoder and used to control the expander. It will be seen that, at low audio levels, a particular sample in a block may be represented by several different output words, depending on which coding slope or range is being used for that block.

Several different near-instantaneously companded systems have been proposed. The BBC has considered the development of three, which are known as NICAM 1, NICAM 2, and NICAM 3; in which the acronym NICAM stands for 'Near-Instantaneously Companded Audio Multiplex'.

2.2.1 NICAM 1

NICAM 1 is a four-range system, with compression from 13 to 10 bits per sample. In this system the samples are initially represented by linearly-coded 13-bit words. Consecutive samples are grouped in blocks of 32, and the highest value sample in each block is determined. If any values exceed half the permitted peak audio level the top range is used for all the samples in that block. Maximum values between half and a quarter will employ the second range, and so on. If all the sample values in a block are less than one-eighth of the permitted peak audio level the lowest range is used. A range code signal is sent with each block. It should be noted that the highest level signals are coded to a discrimination of 10 bits.

2.2.2 NICAM 2 *and* NICAM 3

NICAM 2 and NICAM 3 are very similar to NICAM 1, but they both start with samples before companding coded to 14-bit accuracy, in order to overcome the basic quantizing noise limitation of a 13-bit system. NICAM 2 is a four-range system with compression to 11 bits per sample, whilst NICAM 3 is compressed to 10 bits per sample, and hence five ranges are required. Figure 2 shows the positive quadrant of the compression transfer characteristic for NICAM 3, and it will be seen that signal samples which are higher in level than half the maximum amplitude (and any other signals in the same 32-sample block as these high level signals) will be coded to a discrimination of 10 bits, whilst if all the samples in a block are less than one-sixteenth of the maximum amplitude, the coding accuracy is 14 bits per sample.

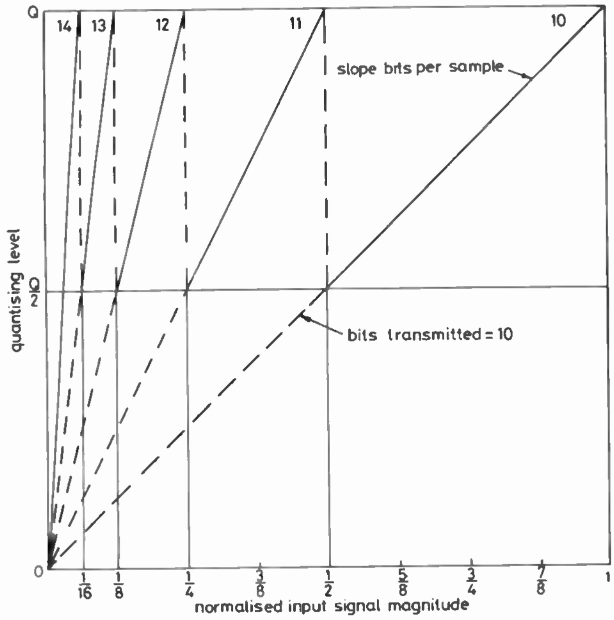


Fig. 2. NICAM 3.

2.3 Subjective Tests

Subjective tests have been carried out comparing various digital companding systems including the 13-segment *A*-law, NICAM 1, NICAM 2, NICAM 3, and a similar near-instantaneous system companding from 14 to 9 bits which had been proposed by Telediffusion de France.[6] These tests, which are fully described in References 7 and 8, involved both single codecs (coders and decoders) and four codecs in tandem.

The material used for the subjective tests consisted of three items, these were: an electronically-generated musical phrase comprising the first four notes of the well-known tune 'Frere Jacques', a short piece of piano music, and a glockenspiel arpeggio. These items, which were all monophonic, were chosen because it was known that they were likely to show up any programme-modulated noise effects. The piano and the glockenspiel items were taken from an analogue tape-recording using Dolby-A noise reduction.

The listeners for these tests consisted of 17 experienced technical staff, and a high-quality monitoring loudspeaker was used in a listening room which was considered to be representative of a good domestic environment. The equipment used for carrying out all the tests comprised a 14-bit linear analogue-to-digital converter and digital-to-analogue converter, the digital signals being processed by a very fast microprocessor to simulate the system being tested.

Each test involved a comparison of two of the systems, A and B, which were presented twice in each test in the sequence ABAB. Tests in the reverse order were also included. Listeners were asked to grade the systems according to the CCIR 7-point comparison scale reproduced here:

+3 A much better than B
+2 A better than B
+1 A slightly better than B
0 A same as B
−1 A slightly worse than B
−2 A worse than B
−3 A much worse than B

Prior to the test sequences the listeners attention was drawn to an example of severe programme-modulated noise, and they were asked to listen for this effect as well as for other impairments such as background noise.

The results of the subjective tests are shown in Tables 1 and 2. Table 1 gives the mean subjective grades obtained with single codecs, and Table 2 gives results obtained when four codecs of some of the systems were put in tandem (a 14-bit digital tape recorder was used for this purpose).

From Table 1 it can be seen that NICAM 2 gave the lowest impairment levels, followed by 13-bit linear, NICAM 1 (and NICAM 3 which is very similar to NICAM 1), TDF, and *A*-law. Note that the particular *A*-law system tested was the 13-segment one which compands from 14 to 10 bits. The 11-segment version was not tested, but since the effective number of bits for

Table 1

Mean grades awarded by listeners in subjective tests comparing single codecs

Test item: Systems compared A	B	Electronic 'Frere Jacques' test signal	Piano music (Schubert)	Glockenspiel arpeggio	Mean result for the 3 items
A-law	TDF	−1·24 (0·18)	−0·35 (0·26)	−0·88 (0·24)	−0·82
NICAM 1	TDF	+1·29 (0·32)	−0·15 (0·27)	+1·24 (0·25)	+0·72
NICAM 2	NICAM 1	+0·32 (0·16)	−0·09 (0·17)	+0·47 (0·23)	+0·23
13-bit linear p.c.m.	NICAM 1	+0·71 (0·21)	+0·12 (0·21)	— —	+0·42
13-bit linear p.c.m.	NICAM 2	−0·32 (0·11)	−0·03 (0·21)	— —	−0·18
NICAM 3	NICAM 1	0·00 (0·16)	−0·22 (0·26)	+0·03 (0·18)	−0·06

Note: The standard error of the mean grade is given in brackets.

Table 2

Mean grades awarded by listeners in subjective tests comparing 4 codecs in tandem

Test item: Systems compared A	B	Electronic 'Frere Jacques' test signal	Piano music (Schubert)	Glockenspiel arpeggio	Mean result for the 3 items
A-law	TDF	−1·76 (0·14)	−0·12 (0·26)	−0·26 (0·33)	−0·71
NICAM 1	TDF	+2·24 (0·26)	−0·41 (0·24)	+1·88 (0·32)	+1·24
NICAM 2	NICAM 1	+0·88 (0·36)	+1·24 (0·25)	+0·65 (0·26)	+0·92

Note: The standard error of the mean grade is given in brackets.

the highest level samples is nine, it is expected that the results would be similar to those obtained with the TDF system. Unfortunately, it would not be possible to obtain more than five sound-programme channels in 2048 kbit/s with this system.

It was concluded as a result of these tests that all the NICAM systems would provide a higher quality than would either the 14- to 10-bit A-law or the 14- to 9-bit TDF system. Neither of the latter two systems were considered to be completely satisfactory for the BBC national distribution network, but there was little difference between the subjective grades, with respect to programme-modulated-noise, given to the three NICAM systems. However, the adoption of NICAM 3 as the preferred system was felt to be justified, as it is compatible with the performance which is expected from the rest of the broadcasting chain, bearing in mind modern good-quality domestic receivers, and future digital techniques such as recording, which will eventually be used in studio centres. Also with NICAM 3 it is possible to obtain six high-quality sound-programme channels in 2048 kbit/s, whilst NICAM 2 would only allow five such channels to be obtained. Note that amongst the systems considered only NICAM 1 and NICAM 3 provided coding of the highest level signals to 10-bit accuracy. Programme-modulated noise depends particularly on the accuracy to which high-level signals are coded, whilst the background noise with no, or low-level, signals, depends on the accuracy to which such signals are coded. NICAM 2 would give 11-bit accuracy to the highest level signals, but it was felt that this was not necessary as the performance of the 10-bit systems in respect of programme-modulated-noise was satisfactory.

3 Bitstream Format

Where possible it was decided to conform to internationally agreed proposals[6] for the digital transmission of high-quality sound programmes. These include the sampling frequency of 32 kHz. If 20 kbit/s of the 2048 kbit/s are allocated for the multiplex 'housekeeping', i.e. for an overall framing pattern and special synchronizing or justification bits, 2028 kbit/s remain, which means that 338 kbit/s are available for each of the six channels. Ten-bit programme samples require 320 kbit/s, leaving 18 kbit/s for the individual channel housekeeping.

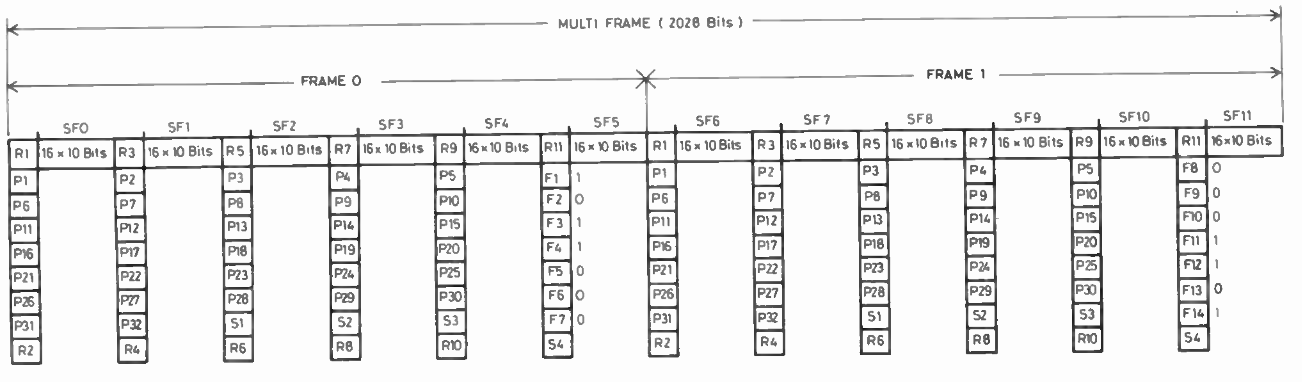
3.1 Single Channel

As explained in Section 2 the samples are grouped in companding blocks or frames of 32 samples, and a range identifying word (to identify which of the five possible companding slopes is appropriate to the particular block) has to be determined. Three bits would be necessary to identify one of five states, but by integrating the identification for three successive blocks, a small reduction has been achieved in the number of bits required for this purpose. The number of possible states for three blocks is 5^3 or 125, and this number requires seven bits to identify it. An error in the range code word could cause a very audible impairment, and hence an additional four bits per word have been allocated, which will enable single errors in any seven-bit-range code word to be corrected. It has been estimated that this should enable satisfactory operation at error rates of at least 1 in 10^5.

These three sample blocks, together with various housekeeping bits, form a frame, and since there are 96 samples in a frame, the total time available is 3 ms. The number of bits per frame is thus $3 \times 338 = 1014$ bits, and these have been allocated as follows:

	Allocation/frame	Bit-rate/channel
Sample words	960 bits	320·0 kbit/s
Range coding (with error protection)	11 bits	3·$\dot{6}$ kbit/s
Sample word error protection	32 bits	10·$\dot{6}$ kbit/s
Signalling	4 bits	1·$\dot{3}$ kbit/s
Framing	7 bits	2·$\dot{3}$ kbit/s
Total	1014 bits	338·0 kbit/s

Figure 3 shows the arrangement for two frames, known as a multi-frame. The housekeeping bits are shown vertically, but in the serial output bitstream they occur sequentially at the end of each sub-frame, or group



The sample bits are shown as groups of 16×10 bits
F = Framing Bit
P = Sample Parity Bit
R = Range Code Bit
S = Signalling Bit
SF = Subframe

Fig. 3. NICAM 3, single-channel format.

of 16 samples. This arrangement has been chosen as a compromise between simplicity and the need to separate and spread out the sample word error protection bits and the range coding bits. Thirty-two bits have been allocated for sample word error protection. A relatively simple error concealment system has been developed, in which one parity bit deals with three successive samples. In the event of an error being detected at the d.a.c. all three samples are replaced by the previous correct sample. With such a simple system only the five most significant bits in each sample are protected as occasional errors in the five least significant bits are not very serious. Satisfactory operation at error rates up to 1 in 10^5 should be achieved, but if required, a more complicated system giving single error correction may be employed. Further details of these techniques are given in Section 5.6.

Seven bits per frame are used as a framing pattern. These are inverted in alternate frames so that the complete pattern comprises 14 bits in a multiframe of 2028 bits. This has been chosen to minimize the probability of spurious recognition of the pattern in the sample and other housekeeping bits. A reframing time, after individual channel frame loss, of about 12 ms is expected.[9]

The four bits per frame which are left have been allocated for signalling. This facility is available for a variety of purposes including local opt-out and transmitter switching.

3.2 Six-channel Multiplex

Six high-quality sound-programme channels will commonly be multiplexed up to 2048 kbit/s, and Fig. 4 shows how this will be achieved. Pairs of coders (and decoders) will use common housekeeping cards for the reasons explained in Section 4, and hence the bit-rate per coder-pair may be regarded as being 676 kbit/s. The 2048 kbit/s frame has been set at 1 ms, so that 20 bits per frame are available for housekeeping purposes. Seven bits per frame have been allocated as an overall framing pattern, together with seven bits from an adjacent frame, and it is expected that the 2048 kbit/s reframing time after frame loss will be about 2 ms.

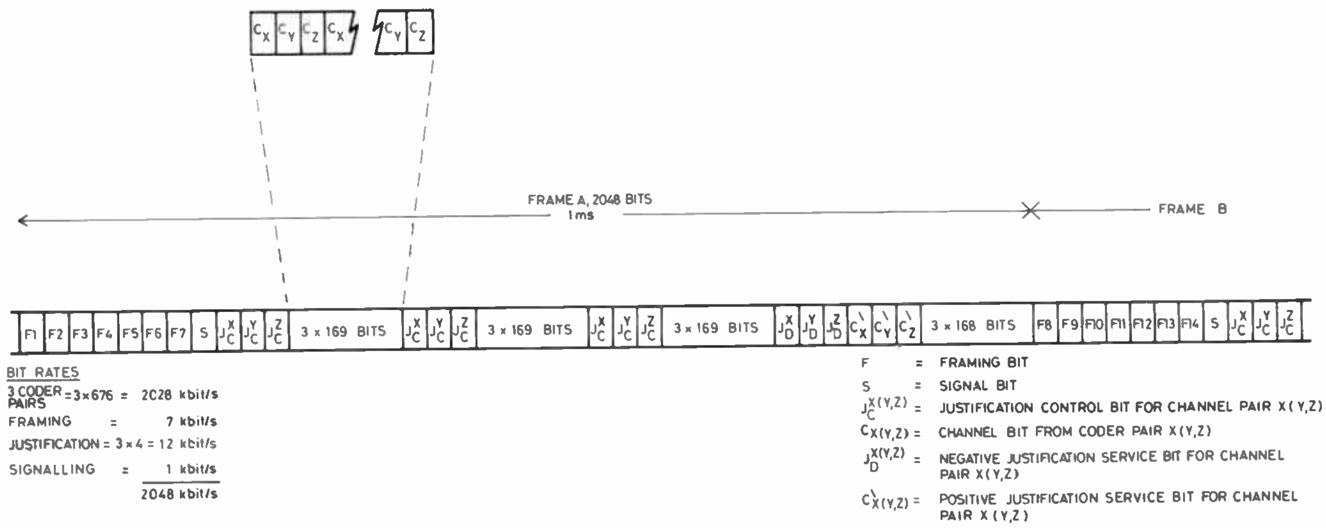


Fig. 4. NICAM 3, six-channel multiplex format.

Justification control and service bits have been included. They may be used to enable asynchronous 676 kbit/s inputs to be multiplexed together. However, as explained in Section 4, if, as planned, all the 676 kbit/s inputs are synchronous, these bits will not be so employed except that the bits shown in Fig. 4 as $C'x$, $C'y$ and $C'z$, will be absorbed into the channel bits immediately following them, which will then become 3×169 bits.

One bit has been allocated for signalling purposes; this may be used, for example, to identify particular 2048 kbit/s bitstreams, which can form part of a higher order multiplex such as 8448 kbit/s.

4 Design Constraints and System Structure

4.1 Requirements

The BBC's existing p.c.m. distribution system multiplexes 13 high-quality sound-programme channels onto a 6336 kbit/s bitstream, which is transmitted over analogue monochrome television links.[3] Although all the coder channels are fully equipped at the sending point in London, decoders are equipped with channel units according to the number of programmes required. Duplicate equipment is installed and powered to provide immediate reserve facilities. This is a somewhat inflexible system but was considered worthwhile in view of the number of channels required on the main distribution network.

Such a system would be very inefficient for outside broadcast, local opt-out, and contribution purposes, in view both of the bandwidth occupied and of the large amount of equipment required. Thus it was decided that any new design should be capable of operation on 2048 kbit/s digital circuits, and that it should be possible to insert or extract channels digitally at intermediate points. Such circuits could be multiplexed up to 8448 kbit/s or even higher multiplexes if required.

A careful study of the BBC's needs showed that optimum flexibility would be achieved with single-channel coders and decoders which could be used in conjunction with bitstreams of one, two, six or higher channel capacities. However, the needs of stereo transmission make it desirable to encode both channels with one piece of equipment, and it is essential that both channels are transmitted by the same route and suffer the same delays. The loss in general flexibility as a result of pairing-off channels into two channel coders and decoders is small, partly because many circuits are required for stereo anyway. In addition, the mechanical arrangement chosen conveniently deals with two channels in one 175 mm (4 U) high, 483 mm wide card-frame.

At first it was considered desirable that it should be possible for any three coder-pairs which are multiplexed onto 2048 kbit/s to be asynchronous, thus avoiding synchronizing problems when the coder-pairs are remote from one another. To this end bits have been allocated in the 2048 kbit/s bitstream format for the purpose of justification, which is a technique involving the addition or removal of dummy bits in the multiplexer, so that asynchronous signals may be synchronized.

However, after a further consideration, it was realized that this arrangement, although very flexible, was likely to be much more expensive than would be the case if all the coder-pairs in a particular 2048 kbit/s bitstream were to be synchronous. After all, in a large number of applications coder-pairs will be close together, and hence the expense of providing for asynchronous working at all the coders and decoders is largely unnecessary anyway. Another consideration which was taken into account was that at digital mixers it will be necessary for all input bitstreams to be synchronous, and accordingly it was agreed to work on the assumption that all the coder-pair outputs would be synchronous, and to deal with the problem of synchronizing remote coders separately. Thus the basis for design eventually chosen was that separate two-channel coders and decoders would be provided, with clock sources included in the multiplexers and demultiplexers. A single master clock source is all that is needed in a 2048 kbit/s coder equipment (similarly for 2048 kbit/s decoder equipment), subsidiary clocks in the coder- and decoder-pairs being derived from these master clocks.

4.2 Typical Facilities

The need for a six-channel coder site is met by using three coder-pairs, together with a clock source and multiplexer which are included in the card-frame of one of the coder-pairs. A similar arrangement is employed at a six-channel decoder site, but using a demultiplexer, etc., instead of a multiplexer. The output from a coder-pair in this case is obtained from a parallel to serial converter, and consists of an intermittent bitstream clocked at 2048 kHz, but with a mean bit rate of 676 kbit/s.

If the number of channels required on a 2048 kbit/s circuit is less than six, this is easily accomplished by leaving out channel cards and/or coder- and decoder-pairs.

Figure 5 shows in block diagram form some of the applications envisaged for this equipment.

The basic link (a) is shown with all six channels equipped, but the bitstream is demultiplexed at an intermediate point. This may or may not be associated with a decoder, depending on whether any local audio feeds or aural monitoring facilities are required. The first demultiplexer has three outputs, and a new piece of equipment labelled 'Inserter' may be associated with one or two of these outputs to become the inputs of the second multiplexer. Since multiplexers are normally carried within a coder-pair card-frame, this multiplexer would be carried within the inserter. At the decoder site

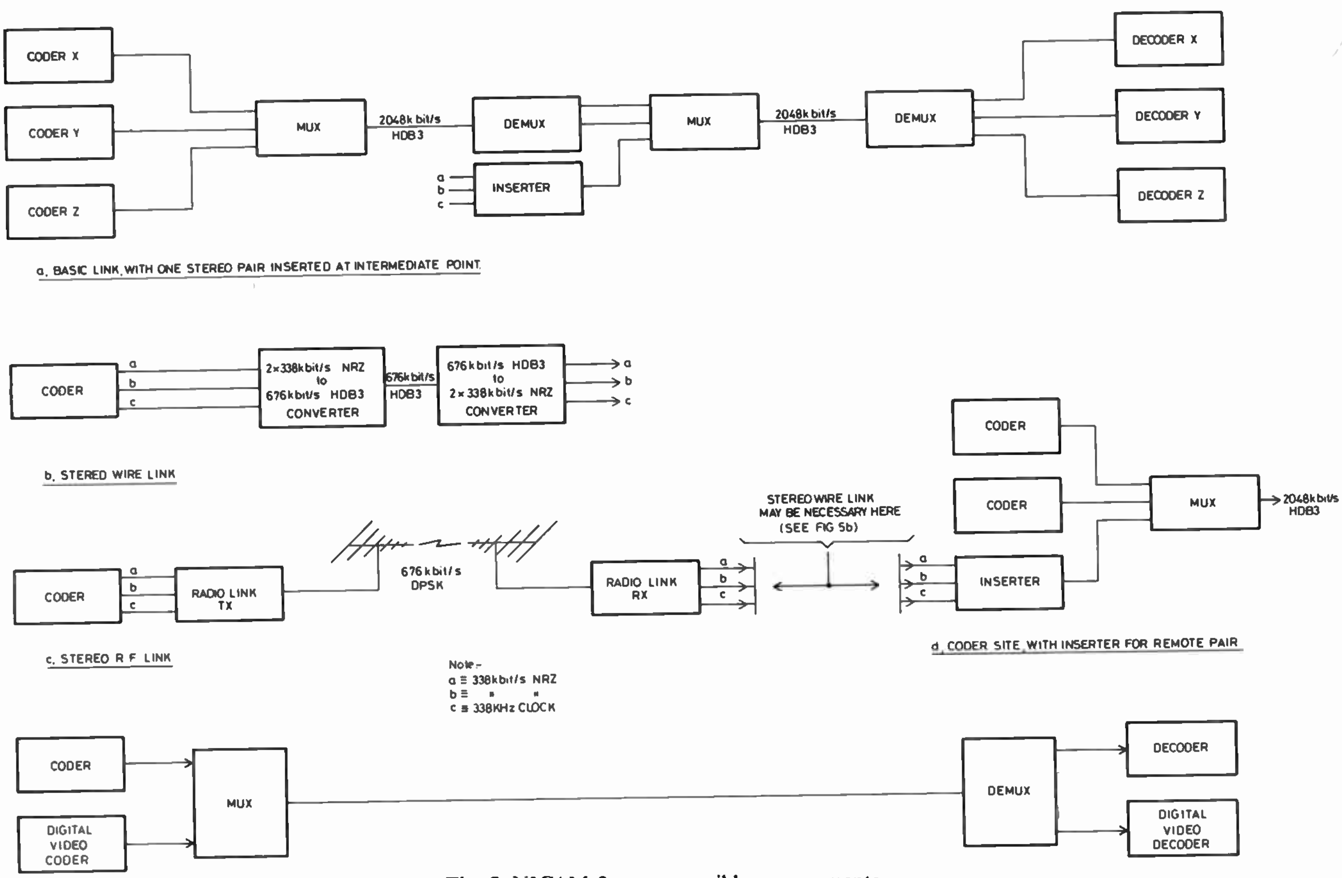


Fig. 5. NICAM 3, some possible arrangements.

'Decoder Z' would decode the inserted part of the bitstream. Normally, for insertion of a stereo-pair it is expected that two synchronous 338 kbit/s non-return-to-zero (NRZ) bitstreams and clock will be the form chosen for the interface between the coder and the inserter, to avoid the complication of HDB3 coding and clock recovery. High Density Bipolar (HDB) codes ensure that only a predetermined maximum number of zeros may be transmitted between successive marks; the codes are known as HDB*n* where *n* is the maximum allowable number of zeros. HDB3 is the code normally employed on 2048 kbit/s circuits. For distances up to tens of metres, the 338 kbit/s NRZ bitstreams and clock may be used, but when greater distances are involved a stereo wire link, Fig. 5(b), could be used. This comprises the clock generator required for 676/338 kbit/s and HDB3 coding and clock recovery. In practice the arrangement will be as shown, with a coder-pair at the sending point. The 676 kHz clock, and the clock for the coder, will be generated on a card in the coder, and a parallel-to-serial converter used to generate 676 kbit/s HDB3 directly. The receiving end may well be integral with the inserter.

Where coders and decoders are installed at a terminal or intermediate point on the main distribution network, the clocks may all be locked together. One technique which is being considered is the possibility of synchronizing all the source clocks to the Droitwich 200 kHz Radio 4 carrier, since this is derived from a rubidium standard, and it, or other co-channel transmitters which are locked to it, may be received anywhere in the United Kingdom. This system should enable remote coders to be synchronized with the main network, any low-frequency phase jitter being taken care of by means of digital storage at the inserter. Another possibility would be to employ a crystal oscillator at the remote coder with a stability high enough to keep clicks on the decoded audio down to, say, one every two hours, as this may be acceptable. Future developments which are planned include a sample-rate synchronizer[10] for use in conjunction with an inserter, in which additional storage is provided and the equipment accepts a plesiochronous input, or one which is only nominally the same frequency. The output of such a synchronizer is synchronous with the accessed bitstream, the sample rate difference being absorbed in the store until a short period of silence occurs in the programme. 'Silent' samples are then omitted or repeated until the store is reset to its half-full condition.

Figure 5(c) shows a stereo r.f. link which is being developed. The signal will be modulated onto an r.f. carrier using differential phase-shift keying, occupying about 1 MHz of bandwidth. The inputs to, and outputs from, the r.f. link, will be the two 338 kbit/s signals and clock previously referred to, although if necessary an

HDB3 section with appropriate interfaces, may be inserted between either the coder and the transmitter, or the receiver and the decoder. Alternatively the arrangement shown in Fig. 5(d) may be employed where the receiver output is taken either directly or via an HDB3 section, to an inserter in a contribution network. This inserter is the same item as in Fig. 5(a).

Figure 5(e) shows a coder and decoder associated with a digital video coder and decoder. Precisely how these will be interfaced has not yet been determined, it may be that the audio data will be transferred to the multiplexer at an intermediate bit rate such as 676 kbit/s, or it may be possible to effect the transfer at the output bit rate.

It should be noted that at any point in Fig. 5 where a bitstream of 2048 kbit/s HDB3 is shown, multiplexing and demultiplexing to 8448 kbit/s or higher may take place without affecting the 2048 kbit/s signals.

4.3 Stand-by Facilities and Monitoring Arrangements

Since the standard six-channel equipment for 2048 kbit/s consists of three coder and decoder pairs together with multiplexers and demultiplexers, it is not necessary for stand-by purposes to duplicate completely all the equipment. The arrangement which has been adopted consists of a single spare coder-pair and multiplexer at the sending end, and similarly a single spare decoder-pair and demultiplexer will be required at the receiving end. In addition an automatic monitoring and switching unit will be required at each end.

The automatic monitoring equipment is very similar as far as both the coder and the decoder are concerned. It is divided into separate analogue and digital sections, and although the following description deals only with the coder, the details concerning the decoder monitoring follow exactly the same principles.

The analogue monitoring is carried out on each audio channel, and consists of a comparison of the indication obtained from a modulation detector connected to the input filter, with the output from the unit which determines the particular companding range applicable at that time. The length of time for which the modulation detector holds a response is longer than the 1 ms compression block, so a fault output is generated only if there is a disagreement (e.g. appreciable audio input but no compression) extending over several seconds. The monitor should operate satisfactorily to levels 30 dB below peak, and it is considered that this should be satisfactory for the purpose of detecting major faults, either in the analogue unit or in the a.d.c.s.

Digital monitoring is more complex but consists in the main of self-checking functions on each card; for example, failure of a clock feed or command recognition, or the detection of illegal data combinations. Each digital card is connected to a one-line fault bus, and the existence of a fault will also be shown by the illumination of a red l.e.d. on the card.

In the event of a fault being detected in a coder-pair, the spare coder-pair has to have the appropriate inputs

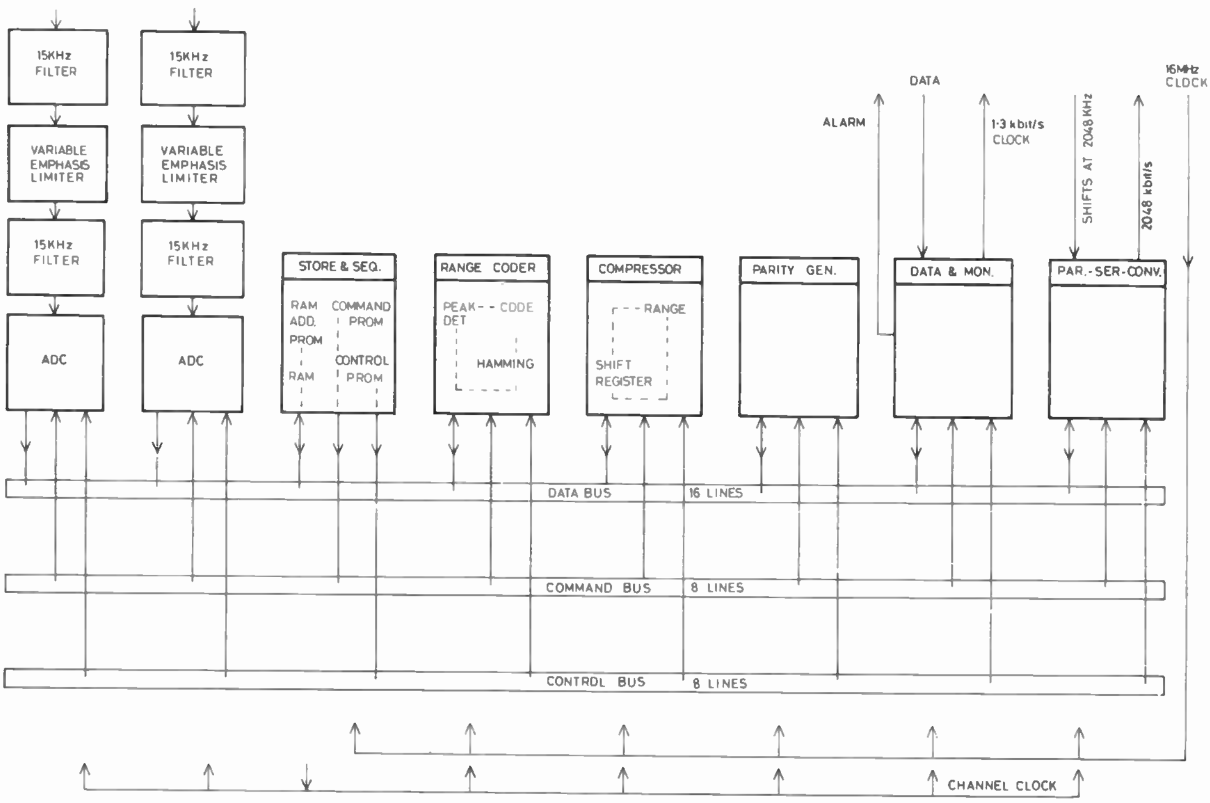


Fig. 6. NICAM 3, dual-channel coder block diagram.

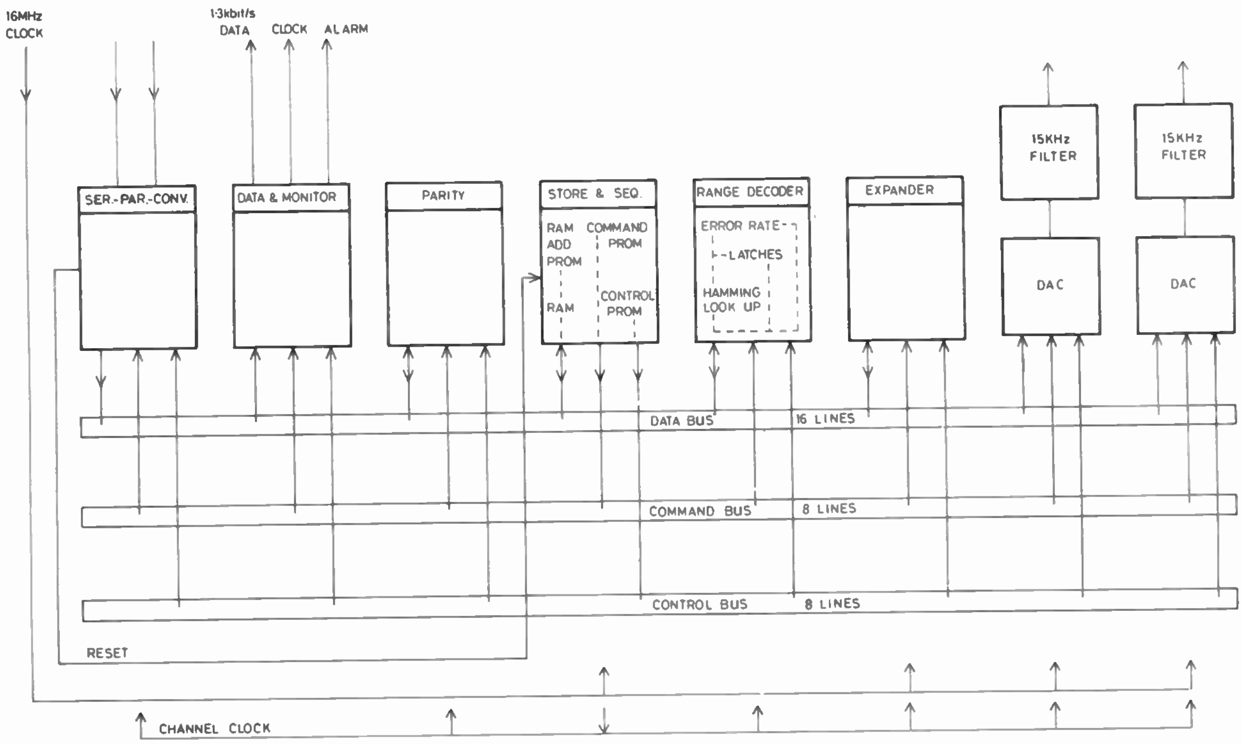


Fig. 7. NICAM 3, dual-channel decoder block diagram.

switched to it, and its output also has to be routed to the multiplexer in place of the output from the faulty coder. These operations, and, if necessary switching in the spare multiplexer, are taken care of by the automatic monitoring unit.

4.4 Maintenance

Maintenance of the equipment has been carefully considered. The original p.c.m. distribution system is maintained successfully on a card replacement basis in the field, with a well-equipped maintenance base in London to effect repairs. For NICAM 3, the same policy could be adopted, the detection of faulty cards in the field being assisted by on-card monitoring. Apart from traditional instruments the field technician may also be equipped with a 'Signature Analyser'. This instrument is particularly useful to detect whether a complex logic waveform is correct or incorrect by displaying a four-figure hexadecimal number. By annotating the handbook with these 'signatures' in the same manner as circuits which include waveforms, mainframe checks can be carried out, particularly the correct operation of the command and control busses. Plugging in a dummy a.d.c. card which produces repetitive dummy sample words would extend the test to include the data bus and hence r.a.m. operation, companding and housekeeping generation.

5 Circuit Description

Figures 6 and 7 are block diagrams of the dual-channel coder and decoder respectively. It will be seen that a bus structure has been adopted for interfacing between the digital cards, similar to that commonly used for microprocessor systems.

5.1 Analogue Units

At the coder the analogue input units consists of filters, limiters, and delay lines, although if the signals have previously been limited the last two items may be omitted.

The audio signals are filtered to avoid components above 15 kHz thus preventing aliasing problems. It is undesirable to permit limiting action to occur on components which will not be transmitted anyway, so there is one three-element filter before the limiter, and, as the limiter may produce harmonics, a second similar filter immediately precedes the a.d.c. The limiter is a two-stage type known as a variable-emphasis limiter.[11]

The first stage is a flat delay-line-type limiter with automatic control of recovery time-constant. In this section no clipping should occur because gain reduction is effected on the delayed programme signal. The recovery time-constant is rapid if a quiet interval follows limiting action, but is extended up to ten seconds gradual recovery of gain if the programme level is high. The second stage of limiting has no delay line and does not alter the gain of the main part of the spectrum. Instead, the circuit applies 50 μs pre-emphasis as required for v.h.f. broadcasting and television sound, and if an overload occurs due to this, the 50 μs time constant is reduced thus reducing the gain at all frequencies above 1 kHz. By employing a variable-emphasis limiter of this type at the input of the sound-programme distribution network, further limiters are not required at the transmitter. After a signal has been variable-emphasis protected in this way it can be de-emphasized, and a different pre-emphasis characteristic may be used for network transmission if required, but the basic 50 μs protection is still retained, thus avoiding the possibility of serious over-deviation of an f.m. sound transmitter.

Although it would have been convenient to use the same pre-emphasis characteristic for NICAM 3, subjective tests[3] have indicated that a better characteristic is that recommended by the CCITT in their Recommendation J17. Hence this pre-emphasis has been used following 50 μs de-emphasis at the output of the variable-emphasis limiter. For conformity with other proposals for digital sound-programme systems a loss of 6·5 dB at 800 Hz has been chosen.

In the decoder the analogue units comprise similar filters to those used in the coder, together with CCITT de-emphasis, and audio output amplifiers.

5.2 A.D.C.s and D.A.C.s

The 13-channel p.c.m. system uses double ramp counter techniques for the a.d.c.s and d.a.c.s.[12] However, whilst this was quite satisfactory for 13 bits, it was considered that instrumental difficulties were likely to be too great to employ the same principle for 14 bits, since the time between samples with a sampling rate of 32 kHz is only 31·25 μs.

An a.d.c. and a d.a.c., which operate on the floating point principle, have been developed for studio applications, and a version of each of these may be employed in NICAM 3. They are capable of 16-bit resolution and are based on hybrid 12-bit a.d.c.s and d.a.c.s. In the a.d.c. a buffered feed of audio is applied to a full-wave rectifier, and this drives a sample peak-level detector. The peak amplitude of a sample is stored in digital form, and is used to control a programmable gain amplifier, which adjusts the amplitude of the sampled audio. Samples are converted into 12-bit words in the hybrid a.d.c., and for NICAM 3 two extra bits are added at the appropriate end or ends of a shift register, as determined by the sample peak detector.

In the d.a.c. the two most significant bits of each 14-bit sample word are used to address a p.r.o.m., which controls a shift register containing the sample word, so that the 12 most significant active bits are presented to a multiplying d.a.c. At the same time the p.r.o.m. drives a ranging d.a.c. which produces a reference voltage proportional to the range. This reference voltage is applied to the multiplying d.a.c. The decoded audio signal from the multiplying d.a.c. is passed through a sample-and-hold circuit which will remove any 'glitches' that are present.

5.3 Store and Sequencer

The purpose of the store and sequencer unit is to provide control signals to the processing units, i.e. compressor, parity, and frame code generator, etc., in a coder or decoder. It includes a central store for the purpose of data transfer between the individual units. The actions performed by the store and sequencer are determined by two p.r.o.m.s and by altering the contents of these, subsets of the NICAM 3 instructions can be used for test purposes. The sequencer could also control processing units which may be required in the future development of NICAM 3.

The control signals produced by the store and sequencer are at rates which are both multiples and sub-multiples of the audio sampling rate. For each audio sample interval the sequencer issues 32 commands, consisting of two identical blocks of 16 commands because the unit is used for two-channel applications. The first block is applied to one channel and the second to the other. As each sample occupies 31·25 μs commands are issued every 0·98 μs.

Each command is identified by an 8-bit command byte. Two bits from this byte are used to select one of four control fields which determine the detailed timing control used during the command. Three bits are used to control which of the processing units should be activated. The remaining three bits determine the particular board function that must be completed during the activation time period.

The card is driven from a 16·384 MHz clock. This is derived from 32 kHz sampling × 16 commands × 2 channels × 8 control intervals × 2 (division for control interval clock). A counter drives a command p.r.o.m., control p.r.o.m. and an address p.r.o.m. The address p.r.o.m. drives a 512 location by 16-bit wide r.a.m. onto a bi-directional data bus. The command p.r.o.m. produces 1536 commands of 64 different types.

The store and sequencer unit in the coder is similar to that in the decoder, but the p.r.o.m.s are programmed differently.

5.4 Range Coder and Decoder

The range coder card provides range code information for each of the pair of channels being coded. NICAM 3 employs five ranges to compress from 14 to 10 bits, and the range coder examines the four most significant bits of each sample to determine which range is required. A 3-bit word is produced which indicates the highest range (least slope) required by each group of 32 sample words. Three consecutive 3-bit words are then integrated, and a 7-bit word is derived, to determine uniquely which of the five ranges each of the 3 groups require.

Four bits are added to each 7-bit word to provide single error correction according to a system proposed by R. W. Hamming.[13] The generation of the resulting 11-bit word is carried out by addressing two p.r.o.m.s with the three 3-bit words defining the three ranges.

This procedure is the same for both channels in a coder-pair, and hence only one range coder is needed, multiplexed between the two channels.

The range decoder performs the inverse of the above operation. First the 11-bit word is applied to the address of a p.r.o.m. and a corrected 7-bit word is produced. This is then passed to another p.r.o.m. which provides the required three 3-bit words.

5.5 Compressor and Expander

The compressor consists basically of a shift register, which is sequentially loaded with each 13-bit (magnitude only) sample. The 3-bit range code word for each group of 32 samples determines which four bits of each sample are discarded by arranging for the shift register to be clocked, so that the correct number of bits are removed from the appropriate end of each sample.

The expander is also a shift register, which is loaded sequentially with the nine magnitude bits of each 10-bit compressed sample word. Again the 3-bit range code word causes the shift register to be clocked so that the required number of most significant bits (m.s.b.s) and/or least significant bits (l.s.b.s) are added to produce the appropriate 13-bit magnitude word.

M.s.b.s that were removed in the compression process only need to be replaced by logic '0's in the expansion process. However, when the l.s.b.s are removed the result is a continual rounding down of the samples. It is therefore necessary to replace these l.s.b. zeros with a correction factor equivalent to '0·5'. This will produce an average result between 'rounding up' and 'rounding down', and should reduce the distortion introduced by companding to a minimum. The correction factor added is '0111' after the last bit transmitted. Table 3 below indicates the extra bits which are added to any compressed 10-bit word for ranges 0 to 4 during the expansion process. The particular 10-bit word chosen for the table is 1011001101 but this has no special significance.

Table 3

Showing the m.s.b.s and l.s.b.s added during expansion from 10 to 14 bits

Range	10-bit word (sign bit … l.s.b.)	14-bit word (sign bit; Additional m.s.b.s … l.s.b.; Correction factor)
0	1 0 1 1 0 0 1 1 0 1	1 0 0 0 0 0 1 1 0 0 1 1 0 1
1	As range 0	1 0 0 0 0 1 1 0 0 1 1 0 1, 0
2	,, ,, ,,	1 0 0, 0 1 1 0 0 1 1 0 1, 0 1
3	,, ,, ,,	1 0 0 1 1 0 0 1 1 0 1, 0 1 1
4	,, ,, ,,	1 0 1 1 0 0 1 1 0 1, 0 1 1 1

The expansion process is identical for the other audio channel, the same hardware being multiplexed between the two channels.

5.6 Sample Parity

Sample error protection can assume two different forms in NICAM 3, depending upon the type of bearer circuit available. Where Post Office digital bearer circuits are employed a simple form of sample parity which provides error concealment is proposed. This is because typical error rates on these circuits are expected to be not worse than about 1 in 10^5. However, in the case of radio-link circuits where the link is subject to severe fading, a more sophisticated form of error protection could be used. An error correction system employing a Wyner–Ash 16, 15 code, [14, 15] has been devised, and this could replace the error concealment system.

Both the above methods of sample error protection use 32 parity bits per frame. Only the 5 m.s.b.s of each 10-bit compressed sample are protected, and this has been found to be satisfactory subjectively. Protecting more bits does not necessarily improve the performance of the audio signal in the presence of errors.

There are 32 bits available to protect 96 samples, hence for the simple error concealment system a detected error will result in the replacement of three samples at the d.a.c. by three repetitions of the previous correct sample. If long bursts of errors are encountered, the held voltage at the d.a.c. output will gradually decay to zero, in order to minimize the disturbance on recovery.

Thus error concealment will be most effective in dealing with relatively isolated single bit errors, whereas the Wyner–Ash technique has been designed to correct bursts of up to 8 consecutive protected bits in error.

The bits of the sample words are re-ordered for transmission so that the protected 5 m.s.b.s are interleaved with the unprotected 5 l.s.b.s. Furthermore, as shown in Fig. 4 the 2048 kbit/s bitstream commutates between the six channels. Thus protected bits are 12 bits apart providing considerable burst error protection, and since 5 bits of three samples are protected together, a burst as long as 180 bits could result in only one parity failure and sample repeat process, in each audio channel.

5.7 Parallel-to-Serial and Serial-to-Parallel Converters

The operation of these units is fairly straightforward. In the case of the parallel-to-serial converter in the coder, sample and housekeeping data, which are present intermittently in parallel form on the data busses of each coder-pair, are clocked out in serial form at a rate suitable for the particular application, for example, bursts of 2048 kbit/s, or a continuous bitstream of 676 kbit/s.

The serial-to-parallel converter in the decoder is required to reverse this process, but to achieve this, the unit must first recognize the individual channel frame alignment words and use this information to reset the store and sequencer unit.

5.8 Multiplexer and Demultiplexer

The 2048 kbit/s multiplexer accepts the three tributary bitstreams from the coder-pairs and combines them so that the output data rate is continuous at 2048 kbit/s. A fourth input to the multiplexer accommodates the output from the reserve coder-pair, as explained in Section 4.3. An associated clock card also includes a binary-to-HDB3 converter.

The demultiplexer performs clock recovery on the incoming bitstream and converts it from HDB3 to binary. It separates the 2048 kbit/s frame word in order to decode the signalling channel and lock the shift pulse generator. The bitstream is fed to the three decoder pairs and reserve and each is also fed with a set of shift pulses which clock in the appropriate bits to each decoder from the complete 2048 kbit/s signal. (Note that the shift pulses sent to the reserve decoder pair will correspond to those sent to one of the main decoder pairs.)

5.9 Signalling Facilities

As explained above, signalling bits are included both in the individual channel bitstreams, and at the multiplexed 2048 kbit/s level. Appropriate input/output ports are provided together with appropriate clock feeds, but the coding and decoding arrangements are not part of the NICAM 3 equipment, and will not be described here.

6 Conclusions

A digital processing system known as NICAM 3 has been described, which is designed to be used for many of the BBC's future high quality sound-programme circuits. The design has concentrated on flexibility, in order to accommodate most of the likely needs. In particular, six 15 kHz channels can be provided on dedicated 2048 kbit/s digital circuits. The sound quality obtained with NICAM 3 is expected to be better than any other companded system so far examined.

7 Acknowledgments

The work described represents the joint efforts of teams in the Research and Designs Departments of the BBC, and the authors wish to thank the Director of Engineering of the British Broadcasting Corporation for permission to publish this paper.

8 References

1. CCITT, Sixth Plenary Assembly, Recommendations G731 and G741, III–2, p. 425 and pp. 444–46, CCITT, Geneva 1976.
2. Shorter, D. E. L., 'The distribution of television sound by pulse-code modulation signals incorporated in the video waveform', *E.B.U. Review*, no. 113–A, pp. 13–8, February 1969.
3. Croll, M. G., Osborne, D. W. and Spicer, C. R., 'Digital sound signals: the present BBC distribution system and a proposal for bit rate reduction by digital companding', I.B.C. Conference Publication No. 119, pp. 90–5, 1974.
4. CCITT Sixth Plenary Assembly, Recommendation G711, III–2, pp. 407–14, CCITT, Geneva 1976.
5. Richards, D. L., 'Transmission performance of telephone networks containing p.c.m. links', *Proc. Instn Elect. Engrs*, **115**, no. 9, pp. 1245–57, September 1968.
6. CCIR XIVth Plenary Assembly, Report 647–1, XII, pp. 150–8, CCIR, Kyoto 1978.
7. Gilchrist, N. H. C., 'Digital Sound Signals: Tests to compare the performance of five companding systems for high-quality sound signals', BBC Research Department Report No. 1978/26.
8. Jones, A. H., 'Digital coding of audio signals for point to point transmission', International Broadcasting Conference, I.E.E. Conference Publication No. 166, pp. 25–6, 1978.
9. Bylanski, P. and Ingram, D. G. W., 'Digital Transmission Systems', p. 104 (Peter Peregrinus, Stevenage, 1976).
10. Gilchrist, N. H. C., 'Digital Sound: Sampling-rate Synchronization by Variable Delay', BBC Research Department Report No. 1979/19.
11. Gleave, M. M. and Manson, W. I., 'Variable-emphasis limiters for sound-programme signals', International Broadcasting Conference, I.E.E. Conference Publication No. 145, pp. 149–53, 1976.
12. Gilchrist, N. H. C., 'Analogue-to-digital and digital-to-analogue conversion for broadcast quality sound', *The Radio and Electronic Engineer*, **49**, no. 2, pp. 77–84, February 1979.
13. Hamming, R. W., 'Error detecting and error correcting codes', *Bell Syst. Tech. J.*, **26**, no. 2, pp. 147–60, April 1950.
14. Stott, J. H., Oliphant, A. and Osborne, D. W., 'Digital Video: Error-correcting Codes and a Practical Study of a Wyner–Ash Error Corrector', BBC Research Department Report No. 1974/40.
15. Wyner, A. D. and Ash, R. B., 'Analysis of recurrent codes', *IEEE Trans. on Information Theory*, **IT-9**, pp. 143–56, July 1963.

Manuscript first received by the Institution on 18th March 1980 and in final form on 12th June 1980.
(Paper No. 1958/Comm 207)