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Energy in Crisis

IS the present Government *really* interested in the conservation of Energy? This question must be asked in the light of the initial setting-up of an Energy Commission which appeared totally to ignore the efforts and expertise of the Engineering Profession's Watt Committee. It seems strange that while the Department of Energy should have decided to make some financial contribution to the continuation of the work of the Watt Committee, the Government should not accord the Watt Committee direct representation on the Energy Commission. Is this a case of the Government thinking that because it has appointed representatives of the energy industries and of fuel and power industries unions to the Commission, these can adequately present the views and experience of Professional Engineers? Imagine the outcry if the Government were to set up a commission to deal with matters of a medical or legal nature without the doctors or lawyers sitting on it as members to give the benefit of their hard-won knowledge! It is to be hoped that the strongly-worded protest by Professor Sir Hugh Ford, D.Sc., F.R.S., President of the Institution of Mechanical Engineers, will have the effect of changing the mind of the Secretary of State for Energy, Mr Wedgwood Benn, and that the Watt Committee will be able to make direct contributions on this important commission.

The Watt Committee, on which the IERE has representatives, was formed with its present constitution in January 1976 and is composed of 63 learned societies concerned with conservation of energy in its generation and use and the efficient control of energy in all its forms from atomic power to the use of energy in the home. Its first main action was to set up a number of working parties of its members which separately studied the various areas covered in the Government discussion document 'Energy Research and Development in the United Kingdom' prepared by the Advisory Council on Research and Development for Fuel and Power (ACORD).*

The Report commenting on this Discussion Document, now published,† was in fact prepared at the invitation of Dr Walter Marshall, Chairman of ACORD, and appeared in July. The second report† is a full account of the working party on 'Deployment of National Resources in the Provision of Energy in the United Kingdom 1975–2025' and this has attracted a contract from the Department of Energy's Energy Technology Support Unit to develop further their methodology for 'costing' scenarios in relation to capital investment, manpower, materials required and land use. These first two reports have provided an authoritative and independent view of a possible Government Energy Policy.

In conclusion it is pertinent to quote the words of the Chairman of the Watt Committee, Dr J. H. Chesters, O.B.E., F.R.S., when he answered how long the Watt Committee would continue. He replied 'Forever, or at least until there is obviously enough energy available for those who need (rather than waste) it. My personal ambition, which is I guess shared by most if not all our members, is to find new ways of conserving energy and to further the large amount of work already in hand on alternative sources. In both fields we should be concerned not just with R and D but with R, D and D, the second D being Demonstration. Too often we leave someone else to tackle this last stage. With our wide membership and skills of half a million engineers, scientists, accountants, economists, architects and the like we should be able, like James Watt himself, to come up not only with some good ideas but some good 'engines'!

One can only hope that the Government will at last realize what the Chartered Engineer and his colleagues in these other professions can do to help solve the world-wide Energy Crisis.

M. S. BIRKIN

* Department of Energy Paper No. 10. HMSO, £2.65.
† Watt Committee Reports Nos. 1 and 2, I.Mech.E., London SW1H 9JJ. £10 each (half price to member societies).

Contributors to this issue*

Tony Welch (Fellow 1966, Member 1952) spent ten years in the Electrical Branch of the Royal Navy, specializing in radio communications, radar and navigational electronics. From 1950 to 1954 he was with the Radio Advisory Service of the Chamber of Shipping and he then joined Decca Radar Ltd., to conduct field studies in new applications of radar, subsequently becoming manager of the radar applications group. In 1965 Mr Welch formed a specialist company, T. W. Welch & Partners Ltd., to provide consultant services in the formulation of operational requirements, feasibility and cost studies and system design for radio, radar and navigational systems. Mr Welch became a member of the Institution's Aerospace, Maritime and Military Systems Group Committee in 1974 and was its Chairman from 1973 to 1977. He is Chairman of Governors of Guildford County Technical College and Chairman elect of the Association of Colleges of Further and Higher Education. He represented the Institution on the Organizing Committee of the 'RADAR 77' Conference and is currently Chairman of the Organizing Committee of the Institution's Conference on 'Electro- magnetic Compatibility' April, 1978.

Larry Dunn is a Senior Associate Physicist in the Media Technology Department of IBM's General Products Division Laboratory at Boulder, Colorado. He joined IBM in 1968 as a Customer Engineer in Los Angeles, California, and transferred to the Boulder laboratory in 1971. Before joining IBM, Mr Dunn was an electronics instructor in the U.S. Navy. He received the B.S. degree in engineering physics from the University of Colorado, Boulder, in 1976. Mr Dunn's present work at IBM involves analysing the read/write processes of magnetic recording.

Geoffrey Bate was born and educated in England, receiving both his B.Sc. with honours in Physics and his Ph.D from the University of Sheffield. After obtaining his doctorate he served four years as a Scientific Officer in the Royal Naval Scientific Service, working on infra-red photo-conductors. He then went to the University of British Columbia, Vancouver, Canada, as Research Associate and later Assistant Professor. He joined IBM in Poughkeepsie, New York, as Staff Physicist to work on magnetic recording. Dr Bate is at present Senior Physicist in the GPD Laboratory at Boulder, Colorado.

Rodney Ward graduated in Physics from London University in 1966 and following work on type II superconductors, he was awarded a Ph.D. by Essex University in 1970. He joined the Mullard (now Philips) Research Laboratory in the same year and took up work in the Image Devices group. Here he was concerned primarily with channel image intensifiers for night vision and took a special interest in the problems of noise and picture quality. In 1976 Dr Ward joined the Electron Lithography group to work on an electron image projector for the fabrication of integrated circuits.

Alfred Woodhead (Fellow 1967) graduated in Physics and Radiophysics at the University of Sheffield in 1944, and after serving a one year apprenticeship at Metropolitan-Vickers Ltd., Manchester, worked for a further $1\frac{1}{2}$ years in the Electronics Design Laboratory. In 1947 he joined the Mullard company's research facility, now the Philips Research Laboratories, Redhill, where his early work was concerned with travelling wave tubes and gas discharge devices. In the early 1950s he took up work on image devices and has continued in this field ever since, his main interest being in image intensifiers for high-speed photography, medical X-ray diagnosis and particularly night vision. Since 1961 Mr Woodhead has been in charge of the Image Devices group and for the past seven years deputy head of the Applied Physics Division, his prime responsibilities including image intensifiers, cathode-ray tubes and associated optical techniques.

*See also pages 561 and 570

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The channel electron multiplier and its use in image intensifiers

A. W. WOODHEAD,
B.Sc., F.Inst.P., C.Eng., F.I.E.R.E.*
and
R. WARD, B.Sc., Ph.D.*

SUMMARY
The main application for channel electron multipliers is in the production of compact, high-gain image intensifiers. The channel plate has certain unique characteristics which influence the design of the intensifier and the performance of the finished device. It is the purpose of this paper to relate the characteristics of the channel plate to the demands of the tube with particular reference to image resolution, noise and tube life. The introduction of the channel plate into an image device is not without its problems. Some of these are discussed together with various solutions which have been adopted and their consequent effects on tube performance are described.

* *Philips Research Laboratories, Redhill, Surrey, RH1 5HA.*

1 Introduction

Image intensifier tubes which use channel electron multipliers are emerging from the research and development laboratories to appear on the production line.

In 1971 and 1973 three issues of the journal *Acta Electronica* were devoted exclusively to papers on the channel multiplier and its application[1,2,3] whilst Schagen[4] has given an extensive review of the subject. It is the purpose of this paper to bring up to date the published information in this field particularly with respect to the characteristics of resolution and noise.

The channel electron multiplier consists of a resistive tube usually 40 times longer than its diameter. A potential of 1000 to 2000 V is applied between the ends of this tube. In vacuum, electrons entering the channel at the low potential end will, on striking the wall, release secondary electrons. Under the influence of the electric field the secondary electrons will be accelerated down the channel before further interacting with the wall and releasing more secondaries. Provided the channel material has a secondary emission coefficient greater than one, an electron cascade will build up along the channel. Figure 1 shows a graph of gain against applied voltage for a typical channel multiplier.

Multipliers are usually made from lead-containing glasses which can be readily formed into tubes of the required dimensions. The desired electrical resistance is achieved by reducing the metallic oxides of the glass by heating in a hydrogen atmosphere. Electrical contacts are made to each end of the channel by evaporated nichrome electrodes.

The gain of a multiplier of a given material is determined only by the applied voltage and the ratio of the length to diameter of the channel. The device can therefore be miniaturized so that many channels can be operated in parallel in a two-dimensional array called a micro-channel plate. In a typical 25 mm plate there will be about 2·5 million channels, each of them 12·5 μm internal diameter, stacked in a hexagonal close-packed array 0·5 mm thick. Figure 2 shows a channel plate and its structure. A micro-channel plate is simple to operate and extremely compact yet it will amplify the electron input and still retain the spatial distribution of an image. Channel plates have been used in various types of intensifiers and cathode-ray tubes and many of these applications are described in references 2 and 3. Some of the most important include image intensifiers for night vision applications, X-ray diagnostics and non-destructive testing. The low energy of the input electrons and the high gain attainable in conjunction with the short transit time of the electrons through the multiplier make it particularly useful in devices for studying high speed phenomena. Descriptions have been given of image tubes which can be gated to obtain exposures of a few nanoseconds from a weak light source, a cathode-ray oscilloscope which can be used to record traces at frequencies above 1 GHz and a photomultiplier which will detect a light pulse of 500 ps half-width.

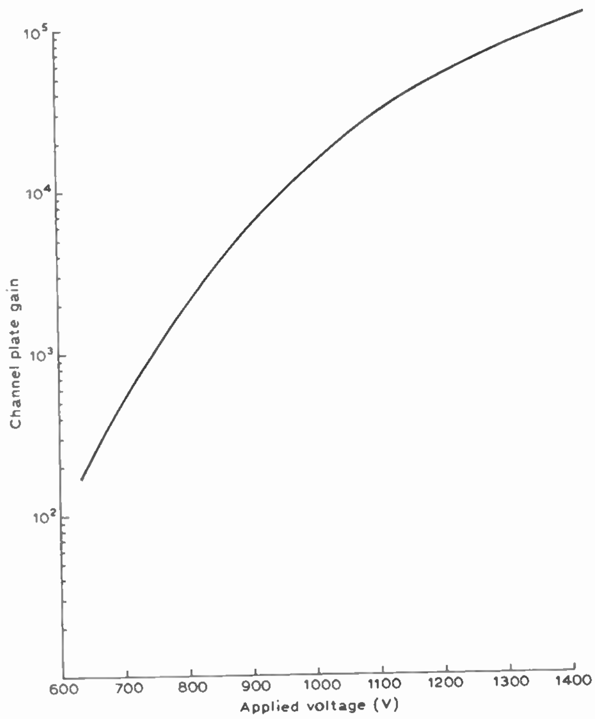
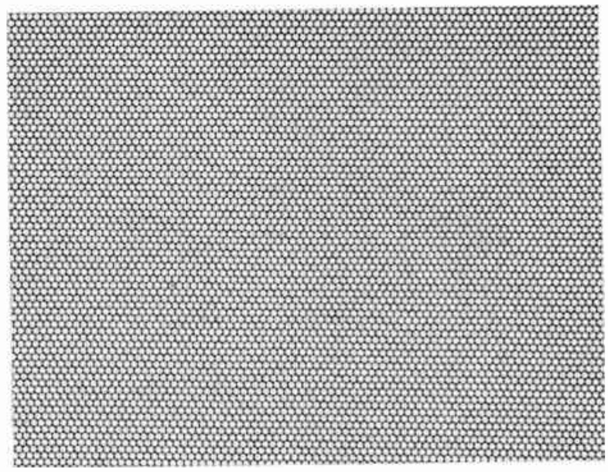
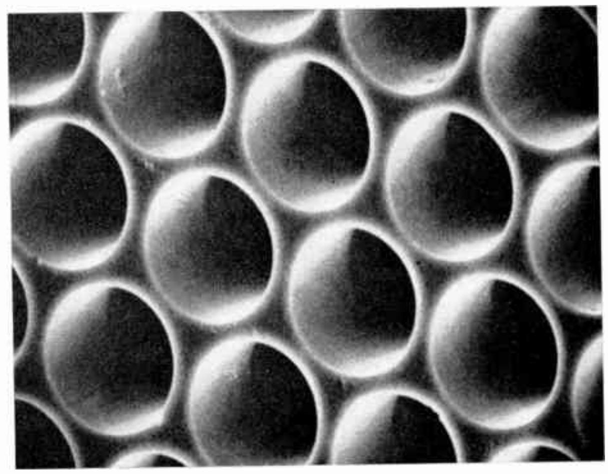


Fig. 1. Gain as a function of voltage for a typical multiplier.



(a) Transmission optical micrograph.



(b) Scanning electron micrograph.

Fig. 2. Channel plate showing its structure

Although the action of the channel multiplier has been described in terms of an electron input, any particle or radiation which will interact with the channel walls to release electrons can be detected and the resulting signal amplified. For example, the channel plate has been found to be particularly useful in field ion microscopy where the input is a gaseous ion.[5]

In addition to the requirement of a high gain, the application of channel plates in image tubes and cathode-ray tubes imposes many other demands on their characteristics.[6] In this paper, it is our intention to confine our attention to those characteristics which are particularly relevant to image intensifiers.

Two basic forms of image intensifier are shown in Fig. 3. Figure 3(a) shows a tube of a wafer-type structure in which the electron image is transferred from the photocathode to the channel plate across a small gap in which there is a high electric field. The transverse spread of the electrons is thus limited and the image quality preserved. Electrons from the channel plate are similarly imaged on to the output screen. Such tubes are called 'wafer' or 'proximity' tubes. It should be noted that, because there is inversion in the objective lens, the image on the fluorescent screen will be upside down so that for direct viewing further optical inversion is necessary. This is commonly achieved with a 'twister' fibre optic which adds to the length and weight of the tube.

The tube shown in Fig. 3(b) employs an electron lens to project the electron image from the photocathode to the channel plate. The tube itself is therefore somewhat longer but there is no need for optical inversion of the image. The electric field in the cathode-channel plate region is much lower than in the wafer tube. In other versions of this basic design the field at the channel plate can be either positive or negative depending upon the lens design and, as will be seen in Section 2.3, this can affect picture contrast.

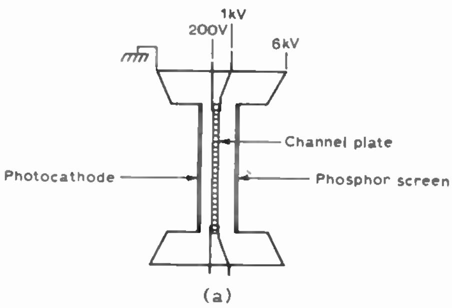
Both structures have their advantages and disadvantages but in either form sufficient intensification can be achieved for a single electron leaving the photocathode to be recorded at the fluorescent screen either by the human eye or on photographic film.

2 Resolution of a Channel Image Intensifier

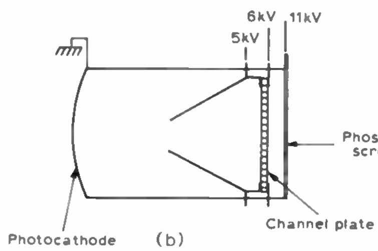
2.1 Channel Plate Geometry

The two most important parameters which determine the information content of the image on the screen of an intensifier are the resolution and the noise. In a channel image intensifier the resolution will be mainly determined by the channel plate.

A most informative way of studying the resolution of an optical or electron optical system is to use the concept of the modulation transfer function (m.t.f.).[7] Very simply, the m.t.f. describes how the modulation of a black and white (100% contrast) line pattern of a given size is



(a) wafer channel tube.



(b) inverter channel tube.

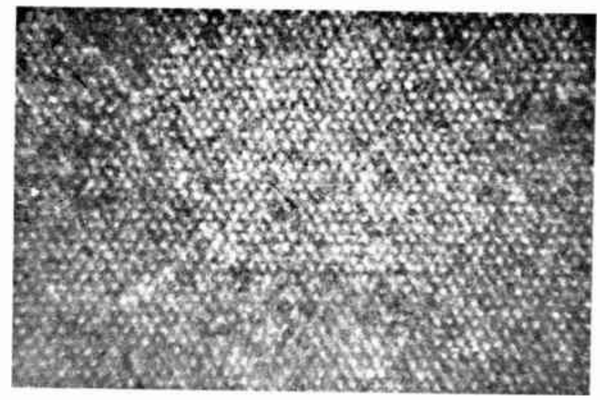
Fig. 3. Tube types

degraded by the imaging system. It is best illustrated by a graph showing the output contrast as a function of spatial frequency. As might be expected, at the high spatial frequencies the contrast in the reproduced image decreases until the pattern can no longer be distinguished by the eye. The spatial frequency at which this occurs is called the limiting resolution.

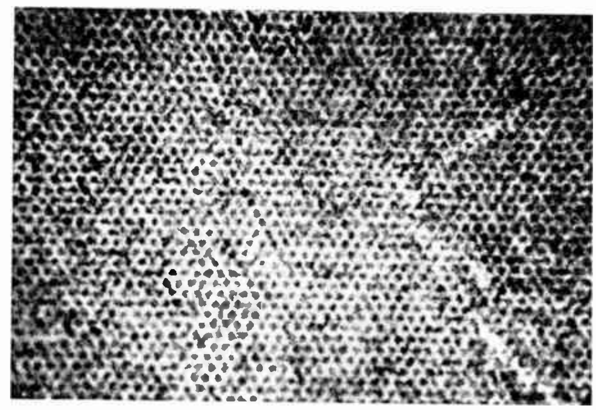
Because the channel plate is composed of a large number of discrete elements, the limiting resolution is determined by the array geometry and its dimensions. The maximum resolution will depend upon the orientation of the test pattern with respect to the array. For an hexagonally packed array, the limit of resolution is $1000/1{\cdot}732D$ cycles . mm^{-1} where D is the centre to centre spacing or pitch of the channels. In the most favourable orientation the limit will be $1000/D$ cycles . mm^{-1}.

The electron beams emerging from the channels may spread before reaching the fluorescent screen, further reducing the resolution of the device. Guest has investigated this problem by combining a computer model of the channel multiplier[8] with field plotting and ray-tracing programs.[9] Using this model the effect on the resolution of the image tube due to the variation of a number of the tube parameters has been studied and some of the results are presented here.

It was shown that the distribution of electrons emerging from the channel was not uniform but tended to form an ill-defined ring, slightly smaller than the channel diameter. This ring of electrons is then acted upon by the electrostatic lens formed by the electric field in the region between the channel plate and the output screen penetrating into the channel. For a given plate-screen distance the output from the channel can be made to appear as a focused point on the screen which, as the lens strength is varied, will turn into a ring. Figure 4 shows how these two



(a) 'dot' structure with 400 volts across channel plate.



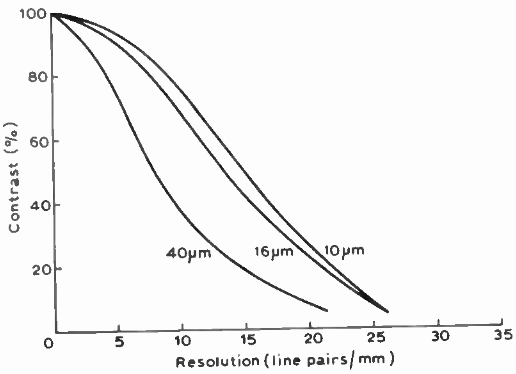
(b) 'ring' structure with 750 volts across channel plate.

Fig. 4. Lens action at the output of a channel (16 μm channels, channel plate to screen spacing 0·9 mm, screen voltage 5 kV).

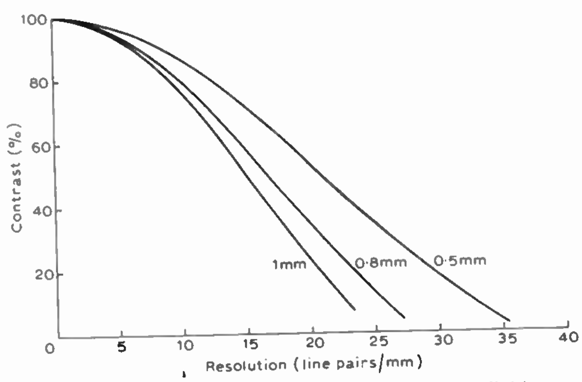
results have been obtained by changing the voltage applied to the channel plate.

With this experimental verification of the qualitative accuracy of the results, calculations of the m.t.f. were made for a wide range of conditions. As might be expected the results of such a study are complex but in all cases reducing the space between the channel plate and the screen, keeping the field strength constant, improved the m.t.f. Figures 5(a), (b) and (c) show some changes in the m.t.f. which have been calculated for a variety of channel plate and tube parameters.

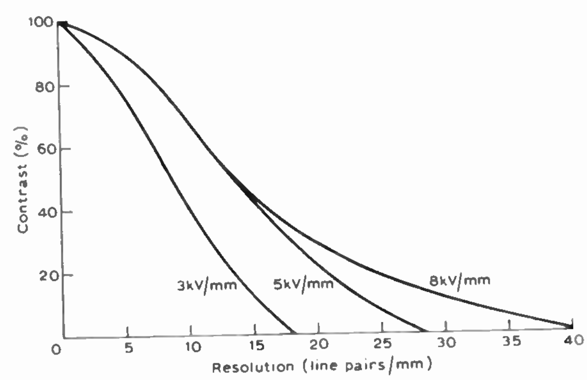
The results of allowing the output electrode to penetrate the channel, the so-called 'end-spoiling', is particularly interesting. It has been assumed in the calculations that any electrons which strike the electrode will be 'lost' and, whilst this will not be completely true in practice, one of the effects of increasing the length of this electrode is to reduce substantially the number of electrons leaving the channel. The electrons which are 'lost' from the beam are those which would diverge most strongly once out of the channel so that the increased length of the output electrode has a pronounced collimating effect on the beam. Increasing the depth of penetration of the output electrode steadily improves the m.t.f. but at the same time reduces the effective gain of the channel. Figure 5(d) shows the calculated m.t.f. of 16 μm channels with electrodes which



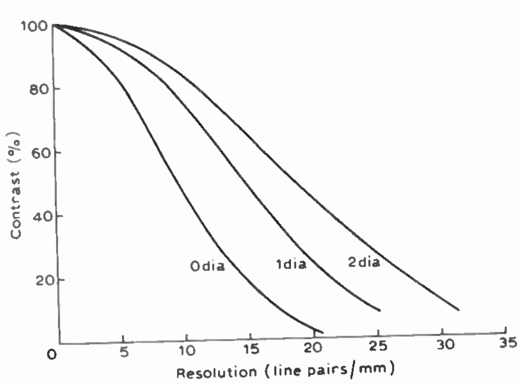
a) Channel diameter (channel diameters marked, field strength 5 kV/mm, channel plate to screen spacing 1 mm).



b) Channel plate to screen spacing (spacings marked, field strength 5 kV/mm, 10 µm channels).



(c) Field strength (field strength marked, channel plate to screen spacing 1 mm, 16 µm channels).



(d) Electrode penetration (penetration in channel diameters marked, field strength 5 kV/mm, channel plate to screen spacing 1 mm).

Fig. 5. Variation of modulation transfer function (contrast vs. resolution) for various parameters.

penetrate 0, 1 and 2 diameters into the channel. In practice it has been found that increasing the electrode penetration from a nominal 0·5 to 2 diameters increased the limiting resolution from an average of 24 line pairs/mm to 30 line pairs/mm, the limit imposed by the channel dimensions.

Although the dimensions of the channels define the maximum resolution of the plate, images up to this limit can be transferred at a high contrast. Starting just below the resolution limit, moiré effects cause various ambiguities to occur. Spurious line patterns at different spatial frequencies or orientations appear. This can be seen quite clearly in Fig. 6 which shows an image formed by a channel plate of 16 µm channels, 20 µm pitch, for which the resolution limit is 29 line pairs/mm. The moiré effects can be seen in the pattern. Below the resolution limit the real lines can still be discerned but at higher spatial frequencies the moiré lines are the more prominent.

2.2 Saturation Effects

So far it has been assumed that the channel plate is operating as a linear device. One of the features of this multiplier is its saturating characteristic which significantly reduces the effect of bright lights, so often a problem in imaging systems. Operation in the non-linear region will reduce the contrast in the transferred image and hence the resolution. In a typical channel plate operating at 1000 volts there will be a standing current of about 1 µA flowing down the walls. The amplified output is a space charge current which builds up towards the output end of the channels. This current must be supplied from the channel walls and when it exceeds about 10% of the standing current, the electric field distribution near the output is disturbed leading to reduced gain and a non-linear characteristic.

Extending the output electrode further into the channel reduces the electron output. Thus the measured gain is

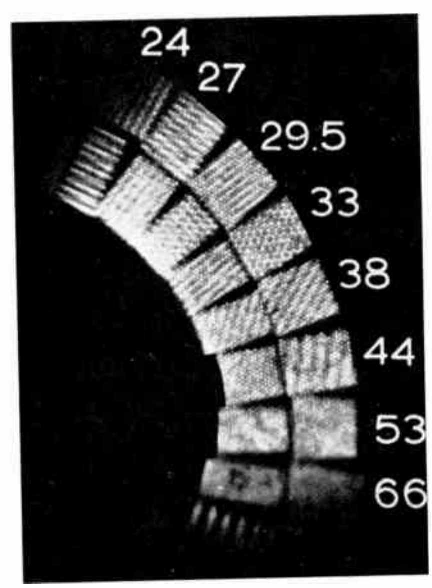


Fig. 6. Moiré effect in the image formed by a channel plate (spatial frequency in line pairs/mm marked).

reduced and the onset of saturation occurs at a lower output. If, as assumed in the calculations, no electrons leave the electrode then the reduction in gain will be about three times for a 2 diameter long electrode. Measurements indicate a reduction in gain and saturation level of between 2 and 5 times for this electrode penetration.

2.3 Effect of Backscattered Electrons

A further reduction in resolution can occur when input electrons strike the closed area of the channel plate giving rise to low-energy secondary or high-energy backscattered primary electrons. These electrons can be particularly troublesome in tube structures in which the electric field causes them to return to the channel plate at a point which can be many channel diameters away from their point of origin. The results are apparent as a reduction of contrast in those dark parts of the image immediately next to a bright area.

Backscattered electrons from the fluorescent screen spreading in the channel plate-screen space can also cause similar lowering of the contrast.

3 Methods of Reducing the Effects of Gas

3.1 Ion Generation in Channel Plates

During operation, positive ions are generated mainly in the last 30% of the channel where the electron density is highest. The ions are accelerated by the field towards the channel input. Some of these collide with the walls, release secondary electrons and initiate a new cascade. Others escape at the channel input to be further accelerated before impinging on the photocathode surface. The bombardment of the photocathode by high energy ions ultimately results in severe deterioration of the photosensitive surface. Each ion impact releases a large number of secondary electrons from the photocathode. These secondaries are intensified by the system in the same way as a photoelectron and produce bright scintillations at the fluorescent screen. Some methods of suppressing these effects will be discussed.

3.2 Electron Bombardment

The electrical conductivity of the channels is achieved by reduction in hydrogen gas. During this process significant quantities of methane, carbon monoxide and carbon dioxide are formed in the bulk of the glass. These gases are not removed by the normal tube bake-out process but only by intense electron bombardment.[10] All tubes include such a step in the manufacturing process. In some structures this may be the only means of reducing the adverse effects of gas ions and the electron bombardment may have to be prolonged. In this case the gain of the channel is usually reduced and adequate tube life is still difficult to achieve.

3.3 Ion Traps

In certain inverter tube designs the electrode potentials are arranged so that positive ions from the channel plate are prevented from reaching the photocathode. In its simplest form this will be achieved if the anode is positive with respect to the channel plate (see Fig. 1). The disadvantage of this approach is the lowering of the image contrast which results if the ions return to the channel plate at a point remote from their point of origin.

3.4 Curved Channels

Ions which are generated near the output end of the channel can be prevented from reaching the input by curving the channel. This technique is well-known in single-element multipliers[11] and was suggested as being applicable to channel plates by Washington.[12] Such plates, shown in cross-section in Fig. 7, were first realized in L.E.P. (Laboratoires d'Electronique et de Physique Appliquée), France.[13] With these plates gains in excess of 10^6 can be obtained without ion-feedback effects.

3.5 Electron Transparent Membranes

If the axes of the channels are perpendicular to the plate surface, electrons whose trajectories are also orthogonal to the plate may pass down a channel without interacting with the walls. Where this occurs, for example, at the centre of the plate in an inverter tube, the gain will be low. The 'black-spot' formed by this area of low gain may be moved out of the picture area by making the channels at an angle to the surface. In many cases the bias angle required to do this is too large to be practical.

This difficulty and that of ion feedback can be overcome if a film which is transparent to electrons but not to ions is placed over the entrance to the channels. Such a membrane will scatter the input electrons and reduce their energy to a degree which will depend upon the material, its thickness and the electron energy.[14] Only a small amount of angular scattering is required to make the gain independent of the electron trajectory. Thin films of aluminium or its oxide are very suitable for this purpose. A thin plastic membrane is deposited on the channel entrance and on to it a thin film of aluminium is evaporated. Oxide layers about 3 nm thick are formed on each surface on exposure to air and these can be made thicker

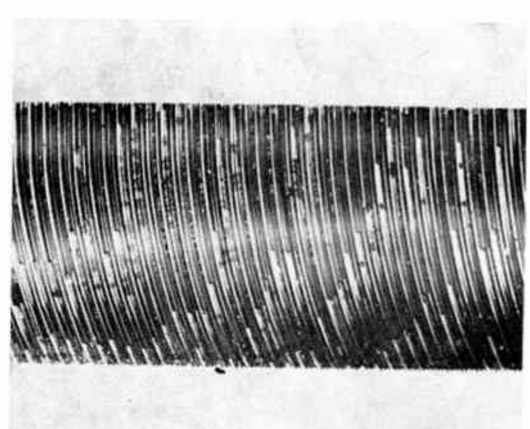


Fig. 7. Cross section through a curved channel plate.

by heat treatment. The plastic membrane is removed by baking to leave a self-supporting film which can be as thin as 3 nm.

4 Noise

4.1 Noise Factor

At very low light levels the ability to detect an object depends upon being able to distinguish between the number of photons received from the object and the number received from its surroundings. Since the emission of photons is a random process the statistical fluctuation in these numbers gives rise to an associated noise. If the gain mechanism of an image intensifier leads to an effective loss of photoelectrons or a large variance in the amplitude of the scintillations on the output screen then the signal-to-noise ratio will be reduced below the level set by the number of detected photons.

The deterioration in signal-to-noise ratio can be expressed as a noise factor F, so that

$$F=\frac{(S/N)^2{}_{\text{input}}(\Delta f)}{(S/N)^2{}_{\text{output}}(\Delta f)} \qquad (1)$$

where $(S/N)_{\text{input}}$ is the signal-to-noise ratio for electrons leaving the photocathode and $(S/N)_{\text{output}}$ is the signal-to-noise ratio at the phosphor screen, each taken over the same bandwidth Δf.[15,16]

The noise factor defined in this way† gives the effective loss in photocathode sensitivity due to noise in the intensifying process.

4.2 Sources of Noise

There are two effects which reduce the signal-to-noise ratio, namely the loss of detected photoelectrons which reduces the signal and fluctuations in the gain which increases the noise.

Electrons are lost because the open area of the channel plate is commonly around 60 to 70% of the total area. Electrons which fall on the glass web are frequently lost or redistributed to remote channels, while not all electrons entering a channel initiate and sustain a cascade.

The statistical nature of the gain process leads to a variation in amplitude of the output pulses. The pulse height distribution usually has a negative exponential form. Ion feedback in the channels and fixed pattern noise in the channel plate or phosphor screen will further broaden the pulse height distribution.

The noise factor may be written[17]

$$F=\frac{1}{D}(1+V) \qquad (2)$$

where D is the detection efficiency defined as the ratio of the number of scintillations on the phosphor to the number of electrons leaving the photocathode and V is the relative variance of the pulse height distribution of the light output from the fluorescent screen.

† It should be noted that in the USA it is common practice to define the noise factor as $\frac{(S/N)_{\text{input}}(\Delta f)}{(S/N)_{\text{output}}(\Delta f)}$ which is equivalent to $\sqrt{F}$ as defined above.

4.3 Pulse Saturation

The pulse height distribution for various channel plate gains is shown in Fig. 8. For gains below about 10^4 electrons/pulse the distribution is close to exponential and the relative variance is unity. As the gain increases the distribution becomes more peaked and when it reaches 10^5 the relative variance is only 0·3. At higher gains ion feedback leads to an increase in the number of large pulses, thus broadening the distribution and increasing the variance. If the channels are curved ion feedback is restricted so that at high gain very highly peaked pulse height distributions can be obtained.

The narrowing of the pulse height distribution at high gain is due to pulse saturation within the channels and is caused either by space charge effects[18,19] or by wall charging.[20] To take advantage of pulse saturation effects to reduce the noise the input level must be kept low, otherwise, with the high gains employed, the output current will enter the non-linear region and there will be a marked loss of contrast.

4.4 Improved Pulse Height Distribution from High Secondary Emitters

The relative variance depends strongly on the secondary emission coefficient of the first collision. When δ, the secondary emission coefficient, is greater than about 5 then the expression

$$\nu\sim\frac{2}{\delta}$$

gives a reasonable approximation to the relative variance.

For the normal glass walls of the channel $\delta\sim2$ and equation (2) is not strictly applicable.

In a demountable vacuum system comparisons have been made between two halves of a channel plate one of which has been coated with a material of high secondary emission coefficient. Figure 9 shows typical pulse height distributions for caesium iodide compared with the uncoated plate. The increase in gain for the coated half is about 5, which if this is due solely to the increased yield, indicates a secondary emission coefficient of at least 10. From equation (2) the relative variance would be less than 0·2 whilst from the measured pulse height distribution the relative variance is 0·4. This disparity arises because the structure of the surface of the evaporated layer causes the secondary emission coefficient to vary spatially thus increasing the variance.

The addition of a scattering membrane will, because of the wider spread in the angle of approach and the energy of the electrons, introduce yet a further variation in the secondary emission which will increase the variance to at least 0·5. Slightly less favourable results have been achieved with magnesium fluoride. Similar results with caesium iodide and potassium bromide have been

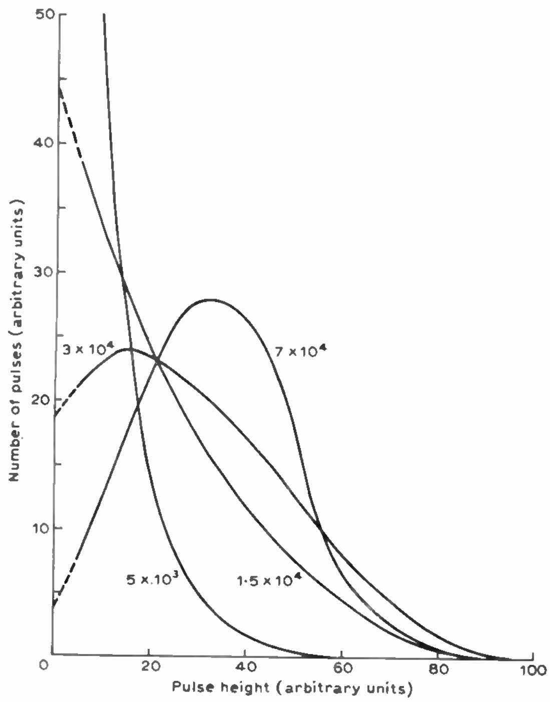


Fig. 8. Variation of pulse height distribution with channel plate gain (gains marked).

reported.[21] All these materials are incompatible with the normal tube processing and would therefore be difficult to use in a completed device. Magnesium oxide is more suitable in this respect. Pollehn[21] reported a gain increase of two with this material but only a marginal improvement in noise factor. Much higher secondary emission yields have been achieved from evaporated layers of magnesium oxide and this material holds the most promise for improving the pulse height distribution.

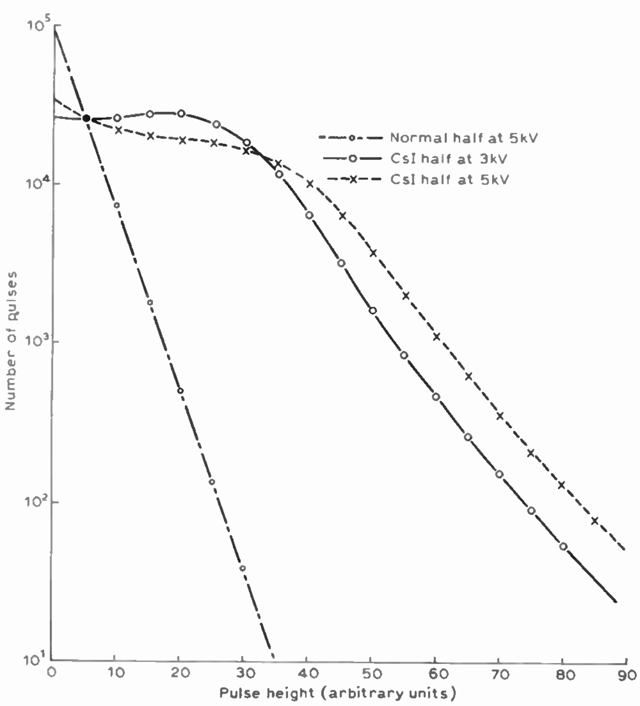


Fig. 9. Pulse height distribution for a CsI coated plate compared with the distribution for an untreated plate.

4.5 Detection Efficiency of Open Channels

The detection efficiency can be determined by counting the total number of pulses in the pulse height distribution and expressing this as a fraction of the number of incident electrons.

The probability of a secondary electron being produced is dependent upon the secondary emission coefficient which in turn is dependent upon the angle of incidence of the primary electron to the channel wall.

Figure 10 shows the variation of the detection efficiency with the incidence angle. At low angles it is limited only by the geometric open area of the plate which is about 65%.

As already stated electrons striking the closed area of the plate can be backscattered or produce secondaries. When there is a high positive electric field, such as in the wafer tube, the low energy electrons will return to enter channels adjacent to their point of impact. These electrons can increase the detection efficiency to about 80% without seriously affecting the resolution.[21,22]

For a given minimum wall thickness, plates with square channels will have a greater open area than plates with circular channels. No difference in detection efficiency between square and round channels of equal open area has been found.

The open area can be increased without weakening the plate structure by funnelling the channel input. Figure 11 shows a plate with circular channels where this has been done. It also illustrates the demands made upon the geometrical uniformity if this is to be a reproducible operation.

4.6 Detection Efficiency of Covered Channels

Detection efficiency as a function of input energy for a range of aluminium film thicknesses is shown in Fig. 12.

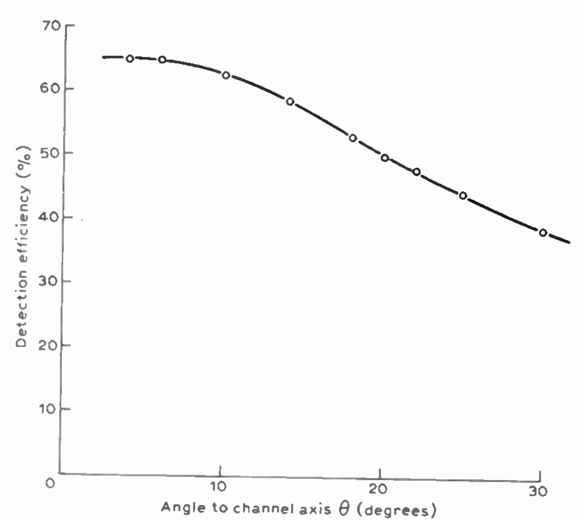


Fig. 10. Detection efficiency as a function of the angle to the channel axis.

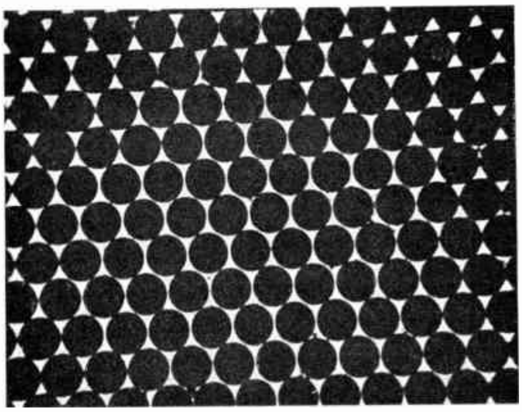


Fig. 11. Channel plate with funnelled input.

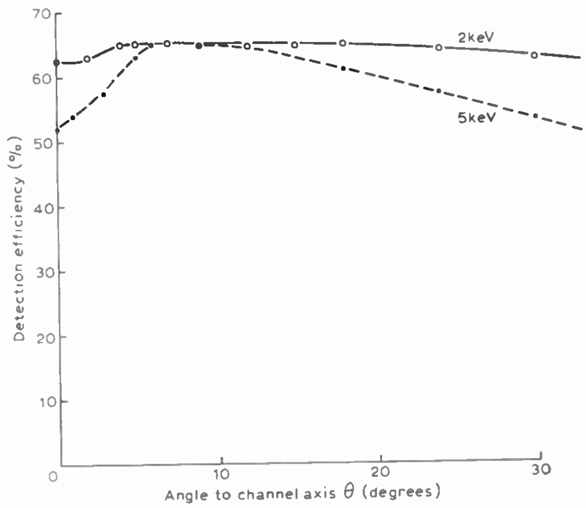


Fig. 13. Angular dependence of the detection efficiency for two input energies marked.

Provided the primary energy exceeds 1·5 keV the detection efficiency of the thinnest films is only slightly below that of the uncoated plates. As the film thickness is increased the detection efficiency falls at all energies of interest. This fall is not due to absorption of primaries in the film but results from the large increase in the scattering angle which increases the angle of incidence for the first collision.

When a plate is covered with a very thin film of aluminium oxide there is an angular dependence of the detection efficiency for 5 keV electrons which is not apparent for 2 keV electrons as shown in Fig. 13. The scattering angle for the higher energy electrons is not sufficient to remove completely the 'black-spot' effect as shown by the dip in the curve when the incidence angle coincides with the bias angle of the channel. The highest detection efficiencies are achieved with the thinest films and a primary input energy of 2 keV.

4.7 Noise Factors of Completed Tubes

Not all the experimental results presented in the previous sections have been translated into manufacturing processes. Noise factors of commercially available channel image intensifiers are usually in the range 2 to 5 and depend upon the input signal level and the gain.

It is important that noise figures are not considered in isolation. For example, in night viewing applications it is at least as important to maintain a high contrast transfer as it is to have a low noise factor.[23] A low noise figure may be due to redistributed electrons and associated with a low contrast image. Such a trade-off could result in a less effective performance. Each device is a compromise between differing aspects of performance, size, weight and cost. The application determines which is the most appropriate.

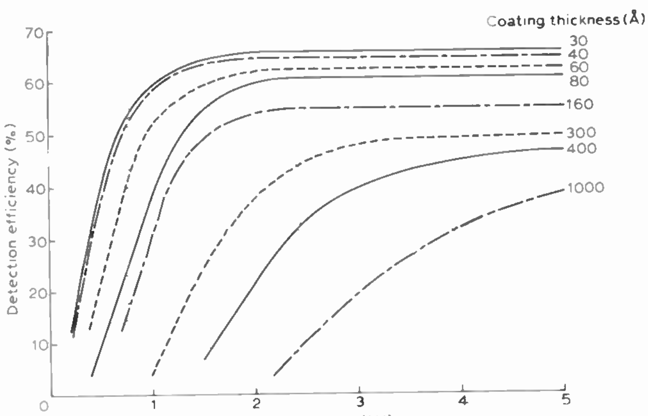


Fig. 12. Detection efficiency as a function of electron energy for a range of Al film thicknesses (thicknesses in Å marked).

5 Channel Intensifiers as Night Vision Aids

In the Introduction many applications for image tubes incorporating channel electron multipliers were mentioned. By far the largest volume of such tubes will be produced for the night vision market and therefore one of the main aims must be to satisfy the requirements of this application.

Broadly speaking, short-range night viewing tasks take place over distances up to one or two hundred metres and are carried out with portable equipment containing image tubes which respond to visible and near infra-red radiation. Long range requirements of a kilometre and more can be satisfied with more sophisticated equipment using detectors which respond in the far infra-red, 3–5 μm and 10–14 μm wavebands.[24]

Present-day short-range equipments mainly use cascaded image intensifiers,[25] that is, three-stage inverter tubes coupled through fibre optic input and output windows to form a single tube.

Two of the most important performance characteristics in this application are resolution and noise. Cascade tubes have noise factors of about 1·5 and it can be anticipated that channel tubes will eventually be manufactured with comparable figures. Channel diameters of 12·5 μm are typical and give the best compromise between maximum open area and resolution. With these plates a resolution in excess of 30 line pairs/mm on the viewing screen is usual and this is about the same or better than

Fig. 14. A pair of goggles, containing two channel image intensifiers, suitable for head mounting.

cascade tubes. Thus in terms of overall performance, the two types of tubes can be comparable.

Channel tubes, however, are much shorter and lighter than cascade tubes so that equipments can be made which are more readily portable. The compactness of the channel tube also lends itself to new equipment design concepts, one of which is illustrated by the goggles shown in Fig. 14.

Bright lights in the field of view usually produce so much scattered light in the cascade tube system that the remainder of the image is obliterated. The self-limiting action, due to saturation effects in the channel multiplier, ensures that channel tubes do not suffer from these disadvantages to anything like the same degree. It is these two operational features of the channel tube which, with its good imaging performance, make it so attractive for night vision applications.

6 Acknowledgments

The authors would like to acknowledge the contribution to the contents of this paper of many colleagues in Philips Research Laboratories and the Electron Optical Devices Division, Mullard Ltd., Mitcham. In particular we would like to thank Mr. A. J. Guest and Mr. R. T. Holmshaw whose work has been used extensively. We would also like to thank colleagues at L.E.P. for the photograph of a channel plate with curved channels.

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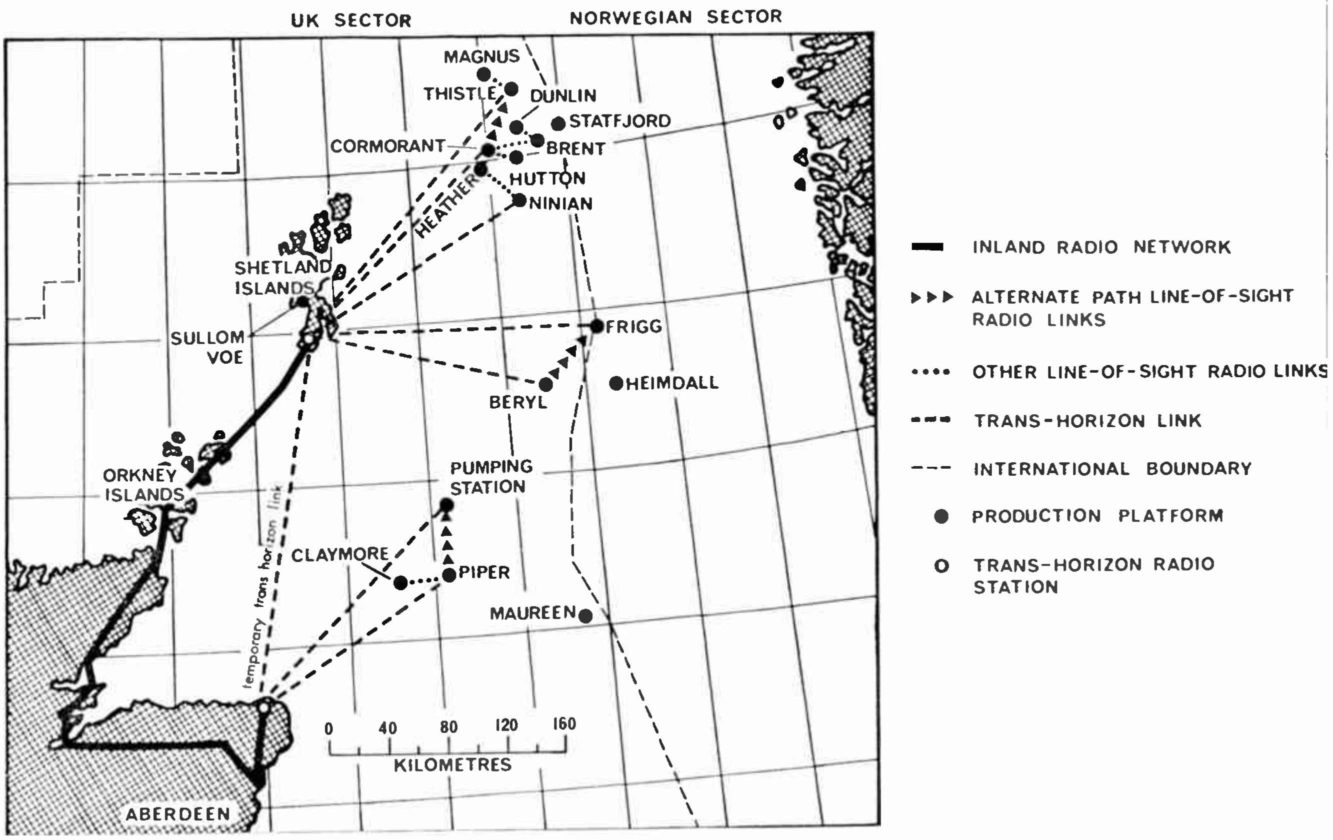
(Paper No. 1795/CC 277)

Troposcatter Communication in the North Sea



Existing and projected Post Office radio links for British installations in the North Sea.

The Thistle 'A' oil platform, (BNOC Development) sited 240 km north-east of the Shetlands, and the Frigg gas production unit (Total), 200 km due east of South Shetland—the most easterly British platform in the northern sector of the North Sea—now have full public telephone and telex communications with the mainland.

The Post Office has now brought these services to six off-shore sites (Beryl A and Piper last year, and Claymore and a pumping station earlier this year). The first five platforms completed phase one of the Post Office's North Sea programme and Thistle is the first platform to be linked up in phase two. The others are Shell's six platforms in the Brent, Cormorant and Dunlin fields, and Conoco's Murchison platform which will be progressively linked to the UK telecommunications network over the next 18 months.

Focal points of these North Sea services are the shore radio stations, strategically sited to serve almost the entire British sector of the northern North Sea area by trans-horizon tropospheric scatter links. One station—the control centre—is sited near Fraserburgh, Aberdeenshire, and two others are on South Shetland. Signals from the South Shetland stations are currently relayed by a tropo link to the Fraserburgh station, where they are fed into Britain's inland network. This link will eventually be replaced by a series of line-of-sight microwave relays routed through the Orkneys.

As can be seen from the map, there are at present three off-shore networks linked to the UK telecommunications system, and alternate routes are set up to each off-shore system to give additional reliability of operation. Two separate troposcatter paths are provided from land to a selected pair of platforms distant from each other by 20 to 50 km. These platforms are then linked to each other by line-of-sight microwave radio; this completes the triangulation for alternate path operation. Other platforms near the selected pair are connected to the system—and thence to the shore—by local over-sea line-of-sight links. The platforms are served over one trans-horizon link at a time, which is alternated with the other week and week about. The working troposcatter path relays communications to the other platforms over the line-of-sight links.

UDC 621.397.62:621.391.883.2

Television signal-to-noise ratio before and after demodulation

B. W. OSBORNE,

M.Sc., F.Inst.P., C.Eng., F.I.E.R.E., M.I.E.E.*

SUMMARY

The reception of amplitude-modulated television signals is considered, under noise-limited conditions where the signal-to-noise ratio of the demodulated signal is controlled by the noise figure of the receiving equipment.

The magnitude of the 'demodulation factor', relating the signal-to-noise ratio on carrier to that at video frequency after demodulation, is discussed.

It is concluded, from experimental evidence, and from consideration of the demodulation process, that for system I the value of the factor lies close to 3 dB.

* *Rediffusion Engineering Ltd., 187 Coombe Lane West, Kingston-upon-Thames, Surrey KT2 7DJ.*

1 Introduction

In this paper we consider television reception under noise-limited conditions, where the noise on the demodulated signal is that associated with the noise figure of the receiving equipment.

We will follow Friis[1] in using the term 'noise figure', rather than 'noise factor'. It is now customary to quote 'noise figure' in dB relative to the ideal receiver; and to restrict the use of the term 'noise factor' to numerical power ratios.

It is assumed that the television signal being received is an amplitude-modulated vestigial sideband (v.s.b.) signal; and that consequently, on system I, the modulation frequencies up to 1·25 MHz are transmitted double-sideband, the higher modulation frequencies being transmitted single-sideband.

It is also assumed that the energy spectrum of the video frequency noise is effectively restricted to frequencies up to 5 MHz, and that signal-to-noise measurements at video frequency are made through a 5 MHz low-pass filter, without any 'weighting' for the variation with video frequency of the subjective effect of noise.

Although the video spectrum of system I nominally extends up to 5·5 MHz, the restriction to 5 MHz in noise measurements is correct practice, as the effective energy bandwidth resulting from the use of a practical low-pass filter approximates to 5 MHz.

The subjective effect of noise impairment on the television picture has been discussed elsewhere;[2,3,4,5] and for unweighted noise on system I is illustrated in Fig. 1 (after Geddes[3]).

The gradient of the curve of Fig. 1 indicates a change of 5 dB in the video signal-to-noise ratio for a whole grade on the impairment scale, over that part of the curve between grades 2, 3 and 4. Thus a change in the signal-to-noise ratio of 6 dB, in this part of the characteristic, represents a shift exceeding a whole grade.

2 Noise Levels and the Definitions of Signal Levels

2.1 The Noise Level at the Receiver Input

On other systems, the signal-to-noise ratio required for a given impairment grade does not differ greatly from Fig. 1. On system M for example, from extensive subjective tests, Carson[4] quoted a video signal-to-noise ratio of 39 dB as being 'just perceptible' according to 50% of his observers.

Nyquist[6] concluded that the electromotive force due to thermal agitation in conductors is a universal function of frequency, resistance and temperature and of these variables only. From consideration of the modes of vibration or degrees of freedom within a frequency range B, he derived an expression for the total energy of the vibrations within this bandwidth, and showed that the average (noise) power transferred by a conductor at a temperature T is kTB, k being Boltzmann's constant ($1{\cdot}38 \times 10^{-23}$ joule/kelvin).

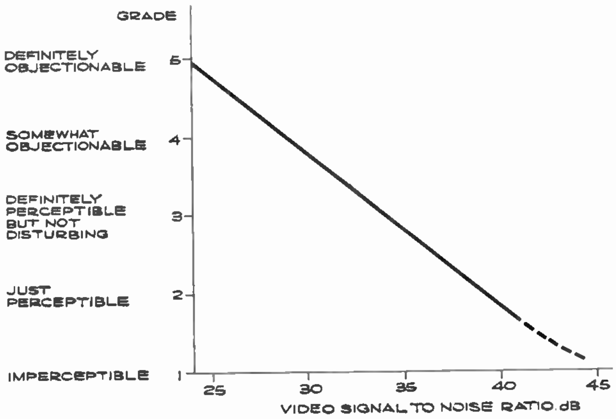


Fig. 1. The subjective effect of noise on a 5 MHz 625-line system (after Geddes).

A practical receiver, or low-noise pre-amplifier, will inevitably generate more noise than kTB, and its noise figure F can conveniently be expressed in dB with reference to kTB. An ideal receiver is then said to have a noise figure of 0 dB.

At 290 K the value of kTB over a 5 MHz bandwidth is 2×10^{-14} W, i.e. 137 dB below one watt. If the source and input impedances are both equal to R, this represents a noise voltage of $(4\,kTBR)^{1/2}$ at the receiver input, under matched impedance conditions. For $B = 5 \times 10^6$, $R = 50$ and $T = 290$, the equivalent e.m.f. is 2·0 μV; the power transferred, kTB, is $2{\cdot}00 \times 10^{-14}$ watts; and the noise voltage developed across a 50 Ω load at 290 K is $(2{\cdot}00 \times 50 \times 10^{-14})^{1/2}$ volts, or 1·00 μV.

2.2 The Signal-to-Noise Ratio

At video frequency the signal level conventionally used when quoting signal-to-noise levels is the voltage amplitude of the black-to-white transition, i.e. ignoring the synchronizing pulses (Fig. 2). The noise level refers to the r.m.s. noise measured over the 5 MHz bandwidth. The signal-to-noise ratio at video frequency is the ratio of the black-to-white voltage excursion to the r.m.s. noise.

On a negative modulated carrier on system I having a 70 : 30 picture to synchronizing pulse ratio and with 20% residual carrier level, the amplitude of the black-to-white transition is only 56% of the maximum signal amplitude.[7]

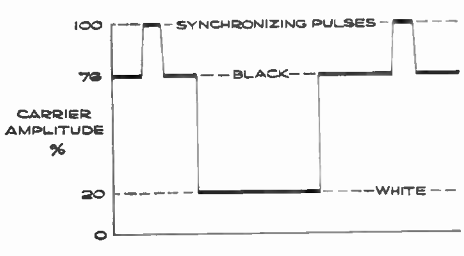


Fig. 2. The relative amplitudes of the synchronizing pulses and the black-to-white transition in the system I television signal.

The level of a negative-modulated television signal is conventionally taken to be the r.m.s. level of a carrier frequency sine wave of the same amplitude as that during the line synchronizing pulses, i.e. when the negative-modulated television carrier reaches its maximum amplitude.

The r.m.s. signal level is 71% of the maximum signal amplitude; and is thus greater by a factor of 1·27 than the black-to-white transition. This voltage ratio corresponds approximately to 2·1 dB.

3 The Demodulation Process

3.1 Vestigial Sideband Television Transmission

Suppose that the transmitted v.s.b. television signal is modulated by a 'multiburst' test signal, and that it is then demodulated by a wide-band detector having a flat amplitude/frequency characteristic. The output of this detector will be as shown in Fig. 3. The low frequency modulating signals (1 in Fig. 3) within the vestigial bandwidth are transmitted double-sideband. The two sidebands are re-combined on demodulation, and the detected signals from the two sidebands, being coherent, add linearly.

It is these low video frequency sidebands, in the double-sideband part of the frequency spectrum of the v.s.b. television signal, which determine the amplitude of the black-to-white voltage excursion of the demodulated signal, i.e. the signal level used in the definition of the signal-to-noise ratio at video.

The higher modulation frequencies, i.e. above 1·25 MHz on system I or above 0·75 MHz on system M, are transmitted single-sideband. The wide-band demodulator output therefore provides these modulation components at half-amplitude, as at 2, 3, etc. in Fig. 3.

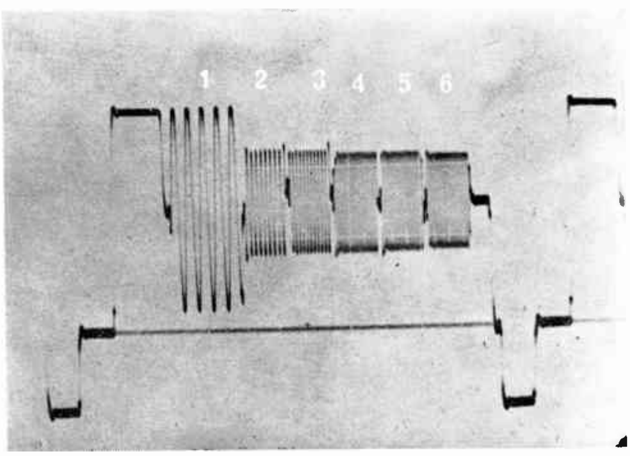


Fig. 3. A 'multiburst' test signal after v.s.b. modulation, when detected in a wide-band demodulator, and prior to any video-frequency correction of the amplitudes of the higher frequency components of the signal. The low-frequency modulating signals (1) of frequency below 1·25 MHz are carried by both sidebands and appear at full amplitude after detection; whereas the higher frequency components (2), (3), (4), (5), and (6) are only carried by the upper sideband of the transmitted signal.

3.2 Alternative Demodulation Techniques

A necessary function of the v.s.b. demodulator is to restore these higher frequency components to their correct amplitude.

Various alternative design techniques are available, have been discussed elsewhere,[8,9,10] and include:

(a) Correction at video frequency after detection, the i.f. amplifier having a flat amplitude characteristic over the passband, and the video circuit having 6 dB more gain at the higher video frequencies.

(b) Restoration of the missing sideband of the v.s.b. signal before detection, a technique proposed by Macdonald and Roy.[8]

(c) The 'exalted carrier' technique discussed by Loughlin,[9] the i.f. amplitude/frequency characteristic being such as to boost the vision carrier level prior to detection. The output from an extra narrow-band detector is added in anti-phase after detection so as to cancel the resultant enhancement of the low video frequency signal components.

(d) The shaping of the amplitude/frequency characteristic at i.f. before detection, the vision carrier level at the detector input being 6 dB below that of sidebands in the single-sideband zone (the so-called Nyquist flank) and with a flat amplitude/frequency characteristic at higher video frequencies.

(e) A method used by the author[10] in which the vision carrier reaches the second detector input at −6 dB relative to the edge of the vestigial zone, and with the upper video frequency sideband detected at progressively lower levels, so that the colour sub-carrier level at the detector input is only some 2 dB above the vision carrier. The higher video frequencies are corrected in amplitude after detection, and this results in a reduction of quadrature distortion and of luminance shift due to chrominance when an envelope detector is used.

Idealized i.f. amplitude/frequency characteristics for these alternative techniques are shown in Fig. 4, as at the input to the second detector, and ignoring the sound traps. The associated video frequency characteristics are shown on the right-hand column of the figure.

It will be realized that the ratio of the vision carrier level to noise at the detector input, for a given video signal-to-noise ratio at the receiver output, varies substantially according to which demodulation technique is used.

It should be noted that the reasons for using techniques (b) and (c) do *not* include a reduction in the detected signal-to-noise ratio.

3.3 The Effect of Demodulation on the Noise Level

Within the vestigial bandwidth, and for low modulating frequencies, two sidebands are present, one on each side of the vision carrier. On detection the noise in these sidebands is combined, but does not add linearly, as do the coherent sidebands of the video signal. The detected noise adds on a power basis, so that at low video frequencies, corresponding to sidebands near the vision carrier, the detected noise output is reduced by 3 dB compared with the signal. The effective energy bandwidth of the noise is reduced slightly,[11] because of this small loss of low-frequency noise after detection. This reduction in energy bandwidth is generally smaller than the likely error of measurement, and so will only need to be taken into account when it is desired to calculate signal-to-noise ratios to a higher accuracy than the ±0·5 dB obtainable experimentally.[12,13] As one grade of impairment approximates to a 5 dB change in signal-to-noise ratio (Fig. 1), it is for most purposes, on system I, a sufficiently close approximation to assume that the detected energy bandwidth of the noise is 5 MHz.

The subjective effect of obtaining a reduction in noise level at the lower video frequencies is beneficial.[14]

3.4 The Video Signal-to-Noise Ratio Obtained for a Given Input Signal Level and Noise Figure

The factors involved in receiving u.h.f. television transmissions with low noise impairment, where the incident field strength is low and the dominant impairment is noise, have previously been discussed by the author.[15,16]

In general terms, if a transmitter radiates power at a level of P dB above 1 watt, and the path attenuation is x dB to a receiving aerial of gain G dB, then the signal power available from the receiving aerial is $(P+G-x)$ dB relative to 1 watt. If the receiver noise figure is F dB, the effective noise power at the receiver input is F dB above kTB.

Since for $B=5$ MHz and $T=290$ K, kTB is 137 dB below 1 watt, and the noise power into the matched load represented by the receiver input is $(F-137)$ dB relative to 1 watt.

The signal-to-noise ratio at the receiver output is therefore $(P+G-x-F+137-D)$ dB, where D is the 'demodulation factor', the relationship between the signal-to-noise ratio on carrier and that at video, for the same energy bandwidth. D is a constant for a particular television system.

In calculating the video signal-to-noise ratio obtained when applying an input voltage V to a receiver or pre-amplifier of noise figure F, it is often convenient, when using a properly matched 50 Ω input impedance, to express V and F in terms of voltage with reference to 1 μV.

If the input signal level V is 400 μV, i.e. 52 dB above 1 μV, and if the noise figure F is 6 dB, then (from Sect. 2.1) the noise level at the receiver input is 6 dB above 1 μV and the ratio of signal-to-noise at the receiver input is $(52-6)$ dB or 46 dB. That at video is therefore $(46-D)$ dB.

4 U.H.F. Reception under Noise-limited Conditions

The video signal-to-noise ratios obtained on system I under noise-limited conditions, for various values of

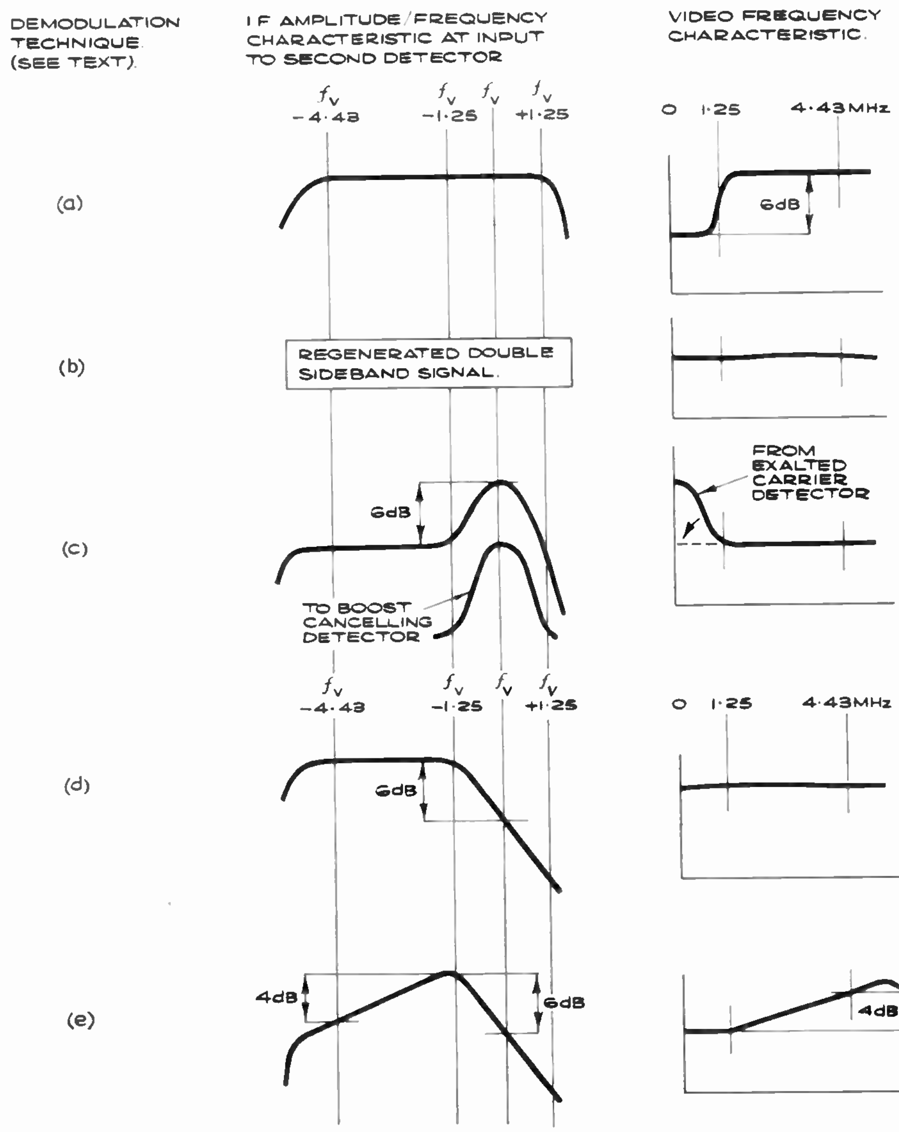


Fig. 4. Idealized i.f. amplitude/frequency characteristics.

incident field strength, aerial gain and noise figure, have been discussed previously.[15,16] Some examples will be quoted here.

(a) The noise figure of a parametric amplifier had been measured by two different means (noise diode, and hot and cold resistor methods) and, including the loss due to the ferrite circulator, was found to be about 1 dB. This unit was used with a second stage of 10 dB noise figure, the pump level being adjusted so as to restrict the gain of the parametric amplifier to 16 dB in order to ensure adequate bandwidth. The noise figure of the second stage being 10 dB, the effective noise of the two units in series approximated to 1·25 dB, the equivalent noise temperature being 100 K.

The parametric amplifier was then fed under laboratory conditions with a v.s.b. signal at u.h.f. on channel 34, at a level established to be 40 μV across the 50 ohm impedance.

The signal-to-noise voltage ratio before detection, on the basis of the known input level and noise figure, was therefore about 34·7, i.e. 31 dB. That after detection was estimated (by photographic comparison) at about 29 dB.

This was consistent with a value D of 2 or 3 dB; and despite the limited accuracy of this particular experiment it was clear that the result was inconsistent with any value of D greatly exceeding 4 dB.

Following these experiments parametric amplifiers were used for several years at eight different cablevision receiver sites for the reception of BBC-2 colour television programmes over long distances,[15,16] often with an input signal of only about 120 μV.

(b) More recently the availability of more accurate noise measuring equipment has simplified experimental measurement of the signal-to-noise ratio. Rhodes[13] has described the technique in which the noise present on a quiet line (e.g. line 13) of the field suppression period is compared with locally generated noise (Fig. 5) substituted during part of that line.

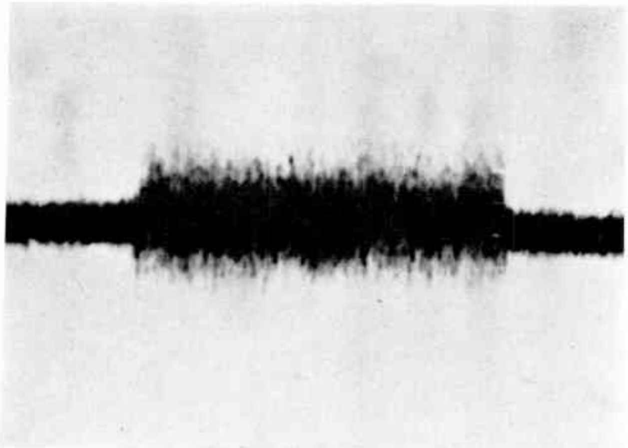


Fig. 5. Noise inserted at black level during part of a quiet line (using Tektronix type 148 insertion test signal generator). For noise measurement the level of the inserted noise is adjusted to equal that of the noise present on the signal, as viewed in either side of the inserted noise, and with a 5 MHz low-pass filter in circuit.

The present availability of equipment of this kind has enabled accurate measurements of the video frequency signal-to-noise ratio to be made on the composite television signals received at remote receiving sites during broadcasting transmissions.

As an example of one of many such measurements from which the effective value of D can be deduced, a low-noise amplifier, having an accurately measured noise figure of 5 dB and sufficient gain to swamp any noise contributed by the following receiving equipment, was fed with an input signal consisting of a received television signal on system I at a level of 400 μV. The circuit impedance was 50 Ω.

The video frequency signal-to-noise ratio obtained was measured to be 44 ± 1 dB; and this was consistent with a value of D lying between 2 dB and 4 dB.

This particular video frequency signal-to-noise ratio has in fact been used for over 12 years as a desirable performance target at aerial sites feeding cablevision networks, where the incident field strength permits.

The actual signal-to-noise ratio achieved at individual locations is measured at video frequency after demodulation, by the method described above.

(c) As a third example, consider the domestic reception of u.h.f. television signals in the 'fringe' area near the boundary of the service area of the transmitter, and suppose that noise rather than co-channel interference is the dominant impairment.

If we assume the use of a receiver having a noise figure of 6 dB, the effective noise input voltage into 75 Ω over a 5 MHz energy bandwidth is 2·5 μV. To obtain for example a video frequency signal-to-noise ratio of 40 dB, we require, for $D = 3$ dB, an input signal of 400 μV. If the aerial gain is 14 dB, then the corresponding band 4 field strength for this noise impairment is about +58 dB above 1 μV/metre (depending on the particular band 4 channel in use). This was confirmed experimentally.

(d) Measurements on system M, a system employing different modulation characteristics and with a reduced noise bandwidth, were made at v.h.f. in 1970, using a Telemet type 4500 demodulator of noise figure 5 dB.

The video frequency signal-to-noise ratio, obtained with a known signal input level to the demodulator, was measured by visual assessment of the peak noise level on an oscilloscope (the noise insertion equipment (Fig. 5) not then being available). The observed noise level was converted to an r.m.s. level by applying a 14 dB conversion factor, and related to the measured black-to-white transition on the demodulated video frequency waveform.

Though the magnitude of the peak-to-r.m.s. noise conversion factor has been argued, and the measurement method used at that time was of limited accuracy, the results were consistent with a value of D of 4 dB.

It was noted that the use of a 16 dB peak-to-r.m.s. noise conversion factor would have resulted in a *lower* value of D.

(e) Further laboratory measurements were made more recently (1977) using the noise insertion method to measure the variation of the video signal-to-noise ratio, after detection, with the level of the u.h.f. input signal. The latter was a system I broadcast transmission. Precautions were taken to ensure that the chrominance-to-luminance ratio was correct, and the noise was measured through a 5 MHz low pass filter.

The results obtained are shown in Fig. 6.

Receiver A was of 75 ohm input impedance, and all signal level and noise figure measurements at u.h.f. were made at this impedance. The noise figure of receiver A was found to be 7·5 dB.

From Fig. 6, for an input of 46 dBμV, the resultant signal-to-noise ratio was 34 dB. As the noise level at the 75 ohm input to receiver A was 9·5 dBμV, the value of D was deduced in this instance to be (46 − 34 − 9·5) dB, i.e. $2\frac{1}{2}$ dB.

Receiver B comprised a frequency converter and demodulator of 50 ohm input impedance. All u.h.f. signal level and noise figure measurements on receiver B were made at this impedance. The noise figure of receiver B was measured (using the Rohde and Schwarz noise

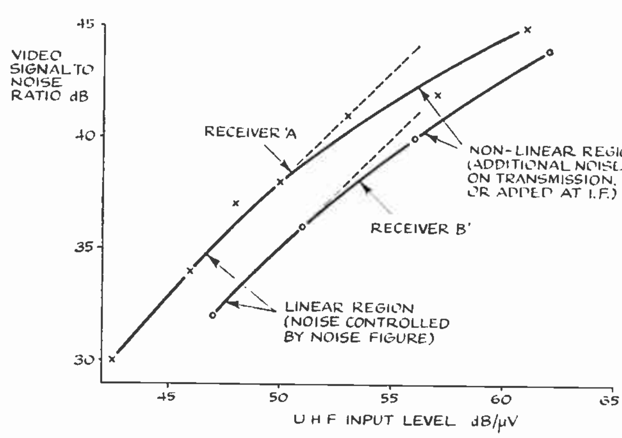


Fig. 6. The variation with u.h.f. input signal level of the signal-to-noise ratio after detection for receivers of different noise figures.

generator type SKTU in a screened room) and found to be 11 dB.

From Fig. 6, for an input of 50 dBμV, the resultant video signal-to-noise ratio was 35 dB. The noise level at the 50 ohm input to receiver B was 11 dBμV, and the value of D was deduced in this instance to be $(50-35-11)$ dB, or 4 dB.

Note that, in Fig. 6, the departure from linearity of curves A and B is to be expected, as at the higher input levels the curves become asymptotic to the signal-to-noise ratio of the signal itself. The noise from the receiver input circuit adds (on a power law basis) to that of the transmitted signal.

Any receiver used for measurement purposes must have a noise figure that is independent of the receiver input level, i.e. the receiver noise figure must not degrade due to noise being added at i.f. as a result of a.g.c. action. This subject has been discussed elsewhere (e.g. Ref. 23, pp. 23–5).

Consider cable television networks using frequency domain multiplex which are designed to meet a given signal-to-noise ratio before demodulation, e.g. 43 dB. Receivers should be fed from the networks at input levels sufficiently high for the receiver noise to have little effect. In this instance the curve for the video signal-to-noise ratio against receiver input level would become asymptotic to the horizontal line corresponding to 40 dB video signal-to-noise ratio (i.e. 43 dB before demodulation).

5 The Value of the Demodulation Factor *D*

On system I, a contribution to D of 2·1 dB arises directly from considerations of the modulation characteristic and the residual carrier level (Sect. 2.2).

The value of D may be increased marginally by the detection process itself; and we may deduce a small *decrease* in D due to the power law addition of noise in the vestigial frequency spectrum.

The use of synchronous detection is not thought to affect the value of D to a significant extent,[17] and recent experiments support this view.

Measurements of noise figure, signal levels and the resulting video frequency signal-to-noise ratio (briefly described in Section 4) confirm experimentally that on system I the value of D approximates to 3 dB, the major contribution being that due to the modulation characteristic. None of the other mechanisms appear to influence D by more than 1 dB.

It may also be noted that a similar value of D, of about 4 dB, has been used by Carson[4] and Hand[18] on system M, a system employing a slightly different modulation characteristic and a lower noise bandwidth; and that Bedford[19] used a value of 4 dB for D when considering satellite communication on system I.

It is important to realize that the ratio of the vision carrier to r.m.s. noise at the input to the detector does *not* determine the signal-to-noise ratio after detection, the former being an arbitrary ratio which is dependent on the method of v.s.b. signal detection chosen for the particular demodulator design.

The black-to-white transition in the signal after detection results from the addition of the *coherent* information in the two sidebands. Note that the v.s.b. television signal is effectively transmitted double-sideband for the low modulation frequencies involved; and that, for a detector operating under sufficiently linear conditions,[20] there is in general no degradation of signal-to-noise ratio in the detection process.

6 The 6 dB Fallacy

If for example the v.s.b. demodulator uses method (d) or (e) of Section 3.2 above, the ratio of the level of the vision carrier to r.m.s. noise at the *input* to the second detector of the receiver is 6 dB lower than in a receiver using method (a). An even greater difference exists if comparison is made with method (c). This 6 dB factor has sometimes been included[e.g.,21,22] in determining the value of D, which then lies between 8 and 9 dB.

It is however maintained by the author[15,16,23] that D lies close to 3 dB, and that there is no valid reason for the inclusion of any additional factor.

Experimental results are consistent with a value for D of 3 ± 1 dB on system I.

This matter is of some practical importance in the proper choice of aerial gain and noise figure when specifying the receiving equipment to be used, for a given incident field strength; and in calculating whether satisfactory reception is possible at individual receiving sites, to which the path attenuation has been determined.[15]

The value of D is also relevant when considering the effective radiated transmitter power required to provide a specified video signal-to-noise ratio at the receiver output for particular values of path attenuation, receiving aerial gain, feeder loss and receiver noise figure. To take D as 9 dB instead of 3 dB, for example, results in a calculated transmitter radiated power requirement which is in error by a factor of 4.

7 Acknowledgments

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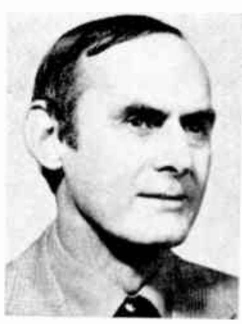
The Author



Basil Osborne (Fellow 1962, Member 1952, Associate 1946) obtained his B.Sc. (special) degree in Physics at Southampton in 1947, following wartime service at TRE Malvern. He served on the Institution's Technical Committee from 1955 to 1968, he is at present on the Communications Group Committee, and he was a member of organising committees for conferences on Television (1959) and Video and Data Recording (1976). His early work on ionospheric research and radio propagation with the Radio Division of the National Physical Laboratory involved investigation of the electron content of the ionosphere and of equatorial F region after sunset. After continuing this research from 1952 to 1954 as a lecturer in physics at the University of Malaya, he later worked in England and Bermuda on colour television circuits and displays. While with Rediffusion Research Limited from 1958 to 1968, his fields of interest ranged from propagation and cables to circuits and systems. In the USA for the next two years, he was primarily engaged in demodulator design and waveform measurement, and he became Director of Engineering at the Telemet Company in 1969. Returning to Rediffusion Engineering Ltd., in 1970 as Head of Operational Services Department for the home operating companies, his responsibilities include engineering audits for the maintenance of engineering standards. Mr Osborne's first contribution to this Journal was made in 1952, and altogether he has published over 20 papers in physics and engineering including a book on colour television reception.

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Experiments on the writing process in magnetic recording

GEOFFREY BATE, Ph.D.*

and

LARRY P. DUNN, B.Sc.*

Based on a paper presented at the Conference on Video and Data Recording held in Birmingham on 20th to 22nd July 1976.

SUMMARY

To provide an understanding of the relative recording performance of different tapes the paper determines what takes place when the magnetic field from a writing head acts on the particles in the tape. Methods of measuring the following are described: (1) the shape, size, and position of the recorded transition between two oppositely-magnetized regions as a function of writing current; (2) the depth of recording; and (3) recording demagnetization as a function of density.

* *General Products Division Laboratory, International Business Machines Corporation, P.O. Box 1900, Boulder, Colorado 80302, USA.*

1 Introduction

Although magnetic recording has been in use for several decades, one aspect of the process, that of writing, is still imperfectly understood. This is not surprising for we know that particles in the tapes (say) experience a complex sequence of time-varying magnetic fields which change also in magnitude, direction and polarity during the progress of particles past the writing head. In addition, particles are subjected to interaction fields from their neighbours, and these fields also are neither constant in magnitude nor direction. However, to understand the relative performance at high recording densities, those above 1000 flux changes per millimetre (f.c./mm), of tapes made of different particles, it is necessary to describe what happens when the magnetic field from the writing head acts upon the particles.

Specifically, we describe methods by which (1) the shape and size of the recorded transition between two oppositely-magnetized regions in the tape, and its position with respect to the writing gap, may be found as a function of writing current; (2) the depth of recording may be measured, therefore explaining the shape of the curve derived from the optimum writing current (that required to produce maximum output) versus density; (3) the recording demagnetization is measured as a function of density. Recording demagnetization occurs when a magnetized region in the tape becomes partially or fully demagnetized in response to the sequence of alternating fields to which it is exposed as it moves away from the gap of the writing head. The typical dependence of output signal on writing current at different densities is shown in Fig. 1. At any density, the output at first increases as writing current increases· the fields from the head grow stronger and penetrate further into the tape and are thus able to switch more particles. The adverse effects of recording demagnetization and tape dead layer[1,2] also increase with writing current, and for each density the curve shows a maximum signal at the optimum writing current. The locus of this current is also shown in Fig. 1. For the heads and tape used in this experiment, the optimum current decreases as density increases from 80 f.c./mm to about 600 f.c./mm, but above and below these densities the optimum current does not change. Our intent is to show how this behaviour can be explained in terms of the reaction of particles to the fields of the writing head.

2 The Transition Region

When the field of the writing head is reversed, the magnetization in the tape is also reversed, but even when the field reversal occurs in nanoseconds, and the tape is moving very slowly, the variation in magnetization along the tape takes place over a finite distance. This distance, the transition region, depends on the gradient of the writing field and the slope of the curve of decreasing-remanence versus field for the magnetic particles. Clearly the maximum recorded density at which the particles on each side of a transition retain maximum remanence will

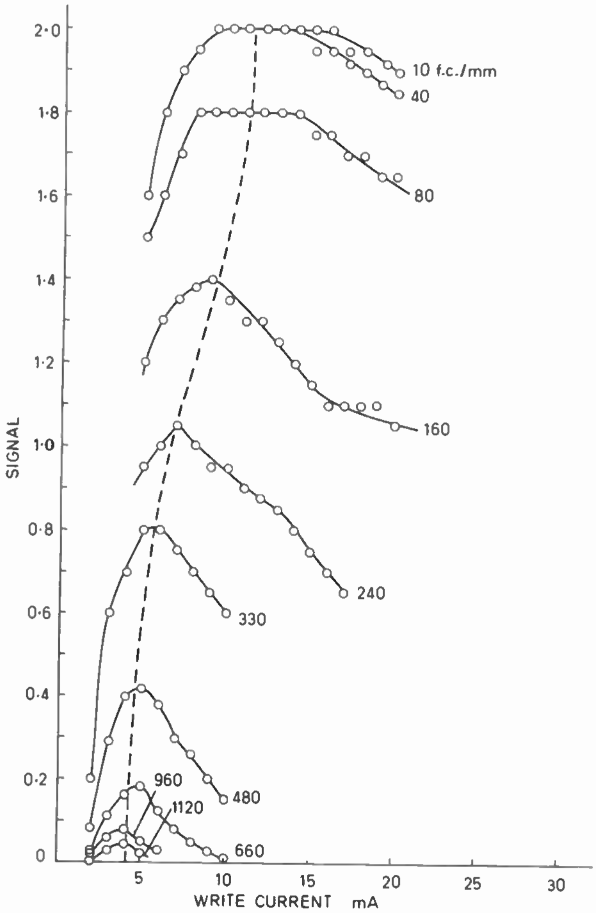
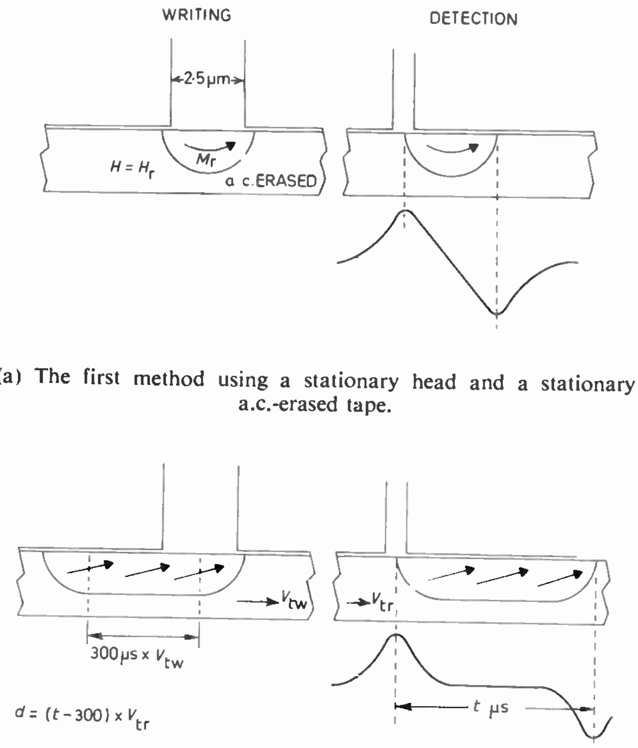


Fig. 1. The signal in millivolts obtained by writing on a tape of CrO_2 particles, 3·75 μm thick with a head gap of 2·5 μm and reading with a gap of 1 μm. The broken curve shows the locus of the optimum writing current.



(a) The first method using a stationary head and a stationary a.c.-erased tape.

(b) The present method in which the tape moves slowly while a single pulse of known duration is applied to the head.

Fig. 2. Methods for measuring the recorded transition:

depend on the length of the transition region compared with the length of one flux reversal. We measured the size, shape, and position of the recorded transition by the following method, the principle of which is shown in Fig. 2.

A stationary tape, initially a.c.-erased, was placed in contact with the writing head through which direct current was then passed creating a semi-cylindrical magnetized region in the tape. The length of the region could be measured by developing the tape with Bitter colloid and measuring the distance between the lines formed at each end of the dipole. Or, as we preferred, the tape was moved slowly, 25 cm/s, past a narrow-gapped reading head when the length of the dipole could be found from the time separation between the pulses and the velocity of the tape. Unfortunately, the pulses overlapped as shown in Fig. 2(a). To overcome this problem we drove the writing head with a single pulse of duration 300 μs while moving the tape very slowly past the head so that the tape moved a negligible distance during the pulse. This had the effect of introducing a block of known length into the magnetized region as shown in (b), and no overlapping of the pulses occurred when read back. The length of the recorded region could then be found by subtracting 300 μs from the observed time separation between the pulses and by multiplying the results by the tape velocity during reading. Experiments with pulses of different durations showed that the length of the recorded region was independent of pulse duration at least over the range of 300 to 1000 μs.

Figure 3 shows the 'recording radius' (half the length of the recorded region) of four different tapes as a function of writing current. The tapes were chosen for their differing values of remanence-coercivity, H_r. The field contour

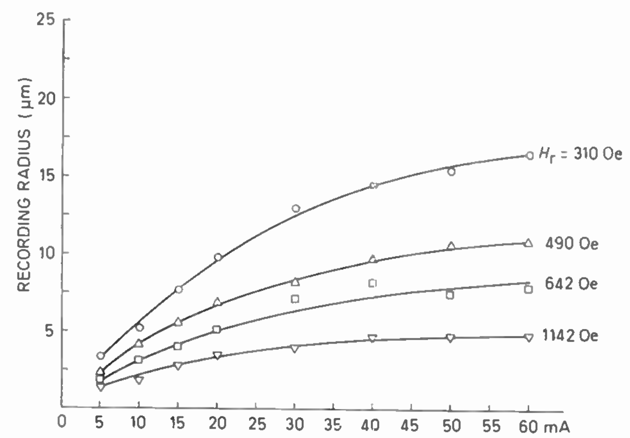


Fig. 3. The recording radius measured by the method shown in Fig. 2(b) for four tapes as a function of the writing current in a head whose gap was 2·5 μm.

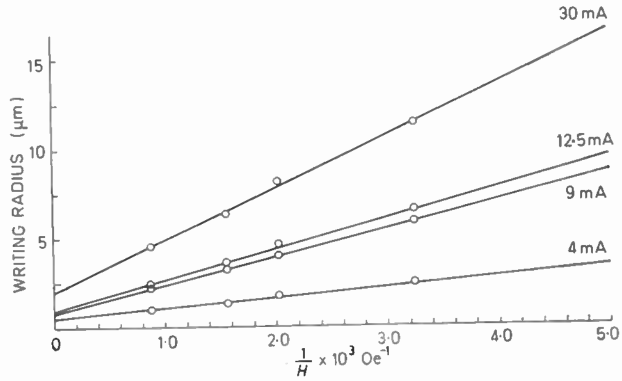


Fig. 4. The recording radius as a function of $(1/H)$ with writing current as parameter.

$H = H_r$ marks the magnetic centre of the recorded transition.

Some of these results are replotted in Fig. 4 with $(1/H)$ as the abcissa and with the writing current as the parameter. We found that for the currents of interest in Fig. 1, the writing radius varied linearly with $(1/H)$; a result predicted by the simplest of all head models, namely that of a current-carrying wire parallel to the gap. We determined the width of the transition region on the surface of the tape by finding experimentally two fields H_1 and H_2 for each tape at which, respectively, less than 5% and more than 95% of the change in remanence occurred (Table 1). This is shown schematically in Fig. 5. Then by using Fig. 4 for any desired current we found the values of the writing radius which corresponded to H_1 and H_2. The errors involved in obtaining the slopes of the lines in Fig. 4 were minimized by the wide range of the values of the four sample tapes. The position and width of the transition region inside the tape were found by repeating the measurements with a shim 2·5 μm (1 tenth of a thou) thick on the writing head. Then having determined the four corners of the transition we could make a scale drawing showing the head gap in relation to the transition at the moment of writing. This was done for four tapes and three writing heads and representative results are shown in Figs. 6 and 7.

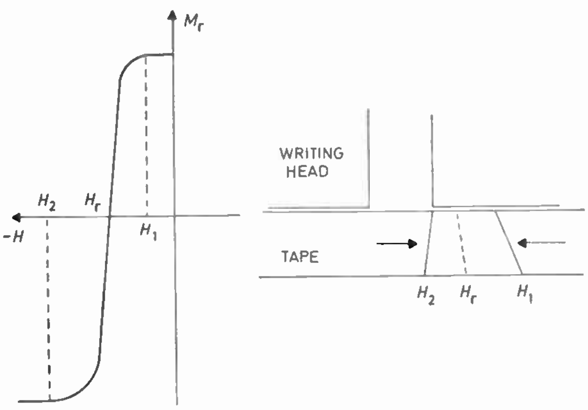


Fig. 5. The relationship between H_r, H_1, and H_2, on the descending remanence curve and in forming the transition region in the tape.

Table 1

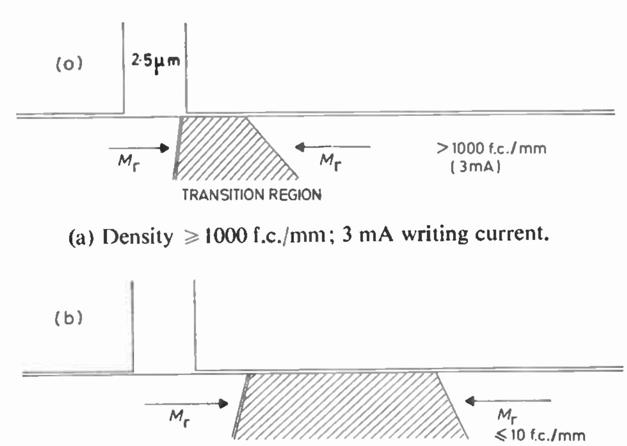
	H_r A/m	H_r Oe	H_1 A/m	H_1 Oe	H_2 A/m	H_2 Oe	$\frac{H_2-H_1}{H_r}$
S500	$2\cdot47\times10^4$	310	$1\cdot11\times10^4$	140	$5\cdot16\times10^4$	649	1·642
CrO_2	$3\cdot90\times10^4$	490	$1\cdot83\times10^4$	230	$6\cdot37\times10^4$	800	1·163
EX 1	$5\cdot11\times10^4$	642	$2\cdot47\times10^4$	310	$1\cdot31\times10^5$	1640	2·072
EX 2	$9\cdot09\times10^4$	1142	$2\cdot79\times10^4$	350	$1\cdot78\times10^5$	2240	1·655

At low densities [Figs. 6(b) and (7b)] the optimum writing current is relatively high and the transition is written downstream of the writing gap. As the density increased, the optimum writing current decreased (as seen in Fig. 1); this corresponds to the transition region occurring closer to the writing gap. At high densities, no further decrease in the optimum writing current occurred. Figures 6(a) and 7(a) show that the physical significance of this is that the transition region has reached the corner of the gap. Any further reduction of current would cause the transition to be written inside the gap, and this is undesirable since we found that output pulses obtained at currents below optimum invariably were poorly defined. The length of the transition at very low density for the CrO_2 tape was less than that of the iron oxide tape (γ) since

$$\frac{(H_2-H_1)}{H_r}\,CrO_2 < \frac{(H_2-H_1)}{H_r}\gamma.$$

This difference in transition length satisfactorily explained the ratio of the pulse amplitudes obtained for the two tapes.

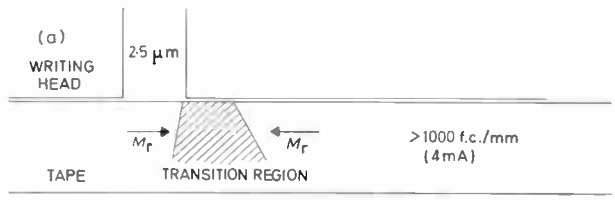
The effect of the width of the transition region on the remanent state of a tape recorded at different densities is shown in Fig. 8. At the lowest density, a digitally-recorded tape consists of long regions in which the magnetization is at maximum remanence separated by transition regions. However, as the density is increased the transition region length decreases only slightly. At still



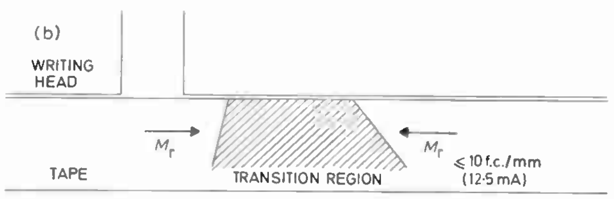
(a) Density ⩾ 1000 f.c./mm; 3 mA writing current.

(b) Density ⩽ 10 f.c./mm; 10·5 mA writing current.

Fig. 6. Scale drawing of the transition regions in the iron oxide tape and their relation to the recording gap.



(a) Density ⩾1000 f.c./mm; 4 mA writing current.



(b) Density ⩽10 f.c./mm; 12·5 mA writing current.

Fig. 7. Scale drawing of the transition regions in the chromium dioxide tape and their relation to the recording gap.

higher densities, overlapping of the transition regions occurs and no part of the tape is in the maximum remanent condition. This situation becomes progressively worse as the density is increased until at the highest density shown, each magnetized region emerges from the writing process after at least three significant reversals of the head field. The field is diminished with each reversal, but since the transition region is bounded by the contours $H=H_1$ and $H=H_2$, the field is still large enough to produce a change in the remanent magnetization.

3 Recording Demagnetization

The process just described is called 'recording demagnetization' and it is possible to get a rough idea of its relative importance in different tapes in the following way. We know the dependence of head field on distance for any current from Fig. 4, and hence for any desired density we can determine the sequence of in-plane fields experienced by the tape particles during the writing process. The tape samples can then be subjected to this sequence in the vibrating-sample magnetometer and the final remanence measured. Results for two tapes are shown in Fig. 9; one was made of highly-oriented particles of chromium dioxide, and the other was made of unoriented particles of iron oxide. This is a 'worst-case' result since the fields applied in this experiment were entirely in the plane of the tape whereas in a true recording situation each field would be applied at a different angle. Furthermore, the angles would vary with depth below the surface of the tape and so different strata would presumably give the zero-remanence state (shown by the unoriented iron-oxide tape at $9{\cdot}2\times10^3$ f.c./mm) at different densities.

Figure 9 shows that the tape made of CrO_2 oriented particles survived the sequence of head fields more successfully than the γFe_2O_3 unoriented tape. [The reason is that $(H_2-H_1)/H_r$ for oriented $CrO_2<(H_2-H_1/H_r$ for unoriented γFe_2O_3.] A non-existent ideal medium with a perfectly rectangular remanence characteristic (from perfectly oriented identical particles) would show no recording demagnetization in this experiment since $(H_2-H_1)=0$, in this case, and the particles would be switched only once regardless of the density.

In addition to recording demagnetization, another undesirable effect on the recorded pattern occurs as a result of the overlapping and the shape of the transition regions and is shown in Fig. 8. The recorded regions are inclined to the surface of the tape at an angle which depends on the inclination of the $H=H_1$ contour. The read-back signal is reduced compared to the situation when the recorded regions are perpendicular to the surface since the direction of magnetization reverses at some distance below the surface of the tape. This effect is probably not important since we need a high density to have narrow stripes, but at high densities separation losses are severe and we are less sensitive to the state of magnetization far below the surface. This effect was first discussed by Iwasaki and Suzuki.[3]

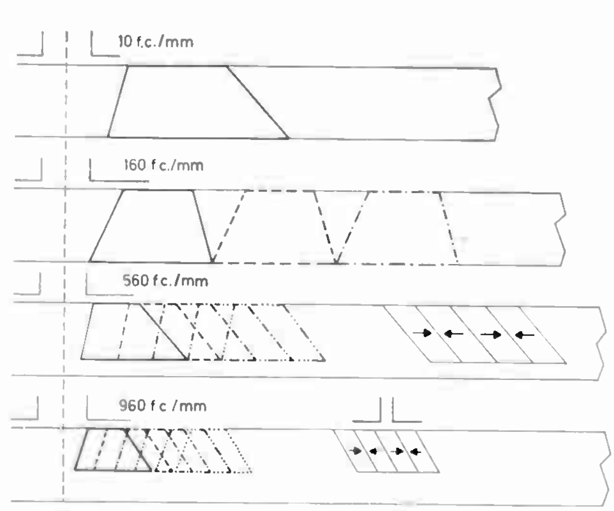


Fig. 8. Scale drawing of the transition regions at optimum writing current for each density showing the degree of overlap of the regions and Iwasaki–Suzuki effect.

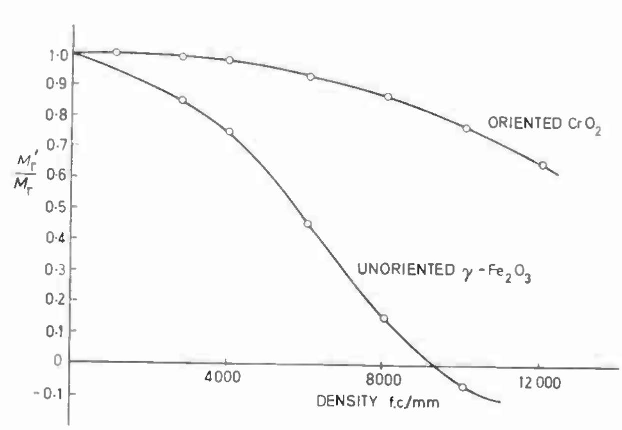


Fig. 9. The relative effect of recording demagnetization as a function of density for two tapes, oriented chromium dioxide particles and unoriented iron oxide particles.

4 Depth of Recording

Figure 4 shows that the head field decreases inversely with distance, and Table 1 shows that each tape had a range of switching fields of several hundred oersteds. Thus, to speak of the 'depth of recording' as if it were an exact length is clearly wrong. However, the concept can be of practical value in finding the best combination of gap length, head current, and coating thickness for a particular recording application. We chose to define it by means of the following experiment.

A tape was initially recorded in an 'all ones" pattern at an extremely low density 4 f.c./mm. The tape was then d.c.-erased using the head and drive of interest, with a series of increasing currents. At each step the low density signal was measured and compared with the initial value to determine the fractional penetration of the erase field into the tape. We used a very low density in the pre-recorded pattern to ensure that the measurements were minimally affected by separation losses. In the final stages of erasure, what remained of the pre-recorded pattern was separated from the reading head by almost the thickness of the coating. Figure 10 shows the results of this experiment as applied to a chromium dioxide tape that was 3·75 μm thick and then erased by a head with a gap of 2·5 μm. Also plotted in the Figure are the optimum writing currents for this head and tape at densities from 10 f.c./mm to 1000 f.c./mm. For densities ⩽ 160 f.c./mm the optimum writing current corresponds to complete penetration of the coating while at the highest density the penetration involved 60% of the coating thickness. We have already shown that if we used a writing current smaller than 4 mA, the transition would occur inside the gap and we could calculate, using the common expression for separation loss, what fraction of the signal at 1000 f.c./mm would be obtained from those regions of the tape situated more than 0·6 × thickness away from the head. This is found to be 0·001. Thus, the reason that the optimum writing current at 1000 f.c./mm is 4 mA, and not some higher current, is that any further penetration of the coating would add negligibly to the signal. Furthermore, increasing the writing current above 4 mA would cause the transition region to move away from the gap corner and toward lower values of the writing field gradient and thus bring about a reduction of the signal.

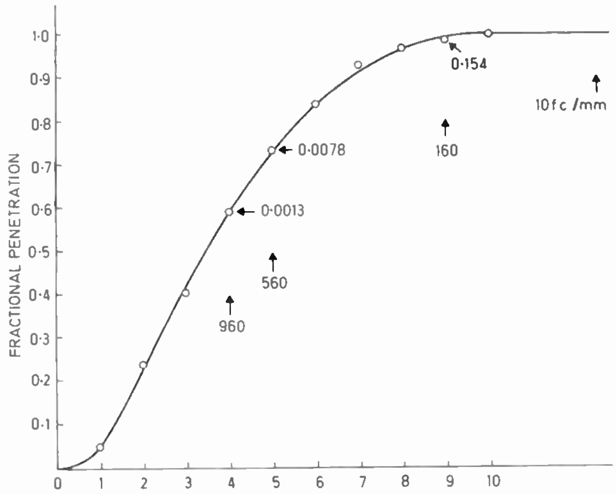


Fig. 10. The fractional penetration of d.c.-erasure as a function of current. The optimum writing currents for four densities are also marked.

5 Conclusion

We interpret the behaviour shown in Fig. 1 in the following way. The curve corresponding to each density is the result of competing effects. On the one hand increasing the writing current causes increased penetration of writing flux and the involvement of more particles in the writing process. On the other hand the recording demagnetization, the Iwasaki–Suzuki effect and the dead-layer of non-contributing particles at the surface of the tape all became more serious with increased writing current. At low densities the peak is not very pronounced. It is reached when the writing flux saturates the tape (Fig. 10). No further increase in output can result from an increase in current, but the only adverse effect is to increase slightly the width of the transition region (Figs. 6 and 7), thereby slightly reducing the signal. Increasing the density does not change this situation until the density becomes high enough that some overlapping of the transition regions occurs (Fig. 8). At this stage the peak is more pronounced than it was at lower densities since increasing the writing current beyond the optimum causes still more overlapping of the transition regions and reduction of the signal. Further increases in density cause the optimum writing current to occur at progressively lower currents since recording demagnetization and the Iwasaki–Suzuki effect became ever more serious. Eventually a density is reached (about 600 f.c./mm in Fig. 1) at which the optimum writing current brings the inner edge of the transition region to the gap corner (Figs. 6 and 7). This current remains optimum for still higher densities since poorly defined transitions (and signals) are obtained whenever the transition is written inside the gap. The preliminary measurements of recording demagnetization (Fig. 9) when considered together with the dead layer results which we reported previously[1,2] provide persuasive arguments that recording surfaces intended for high density applications should have the highest possible degree of particle dispersion and orientation.

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The television colour burst signal as a secondary frequency standard

C. A. JENNESS, N.Z.C.Sc., C.Eng., M.I.E.R.E.*

and

R. A. MORRIS, B.Sc.*

SUMMARY

The colour burst signals transmitted by the New Zealand television networks (TV1, TV2) are normally generated by rubidium vapour oscillators. While not primary standards, these oscillators are extremely stable and, provided they are calibrated, can serve as frequency standards. Every colour television receiver normally contains a quartz oscillator which is accurately locked in phase to the colour burst subcarrier and thus back to the rubidium vapour oscillator. Thus the colour burst subcarrier, available from any colour television set, is potentially a high quality frequency standard. The equipment used by the Physics and Engineering Laboratory to check this system is described, together with practical examples of the use of the colour burst subcarrier for calibration purposes.

* *Department of Scientific and Industrial Research, Physics and Engineering Laboratory, Private Bag, Lower Hutt, New Zealand.*

1 Introduction

The Physics and Engineering Laboratory of the Department of Scientific and Industrial Research is responsible for the maintenance and operation of New Zealand's primary frequency standard. This standard is available to outside users, for calibration purposes, by means of radio transmissions at 2·5 MHz from a transmitter whose carrier is derived from a caesium beam frequency standard. As these transmissions are not usable over the whole of the country due to radio propagation limitations, other means of making the frequency standard available have been studied.

The advent of colour television in New Zealand has provided the opportunity of distributing a highly stable frequency standard throughout the country. The New Zealand colour television network uses one of the PAL systems which requires a stable subcarrier of 4·43361875 MHz $\pm$ 1 Hz modulated by the two colour difference signals. The subcarriers for both television networks are stabilized by rubidium vapour oscillators which have an ageing rate (long term drift) of better than 1 part in 10^{11} per month. (This is approximately 50–100 times better than a high quality quartz oscillator.) The colour burst signal is transmitted from the television control centres as a subcarrier in the form of a burst of approximately 10 cycles of 4·43361875 MHz at the start of each line of the colour picture. As the quartz oscillator in the receiver is phase-locked to this burst and thus to the rubidium vapour oscillator, its output may be used as a working frequency standard. The use of the colour burst signal from the American N.T.S.C. system for this purpose has been described by D. Davis,[1,2] but it is believed that this is the first time a system has been described using the PAL subcarrier.

2 Practical Use of the Colour Burst Signal

The equipment to be described was developed to monitor the colour burst frequency and to determine the feasibility of using this signal as a working frequency standard throughout New Zealand.

The colour burst signal is derived from a commercial television receiver by loosely coupling a tuned buffer amplifier to the output of the phase-locked quartz oscillator.

This signal may be used directly to calibrate the internal timebase of a frequency counter (see Sect. 2.1) to an accuracy of approximately 2×10^{-9}. For more accurate calibrations the comparator unit that is described in Section 3 may be used as outlined in Section 2.2.

2.1 Calibrating the Internal Time Base of a Frequency Counter

For checking the internal time-base oscillator of a frequency counter, to an accuracy of approximately 2×10^{-8}, the colour burst frequency may be displayed on the counter using the 10-second gate. By noting the difference between the displayed frequency and the true colour burst frequency 4·43361875 MHz, the offset of the internal counter oscillator may be determined. If a higher order of accuracy is desired (2×10^{-9}) the 10-second gate on some frequency counters can be extended to 100 seconds. This is the practical limit of obtaining a direct reading as there are occasions (i.e. during some advertisements, black and white programmes, local news, etc.) when the colour burst frequency is either not transmitted or is not locked to the rubidium vapour oscillator. Calibration to a higher precision would not normally be justified due to the instability of the internal time-base oscillator.

2.2 Calibrating High Quality Oscillators

Occasionally an accuracy of better than 2×10^{-9} is required, e.g. for calibrating and establishing a history of the frequency drift of very-high-grade quartz oscillators or the monitoring of other atomic frequency standards.

Daily readings of the frequency offset of the rubidium vapour oscillator (by the use of the transmitted colour burst signal) have been plotted in Fig. 1. Whilst the long-term drift is better than 1 part in 10^{11} per month, day-to-day fluctuations are in some cases as much as 3 parts in 10^{12}.

The equipment described (Sect. 3) may be adapted to compare other oscillators with the colour burst signal by replacing the 5 MHz reference from the caesium beam oscillator (Fig. 2) with the 5 MHz output from the oscillator to be calibrated. In this situation, the colour burst frequency of the rubidium vapour oscillator becomes the reference and by reading the sawtooth period off the chart record, the magnitude of the offset and its sign may be determined.

3 Comparator Unit

This Section describes the comparator unit that was designed and used for monitoring the transmitted colour burst signal. For the purpose of this description the colour burst signal is considered as the oscillator under calibration and a caesium beam oscillator is the reference. (Detailed technical information may be obtained from the authors.)

It should be noted that commercial caesium beam oscillators are absolute standards. One well-known make has a stated accuracy of $\pm7\times10^{-12}$ and a long-term stability of $\pm3\times10^{-12}$ for the life of the tube. Rubidium vapour oscillators are *secondary* standards and have a stated long term stability of better than $\pm1\times10^{-11}$/month.

3.1 Principle of Operation (Fig. 2)

A 5 MHz reference signal is supplied to the complete unit from the primary frequency source, a caesium beam oscillator. This signal is divided by a factor of 256 to provide an output of 19531·25 Hz that is used as the reference signal to the harmonic mixer. The colour burst frequency, obtained from the quartz oscillator in the colour television receiver, has an average value of 4433618·75 Hz.

As this signal is high in frequency by 25 Hz with respect to the 227th harmonic of the reference signal, the filtered output of the harmonic mixer is a sawtooth that has a period corresponding to 25 Hz plus or minus the offset of the rubidium vapour oscillator. The sawtooth output is amplified and squared to provide a 25 Hz square wave to one input of a comparator where it is compared in phase with a 25 Hz square wave derived from the 5 MHz reference oscillator. The output of this edge triggered R/S flip-flop comparator is also a sawtooth whose period is a function of the frequency difference between the reference oscillator and the colour burst signal. The sign of the offset (positive or negative) can be determined by the slope of the comparator output.

4 Chart Records

Sample chart recordings are shown in Fig. 3. The frequency offset of the colour burst signal is determined from the period t (20160 seconds for Fig. 3a) and the comparator input frequency (4433618·75 Hz) giving an offset of $1{\cdot}12\times10^{-11}$. As the slope of the sawtooth is positive, the frequency of the rubidium vapour oscillator is high with respect to the caesium beam oscillator.

The recording shown in Fig. 3(a) is of the colour burst subcarrier transmitted from TV1 in Wellington. The propagation paths involved in this recording are a 15 km

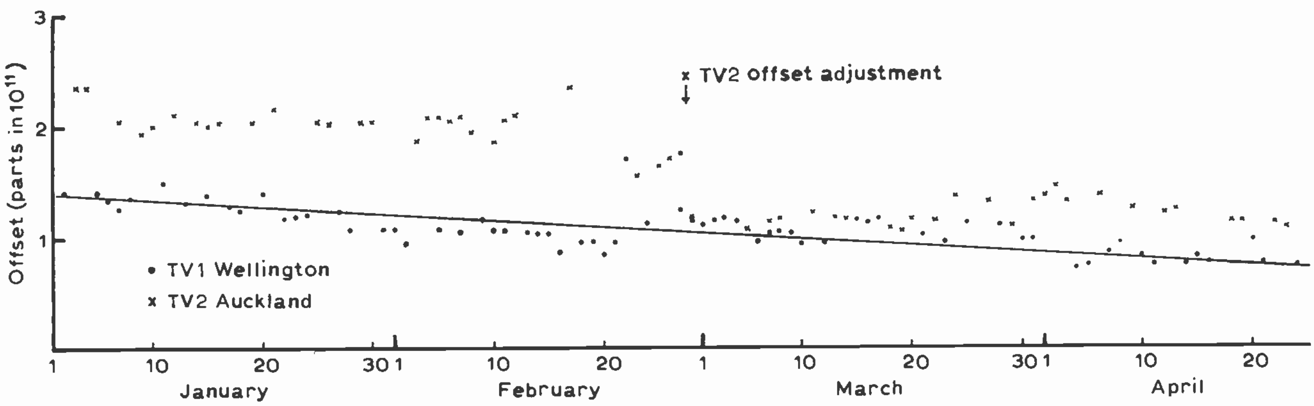


Fig. 1. Frequency stability of rubidium vapour oscillator relative to caesium beam oscillator.

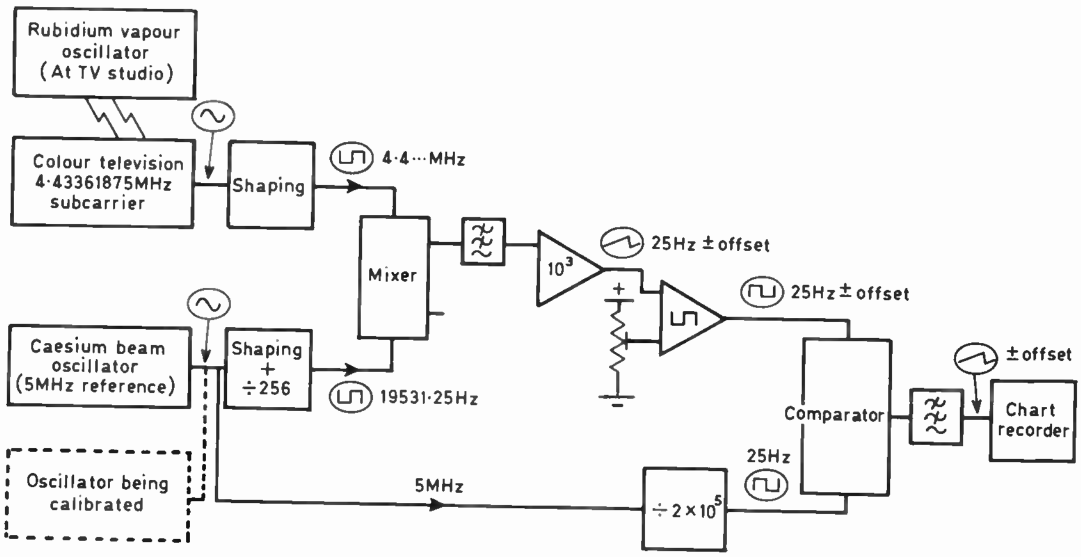
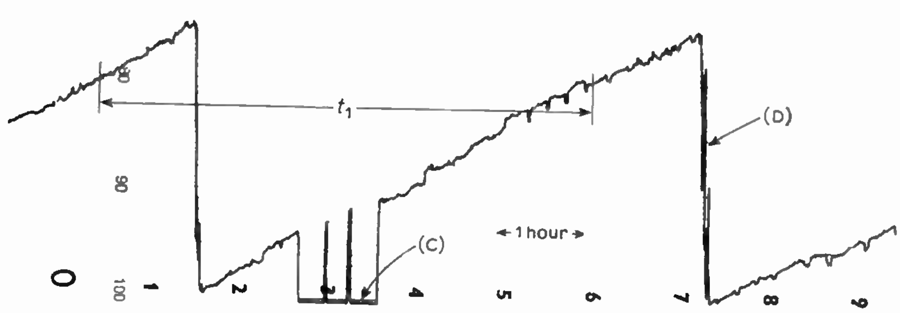


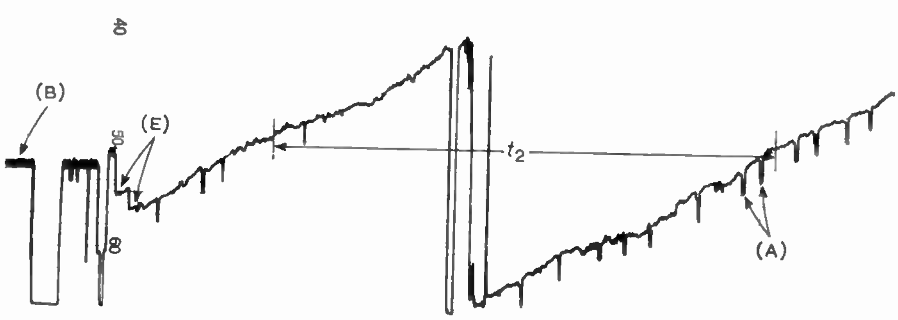
Fig. 2. Block diagram of the colour burst frequency comparator.

microwave link from the studio to the main transmitting antenna and a further 10 km path (in the 41–51 MHz band) to the receiver located at the laboratory. The recording shown in Fig. 3(b) is of the colour burst subcarrier that originates from the TV2 studios in Auckland, approximately 600 km from Wellington. The connection between the two centres is almost entirely by microwave links with a final 10 km path (in the 181–188 MHz band) to the receiver in the laboratory. In spite of the distance involved and the changing atmospheric conditions between the links, the colour burst signal is quite usable as a frequency standard.

Some features on the recordings require further comment. Small discontinuities on the trace at approximately 15 minute intervals (point A, indicated by the arrows) are produced by small phase shifts in the colour burst signal when changing from a programme to local advertisements. The thick centralized trace (point B) occurs when the transmitted colour burst reference signal has been switched from the rubidium vapour oscillator to some other



(a) TV1 Wellington (41–51 MHz),



(b) TV2 Auckland (181–188 MHz).

Fig. 3. Frequency recordings obtained using the comparator

reference whose frequency offset is such that the output signal from the comparator is above the passband of the d.c. filter circuit (e.g. a quartz oscillator with an offset of 1×10^{-7}).

When the colour burst signal is not transmitted the quartz oscillator in the television receiver is so far off frequency that there is no output from the low-pass filter following the harmonic mixer and thus the comparator is reset to zero as indicated by point C. Any phase jitter on the colour burst signal will produce an uncertainty at the retrace point of the sawtooth ramp as indicated by point D. The long transmission path of the TV2 program originating from Auckland (600 km from Wellington) produces considerable phase jitter on the received signal but this does not significantly affect the accuracy of the period measurements. Some recordings of the colour burst signal originating from TV2 show step phase changes (point E), which can be attributed to changes in the signal path length either in the equipment (e.g. different cable lengths to the equipment) or re-routing of the signal via a different microwave link to Wellington.

5 Conclusion

The equipment described in this paper has been used successfully for over 30 months. From the results obtained it has been possible to determine the frequency offset of the rubidium vapour oscillator to better than 1×10^{-11}. Field trials have shown that it is possible to use the colour burst subcarrier as a working frequency standard throughout New Zealand.[3] Using the colour burst signal derived from the television receiver the internal timebase of a frequency counter may be quickly calibrated. By the regular monitoring of the television corporations' rubidium vapour oscillators and by the application of the correction for frequency offset it will be possible for those who have atomic oscillators in other areas of New Zealand to maintain a check on their equipment.

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(Short Contribution No. 190/M16.)

The Authors

Colin Jenness (Member 1971) joined the Radio and Physics section of the Physics and Engineering Laboratories of DSIR, New Zealand, in 1956. In 1960 he spent a one-year spell on the scientific staff at Scott Base, Antarctica. Subsequently he attended the Wellington Polytechnic, where he gained the New Zealand Certificate of Science in 1965 and the IERE Graduateship Examination in 1968. Since 1968 he has been with the Electronic Design Section of PELW, developing specialized electronic equipment for scientific research projects. He was recently involved in the establishment of a thick film facility at the Laboratory and as part of the thick film work a miniaturized radio transmitter was developed for use in a radio telemetry system for the study of free-ranging opossums in the New Zealand native forest. He worked on the preliminary studies and development of equipment to determine the feasibility of using the New Zealand colour television network as a means of providing a standard frequency signal thoughout the country and is at present developing equipment associated with a calculable capacitor for the Electrical Standards Section of the Laboratory.

R. A. Morris is now Chief Electrical Engineer of the New Zealand DSIR's Physics and Engineering Laboratory. Previously as the Divisional Head of the Electronics group he was responsible for the design and development of a numerically controlled profile milling machine system for the laboratory and the establishing of an Alouette/ISIS receiving station at the PEL field station. His more recent work has been in the design and development of a microprocessor-controlled meat weighing and grading system and an automatic carcass marshalling system, both for use in the New Zealand meat industry. A graduate of Canterbury College, Mr Morris was at the Royal Radar Establishment, Malvern, from 1952 to 1955, and he joined the Physics and Engineering Laboratory in 1958. He was scientific leader at Scott Base, Antarctica, during the ummer of 1963–64.

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New displays for old radar

T. W. WELCH, C.Eng., F.I.E.R.E.*

Based on a paper read at a meeting of the Aerospace and Maritime and Military Systems Group in London on 13th March 1974.

SUMMARY

Problems encountered in engineering the interface between a modern data extraction and display system and an existing secondary radar system of earlier design are described. The radar and the ATC building, which are in Iceland, are about 55 km apart. This paper discusses various interference design problems encountered before, during and since the installation and commissioning of the system and the solution found effective for each. The topics discussed include protection of the existing radar system from fault conditions in the new equipment, early difficulties encountered in passing data over the existing telephone circuits, malfunctions caused by harmonic content in the selsyn azimuth data and by departures from specification of the video output of the original radar, and some s.s.r. siting lessons learned from the results obtained.

* *T. W. Welch & Partners Ltd., 64 Ash Hill Road, Ash, near Aldershot, Surrey.*

1 Introduction

In the summer of 1970, following extensive discussion with its Operational Air Traffic Control Staff, the Directorate of Civil Aviation, Iceland (DCA), agreed with a request from the Controllers manning the Air and Oceanic Control Centre at Reykjavik that some kind of en-route radar aid must be provided. A consultant study of the operational requirement and of the most effective means of satisfying that requirement was commissioned in September 1970 with a target date for completion of at least a useful first phase by mid-summer 1972.

For various reasons which it would be inappropriate to report in this paper, but which it is hoped to report elsewhere, the outcome of the initial study included:

(i) A firm recommendation that a modern display system, using synthetically-generated position symbols (i.e. symbols and characters derived by computer instruction from the raw video, which is not itself displayed) and SSR-derived identity labels from any suitable SSR sensor, should be installed within the existing Control Centres building at Reykjavik.

(ii) A recommendation that, for the time being, this system should consist of two displays, with independent code selector units to provide choice of the displayed data. Provision was to be included for future increase in the number of display units.

(iii) A recommended viewing range of just over 400 km (200 nautical miles) for one display, for oceanic control and/or the integration of outbound international flights from Iceland with the overflying traffic pattern; the other display was recommended to have a viewing radius of about 200 km to provide for the control and expenditious handling of aircraft flying in the ACC (Iceland Domestic) Sector and the separation from such domestic traffic, and from one another, of aircraft descending into the Reykjavik/Keflavik terminal areas from the International Oceanic traffic pattern.

(iv) In order to preserve the high-brightness feature of a high-refresh-rate synthetic presentation and thus to avoid the necessity to set up a separate dark radar room or to 'black out' completely a pleasantly lit existing Centre, it was recommended that no provision should be made for presentation of data at 'radar' data rate.

(v) During the initial study it was noted that a radar complex including an SSR of suitable performance of which the coverage included the region of interest to DCA, was operated by a different Agency on a site some 20 nautical miles (40 km) distant from the Air Traffic Control Centre. Various proposals had been made in the past for passing radar data from this complex for use in Civil Air Traffic Control; these had all involved the transmission of raw radar data on wideband links and had, for one reason and another, been rejected. It was evident to the Consultant, however, that newly available data extraction techniques could be used and that it was quite undesirable to place a second interrogator so close to the existing one. It was now recommended that DCA approach the Operating Agency to discover whether, in principle, mode trigger, azimuth data and video responses from the SSR element of the complex could be made available for Civil use.

(vi) Pre-supposing agreement, it was recommended that a data extractor be installed at the radar site to recover the information of interest to DCA and that this information, after processing into a suitable message format, should be transmitted to the ATC Centre at Reykjavik in a voice bandwidth on existing telephone circuits provided by the PTT. One such circuit was to be a permanently-connected land-line, whilst the other was to be a 'reserved' channel on a modern, multi-channel microwave link between terminals about two miles from the radar site and a similar distance from the ATC Centre.

These proposals had the technical merit of avoiding the introduction of an additional interrogator into the area (thus complying with the spirit of International agreements regarding unnecessary emissions as well as with ICAO recommendations to avoid proliferation of interrogators for operational reasons). More important they minimized the capital outlay on equipment to be met in the initial phase of development of the system, thus permitting a greater expenditure than might otherwise have been possible on the display system, so that it did not suffer undue degradation from the original concept under financial pressure.

The report arising from the initial study also made recommendations for pre-training of Operational and Technical staffs and for the subsequent further development of the total ATC radar system. These matters are not relevant, in detail, to the subject of this paper.

Because of the very compressed time-scale against which it was hoped to implement the proposals, negotiations with the radar-operating Agency and with the PTT were opened even before completion of the initial study report; simultaneously, equipment manufacturers in various countries were invited to submit pre-qualification proposals. Agreements in principle for the supply of the raw data and transmission of the processed data were quickly reached, more detailed proposals and formal tenders were sought from the Industry, a Contractor selected and equipment specifications and prices agreed. A UK Company gained the Contract for equipment supply, supervision of installation, initial post-commissioning maintenance support and Technician pre-training. In passing, it may be noted that although the actual contract date was delayed (through Government changes following an election in Iceland) from an intended date in April 1971 to 1st June, 1971, the Contractor succeeded in meeting the installation target date of May 1972, with commissioning in July 1972. It is perhaps a pity that this sort of schedule-keeping performance is not experienced more often. Another UK Company secured the Contract for training and examination to International standards of the Operational ATC Staff.

In the immediate pre-contract period, meetings were set up between the radar Operating Agency, the selected Contractor, DCA and the Consultant Engineer, to arrange an interface agreement and to ensure that the Contractor (who, of course, was quite unable to accept responsibility for the inputs to his data extraction equipment) had full opportunity to consider the various input parameters and to propose appropriate interface arrangements. Specifications were agreed with the radar Operating Agency for the data rate, pulse shapes and amplitudes, impedances, azimuth data transmission type (selsyn) and amplitudes, and the particular terminal boards, with terminal or socket identities, at which the various data would be taken were identified. The operating Agency required protection of its equipment from any cable faults, misconnections or other hazards arising from the interface with the proposed new equipment, which DCA undertook to provide. Figure 1 is an outline schematic diagram of the system as it exists today.

Problems were encountered in bringing about successful interfacing both in the pre-installation and post-commissioning periods and it is the primary purpose of this paper to report upon some of these.

2 Problems Arising from the Interface Agreement

As has been said above, the initial interfacing agreement specified the particular terminals and their positions at which data could be taken to feed the DCA extractor. The radar operating Agency required that its equipment should be protected by the installation of suitable protection devices as close as practicable to the data terminals. This precluded acceptance of the input isolation and protection devices already included within the Extractor cabinet to be supplied by the Contractor, who was unwilling, for a one-off job, to consider separating them from the cabinet for installation at the data terminals.

Protection for the azimuth data circuits was simple and straightforward. Azimuth information to be provided from the aerial shaft was in the form of 1 : 1 and 36 : 1 selsyn transmission, having a maximum voltage per phase of 90 V r.m.s. at 60 Hz. The reference phase was to be supplied at 120 V r.m.s. 60 Hz. The Agency asked that the selsyn data lines be protected by 1 A fuses and the reference phase line and neutral connections by 10 A fuses. In fact, since the Contractor's equipment required a synchro-maintained servo converter (to produce a North marker and 4092 azimuth count pulses per aerial rotation) the current demands were much below these figures, and the required protection was provided by a simple 8-way fuse box with indicating fuse-holders, installed adjacent to the terminals provided by the Agency. This had subsequently to be scrapped because of problems with the selsyn data (reported later in this paper) but it fully satisfied the

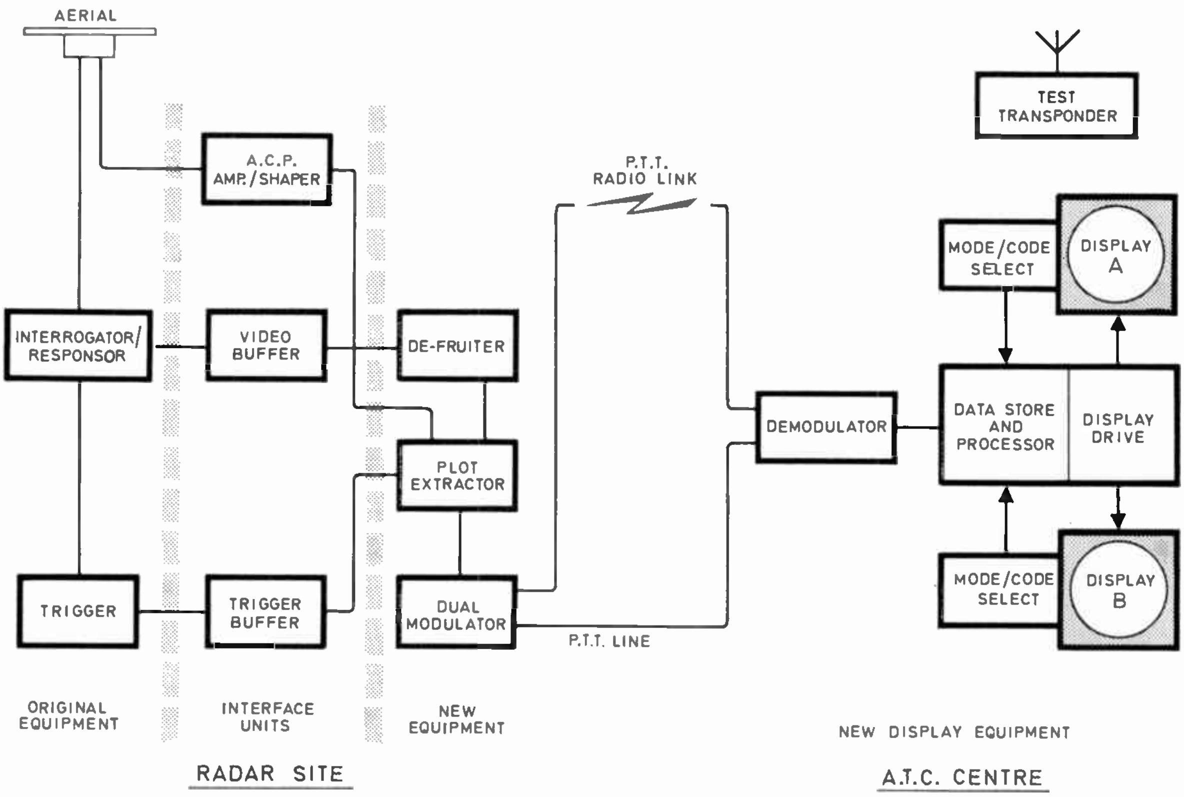


Fig. 1. Schematic diagram of the final system.

requirements of the Agency at the time of installation.

Trigger and video were to be supplied on coaxial output spur connectors from existing 50 Ω circuits. The cable-run to the input terminal of the isolating buffer was to be less than ½ metre, so that no separate termination would be needed. The isolating buffer was required by the Agency to provide at least 40 dB isolation of the input terminal from any event which might occur within or beyond the buffer. Trigger amplitude was to be within the range 25 to 50 V, across the existing terminating impedance of 50 Ω.

A suitable buffer unit was designed by the Consultants in UK and a bread-board model built and tested. Prior to installation of the display equipment, two units to the original design, including provision for attenuation of the outputs to a nominal level of 5 V, were built by DCA Technicians in Iceland and installed close to the Agency's terminals at the radar site. The circuit of the units, which apart from the output attenuation resistor values were intended to be interchangeable as between trigger and video, as shown at Fig. 2. The measured performance, which was rigorously checked by Engineers of the Agency at the time of interfacing to the extractor, compared with the design objective as follows.

Under normal operating conditions, the input load presented to the driving source was 500 Ω (design aim 1000 Ω minimum), with a d.c. offset within ±0·2 mA (design aim ±2·0 mA max.). Only under fault condition did the loading approach the limiting values of the design parameters.

The effects of semiconductor failure were:

D1 o/c: Input d.c. changes from nominal balance to −1·5 mA.

D1 s/c: Input unaffected up to a level of 10 V; above 10 V additional input loading of 1·2 kΩ is presented by R3.

TR1 base/emitter s/c or collector o/c: Input changes from nominal balance to +2·0 mA (design limit).

TR1 base/collector s/c: Input unaffected.

Failure of any semiconductor following TR1 did not affect the input conditions.

The gain was found to be approximately 0·95 (design aim 0·9 minimum), the intrinsic rise/fall time about 35 ns (design aim 50 ns maximum) and the output limit level was found to be about 8 V (design aim at least 5 V).

One additional test applied by the Agency's Engineers was the application of large voltage waveforms of various shapes and frequencies at the output of the buffer whilst exploring at the input terminal with a calibrated oscilloscope. Their subsequent report to the Agency on the success of the interface tests noted that 'the isolation in this test was very much in excess of the required 40 dB'.

In actual practice, by the time of making the interface (some 14 months later than the 'in-principle' agreement) the layout and operational arrangements at the radar site were found to have changed in such a way that the trigger input buffer had to be fed in parallel with a terminated 50 Ω circuit at a considerable distance. The input cable had therefore to be led up to the buffer, where it was 'Tee'd'

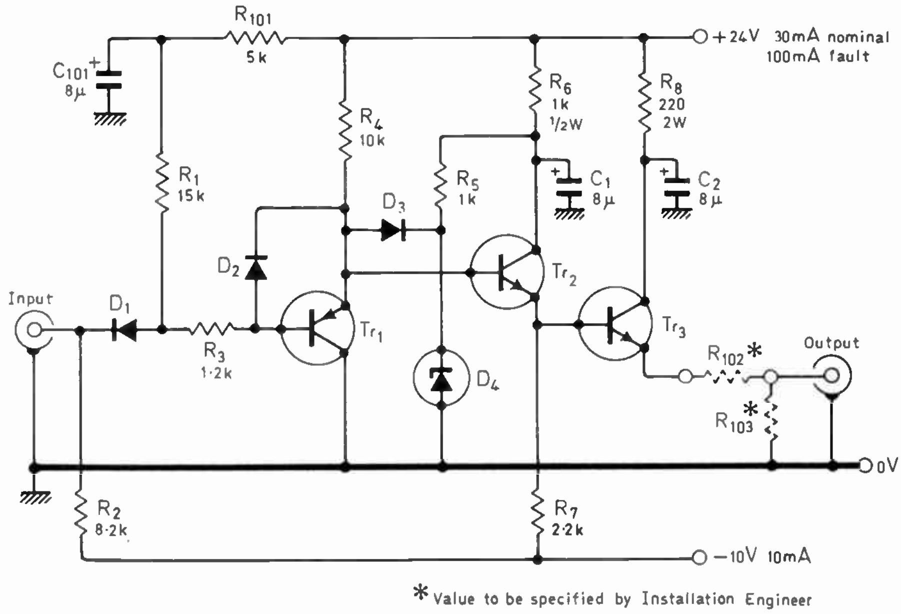


Fig. 2. Trigger and video isolating buffer.

at high impedance, and back by the same route to the originally driven circuit, whilst trigger and video amplitudes reached levels of 70 V and 30 V respectively (original specifications 50 V and 7 V maximum). The consequently necessary changes to cable runs and input attenuation arrangements were made on site within an hour of the changes being revealed to DCA staff and the units have functioned continuously from May 1972 to date with no fault.

3 Telephone Circuits

The specification of the data transmission equipment to be supplied by the Contractor required that the transmission circuits be to the standards of CCITT specification M89, and the Icelandic PTT saw no special difficulty about this although the interpretation of M89, particularly in respect of impulse noise, was in some little doubt.

The original plan (see Fig. 3) was to provide two separate lines from the radar site to the main frame of a nearby village telephone exchange (A), where one circuit would be routed via a spare pair in existing cables to the main frame at Reykjavik PTT Headquarters and thence on existing cables to Reykjavik Air Traffic Control Centre. The other circuit was separated at the 'sending end' village and passed to a spare channel on an existing multichannel wideband microwave link, to the PTT HQ roof, then on cable from the demodulator at the top floor level of the HQ to the main frame at the bottom of the building, and onwards to the ATC Centre by normal (existing) cables. Experience with ATC telephone links, routed by identical paths for many years, indicated that the microwave link path was normally the better, with much higher signal levels and much less noise interference than the land-lines.

Well before installation of the Extractor/display equipment the PTT identified the pairs to be used in the various frames, sub-frames (S) and cables along the route and, having set up the necessary 'permanent' and 'reserved' connections, tested the lines. Both were shown to meet, prima facie, the requirements of M89 as to frequency response and psophometric noise.

On installation of the equipment, however, it was found very quickly that, for much of the time, far too many parity errors were being identified at the receiving end with consequent automatic shut-down of the display computer.

The 'microwave' path, far from having the expected superior performance, was much worse than the land-line. It was quickly concluded that unacceptably high levels of impulse noise were being induced on to the lines at one or more points and extensive and prolonged investigation began.

Many sources of potential noise were identified and either cured or by-passed. Wherever possible, the lines were taken out of frames and sub-frames and passed directly through from input strip to output strip by the shortest possible connections. In one very old sub-frame, carbon-block surge protectors were found to be noisy and were replaced by more modern protective arrangements. At one sub-frame where the cable from the radar site to the village exchange was joined by another from a remote village, some rather old signalling systems were found to be bringing excessive noise impulses into the onward combined cable, and some re-routeing was arranged to alleviate this. Eventually, the 'land-line' circuit was taken in a different cable from the 'microwave' circuit to an alternative exchange (B) somewhat more distant from the radar site and thence by a slightly different route towards Reykjavik. From the nearest sub-frame to the Air Traffic Control Centre, this circuit was routed direct to the ATC building, thus keeping it out of the City Centre and, especially, out of the main terminal frame at Reykjavik. The earlier efforts had shown a marked

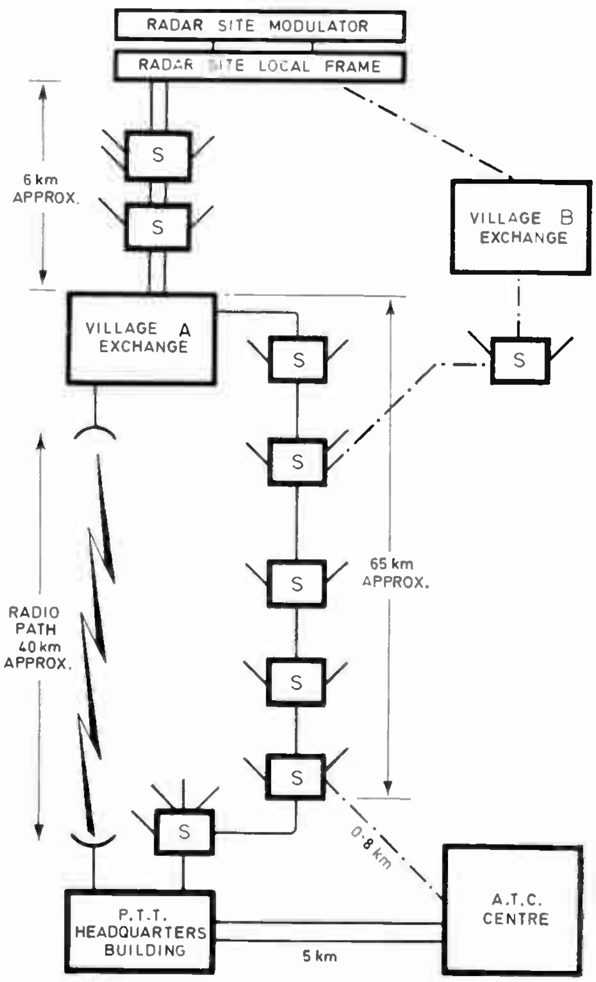


Fig. 3. Original and final data transmission circuits.

improvement in the 'microwave' circuit and this was now useable, though still inferior to the land-line, probably because of its unavoidable routeing through the PTT HQ building.

Thus, although at one time the problem of providing satisfactory circuits over the (approximately 56 km (35 miles) land-line distance appeared so formidable that it was contemplated whether to provide an *ad hoc* v.h.f. or microwave link, the problem has now been satisfactorily (though not completely) solved.

4 Azimuth Data Inadequacies

As has been said above, it was originally intended that the North mark and azimuth count pulses required by the extractor and display system should be derived from selsyn aerial turning data by means of a synchro-input azimuth data converter. This course had been explored with both the Operating Agency and the Contractor prior to settlement of the final schedule of equipment to be supplied, and had appeared entirely satisfactory.

At the time of initial setting-up, some difficulty was encountered in obtaining smooth operation of the synchro drive in the azimuth data converter but after adjustments to feed-back it had appeared to settle down. In the following few weeks, several instances were encountered of 'double North marks', resulting in anomalous performance of the display computer and there was other occasional evidence of imperfections in the azimuth data passed to the extractor and display system. On each such occasion, it was found necessary to re-adjust the azimuth converter and to re-set its digitizer. Eventually, the unit ceased to function altogether and, on the arrival of technical staff at the remote radar site, it was discovered that a nylon bearing in the synchro servo system had failed. A temporary new bearing was fabricated locally from PTFE whilst a new complete azimuth data converter was in course of delivery from the Contractor. The temporary bearing failed and was renewed several times, it being thought that the repetitive failures were due to the 'home-made' bearings themselves. However, when finally the replacement unit was fitted, it suffered an early failure of the same bearing. Investigation and consideration by both DCA and Contractor's technical staffs led to suspicion of the input from the aerial selsyns, though since all the Operating Agency's own equipment driven from the same selsyns was working perfectly well, this suspicion at first seemed unfounded. Closer investigation showed that the selsyn output was unusually rich in third and fifth harmonic content, producing a condition in which it was impossible to reach zero error voltage. The Contractor had, of course, accepted no responsibility at all for the failure of the system to work through imperfections in the inputs, but co-operated fully in search for a solution to this particular problem. An experimental low-pass filter was designed by the Contractor who also supplied the necessary components for its construction by DCA staff. Measurements made with the filter fitted in various places suggested that the addition of such units in all seven inputs to the synchro servo system might well solve the problem; this solution was regarded as inelegant and very demanding of space and, since there was no absolute certainty of its success, it was decided to explore the possibility of fitting a digitizer directly to the shaft of the Operating Agency's aerial.

A meeting was called with the Technical staff of the Operating Agency, at which the Consultant to DCA outlined the problem and the steps taken thus far to resolve it. The enquiry was made as to the possibility of fitting a shaft digitizer. The Operating Agency responded most generously, not only by permitting the addition of such a unit but even to the extent of supplying and fitting it, including the running of the cables to the DCA extractor rack at no cost to DCA. The output produced by the shaft unit required some shaping and processing for successful interface with the azimuth count circuits in the extractor and the Contractor again provided a circuit design and duplicate sets of components for the construction of the shaper/amplifier by DCA staff. Since its installation no more trouble has been experienced with azimuth or North mark data and certain mysterious malfunctions of the display computer have also ceased.

5 Status Check on Radar Head

From the time of initial concept of the system, it was realized that employment by an Air Traffic Control Authority of data derived from a radar system operated by a different and independent agency might pose some operational and administrative problems. Many of these, of course were soluble by the setting-up of procedures for both regular and emergency communication between the two Authorities, including prior advice by the Operating Agency to DCA of any planned down-time for the radar system and for urgent advice of any unplanned down-time (which can occur even in the most sophisticated maintenance organization).

During the initial study it was noted that, fortuitously, the upper floor of the DCA building in Reykjavik is line-of-sight to the remote radar station. A local transponder was therefore installed within one of the display consoles at Reykjavik, to permit ATC operational staff to make an immediate check on whether the radar site is interrogating normally, to check by observation of the displayed response that the processing circuits are functioning normally, and to provide assurance that (in one position at least) range and azimuth are being correctly reported on the display. A bank of switches simulates the input from the coding altimeter to provide for checking of 'live' mode-C responses. This simple and inexpensive test facility has proved most valuable not only to DCA but also, frequently, to the Operating Agency in providing a 'live' and controllable external test response.

6 'Frozen' Presentation

The updating of the data in the display computer store is initiated at each aerial revolution by the arrival of the North marker pulse over the data link. Amongst the in-built features of the system is one which brings about an automatic change-over from one transmission circuit to the other if no North marker is received for two successive aerial rotation periods. (It should be noted that there are other checks which bring about the same result.) In the system as originally installed, however, if no North marker was found to be present on the second line, no further specific action was initiated to inform the ATC Controllers of the situation; worse, from the operational viewpoint, the display unit continued to present the data held in the store at the last receipt of a North mark. This situation could arise from a variety of circumstances, including the stopping of the radar aerial, total failure of azimuth data input to the extractor, or failure of the radar site or display site modems. The use of the displays in the Icelandic ATC context is as 'appreciation' displays, to which Controllers turn from time to time to obtain useful information in what remains basically a 'procedural' ATC system. Thus there is, normally, no Controller continuously observing or tracking the development of aircraft tracks on the display and a Controller turning for aid to a display had no immediate evidence that it was 'frozen', or how long it had been so. This situation could not be accepted for operational use.

The logic included in the original system produced computer-generated signals to indicate absence (*inter alia*) of the North marker from either line, separately. Also included in the computer was a terminal (unused in the original system) at which a shift of logic level would clear the held data, but not the operating program, from the store. Using redundant logic included within the equipment supplied, the two 'line failure' signals were gated to provide a new signal, designated 'both lines bad' (BLB). A small external unit was then designed and constructed, the input to which was the 'BLB' signal and the output of which:

(i) Immediately sets up visual and audible warnings to the Controllers that the display is 'frozen'.

(ii) After an interval (made variable from about ½ minute to about ½ hour), provides a 'clear store' signal to the computer. This was because, on receipt of the visual/audible warning, Controllers need to assess the current situation quickly to aid in the speedy restoration, where required, of full 'procedural' separations of aircraft. In addition, provided it is understood to be 'frozen', the situation display can continue to be useful for some time after it has ceased to update. In practice, the delay has been set to about 8 minutes (Fig. 4).

The audible warning was at first the subject of some controversy. Patently, during a lengthy 'freeze', there had to be facility for switching off the necessarily loud buzzer. In other such audible warning systems, however, it had been found that, once switched off, the warning circuits were often not set to 'on' again on restoration of the service, thus preventing the initiation of the warning

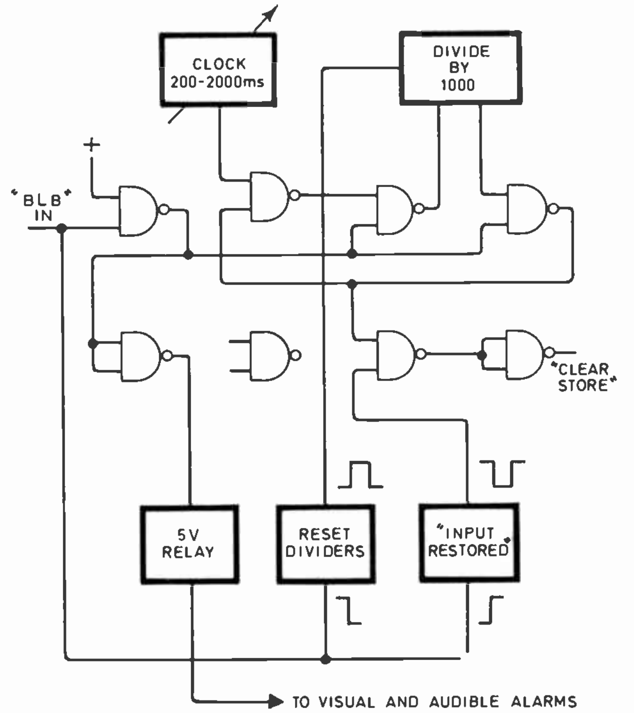


Fig. 4. 'Frozen' display alarm and delayed 'clear store' unit.

signal on a later failure. The problem was simply solved by using a change-over relay in the buzzer circuit and a change-over switch at the Controller's position. Thus the buzzer operates on failure, is switched 'off' to prevent the noise, operates again on restoration of the data and is again switched off, thus setting up the circuit to accept the next warning. This simple system is in course of adoption on similar warning circuits.

7 Deterioration of Video Input

After some months of reasonably successful operation, during which the m.t.b.f. of the system showed a steady improvement, fairly frequent anomalies began to be observed on the displays; unaccountable absence of the identity code from the displayed data, frequent and improper changes in the displayed code, uncertainty of selection etc., all became unacceptably frequent occurrencies. Not unnaturally, it was suspected that either the data extractor or the display computer was misbehaving, although the checks available from in-built test routines could not pin-point the cause. Eventually, the Contractor sent an engineer to the site to recheck and, if necessary, repair the various elements of the system. On tracing the problems backwards through the processing chain, he concluded that the fault must lie with the data input and accordingly, with the co-operation of Technicians of the Operating Agency, he made observations of the waveforms being input to isolating buffers. These showed gross departures from the specifications originally agreed between the Operating Agency and DCA and were evidently the cause of the malfunctions in the DCA display system, although they had not caused sufficient difficulty on the cruder passive decoding system used by the Operating Agency to demand attention by maintenance staff. The problem was corrected by more regular checking of the output and more frequent application of setting-up routines. The Operating Agency is itself now employing a more modern digital data extraction system and, therefore, its own requirements for stability of radar input data may well prevent any repetition of this experience.

8 SSR Siting Lessons

The employment by DCA of data from an already-existing SSR sytem, operated by a different agency, precluded, of course, any special consideration being given to the actual siting of the SSR head. However, it was roughly in the right place (since its coverage extended over an area similar to that of ATC interest), its aerial was mounted high and in the clear in relation to a cluster of surrounding buildings and there were no evident important shadows cast by natural or man-made obstructions. Moreover, to the best of the information available to DCA, it was performing, to the satisfaction of the Operating Agency, a function not very different from that required for ATC purposes. Thus, it seemed eminently suitable as a source of data for DCA use, especially having regard to the considerations outlined in the Introduction.

However, one or two effects of the site have been noted which, whilst not the cause of any major performance defects now that they are known to and understood by the Controllers, will represent invaluable lessons in the eventual siting of DCA's own radar head.

Firstly, the radar is sited very close to an area of fairly intensive local, low-level activity, with aircraft having active transponders frequently passing within one or two miles of the radar head at low altitude. This imposes severe demands on the side-lobe suppression elements of the system and fairly frequent 'ring-around' responses are seen. These are, perhaps, a greater nuisance on the synthetic, labelled display than on some older forms of presentation, because of the display area occupied by each 'false' report. Thus, although there may be temptations arising from the ownership of land, ready availability of services, ease of access and other economic factors to use similar sites, the risks of degradation of system performance must be very carefully considered before selection of any such 'easy' site is agreed.

Secondly, although inspection of the site would indicate that the aerial is well clear (by height) from the surrounding buildings (Fig. 5) the geometry of one or two of these is such as to provide extended 'false tracks' for aircraft on

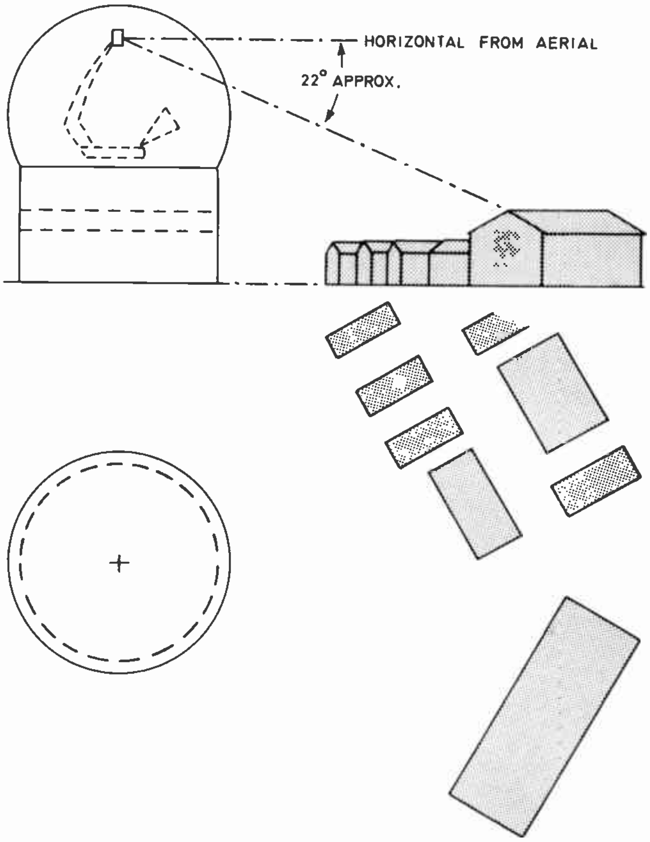


Fig. 5. Building around radar site—elevation and plan schematics (not to scale').

The large building gives false tracks by reflection from the wall facing the radar (see Fig. 6.)

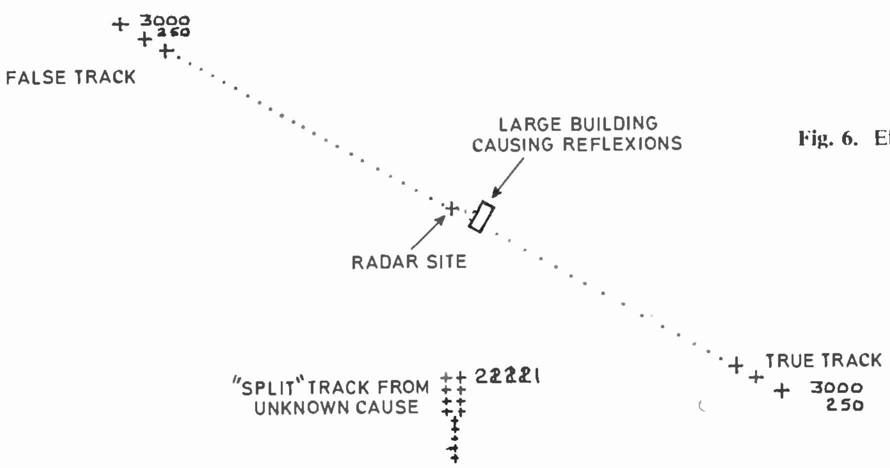


Fig. 6. Effects of site buildings on display.

some azimuths at some altitudes. Additionally in a particular narrow azimuth sector some obstruction, as yet unidentified, appears to cause deformation of the aerial radiation pattern with the result that individual responses, and sometimes quite extensive tracks, are represented on the display as two closely adjacent but separate ones (Fig. 6). Thus, the advice about the separation of the aerial site from buildings given in ICAO Annexe 10 is seen to be well-founded, whilst careful attention to the architecture of new buildings which necessarily occupy positions close to the SSR aerial could assist in the harmless dispersal of reflected energy in directions (e.g. upwards!) where it can do no operational harm.

9 Conclusion

The initial phase of the Icelandic ATC en-route radar system has been successfully completed and the 'new displays for old radar' concept, which has permitted the installation of a modern versatile display system, has been realized. DCA Iceland has a working and useful *en-route* radar aid in a much shorter time-scale, and with much better display arrangements, than might have been expected to be possible had it been necessary to acquire and instal a new radar head with all the costly site preparation and work services undertakings necessary to such an enterprise. That it is 'second-best', in relation to a system of which DCA owned and operated all the elements is certain—but, after all, it was the acknowledged initiator of modern radar systems who advocated the policy of adoption of the 'third-best'.

10 Acknowledgments

Thanks are due to DCA Iceland and particularly to the Director-General of Civil Aviation, Mr. Agnar Kofoed-Hansen and his Deputy Director-General, Mr. Leifur Magnusson, for the opportunity to undertake this project in a Consultant capacity and for permission to publish this account of some of the interface problems encountered.

Thanks are also due to the Operating Agency for permission to publish those aspects of this account which relate to the radar site, as well as for extensive and generous co-operation during the realization of the project.

Finally, thanks are gratefully extended to the Chief of the Radio Section, DCA Iceland and his apparently untiring staff, whose stalwart efforts resulted in the 'taming' of the project within a satisfactory time-scale. Also to the staff of the Icelandic PTT and particularly to Mr. Olafur Tomasson for their patience and persistence in improving land-line performance.

Manuscript first received by the Institution on 13th January 1974 and in final form on 14th November 1977.
(Paper No. 1798/AMMS 83)

IERE News and Commentary

The 52nd Annual General Meeting of the IERE

Held at the London School of Hygiene and Tropical Medicine on Thursday, 13th October, 1977.

The President, Dr P. A. Allaway, opened the meeting at 6 p.m. when 42 corporate members were present.

The Secretary, Air Vice-Marshal S. M. Davidson, confirmed that due notice of the meeting, the sixteenth Annual General Meeting of the Institution since its incorporation by Royal Charter, had been sent to all members in the June issue of *The Radio and Electronic Engineer*, with the nominations for election to the 1977-78 Council. The Notice and Agenda of the meeting had been published in the August/September issue of the Journal.

The Secretary then reported that the minutes of the 51st Annual General Meeting, held on 6th October 1976, had been published in the November 1976 issue of *The Radio and Electronic Engineer* (Vol. 46, No. 11, pp. 561-565). No comment having been received on these minutes, which had been circulated to all members during the first week of December 1976, the President proposed that they be taken as read: this was unanimously agreed and the President thereupon signed them as a correct record.

The Secretary of the Institution, Air Vice-Marshal Sinclair Davidson, reads the notice convening the Annual General Meeting.

Annual Report of the Council

Dr Allaway then presented the 51st Annual Report of the Council for the year ended 31st March 1977, which had been published on pp. 409-422 of the August/September issue of *The Radio and Electronic Engineer*, and said:

'My primary duty at this Annual General Meeting is to introduce the Annual Report, and I am sure you will appreciate that my major problem in doing this is that of summarizing a report of proceedings up to last March whilst I am aware of—but should not, strictly speaking, refer to—subsequent developments. Such is progress that some events, problems and circumstances become historic—historic in the sense that they are resolved or overtaken—in six months.

'This is the case when first I refer to the report of the Executive Committee on a matter of supreme importance in our internal affairs—the housing of four Institution. Six months ago it was reported that the increasing occupation costs at Bedford Square were of such a magnitude that it was imperative that we retrench by giving up as much accommodation there as we could, so reducing the burden of rent, rates and service charges. It was realized that this would not suffice indefinitely, and here I stray beyond the confines of the report to confirm the news given in last month's Journal, that the Institution has, just four weeks ago, moved into more compact premises at 99 Gower Street—smaller but very much more suitable to our current needs. The property was obtained under a favourable, long-term lease, and the immediate savings thereby achieved have given a much healthier look to the Institution's current year budget. This very successful administrative action

(*Photograph above*) Before the meeting starts, Mr Graham Clifford talks with Mr R. W. Stobbart, Clerk to the Council. In the front row are (left to right) Professor Alec Gambling, Professor William Gosling, and Sr. A. Unzaga of the Cuban Embassy. Behind are several Council Members and Premium winners.

also gives us the time we need to build up the Building Fund on which our longer-term plan to secure a permanent home for the Institution depends.

'Next I have to refer to the numerical strength of our Institution and the pause in its growth that was predicted in the previous Annual Report. This is, of course, a cause for great concern—concern which is common throughout the professional engineering institutions. The causes underlying the problem are not hard to find: the increasing pressure of inflation on personal budgets; uncertainties about the future and, most worrying of all reasons, the increasing difficulties encountered by many candidates for corporate membership in their struggle to satisfy the narrowing and, so far, inflexible standards demanded of them under current CEI regulations. About inflation and its associated problems we can do little but endeavour to manage our affairs as economically as possible, so as to delay as long as possible the need to increase members' subscriptions. About flexible (but not, I stress, lower) standards and the lengthening of our horizons to encompass all those who are deemed worthy and desire membership, we think we can do much: the forthright approach to this aspect adopted by the Institution is apparent in the report of the Education and Training Committee in particular. Your Council is confident that given determination and goodwill these in-house problems will be resolved reasonably quickly. Succeed we must because it is no exaggeration to say that if we do not then we could be in danger of failing in our primary objective as an Institution, laid down in our Royal Charter—"... to advance the science and practice of radio engineering", and yet more precisely—"... the theory, science, practice and engineering of electronics *and all kindred subjects and their applications*".

'I would only add one simple concept; and here I refer back to my Presidential Address. If every member were to make a determined effort and encourage one, or two, or even three, of his qualified colleagues to seek membership, our numbers would increase at a rate which would greatly exceed our wastage. And if these new recruits included a good proportion of the younger electronic engineers now working in industry, the research establishments and in education, the future success of the Institution's mission would be assured.

'In striving to meet the requirements of our Royal Charter I am happy to refer to the reports of the Professional Activities and Papers Committees. Four major conferences were held during the year, attracting over 1,000 delegates to hear 128 papers presented. In addition, fourteen colloquia and eleven lectures were held in London, and in the Local Sections no less than 123 meetings were organized. Rising costs prevented a desired increase in the size of the Institution's Journal but nevertheless some 66 papers, addresses and articles were published, so that the volume has been broadly maintained throughout the year under review.

'We shall soon be hearing the report by our Honorary Treasurer on our finances and I will not encroach on his ground except that I must say how gratified I was to note that in a year when inflation was running well into double figures, the cost of administration was held at less than 6% higher than the previous years, and for this achievement I congratulate all our officers and staff.

'And here I want to refer again to the service rendered to the Institution by Graham Clifford. My predecessor, as President, His Royal Highness the Duke of Kent, paid tribute at the last Annual General Meeting to the work of Mr Clifford, and his great contribution has been highlighted in the Annual Report. He retires finally from the service of the Institution in February next year and I want now—on behalf of Council and our members—to wish him good health so that he and Mrs Clifford can enjoy a long and happy retirement.

'I hope I have said enough to indicate that it is my belief that the Annual Report for the year ended 31st March 1977 gives a fair account of a year which was generally successful in terms of our professional activities and during which a start was made on the administrative actions which must now be followed through if our particular part of the battle with inflation is to be won.'

Comments were invited and none being forthcoming the President formally moved the adoption of the Institution's Annual Report for the year ended 31st March 1977 which was approved unanimously.

Auditors' Report, Accounts and Balance Sheet

The President called upon the Honorary Treasurer, Mr S. R. Wilkins, to propose the adoption of the Institution's Accounts for the year ended 31st March 1977, who said:

'When I reported to you last year it was my unenviable duty to present a picture which emphasized the disastrous effects of continuing inflation on our financial position. It was then obvious that only by the most rigid control of

Mr S. R. Wilkins, Honorary Treasurer makes a serious point while presenting the accounts.

expenditure and the constant exercise of economies in all departments of the Institutions' activities could we hope to combat the effects of the continuing inflationary spiral and at least contain the situation for the ensuing year.

'How well everybody has responded to this challenge can be judged from the figures presented in the accounts which show that despite inflation of between 13 and 14% the costs of running the Institution have risen by only 6%, with no deterioration of the services available to members.

'On the income side we have felt the impact of the first full year's returns from the new subscriptions introduced 18 months ago and this, coupled with improved results from all other sources of the Institution's income, has resulted in an increase over last year of nearly £61,000.

'The net result of all this is that after a most difficult year we ended up with a deficit of income over expenditure of just over £6,000—a result which compares more than favourably with last year and for which all concerned deserve our congratulations. Whilst this result must be considered to be encouraging, in no sense must it give rise to any feelings of complacency and the tightest control of expenditure must be maintained if we are to contain the continuing effects of the inflation which is still a major factor in our daily life.

'Despite the savings made during the past year by vacating part of the space at 8 and 9 Bedford Square, the cost of the Institution's accommodation has, for some time, given rise to serious concern. The short-term compromise rental agreement which was negotiated for Bedford Square expires at the end of this year at which time the rental could well have been nearly doubled.

'You are aware of Mr Clifford's excellent efforts in promoting a special fund to meet the Council's ultimate housing objective—the purchase of suitable freehold premises—and the Institution is indebted to all those who have already responded so generously to his appeal. The present exorbitant cost of suitable premises, however, makes it inevitable that this plan remains a long-term objective.

'In the meantime the Institution has taken steps to obtain smaller and more cost-effective rented premises at 99 Gower Street which should stabilize its future housing costs at a figure that is very much lower than we would have faced had we remained at Bedford Square.

'The fully detailed accounts were circulated to all our members with the Annual Report. With the help of our auditors who are present this evening I shall now be pleased to answer any questions that members might care to ask and then, if you will permit me, I would like on behalf of the Finance Committee and the Council to propose the adoption of the Accounts as published together with the Auditor's Report.'

No questions were asked and Mr J. Langham Thompson (Fellow) seconded the Honorary Treasurer's proposal, which was carried unanimously.

Election of the Council for 1977-78

The President said that there had been no opposing nominations to those made by Council and circulated to corporate members in a notice dated 9th June 1977 in the June 1977 issue of *The Radio and Electronic Engineer*. Dr Allaway continued:

'We are therefore honoured that we should have as our new President, Professor W. A. Gambling. Professor D. E. N. Davies, Professor W. Gosling, Mr D. W. Heightman, Mr R. C. Hills, Professor J. R. James and Mr J. Powell are re-elected as Vice-Presidents. Mr A. F. Dyson is elected to fill a vacancy for a Member. Mr S. R. Wilkins is re-elected as Honorary Treasurer, and the remaining members of Council will continue to serve in accordance with the period of office laid down in Bye-law 48.'

Dr Allaway said that he could not let the occasion pass without formally expressing his appreciation for the services of the retiring members of Council, Mr A. A. Dyson (Past President) and Mr M. S. Birkin (Member), and on relinquishing the office of President himself he wished to record his thanks and appreciation for their valued support and indeed that of all members of Council.

Appointment of Auditors and Solicitors

The President said that he proposed to combine Items 5 and 6 of the agenda, namely the appointment of auditors and solicitors, and he asked for members' approval to the re-appointment of Gladstone, Jenkins and Company as the Institution's auditors, their remuneration to be at the discretion of the Council, and the re-appointment also of Braund and Hill as solicitors to the Institution. This motion was carried unanimously.

Presentation of Premiums

The President then called upon Mr F. W. Sharp, Editor of the Institution's publications, to describe the awards and introduce the winners.

Twelve of the annual Premiums were to be awarded for 1976 and details were published in an Appendix to the Annual Report. Mr Sharp reported to the President that one or more of the recipients of seven of the Premiums was present to receive their awards in person. Wherever possible, arrangements were being made for presentations to those unable to be present to be made locally by Section Chairmen.

Of the three recipients sharing the Clerk Maxwell Premium for this joint paper on work carried out in the Electronics Group at the University of Bath, only Professor William Gosling was able to be present in person as his co-authors, Dr S. R. Al-Araji and Mr J. R. Olivera, had returned respectively to the University of Baghdad and the Polytechnic Institute in Havana. Mr Olivera's award was being accepted by Sr A. Unzaga, Head of the Economic Office of the Cuban Embassy in London.

Dr Allaway presents the Clerk Maxwell Premium to Professor Gosling, while Sr. A. Unzaga stands by to receive Mr Olivera's share of the Premium.

Other Business

The Secretary having reported that he had not received notice of any further business, Professor Gambling rose and asked members to join him in thanking Dr Allaway for his Presidential guidance throughout the past Institution year which, might be regarded as having been especially difficult in many respects. 'Not only has he coped splendidly with

The four recipients of the Rediffusion Television Premium, (right to left) Mr Peter Stevens, Mr Ian Wilson, Dr Ernest Patterson and Mr Kenneth Lever pause for the photographer's record with the President and (far left) the Institution's Editor, Mr Frank Sharp.

The winners of the Local Sections Premium, Dr Raymond Batt (centre) and Professor Douglas Harris, with the President.

The President congratulates Mr Francis Sladen, co-author of the paper awarded the Marconi Premium. In the centre, Mr Dennis Ralphs, the senior author.

Dr Allaway, a Member of the Court of Brunel University, congratulates Mr Mike Lea, a Senior Lecturer at the University, on the award of the award of the Leslie McMichael Premium.

The Sir Charles Wheatstone Premium is handed to Mr Trygve Gytre of the Institute of Marine Research, Bergen.

Mr William Forsythe exchanges a few words with Dr Allaway after receiving his Charles Babbage Premium.

The 25th and 26th Presidents of the Institution exchange good wishes.

the onerous task of succeeding a particularly illustrious predecessor but he gave willingly much time and effort as President-Elect before he actually became President, since His Royal Highness The Duke of Kent, though meticulous in his attention to Institution affairs, was obviously not able to be present at all meetings and events during his year of office.'

'Throughout his term as President-Elect and President, Dr Allaway provided a very firm lead and invaluable business counsel in the battle with the Institution's general financial problems and—in particular—ensured that the necessary action was taken in timely manner to resolve the immediate housing problem. The Institution has special cause to be grateful to him for all this and for his lead-role in the appointment of the new Secretary, which was an unprecedented event in the history of the Institution, the name of the retiring Secretary, Mr Clifford, having over the years become almost synonymous with that of the IERE.'

Professor Gambling's vote of thanks to Dr Allaway was supported with acclamation by all those present.

Dr Allaway thanked Professor Gambling and the members, saying that it had given him much pleasure to be of some service to his Institution, whereupon he declared the meeting closed at 6.40 p.m.

(Note. Professor Gambling will give his Presidential Address in London on Tuesday, 24th January 1978, taking as his theme 'Electronics, Universities and Institutions'.)

Announcements

National Electronics Review

The issues of *National Electronics Review* for the July/August and September/October 1977 included the following main articles:

The Future of the British Electronics Industry (Based on a report prepared by Lord Penney)

Company Profile: Kemo Limited

Compact High-power, Agile Microwave Source

Electronics Research: The Department of Electronics and Electrical Engineering, Glasgow University (Part 2)

Tribute to Lord Mountbatten (on his retirement from Chairmanship of the Council)

Future Telecommunications Services by A. A. L. Reid (Reprinted from *The Radio and Electronic Engineer*)

Company Profile: Astralux Dynamics Ltd.

The IBA and Electronics Development

International Broadcasting Convention—A Short History by John D. Tucker

The subscription to the *Review* is £4·00 (£2·75 to members of the IERE); single copies 75p.

Israel Section Meeting

A general meeting of members of the Israel Section of the Institution took place recently in Tel Aviv. Two invited lectures were given, the first by Dr B. Lavercombe, Science Officer of the British Council in Israel, who spoke on 'Organisation of the Engineering Institutions in the United Kingdom'. After luncheon, Dr Y. Lando, who heads the national project on solar energy in Tadiran Israel Electronics Industries Ltd., lectured on 'Solar Energy Development in Israel'.

The meeting was held during the 10th biannual Convention of Electric and Electronic Engineers in Israel. This Convention was organized by the Israel Chapter of the IEEE and co-sponsored by the IERE Section, and the IEE Section in Israel, the Israel Association of Architects and Engineers and the Haifa Technological Institute. 1100 professional engineers attended the opening session, which was held at the P.A.L. Hotel in Tel Aviv. The session was addressed by Prof. E. Katzir, President of the State of Israel, and by Mr Y. Horovitz, Minister of Commerce, Industry and Tourism, and the opening lecture was given by Col. (res.) Y. Lavi, formerly Chief Signal Officer and Director General of the Ministry of Defence. A well-supported exhibition was held at the nearby Tel Aviv Hilton Hotel in which Israel manufacturers of original electronic equipment as well as those representing overseas firms took part.

Incentives for Instrumentation and Automation

A £10M scheme to encourage new investment in the Instrumentation and Automation Industry has been announced by the Department of Industry. Assistance will be made available under Section 8 of the Industry Act 1972 to encourage additional new investment in capital equipment, plant, machinery and buildings. This is similar to the provision under which a £20M scheme for electronic components industry was launched earlier this year. (See July Journal, page 301). Assistance will be provided on a selective basis in the form of a grant of up to 20% of the net eligible costs of equipment, plant and machinery and up to 15% in the case of buildings. The scheme will apply to all UK firms working in the instrumentation and automation industry.

Conference on 'Measurement and Control in the Handling and Processing of Materials'

The Control and Automation Division of the Institution of Electrical Engineers, in association with the IERE, the Institute of Physics, and the Institution of Mechanical Engineers, is organizing a Conference on 'Measurement and Control in the Handling and Processing of Materials', to be held at the IEE, Savoy Place, London on 26th to 27th April 1978.

It is believed that a large number of industries share common problems in handling satisfactorily and economically the flow and storage of bulk materials. These raw or partially processed materials are the major outputs from the extractive industries, such as sand, gravel, cement and grain, coal and metalliferous mining and quarrying, and form the major inputs to the user industries such as power generation, chemicals and foodstuffs and the makers of iron, steel and non-ferrous metals.

The Conference will discuss measurement and automatic control applications and problems relating to:

(a) the handling of such materials, including the storage, transfer and re-cycling;

(b) the preliminary processing of raw materials either by the supplier or the user, prior to their entry to the main 'reactor'.

It is intended to present and discuss papers covering the entire range of activities involved in achieving satisfactory control, ranging from theoretical or empirical process modelling and identification through simulation and control system design to user experience with existing systems, future plans and speculations. The papers will also discuss the design, performance and compatibility of the mechanical equipment and the measuring devices used in the overall systems.

Further programme details and registration forms can be obtained from the Conference Department, The Institution of Electrical Engineers, Savoy Place, London WC2R 0BL.

IERE Conference on 'Microprocessors in Automation and Communications'

The advent of the microprocessor coupled with the availability of inexpensive, high-density memory devices is resulting in the most significant development yet in the state of the art of electronics. This development, which provides inexpensive and reliable intelligence to the widest possible variety of equipment ranging from toys and washing machines to supersonic aircraft and space probes, will revolutionize society.

It is essential that the engineer and the scientist understand what is now possible in this field, and appreciate not only the advantages that such modern technology brings, but are aware also of its potential for misuse.

The aim of the conference, to be held at the University of Kent at Canterbury from 19th to the 22nd September 1978, is to provide a forum for recent advances in the application of this technology. The following list outlines the scope of the conference and shows the topics on which papers have been invited.

Industrial automation (On-line control; process monitoring; distributed systems)

Telecommunication systems (Radio systems; line systems; telemetry/remote control; intelligent terminals; packet switching systems)

Interfaces (Machine/machine and man/machine systems; standards)

Commercial applications (Office machinery; financial: stock control; point of sale)

Social, psychological and financial implications (Cost effectiveness of microprocessors in systems; social change; psychological acceptance)

Consumer and entertainment applications

Transport systems (Land, sea and aerospace)

Security applications (Security of property and identification system; cryptographic and authentication systems)

Medical equipment

Military systems

Educational and instructional uses (Teaching machines etc.; prototyping aids; information)

Software (Languages; cross assemblers; presentation)

System simulation design and development aids

Energy conservation

Systems reliability and maintenance

Further information and registration forms for the Conference will be available in due course from the Conference Secretariat, IERE, 99 Gower Street, London, WC1E 6AZ.

Standard Frequency Transmissions—October 1977

(Communication from the National Physical Laboratory).

October 1977	Relative Phase Readings in Microseconds NPL—Station (Readings at 1500 UT)		
	MSF 60 kHz	GBR 16 kHz	Droitwich 200 kHz
1	2·3	5·1	4·5
2	2·1	5·6	4·3
3	2·0	5·0	3·9
4	1·9	5·8	3·5
5	2·0	5·5	3·5
6	2·0	4·7	3·7
7	2·0	4·9	3·6
8	1·7	4·8	4·1
9	1·7	4·6	4·2
10	1·5	4·6	4·3
11	1·7	4·3	4·5
12	1·5	3·4	4·8
13	1·3	4·4	4·8
14	1·3	4·3	5·0
15	1·3	4·9	5·4
16	1·3	3·6	6·4
17	1·3	4·5	7·0
18	1·2	4·2	7·3
19	1·1	4·3	8·2
20	1·1	4·4	9·3
21	1·2	4·2	10·0
22	1·1	4·4	10·3
23	1·2	4·1	10·1
24	1·2	3·9	9·2
25	1·3	4·7	8·2
26	1·1	4·0	7·2
27	1·2	4·5	5·8
28	1·1	4·4	4·8
29	1·0	4·4	4·1
30	1·1	—	3·3
31	1·1	4·3	2·8

Notes: (a) Relative to UTC scale $(UTC_{NPL}\text{–Station}) = +10$ at 1500 UT, 1st January 1977.

(b) The convention followed is that a decrease in phase reading represents an increase in frequency.

(c) Phase differences may be converted to frequency differences by using the fact that 1 μs represents a frequency change of 1 part in 10^{11} per day.

Reduced Rates for IEE Publications

Under the mutual arrangements existing between the two Institutions, members of the IERE may subscribe to IEE periodicals at the following reduced rates which apply for 1978. (The subscriptions to non-member customers are shown in brackets.)

Electronics and Power	£18·00	(£24·00)
Proceedings IEE	£72·00	(£96·00)
Electronics Record	£24·00	(£32·00)
Power Record	£24·00	(£32·00)
Control and Science Record	£24·00	(£32·00)
Electronics Letters	£46·00	(£61·00)
Microwaves, Optics and Acoustics	£22·00	(£29·00)
Electronic Circuits and Systems	£22·00	(£29.00)
Solid-State and Electron Devices	£22·00	(£29·00)
Electric Power Applications	£22·00	(£29·00)
Computer and Digital Techniques	£22·00	(£29·00)

Rates for non-members and members overseas and combined paper and microfiche copy, Subscriptions, and prices for single copies, may be obtained on application.

Members of the IERE may also purchase single copies at reduced rates of the following volumes of papers read at conferences for which the Institution was a co-sponsor:

'Precise Electrical Measurement' Sussex, September 1977 (IEE Conference Publication 152) £6·40 (normal price £9·20)

'Radar-77' London, October 1977 (IEE Conference Publication 155) £14·40 (normal price £20·60)

'Power Electronics—Power Semiconductors and their Applications' London, September 1977 (IEE Conference Publication 154) £6·80 (normal price £9·70)

'Distributed Computer Control Systems' Birmingham, September 1977 (IEE Conference Publication 153) £6·80 (normal price £9·70)

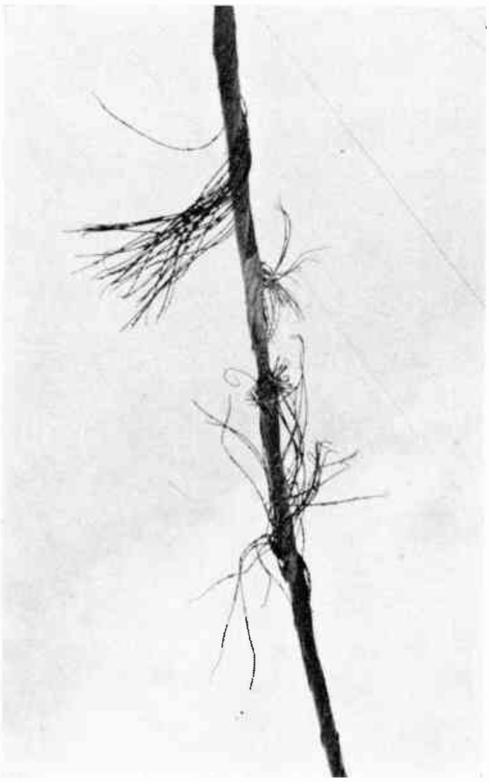
Orders from members wishing to take advantage of these special rates should be placed through the IERE Publications Sales Department, 99 Gower Street, London WC1E 6AZ.

Royal Society Mullard Award

Dr G. N. Hounsfield, C.B.E., F.R.S., has been awarded the Royal Society Mullard Award for 1977 in recognition of his conception and development of the EMI-Scanner, a computerized three-dimensional X-ray system. The Award is made annually in recognition of an outstanding contribution to the advancement of science, engineering or technology which has led directly to national prosperity in the United Kingdom.

Collision Course

Being a radio engineer is not all electronics as illustrated by the experience of engineers of the Independent Broadcasting Authority who are wondering if the fates are being particularly unkind to them. In 1973 an aircraft was in collision with the IBA mast at Caradon Hill in Cornwall but fortunately the only damage sustained was to a guy rope and its attachment plates which were replaced. Although the aircraft was destroyed the pilot escaped and it was thought unlikely that such an accident would occur again.



However in misty weather on 19th August 1977 a USAF *Phantom IV* jet fighter collided with the IBA's 1000 ft (300 m) transmitting mast at Caldbeck, Cumbria, partly severing one of the main guy ropes and cutting completely through the aircraft wing about 4 ft (1·2 m) from the tip. The pilot managed to land the aircraft safely at a base in Oxfordshire.

An examination of the damage by IBA engineers revealed that the aircraft had passed between the mast column and a $2\frac{1}{8}$ in (5·4 cm) diameter steel wire attached to the mast at 800 ft and had cut over half the 169 individual strands at a point 600 ft above ground level, as shown in the photograph. Calculations showed that, provided the wind did not exceed 10 miles per hour (16 km/h) the mast would remain safe enough to climb to enable temporary support guys to be attached at the 800 ft level. In a combined operation by IBA rigging staff and erectors from Balfour Beatty Ltd. working virtually round the clock, two $1\frac{1}{4}$ in (3·18 cm) diameter steel wire ropes were installed over the next few days during calm weather. The damaged stay rope was removed and for extra security a third temporary stay was then installed in parallel.

The structure is now capable of withstanding its full design wind loading and will remain remain temporarily supported in this manner until a permanent replacement guy can be manufactured and installed before the winter.

During the entire incident and repair period no loss of transmissions occurred from either Caldbeck or its dependent relay stations.

New and Revised British Standards

The need for correct interpretation and valid presentation of data is becoming increasingly important in industry, commerce, government departments, research organizations and educational institutions. The British Standards Institution has in part answered this need by issuing a revision of BS 2846 **Guide to statistical interpretation of data** which now incorporates a series of standards developed internationally with ISO.

The series has now been completed with the publication of Part 5 *Power of tests relating to means and variances* (price £6·60). This provides a comprehensive series of operating characteristic curves which express graphically the various probabilities associated with values of the mean and variance found by statistical analysis, to assist with the selection of sample sizes appropriate to the risk which either producers or consumers are willing to accept.

Other parts of BS 2846 are as follows: Part 1 *Routine analysis of quantitative data* (£4·70); Part 2 *Estimation of the mean-confidence interval* (£2·70); Part 3 *Determination of a statistical tolerance interval* (£4·70); Part 4 *Techniques of estimation and tests relating to means and variances* (Part 5 is complementary to this) £6·60; and Part 6 *Comparison of two means in the case of paired observations* (£2·70).

Safety requirements and tests for room, set-top and similar indoor aerials used with radio and television receivers are specified in BS 5373 **Electrical safety requirements for room aerials** (£1·20) which also covers aerials built-in as an integral part of the receiver, if these are removable by hand.

The standard provides for supplementary insulation in the aerial to reinforce the primary insulation of the receiver. This insulation is also considered necessary to ensure adequate safety for aerials easily accessible and subject to frequent handling.

BS 5373 deals with electrical safety only and not with the performance of other properties of the aerial. It will be used by the British Electrotechnical Approvals Board (BEAB) for testing and approval purposes.

Identical with IEC Publication 414, BS 5458 **Safety requirements for indicating and recording electrical measuring instruments and their accessories** (£4·70) specifies requirements to ensure reasonable personal protection and protection against damage to the surrounding area and it also specifies the tests for showing compliance with these requirements. It also gives the terminology used for dealing with safety matters. The new standard covers direct acting indicating and recording instruments, indirect acting instruments and also certain accessories used with these instruments.

The British Standards Institution has issued BS 5478 **Calculators and adding machines,** a new standard designed to replace the existing BS 1909 which has become out of date. It is published in two parts, each of which is identical with the corresponding international specification.

Part 1 *Numeric section of ten-key keyboards for calculators and adding machines* (£1·20) defines the composition and layout of such keyboards as well as the shape of keys, slope of keyboard plane, maximum key stroke, and key spacing. No reference is made to function keys since this aspect is considered in Part 2 *Layout of function keys on adding machines* (£1·20). An equivalent specification for calculators may be published separately at a later date.

BS 5478 supplements an earlier publication (BS 5448) which established in more general terms the layout of numeric keys and others closely associated with them (e.g. space, decimal and minus signs) for all types of office and data processing equipment having a numeric function.

British Standards may be obtained from BSI Sales Department, 101 Pentonville Road, London N1 9ND.

Progress on the New 16A Plug and Socket System

The first in a series of draft international proposals for a unified plug and socket system, now being developed in the International Electrotechnical Commission, has been approved on behalf of the United Kingdom by the British Electrotechnical Committee. Approval of this first draft does not commit this country to accept any further proposals or to final adoption of the system.

Forty-two countries have considered the draft which deals solely with the dimensions and arrangement of pins in a 16 A plug and socket system. It will be some months before the result of the world vote is known. Additional drafts, covering other aspects of the plug and socket design and construction, will also be the subject of consultation throughout the IEC. The UK approval follows months of consultation with consumers, manufacturers, installers, government departments and professional institutions; and the opinions of UK consumer bodies are reflected in the comments accompanying the UK vote.

If a corresponding British Standard were to be published it would require all socket-outlets to have shutters, and would require a minimum recess depth of 9 mm in order to provide assurance that live parts cannot be touched. In addition, the relevant British Standards would require socket-outlets and adaptors to be fused where necessary, although these features are not included in this IEC draft. Although plugs in the new system would not be fused, compliance with the UK Wiring Regulations would provide adequate protection for the safety of the installation as a whole, and for flexible cords used with appliances.

It is emphasized that the introduction of any new system in the UK would not involve an immediate compulsory change of plugs and socket-outlets in existing systems but would be a very gradual process over a lengthy period.

The Government has recently published its views on the subject: 'Government departments concerned have carefully considered the implications and are satisfied that if the proposed new system were introduced in the UK existing safety levels could be maintained. Costs could also be kept low, since no change would be required to existing serviceable installations Consumers would be faced, however, for a considerable time with the inconvenience of an additional variety of plug.

'The present proposals, although fundamental, do not specify a complete system and until full details of this are available, the Government cannot endorse their formal acceptance'.

Discussions have been going on at international level for over ten years to find a system which would be universally acceptable, initiated by the need of many countries to have an international standard. The major UK effort in these discussions has been to evolve a safe system which can coexist with our present practice. The proposed 16 A plug and socket has this advantage.

EUREL General Assembly 1977

The General Assembly of EUREL, the Convention of National Societies of Electrical Engineers of Western Europe, was held on 8th September 1977 in The Hague. Technically The Hague is not the capital of Holland (which is Amsterdam) but it is the seat of Government and the Royal residence, and consequently the headquarters of the Dutch Koninklijk Instituut Van Ingenieurs (KIVI), where the Assembly meetings took place, is situated in this city. It is located close to the main Government Ministries and consists of a very elegant 18th-century building with a large but tastefully designed 20th-century extension at the back. The President of EUREL for 1976/77 was Eng. H. W. F. van't Groenewout, who welcomed the delegates from 11 European countries at the beginning of the Assembly. The report of the Executive Committee stated that EUREL had given support to 11 international conferences in its area, including 2 IERE-supported conferences and it is felt that this helps to give a European dimension to the conference activitities of member societies. EUREL itself organized the EUROCON 77 conference in Venice in May—a full report of which appeared in the July issue of *The Radio and Electronic Engineer*. To summarize briefly, EUROCON was a great success with 700 participants from 34 countries. In addition 60 student members attended the special sessions of the conference for young engineers. The only aspect which was somewhat less successful was the attempted session dealing with problems in the developing countries. This was not well supported, with only 12 delegates from these countries attending, and therefore the future of this aspect of EUROCON is in doubt. On the financial side EUROCON almost exactly broke even, which is of course what was intended. As a result of the success of this conference it was decided to go ahead with the planning of EUROCON 1980, with Stuttgart, West Germany, as a likely venue. A number of topics were discussed as possible conference themes butit was generally concluded that the major, but not exclusive, subject would be micro-electronics with some emphasis on such topics as micro-processors, custom l.s.i. and v.l.s.i. Encouragement would be given to the introduction of material on c.a.d. techniques.

Another matter considered by the Executive Committee was relationships with other organizations, in particular some Eastern European countries have made requests for memberships. It was felt that a move in this direction would be premature at this time and that it would be better for the East European countries to be involved by bilateral arrangements with existing members, e.g. the excellent co-operation which now exists between the Italian and Polish Institutions. The IEEE, which regards Europe as its Region 8, has also been conducting conversations with EUREL but is clearly excluded from full membership since EUREL is an association of national societies, a description which can hardly be said to fit Region 8.

The first resolution considered by the General Assembly was on the problem of radio spectrum congestion. This had been initiated by the IERE and supported by the IEE. This was accepted with slight modifications and appears in full at the end of this report.

During the year EUREL has carried out a survey on the qualifications of electrical engineers in the various member countries and a very detailed document was submitted to the Assembly for consideration. It is hoped that a summary will appear in the Journal in due course. Broadly its general conclusion was that there is enormous variety in the qualifications of electrical and electronic engineers in Europe and much scope remains for trying to achieve some common ground. There was discussion of the possibility of a survey of the future needs of Europe for engineers, but after consideration it was felt that this was too difficult a topic to be likely to yield a successful outcome at the present time. There were considerable differences between the definition of a professional engineer in the different countries and this made estimation of requirements particularly trobulesome.

A survey had also been carried out on the relations between engineering institutions and societies and their Governments in the various countries, and in this respect the UK showed up particularly well. In some countries there seems to be almost no formal contact at all and there was a general feeling that EUREL should seek to improve this situation where it existed.

A matter which has exercised the minds of the Executive Committee considerably during the year and which has also been discussed at successive General Assemblies, is the possibility of a common code of professional ethics for electronics engineers throughout Europe. Although there appears to be very general agreement that such a code is highly desirable, the pattern of working in different countries appears to be so different that hitherto it has not been easy to get a common statement. The advice of the Executive Committee was that first of all an attempt should be made to achieve certain recommendations on basic principles and which could be accepted by all countries. Derived from these principles, Codes of Practice could then be worked out for the individual countries, taking account of the national situation. The General Assembly decided to remit this matter back to the Executive Committee for further consideration.

There was a lively discussion on the question of student activities in the member societies in Europe, particularly since the EUROCON 1977 student meetings had gone so well. A general concern was expressed to improve the provision for students and young engineers in the electrical and electronic professions in Europe generally; it seemed that Britain and Germany had already pointed the way with local Institution branches either in or closely associated with centres of higher education which gives rise to good student participation and a growth of student membership. For the Executive, Mr Roosdorp commented that students at the Venice Conference had drawn attention to the problem of transition from school to the University, and had suggested that the professional insitutions might particularly give some thought to trying to ease this difficult time for young people joining the profession. The aim should be to keep up their motivation for engineering studies and this might well be done by improving contacts with practising electrical and electronic engineers. Students were also expressing a wish for some kind of Europe-wide organization which would help them to travel and make contacts in other countries. Obviously there is a funding problem here, but the Assembly was sympathetic to the idea if practical means could be found for implementing it. For Switzerland, Mr Dunner described interesting innovations in his own country where young engineers had been particularly well served by lectures and discussions on less directly technical topics, such as the role of the engineer in society, problems of the working environment and so on. But Mr Bianci for Italy pointed out that lectures of this kind inevitably have a strong national flavour so that it might be more difficult to arrange them on a nation-wide basis.

The next item discussed was the possibility of a West European electro-technical journal under the auspices of EUREL. This proposal did not meet with universal approval and in particular the Italian delegation argued that there was too much paper in circulation already and doubted whether the need for another journal existed! However, other members pointed out that existence of a EUREL journal could be particularly helpful to smaller countries which could not support national journals of their own and the Netherlands delegation made the offer that the *Journal of Applied Science and Engineering*, published by KIVI, would be prepared to run a EUREL section for papers contributed through EUREL from the smaller member societies. Whilst it was appreciated that this would only be satisfactory as a temporary expedient, it seemed hopeful as an operation that could be undertaken without financial commitment by individual societies.

Professor Dadda of Italy then presented a paper on the possibility for Europe-wide specialist groups. The idea here was to organize groups which would represent special interests (computers, communications and so on) on a Europe-wide basis, associated also perhaps with the circulation of European specialist journals. The British delegation pointed out that this was already a feature of British institutions and whilst some kind of links between specialialized groups in Britain and those in other European countries might be possible, it was very unlikely that the national societies would wish to give up altogether their own specialized group organizations. The matter was clearly one which needed much further discussion and therefore was remitted to the Executive Committee for report.

The next business was the election of the President for 1978 and under the original agreements by which EUREL was set up, it was the turn of Finland to put forward the President. It was therefore proposed and unanimously agreed that Mr Antti Potila would be President for 1978 and the next meeting of the General Assembly would be held in Helsinki in September of that year. As in past years, the German society (VDE) will continue to provide secretarial functions for EUREL and Dr. Fleischer will act as Secretary. It was pointed out that this generous arrangement by the VDE could not continue forever and that the question of a permanent secretariat funded by the members of EUREL would have to be considered at some time in the future. The Executive Committee for 1978 will consist of General Bertrand (France), Dr Fleischer (West Germany), Dr Gainsborough (UK), Mr Baylin (Spain), Mr Lauger (Denmark) and Mr Henskin (Belgium).

In welcoming the new President, the outgoing President, Mr van't Groenewout, said that he felt that EUREL had now got to the point of beginning to ask some awkward questions, e.g. about the education of electronic engineers, the relationships between the professions and Government, and so on. He welcomed this trend and hoped that it would extend still further. A matter of great concern in many countries was the broadening gap between young and old engineers and this is certainly an area where EUREL must ask itself what help it can give to close this gap.

Mr Potila, in reply, said that for the smaller countries of Europe he felt that EUREL had particular value since it helped to break down the relative isolation which they might otherwise feel. The rather short term of Presidency, together with rotation between countries did at least have the advantage of widening the appreciation and the significance of EUREL in different parts of Europe. Mr Potila saw the function of EUREL as to promote co-operation without infringing upon independence, and for this purpose it must be known, and its role appreciated, by all electrical and electronic engineers in Europe. In November 1977 EUREL would be 5 years old, but he felt that it was already well established, and he hoped that the support that it had received so far would continue and extend.

To sum up the feelings of one delegate, the General Assembly at The Hague in 1977 demonstrated continued growth in the significance and usefulness of EUREL as a means of co-operation between the societies of Western Europe. It is clear that some, notably the UK, German and Swiss, are in a much stronger position than others—particularly in relation to their Governments—but a united stand by people with a common professional interest across Europe cannot but be in our long-term interest and, indeed, ought to make our profession more sensitive to the needs of society and the contribution that it can make to the welfare of Europe as a whole.

W. Gosling

EUREL Resolution on the Radio Frequency Spectrum

EUREL, recognizing the importance of radio, and particularly mobile radio, is of the opinion that its effective development will play a vital role in the economic and social progress of Europe for the foreseeable future, the more so since it makes minimal demands on resources both of energy and raw materials.

However, this important resource could be threatened by the growing development of congestion in the radio refquency spectrum, which must be regarded as strictly limited in extent. Such congestion, which is likely to be even more severe in Europe than in other developed regions of the world, is already causing difficulties in some radio bands.

As a consequence, EUREL recommends to European national authorities:

(a) that policies to combat spectrum congestion should be based on the support of research and innovation to minimize the effect of congestion without an unduly restrictive approach to the use of radio, which would result in serious economic disadvantage;

(b) that growth in the use of radio to meet the needs of society should be accommodated to the greatest possible extent by technical advances which minimize the effects of congestion without inhibiting the users;

(c) that every effort should be made to promote a more general understanding of the urgency of the problem of spectrum congestion, and to secure the widest possible application of spectrum conservation, both by more economical use of the radio spectrum and the abatement of spectrum pollution generated by communication equipment or by any other appliance.

Adopted at the EUREL General Assembly, The Hague, on 8th September 1977.

Members' Appointments

CORPORATE MEMBERS

Sir Ieuan Maddock, C.B., O.B.E., F.R.S., (Past President) who retired as Chief Scientist of the Department of Industry in March this year, has been appointed Secretary of the British Association for the Advancement of Science in succession to Dr Magnus Pyke. Sir Ieuan has taken an active part in the affairs of the 'B.A.' for many years and has addressed its Annual Meetings on technological matters on several occasions. Recently he was appointed a consultant to TecQuipment Ltd., who are manufacturers of engineering teaching equipment.

Mr. R. W. Cannon (Fellow 1968) has been appointed Managing Director of Cable and Wireless Ltd., with responsibilities for the Company's concessional business. He was previously an Executive Director concerned principally with the Arabian Gulf. In 1970, when he was Deputy Engineer-in-Chief, Mr. Cannon received the Institution's Leslie McMichael Premium for a paper on 'Global Communications' which he presented at the 1968 Convention on 'Electronics in the 70s'. He served for a number of years on the Communications Group Committee.

Mr. F. H. Steele, B.Sc. (Eng)., F.C.G.I. (Fellow 1974) who has been in charge of the Engineering Division of the Independent Broadcasting Authority for the past eleven years, is leaving at the beginning of 1978 to become Managing Director of Sony Broadcast. Mr. Steele is one of the few senior broadcasting engineers in this country whose professional career has wholly been spent in commercial television; he joined Alpha Television Services in 1957 following five years with the Marconi Company. Under his leadership the Authority's network has grown from fewer than 40 transmitters in 1967 to nearly 400, while the number of operators and maintenance staff has remained constant. The introduction of colour and the establishment of the Independent Local Radio transmitters have also been his responsibility. Mr. Steele gave the highly regarded 1975–76 series of Faraday Lectures for the IEE on 'The Entertaining Electron'.

Wing Cdr W. Adams, RAF (Ret.) (Member 1964) has joined the Airborne Early Warning Division of Marconi-Elliott Avionic Systems Ltd., Radlett, as a Senior Engineer. His last Service appointment was Command Electrical Engineer at HQ Training Command, RAF Brampton.

Mr. K. R. Banham (Member 1973, Graduate 1967) has been appointed Project Manager with Rediffusion Industrial Services Ltd., Surbiton. He joined Rediffusion Vision Services Ltd. in 1966 and moved to his present organization in 1970 as a Commissioning Engineer.

Mr. W. H. P. Canner (Member 1970) who is a Lecturer in the Department of Maritime Studies at the University of Wales Institute of Science and Technology, Cardiff has been awarded the M.Sc. degree of the University of Wales. The degree was obtained for a thesis on 'The automatic navigation of ships' and part of this research was the subject of a paper on 'Coupling a position finding system to a marine automatic pilot without the use of an intermediate computer' published in the March 1973 issue of *The Radio and Electronic Engineer*.

Dr P. C. P. Chung (Member 1973, Graduate 1968) is now Supervisor, Software Development, with the Digital Equipment Corporation, Maynard, Maryland, USA. After obtaining his doctorate in telecommunications from the University of Essex in 1974, he worked for GTE International Systems Corporation, Waltham, Massachusetts as a Systems analyst.

Mr. R. Collis (Member 1973, Graduate 1969), who was appointed an Area Traffic Engineer with Oxford County Council in 1974, has taken up a 2½ year contract with the Hong Kong Government as Traffic Signal Engineer.

Mr. C. S. Cumner, M.Sc. (Member 1976, Graduate 1970) has been appointed Engineering Projects Development Manager for The Distillers Company (CO2) Ltd. He was previously Deputy Chief Engineer and Executive Assistant to the Managing Director of Stein Atkinson Stordy Ltd., who are furnace designers and manufacturers.

Sqdn. Ldr. F. C. East, D.M.S., RAF (Member 1971, Graduate 1965) has taken up a staff appointment in Signals 53c (Air) at the Ministry of Defence following two two years as Installation Control Officer, Ground Radar Installation Squadron, in the Radio Engineering Unit at RAF Henlow.

Mr. H-K. Foo (Member 1974, Graduate 1968), formerly a Senior Lecturer with the Department of Electrical Engineering at the Kwai Chung Technical Institute, Hong Kong, has been appointed Education Officer (Administration) in the Technical Education Division of the Hong Kong Education Department.

Mr. M. R. Green (Member 1963, Graduate 1961) is now Site Quality Assurance Manager with Plessey Avionics and Communication at West Leigh, after having held similar posts with Marconi Space an Defence Systems Ltd.

Flt. Lt. R. M. Harrison, RAF (Member 1973, Graduate 1968) has returned from a Staff appointment at HQ RAF Germany and is now *Nimrod* MCT Project Officer with the Central Servicing and Development Establishment, based at Marconi Space and Defence Systems Ltd., Dunfermline.

Mr. B. L. Hart, B.Sc. (Member 1961, Graduate 1955) who is a Senior Lecturer in charge of the Postgraduate Electronics Laboratory at the North East London Polytechnic, Dagenham, Essex, has been appointed Honorary Lecturer in the Department of Electronic and Electrical Engineering at the University of Sheffield, Mr. Hart has contributed several papers on circuit design to the Institution's ournal over recent years.

Mr. J. W. Harman, M.Sc. (Member 1973, Graduate 1965), for 5½ years Engineering Manager with Kremer Automation Ltd. of Reading, has joined Posidata Ltd., Basingstoke, as Senior Project Engineer.

Wing Cdr. D. C. Isham, RAF (Member 1976, Graduate 1958) has been appointed Technical Staff Officer to the Director of the Electrical Quality Assurance Directorate, following two years with the Directorate as Principal Quality Assurance Officer.

Sir Ieuan Maddock

R. W. Cannon

F. H. Steele

W. H. P. Canner

B. L. Hart

Mr. C. H. Langton, M.Sc. (Member 1963, Graduate 1952) who has been on the staff of the York College of Arts and Technology for the past 15 years, latterly as Senior Lecturer in Electronic Engineering, is now an independent consultant electronics engineer.

Mr. C. J. Lester (Member 1973, Graduate 1971) has left the English Electric Valve Company Lincoln, where he has been an engineer in the Duplexers Department, and is now a Field Sales Engineer with the Solid State Microwave Group of Ferranti Ltd., Manchester.

Lt. Cdr. J. Lowcock, RN (Ret.) (Member 1973) who joined GEC Gas Turbines Ltd. as a Contracts Officer in 1974, is now Contracts Manager with Pye Business Communications Ltd.

Mr. W. McSweeney (Member 1972, Graduate 1963) who went to the USA ten years ago after working with British Relay (Electronics) Ltd. is now a Senior Staff Engineer in the Video Department of Ampex Inc., Redwood City. He has held senior appointments with Cartrivision and Consolidated Video Systems, and more recently was Chief Engineer of Video Engineering at Echo Science Inc.

Air Cdre. J. Mathews (Member 1971) has retired from the RAF, his last appointment being Director of Weapon and Support Engineering (RAF) at the Ministry of Defence. He is now with the GW Division of British Aerospace Ltd., Stevenage, as Service Manager of the Product Support Department.

Capt. K. G. Melton, REME (Ret.) (Member 1975, Graduate 1970) who was appointed a Quality Officer with EQD, Ministry of Defence, in 1975, has embarked on a one-year Teacher Training Course at Huddersfield Polytechnic.

Mr. M. J. Moorhouse, P.Eng. (Member 1973, Graduate 1967) who has been with the Canadian Broadcasting Corporation since 1975, is now Assistant Regional Engineer in Alberta.

Flt. Lt. A. F. P. Newns, RAF (Member 1972, Graduate 1968) has been posted from RAF Wattisham, where he was Officer Commanding Ground Radar Flight for two years, to the Staff of HQ RAF German, Rheindahlen.

Mr. H. J. H. Perry (Member 1960) has been appointed Quality Assurance Manager for Davis & Geck, Inc., a subsidary of the American Cyanamid Corp. at Manati, Puerto Rico. Mr. Perry was formerly Quality Assurance Manager for Infochem Corp., a subsidiary of the Dutch Axo Corp. Both these corporations are manufacturers of medical devices.

Mr. T. P. Reid (Member 1961, Associate 1959) is now Chief Engineer (Ultra Sound), GEC Medical Ltd. He was previously an Executive Engineer with Ultra Electronics Ltd.

Sqn. Ldr. F. B. Sansom, RAF (Ret.) (Member 1972, Graduate 1970) has joined International Computers Ltd., as Project Manager, Worldwide Training Service.

Sqn. Ldr. I. Shephard, RAF (Member 1973) is now Senior Engineering Officer, No. 9 Squadron, RAF Waddington. From 1974 to 1977 he was on the Staff of the Ministry of Defence as Air Engineering 10a.

Mr. F. R. Williams (Member 1973, Graduate 1976) who is with the Central Electricity Generating Board, has been promoted to 1st Engineer (Telecommunications and Measurement) in the Plymouth Transmission District.

NON-CORPORATE MEMBERS

Mr. A. P. Buttle, B.Sc. (Graduate 1973), formerly a Senior Systems Engineer with Marconi Radar Systems Ltd., has been appointed a Senior Scientific Officer at the Admiralty Underwater Weapons Establishment.

Mr. C. F. Campbell (Associate 1962) has recently taken up an appointment as Commercial and Sales Director of Vosper Private Ltd., Singapore.

Mr. M. W. Clark, C.B.E. (Companion 1965) has been appointed a Vice-President of the Society of Electronic and Radio Technicians. Mr. Clark is Deputy Chairman and a Deputy Chief Executive of The Plessey Company Ltd.

Mr. D. M. Dawson, B.Sc. (Graduate 1972) has joined Dowty Electrics Ltd. as a Project Engineer; he was previously a Design Engineer with the Aviation Division of Smiths Industries Ltd.

Mr. T. J. Deadman, M.Sc. (Graduate 1967) is now Research and Engineering Manager of Sangamo Weston Ltd., Port Glasgow. Previously he was Engineering Manager with Sangamo Weston Controls Ltd., Bognor Regis.

Mr. R. A. Gould (Associate 1963) has joined the Department of Musical Instrument Technology at the London College of Furniture as a Senior Lecturer, after nearly 20 years with Hawker Siddeley Dynamics Ltd., working in the fields of avionics and oceanographic systems.

Flg. Off. I. D. Matthews, RAF (Associate Member 1974) is now a student on Initial Engineering Course at the Royal Air Force College, Cranwell, following the award of a commission; he was previously Senior N.C.O. 3rd Line Radar Servicing, RAF Luffenham.

Temp. Lt. Cdr. P. G. Muir, RNZN (Ret.) (Associate Member 1972) has recently retired from the Royal New Zealand Navy to take up an appointment as the Area Engineer, Instrumentation and Control, with New Zealand Steel Ltd., Auckland, New Zealand.

Mr. J. Savage (Companion 1972) has joined Tracor, Inc., as director of international operations with marketing responsibility in Europe, Africa, and the Middle East. He was until recently director of Strategic Planning for Plessey Avionics and Communications.

Mr. G. W. Scott (Graduate 1968) has left the Royal Air Force where his last posting was to the Projects Wing, RAF Swanton Morley as Chief Technician and he is now a Project Spares Engineer with Marconi Radar Systems Ltd.

Mr. Wise (Associate Member) is now a Lecturer at the Engineering Training Centre of International Computers Ltd., Letchworth. After leaving the RAF in 1976, he was a Senior Technician in the Electro-Biomedical Department of the Copthorne Hospital, Shrewsbury.

Letter to the Editor *(cont from facing page)*

'cut-off date'. Its case is that any such date, however remote, will inevitably penalize those engineers whose achievement of the high standard of responsible employment which the Institution seeks of its Corporate Members has taken far longer than normal, not because of any lack of ability or drive on their part, but because of the small number of posts at the required level which are available within their employing organization. We hope we shall win our case, but we know we shall not be unopposed. There are those who will argue 'The man who spends all his life working for an organization in which promotion prospects are so limited is a stick-in-the-mud—and we do not want such people as Chartered Engineers'. In some cases this harsh judgement may be uncomfortably close to the truth, but we would argue that it is for individual Institutions, not a CEI Committee, to decide what is to be done about those of their members (very few, we hope) who have been content to rest on their laurels.

Letter to the Editor

From: Mr R. K. Amakyi (Graduate)

Graduate Members and the CEI Part 2 Academic Test

I have read with concern the Notice to some Graduate Members, published in March and May 1977 issues of the Journal, on the deadline for transfer to Corporate Membership, through the CEI Part 2 Academic Test, which is to be phased out after 1979. I have also read the letter sent out by the Council to Graduate members in this category, advising them on the issue.

Much as I appreciate the effort being made by the Council to standardize the qualification of a Chartered Engineer, I feel it is not being fair and realistic to those Graduates who were admitted to membership before 1974.

The IERE Council should, really, consider it a moral obligation to make special dispensation for people in this predicament, just as was done for some people during the transition from Brit. I.R.E. to IERE. Some people who were members of the old Brit. I.R.E. were transferred to the new IERE, regardless of their qualifications, without being made to write an examination; some of these people are, in fact, Fellows of the Institution now.

Academic standards continue to rise, and it should not amaze us if we should have a situation some day when admission to Corporate Membership may require a Doctorate Degree in Engineering. Should a situation arise, would the present Corporate Members, who do not hold the minimum of a Doctorate Degree, be asked to write an examination in lieu of it, for the purpose of standardization?

Would it not be fair to suggest that Graduate Members should be treated under Transfer Regulations prevailing at the time of their admission?

There were three courses of action suggested in the recent letter, for these Graduate Members:

1. *These people should prepare to write the Academic Test, bearing in mind that there are only two opportunities left to them (May 1978 and May 1979).*

The Institution admits, though, that courses in preparation for these examinations are difficult to find, and that in some cases, it may not even be possible for people to write the examination.

2. *They may opt to remain Graduate Members indefinitely.*

It goes without saying, that this would not be a wise choice, since it would not mean progress.

3. *They could transfer to the Class of Associate Members or Associates, and register as Technician-Engineers.*

The Institution doubtless, realizes that this would not make much sense, for some of these people have been engaged since their admisssion in responsible engineering positions in reputable organizations.

The Institution obviously expects a good number of these Graduate Members to be anxious to write the Test, no matter the odds.

One thing is quite clear, though. It does not appear as if the object of the exercise is to retrain these people to become better practising engineers. I cannot see therefore why the Institution or the CEI cannot adopt a more objective and realistic approach to this problem, for mutual benefit of all.

RICHARD K. AMAKYI

Engineering Division,
Ghana Broadcasting Corporation,
P.O. Box 1633, Accra, Ghana.

9th August 1977

The Education Qffiicer, Mr. K. J. Coppin, replies:

Few members will be surprised to learn that the Institution has received a number of letters from its pre-1974 Graduates expressing similar views; many will no doubt sympathize with the argument that, since on previous occasions when the Institution raised the academic requirements for Corporate Membership it did not apply the new standards retrospectively, it is inequitable that it should do so now.

Unfortunately, whatever view the Institution's Council might take of the argument, there are a variety of reasons why it could not make a special dispensation for those Graduates to whom the recent notices and letters were addressed. The strongest of these is the undertaking given when it became one of the founder members of the Council of Engineering Institutions, *all* of which agreed that, after 31st December 1973, they would not admit to Corporate membership anyone who did not hold a degree in engineering or an allied discipline awarded by a UK University, or other qualification judged to be of equivalent standard. It was realized that this would be a severe blow to people who had already obtained, or were studying for, academic qualifications which they had expected would meet the Institution's requirements for Corporate Membership, and it was therefore agreed that people who had obtained such qualifications by 31st December 1970 would be admitted as Members without further examination up to 31st December 1973. Those not admitted by that date would be required to pass an Academic Test consisting of two subjects from Part 2 of the CEI examination before an application for admission as a Member could be considered.

However strongly individual Graduates may feel that the Institution should not have agreed to this arrangement, it clearly could not now back out of it, especially when one remembers that many of its pre-1974 Graduates (over 400 in 1971 alone) accepted the Institution's advice and undertook the Test as 'insurance' against the possibility that they might not meet the responsible experience requirements for election as Members before the end of 1973.

Having explained why the IERE cannot grant any kind of special dispensation, we will admit there has been some degree of short-sightedness regarding the possible consequences of the agreement. Since the period between the end of 1970 and the end of 1973 was not really long enough for the majority of new Graduate members to reach the level of responsibility required of Members, a longer time should have been given. Since the number of those who have not yet attempted the Academic Test gets smaller every year, we should have realized that it would be more and more difficult for those Colleges which would provide courses to find enough support to justify them, and for many Graduates the only possible means of preparation left would be home study—perhaps with assistance from colleagues or a correspondence course.

It is an unhappy situation, but one which at this late stage the Institution can do little, if anything, to remedy. Mr Amakyi asks, rightly, what would happen if the academic requirements were raised again. They well might be. Currently, following the publication of CEI's new statement of academic policy (Statement No. 12), the *range* of acceptable degrees is being reduced: certain degrees which have hitherto entitled their holders to exemption from the CEI examination will cease to do so in future—principally because the *engineering* content is considered to be inadequate. Could there, in consequence, be a new group of 'disfranchised' Graduate members? The Institution is currently doing its utmost to ensure that the answer to this question is 'No'. It is arguing strongly against the establishment of another

(continued on facing page

Colloquium Report:

Training Technicians in Electronics

Organized jointly by RAF Locking and the Education and Training Group and held at RAF Locking on 28th September 1977

This Colloquium was originally designed to enable Industry as well as the Armed Forces to speak about the training of electronic technicians, but it turned out that all but one of the speakers were from the Armed Forces. So naturally the Colloquium revolved around what the Armed Forces were doing in training their technicians. The material covered by the speakers, however, proved to be just what the 'customers'—drawn from the Forces, industry, Government Departments and educational establishments—said they wanted.

After an introduction by the Chairman, Mr Derek Smith, the morning session began with a presentation by Mr Raymond Rogers of the Technician Education Council on 'TEC Awards in Electronics'. The four different awards were described and their relationship one with another, the unit credit system and its flexibility was expounded, and the way practical units fitted into the scheme and finally methods of assessments were explained. This presentation was very enlightening as many of the delegates were unsure about the new awards and those who were connected with the new courses were able to obtain latest information.

In the second presentation, entitled 'A TEC Syllabus Submission—Case Study.' Wing Commander Huw Rees, O.B.E.,† of RAF Cosford, explained that the RAF were quick to recognize that the TEC had the flexibility to suit the various RAF technician courses. RAF Cosford was asked to pioneer the fitter (technician) courses for TEC recognition with the constraints that the length and content of the courses were not to be changed and that the policy was to gain the maximum recognition for all the courses. He then related how the pilot scheme was centred around the Electronic Fitter Air Radar course and how the first submission was made. From discussions with the TEC and lessons learned, a final submission was made and approval gained in May 1977. In conclusion Wing Cdr. Rees recommended that the first step in preparing a submission based on an existing syllabus should be to break down the course into units at the various levels. This provides a measure of the course, and in the course in question was a basic certificate with six 'endorsement' or supplementary units, two at level 3 and four at level 4. Also he suggested that for the Service type course, i.e. full-time with practical units in-house, TEC ought to accept the course as a complete package along with its assessment pattern.

The next speaker, Squadron Leader Gerry Parkes of RAF Locking, gave a very interesting presentation on the 'SAFARI' project. (SAFARI stands for *S*imulation *A*nd *F*ault-finding *A*irfield *R*adar *I*.) Because in the Royal Air Force training was carried out on many pieces of complex equipment, the provisioning for this represents a high capital cost investment and the situation had emerged in which alternate but equally effective methods needed to be found. The SAFARI project was a feasibility study into the use of Computer Assisted Learning for training technicians in fault finding and diagnostic skills on complex electronic systems. The study commenced at No 1 Radio School, RAF Locking, in May 1976 with funding provided jointly by the National Development Programme in Computer Assisted Learning (NDPCAL) and the Ministry of Defence. The projects had already achieved a number of the original study objectives, notably the in design and construction of a low-cost, computer-based learning system using a simulation of a large radar system, the Plessey Airfield Radar I. Furthermore, this new CAL system had allowed training instructors, with no previous computer experience, to produce learning packages to meet the training requirements. Already, the use of CAL had demonstrated a number of factors which made it an aid to effective learning, and he quoted, as examples high trainee motivation, exercise grading, immediate feedback of results, accurate recording and, most important, the ability to provide tuition tailored specifically to the identified needs of each student. Sqn Ldr. Parker concluded by saying that work was continuing into measuring the effectiveness of CAL replacing or reducing the need for operational equipment on training units and simultaneously the suite of programs comprising the SAFARI system were being converted into a transferable condition so as to work on other, completely different computer systems.

Mr Colin Sparkes of the Royal Military College of Science at Shrivenham gave the next talk which was entitled 'Use of CAL in Electronics at RMCS'. In an appropriate follow-up to the previous presentation, he explained how the Electronic and Electrical Engineering Dept of the RMCS used a PDP11/40 computer as an instructional tool to support traditional lectures. There was a dialogue between the Computer Assisted Learning (CAL) package and the student through the system device, a VT52 alpha-numeric terminal and with graphics displayed on a Tektronix 4010-1 display unit. The system was used as calculator and as a plotter, the students being able to input their own values for variables of equations offered by the package and exercise the material presented in an interactive way. The computer offered a unique contribution to the presentation of material in that it afforded the ability to perform complex and repetitive calculations with great accuracy and speed. The ability to present the students with a quick and accurately plotted response allowed them to get a better appreciation and feel for using a number of standard and widely used plots. Mr Sparkes then illustrated how the system could help in explaining the use of a Smith's chart for use in transmission line theory. In conclusion the financial and educational values were discussed.

Squadron Leader Keith France of the Royal Air Force College, Cranwell, brought the morning session to a close with a presentation called 'The Development of an Interactive Graphics Package for Teaching Control Engineering'. He first emphasized that the courses at the College had only a short time devoted to control engineering and then went on to say that the teaching of classical linear control systems theory was bedevilled by two basic difficulties. Engineering students naturally clamour for practical applications and yet these applications cannot be illustrated until several rather subtle and interrelated concepts are properly understood. But, even if the concepts are well understood, obtaining quantititive results involves, except in unrealistic and trivial cases, an inordinate amount of tedious arithmetic.

The basic problem, he explained, was to obtain the frequency response and the time response of systems. Also he said that he felt that the root locus method was best for giving the student a feel for how a system would behave. So using the root locus technique, an interactive graphics program had been developed for use on the DEC 20 computer

†Wg Cdr Rees (Member) died on 7th November; a note on his career will appear in an early issue of the Journal.

to drive a Calcomp graph plotter. The next stage would be to design other programs using different techniques to study the responses in closer detail.

After lunch Colonel Gordon Young of the 8th Signal Regiment Catterick delivered his paper entitled 'CLASS-LAB Training'. His stated aim was to illustrate how student centred learning was applied in Royal Signals Basic Technician courses and he reviewed the various possible ways of teaching Electronic Principles, the construction of the Royal Signals Basic Technician course and the purpose of electronic principles teaching within it. He then defined the CLASSLAB and outlined its use in student centred learning. By means of closed-circuit television a recording was shown of a typical traditional instructor centred teaching situation, followed by a CLASSLAB teaching situation. It must be said that the acting was first class and the star has been nominated for an 'Oscar'! Col. Young concluded by describing the hardware/software support required for CLASSLAB and the advantages that he had found using it, based on approximately 20 courses.

Lieutenant Commander John Derby from HMS *Collingwood* was next on the platform with his paper 'Electronic Training—An Empirical Approach'. He first explained—with the aid of some splendid artistic viewfoils—how in the past servicing in the Navy had been carried out. The increasing complexity of modern equipment, coupled with rising costs and the present economic climate made the provisioning of training equipment much more difficult, while the greater reliability of these equipments led to reduced staffs, with wider individual responsibilities but with a lower incidence of experience in particular areas. Improved functional layouts with good documentary support might lead to easier analysis of a high percentage of faults and for these reasons it was expected that the future maintainer may spend a high percentage of his time identifying the more difficult faults lying between boards and seeking the causes of symptoms reflected around interacting loops. Therefore if theoretical training supported by idealized experiments was not consolidated by practical equipment the man would not have the competence to judge, or the confidence to solve, the more complex problems in the difficult marine environment. It has been felt at HMS *Collingwood* that if these problems were to be solved economically it was necessary to isolate circuit elements from their parent equipments whilst simulating real conditions. Experiments had to be created that forced the trainee to use the full range of instruments correctly and accurately to relate cause and effect, and finally to apply the essential intellectual disciplines to ensure that he works deductively and logically. Such methods had been made at HMS *Collingwood* and early indications were that they were successful.

Mr James Helder of Arborfield was next, giving a very lively presentation called 'Methods and Media for a New Treatment of Electronic Fundamentals for Teaching Potential Technicians in REME'. He told how the new course design in basic electronics for REME Technicians was based on specially-designed electronic system hardware and this enabled the course to be taught initially from whole structures and then inwards towards the detailed parts as the course progressed. This was an analysis approach rather than the usual synthesis from basic physics of components and was termed a 'whole-to-part' treatment. Specially-designed teaching hardware for the course also enabled each concept or teaching point to be placed in a practical functional context and this helped to avoid theoretical treatments which could mislead in practice. The course had been designed to be operated in specially constructed combined laboratory-classrooms and led from conventional exposition, using normal visual aids to a demonstration console where qualitative description of electronic ideas could be presented quickly and effectively by a comprehensive set of analogue and digital displays and instrumentation. Immediately following the description and qualitative demonstration the students then worked in pairs at purpose-built consoles containing all the necessary instruments for measurement and analysis. Thus the theoretical material was immediately reinforced by student practical work. He continued by saying that the 'software' for the course was comprehensive and a feature of the supporting written material was that all the electrical and electronic subjects which required comprehension, application, analysis or synthesis were treated by programmed learning texts, whilst the basic knowledge areas were presented in precis form. The programmed text avoided 'Skinner small steps' and assumed that the students learned by their mistakes as well as by positive reinforcement. The programmed texts could be used for individual learner self-tuition but it was assumed that the lecturer was on hand to help when necessary. Alternatively, the texts provided a comprehensive lesson sequence for an Instructor-controlled lesson. Mr Helder concluded by saying that such a course was expensive to set-up but they had found it to be very effective and not too costly when a large number of students were being trained.

The penultimate paper, 'The Systems Approach to Training —A Pragmatic Approach', was delivered by Squadron Leader Norman Wright of RAF Cosford with an introduction by Wg Cdr Huw Rees who recalled James, Nichols and Phillips' book on 'The Theory of Servomechanisms' in which the first statement crystallized to him the state of SAT today—'It is nearly as hard for practitioners in the servo art to agree on the definition of a servo as it is for a group of theologians to agree on sin'.

In the short time available it was difficult to give a definitive statement of Cosford's Pragmatic Approach but he said he would attempt to lay down the philosophy behind the method and Sqn Ldr Wright the strategy. He used as his basis the simple servo system with the forward path of the controller and machine being made up of the teacher/trainer, the teaching machine and resources. The feedback element being the testing (T) and with a system with a high forward gain—controller and machine manned by enthusiastic and dynamic elements (teachers and trainers)—the output becomes $1/T$. This simplified model explained why syllabuses were in objective terms, why it was important to test objectives and, additionally, why it is important to adopt a dynamic approach to the training situation. He concluded his introduction by quoting Professor Rosenbrock, 'Criteria for success seem to be a careful choice of plant, an enthusiastic user, an extensive study of the process, clear and modest aims, and the determination and flair to make the system work'.

Squadron Leader Wright carried on the presentation by explaining that the big problem of writing objectives in the Service was the lack of a Service-wide task analysis. This system he defined as a 'top down' approach and the best; however by using the wealth of experience of the instructors at RAF Cosford he had used a 'middle cut' approach. By using their experience they had been able to bring the greatest improvements to training in the shortest possible time. Testing techniques were discussed and the results of the first year were evaluated. Some by-products of the Pragmatic Approach in the areas of equipment procurement and modular course design were also mentioned. He concluded by saying that there was a need for an autocratic controller at each level in the training organization, from the policy maker at the top of the module to the unit designer at the bottom.

Mr Peter Edwards of RAF Cosford gave the very interesting final contribution on 'A Training Aid to Teach the Practical and Logical Approach to Electronic Fault Location'. He explained that it was essential that electronic tradesmen should be able to approach a fault situation in a clear, concise and logical manner. It was also desirable that all tradesmen use a similar procedure to ensure a smooth handover when a shift changes during a lengthy fault diagnosis. The trainee at RAF Cosford was trained to follow a systematic approach diligently and avoid diversionary 'red-herrings', by the use of a training aid which placed him in a live situation with real faults and enabled his progress to be monitored. He then went on to describe the training aid in detail and its evolution, showing a class demonstration board and a student's chassis on each of which there was a different set of 8 switchable faults. In conclusion Mr Edwards spoke of his experience over 2½ years using the system and discussed the advantages of the method and the bonuses obtained.

At the close Mr Derek Smith, Chairman of the IERE Education and Training Group thanked the speakers and the delegates as well as Group Captain J. M. Walker, the Station Commander RAF Locking, and his staff for all the hard work that they had done in organizing the Colloquium.

J. M. WALKER

W. J. BAKER

Applicants for Election and Transfer

THE MEMBERSHIP COMMITTEE at its meeting on 15th November 1977 recommended to the Council the election and transfer of the following candidates. In accordance with Bye-law 23, the Council has directed that the names of the following candidates shall be published under the grade of membership to which election or transfer is proposed by the Council. Any communication from Corporate Members concerning the proposed elections must be addressed by letter to the Secretary within twenty-eight days after publication of these details.

November Meeting (Membership Approval List No. 240)

GREAT BRITAIN AND IRELAND

CORPORATE MEMBERS

Transfer from Member to Fellow

WRIGHT, Frank William. *Rustington, Sussex.*

Transfer from Graduate to Member

BHAKTA, Prahladbhai T. *Coventry.*
BROWN, Anthony George. *Greenford, Middlesex.*
HARDING, Robert James. *Wokingham, Berkshire.*
HONEYSETT, John Eric Cane. *Farnborough, Hampshire.*
LATCHU, Harris Chesterfield. *Hornchurch, Essex.*
PRICHARD, Peter Keith. *High Wycombe, Buckinghamshire.*
SINGMIN, Andrew. *Croydon, Surrey.*
SLATER, John Arthur. *Swanley, Kent.*
THOMPSON, Keith Stanley. *Ascot, Berkshire.*

Direct Election to Member

ALLERSTON, Stephen James. *Hitchin, Hertfordshire.*
BELL, Alistair Croft. *Guisborough, Cleveland.*
BOWLER, Alan Melville. *Slough, Buckinghamshire.*
GODFREY, John Smylie. *Newtownabbey, County Antrim.*
MARSHALL, Alan. *Teddington, Middlesex.*

NON-CORPORATE MEMBERS

Transfer from Student to Graduate

BEJIDE, Olubunmi E. *London.*
DAVIS, Richard Burn. *Camberley, Surrey.*
LANCASTER, Horace Anthony. *London.*

Direct Election to Graduate

BEGG, Stephen Michael. *Andover, Hampshire.*
COFFEY, Thomas. *Enfield, Middlesex.*
CUDBY, Arthur John. *Alton, Hampshire.*
HEATH, Derek Alexander. *Twickenham, Middlesex.*
HOPKINS, Michael William. *Farnborough, Hampshire.*
PATEL, Jay Prakash N. *London.*
RAYNARD, John Steele. *Chessington, Surrey.*

Transfer from Student to Associate Member

AIREY, Derek John. *York.*

Direct Election to Associate Member

ALOR, Gabriel Ugwu O. *Plymouth.*
BENNETT, Wilfred. *Lichfield, Staffordshire.*
BIRD, John Francis. *London.*
BUTCHER, Philip Robin. *Havant, Hampshire.*
CAIN, Martin David. *London.*
DICKINSON, David James. *Shirley, West Midlands.*
GUTTERIDGE, Peter James. *St. Albans, Hertfordshire.*
MOORE, Brian. *Fleet, Hampshire.*
PRIMO, Leslie Sydney. *Ilford, Essex.*
REYNER, John Neville. *Colne, Lancashire.*
TIERNAN, Kevin Marian. *Drogheda, Co Louth.*
UKONU, John Ihue. *Plymouth, Devon.*
WRIGHT, Richard Walter. *Southampton.*

Direct Election to Associate

MAHER, William Noel. *Limerick City.*

Direct Election to Student

ASKHAM, Robert Philip. *Sheffield.*
BAHAMAN, Mokhtar. *Southampton.*
BENTLEY, Ian. *Bath, Avon.*
CLARKE, Roger Howard. *Ipswich, Suffolk.*
CLARKSON, Graeme Charles. *Selby, Yorkshire.*
COSIER, Graham. *Ipswich, Suffolk.*
GRIFFITHS, Robert Paul. *Swansea.*
HARRIS, Antony James Nigel. *Bath, Avon.*
HEFFRON, Martin Oliver. *Dublin.*
OLDFIELD, Martin Peter. *Pudsey, Yorkshire.*
PUROHIT, Naresh Shantilal. *Leeds.*
RENSHAW, Paul David. *Huddersfield, Yorkshire.*
SMITHERS, Colin Richard. *Guildford, Surrey.*
TALBOT, Andrew John. *Leeds.*
TAN, Chor Hwee. *Swansea.*
TAN, Keng Hiong. *Swansea.*
TROUTE, Henry John. *Athy, Co. Kildare.*
UGENNE, Chikeze James. *Swansea.*

OVERSEAS

CORPORATE MEMBERS

Transfer from Member to Fellow

PARSONS, John William. *Overijse, Belgium.*

Transfer from Graduate to Member

CHEUNG, Lap Yan. *Hong Kong.*
DASGUPTA, Mrinmoy Kanti. *Winnipeg, Manitoba, Canada.*
KULAHIAN, Kevork. *Los Angeles, California, USA*

Transfer from Student to Member

GARDINER, Kevin Patrick. *Port Sud, Breuillet, France.*

Direct Election to Member

JOHNSON, Raymond Barry. *Nairobi, Kenya.*
WONG, Kam Cheung. *Hong Kong.*

NON-CORPORATE MEMBERS

Transfer from Student to Graduate

LAW, Wai-Kuen. *Hong Kong.*
LEE, Siu Cheong. *Hong Kong.*
LI, Ho-Wan. *Hong Kong.*

Direct Election to Graduate

OTUAGA, Israel Avware. *Auchi, Bendel State, Nigeria.*
ROCHA, Antonio Jose. *Hong Kong.*
SARUMI, Samuel Kehinde. *Ilesha, Nigeria.*

Transfer from Graduate to Associate Member

RICHARDS, Felix Heedman. *Mombasa, Kenya.*

Transfer from Student to Associate Member

LEOW, Ban Siong. *Singapore.*
NAGALINGUM, Moorgessen. *Thomastown, Victoria, Australia.*

Direct Election to Associate Member

AJIKE, Ikenga. *Ile-Ife, Nigeria.*
CHONG, Foong Yarm. *Penang, Malaysia.*
DOBBS, Derek Sheriff. *Manama, Bahrain.*
KAN, Kam Yuen. *Brunei.*
KING, Ronald Woodley. *St. George, Barbados.*
LAKEMAN, David Tyrrell. *Tripoli, Libya.*
LAW, Ping Sew. *Kuala Lumpur, Malaysia.*
NWOYE, Sylvester Vzo. *Kitwe, Zambia.*
TING, Hung Ping. *Kuching, Sarawak, Malaysia.*

Direct Election to Student

CHAM, Saik Weng. *Singapore.*
CHAN, Wai Kong. *Hong Kong.*
CHOI, Kong Fan. *Hong Kong.*
CHOI, Wai Cheung. *Hong Kong.*
CHOW, Yun Ki David. *Hong Kong.*
CHUA, Lay Hong. *Singapore.*
HO, Hon Long. *Hong Kong.*
KAM, Ping Kay. *Hong Kong.*
LEE, Chu Seng. *Singapore.*
LEONG, Peng Kwai. *Singapore.*
ONG, Yeok Siew. *Singapore.*
SING, Siu Mam. *Hong Kong.*
TANG, Ka-Leung. *Hong Kong.*
YAU, Wai Wing Antony. *Hong Kong.*

Erratum

The following candidate was omitted from List 239 published in the November Journal

Direct Election to Associate Member

GRANT, David. *Wimborne, Dorset.*

Forthcoming Institution Meetings

Tuesday, 10th January

MEASUREMENTS AND INSTRUMENTS GROUP

Colloquium on MEASUREMENT AND POLLUTION

Royal Institution, Albemarle Street, London W1, 2 p.m.

Advance registration necessary. For further details and registration forms apply to Meetings Officer, IERE.

Thursday, 19th January

AUTOMATION AND CONTROL SYSTEMS GROUP

Highways and byways of ultrasonics

By A. E. Crawford (*D.D.S. Engineering*)

London School of Hygiene and Tropical Medicine, Keppel Street, London WC1. 6 p.m. (Tea 5.30 p.m.).

Tuesday, 24th January

Presidential Address of Professor W. A. Gambling—Electronics, Universities and the Institutions

London School of Hygiene and Tropical Medicine, Keppel Street, London WC1, 6.30 p.m. (Tea 6 p.m.).

Wednesday, 25th January

COMMUNICATIONS GROUP

Colloquium on INTERWORKING BETWEEN P.C.M. AND F.D.M. SYSTEMS

Royal Institution, Albemarle Street, London W1, 10.30 a.m.

Advance registration necessary. For further details and registration forms apply to Meetings Officer, IERE.

Tuesday, 31st January

EDUCATION AND TRAINING GROUP

Colloquium on ENGINEERS CAN COMMUNICATE?

Royal Institution, Albemarle Street, London W1, 10.30 a.m.

Advance registration necessary. For further details and registration forms apply to Meetings Officer, IERE.

Tuesday, 14th February

JOINT IERE/IEE MEDICAL AND BIOLOGICAL GROUP IN ASSOCIATION WITH HPA, BIR AND BPRA

Colloquium on THE THEORY AND PRACTICE OF DATA DISPLAY

Royal Institution, Albemarle Street, London W1, 10.30 a.m.

Advance registration necessary. For further details and registration forms apply to Meetings Officer, IERE.

Tuesday, 28th February

COMPONENTS AND CIRCUITS GROUP

Colloquium on COMPONENT ASPECTS OF FIBRE OPTIC COMMUNICATIONS

Royal Institution, Albemarle Street, London W1, 2 p.m.

Advance registration necessary. For further details and registration forms apply to Meetings Officer, IERE.

Tuesday, 7th March

AUTOMATION AND CONTROL SYSTEMS GROUP

Colloquium on THE MICROPROCESSOR AND THE MANAGER

Royal Institution, Albemarle Street, London W1, 2 p.m.

Advance registration necessary. For further details and registration forms apply to Meetings Officer, IERE.

Southern Section

Wednesday, 11th January

CEI DISCUSSION

Professional engineers and the trade unions

Headed by a panel including Mr. Tony Dummett

Physics Lecture Theatre, Southampton University, 6.30 p.m.

Wednesday, 18th January

JOINT MEETING WITH RTS

The Southampton Hospital broadcasting system

By G. A. Allcock (*University of Southampton*)

Boldrewood Theatre, University of Southampton, 7 p.m.

Friday, 10th February

Microcomputers and their applications

By H. Kornstein (*Intel Corporation*)

Isle of Wight College of Arts and Technology, 7 p.m.

Thursday, 23rd February

MADGE—A microwave landing system based on interferometry techniques

By D. Atter (MEL)

South Dorset Technical College, Weymouth, 6.30 p.m.

Thursday, 23rd February

JOINT MEETING WITH RTS

Visual side of video

By J. Dilly (*Southern Television*)

Southampton Television Centre, 7.30 p.m.

Thames Valley Section

Wednesday, 25th January

Colloquium on THE DESIGN OF HI FI AUDIO POWER AMPLIFIERS

Details of this meeting were given in the October issue (page 481).

J. J. Thomson Physical Laboratory, University of Reading, 2 p.m.

Advance booking is necessary although tickets are free to members: Apply in writing to Mrs. E. R. Atkinson, Department of Cybernetics, University of Reading, 3 Earley Gate, Whiteknights, Reading RG6 2AL, Berks. **Each applicant will be limited to one ticket.**

Thursday, 16th February

EMI C. T. Scanner

By E. Horne (*EMI*)

Caversham Bridge Hotel, Reading, 7.30 p.m.

Kent Section

Monday, 30th January

Why computer aided design?

By R. Fox (*University Computing*)

St. George's Hotel, New Road, Chatham, Kent, 7 p.m. (Tea 6.30 p.m.).

Beds and Herts Section

Thursday, 26th January

Quadraphonics

By I. Collins and C. Daubney (IBA)

Synopsis: The paper outlines the development of sound reproduction from the first gramophone systems through stereo to the various current proposals for quadraphony. Both Matrix and so-called discrete systems are considered and suggestions made for the requirements which a broadcast system would need to meet if it were to obtain widespread acceptance in Europe. Following from these suggestions some remarks are made concerning the systems which are preferred for broadcasting purposes.

Extensive use will be made of demonstrations.

Hatfield Polytechnic, 7.45 p.m. (Tea 7.15 p.m.).

Thursday, 23rd February

Seismic methods as applied to North Sea oil exploration

By a speaker from Geophysical Service International

Synopsis: Seismic sounding techniques are used to map geological horizons below the Earth's surface. Ways in which data are collected will be illustrated along with various navigation systems utilized for accurate positioning. The methods used in digital computer processing to remove unwanted noise from the recorded data will be shown. Finally some of the very recent techniques used in North Sea exploration will be illustrated.

Mander College, Bedford, 7.45 p.m. (Tea 7.15 p.m.).

East Anglian Section

Tuesday, 17th January

Digital television—a logical choice?

By K. H. Barrett (*IBA*)

Audio Visual Centre, University of East Anglia, Norwich, 7.30 p.m. (Tea 7 p.m.).

Thursday, 26th January

JOINT MEETING WITH IEE

Compatible noise reduction in stereo broadcast systems

By Dr A. R. Bailey (*University of Bradford*)

University Engineering Laboratories, Trumpington Street, Cambridge, 6 p.m. (Tea 5.30 p.m.).

Thursday, 9th February

JOINT MEETING WITH CES

Developments in marine communications

By G. J. McDonald (*Marconi Marine*)

Hoffman's Training Centre, Bishops Hall Lane, Chelmsford, 7.30 p.m.

Thursday, 16th February

Television reception techniques using adaptive arrays

By Dr. M. D. Windram (*IBA*)

Chelmsford Civic Centre, Chelmsford, 6.30 p.m. (Tea 6 p.m.).

South Western Section

Wednesday, 1st February

JOINT MEETING WITH RAeS AND IEE

Automatic landing systems in civil aircraft

By G. W. Grice (*British Airways*)

Chemistry Lecture Theatre, University of Bristol, 7 p.m.

Tuesday, 7th February

JOINT MEETING WITH IEE

From radio activity to radio science

By G. Millington

The College, Swindon, 6.15 p.m.

Wednesday, 8th February

JOINT MEETING WITH IEE

Little is beautiful

By Dr. J. Allison (*University of Sheffield*)

Main Lecture Theatre, Plymouth Polytechnic, 7 p.m. (Tea 6.30 p.m.).

South Midlands Section

Monday, 9th January

JOINT MEETING WITH IEE

Design of modern radio receivers

By B. Cooke (*Eddystone Radio*)

BBC Engineering Training Centre, Wood Norton Hall, Nr. Evesham, Worcs., 7.30 p.m.

Wednesday, 15th February

JOINT MEETING WITH IEE

Automatic handwriting and speech recognition signals

By R. S. Watson and B. E. Pay (*National Physical Laboratory*)

Majestic Hotel, Park Place, Cheltenham, 7.30 p.m.

West Midlands Section

Wednesday, 11th January

Technology in the service of the police

By T. H. Farr (*Home Office*)

Birmingham Polytechnic, 7 p.m.

Thursday, 16th February

JOINT MEETING WITH IEE AND IPOEE

The Dolby noise reduction system

By Mr. Iles (*Dolby Laboratories*)

Duncan Hall Post Office, Training College, Stone, 7 p.m. (Tea 6.30 p.m.).

East Midlands Section

Tuesday, 17th January

The engineer—a management/personnel view

By R. Palmer (*Leicester Polytechnic*)

Lecture Theatre, Physics Department, Leicester University, 7 p.m. (Tea in Charles Wilson Building at 6.30 p.m.).

Wednesday, 15th February

JOINT MEETING WITH IEE

Experimental railway signalling system using microprocessors

By H. Ryland (*British Rail*)

Edward Herbert Building, Room J001, Loughborough University of Technology, 7 p.m. (Tea in committee rooms, 6.30 p.m.).

North Eastern Section

Tuesday, 10th January

The influence of LSI on digital system design

By Professor D. W. Lewin (*Brunel University*).

YMCA, Ellison Place, Newcastle upon Tyne, 6 p.m. (Tea 5.30 p.m.).

Thursday, 16th February

JOINT MEETING WITH BCS

.... and the MU5 begat the 2900....

By Prof. R. N. Ibbett (*University of Manchester*)

Barras Bridge Building, Newcastle University, 7 p.m.

North Western Section

Thursday, 19th January

Radio paging

By N. W. Brown (*Post Office*)

Synopsis: A general introduction to Radio Paging is given and mention is made of the Post Office Thames Valley trial. The paper then describes in detail the engineering aspects of the London service which has been designed to serve the Greater London Area from a fully automatic 100 000 code capacity control unit. Full STD access is afforded to persons making the paging calls which are validated and then acknowledged by recorded announcements.

Renold Building, UMIST, Sackville Street, Manchester, 6.15 p.m. (Tea 5.45 p.m.).

Thursday, 23rd February

What is a technician engineer?

By A. C. Gingell (*IEETE*)

Synopsis: The function and status of the Technician Engineer will be described to introduce discussion of the subject. It is hoped that a senior member of CEI North West Committee will also be present.

Renold Building, UMIST, Sackville Street, Manchester, 6.15 p.m. (Tea 5.45 p.m.).

(NOT IN THE BOLTON INSTITUTE AS STATED IN THE COMBINED PROGRAMME OF MEETINGS)

South Wales Section

Wednesday, 11th January

JOINT MEETING WITH IEE

Analysis for production control in an integrated steel works

By K. E. Morgan (*British Steel*)

Room 112, Applied Physics Department, UWIST, Cathays Park, Cardiff, 6.30 p.m. (Tea 5.30 p.m.).

Wednesday, 8th February

Satellite communications—'voices in orbit'

By R. J. Kernot (*Post Office Telecommunications*)

Synopsis: Reliable global communications can only be fully satisfied by satellite systems. One of the earliest proposals for a communications satellite system was by Arthur C. Clarke in 1945. He proposed the use of 3 repeater stations established 22,300 miles above the equator to provide global coverage. Such geosynchronous satellites operate today in the *Intelstat* system. The present *Intelstat IVA* satellites have been developed from *Echo* balloons, *Telstar*, *Relay*, *Early Bird* and other *Intelstat* Technology.

Room 112, Applied Physics Department, UWIST, Cathays Park, Cardiff, 6.30 p.m. (Tea 5.30 p.m.).

Merseyside Section

Wednesday, 8th February

Cosmic research using high altitude balloons

By Dr. R. Edge (*Bidston Observatory*)

Synopsis: Large high altitude balloons provide a comparatively inexpensive means of lifting heavy scientific instruments to within a few millibars of the top of the atmosphere.

Department of Electrical Engineering and Electronics, University of Liverpool, 7 p.m. (Tea 6.30 p.m.).

Northern Ireland Section

Thursday, 12th January

Microprocessors

By Professor W. D. Ryan (*Queen's University, Belfast*)

Ashby Institute, 6.30 p.m.

Tuesday, 7th February

Charge coupled devices

By W. Morris (*Short Bros. & Harland*)

Cregagh Technical College, 7 p.m.

Subject Index

Papers are denoted by printing the page numbers in bold type

Index of Persons

Names of authors of papers or articles published in the volume are indicated by bold numerals for the page reference.

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