<table>
<thead>
<tr>
<th>Country</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>Australia</td>
<td>$A1.20</td>
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<tr>
<td>Canada</td>
<td>$1.50</td>
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<tr>
<td>Denmark</td>
<td>Kr.11</td>
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<tr>
<td>Finland</td>
<td>6.20</td>
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<tr>
<td>Germany</td>
<td>Dm.4.50</td>
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<tr>
<td>Holland</td>
<td>Dfl.4.50</td>
</tr>
<tr>
<td>Italy</td>
<td>L.900</td>
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<tr>
<td>Malaysia</td>
<td>M53.25</td>
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<tr>
<td>New Zealand</td>
<td>$NS1.40</td>
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<tr>
<td>Norway</td>
<td>Kr.10</td>
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<tr>
<td>Portugal</td>
<td>Esc.4.00</td>
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<tr>
<td>South Africa</td>
<td>R.11</td>
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<tr>
<td>Spain</td>
<td>0.30</td>
</tr>
<tr>
<td>Sweden</td>
<td>Kr.6.90</td>
</tr>
<tr>
<td>USA</td>
<td>$1.50</td>
</tr>
</tbody>
</table>
The Most Advanced Spectrum Analyser

You've never seen a faster, more accurate way of measuring frequency response from 30Hz to 110MHz

The TF 2370 Spectrum Analyser employs advanced technology to provide a complete system for measuring response, level, frequency, signal purity, modulation and much more, with a speed and degree of accuracy previously unobtainable. A digital memory permits the use of a standard monitor tube and internal logic selects gain ratios and sweep speeds for optimum performance. The specification speaks for itself:

- Flicker-free 100 dB display of frequency response from 30 Hz to 110 MHz on a high brightness c.r.t.
- Electronic graticule, with a ±15% variation of horizontal divisions for pin-point positioning against waveform display.
- Three amplitude scales: one linear and two logarithmic with expansion to 1 dB/div, with an accuracy of ±0.1 dB/div.
- 9-digit electronic counter automatically gives centre frequency, reads any other frequency corresponding to manually-adjusted 'bright line' position on display, or the difference frequency between the two, at the press of a button. All to an accuracy of ±2Hz ± reference frequency accuracy on high resolution and manual. Internal reference frequency provided with setting accuracy of 1 in 10¹.
- Internal generator supplies synchronous signal source for measuring such items as networks and filters.
- For comparative measurements, unique memory storage system will retain one display indefinitely as required, for simultaneous display with response produced by items under test.
- Automatic adjustment of amplifier gains to give optimum lowest-noise performance with full protection against input overloading.
- Automatic selection of optimum sweep speed.
- With the 5 Hz filter, signals 100 Hz from a response at 0 dB can be measured to −70 dB.

Please send for full information or ask for a demonstration - seeing is believing!

mi: The Innovators
MARCONI INSTRUMENTS LIMITED,
Longacres, St. Albans, Hertfordshire, England, AL4 0JN. Telephone: St. Albans 59292 Telex: 23350.
A GEC-Marconi Electronics Company
WW—001 FOR FURTHER DETAILS
### LOW COST VOLTMETERS

from the range of

**LEVELL**

PORTABLE INSTRUMENTS

---

### A.C. MICROVOLTMETERS

**VOLTAGE & dB RANGES:** 15µV, 50µV, 150µV, 500V

Acc. ±1% ±1% f.s.d. ±1µV at 1kHz - 100, 90... +50dB

Scale: 20dB / -6dB rel. to 1mV/600Ω

**RESPONSE:** ±3dB from 1Hz to 3MHz, ±0.3dB from 4Hz to 1MHz above 500V. Type TM3B can be set to a restricted B.W. of 10Hz to 1kHz or 10kHz.

**INPUT IMPEDANCE:**
- Above 50mV: >4.3MΩ <20pf.
- On 50µV to 50mV: >5MS2 <'50pf.

**AMPLIFIER OUTPUT:** 150mV at f.s.d.

<table>
<thead>
<tr>
<th>Type</th>
<th>£85</th>
<th>£95</th>
</tr>
</thead>
<tbody>
<tr>
<td>TM3A</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TM3B</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

---

### D.C. MULTIMETERS

**VOLTAGE RANGES:** 3µV, 10µV, 30µV... 1kV

Acc. ±1% ±1% f.s.d. ±0.1µV at 100MHz.

**CURRENT RANGES:** 3pA, 10pA, 30pA... 300mA

Acc. ±2% ±2% f.s.d. ±2pA at 100MHz.

**RESISTANCE RANGES:** 3Ω, 10Ω, 30Ω... 1GΩ linear

Acc. ±1% ±1% f.s.d. up to 100MΩ.

**RECORDER OUTPUT:** ±1V at f.s.d. into >1kΩ on L.F.

<table>
<thead>
<tr>
<th>Type</th>
<th>£125</th>
<th>£135</th>
</tr>
</thead>
<tbody>
<tr>
<td>TM9A</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TM9BP</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

---

### BROADBAND VOLTMETERS

**H.F. VOLTAGE & dB RANGES:** 1mV, 3mV, 10mV... 3V

Acc. ±4% ±1% f.s.d. at 30MHz, ±0dB, ±0dB, ±3dB rel. to 1mV, ±5dB

±0.7dB from 1MHz to 50MHz. ±3dB from 300kHz to 400MHz

**L.F. RANGES:** As TM3 except for the omission of 15µV and 150µV

**AMPLIFIER OUTPUT:** Square wave at 20Hz on H.F., with amplitude proportional to square of input. As TM3 on L.F.

<table>
<thead>
<tr>
<th>Type</th>
<th>£135</th>
<th>£145</th>
</tr>
</thead>
<tbody>
<tr>
<td>TM6A</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TM6B</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

---

### D.C. MICROVOLTMETERS

**VOLTAGE RANGES:** 30V, 100V, 300V... 3000V

Acc. ±1% ±2% f.s.d. ±1V, ±1V, ±5V at f.s.d.

**CURRENT RANGES:** 30µA, 100µA, 300µA... 300mA

Acc. ±2% ±2% f.s.d. ±2µA, ±2µA, ±50mV at f.s.d.

**LOGARITHMIC RANGE:** ±5µV at ±10% f.s.d. ±50mV at ±50% f.s.d. ±500mV at f.s.d.

**RECORDER OUTPUT:** ±1V at f.s.d. into >1kΩ

<table>
<thead>
<tr>
<th>Type</th>
<th>£77</th>
</tr>
</thead>
<tbody>
<tr>
<td>TM10</td>
<td></td>
</tr>
</tbody>
</table>

---

These highly accurate instruments incorporate many useful features, including long battery life. All A type models have 83mm scale meters, and case sizes 185x110x130mm. B types have 127mm mirror scale meters and case sizes 260x125x180mm.

**LEVELL ELECTRONICS LTD.**  
Moxon Street, High Barnet, Herts. EN5 5SD  
Tel: 01-449 5028/440 8686

Prices are ex works with batteries. Carriage and packing extra. VAT extra in U.K. Optional extras are leather cases and mains power units. Send for data covering our range of portable instruments.

WW-042 FOR FURTHER DETAILS
New portable DMMs.

Only Fluke make them—only ITT sell them.

New Fluke DMMs Fluke have introduced two new digital multimeters. That is big news in itself, because when you are already producing the best selling instruments on the market, how do you bring off another success? The answer has been to take an outstanding specification and shrink it into a truly portable instrument.

**True RMS a.c.** This is the most important feature—especially when you realise that it is incorporated in a battery operated instrument that measures less than 6 x 5 x 2½ in. and weighs only 2½ lb. It means that you can take lab. quality measurement out in the field, free from the shackles of size, weight and power points.

**Two versions – 8030 & 8040** Both models offer five ranges over five measurement functions and include autozero. The 8030 is a 3½ digit instrument with a useful diode test facility. The 8040 has 4½ digits and incorporates autoranging.

The only way to buy Both these briefcase sized DMMs are available from ITT Instrument Services; and from nobody else, not even from Fluke. Which brings together the best sellers among portable DMMs and the biggest name in the instrument distribution business. That means no-delay telephone ordering, streamlined internal processing, and delivery from stock.

Ask for a spec. sheet now. Or better still, get ITT to arrange a demo. You will be more amazed by the performance than the price!

ITT Instrument Services

The only way to buy.
Harlow (0279) 29522.

Fill in this coupon for your copy of the data sheet on the 8030 and 8040 and send it to:
ITT Instrument Services,
Edinburgh Way, Harlow, Essex.

Name ____________________________
Company _______________________
Address _________________________
Tel No ___________________________
Water is pure and clear. Still, if we look at a leaf which is partially submerged in it, the leaf looks distorted. It is surprising how easy it is to introduce distortion, even by the simplest type of operation on the real thing. The bent leaf doesn't really bother us very much, but when distortion in sound results from the use of equipment, this bothers us a lot!

Some OTARI specialists spend most of their day making sure that the equipment that we produce has the lowest possible wow and flutter, and the highest possible S/N ratio. Naturally, these are not the only features which create the top performance of OTARI products, but they reflect the care that results in a totally balanced OTARI product, and better service.

Trust through experience — one encounter with OTARI equipment and from then on, You will trust the OTARI name.
Why scrap good mono cameras?
EEV is still making image orthicons.

Why change equipment which has many more years of useful life ahead?
EEV is still making image orthicons in very large numbers. And we’re constantly developing them with improved performance.
So you can be sure of continuity of supply of high-quality 3" and 4½" tubes.
Our prices are competitive. Our service backup is worldwide. All the knowhow and skill of 24 years production goes into every EEV image orthicon.
Our tubes are all you need – to keep on getting good pictures, colour or black and white, from older generation cameras.
Write for data and prices. If you have a specific requirement, contact your local EEV agent or call Camera Tube Sales at Chelmsford, England.

EEV and M-OV know how
Members of GEC - turnover £1902 million
**HIGH POWER DC-COUPLED AMPLIFIER**

- **UP TO 500 WATTS RMS FROM ONE CHANNEL**
- **DC-COUPLED THROUGHOUT**
- **OPERATES INTO LOADS AS LOW AS 1 OHM**
- **FULLY PROTECTED AGAINST SHORT CCT, MISMATCH, ETC.**
- **3 YEAR WARRANTY ON PARTS AND LABOUR**

The DC300A Power Amplifier is the successor to the world famous DC300 which is so widely used in Industrial, and Research applications in this country. It is DC-coupled throughout so providing a power bandwidth from DC to over 20,000Hz. The ability of the DC300A to operate without fuss into totally reactive loads while delivering its full power, and maintaining its faithful reproduction of Pulse or complex waveforms has established the DC300A as the world's leading power amplifier. Each of the two channels will operate into loads as low as 1 ohm, and the amplifier can be rapidly connected as a single ended amplifier providing over 650 watts RMS into a 4 ohms load, and still providing a bandwidth down to DC. Below is a brief specification of the DC300A, but if you require a data sheet, or a demonstration of this fine equipment please let us know.

<table>
<thead>
<tr>
<th>Specification</th>
<th>DC300A Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Power Bandwidth</td>
<td>120-256VDC</td>
</tr>
<tr>
<td>Power at clip point (1 channel)</td>
<td>150 watts + 0db</td>
</tr>
<tr>
<td>Phase Response</td>
<td>0.05% DC to 20kHz</td>
</tr>
<tr>
<td>Harmonic Distortion</td>
<td>Below 0.05%</td>
</tr>
<tr>
<td>Intermod. Distortion</td>
<td>0.05% 0.01 watt to 150 watts</td>
</tr>
<tr>
<td>Damping Factor</td>
<td>Greater than 200 DC to 1kHz at 8V</td>
</tr>
<tr>
<td>Hum &amp; Noise (20-20kHz)</td>
<td>At least 110db below 150 watts</td>
</tr>
<tr>
<td>Slewing Rate</td>
<td>80 volts per microsecond</td>
</tr>
<tr>
<td>Load impedance</td>
<td>1 ohm to infinity</td>
</tr>
<tr>
<td>Input sensitivity</td>
<td>175 V for 150 watts into 8V</td>
</tr>
<tr>
<td>Input impedance</td>
<td>100 ohms to 100k ohms</td>
</tr>
<tr>
<td>Protection</td>
<td>Short mismatch &amp; open cct protection</td>
</tr>
<tr>
<td>Power supply</td>
<td>120-256V 50-400Hz</td>
</tr>
<tr>
<td>Dimensions</td>
<td>150 — 150 watts per channel</td>
</tr>
</tbody>
</table>

Other models available from 100 watts to 3000 watts

**MACINNES LABORATORIES LTD.**
Macinnes House, Carlton Park Industrial Estate
Saxmundham, Suffolk IP17 2NL. Tel: (0728) 2262 2615

**MACINNES FRANCE**
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Tel: 203-50-01
Thanks to TRW
I no longer watch
the Four Ronnies

The new TRW TP393 wide band 40-860 MHz gold metallized transistor gives significantly improved, master TV aerial amplifier performance at no increase in cost.

The TP393 gives higher gain and higher output and a lower noise figure. It has a similar input impedance to competitive devices and is mechanically identical, enabling it to be dropped into existing circuits, with noticeably better results.

Check the parameters listed below then send for full data.

<table>
<thead>
<tr>
<th>PARAMETER</th>
<th>TEST CONDITIONS</th>
<th>SYMBOL</th>
<th>UNIT</th>
</tr>
</thead>
<tbody>
<tr>
<td>TRANSITION FREQUENCY</td>
<td>5V 30mA 500 MHz</td>
<td>FT</td>
<td>3.0</td>
</tr>
<tr>
<td>NOISE FIGURE</td>
<td>2mA 5V 500 MHz</td>
<td>NF</td>
<td>2.0</td>
</tr>
<tr>
<td>INTER-MODULATION</td>
<td>5V 30mA 500 MHz</td>
<td>IMD</td>
<td>300</td>
</tr>
<tr>
<td>INPUT S-PARAMETER</td>
<td>5V 30mA 500 MHz</td>
<td>S11</td>
<td>0.33182</td>
</tr>
<tr>
<td></td>
<td>5V 30mA 1000 MHz</td>
<td>S11</td>
<td>0.38[53]</td>
</tr>
</tbody>
</table>
Wireless World, February 1977

A wide range of transformers manufactured in production quantities to customers individual requirements

Prompt Prototype Service available

Drake Transformers Limited
Telephone: Kennel Lane, Billericay 51155
Billericay, Essex.

New low cost microcomputer for learning the ‘how’ of microprocessors ....

Now, there is a new Microcomputer to provide “hands on” experience to master and apply microprocessors - the Limrose MPT8080.

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The comprehensive instruction manual is so straightforward that even a person with limited technical knowledge can rapidly learn how microprocessors work.

The Microtutor MPT 8080 is not just a learning module - it’s a full 8-bit, parallel, microcomputer with an 8080 CPU, 1K RAM, and various input and output ports. It can be single-stepped or run continuously to facilitate a thorough understanding of hardware/software interaction and programming of microprocessors.

The MPT 8080 can also be used as a prototyping computer and expanded with additional memory and ports.

For instant information, please contact:

Limrose Electronics Limited
241-243 Manchester Road, Northwich, CW9 7NE
Tel. 0606 41696/7

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ADDRESS

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Cables: Leemag London SW18. Telex 923455 Wembley

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Telex: 96283

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Thorn Measurement and Components Division

WW — 059 FOR FURTHER DETAILS
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Sensitivity:
1200V DC range: 10,000 0/V
1200 AC range: 6,000 0/V
600V AC range: 15,000 0/V
300V AC range: 15,000 0/V
Other AC ranges: 20,000 0/V
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Phone: 01/837/7937

12 Wireless World, February 1977
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- Rating 100V DC
- Size 10 x 15 x 4 cm
- Fits neatly in to the palm of the hand

**Price £74 EX VAT**

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- **Universal Timer**
  - 1 use to 1 000 000 secs
- The Mini-T-Dekade has unique features offering engineers a new fast, accurate means of designing and building electronic circuits
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- Time ranges are switched in 2 decades using BCD code
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- DC
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- Power supply: 12V 225m Ah

**Price £195 EX VAT**

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  - **Mini DVM Type 3201**
  - Functions:
    - DC V 200, 2000 mV, 20, 200 V
    - AC V 200 mV, 20, 200 V
    - DC A 200, 2000 mA, 20, 200 mA
    - AC A 200, 2000 mA
    - Ohm 2, 20 kΩ, 200 kΩ

**Price £84 EX VAT**

**Auto ranging Automatic Capacitance Bridge**

- **Model ESP 300A 1pF to 2000 μF**
- A complete range of British-made instruments designed to simplify capacitance measuring
  - Accurate and sensitive
  - Requires no manual balancing
  - Takes less than a second to measure a capacitor
  - Updates changes in capacitance automatically
  - Wide range of applications

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Northamptonshire NN11 7HH
Telephone: Rugby (0788) 890972

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- Max Dissipation 0.5 W
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- Fits neatly in to the palm of the hand

**Price £64 EX VAT**

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  - Linear Scale
  - Direct reading
  - Measures any type of capacitor including electrolytics

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including ten turn manual tuning pot
£28.50

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including LED indicator
£7.60

M3 PUSH BUTTON PRE-SELECT UNIT
six channel & provision for manual tune
£15.95

M4 REGULATED POWER SUPPLY
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M5 TOUCH TUNE PRE-SELECT UNIT
A touch switched replacement for M3
£17.54

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Purton, WILTS
SN5 9DG

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3 CHANNEL AUDIO VISUAL
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140 SERIES 4 CHANNEL

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Front cover shows a group of silica optical fibres made by Standard Telecommunication Laboratories for use in optical communication systems.
Photographer Paul Brierley

IN OUR NEXT ISSUE

Electronic rhythm accompaniment. Constructional design for a "rhythm section" which controls the musical timing of sources giving percussion sounds and can be used with an electronic organ.

Interference from amateur stations with television, sound and audio equipment — how bad is it? Results of a RSGB survey that attempts to assess the situation fairly.

Television test generator. Construction of a laboratory instrument giving cross-hatch, dot matrix, colour bar and grey scale patterns. Simple design based on t.t.l. integrated circuits.
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Attitudes to mobile radio

If the government has done nothing to promote public discussion on frequency reallocations in preparation for the 1979 World Administrative Radio Conference, at least a start has been made by one British manufacturer, Pye Telecommunications, in the important field of private mobile radio (p.m.r.). While the Home Office’s “Warden report” on this subject remains secret, Pye has issued a 71-page study on “The future frequency spectrum requirements for private mobile radio in the United Kingdom” which is notable for being well researched, thorough and honest. This is in fact the “Pannell report” (named after W. M. Pannell, its principal author) referred to in last month’s article on citizens’ band radio.

Of course it would be naive to expect a report emanating from a manufacturer not to be sympathetic to that firm’s commercial interests, and in fact the Pannell report is openly expansionist (not to say slightly predatory, about other people’s frequencies) in its general approach to the development of p.m.r. By contrast the secret Warden report, we are informed, tends to be conservative and restrictive. For example, while both reports agree there will certainly be a shortage of frequency spectrum for p.m.r., Pannell says the UK will need at least 190MHz by the year 2000 but Warden reckons no additional spectrum will be needed till 1985 and after that only an extra 33MHz beyond the 36MHz at present available. Pannell thinks the present p.m.r. growth rate of 10% per annum could accelerate to 15-20%, resulting in about 2m mobile radios by the year 2000, while Warden says 15% growth is unrealistic and estimates 1.3m mobiles by that date. Pannell considers the present channel loading (in mobiles per channel) to be “uncomfortably high” while Warden says that even higher channel loadings will be necessary and the use of exclusive channels will rarely be sanctioned. To permit working with this greater congestion Warden emphasizes the necessity for technical aids such as signalling systems using sub-audio tone squelch and sequential tone and digital signals, while Pannell plays these down in relation to the need for more channels and speaks of avoiding “expensive development of new types of equipment.” As for their attitudes towards the user, while Pannell stresses in general terms the economic benefits, such as vehicle fuel saving, to be expected from wider use of mobile radio, Warden, starting from a conservationist position, concludes that each demand for frequency space will have to be supported by a particular proof of real need and a resulting benefit to the public — and also that comparisons will have to be made between different users on this basis.

Clearly there is a strong subjective element in forecasting the future. Both reports are biased by the priorities of the organizations that produced them. The truth may lie somewhere between. What we need now is a public conference, perhaps run by one of the engineering institutions, that would allow free comment from as many people as possible concerned with p.m.r. and would formulate clear and specific recommendations to be put to those who will represent the UK at the forthcoming WARC 1979.
VIEWDATA

The Post Office's textual information and communications system: 1 — background and introduction

by S. Fedida, B.Sc.(Eng.), M.Sc., F.I.E.E., A.C.G.I. Post Office Research Centre

Viewdata is a system for disseminating and retrieving computer based information, using the domestic telephone line for communication and the domestic television set for display. It differs from teletext which is a specific system of broadcasting textual information interleaved with pictorial information: the two systems are complementary rather than competitive. This article looks at earlier systems of accessing computer data banks from remote points using telephone lines and then introduces the Viewdata system now on pilot trial in the UK.

Essentially the concept of accessing a computer data bank from a remote point using telephone lines is not new. The technique was demonstrated in the mid-60s by Dr Sutherland of the Massachusetts Institute of Technology, and has been used increasingly ever since, but mainly by the professional computer user. Indeed networks of computers have been installed in various parts of the world for this purpose and for the purpose of computation. In the US an ambitious computer network ARPANET has been in operation for some years and has been extended to provide world wide coverage. In Europe a new system EURONET is in process of being implemented to provide a computer network for scientific and technical information in the European Community.

Many private computer networks have also been installed world wide to provide business and scientific computer facilities on in-house bases. Viewdata on the other hand belongs to a family of computer-based information systems which are intended for the general public, i.e. users who have no computer training whatever and indeed who do not intend to undergo such training.

Systems of these kinds have to be specifically tailored to this class of users who may well have, and indeed will have, considerable expertise and intellectual ability but not necessarily in the intricacies and minutiae of computer programming. In general they are anxious to use the capabilities of computers both for the purpose of information retrieval and other purposes, but have neither time nor indeed the inclination to submit to the usually tiresome computer protocol. (The protocol is the set of rules and instructions which govern access to computers and the use of their programmes.)

Several attempts have been made in the recent past to bring computer-based information to the people.

The Reston experiment. A well documented attempt is the Reston experiment in Virginia USA, using the Mitre Corporation interactive television system TICCIT which stands for "time-shared, interactive, computer-controlled information television" utilising a standard television receiver as a display.

Essentially the system requires that the user be connected to a cable television network, over which are transmitted a number of still tv frames, 60 different frames per second. Thus assuming an information cycle time of 10 seconds, i.e. each user accesses a different frame every 10 seconds, the system can support 600 users simultaneously on a dedicated tv channel, each user receiving his own selection of information.

Associated with the user television receiver is a video tape recorder, which takes a recording of the frame intended for the user and plays it back to the tv at the rate of 60 times a second.

The individual selection of information frames is carried out using a telephone connection from the user to the computer centre, together with the push-button set on the telephone with which the user may key the number of the frame required. When this is done the computer transmits this frame followed by a user address, which is
coded on line 480 or 481 (for even and odd frames) of the tv scan. A coupler/decoder at the user end examines this address and connects the video recorder to cable for the duration of the following frame, thus capturing the frame selected.

The home equipment needed in this system is not only a tv set but also a video tape recorder and a special adapter, while the communications medium consists of a wideband cable and a telephone connection.

In-Touch. This computer information service\(^1\) was launched in Seattle, Washington in 1973 with the backing of the Seattle First National Bank for the purpose of providing a number of financial and budgeting service to the home user and the small business. It uses the push-button telephone, to send instructions to the computer, which then provides a voice response. The terminal equipment is minimal. The main problem of course is to overcome the obvious limitations of the terminal equipment both in transmitting and receiving information are effectively overcome. The other problem noted by the originators of the scheme, and somewhat related to the above but clearly much more complex, is to arrange the dialogue between computer and user that the latter needs no special computer training whatever. It is believed that this system closed down after an intial one-year experimental period.

DIALS (calculation by telephone). This system\(^2\) was developed by NTT (Nippon Telegraph and Telephone Co.), the public telephone administration in Japan, to provide a calculation service to telephone subscribers, on an on-line, real-time basis. The public service was initiated in 1970/71. In this case also the push-button telephone is used as a transmit and receive terminal, outgoing instructions being keyed on the push-button keypad and transmitted to the computer as a sequence of audio tones. The computer response is a voice signal which gives the result of the computation.

The calculation facilities offered by DIALS are fairly complex. They include the simple arithmetic operations \(+, -, \times, +, \sqrt{\text{v}}\) and also basic facilities such as trigonometric functions, logarithms and so forth. It is also possible to input an algebraic expression with dummy arguments which is memorised by the computer. This is then followed by sets of arguments supplied by the user on which the computer operates. Finally it is possible to call some library programmes, for example for statistical work, compound interest and the like.

Clearly the standard 12-button telephone keyboards cannot be used without substantial modifications to transmit the required instructions. This is overcome by superimposing a removable template on to the dial and using groups of numbers and symbols for each of the required calculation symbols. A diagram of the overlay is shown in Fig. 1. For example, an expression such as \(4 \times (3 + 5) - 6.2\) is transmitted as 
\[
4^7 \times 1305*286^{*}52^{*}5
\]

The end group of symbols \(*\) signifies the "go" instruction (instructing the computer to go ahead with the computation).

Trigonometric and logarithmic functions are transmitted as a number preceded by F and followed by the argument in brackets, e.g. \(\log_{10}(X)\) is transmitted as F2(X), while library programmes are given a number preceded by L, e.g. the integrating function is L36.

The use of the template has been explained at some length to indicate the complexity introduced in a system of this kind, if one is limited to using just the 12 buttons of the telephone push-button set. This complication is avoided in Viewdata in a number of ways to be described later.

The use of a voice response system for imparting the kind of information mentioned above is obviously fraught with pitfalls, and the complexity of the coding needed to pass instructions no doubt added to the difficulties.

Bell Picturephone computer access system. As part of the development of Picturephone in the USA, means were developed to display computer generated information on the Picturephone station set.\(^3\) Picturephone is a Bell Telephone development which provides face to face communication between telephone subscribers—a two way video telephone. Special lines (video access lines) must be installed to transmit Picturephone information to the subscribers. These consist of two pairs of lines equalized to transmit satisfactorily, at least in the initial stages, a bit rate of 6.312 Mbit per second. In addition the normal telephone connection is also required. A typical local arrangement is shown in Fig. 2.

Given an environment which has already been designed and established to support Picturephone, it is clearly possible to enhance the video facility by providing the option of displaying computer-based information as an alternative to the normal pictorial information. To do this a display data set (equivalent to a modem in UK terminology) was developed to provide computer access to Picturephone users. Essentially this data set at the exchange, acts as an interface between the computer and the Picturephone station at the user's premises.

Instructions to the computer are sent by the customer to the exchange using the push-button telephone (m.f. signalling) as in the previous systems. This is converted by the display data set to ASCII characters and transmitted to the computer along a narrow-band data line, which could be a standard voice circuit. The computer response, which is a string of ASCII characters, is received by the display data set and stored therein. It is converted in the data set to a video signal which is then transmitted to the Picturephone station as if it were a normal Picturephone signal. Since there is no storage at the subscriber's end this information needs to be sent repeatedly, television fashion, to keep the display refreshed, at 30 times per second.

Clearly this technical solution to the retrieval and display of computer based information is satisfactory in an environment where the Picturephone is already established as a viable communication service, and its development might then have followed the lines of Viewdata in terms of protocol, extra facilities etc., had it been persevered with.

Viewed however, as a means of providing simply a new information and communication service to the general public, its association with Picturephone delayed and indeed hindered its proper development and timely introduction, since it depended on the establishment of a wideband Picturephone capability across the country to achieve the penetration needed to make the service economically viable and truly available to the general public.

Development of Viewdata

The Viewdata concept began in the Post Office Research Department in 1970/71, more or less concurrently with the systems mentioned earlier. As with these systems there was the notion that there was an important potential for applying computer-based information systems to the public service area, but that, while technologically there were no insuperable hurdles to overcome, nevertheless there were fundamental problems that had to be resolved before practical and economically viable systems could be designed and engineered to be usable by the general public.

\(^{1}\) American Standard Code for Information Interchange.

---

![Fig. 1. Overlay template attached to push-button telephone used in DIALS calculation service](image-url)
In common with all these systems, Viewdata set out to solve these problems. As was to be expected, each solution turned out to be somewhat different, partly to adapt to a different environment, but also because of different design philosophies. These problems are in the following areas:

- the terminal
- the transmission system
- the computer relationship
- the system potential

The terminal. The terminal used to communicate with the computer clearly has to be a low-priced, attractively styled and reliable piece of electronics to ensure a wide market penetration with the general public.

The push-button telephone is clearly such a terminal. Indeed in the standardisation of m.f. telephone systems, this possibility has been kept firmly in view, and has resulted in proposals for enhanced push-button sets containing 16 keys. 1

While the push-button telephone is a suitable transmission terminal, for many users it has obvious limitations for the more advanced applications. Indeed attempts at squeezing a large alphabet from the limited number of keys only leads to confusion and irritation on the part of the user. As a receiving terminal it requires that the computer response be a voice response. Here also this could well be acceptable some time, but it suffers from very serious limitations. Where the amount of information is fairly limited, e.g. one or two items of information, voice response is probably acceptable to many users. Even then, the fleeting nature of the voice response hinders comprehension very seriously and messages need to be repeated several times to allow full understanding, the taking of notes etc.

Two of the systems described above used the pushbutton telephone, but the extent and versatility of the service planned for Viewdata made the push-button telephone associated with voice response quite unsuitable for a good general purpose information system capable of growing to meet the needs of the users.

The alternative to a voice response system is the visual display. This is easier to implement and vastly cheaper as far as the computer is concerned and to the user it offers unparalleled scope in comprehension and in the range of information that can be put over. It can lend itself to multilingual and graphical information fairly readily. One of the important aspects of Viewdata is the possibility of implementing a wide range of information services across multi-national boundaries.

Visual displays have been in widespread use in the computer field for some years, but their cost is still well above that considered acceptable to the mass market. It is therefore not surprising that many information systems have sought to capitalise on the domestic television display, which, with suitable
modifications, may be adapted to become the ideal information terminal for home use. It also has considerable attractions in the form of a dedicated communication station for office use — what we have called the Viewdata-phone (see below).

Ideally an unmodified tv set, with an adapter box capable of transforming it into a computer terminal, is the best approach, and while this is technically quite feasible for Viewdata, where transmission data rates are low, and colour is not an essential facility, it is much less suitable for teletext. In the last-mentioned case and where a colour display is required in Viewdata (and there is no doubt that the addition of colour gives considerable visual appeal), a built-in adapter is preferable.

It is hoped that tv sets with integral adapters, and external adapters for existing tv sets, will be available on the market quite soon.

The transmission system. Initially the major impetus to the development of information systems for the home was provided by the availability of spare bandwidth in cable tv systems. Clearly this makes sense, since the spare bandwidth is available at marginal cost, the main use being to convey television programmes. Hence in countries where cable tv networks are fairly extensive, such as the USA and Canada, the emphasis has been on using this medium for the transmission of information.

The Reston experiment mentioned above is an example of such a system and clearly provides a great deal of information, e.g. pictures, which cannot be easily accommodated with narrow band systems such as those depending on telephone lines. This system, however, requires the use of the telephone network as well, to provide the selection means and thus lose the advantage of marginal costing of unused bandwidth of the tv cable installation.

Alternative systems based on the "frame grabbing" principle and transmitting the whole data base continuously over a tv broadcast channel on cable or off air are also possible and indeed could become very attractive. In these systems the page selection is carried out at the receiving point and hence they do not require a return communications channel. Properly designed they are capable of transmitting a great deal more information than the Reston system, provided pictorial information is not required. A single tv channel, for example, could provide the equivalent of 30,000 pages of alphanumeric information.

The absence of a return channel to the information source obviously implies that the system is not interactive, i.e. the user cannot respond to the information provided, or generate information himself. Thus the system is completely passive and cannot provide services requiring user interaction.

Where spare tv channels are not available, either off-air or in a cable tv environment, or when interactive operation is required to support a broad range of additional services as provided by Viewdata, then the telephone transmission medium is the best available.

This is why Viewdata has been implemented as an "intelligent" communications medium using the telephone system. In order to impose the minimum of constraints on the rapid build up of the service and ensure rugged and reliable operation, only the current well-proven transmission performance of the telephone network is postulated; as indeed is the existing telephone switching environment. Thus the current experimental Viewdata system on pilot trial uses 1200 bits per second for computer to terminal and 75 bits in the reverse direction. As developments and enhancements take place in this area, they will be gradually introduced in Viewdata with the aim of improving performance and reducing costs.

The computer relationship. In Viewdata as in the other systems noted earlier, the problem of how to enable users with no special computer training to access and instruct a computer loomed large, mainly because computer programming had developed from the very beginning, and with very few exceptions, into an increasingly complex set of routines. These demanded a great deal of concentration, attention to detail and constant and continuous practice to be mastered effectively.

In a sense the computer programmer is a designer of a logic system, who uses logical instructions instead of using logical circuit interconnections like his colleague who designs hardware logic systems. But whereas we do not expect the user of a piece of logic hardware to be able to design it, in the computer field there is not a great deal of distinction between the design programmer and the user programmer. This is in part due to the extraordinary flexibility of the computer. Dedicated and trained users are able to modify a programme or if necessary write new ones to suit their specific applications.

To quote from the originators of In-Touch, "There is the problem of how to communicate with someone who only had a high school education or less". "How do you get them to operate a computer error free?" "Having done that you must program the computer to respond satisfactorily to the communication by that customer. You also have to configure the hardware (and the software) consistent with customers who are not sophisticated and therefore do not expect anything to break."

These comments are particularly relevant to the situation prevailing in Viewdata and some of the above systems, where the range of services extend far beyond the provision of a simple set of information. But in Viewdata the designers of the system have taken a substantially more enlightened view. They do not look down on the user as being "naive", "unsophisticated" or slightly below par as regards educational standards. It is rather a question of specialised training, which few people outside the ranks of
those who do computer programming as a full time occupation have the opportunity or even the willingness to acquire.

A clear distinction is drawn between computer programmers who design programmes and computer users who use them and are thus enabled to instruct the machine (computer) to do all that the designers intended them to do.

The first objective is to get the machine to the people, and when this has achieved a high degree of penetration, then is the time to refine it to attempt to meet the needs of those who may want to do more with the machine than most people.

The computer dialogue. How then is it possible to overcome the very considerable problem of ensuring adequate communications between user and computer? The key is in the dialogue between the two.

The computer must first of all "understand" what the user wants. The usual method of communicating with computers is to design a special programming language which the user has to learn and which the computer is programmed to "understand." This works adequately in conventional computer programming but is clearly far too complicated in this application. Another approach is to use a prompting system: the computer offers a number of choices from which the user selects the one most appropriate to his requirements. This clearly limits the user's freedom but nevertheless avoids many of the problems connected with formal computer languages.

The simplest of these dialogues is an index from which the user selects the topic he requires (see Figure 3). This of course is the technique used in teletext. But the index in Viewdata is progressive (see Fig. 4), unlike that in teletext, where since the total amount of information on offer is very limited, the whole index may be displayed on one frame only.

In Viewdata the information is subdivided in a tree structure. The top of the tree is a list of main topics, each of which is then subdivided into sub-topics all the way down to the piece of information required. (See Fig. 5) Some of the branches in Viewdata may extend down to perhaps 8 to 10 levels, thus implying a choice from several hundred million pages.

The reason for the difference is to do with the scope and depth of treatment of the information supplied. Whereas in teletext the content of a magazine of which only one is transmitted at present is 100 pages, in the proposed Viewdata system a small local system might contain as many as 50,000 to 100,000 pages of information. Clearly it is therefore necessary to subdivide this into a number of sub-sections, according to an easily understood classification which enables the user to find the bit he wants quickly and simply.

Some of the information is given in great detail and the corresponding page number could have 6, 7 or even 8 digits (see Fig. 6). It would clearly be impracticable to offer such a complex index in one jump. Hence the selection system chosen.

At every selection step the user only needs to key a single digit to move to the next level down, thus considerably simplifying and speeding up the whole operation.

Other selection or retrieval systems are, of course, possible. For example, it would be possible to print the total computer index and have it available like a directory to all users. This entails the additional expense in printing and distribution, presents serious updating problems and may confuse many users. By incorporating the index in the system this is made self-contained and flexible.

A fundamentally different approach to the step by step index is that used in many information retrieval systems. This is the use of "key-words." An example of the use of keywords would be to key "football results.". There are several problems associated with a selection by keywords. These are fairly easy to resolve in computer data bases intended for the professional, but not so easy for a public service.

First the keyword approach requires a "thesaurus," a dictionary of terms used together with their synonyms which are meaningful to the computer. Secondly, the user would require a much more complex keyboard than the basic keyboard normally provided. Thirdly the use of keywords involves the computer in what could be a considerable search, and hence would cause the computer costs to escalate probably beyond the means of the general public.

It is for all these reasons that the index selection was chosen. With this arrangement the whole system is kept basically simple and easy to understand.

(To be continued)

References
The usual way to avoid transient intermodulation distortion in an audio power amplifier is to use a very large open-loop bandwidth and a high-frequency preamplifier roll-off.

In this article it is shown that this is not to an amplifier only way; it is possible to reach the same goal by making the first stage inside the feedback loop determine the open-loop bandwidth. This bandwidth can then be arbitrarily low, permitting the use of standard lag compensation stabilisation.

During the last few years it has become more and more obvious that the traditional steady-state measurements of harmonic and intermodulation distortion in an audio system do not give the whole truth about the qualities of the system when handling complex signals like music. As a result, much work has been done in studying the dynamic behaviour of different links of the audio reproducing chain.

The most interesting work in this field in recent years is probably Professor M. Otala’s identification of the mechanisms producing transient intermodulation distortion. Work by Otala and others\(^1,2\) show that negative feedback, when incorrectly used in an amplifier design, may make the amplifier sound worse than it did without feedback, while measurements of steady-state harmonic and intermodulation distortion show an improvement in amplifier quality (Jan., pp. 41-3).

Transient intermodulation arises when heavy negative feedback is applied to an amplifier with low open-loop bandwidth. It is basically an overload phenomenon, giving an audible result that resembles crossover distortion. Transient intermodulation can be avoided by careful design\(^1,2\) and probably the best known of the design rules that have evolved is that the amplifier open-loop bandwidth should be greater than the bandwidth of the preceding preamplifier or transducer, which must therefore not be unnecessarily large. A preamplifier bandwidth of several hundred kilohertz might give, power amplifier troubles and should be rolled off using a passive RC filter.

In a power amplifier, a large open-loop bandwidth is not easy to obtain. Firstly, fast power transistors are neither easily obtained nor cheap. Secondly, the simplest way to stabilize an amplifier is to use lag compensation, which requires a dominant low-frequency pole to be inserted in the open-loop frequency response of the amplifier. When pushing this pole above 20 or even 50kHz, the rest of the amplifier must be designed for a bandwidth of perhaps several megahertz. This method can, of course, be used and has been very successful\(^3,4\). The first difficulty can be overcome by using the output transistors in the emitter-follower configuration, thus increasing their cut-off frequency. The second can be evaded by using lead compensation\(^5,6\) instead.

There are other drawbacks with extremely wide-band amplifiers; for example, such an amplifier must be very well shielded, as it is prone to pick up radio transmissions inside (and outside) its passband. High frequency noise could also be a problem, from the intermodulation point of view. However, there is no doubt that designing a t.i.m.-free amplifier is a rewarding task for the serious listener, as it is particularly annoying\(^3\); a t.i.m.-free amplifier sounds better than most traditional designs, especially on transient-rich musical material.

Is there, then, a way to design a t.i.m.-free amplifier without having to rely on a very high open-loop bandwidth? To answer this question we take a close look at the mechanisms producing t.i.m.

**Feedback in an amplifier**

Suppose that we have a one-stage amplifier as in Fig. 1. The gain of this stage can be approximated by \(V_{\text{out}} = G(V_{\text{in}} - V_0)\), where \(G = \frac{Aa}{a+s}\), with \(s=j\omega\); we have a low frequency gain of \(G = A\) and an upper cut-off frequency \(2\pi f_c = a\). If we now apply the input signal \(V_{\text{in}}\) to input 1 and a feedback signal \(\beta V_{\text{out}}\) to input 2 we get \(V_{\text{out}} = \frac{V_{\text{in}}G}{1+\beta G} = V_{\text{in}}\frac{Aa}{s+a(1+|\beta|)}\).

From this equation the low-frequency gain with feedback is \(A/(1+|\beta|) \approx |\beta|\), and the upper cut-off frequency is now \(2\pi f_c = a(1+|\beta|)\). Further analysis shows that low frequency distortion, rise time and output impedance have been reduced and input impedance has been increased by a large factor. Thus, on this single stage, negative feedback has nothing but beneficial effects.

If the two similar single-stage amplifiers of Fig. 2, with gains \(G_1 = Aa/(a+s)\) and \(G_2 = Bb/(b+s)\), are cascaded, total gain is \(G = G_1G_2 = Aab/(a+b+s)\), see Fig. 3. If we now apply feedback in the same way as before we obtain

\[
V_{\text{out}} = \frac{V_{\text{in}}}{(s+a)(s+b)} \left[ 1 + \frac{\beta Aab}{(a+s)(b+s)} \right]
\]

\[
= \frac{V_{\text{in}}}{s^2 + s(a + b) + ab(1 + |\beta|AB)}
\]

The non-inverting configuration has...
been chosen to avoid confusion in signs. The open-loop gain for this cascaded amplifier has two poles, at a and b. To obtain a stable amplifier it is necessary that the open-loop gain diminishes by less than 12dB/octave at the intersection of the open-loop gain curve and the desired closed-loop gain line (broken line in Fig. 3). Supposing A and B to be large we thus have, with feedback, a stable amplifier in which we probably have reduced harmonic and intermodulation distortion to very low values and which has a very large closed-loop bandwidth.

**Dynamic considerations**

To see how transient intermodulation arises and thus how it can be avoided consider the voltage at point P (Fig. 2). The voltage \( V_p \) at this point is

\[
V_p = V_{out}/G_2 = \frac{V_{in} - \beta V_{out}}{A_0(b + s)}
\]

As a suitable transient signal we can apply a unit step voltage to the input, that is

\[
V_{in}(t) = \begin{cases} 0, & t < 0 \\ 1, & t > 0 \end{cases}
\]

The voltages \( V_p \) and \( V_{out} \) can easily be found as functions of time by using standard Laplace transform techniques. First we solve the equation \( s^2 + s(a + b) + ab(1 + \beta AB) = 0 \) to find the roots \( p_{1,2} = -0.5(a + b) \pm 0.5(a - b)^2 - 4ab\beta AB \). We then find, for \( p_1 \) and \( p_2 \) both real and \( t > 0 \):

\[
V_{out}(t) = \frac{AB}{1 + \beta AB} \left( 1 + \frac{p_1 e^{p_1 t}}{p_1 - p_2} - \frac{p_2 e^{p_2 t}}{p_1 - p_2} \right)
\]

\[
V_p(t) = \frac{A}{1 + \beta AB} \left( 1 + \frac{(b + p_1)p_2 e^{p_1 t}}{(p_1 - p_2)b} - \frac{(b + p_1)p_1 e^{p_2 t}}{(p_1 - p_2)b} \right)
\]

By taking the time derivative of these two equations we find that \( V_{out} \) is always monotonically rising with no overshoot, and that the derivative of \( V_p \) with respect to time is zero for

\[
t = t_0 = (p_1 - p_2)^{-1} \log \left( \frac{(b + p_2)/(b + p_1)}{(b + p_2)/(b + p_1)} \right)
\]

This means that for \( t_0 > 0 \) we must have a maximum in \( V_p \) at time \( t = t_0 \). This maximum value of \( V_p \) might be very large, and here is the mechanism that produces t.i.m. If the maximum value \( (V_{p_{max}}) \) of \( V_p \) is larger than the maximum voltage capability of the amplifier at point P, we get an overload situation in which the amplifier may be blocked for several milliseconds, thus causing severe intermodulation. Fig. 4 shows a plot of \( V_{p_{max}}/V_p(t \to \infty) \) versus \( a \) for \( b = 10^3 \) and \( b = 10^6 \) and for different values of \( \beta AB \). The value of \( V_{p_{max}}/V_p(t \to \infty) \) is approximately equal to \( \beta AB \) if \( a \) is large. To see why, let \( a \to \infty \) in equation 1:

\[
V_p = \frac{V_{in} A(b + s)}{s + b(1 + \beta AB)}
\]

With \( V_{in} \) a unit step voltage as before this gives

\[
V_p(t) = \frac{A}{(1 + \beta AB)} \left[ 1 + \beta AB e^{-10^4(1 + \beta AB)} \right]
\]

and \( V_{p_{max}} = (1 + \beta AB)V_p(t \to \infty) \), in agreement with Fig. 4 (cf also Fig. 5.

**Fig. 3. Gain vs frequency plot for the amplifier in Fig. 2; both axes logarithmic.**

**Fig. 4. Plots of \( V_{p_{max}}/V_p(t \to \infty) \) vs \( f_0 = a/2\pi \) (in Hz) for \( \beta AB = 10, 30, 100, \) and 300. Broken lines: \( b = 10^6 \), solid lines: \( b = 10^3 \).**

**Fig. 5. Gain vs frequency plot for the amplifiers in the example (logarithmic axes).**

**Fig. 6. Plot of \( V_{in}(t), V_p(t), \) and \( V_{out}(t) \) for two amplifiers with a step voltage input signal. \( V_{in} \) and \( V_{out} \) are the same in both cases; for \( V_p \) we have: solid line: case 1, broken line: case 2 (see text).**

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ref.1, for \( \gamma = 0 \). Thus for \( a > b \) we always get, for a step input, a maximum voltage \( V_a \) that is approximately \((1 + |A|B)\) times the steady state voltage at infinite time.

To eliminate t.i.m. we want to minimize or, still better, avoid this overshoot. One way to do this is to use a low value of the bandwidth and thus decrease the overshoot still further or even eliminate it by slowing down the rise of the input voltage, and in this way it is thus possible to design an amplifier with very low t.i.m.

There is, however, another way. If \( t_s = 0 \) we see that \( V_a \) rises monotonically to its final value and no overshoot or blocking is possible. From equation 2 we see that \( t_s = 0 \) is equivalent to
\[
(b + p)/((b + p)t_s) < 1,
\]
which is equivalent to \(a < b < (a-b)^{-1} |A|B\). Thus, if \(a < b\) no blocking can occur and no t.i.m. is generated, however small \(a\) is! This possibility seems to have been overlooked earlier.

Let us look at a simple example. Suppose that a two-stage amplifier has open-loop stage bandwidths \(a\) and \(b\).

We study two cases: case 1 \( a = 10^6, b = 10^8 \) (this resembles those studied in refs 1 and 4; it is shown as point Q in Fig. 4) and case 2 \( a = 10^9, b = 10^8 \). In both cases \(1 + |A|B = 2.1\). The gain v frequency plot in Fig. 5 describes both amplifiers equally well, and shows two things. The amplifier is probably stable and has a closed-loop bandwidth of approximately 30kHz. And secondly, as the amplifier open-loop bandwidth is only \(10^6/2e \approx 1.6\)kHz this amplifier might give rise to appreciable values of t.i.m., even if preceded by a pre-amplifier with 20kHz bandwidth.

Fig. 6 plots what happens if we apply a unit step voltage \( V_a \) to the amplifier input. (All voltages have been normalized to give \( V_o = V = V_{o_{in}} = 1 \) at infinite time). In both case 1 and case 2 we have the same \( V_{a_{in}}(t) \) and \( V_{o_{in}}(t) \), if the amplifiers have infinite voltage capabilities. \( V_o(t) \), however, differs strongly between the two cases, and we see that while the amplifier in case 1 might produce severe t.i.m. with a transient input, this is not possible in case 2. It should be pointed out that if the amplifier in case 1 was designed with this situation in mind and the gain \( A \) before the "slow" stage 2 was kept low, an overshoot of this magnitude might be within the voltage capabilities of stage 1 and thus no harm, that is, t.i.m., would be done in either case. However, from Fig. 6 and the preceding discussion it seems wise to let the first stage in the feedback loop determine the overall open-loop bandwidth.

**Conclusions**

A good design procedure to obtain a t.i.m.-free amplifier is given in refs 1-3.6. From the preceding discussion in this article, however, it seems that this procedure could be simplified. Simply stated: instead of designing the power amplifier for an open-loop bandwidth greater than that of the pre-amplifier, all that is needed to avoid t.i.m. is to let the first stage in the power amplifier determine the open-loop bandwidth. This bandwidth could then, theoretically, have any value; even with an open-loop bandwidth of \(1\)Hz we would still have no t.i.m.! On the other hand what should always be avoided is to let the last stage be the slowest, especially if this has a low gain.

Low first stage bandwidth could be obtained in several ways, for instance by input lag compensation; by using a very-high-impedance current source as collector or by using a very low collector current in the input stage. The low current technique has the advantage of giving at the same time very low input noise. One drawback is that the second stage in this case must have high input impedance and low input capacitance so as not to exceed the first stage output current capability and thus cause t.i.m. in this way instead.

The stages following the first can be designed using accepted "rules". Transistors should be run at high collector currents and voltages to give large overload margins and local feedback used to obtain a high bandwidth. Distortion can be reduced by using a symmetrical design. If the input stage bandwidth is not low enough to give a stable amplifier at the desired feedback lead compensation can be used to enhance stability.

By designing the power amplifier in this way it would also be possible to use larger amounts of feedback than in an amplifier relying only on a wide-bandwidth to eliminate t.i.m., and thus very low harmonic and intermodulation distortion could easily be obtained. However, this possibility should be used with caution, as there is always a possibility of current or voltage limiting at some stage in a real amplifier with heavy enough feedback.

No experimental work has been done on this subject yet because of lack of available time, but it would certainly be very interesting to see or listen to the result of some experiments along these lines.

**References**


HF predictions

Recurrent type magnetic disturbance is due on the last few days of both January and February. This series of disturbances started in August 1975, replacing a pattern of two disturbed periods per month which had lasted for two years. The new pattern started to break up in April 1976 but revived and is now the only series present.

The disturbances referred to are abnormal variations in the strength and direction of the earth's magnetic field which are usually accompanied by poor ionospheric conditions in temperate latitudes.
Satellite broadcasting conference

A conference opened on January 10 to attempt to establish a worldwide plan for satellite broadcasting in the 12 GHz band, now shared with fixed and mobile radio. "In certain parts of the world," said an ITU communiqué, "there is an urgent need to use frequencies in this band for terrestrial purposes." This reason was evoked in Resolution number 27 of the ITU plenipotentiary conference (Malaga-Torremolinos 1973) which led to the conference being held at the beginning of 1977. By holding the conference at an early date, countries wishing to use this frequency band for terrestrial services will be able to do so without causing excessive interference to, or suffering excessive interference from, stations in the broadcasting-satellite service which may be introduced later. Countries that do not intend to use broadcasting satellites for many years to come may be confident that suitable frequency channels and orbital positions will be available when required in the future.

The conference, held in Geneva and expected to last five weeks, will be administering more than the 11.7 to 12.2 GHz frequency band. Another "limited natural resource" besides radio frequencies is the geostationary satellite orbit. A previous ITU conference in Geneva in 1971 resolved that "all countries have equal rights in the use of both the radio frequencies allocated to various space radiocommunications services and the geostationary satellite orbit for these services and that the radio frequency spectrum orbit are limited natural resources and should be effectively and economically used."

Because the 12 GHz band is already shared the ITU administrative council asked all telecommunications administrations to submit their requirements for a broadcasting satellite service, including the area to be served, the number of channels, the television standard to be used and the hours of operation, to the International Frequency Registration Board. As a result the IFRB has prepared means of determining: the minimum required technical criteria for sharing; a frequency and orbital position assignment plan; and the interference likely to result from the use of such a plan. Characteristically, preparation for the conference has involved more committees than you could shake a stick at. Two CCIR study groups met in February and March, 1976 and four more in May and June. They in turn formed a "Joint Working Group" to prepare a report for the conference. Yet another working group, set up by yet another conference in New Delhi in 1970, is preparing yet another "comprehensive report" to help the present conference reach a decision.

All this is necessary to ensure that the result is a series of decisions which have the widest possible approval; behind each study group and working party is a plethora of more committees which, in the democratic countries at any rate, have been formed to see that each country gets its view, arrived at by wide consultation, across to the conference. In such matters, of course, that does not apply to the United Kingdom.

Unique optical link

Given the right pricing, optical fibres will play a substantial part in the Rediffusion radio and television cable distribution network. This was one of the consequences of the Rediffusion trial link at Hastings, described by A. E. Cutler of Rediffusion Engineering Ltd at a recent IEE lecture.

Low-loss step-index optical fibres are now available with a transmission capability of the order of tens of MHz-km, making possible television links over a kilometre long without the need for equalization. Whilst they have been demonstrated in the laboratory, the Hastings link was the first to be installed in a normal operational environment and was undertaken to obtain experience of the problems in this field. Rediffusion believe it to be the first optical link to serve the public.

The cable, drawn into ducts containing existing network cables, replaced a section of a vision trunk route feeding 34,000 homes. Although optical fibres have been made with attenuations of only a few dB/km, the only cabled fibres available in mid-1975 produced an overall link loss of 18dB, which was almost on the upper limit of acceptable loss for an 8.9 MHz carrier system to see that then current components. Because micro-bending of the fibres causes increased attenuation, BICC put the fibres in a hollow cavity between steel strength members, within a polyethylene tube. The fibre, a Corning germanium-doped silica type, has an 85µm core with 125µm silica cladding of refractive index 0.8% different.

The terminal equipment used a Plessey infra-red i.e.d. radiating several milliwatts, but coupling only 50µW of this into the fibre. Because of the non-linear current-light characteristic of the diode the drive waveform is predistorted by a feedback loop containing a non-linear element. Receivers used a 1-P-P-i-n diode and cascode preamplifier circuit with the low noise level of 0.9pA/√Hz. Improved devices have become available and been installed - the RCA avalanche photodiode with its a.g.c. characteristic - but Dr. Cutter felt that the p-i-n would eventually supplant the a.g.c. on account of their inherently higher noise level. (A p-i-n diode and bipolar preamp can give 5dB lower noise with 1pW of input power.)

Tv "sound" for the deaf

Anyone who doubts whether sound conveys most of the information in a television programme should try watching without the sound, then listening without the picture. For most programmes the deaf gain much less from television than the blind, who can, if registered, get £1.25 off the price of a television licence. The deaf are also deprived of the use of the telephone.

Defa-fax is a research and development group mainly specialising in the making and distribution of teletext decoders to enable the deaf and hard of hearing to receive visual subtitles, which they are pressing the broadcasting authorities to transmit. Although the electronics industry hopes that the cost of teletext decoders will fall as volume increases, just as the costs of calculators and digital watches have done, Defa-fax note that increased labour costs and taxation have driven costs up. "So it seems the greatest possible help can be given to the deaf either by self-employment or by volunteer skilled labour. Another alternative is to use deaf or disabled persons in either the skilled or semi-skilled aspect of the manufacture of the decoders or recruit skilled volunteer labour to complete the decoders." All the units will be for hire.

Defa-fax have decided to use the decoder design published in Wireless World beginning in November 1975. They have approached many manufacturers and suppliers to see if they can get components at a discount, though so far the only positive reaction has come from Orchard Electronics. Orchard, who are based at Wallingford, Oxfordshire, hold an electronics club every Friday night. According to Mr. D. M. Trueman of Orchard, "It is fascinating to hear the enthusiasm. Members include plumbers, bus drivers, farmers, video engineers, computer engineers, accountants and schoolboys. They
come 15 miles and more.” They have already built one Wireless World tele-
text decoder. Another Deaf-fax project is a video-writer, which enables the deaf
to “talk” to one another over a PO line
by using a keyboard and the television
set.

So far the interest of the BBC has
been very discreet, but it is understood
that the editor of the Ceefax service,
Colin McIntyre, is very interested in the
project, and the Royal National Insti-
tute for the Deaf and the National Deaf
Children’s Society may put their weight
behind efforts to persuade the govern-
mant to support a captioning service.
The NRDC has put the organisers in
touch with the inventor of CHIT, a
method of conveying freehand draw-
ings over telephone lines now commerci-
cially available as Datapad from Quest
Automation.

Similar pressure is being put on the
German government by the German
Society to support the hearing and speech
impaired.

Domestic “post fade”

Somewhat belatedly, perhaps, Philips
are promoting a special feature of their
N2219 cassette and N4506 reel to reel
tape decks. A press release describing
the introduction of what they have
called “post fade” was issued at the
beginning of December even though the
machines have been available, accord-
ing to Philips’s spokesman, since the
middle of 1976. This was a result of
pressure from the trade, he said. Dealers
had suggested that the “post fade”
feature was unique to the Philips
machines and ought to be more strongly
promoted. It allows users to operate the
erase head during playback so that
unwanted noises can be removed from
previously recorded material. The
amount of erasure can be controlled by
a slider which fades both channels at
once.

○ The term “post fade” is normally used
in professional recording circles to
describe the monitoring of a signal on
the speakers after it has been faded. The
alternative, “pre-fade” listen, indicates
that the signal heard will not be affected
by the fader, even though the signal
going on to tape may be faded. Post fade
has nothing to do with erasure, and
may be driven to conclude that they had picked
up a half-understood recording studio
term with which to overawe prospec-
tive purchasers.

What the Philips press release did
not say, although the spokesman said
the subject had been discussed, was
that to use what might better be called
“controlled erasure” effectively may be
difficult. The only way to know if an
unwanted signal is on the tape is to hear
it. It can only be heard if it passes over
the replay head, by which time it will
have travelled, on the N4506, two inches
on from the erase head which is
supposed to remove it. To remove the
signal the user would have to operate
the erase head some time before the
signal reached the playback head. At
the highest speed: 15in/s, this would
mean 2/10s before the mistake and at
the lowest speed 4/7s. The only accu-
rate way to do this is to mark the tape,
when the mistake reaches the playback
head, at a point exactly as far ahead of
the playback head as the erase head is
behind it. When this mark passes over
the playback head on the next pass the
mistake will then be over the erase head
and the erase head can be operated.

In recording studios the nearest
approximation to such a process is the
“drop-in”, where a section of freshly-
recorded material is slotted into a
previously-recorded passage during
playback. The junior member of the
recording team, the assistant sound
engineer or tape operator, pushes the
record button at exactly the right
moment to allow the tape to travel from
the erase head to the record head off
which the music is being played back. It
is a skilled operation, one that takes
a great deal of practice to do consistently
well. The facility on the Philips machine
seems a useful one, but whether it will
enable “the most amateur enthusiast”
to obtain the “professional results” they
claim for it may be open to argument.

More public US preparation
for WARC

The FCC have announced the appoint-
ment of an 8-person programme manage,
full-time staff of three engineers, three
economists and secretarial staff to a
special task force reviewing u.h.f.
frequency allocations. Pressure for
space in the 470 to 890 MHz band has
increased, since what was once a mainly
broadcast slot for high quality tele-
vision has now become increasingly
used for non-tv applications. According
to a report in the American trade paper
Electronic News, land mobile communi-
cations (470-512 MHz and 806-890 MHz,
the so-called 900 MHz region); offshore
telecommunications and industrial
(488-499 MHz, shared with u.h.f. channel
17); radio astronomy (608-614MHz) and
“government nuclear preparedness”
(470-546MHz) have all been allocated
to the band in the last few years, and now
the Office of Telecommunications
Policy has suggested that some of the
900MHz band should be allocated to an
expansion of the citizen’s band radio
service.

The task force will consider the tv
service to be provided; the needs of
those non-tv services seeking to use
part of the band; and an analysis of the
best means of reconciling the two. The
increasing use of the band has made it
necessary to study how satisfied the
public are with present u.h.f. tv services
and whether there would be a market
for a high quality set with higher
tolerance of the increased interference
that has resulted.

The support for the task force is
drawn from the FCC’s broadcast, cable
television, safety and special radio
services, the chief engineer’s and plans
and policies offices and bureaus, and
the FCC has also approved research
funds to help support the force’s work.

On the c.b. front the FCC has
found that some of the 40 channel c.b.
sets submitted to it perform so impressively
that they may tighten the specification
further. The minimum allowable har-
monic suppression may be increased from
80dB to 100dB. Television inter-
ference had led the Association of
Maximum Service Telecasters to ask

The British North Pole expedition is due to take place in 1977, and an exercise
was recently carried out in Greenland preparatory to the expedition. Here a
member of the expedition carries a personal survival radio, Sarbe 5, made by
Burndept. It provides distress beacon and speech transmissions on an aviation
distress frequency and speech on a second frequency selected by the user.
Electronic systems syllabus approved

The proposed 'A' level syllabus in electronic systems, which has formed part of the Wireless World series, has now received approval from the Schools Council to be run as a full Mode 1 syllabus. This means that it is now available to run in any school under the auspices of the Associated Examination Board (A.E.B.). The syllabus was compiled at the University of Essex by a team under the chairmanship of Professor C. B. Chatwin and comprises three main sections: processing, feedback and communication systems, and a section on systems components (see News, June and December 1975). Copies of the new syllabus can be obtained from the A.E.B. at Wellington House, Aldershot, Hampshire GU11 1BQ.

Teaching texts and experimental notes intended to support courses using the syllabus can be obtained from Mr R. A. Smith, Department of Electrical Engineering Science, University of Essex, Wivenhoe Park, Colchester, Essex CO4 3SQ. The teaching texts also provide further reading for the Wireless World electronic systems articles. Equipment recommended for a group of eight students carrying out the course experiments includes four oscilloscopes, six multimeters, eight stabilized power supplies, a television set and earphones. The course also suggests the use of a set of experimental boards and Locktronics equipment. The last-mentioned items may be obtained from Feedback Instruments Ltd, Park Road, Crowborough, Sussex TN6 2QR at prices ranging from £550 to £1000 depending on individual requirements.

A course being run by the University of Essex for teachers intending to teach electronic systems using the 'A' level syllabus will be held this year June 18-20. It will cover the Wireless World on the subject matter of the syllabus and on practical sessions, when teachers will have the opportunity to gain experience in doing the experiments. This course costs £26, including meals and accommodation, and applications should again be made to Mr R. A. Smith of the University of Essex.

Audio Fair optimism

The organizers of the London Audio Fair, lliffe Promotions, are much more hopeful that the event will go ahead this year (Olympia, September 12-18) than they were at the corresponding time in 1976. Last year the Fair had to be canncelled because of lack of support from potential exhibitors. In late December over 5,000 metres² of floor space had been earmarked by 32 prospective exhibitors. For demonstration of audio equipment a 3m x 6m studio has been designed and demonstrated. It is claimed to have acoustic characteristics equivalent to those of the average domestic sitting-room in which audio equipment is used, with a minimum of sound reaching the exhibition area.

Community television arrives

Channel 40, the independent non-commercial television service for the area served by the Post Office and the Milton Keynes Development Corporation, began a three year experimental period on December 19 with a message from Lord Harris, minister in charge of broadcasting at the Home Office. There has been increasing pressure in recent years to make technical facilities available to local groups or schools for producing their own programmes. Perhaps the best case was made in Anthony Smith's book The Shadow In the Cave, now just reissued in a new paperback edition. The philosophy behind the development is that the large broadcasting organisations are either not attuned to or incapable of providing for the needs of ordinary people in a community. Stations such as Channel 40 could provide a means of by-passing the broadcasters, enabling the television audience to communicate among themselves rather than be merely passive receivers of what is produced by those who think broadcasting should be used as a megaphone.

In Milton Keynes 10,000 homes are connected to the cable system, roughly one-third. By the end of the experiment it is hoped that that number will double, covering about half the population. Channel 40 has three producers, an assistant producer, a technical manager and a secretary. Many groups have borrowed the station's equipment to record their own programmes. At the moment the station will broadcast for an hour on Sunday evening, starting at 1800h, repeating the programme at the same time on Monday night, broadcasting a new programme on Tuesday and repeating that on Wednesday.

The Cable Television Association commented sourly on the experiment in their annual report, published in November: "It is understood that plans continue to be developed for a local community service on the cable television network at Milton Keynes, with funding from Development Corporations. It should be noted however that this service will have the support of public funds, something expressly forbidden by the Home Office to private companies for the community services pioneered by our members."

The report also notes that in the United States 15% of homes are connected to cable, a total of 10.8 million. In Canada the proportion is two-thirds, in Belgium 49%, in Luxembourg 30%, in...
Holland more than half, and in Switzerland 14% “In Great Britain, the country which pioneered cable television, cable systems operating on a speculative basis are now declining and are likely to do so whilst they are not allowed to do more than relay the broadcasters' programmes, and are subject to licensing by the Post Office.”

**Surround sound progress**

In an engineering press statement issued last August, the BBC said that “... little doubt remains that the BBC experimental matrix system, which is known as matrix H, is superior for broadcasting to other systems tested.” And more recently, a BBC engineering information sheet says that the matrix H gives “stereo and mono compatibility much superior to that of any of the systems previously examined.” The choice of words in both cases appears to have been deliberately picked to exclude systems not tested. Natural scientific caution, one might think. But witness also the recent BBC article in *EBU Review* which says that the decoded result can be made to match more closely that from a four-channel discrete system than is possible with any current commercial system...”

The word “commercial” here quite clearly excludes the one major system which has not quite reached the market place, but which its inventors believe offers advantages over matrix H.

The reason why the Ambisonic coding wasn’t included in the BBC’s most recent tests appears to be in part due to some disagreement over how it should be tested and partly due to the equipment not being ready in time. The developers would have liked it to be tested to its best effect but the BBC are more interested in how it performs under normal operational conditions. It is like testing five television systems in black and white, with four black and white sets and one colour, says Michael Gerzon. It may be that the colour set could come off worse had it been optimized for colour.

Though the BBC have no plans to start a regular surround-sound service, the recent statement says “... it would, in the light of its present knowledge, choose matrix H to encode the transmissions,” clearly leaving itself the option of changing. The Corporation plan to make pilot transmissions in the second half of 1977 (at which time decoder details will be published) but C. B. B. Wood, head of engineering information, made it plain that when it comes the public to buy new equipment in significant quantities they will be unable to change.

A recent demonstration of matrix H at Broadcasting House gave an elevated unstable centre front sound with precious little sound from the sides, and generally unconvincing reverberation was reported, due possibly to the non-linear circuitry. There were mixed views about the overall effect, ranging from very good to fatiguing. One listener after a Monteverdi piece remarked “I must be odd, quad doesn’t do anything for me.” (We were delighted to find that the nearest loudspeaker was not the most prominent, as often seems the case.)

The BBC matrix arose out of work by T. W. J. Clementson and P. A. Ratliff — details were given in Research Department report 29 in 1974 — in an effort to get a better mix of mono-stereo surround performance than existing codings offered at the time. But since their earlier work Peter Fellgett’s NRDC-backed Ambisonic scheme has been modified and developed with the help of Michael Gerzon to the point where Ambisonic must now represent the most advanced thinking in surround sound technology.

Matrix H is reported in the *EBU Review* article to give “very accurate directional information for a central stationary listener” but the sound sensation on normal programme material, although “ultimately pleasant,” is reported to be very close to the listener, i.e. sound images seem much closer than the loudspeakers. This, together with a loss of directional information away from the central listening position, no doubt prompted work on the peculiarly-named “logic-enhanced” decoder, which really means a programme-dependent decoding, to try and improve matters. Early experiments had used commercial decoders modified for the H matrix (Sansui’s decoders could be used with around 60° phase shift in one channel), but the recent statement says superior results have been obtained with a specially designed “one filter” decoder. It is hard to believe that Ambisonic’s non-linear Variomatrix technique.

The Ambisonic 45J coding, as it is called, uses a circle locus and can be improved by linear means — in particular by addition of a band-limited third channel, which nowadays is well within the capability of the disc record industry. It is argued that matrix H cannot be satisfactorily augmented in this way because its locus on the phase-amplitude sphere is a bent circle (*Electronics Letters*, 11 Dec 1975).

Although perfect mono and stereo playback compatibility are conflicting requirements, both H and 45J fall within fairly well-defined limits of acceptability. In the two channels with back attenuation in mono playback and phase difference in stereo, there is room for a range of balances. In mono, matrix H gives a total gain variation of 3.6dB over the 30° range of source angles and 2dB in stereo. The Ambisonic 45J gives slightly more variation in mono and slightly less in stereo. H is slightly wider than 45J. Phase difference for a centre front signal is 48° for H and 45° for 45J (hence its name), though it is claimed that H gives significantly more blurred images. (These figures are for optimal or kernel encodings; there is no difference for pairwise mixed material).

But the differences between Ambisonics 45J and other codes doesn’t just centre on the 2–3 channel augmentation (2½ means two channels at h.f. and three channels at l.f.) — the Cooper-Shiga UMX series also has this property and in theory the Sansui code could be a significant is about to be developed. It was built up over the last few years by the Ambisonic team has allowed major advances in microphone design for natural, surround use. In addition novel signal processing techniques for surround information have been developed, and criteria have been established for a family of frequency dependent “psychoacoustic” decoder designs that take account of listener-speaker distance and can be adapted to different loudspeaker layouts. And theoretical studies have provided and adapted the analytical tools needed to handle kernel systems as well as matrix systems (the distinction is one of a continuum of dimensions as opposed to a selection of a few of them).

A visit to Peter Fellgett’s experimental three-channel set up at his home a short time ago produced just about the most natural reproduced sound experience we have yet heard. At its best it was totally involving, much more so than any commercial surround-sound demonstration; they are more than that the writer had twice to be gently reminded it was time to leave; all too often one is glad to leave surround demonstrations).

The job they now have is to put down all they have developed and discovered over the years on paper — if only to make it available to its licensees. Already an agreement with one well-known manufacturer has been made, and its scheme is already being adapted to avoid curtailment of its existing coverage by introducing a third channel of information, but Michael Gerzon feels the possibility of adopting a 2/3-channel system ought not to be ruled out until more thorough investigations have been made. By using a reduced level and bandwidth limited third channel they believe it possible that the mono and stereo signal levels need only be reduced by half a dB. Of course, as David Mears pointed out, the service area of three-channel reception would then be considerably reduced. But the elegance of the hierarchical approach, as in the Ambisonic prototype, is that the extra channel can be deleted anyway and still maintain a surround performance, arguably better than matrix H.
Low-frequency generator
This waveform generator is based on the 8038 i.c. and provides sine, square, and triangular waveforms at spot frequencies of 0.1, 1, 10, 100 and 1000Hz. A steady bias may be added to the waveform so that the output is always one side of zero. The output will deliver up to 100mA and is short circuit proof.

The Motorola 1438 is used together with a 741 operational amplifier so that most laboratory loads may be driven. Resistors R1, 3 and 5 are adjusted so that the peak-to-peak amplitude of the three output waveforms are equal. Resistor R4 is adjusted to give a symmetrical waveform and R2 is adjusted to give minimum distortion of the sine wave output. Output amplitude is set by R6, and a d.c. level of between ±14V may be added to the output by R5. Frequency of the waveform is switched in decades by S3. The power supply should be rated at 150mA.

Graham R. Wilson, Gwent College of Technology, Newport.

Three coupled astables
This circuit produces three symmetrical square waves at 120° to each other. By inverting these, outputs at 60° can be produced. Three comparators from the MC3302P are used, and the device can be operated from 4 to 12 volts. With the component values shown, output frequency is approximately 17Hz.

L. J. Bell, Evesham, Worcs.

Binary state indicator
A simple circuit for displaying the four possible states on two binary lines uses four i.e. ds and one inverter which may be a spare gate or transistor. When x = y, A and B will have both sides at the same level and will therefore be off. Because y is inverted, C and D will have both sides at different levels, so one i.e.d. will be turned on. When x is opposed to y the reverse situation occurs.

David Straker, Dwyran, Gwynedd.
Peak and trough detector

In data-logging systems it is often necessary to measure the peak and trough of a waveform superimposed on a d.c. level. This circuit uses two i.c.s and offers acceptable performance down to about 10Hz. Measurements are made with a conventional d.c. voltmeter.

Input signals are fed to a precision peak detector, which outputs the peak voltage "max". The input signal is also passed through an active low pass filter and inversion amplifier, whose output at TP2 is the mean value. A differential amplifier subtracts the maximum value from the mean, to give the minimum value of the input. A compromise is necessary between response time and lowest operating frequency but the 100µF capacitor can be reduced for higher speed operation. The circuit is set up by shorting the input and adjusting R1 until 0V ± 1mV appears at TP1. Resistor R2 is then adjusted so that 0V also appears at TP2. With +5V ± 1mV applied to the input, R3 is adjusted until TP1 measures +5V ± 1mV, and R4 is adjusted until TP2 measures -5V ± 1mV. Finally, R5 is adjusted until +5V ± 1mV appears at the "max" output.

K. R. Brooks,
University of Bristol.

Grounded gate thyristor

A conventional p-gate thyristor can be triggered by a negative-going pulse as shown in the circuit. When a contact to earth is made via the switch, C1 applies a negative pulse to the thyristor cathode which reverse biases the diode. When the thyristor conducts, the diode is forward biased and only adds about a 0.7V drop. The diode must be rated for the full load current but need only be a low voltage device. In the author’s design, opening of the relay contacts causes the circuit to switch off.

D. Rawson-Harris,
Ferranti Ltd,
Manchester.

Small signal amplifier

There are two basic types of small signal amplifier, the virtual earth type as shown in Fig.1 (Linley Hood’s Liniac), and the high input impedance type as shown in Fig.2. In certain applications, such as a record amplifier, these two configurations can be economically combined as shown in Fig.3. This circuit provides several times as much gain as the Liniac.

D. Rawson-Harris,
Ferranti Ltd,
Manchester.
Sync-pulse delay

In t.v. broadcasting it is sometimes necessary to delay a composite signal. Passive elements can be used but these only offer delays of a few hundred ns. If a longer delay is required, several of these elements are used. This circuit replaces these passive networks and allows a variable delay up to 7.0µs.

C. M. Wong,
Kowloon,
Hong Kong.

"Telecomms industry needs reorganisation" — ASTMS

The erratic investment record of the Post Office, coupled with the reliance of the telecommunications companies on Post Office contracts, has led the Association of Scientific, Technical and Managerial Staffs to recommend, in a policy document on the telecommunications industry, the setting-up of a new publicly-owned company to manufacture telecommunications equipment. ASTMS is against either splitting the Post Office into a postal and a telecommunications corporation, or involving it in the manufacture of equipment now supplied by firms such as Plessey, GEC and STC. "Even though the postal side is more prone to make a loss than is telecommunications, there is no evidence that the overall financial performance of the two divisions operating as separate corporations would be better than their overall performance within one corporation. If there is any question of postal losses acting as a drain on the financial resources of Post Office telecommunications this would argue for more rational housekeeping techniques rather than a divorce." In any case, ASTMS argue, future technology will increasingly blur the distinction between the two forms of communication: "For example the growth of data transmission traffic will bridge the two operations." As to the widening of the Post Office's remit to embrace manufacturing, "The Post Office's poor record stems both from problems within its own organisation, particularly at senior management level, and from its relationship with the supplying companies. These problems cannot be solved by extending the Post Office's remit. ASTMS would rather see a complete overhaul of the way in which decisions are taken within the Post Office."

The telecommunications industry could only survive if it adopted "more dynamic strategies" towards its employees, the Post Office, research and development, investment, and marketing. "ASTMS believe that the only way that the industry can work successfully is for the government to take over the telecommunications sections of the supplying companies and form a new company." The government, through the National Enterprise Board, should have a majority shareholding in the new company, to be called British Telecommunications Ltd, which would carry out a plan agreed with the Post Office, the trade unions and the Government. "The idea of a company where the public sector has a majority shareholding, but which then operates sufficiently independently not to be come a victim of excessive bureaucracy and arbitrary state intervention, is not in itself new. Cable and Wireless Ltd is such a company, operating on the whole successfully." The new company would carry out research and development, design, manufacturing, and installation work, pooling the expertise of the various suppliers into one company. Money from the NEB could be used to manufacture and design components, a capital injection the need for which grows as telecommunications technology concentrates increasingly on large scale integration. ASTMS argue that, in the past, the Post Office has insisted on specifications which the suppliers know are unnecessarily detailed, which impede production, and which reduce the chance to export. For this reason BTL should be in a position to insist that the Post Office either orders equipment meeting international standards or pays a premium reflecting the true cost of making special equipment.

Throughout the document ASTMS emphasises the need to modernise and re-equip the telecommunications industry, and to speed up the progress towards all-electronic telephone exchanges even though this will mean, they estimate, a reduction of 80% in the number of skilled and semi-skilled engineers in the industry in the next ten to 20 years.

- Towards the end of November the managing director of posts, Mr Alex Currall, told a Coventry meeting of the Institute of Administrative Management that his personal view was that posts and telecommunications should be separated.
Nickel-cadmium cells

Experiments in reviving cells you would otherwise discard

by K. C. Johnson, M.A.

The use of nickel-cadmium cells in tape-recorders, pocket calculators and other "cordless" appliances is increasing rapidly. They owe their popularity to the fact that they are both rechargeable and sealed. This is possible because they contain a built-in chemical constant-voltage action, like a sort of zener diode, which enables them to continue to carry current after they have reached full charge with only a small rise in voltage and without any net internal effects. Thus they can operate satisfactorily when connected in series in a battery, no gases are evolved, no water need be added and, according to the manufacturers, they last more or less for ever.

Unfortunately, though, many users tell a different story and this type of cell has acquired a reputation for being unreliable and rather short lived. Since the cells are far from cheap this seems to be an unsatisfactory state of affairs, and the author wondered whether there was any simple explanation. It seems possible that there is, and that cells are being thrown away unnecessarily. Readers may like to help prove or disprove my theories. The secret seems to be to "treat 'em rough". The manufacturers get good life results when they test under severe conditions, while it is the cells that have an easy time that die.

In this type of cell the negative plate is cadmium. As the cell is discharged this material is oxidised from the metallic form to an insoluble hydroxide. The positive plate is nickel, but this is never in the metallic form at any stage. As the cell is discharged it changes from one hydroxide to another, both being insoluble. When the cell is charged both these reactions are reversed and metallic cadmium is reformed. This reversible process is associated with the normal voltage, of about 1.25 volts, between the plates.

If the charging process is continued after this reaction has gone to completion, the makers arrange that it is the nickel side which is exhausted first. Thus oxygen ions arrive but can find no material left to oxidise. They therefore form into oxygen molecules and go into solution in the electrolyte where they diffuse around the cell. In due course they reach the cadmium and are able to oxidise the metal. Thus current is carried across the cell by the recirculation of oxygen, which flows as negative ions in one direction and as neutral molecules in the other. Because of the pressure required to keep sufficient gas in solution the current in this over-charge state must be limited to about 0.1 C, the ten hour rate.* A voltage of about 1.30 V is associated with the recirculation process, so that it provides a very convenient limiting mechanism.

Over-discharge
If a cell is over-discharged, as can happen if it is the first to go flat in a multi-cell battery, then damage may be done. If the nickel side is again exhausted first, then damage may be done. If the nickel side is again exhausted first, as it normally will be, then hydrogen gas will be formed at a voltage a little below zero. Once formed into gas the hydrogen can never be recovered and represents a permanent loss of electrolyte. In some cells the makers put a bit of cadmium hydroxide in the positive plate alongside the nickel, and if this is done the cell will pass current at a voltage of almost exactly zero until this material is in turn exhausted and the generation of hydrogen starts. Clearly if all the cells in a battery are balanced within the appropriate margin the chance of damage will be much reduced. It would seem likely that a semiconductor diode connected across each cell could offer similar protection even if the cells were not carefully balanced.

What then is the mysterious mechanism that makes cells fail prematurely when they are given gentle treatment? It seems that the trouble is that cadmium, like zinc, is a metal that has a "hexagonal", rather than a "cubic", crystal structure. Thus, if it is allowed the choice, it will prefer to form crystalline whiskers rather than a smooth surface, and the atoms in these whiskers will be just a tiny bit, a few tens of millivolts perhaps, less chemically active than those in more randomly built metal. Although the electrolyte is alkaline, cadmium ions will still have some slight solubility and will be able to move about the cell in small numbers. Thus the metal will slowly form itself into crystals even if the cell is left idle, while gentle cycles of charging and discharging are likely to accelerate the process.

If these whiskers build up until they actually penetrate the inter-plate barrier they can obviously cause internal short-circuiting. But as soon as the current rises high enough to give a voltage drop down a whisker equal to the few tens of millivolts energy difference growth will cease. Each whisker thus provides a steady leak of a very small current only. When the cell is discharged, though, the growth can be resumed and a solid short-circuit becomes possible.

Normally the whiskers will grow as the cell is being charged, so that a cell in the early stages of the disease may behave perfectly well until it is perhaps half charged. The whiskers will reach across and bypass the current so that little further charging takes place. After the full charge time the cell is put into service and goes flat much too soon. It is said to have "lost capacity". Only later does it become obviously impossible to get any charge in at all and only then is the cell said to be "short-circuit". It will probably be thrown away as worthless.

Reviving process
If readers have any cells of this type that they are about to discard after this sort of trouble they might like to try to revive them by a process that I have used with some success. Make sure that each cell has the customary safety vent, or beware of explosions if a high gas pressure is generated inside. If a cell is open-circuit then it has probably lost electrolyte, due to leakage or excessive current in either direction, and there is no point in giving it this treatment.

Take each reject cell and apply the usual 0.1 C (ten hour rate) charge current to it. Watch the voltage with a meter, but there is no need to worry if

* See Appendix
This is because the most effective whisker removal action comes only when the oxygen recirculation process is established. The dissolved oxygen diffusing across from the nickel plate finds the troublesome whiskers first and will attack the cadmium in them. Any metal ions which may be formed are then driven back towards their proper electrode by the electric field. Even detached pieces of metal will be oxidized and so returned for further service. Only during overcharge is the field in the right direction to pack the cadmium down on its plate while the metal is being oxidized and may go into solution as ions.

More drastic
When a cell that was on the point of being rejected reaches the overcharge state, as several of mine have done, it can be considered to have been successfully rehabilitated. If a cell fails to respond to the treatment described, then, before you throw it away, try more drastic treatment. If it never made volts at all, try a larger initial current to "unstick" it. If charged but never reached overcharge, continue the bursts of heavy charge current until it is half full or even more before discharging it. The author has only been able to experiment on a very few cells of a single type. The experience of readers may help to improve the process and make it more successful.

In any case, if only a small fraction of the cells treated recover sufficiently to be of further service it will still be well worth trying, as the cells are expensive and the treatment is comparatively simple. The results may not be quite as good as new cells, but they may be very much better than scrap.

Appendix
Typical capacities and charging currents are as follows:

<table>
<thead>
<tr>
<th>Cell size</th>
<th>Capacity 0.1C current</th>
</tr>
</thead>
<tbody>
<tr>
<td>AA, R6 or U7</td>
<td>500 mAh 50 mA</td>
</tr>
<tr>
<td>C, R14 or U11</td>
<td>1500 mAh 150 mA</td>
</tr>
<tr>
<td>D, R20 or U2</td>
<td>3500 mAh 350 mA</td>
</tr>
</tbody>
</table>

Wires and reverse programme sound, forward and reverse communications, vision and sound cueing and synchronising pulses. The system used 60kbits of p.r.s. and Skilful codes, which memories the routing if the power fails.

An unnamed Arabian country has placed a Direction order for a satellite based system to enable computer data to be transmitted over h.f. links. It will be used in a data retrieval system consisting of a central, and a number of out-stations, offering data or voice communications between them and the central base. The order was awarded by a company called Scicon (Scientific Control Systems Ltd) to Racal Communications. Scicon was formed at the beginning of the year "to export and manage the skills of our resource companies in England and Germany in the Arabian Middle East."

The international Short-Wave Wave Club is conducting its tenth poll to find the most popular short wave broadcasting station. The poll has been held once every three years since 1960. The present one began on November 1 and will finish on February 28, 1977. Any listener may participate, though eligible stations are confined to those recognised by the ITU. A list of five stations in order of preference should be sent to Mr G C Gibbs, 118 Bournemouth Park Road, Southend-on-Sea, Essex, SS2 5LS. The 1974 winner was Radio Nederland, followed by the BBC.

A series of lectures on radio navigational aids begins January 19. Lectures, by Professor de Jonge, Amstel Navigation, Marconi-Elliot Avionic Systems, Redifon, and the School of Engineering, Merton Technical College, where the course will be held. Further details from Mr R B C Copsey, Merton Technical College, Morden Park, London Road, Morden, Surrey.

Automatic Control Engineering Ltd say details of courses at their training centre in Sidcup are available from Mr R E Lewis, Technical Manager, AGC Training Centre, Royal House, Station Road, Sidcup, Kent. The only qualification needed to enter courses is conversational ability in English. The centre specialises in "practical training and theoretical tuition of instrumentation and control engineering."

Largely because of the desire to receive British television, Irish viewers tend to be at the receiving end of cable relay systems. The Minister of Posts and Telegraphs, Mr M F O'Brien, has recently said that for those areas of Ireland unable to receive pictures so far by this method, the South and West of the country, there will be no difficulty in arranging for the signals to be relayed to them. The co-operative relay companies beaming the signals from Dublin will be charged £500,000 for the privilege — in direct contravention of the Berne Copyright convention.

Zaire has contracted with a French company for a national space communications network to broadcast radio and tv programmes over its territory and to supplement its telephone and telegraph links. The country already has radio and tv stations, microwave links and a satellite earth station linking it with the rest of the world. The work will be undertaken by Thomson-CSF and will consist of 12 satellite earth stations with 14.5m aerials. 16 tv transmitting stations, and additional complementary telegraph, telephones and television equipment. A repeater on one of the Intelsat satellites will be leased to Zaire.

African developing countries are to be provided with education and information through the French and German "Symphonie" communications satellites. The first earth station was installed in Kigali, Rwanda, late in 1976. It is relaying programmes from Cologne.

Announcements
Ritro Electronics (UK) Ltd has formed as a fifty-fifty partnership between Ritro Electronics bv, component suppliers of Holland and Belgium, and Tahoit Investments Ltd to distribute electronic components in the UK. Tahoit is a company formed by Peter Tagg (a founder and former managing director of GDS-Sales Ltd) and he is the major shareholder. Ritro is at Grenfell Place Maidanhead, Berks.

Syston-Donner have appointed Elektropan of Royston UK distributor for four of their range of pulse generators, the model 98, the 100A, the 110B and 110C.

NRK, Oslo, the Norwegian broadcasting authority, have ordered a £100,000 non-computerised routing control system from Prowest. The system provides switching for forward and reverse vision, forward

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Logic design — 2

Combinational logic

by B. Holdsworth* and L. Zissos†

Department of Computing Science, University of Calgary, Canada.
*Chelsea College, University of London

Two of the most essential features that must be met in the design of logic circuits are the imposed gate fan-in restrictions and hazard-free operation. Gate fan-in is the number of input terminals provided in a gate, i.e. the maximum number of input signals to a gate. Race-hazards are unwanted transient signals (signal spikes), which under certain changes of an input signal and with certain relationships of circuit delays appear in a logic circuit.

Combinational circuits can be constructed using AND, OR and INVERTER gates, NOR gates or NAND gates. It is possible to construct circuits using all of the above elements but such circuit configurations are not, at present, common. Circuits composed entirely of NAND or entirely of OR gates are generally more economical and convenient to use than circuits using AND, OR and INVERTER gates.

The truth table for a two-input NAND gate is shown in Fig. 1(a) and that of a two-input NOR gate in Fig. 1(b). A NAND gate can be used as an INVERTER if all except one of the inputs are tied to logic 1, a practice which, though not always necessary, is strongly advised. For example, if the input A of the gate shown in Fig. 1(a) is tied to logic 1, then the output of the gate is B as indicated by the entries in the bottom two rows of the truth table.

Similarly a NOR gate can be used as an INVERTER if all except one of the inputs are tied to logic 0. The remaining input then appears inverted at the output of the gate. In the case of the gate shown in Fig. 1(b), if input A is connected to logic 0 the output of the gate is B, as indicated by the entries in the top two rows of the truth table.

NAND and NOR gates can also be used to generate the OR and AND functions. For example, the output of a NAND gate driven by signals A and B is A B, which may be written as A + B, as shown in Fig. 2(a). The AND function can be generated by connecting two NAND gates in cascade, the first one generating the NAND function of the two input variables A and B, whilst the second gate acts as an INVERTER, as shown in Fig. 2(b). It follows that a NOR gate fed with inverted variables generates the AND function of the true values of the input variables, whilst two NOR gates in cascade generate the OR function of the variables fed to the inputs of the first gate.

Two levels of NAND gates generate a two-level sum-of-products expression, as shown in Fig. 3(a), which indicates the one-to-one relationship that exists between a sum-of-products expression and its NAND implementation. The reader's attention is drawn to the fact that the realisation of a minimal sum-of-products expression does not necessarily result in a minimal circuit. For example, the implementation of the "Exclusive OR" function f = AB + AB, which is a minimal expression, requires five gates, if inverted variables are not available as shown in Fig. 3(b), whereas the NAND circuit satisfying its non-minimal form f = A(A + B) + B(A + B) requires one gate less, as shown in Fig. 3(c).

In order to implement a function, such as f = (A + BC)E + (G + H)F using NAND gates, it is simpler to work backwards from the output gate. The equation is of the form PQ + RS, where

P = (A + BC) R = F
Q = E S = (G + H)

This type of two-level sum-of-products has already been realised in Fig. 3(a) and is repeated with the relevant input signals in Fig. 4(a). The input line G + H to gate 3 is the output line of a two-input NAND gate, whose inputs are found by inverting the variables G & H. Similarly, the input line A + BC to gate 2 is the output line of a two-input NAND gate, whose inputs are found by inverting the variable A and the product BC, as

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*Department
†L. Zissos

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Fig. 1. Symbols and truth tables for NAND (a) and NOR (b).

Fig. 2. The OR function using a NAND gate at (a) and the AND using NANDs at (b).
Boolean function first derive the NAND-circuit of the dual function and replace the NAND gates by NOR gates.

Example. Implement the function $f = AB + ABC$.

Dualise:

$$f_0 = (A + \bar{B} + \bar{C}) (A + B + C)$$

Express in Sum-of-Products form:

$$f_0 = AB + AC + AB + BC + AC + BC$$

minimising using the method of Part 1:

$$f_0 = AB + BC + AC$$

The NAND circuit of this function is shown in Fig. 6(a) and the NOR function $f = AB + BC + AC$ is given by replacing the NAND gates by NOR gates, as shown in Fig. 6(b).

**Hazard-free operation**

Race-hazards are unwanted transient signals (signal spikes) which, under certain changes of an input signal and with certain relationships of circuit delays, appear in a logic circuit. The NAND circuit of Fig. 7 shows a combinational logic circuit in which "spikes" are generated during a change of input signal $A$ from 1 to 0 when $B = C = 1$. The cause of the race-hazard is that immediately following a change in the signal $A$, $A = \bar{A}$ is either 0 or 1. Hence if a Boolean expression of a signal in a circuit reduces to either $A + \bar{A}$ or $\bar{A}A$, a race-hazard exists at the output of the corresponding gate, otherwise the signal is hazard-free.

In the example shown in Fig. 7, $f = AB + AC$ reduces to $A + \bar{A}$ when $B = C = 1$, revealing the existence of a race-hazard at the output of gate 4. Race-hazards in a circuit can be suppressed by preventing its Boolean expression from reducing to either $A + \bar{A}$ or $\bar{A}A$. This is achieved by the application of the theorem of race-hazards in Part 1. Hence

$$AB + AC = AB + \bar{A}C + BC$$

or, alternatively, expressing the same function as a product-of-sums

$$(A + B) (A + C) = (A + B) (A + C) (B + C)$$

The introduction of the third term prevents the first expression from being reduced to $A + \bar{A}$, since when $B = C = 1$, $AB + AC + BC$ now reduces to $A + \bar{A} + 1 = 1$. Similarly, the second expression, when $B = C = 0$, reduces to $(A + 0) (A + 0) = \bar{A}A.0 = 0$.

**Fan-in restrictions**

The implication of a fan-in restriction (the number of gate inputs) on the realisation of a Boolean function is equivalent to imposing a restriction on the maximum: size of the products and sums in the expression of the function to be satisfied. For example the direct realisation of the function $f = AB + AC + AD$ shown in Fig. 8 requires one three-input NAND gate, three two-input NAND gates and two single-input NAND gates, six gates in all.

If the fan-in restriction is two, implying the use of two-input NAND gates, there are two possible methods of
The restriction shown in Fig. 6 is dualized and implemented in NAND logic. This circuit is then converted to NOR gates to provide the required output.

Fig. 7. Mechanism of "spike" generation.

Fig. 8. "Direct" generation of $f = A B + A C + A D$ when 3-input gates can be unused.

rearranging the given function to satisfy this restriction.

Method 1: bracket two of the three products.
The function is $f = AB + A C + A D$.

The implementation of this function is shown in Fig. 9(a). It meets the fan-in restriction of two but requires eight gates, two more than in Fig. 8.

Method 2: remove a common factor.
The function can then be written $f = AB + A (C + D)$.

The realised form of this function is shown in Fig. 9(b). It meets the fan-in restriction of two and requires only four gates, two less than in Fig. 8. Alternatively the function may be written $f = AB + (AB + AD)$.

The implementation of this function is shown in Fig. 9(c). Again it meets the fan-in restriction of two and it requires the same number of gates as realised in Fig. 8. There is one further factorization of interest and that is $f = A (B + D) + A C$.

but this function has the same form as $f = A (B + D) + B$ and can be implemented with six NAND gates, the same number as in Fig. 8. Obviously the optimal implementation is given when the fan-in restriction of two had not been imposed.

A systematic method can be used to arrive at an optimal expression for a logic function which to be realised using gates with a specified fan-in. The method described is based on the use of the merging table.

For the case of NAND circuits the starting point is the irredundant sum-of-products expression of the function to be implemented.

$f = AB + A C + A D$

The function is dualised and the brackets numbered:

$$f_0 = (A + B)^{(1)} (A + C)^{(2)} (A + D)^{(3)}$$

Next the change in the gate count $\Delta N$, which occurs when pairs of brackets are merged is determined with the aid of the merging table shown in Fig. 10, which has been developed for the case when there is no increase in the size of the sum ($\Delta N = 0$) upon merging brackets.

Merging is the process described in the Fan-in theorem in the first article of this series, where two brackets are replaced by a single bracket i.e.

$$(H_1, + T_1) (H_2, + T_2) = H_1 T_2 + H_2 T_1$$

It is essential to note that merging does not affect terms which are present in both brackets i.e.

$$(I + X)(I + Y) = I + XY$$

To determine the value of $\Delta N$ the components of the two brackets are counted in the following manner.

$x$ = the number of terms in the smaller bracket, excluding common terms.

$y$ = the number of terms in the larger bracket, excluding common terms.

$n$ = the number of terms in the head section of the smaller bracket.

$l$ = the number of variables true or inverted counted in $x$ and $y$.

$t$ = the number of true variables in $x$ and $y$ such that for each

(1) its complement does not occur as a variable in any of the other brackets.
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Fig. 9. Bracketing two products in $f = AB + AC + AD$ enables use of 2-input gates but requires eight instead of six, as in (a). Removing a common factor again meets fan-in restriction to 2 inputs, with varying savings in number of gates, as seen in (b) and (c).

Merging 1/2 gives $f_D = (A + B)(A + D)$

redualising: $f = A(B + C) + A\overline{D}$

see Fig. 9(c).

Merging 1/3 gives $f_D = (A + BD)(A + C)$

redualising: $f = (B + D) + A\overline{C}$

Merging 2/3 gives $f_D = (A + CD)(A + B)$

redualising: $f = A(C + D) + AB$

see Fig. 9(b).

This part will be concluded with two examples, the first one demonstrating the process of minimal design using the merging table and the second one demonstrating the development of a minimal, hazard-free design.

Example 1 Design a minimal two-input NAND circuit to realise the following Boolean function.

$$f = AB + AC + AD$$

This equation is already in its minimal form.

Dualise: $f_D = (A + B)(A + C)(C + D)$

Attempt merging:

<table>
<thead>
<tr>
<th>b/p</th>
<th>n x y r t l i l i</th>
<th>ΔN</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/2</td>
<td>0 1 1 1 2 1 1 0</td>
<td>0</td>
</tr>
<tr>
<td>1/3</td>
<td>0 1 1 1 2 1 1 0</td>
<td>0</td>
</tr>
<tr>
<td>2/3</td>
<td>0 1 1 0 2 2 0 -2</td>
<td></td>
</tr>
</tbody>
</table>

The above tabulation shows that merging brackets 1 and 2 or brackets 1 and 3 does not result in a change in the gate count but that merging brackets 2 and 3 gives a reduction in the gate count by 2, which is the same result obtained working directly with the circuits in Fig. 9.

Merging 1/2 gives $f_D = (A + B)(A + D)$

redualising: $f = A(B + C) + A\overline{D}$

Merging 1/3 gives $f_D = (A + BD)(A + C)$

redualising: $f = (B + D) + A\overline{C}$

Merging 2/3 gives $f_D = (A + CD)(A + B)$

redualising: $f = A(C + D) + AB$

see Fig. 9(b).

Fig. 10. Merging table for $\Delta Z = 0$.

(2) it does not occur in its true form in a product within the expression.

(1) it is not repeated in the expression as an inverted variable.

(2) it does not occur in its true form in a product within the expression.

$N$ is the gate count and $\Delta N$ is the change in the value of $N$ caused by merging two brackets.

The quantities detailed above are tabulated below for each bracket pair of the dual function, $\Delta N$ being obtained from the table of Fig. 10.

\[
f_D = (A + B)'(A + \overline{C}')(A + \overline{D})'
\]
Derive an equivalent hazard-free expression that can be implemented minimally using two-input NAND gates.

If \( A = 0 \) and \( B = 1 \) the function \( f = \overline{A}C + BC \) reduces to \( f = \overline{A} + \overline{A} \) which is the condition for generating a spike when \( C \) changes from 1 to 0.

The hazard-free expression is \( f = \overline{A}C + BC + \overline{A}B \)

Dualise: \( f_0 = (A + \overline{A}C)(B + \overline{C})\overline{(A + B)^2} \)

Attempt merging:

<table>
<thead>
<tr>
<th>b/p</th>
<th>n</th>
<th>x</th>
<th>y</th>
<th>r</th>
<th>t</th>
<th>l-i</th>
<th>( \Delta N )</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/2</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>2</td>
<td>4 - 1 = 3</td>
<td>+ 2</td>
<td></td>
</tr>
<tr>
<td>1/3</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>2 - 0 = 2</td>
<td>+ 1</td>
<td></td>
</tr>
<tr>
<td>2/3</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>2 - 1 = 1</td>
<td>- 1</td>
<td></td>
</tr>
</tbody>
</table>

Merge 2 and 3: \( f_0 = (B + \overline{A}C)(A + C) \)

Redualise: \( f = B(\overline{A} + \overline{C}) + \overline{A}C \)

Implement, as in Fig. 12.

References


Mystery Soviet over-the-horizon tests

It is now common knowledge that a large portion of the h.f. band of the radio frequency spectrum has been suffering over the past few months from interference caused by a very powerful transmitter, or transmitters, located somewhere in Russia or the Ukraine. The interference became so bad that most of the communication services within the band have complained, through their respective organisations, to the Home Office and to the Frequency Registration Board of the International Telecommunication Union (ITU). Other countries (including the USA) who have been similarly affected by the transmissions, have also forwarded complaints to the ITU and the Russian authorities.

A Home Office representative recently informed Wireless World that they have made a complaint direct to the Russian authorities and have been told that they are conducting tests and are taking steps to reduce the interference.

What we, the public still do not know, and are not likely to be told, either by the Russians or our defence organisations and industries, if they know, is what these tests are for. We can only speculate, and perhaps the best way to do this is to study the information at hand and then compare it with systems which we know are within the realms of our present technology, or could be feasible.

Reports indicate that the transmitter is located in the area of Gomel, an industrial town in Byelo-Russia (see Pat Hawker's comments, November issue), and this, according to a recent Daily Mail report, has now been confirmed by NATO direction-finders. Monitoring station engineers agree that the actual powers involved are in the tens of megawatts and Mr Dafydd Williams, chief engineer of the BBC External Broadcasting is reported to have estimated them as 20 or 40MW or more, and audible in every part of the globe.

Some American publications have claimed that the interference was first brought to the attention of the Federal Communications Commission (FCC) in July, principally by radio amateurs. Mr S. A. Cook G5XBB of Intruder Watchtold Wireless World that the transmissions, which have a pulse configuration with a basic pulse-repetition frequency (prf) of ten per second, occur between about 5 and 22MHz, are widely scattered and appear to depend on the maximum usable frequency (m.u.f.) for propagation. For example, at dawn they can be expected between 14 and 22MHz and by 3 p.m. they may be at 14MHz or lower. When the interference first started it persisted for 10 to 12 hours at a time and, at one stage, completely obliterated the 14MHz amateur band. Another report, said to have come from the BBC, indicated that Cairo Radio had also been obliterated. However, a spokesman for the BBC monitoring station said that while this was an exaggeration the interference has been a considerable nuisance and has occasionally made monitoring impossible. Their experience of the interference was that it appeared at various times, on different frequencies and for varying durations within the range 6 to 15MHz.

A representative of the Home Office international monitoring station completed the picture by saying that the signals have been affecting frequencies from 4 to about 27MHz — almost all of the h.f. band.

Amateurs and broadcasters have not been the only ones to be affected by the interference; almost every service has been troubled — except the television services, which are on higher frequencies. Public services such as Post Office radio communications have experienced interference and so have h.f. maritime communications. It would be unrealistic to suppose that these high power signals have not had some effect on the h.f. military services too.

According to Mr Cook, the period of the 10p/s signal comprises a pulse train of up to 20 different squarewave pulses, some less than 2ms in length — an estimated pulse frequency of at least 800 pulses per second. Although the signals

Continued on page 68
Letters to the Editor

RE-INVENTION — HOW OFTEN?

The article on re-invention by F. G. Canning exemplifies his own thesis — that early inventions can be overlooked. He supposes that the Stentorphone of 1921 may have been the first loudspeak ing gramophone. But the Hon. Charles Parsons in 1903 patented the Auxetophone, which reproduced gramophone records audible "over the whole village"; and Parsons refers to an Edison patent of 1877 of a similar, though complic atedly crude, air relay amplifier.

Parsons' instrument was well designed, using a small movement on a 9-carat gold comb providing 7½ inches of controlled air slit for only 80 mg mass. Linearity was studied, and resonances were carefully kept out of the pass band. Thought was given to the self-cleaning of grit, but a later description remarks that the problem of impalpably fine dust was never solved (no electrostatic precipitator!)

The same air comb and horn were fitted by Parsons to stringed instruments. It is reported that an auxetophone-cello gave orchestral quality.

J. M. Littie
Welwyn Garden City, Herts.

References

WARC 1979 AND OFFICIAL SECRECY

You are to be congratulated on a bold editorial (December 1976) that touches on fundamentals in our country. Put simply, in Great Britain unlike for example the USA, the ordinary citizen has on radio or most other matters little or no right of access to much government information, even if it is not classified and he has paid to gather it. The situation may well get worse as we move closer into Europe with its traditions of subservience to bureaucratic power, and as the provisions of our own outdated secr ety laws are revised, not necessarily for the better. The basic principle may well become "can you produce a reason why you should be allowed to know?" as opposed to "can the civil servant produce any good reason why you should not know?"

There may appear to be little difference between the attitudes, and since some citizens have overall doubts of the patriotism of parliament and government alike, it could seem that the difference is small compared to this great problem. Given the basic premise that legislature and government are 100% for the continued wellbeing of the country and an unwillingness to delude themselves or prepared to put party, departmental, or personal, good above their country's good, then good sense and co-operation should and often does (since we still have some fine people in the civil service) produce the desired result. Unfortunately some of us have seen how insidiously conditions changed in the many countries of the pre-war world. We are now perturbed at what is happening here.

Moreover in radio at least there are other considerations. Any government decisions should be made with the wellbeing of the electronics industry in mind and this factor has all too often, in the past, been neglected, or even worse decisions have been neglected or made on wrong grounds.

Those who like to indulge in research into this aspect, could check on the late UK development of the second British long wave allocation, the non-use of crossbar switching, the virtual loss, for years, of any UK market for v.h.f. broadcast receivers. They might enquire what happened to the UK lead in h.f. cathode-ray direction finding. Had different decisions been made in such areas, the UK might have gained hundreds of millions of pounds in exports... But this is in the past, the UK must make sure such opportunities are not missed in the future. In order for this to happen there must be, as nearly as possible, an open forum on such matters, especially where frequency allocations. It should be possible, too, for decisions to be appealed against, preferably in the courts. When a decision is due to be made, this move should be published openly and an invitation cast out to all to have their say. The way not to do it is to form a clique of "yes men", and even worse to classify their discussions be they good or bad.

We must also enquire into another growing area for concern. Not only are we in danger that the conduct of radio affairs may come to be handled on a "need to know" basis within the UK. Such affairs can and are being discussed by a body "CEPT" — "Conference Européenne des PTT's" and this would interpose yet another bureaucratic barrier, for CEPT at present is, by its very terms of reference, a secret body. Its original purpose was a sort of club to discuss telecommunication tariffs — another restrictive system to which our UK delegates with or without governmental sanction, have to conform. Bad enough when they discuss tariffs, but quite unacceptable when such matters as marine single receiver allocations are under discussion, or to make radio policy for the UK, e.g. for the WARC. At least until they open their discussions — at least to users.

All this adds up to something like an FCC, a rather more popular idea, in some European government circles. They claim the FCC is lawyer ridden, too liable to lobbying. Perhaps so, but it is open. In the US the "spooks" and defence people have to settle their little games elsewhere — in the office of telecommunication policy, and what is left is open to the people.

As regards preparation for the WARC 1979, the FCC is required by law to publish open invitations for suggestions and has compiled several preliminary, but freely available, summaries of needs, given to them by people and organisations in response to their invitation. They also have met many associations of specialised users and included their demands for due consideration. Eventually their considerations will lead to a policy document open to all and with which, since it represents data for a continent, may be somewhat inflexible.

Secret formulation of a national policy makes the life of a WARC delegate much easier, but may not even have to ask anyone in order to be able to change. But the results could be catastrophic. Can the UK afford to lose another $100,000,000 for exports?

It has been said that the UK has much to contribute to the ELC in the way of administration, but unless it puts its own house in order in the radio field it can all too easily contribute to unnecessarily hindering the progress to more open regulation of telecommunications and radio in Europe generally.

In the UK for example, no open citizens' band is available, and so the UK has no part in this multi-billion dollar US market. Some say this shows a weakness of our industry, others consider that industry has never had a chance to get in from a home base. Meanwhile the gear is no doubt still being used illegally by bank robbers, and by governmental and nationalised bodies. Perhaps the real reason for the attitude is that our masters know that a people who can freely communicate are more likely to remain free, but they may not see this as a double bind.

Some spectrum conservers see their task as to restrict use, not realising that a frequency whose range goes down from some tens of miles to some few miles because of illegal use is better used than used illegally by bank robbers, and by governmental and nationalised bodies. Perhaps the real reason for the attitude is that our masters know that a people who can freely communicate are more likely to remain free, but they may not see this as a double bind.

We must also enquire into another growing area for concern. Not only are we in danger that the conduct of radio affairs may come to be handled on a "need to know" basis within the UK. Such affairs can and are being discussed by a body "CEPT" — "Conference Européenne des PTT's" and this would interpose yet another bureaucratic barrier, for CEPT at present is, by its very terms of reference, a secret body. Its original purpose was a sort of club to discuss telecommunication tariffs — another restrictive system to which our UK delegates with or without governmental sanction, have to conform. Bad enough when they discuss tariffs, but quite unacceptable when such matters as marine single receiver allocations are under discussion, or to make radio policy for the UK, e.g. for the WARC. At least until they open their discussions — at least to users.

Mr Driscoll's declared reluctance to prolong the discussion on aural phase sensitivity did not prevent him from leading off his December letter with a nice piece of misrepresentation. Firstly, the WARC, in the September Letters I wrote that Mr Moir, in his article "Phase and sound quality", had failed to define the relative phases of the sine-wave components of a complex waveform, and that that was "not good enough".

AURAL SENSITIVITY TO PHASE

Wireless World, February 1977
The result of the reverse play is to change all phase lags to phase leads and vice versa — a rather gross form of phase distortion but it does provide a starting point and the question of the additivity of phase distortion can then be accepted as one of degree rather than of principle.

Another point not so far mentioned at all is that if an input signal of varying frequency is applied to a phase-shifting network, the output will have the correct frequency v. time characteristic. In other words, a frequency modulation has occurred. The extent of this depends upon the rate of change of frequency v. time of the input signal and the rate of change of the frequency of the network. Various elements of an audio chain, such as pick-ups, filters, cross-over networks, loudspeakers, tape recorders and so on, can exhibit quite rapid rates of change of phase v. frequency and a number some portion of the pass-band. It is thus in principle possible that input signals exhibiting rapid frequency modulation (e.g. piano or guitar notes) might emerge from the system with subjectively noticeable frequency changes.

It has been obvious for many years that the piano is one of the most difficult instruments to reproduce with high fidelity. I once owned a famous brand of hi-fi amplifier, whose exact identity shall remain anonymous, but whose top cut filter whilst very effective, produced the most unpleasant side effects especially on speech and some types of music. Most of the sound of the filter performance showed frequency to be about as one would expect and harmonic distortion was very low. The only noticeable oddity was the phase shift which, due to the circuit design, was greater than it need have been for the response slope of the audio chain. Every single note produced by a piano or guitar, as well as by other musical instruments, is frequency modulated. The rate of modulation is high and as different harmonics are involved. Under ideal conditions the human ear can be sensitive to frequency shifts as small as one-tenth of a semitone. If the various harmonics of a complex transient signal were to differ by a different, but noticeable extent, then various inharmonic relationships might become apparent. Further, theory tells us that frequency cannot be reproduced without producing sidebands.

The whole situation is potentially very complicated and before embarking on detailed investigations we need to be quite clear as to whether distorted phase relationships are subjectively audible or not. Your previous correspondents have largely been concerned with the possible effect (often on static test signals) of absolute phase shifts. Personally I am questioning the effect of rate of change of phase on a dynamic frequency modulated signal.

I will leave it to the theoreticians to argue whether the unwanted frequency modulation I have postulated is synonymous with phase shift, or adequately regarded as time delay. They can also ponder the concept (not original) of instantaneous frequency. I regret that the more pragmatic pressures of my professional life will also prevent me from carrying out any calculations or experiments on this interesting subject in the foreseeable future. I hope therefore that readers will accept my word as being questions as much as statements, and not accuse me of claiming to have heard phase distortion whilst not being able to prove it.

A. G. Gorman,
Ruislip,
Middx.
has insufficient loop gain to oscillate (it fortunately has by a factor of about four) it will have a peak of a few dB.

All amplifier designs of this type have some sort of I.F. peak; it could be suppressed by increasing the 22Ω to 220Ω, thus reducing the feedback by 100 times, or best of all don't use any one of the f.s. peaks.

Actually the component values don't seem to have been chosen consistently: the input capacitor of 1nF has a --3dB point of about 1kHz but the decoupling capacitor has a --3dB point about 100kHz which is rather the wrong way round to achieve a proper control of the f.s. response.

Only one more eyebrow to raise on the input amplifier! I quote, "insufficient cut at frequencies above 10kHz" (to give the correct RIAA which should be 6dB/oct. fall from 2.1kHz to >50kHz). I shudder to think what is happening to this amplifier's phase response with all the 'tricky dicky' empirical networks hung on it. This really is the last straw:

Shall I go on to the I.F. amplifier? O.K., I will. But first some comments on the system.

I don't agree with the gain control where it is, the amount of gain following the RIAA is only 65dB maximum bass boost. No matter how good the noise performance of Tr1/Tr2 some I.F. hum and noise will be present at the output all the time. By all means vary the input preset so that the output cartridge is at a suitable level but the system volume control must be later on in the chain, or does Mr Self have another control on his power amplifier? The f.s. booster is a nightmare: why not use a selection of the perfectly good op-amps available (LA4571, TBA231)? Why use a design with an obviously wide bandwidth and enormously high gain to do a job that a lower bandwidth, lower gain (more stable) amplifier can do? There isn't, you see, the problem in this stage of lots of spurious spectral density and fast slew rates — this has all been removed by the input amplifier!

The design here has the following major problems:

1. The open loop gain depends on the transistor hfe (a very variable).
2. The open loop compensation is not calculated to ensure good transient response and/or stability. Is it calculated stability. Is it calculated?
3. The response of the network 270k + 22k (+1n//12nF) does not give anything like the correct I.F. response for RIAA. This stage will start to fall at 50kHz. 26dB at 6dB/oct. to 500Hz then flat to >20kHz. Mr Self's circuit, if he wants to know, starts to fall at 37kHz and falls at 6dB/oct. for 24dB.

Finally, the tone control is the usual "Baxandall" horror, for two reasons. The first, the lift and cut of +15dB is too large, giving audible phase shift problems, and anyway whose power amplifier can handle more than 100W?

The other reason is that the bass lift and cut varies both amplitude and frequency at once. On top of which there is the absurdity of providing selected treble roll-off frequencies alongside completely unknown and variable bass roll-off frequencies!

O.K. I am willing to accept the challenge, if Wireless World is, [Yes -- Editor.] I will describe my alternative version of preamplifier, with details of each design decision and performance objective.

Until then, Mr Self... 

A J. Watts,
S.G.S-ATES (United Kingdom) Ltd.
Aylesbury,
Bucks.

Mr Self replies:
To deal with Mr Watts' main points in the order he makes them:

He is correct in stating that the outputs from cartridges have high frequency peaks and large slew rates, and that this represents a potential problem in the design of RIAA- equalized decoupling networks however, if the treble cut portion of the RIAA curve is incorporated in the first stage, in the form of frequency-dependent negative feedback, the falling high-frequency gains ensure that the signal to noise ratio is substantially "tamed" and so enormous slew rates are simply not required; the open-loop bandwidth of the published disc input stage is quite adequate.

He is wrong in stating that the closed loop bandwidth is limited by the 1n5 input capacitor; this component, in conjunction with the associated 82Ω, resistor, forms an r.f. attenuation network to prevent break-through of radio signals, and has no effect within the audio band. This is because the input stage is in a series feedback configuration, and hence almost the same signal voltage appears on the emitter of the first transistor, in tandem with the output stage, via the high open-loop gain; hence at audio frequencies the capacitance is "bootstrapped" and has no effect.

Similarly Mr Watts is incorrect in saying that the input impedance of this stage will fall significantly at high audio frequencies. A.c. feedback is returned to the emitter of the first transistor, and not the base; this series feedback reduces the input impedance of the stage in accordance with the elementary laws of feedback, so that it has a negligible effect on the impedance seen by the cartridge, which is completely defined by the parallel capacitance of the cartridge and 22kΩ resistors. This gives a constant impedance across the audio band.

The first two transistors are not connected in a classic phase shift oscillator configuration; this requires three RC networks, not two. Hence the circuit cannot oscillate at low frequencies, though it is possible for diminishing phase margins at low frequencies to cause an I.F. hump, if the dc feedback time constants are poorly chosen. This is why the input and decoupling time constants are markedly different. I would prefer not to comment on Mr Watts' phase-shifts and frequencies as of course a single pole cannot ever give a 90° lag; it can only approach it asymptotically.

If a low gain input stage is used to allow a very high overload margin, then there will always be a problem in providing the stage to give less than unity gain at the highest extremes of the RIAA curve. The extra treble cut network (56kΩ and 6n8) does not alter the overall phase response, as its extra phase lag is compensated by the falling phase lag of the input stage due to the h.f. gain levelling out at unity. Since we are dealing with a minimum-phase system (in the sense of having no all-pass filters), then the amplitude/phase response completely defines the phase/frequency response. In other words, if the RIAA curve is correct, then the phase response will be indistinguishable from that of a more conventional circuit using only one treble-cut time constant.

And now to the next stage.

Mr Watts appears to have overlooked the system volume control at the end of the preamplifier chain; one can hardly have a volume control later in the proceedings than this. Since this control is used for day-to-day volume manipulation, and hence is rarely fully up, the residual hum and noise is attenuated with the signal, as Mr Watts suggests, and the desirable "zero noise at zero volume setting" condition is in fact attained.

If this stage is a nightmare to Mr Watts then I venture to suggest he will find trying to extract the same performance from a TBA231 even more of a bad dream. Integrated circuit operational amplifiers were not chosen as they give an inferior noise performance, due to the processes involved in integrating the input stages, and in general only accept lower supply voltages, hence giving less overload margin. As for the "major problems": 1. The open-loop gain certainly does depend on the transistor current gains. However, since this is the case for every amplifier ever built, I am unrepentant. To return to the laws of feedback, one of the prime motivations of negative feedback is to render closed-loop gain predictable by making the effect of open-loop gain changes negligible.

2. If Mr Watts can calculate the phase and gain stability margins of this stage, then I shall be interested to see his results. I find a flat assumption unconvincing and I imagine others will too.

3. If Mr Watts rechecks his calculations, or better still, measures the actual circuit instead of theorising, he will find that the combined response of the first two stages is very close indeed to the RIAA curve.

As for the tone control stage, I suggest it is probably impossible to design a tone control without phase shift.

As explained in the text, the variable turn-over frequency over the bass control is advantageous rather than otherwise. I fail to see how this makes the provision of switched treble turn-over frequencies "absurd."

In conclusion, I can only say that I would like to thank Mr Watts for the friendly and constructive nature of his comments. I can hardly wait to see his own preamplifier design.

---

CITIZENS' BAND IN THE UK?

I note with regret that R. C. S. Withers' organization (UK Citizens' Band Campaign) is advocating the use of 27MHz for a citizens' band service in the United Kingdom ("Letters" December 1976).

Such a service is essentially short range and therefore the selected frequency range should not be used for long distance communication when the maximum usable frequency is high.

A u.h.f. band remote from broadcast television and amateur frequencies would be a first choice. Alternatively a v.h.f. band could be used but there would appear to be many demands for the use of v.h.f. for other services.

There exists a Citizens' Band Association which is promoting the establishment of a v.h.f./u.h.f. citizens' band service in the United Kingdom. They have published proposals for a service, including a technical specification.

H. Turner, Derby.
Electronic systems — 6

More about reception and demodulation

by W. E. Anderton

A good a.m. receiver must be both sensitive and selective. To improve the selectivity of the receiver it is necessary to design sharp tuning characteristics. This can only be achieved by using more tuned circuits. The sensitivity can be improved by introducing radio frequency amplification prior to the demodulation stage. The tuned radio frequency receiver (t.r.f.) achieves these objectives by employing tuned amplifiers prior to demodulation. In general there are two, three or more of these tuned amplifiers in the receiver. The frequency response of this block of tuned amplifiers has a much steeper slope than that of a single tuned stage. This response is far more able to reject adjacent stations and thus the selectivity is vastly improved. The amplification given by each stage enables the demodulation of weak signals from very remote transmitters.

Fig. 1 shows the block diagram of a t.r.f. receiver capable of driving a loudspeaker. The dotted lines connecting the arrowheads show that the tuning of the stages is mechanically linked. If all the tuned stages were identical this mechanical linkage would ensure that in tuning over a wide frequency range the response curves of each individual stage would remain in step. This is referred to as "tracking".

The major disadvantage with a t.r.f. receiver is that the tracking is extremely difficult to achieve. To be successful the tuned stages would be required to track accurately over a large frequency range, say from 150kHz up to 10MHz.

Superheterodyne principles

The superheterodyne (superhet) receiver overcomes the tracking difficulties of a tuned radio frequency receiver. It employs amplification at a constant frequency irrespective of the carrier frequency of the received signal. These amplifiers are termed intermediate frequency (i.f.) amplifiers.

The i.f. is produced by multiplying the received signal with the output of an oscillator. The oscillator frequency is set a fixed amount away from the received carrier frequency. Part 4 (July 1976) described how two frequencies can be multiplied to produce sum and difference frequencies. The sum and difference frequencies become the input to the i.f. amplifier section of the receiver. Generally the i.f. amplifier is tuned to amplify the difference frequency and reject the sum frequency.

Most domestic a.m. receivers utilize the superhet principle. The intermediate frequency in common usage is 470kHz. A typical block diagram as shown in Fig. 2.

The multiplier circuit is generally referred to as the "mixer". The oscillator is termed the "local oscillator". If it is desired to listen to a programme which is transmitted on a carrier of 2.4MHz, then the oscillator has to be set at a frequency of 2.87MHz. The difference frequency produced by the mixer is at 470kHz and is subsequently amplified by the i.f. amplifier. The output of the i.f. amplifier is demodulated using similar circuits to those used in the crystal set.

Radio frequency amplifier

Fig. 2 shows that the input signal is partially selected and amplified by a tuned r.f. amplifier, prior to the mixing process. The reason for the inclusion of this circuit is as follows. Suppose that we wished to receive a transmission which has a carrier frequency of 1MHz. The local oscillator would be set at a frequency of 1.47MHz and the sum and difference frequencies produced by the mixer would be 2.47MHz and 470kHz. If there exists a transmitter with a carrier frequency of 1.94MHz, then the outputs of the mixer, due to the presence of this signal, would be 3.41MHz and 470kHz. The i.f. amplifier would amplify the 470kHz components from both of these stations. The result would be an intolerable interference from the second station. It can be seen that this state of affairs will exist for each station selected, and that the desired transmission will be received along with the signal from any transmitter with a carrier frequency differing by twice the i.f. value. To eliminate this source of interference the superhet needs a pre-mixing stage of r.f. tuning. This stage does not have to be highly selective and the bandwidth can generally be much wider than the transmission bandwidth. The bandwidth must be narrow enough to reject the unwanted signal. This technique is known as "image rejection". The r.f. amplifier is usually a single tuned circuit. It is desirable to have the r.f. amplifier and the oscillator tracking and thus maintaining the image rejection when tuning over the radio spectrum.

Intermediate frequency amplifier

In the t.r.f. receiver, selectivity was achieved by employing multiple tuned
circuits all of which had to track together over the radio spectrum. This combination of amplifiers had a combined frequency response curve which was very sharp and centred on the carrier frequency of the received signal. In the superhet the i.f. amplifiers are all tuned close to a fixed frequency which does not change when the radio is tuned to different transmitters.

The response of the i.f. amplifier is set at the time of manufacture and does not generally need to be re-adjusted. Most domestic receivers have three i.f. amplifiers. The resonant frequencies of the circuits are not all coincident, but are staggered either side of the intermediate frequency. This staggering produces a better response curve which more nearly matches the ideal curve. Fig. 3 shows the frequency response for an intermediate frequency amplifier along with coincident and staggered tuned responses.

**Frequency modulated receiver**

In Part 4, frequency modulation techniques were discussed briefly. Most domestic f.m. receivers use the superhet principle to achieve sensitivity and selectivity. One of the basic differences between a.m. and f.m. superhets is that the latter has circuits which are designed to have a much higher bandwidth. The higher bandwidths used in f.m. transmissions require the use of a higher intermediate frequency to achieve adequate image rejection in the r.f. amplifier. The i.f. is generally 10.7MHz.

**Demodulation of an f.m. signal**

The signal radiated by an f.m. transmitter has an instantaneous frequency deviation from a nominal carrier frequency, which is directly proportional to the instantaneous amplitude of the modulation signal. Consequently to demodulate the received f.m. signal requires a circuit which produces a voltage proportional to instantaneous frequency deviation. Fig. 4 shows the response curve for an ideal f.m. demodulator. The nominal carrier frequency is marked on the curve.

This characteristic can be approximated by operating on the flank of a tuned circuit's response curve. This requires tuning the demodulator so that the nominal carrier frequency is halfway down the response curve. Fig. 5 shows this characteristic. It can be seen that for small frequency deviations the frequency versus amplitude response approximates to a straight line.

Unfortunately a circuit of this kind would still be sensitive to any amplitude variations in the input signal. This problem is overcome by incorporating a limiting or clipping amplifier prior to demodulation. This limiter will provide a constant amplitude signal to the demodulator for a wide variation in input amplitude, thus ensuring that amplitude variations caused by noise or atmospheric attenuations do not reach the demodulator. Fig. 6 shows a block diagram of a typical f.m. receiver.

**Announcement.** See news item on p42 regarding Schools Council's approval for the proposed 'A' level syllabus to run as a full Mode I syllabus.
Further notes on the *Wireless World* teletext decoder

**Modifications and fault-finding**

by J. F. Daniels

In September, 1976, a new broadcast teletext specification was published which contains extra control character allocations and details of a number of other facilities to be offered by the service. This article describes some of the new facilities and also looks at the changes necessary to the *Wireless World* decoder to ensure correct performance under the new specification. Also, some of the more common problems experienced by readers building the decoder are considered, more advice being offered on fault finding and installing in domestic television receivers.

Since the earlier series of articles finished, I have received a large number of letters from people describing their experiences with the decoder and I think it may be helpful to other readers to mention some of the more common problems encountered. Constructors of the decoder can be divided into two categories: there are the computer engineers who have no trouble getting the digital side of the decoder functioning correctly, but have trouble interfacing it into their TV receivers, and there are the TV engineers who have problems with the digital circuits but no trouble installing the decoder into their TV sets!

**Fault finding**

Looking first at the problems associated with the digital circuitry, there appear to be only three recurring problems and two of these are not particularly common. By far the most frequent has been vertical jittering of the teletext display. This looks similar to an incorrect field hold adjustment on the TV receiver, but is, in fact, caused by incorrect dividing in the line-divider circuitry of the decoder. The fault is caused by poor noise immunity on the input to IC6, pin 3 (Jan, Fig. 1), due to too many volts being dropped across R6. The fault is simply cured by reducing the value of R6 from 470 to 270 ohms.

A somewhat less frequent problem, but one that has occurred on more than one occasion, is caused by the clamp pulse on the analogue board being too wide. If this pulse stretches into the start of the clock run-in, a large spike is generated at this point on the video waveform, causing incorrect operation of the automatic-slice-level circuit and results in very poor data separation. The fault seems to occur in cases where C10 (April, Fig. 3) is too large in value due to a poor tolerance component being used. The fault can equally well be cured, however, by reducing the value of R16 from 390 to 270 ohms.

Another somewhat infrequent problem has been due to the page header (row zero) occasionally being written into another row, as well as into its designated one at the top of the page. This is caused by decoding spikes on the output of IC2 (Jan, Fig. 6) causing incorrect loading of the row number information into IC2 (Jan, Fig. 1). The spikes are somewhat variable and will depend to some extent on the delay time through IC1 (Jan, Fig. 6). (It is best to use a 7493A in this position.) A very simple solution to the problem is to feed IC7 pin 9 (Jan, Fig. 6) from a different output of IC2, since not all the outputs will contain spikes; which ones do will depend on the various I.C. delay times. It is best to use as low a pin number as possible on IC2 since this will also determine the start of the line blanking waveform and if a later output of IC2 is used it may not be possible to make the blanking wide enough to encompass the full 40-character-wide row.

A more elegant solution suggested by one reader is to change IC1 for a synchronous counter such as a 74161. This cures any spikes on the outputs of IC2, but does involve some hard wiring on the p.c. board, the connections being rather different to the 7493. The clock and reset inputs are also inverted with respect to the 7493.

The above faults are the only ones which appear to have "recurred" on more than one or two decoders, but a few more notes on do's and don'ts and general fault finding methods might be useful. I make no apology for the fact that some of these points were mentioned in the original series of articles.

Use fairly thick connecting wire for the 0V and +5V rails between the power supply and the decoder to ensure that the I.C.s are working within their specified voltage limits. Any reduction in voltage to the I.C.s will cause their delay time to increase and may cause the decoder performance to suffer accordingly.

If a 'scope is being used to fault find, don't expect all the waveforms to appear as perfect square waves. Some people have spent a considerable amount of time chasing red herrings purely due to the fact that the 'scope they were using had insufficient bandwidth to display some of the faster waveforms correctly. In my experience, faulty t.t.t. gates either have no output at all, or else one of their inputs draws excessive current, causing the previous gate output to be reduced substantially in level. If the waveform appears to have "clean" transitions between about 0.5 volts and 3.5 volts the waveform can almost certainly be assumed to be correct. If the transitions are not clean, that is if there appear to be three distinct levels to the waveform rather than just the two previously mentioned, the reason is almost certainly that two different gate outputs have been shorted together. I would estimate that about 85% of the faults people have experienced have been due to either incorrectly soldered, connected-through holes, or to slivers of solder shorting together tracks on the p.c.b.. Faulty I.C.s seem to be fairly rare, and not nearly so difficult to locate as shorted p.c.b. tracks.

If the decoder does not produce the correct display when first switched on, i.e., random characters only in the correct display area, and the settings of the sync separator, horizontal shift and width have all been optimized, start by checking the line and clock dividers. It is not worthwhile spending a lot of time at this stage trying to see that all the timings of the waveforms are correct; if a waveform is present it is probably correct.

If line and clock divider waveforms are all present, then the fault is probably in the output circuitry between IC17/18 (Mar, Fig. 4) and the decoder output.
Once a display has been obtained, faults can be diagnosed more easily. When lining up the decoder in the "roll" mode it is essential that IC4 (Jan, Fig. 5) pins 13 and 14 are shorted together thus eliminating the effect of VR6 (April, Fig. 3). There is almost no chance of getting the decoder working unless this is done. Because of the fairly critical nature of the timing of IC7 (Jan, Fig. 5) it is advisable to use a polystyrene capacitor as the timing component of this monostable to prevent drift with temperature.

Although originally I said that I intended to describe an improved analogue circuit, the results obtained with the circuit already described have been far better than I hoped, often proving better than some commercial designs under similar signal input conditions. One possible improvement which might give marginally better results under adverse signal conditions, however, is to provide an adjustable delay of the clock signal relative to the data. This can be achieved fairly easily by connecting the gates of a 7404 in series and inserting 2, 4 or 6 gates in series with either the clock or data signal to see if any improvement in error rate can be achieved. I stress that I only consider this would make an improvement under adverse signal input conditions.

**Interfacing**

The problem of feeding the decoder output into the TV receiver are rather difficult to give detailed information on, because of the large number of different types of set on the market. One problem which has cropped up, however, occurs if the switching board is inserted at a fairly low-impedance point in the video amplifier circuits. This can result in "streaking" or trailing of the teletext characters which is caused by low-frequency loss in the decoder video path. If a higher-impedance point cannot be found at which to install the switches, then the coupling capacitors in the switching circuit should be increased in value.

Feeding a suitable video signal to feed into the decoder has been less of a problem than I anticipated, but there are still a few points worth noting. Use an emitter follower mounted in the TV could be transmitted on lines 14 and 15, for instance. Since the Wireless World decoder only checks the magazine number on the page header and not on all the rows of a page, the displayed page would contain some rows from the correct page and some from those currently being transmitted in the other magazine. The following modification, which does not require any extra i.c.s, will ensure that the decoder performs correctly if pages are actually transmitted in this way.

(1) Break the tracks leading to IC63, pin 10 and IC64, pin 13, joining both these i.e. pins to IC75, pin 8.

(2) Break the track to IC75, pin 3 and connect this pin to IC63, pin 4.

(3) Break the tracks at IC65, pins 8 and 9. Connect IC75, pin 2 to IC65, pin 9 and connect IC65, pin 8 to IC64, pin 9.

(4) Connect IC64, pin 10 to IC65, pin 12 and IC64, pin 8 to IC71, pin 8. (Parts 3 & 4 of the modification are drawn out in Fig. 1.)

This modification will ensure that the decoder is not confused when two different magazines are "interleaved". The "roll" mode will also function correctly when interleaved magazines are transmitted, i.e. only pages of the selected magazine number will roll through. The page header will, however, still read the headers from both magazines and this may be somewhat confusing. One modification which some readers have said they would like, is to have the page header continually rotating. (The page selected is indicated on the thumbwheel switches anyway.) This modification can be conveniently combined with one to allow the page headers of selected magazines to be displayed, as follows.

(1) Break the track leading to IC64, pin 5 (March, Fig.1).

(2) Connect IC64, pin 5 to IC71, pin 11.

The clock time displayed in the top right hand corner of the page will be continuously updated at all times irrespective of these modifications.

Although I originally only intended the "roll" mode to be an aid to lining up the decoder, it seems that some people find this a useful method of locating pages, and for this reason it is worthwhile describing a modification to prevent the Hamming-coded characters being written into the top, left-hand corner of the page, and causing the header to turn to graphics. This modification does not require any extra i.c.s. merely a switch with changeover contacts rather than the push button originally suggested. Remove the wire from the "select time" edge-connection and connect the wiper contact of the new roll switch to this edge connection. The wire originally going to this edge connection then goes to the "roll off" contact of the switch. The "select" contact of the switch should be connected to IC67, pin 8 (March, Fig.1).

Before going on to describe the new control codes and their functions there is one more modification which has been suggested by a reader which although I have never found to be necessary on any decoders is probably worth mentioning. This concerns the width of the write pulses fed to the random access memories. There are two conflicting requirements in this area, one being that a short write pulse is necessary to prevent its occurring during an address transition (due to internal address decoding in the r.a.m.) and the other that being an m.o.s. device, a relatively long write pulse is desirable. I originally tested over 200 r.a.m.s and found them all to work perfectly satisfactorily with the write pulse specified in the original circuit, and I was against making it any longer because of the possibility of it occurring during address changes at
some locations on the screen. There is also the problem of not being able to initiate the write pulse until after the parity checker has had a chance to decide whether the character should be written into the store at all. Despite these conflicting requirements I have never experienced any problems, as I said earlier. However, one reader has suggested the following modification which he found to be necessary.

1. Disconnect IC₃₀, pins 10 & 11 (March, Fig.1).
2. Connect the above two pins to IC₃₀, pin 13 (Jan, Fig.6).

This has the effect of increasing the write pulse length considerably, but it may also cause some of the problems mentioned above and I would therefore suggest that it is only tried if some problem with the r.a.m.s is experienced.

New control characters

The latest teletext specification contains a number of new display facilities which enhance the appearance of the display in the manner described below. It should be pointed out that these facilities will only be received on decoders with the extra circuitry necessary for each of the respective features. Unmodified decoders will still function correctly, but without the added features.

Graphics hold

This allows for the spaces normally occupied by control characters to be displayed as the previously transmitted graphics character. This allows abrupt changes of colour to be made in the graphics mode across a display row with a resulting improvement in the appearance of maps, pictures, etc.

Two characters have been allocated for this feature, the graphics hold character located at position 1/14 in the code table and the release graphics character at position 1/15 in the code table. Following the transmission of the hold character, subsequent control characters are to be displayed as the most recent character with bit 6 = 1 in its character code. (This allows the character to be displayed correctly even after characters transmitted in the burst through mode). The graphics release character implies that control characters are once more to be displayed as spaces.

Double height

Two control characters have been allocated to allow the display of some characters in the double height mode. The double height character is located at position 0/13 in the table, and the normal height character is at position 0/12.

Decoders which are capable of displaying double height characters must ignore any information contained in the row following one which contains a double height character. Characters following a double height character should be extended downwards into the following display row, while those following a normal height character should be displayed normally, on the first row only, of a double height pair of rows.

The switch between double and normal height may be made any number of times in a given pair of double height rows.

Separated graphics

Two more control characters allow switching during a row between the normal, contiguous graphics, mode and the new, separated graphics mode. Separated graphics characters are displayed with a boundary between the six separate graphics cells which can enhance the appearance of portraits and some other graphics pictures. The separated graphics character is at position 1/10 in the code table, and the contiguous graphics character is at position 1/9.

Background colour

This is in my opinion the most impressive of all the new display modes. Whereas the background of all normal teletext displays is black, two new control characters allow for the background colour of specified character rectangles to be any of the normal display colours. This is achieved as follows. Whenever the new background control character (position 1/13 in the table) is detected, the background of following characters is switched to be the same as the display colour currently in force during the detection of the new control character. This implies, of course, that the display colour must then be changed before transmitting any new information. (Otherwise the characters would be the same colour as the background and therefore invisi-

ble.) This facility not only allows alphanumeric characters of any colour (except black) to be displayed on a background of any colour, but also graphics characters may be displayed on any colour background without any intervening black spaces even around graphic cell boundaries. (The graphics hold mode only allows direct colour changes between character rectangle boundaries.) Also, new flashes and subtitles may be inset into the tv picture with a "box" colour other than black as at present.

The "black-background" character located at position 1/12 in the code table allows the normal background to be restored during a display row.

Corrections to circuit diagrams.

Jan. Fig. 5: Pin 1 of IC₁₁₀, is CLR not CLK.
Feb. Fig. 1: Data input B to IC₁₁₂, is pin 2 fed (81, 9).
Feb. Fig. 4: Pin 13 of IC₄₀₀, (chip enable) should be grounded.
March Fig. 1: Connection to roll switch from (71, 6) is omitted.
Fig. 5: Pin 9 and 10 on IC₄₀₀, should be interchanged.
March Fig. 4: IC₄₀₂, pin 2 is fed from output blanking edge connector.
April Fig. 3: IC₄₀₄, pin 12 is fed from IC₄₀₀, pin 1.
April Fig. 2: IC₄₀₃, pin +5V should be pin 24.
May Fig. 1: Inputs to CD4016 switches (IC₄₀₀, and IC₃₀₀) reading from top of diagram are:
                        
I would like to thank readers for their interest shown in the series of articles, especially those who offered suggestions for some of the modifications mentioned above.

Literature Received

Radio microphones and transmitters are the subject of a brochure sent to us by EDC. The transmitters, operating in the band 174·1-175 MHz, are of either the built-in or pocket type. EDC are to Leweston, Organford Road, Hefron Heath, Poole, Dorset BH16 6YU, W.W. 401.

Toroidal transformers from Avel-Lindberg are described in a new brochure. The transformers are rated from 15 to 130 VA at up to 48V and are contained in resin-filled plastic cases. The toroidal construction is said to reduce the stray magnetic field by up to the height of Avel-Lindberg, South Ockendon, Essex RM15 5TD, W.W. 402.

New entries in the winter catalogue from Heathkit include three speakers, a receiver with a digital frequency meter and audio distortion meters. The catalogue is obtainable from Heath (Gloucester) Ltd, Gloucester GL2 6EE, W.W. 403.

Silver mica capacitors from Matthey are tabulated in a leaflet, which provides brief mechanical and electrical data on all capacitors available. The leaflet can be had from Matthey Printed Products Ltd, William Clowes St, Hurstmere, Stoke-on-Trent ST6 3AT, W.W. 404.

A brochure from RCA Solid State gives basic characteristics of six c.m.o.s memories. Five r.a.m.s and a r.o.m. are described including three silicon-on-sapphire r.a.m.s. RCA Solid State Europe are at Sunbury-on-Thames, Middx, W.W. 406.

Helical aerials for u.h.f. and v.h.f. mobile transmitters and boot-mounting, whip aerials and bases are briefly described in two leaflets from the Panorama Radio Company Ltd, 73 Wadham Road, London, W.14 2LJ, W.W. 419.
The square wave signal from the SR line divider is selected by S4 and amplified in the motor-drive power amplifier to give an approximately 220V sinewave at 28.8 to 48.0Hz. In Fig. 12 the input signal is amplified by the common emitter stage Tr11 and a.c. coupled to the emitter follower Tr12 which feeds the primary of a small mains transformer, T1, used here as a phase splitter. The centre-tapped secondary paraphase feeds output transistors Tr15 and Tr16. The bias is set by RV11, and the collectors are connected in push-pull by transformer T2, which is a mains transformer reverse connected. The d.c. supply to the output transistors is switched by S4, the drum motor on/off switch. To obtain a near-sinusoidal output, the centre-tapped wounding of T2 is broadly tuned to 38Hz or so by means of the non-electrolytic capacitor C27; due to hysteresis the value has to be found empirically for the 1/4-line frequency (38.4Hz) with the motors both running — a typical value is 12µF. A safety bleed resistor R58 is placed across C27.

Clamp. In Fig. 12, if the drive into C24 should fail for some reason while S4 is made, the output stage could be damaged due to excessive current flowing through T2 and the output transistors. A clamp circuit is included to prevent this. A small portion of the current drive from the Tr12 emitter is taken via R5 and D11 to charge C26. When the potential on this rises, Tr13 turns on and shorts the base of Tr14 to ground, thus turning it off. Since the off resistance of the silicon transistor Tr14 is very high, there is no effect on the bias to the output transistors and the motor drive power amplifier acts normally. If the drive to Tr11 and hence Tr12 fails, no current flows from the Tr13 emitter and C26 discharges through the Tr13 base-emitter junction. Tr13 turns off, its collector potential rises and turns on Tr14. The wiper of RV11 is effectively shorted to ground, and the output transistors Tr15 and Tr16 are safely biased off.

Drum motor. Several motors were tried before a suitable one was found to turn the drum under controlled conditions. After a d.c. motor and its control system were tried, the speed/load performance of the inexpensive brush motor was found to be wanting, and the electronics became very complicated when improvements were sought. A stepping motor was found to be an ideal but expensive solution, and as a more economic compromise a small medium-torque synchronous motor was chosen. Philips make a moderately priced range of synchronous motors, and the model 9904-111-05-111 is suitable. This is a two-stator, reversible motor for use on a 220V 50Hz supply giving 250rev/min with a 3.3W input power and a 37.7 × 10⁻⁴Nm working torque (approximately 3.7gcm). The starting torque is 32.5 × 10⁻⁴Nm, which was marginal for the drum used, and therefore a little persuasion by hand is sometimes necessary to start it turning. A phasing capacitor of 0.12µF at 330V a.c. working was supplied with the motor and simple switching gives reverse direction running. For about £15 or so the motor performs well, the maximum equivalent pull-out rate being more than sufficient for facsimile machine use. With a supply frequency of 48Hz the shaft rotation is 240 rev/min. A suitable stepping motor is the Philips 9904-112-05-101 which has a maximum torque of 65 × 10⁻⁴Nm. This

Fig 12. Motor-drive power amplifier
would need a different drive system of course. Small quantities of Philips motors are obtainable from McLennan Engineering Ltd., Kings Road, Crowthorne, Berks. In passing, various clock-type synchronous motors designed for a 250 rev/min shaft speed at 50Hz were tried, but the torque ratings were too low and the motor either could not maintain even rotation of the drum, or stalled when the drive frequency changed.

Drum pulse sensor and amplifier. For phasing the edge of the picture, it is necessary to sense the picture drum rotation and the instantaneous position. In the prototype the sensing comprised a small piece of so-called "rubber magnet" cemented to the edge of the drum and a 6002D audio replay head from an old cheap Japanese pocket tape recorder placed nearby on a rigid mount. The magnet is similar to the narrow strip magnets used on refrigerator doors and on the backs of nursery spelling letters which are used on steel blackboards. Since the tape head was small and of light construction, cementing to a small metal bracket with epoxy resin was found to be the most expedient method of mounting.

The drum-sensing pulse amplifier (Fig. 13) is a simple three stage circuit. The gain of the two common-emitter stages TR1 and TR3 is set by RV12 and the output is taken to an external socket from the emitter-follower stage TR9 via C33 and via R68 to the light-emitting diode D13 to give a visible indication of drum rotation. The unstabilized supply is tapped from the +40V supply and smoothed by R67 and C33.

Strobe pulse generator (Fig. 14). This produces the strobing pulse which causes the light source driver, on SR pictures, to be off for a period, and to be on for a shorter period while just the picture line of part of the VIS or IR section is printed. The 0.8Hz signal from the divided clock-rate signal is a.c. coupled by C4, shunt rectified by D13 and applied to the trigger input of monostable IC2. The on-period is selected according to the line division in use by S3B, R3B, C5B and one of RV13, RV14 or RV15. This output is taken via R9 to limit the output current. A simple semi-stabilised +5V rail is derived from the +12V line by R3L, D14 and C52.

The light source is possibly the most specialised item of the whole machine. Since a tungsten filament lamp cannot be switched at the rate required for a weather satellite picture - at least 2kHz - due to thermal inertia, and since a Xenon flash tube cannot be brightness modulated at low output levels, the only practical devices available are the laser and the glow modulator. The latter was not considered for reasons of cost and availability and so the glow modulator was chosen. This light source, also known as a crater tube, is a cold cathode device with a narrow, hollow cathode which gives a high ionization density. The tube actually used by the author was the 1B59 which has an equivalent luminous intensity of 300 milli-candela at 30mA cathode current from a near point source 1.4mm in diameter. The striking voltage is approximately 128V and the maximum cathode current is 75mA. The tube has an octal type base, is the same size as a 6SN7/GT valve and can be mounted in any plane. The particular features which make it ideal for facsimile use are that it can be modulated at up to 1MHz, has a blue-violet emission (2870K colour temperature) and has an average life at 30mA of 250h. It is also inexpensive, being available in small quantities for about £1.5. It is made, amongst others, by English Electric in England and Sylvania in the USA, where it carries the equivalent type number R-1130B.

The British military type number is CV5207. Further technical information is given in ref. 8, 9 and 10, and qualitative tests on crater tubes in facsimile service is given in ref. 11.

The crater tube produces virtually a point source of light and requires a lens to focus it to a small spot. As the tube does not become hot when running it can be held by interference fitting in the end of a piece of thin-walled metal tubing of internal diameter 31.8mm. The lens can be mounted in a screwed assembly at the other end of the light tube. The inside of the tube should be painted matt black and an iris plate fitted to stop off-axis light, scattered from the glass envelope end wall, from entering the lens. A good quality short-focus compound lens should be used; cheap single element glass lenses were tried but the minimum attainable spot size was found to be too large. For a final picture 20cm or so square, the spot
diameter should be better (smaller) than 0.3mm. For example, the ESSA-8 picture has 800 lines per picture and a 200mm picture height, which is four lines per mm. The tube base has only two pins, but the spigot is of the international octal type and a normal i.o. socket can be used, the flange holes being used to mount an insulated safety cap (old aerosol can cap) to protect one from the +165V supply. When testing a crater tube remember that it is a negative resistance device, like a neon lamp, and that once struck will conduct to destruction unless a series resistive load is inserted in the power supply line. A series 60mA fuse, as mentioned earlier, is a wise precaution.

**Traverse motor.** It was found that the motor which traverses the light beam along the drum needs to be servo controlled rather than merely driven at a constant rate. Clock-type mains synchronous motors are readily available giving usable output shaft torques in the range 1.9Kgcm (26 ounce-inches) to 10Kgcm (139 ounce-inches) at 1 rev/min. Some manufacturers are: Crouzet in Brentford; Stirling Instruments in Crewkerne; Unimatic Engineering in London NW2 and Memotrace in Northampton. If heavier duty motors are required, professional synchronous motors can be obtained, at greater cost, from such suppliers as Philips, Evershed and Vignoles, TI Supply (Slosyn) and Walter Jones. In the prototype, the motor from a surplus elapsed-time indicator was found quite adequate.

The power supplies required for the electronics are +165V for the crater tube; +40V, +12V and +5V for the bulk of the electronics and -12V for the expander alone. In several places in the prototype the +5V is derived from the +12V rail for convenience. The +165V supply must have very low ripple if hum patterning is to be avoided on the final print. The author used an unstabilised supply with three pi-filter networks, each of 10H and +8 + 8F. Since the crater tube is a current fed device, a drop in the 165V rail with modulation is tolerable providing the mains ripple does not become greater than about 10mV pk-pk, and the voltage across the tube does not fall below the maintaining voltage – typically 130V. It is also advisable to use screened cabling to the light source and to include high frequency decoupling with feed-through capacitors.

**Mechanical construction**

The physical construction of the machine is generally straightforward and need not be described in detail. The parts which may present problems are examined below.

The **picture drum.** The physical size of the picture drum determines the final picture size. If standard size bromide paper is to be used without guillotining, the drum diameter should be chosen accordingly. The writer found it more economic to buy bulk bromide paper in rolls and to cut it to size. In spite of the bother of cutting, this meant that the drum diameter was not critical. When wrapping the paper around the drum, a few millimetres of overlap should be allowed to avoid edge-to-edge butting which can make it loose on the drum. Double-sided sticky tape is used to retain the paper. One strip of this will usually last for about 50 prints.

To allow longer sections of SR passes to be printed, the length of the drum should be about ⅓ times it’s circumference. The writer’s machine uses a drum of 6cm diameter by 30cm long made from Paxolin tube cemented to end plugs of lathe-turned aluminium on a 6mm diameter shaft. To avoid chatter, the drum shaft must be run in ball or roller bearings which should be kept in good condition and well greased. These should be held rigidly on solid brackets or plunger blocks, and coupled to the motor shaft by a semi-flexible spring-disc or metal bellows coupling. The motor should likewise be firmly mounted. Any vibration of the drum will show up on the print as patterning. The drum should initially be turned in a lathe between centres and finally a lathe tool should temporarily, be clamped to the traverse and used to dress the surface of the drum in situ. For the motor mentioned earlier, a drum weight of about 300 to 400g is optimum. It is important to see that the drum mass is evenly distributed radially, and that it is balanced.

The traverse comprises a sledge block running on two straight rails. The prototype used a heavy Paxolin plate approximately 18 x 8 x 2cm thick with two square-section slots 1.0 x 0.7cm milled across the width. The rails are 1.8 x 1.0cm rectangular-section brass rods, selected for straightness and surface planed for smooth running. The slots were milled approximately 0.15mm over width and the Paxolin rail immediately compensated, again, to improve running. The rails were mounted with the fixing screws in slotted holes so that they could be adjusted to lay parallel to each other. These were finally set and locked when the traverse plate could be pulled along the rails from end to end with a pulling force (measured on a spring balance) not exceeding 10g. Any tendency to stick gives uneven line spacing on the picture. Initially, a lead-screw was tried for the traverse drive. A good quality 1mm pitch (OBA) piece of steel studding was rotated between the rails, acting on a tapped brass bush in the traverse plate. This gave alternate cramping and stretching of the lines on the picture due, it was thought, to the thread being slightly skewed to the axis of the studding. No doubt with better engineering this method could be made to work since lathes work on this principle, usually with square-profile Acme-type thread lead-screws. However, a much simpler solution is to use roller end screws. As shown in Fig. 15, two identical rollers are mounted between ball bearings, and at the ends of the rails. At each end of the traverse plate a length of drive cord is attached, run to one roller, wound round twice, run back under the plate to the other roller, wrapped twice and run back to the plate and attached. One roller is driven by the motor and the other idles. If the roller diameter is chosen correctly for the traverse motor shaft rotation speed, the correct rate of picture writing can be achieved. For example, for a picture of height 20cm to be written in 200s (c.f. ESSA-8 real time picture) and using a 1
rev/min motor, the periphery of the drive roller must pay out 20cm in 20s, 6cm in 60s. The circumference must therefore be 6cm and the diameter 19.1mm. The advantages of this system are relative simplicity, equal pull on the traverse plate at each end, obviating skewing and jamming, and the ability to be able to return the traverse to the start position by hand. If a lead screw is used the engineering requirements to stop cocking sideways are severe and a method of disengaging the drive has to be found, unless the slow process of reverse running of the drive is carried out. With the roller system there is just enough slip for the cord to be run over the rollers if held and moderate hand force used. This does, however, tend to stretch the cord — ordinary radio dial drive cord. A better way to reset by hand is to use a clutch coupling between the driven roller shaft and the motor shaft. A very successful and very cheap coupling can be made from two 6mm collet-type potentiometer spindle locks. A short piece of hollow bushing from an old potentiometer should be cut off and used to lock the collets back to back. Both locking cones should be lightly put on and the device slid onto the end of the motor shaft. The cone on that half is tightened really hard and the drive roller bearings are clamped down. The other cone is tightened for picture writing and loosened for running the traverse back to the starting point. Although limit switches should be fitted to the traverse drive system to cut off the motor supply, the use of drive cord and a collet clutch will ensure that no harm can come to the motor or rollers if the switches should fail. For the production of SR pictures of different magnification by simple electrical switching, it was found expedient, with the dimensions given, to drive the feed roller directly for APT/WEFAX and to use a 2:1 step down drive to give a drive roller rotation speed of 0.5 rev/min. The synchronous running of both traverse and drum motors with this gearing gives the correct index of co-operation of the final pictures. A simple gearing using somewhat coarse gears was tried, but chatter bars showed up on the finished picture. A finer gear train was then used which gave satisfactory results. (The coarse gears had a diametrical pitch of 48 and the fine gears had a diametral pitch of 100, according to the train. Gear teeth ratios were as follows: motor-to-shaft 60:60 and shaft-to-roller 45:90, these numbers indicating the number of teeth on the gears). The light source assembly can be mounted on the traverse plate with large capacitor clips. It was found useful to put jacking screws under the clip at the lens end of the light tube so that the light beam could be put exactly on a radius from the axis of the drum. Although the spot of light is very small, adjustment of the spot height was found to affect the clarity of the final picture. The cable to the crater tube should be firmly clamped at both ends and should be flexible, to avoid hampering the movement of the traverse. It should also be screened to avoid undue pick-up. If a threaded lens mount is not to hand, a practical alternative is to cement or solder the outer shell of a redundant round multi-way cable socket to the end of the light tube. The lens can be made to push fit into the mating plug shell and this can be screwed in and out of the socket. Once focussed the thread can be locked with a set screw. The near obsolete military series of connectors MS/AN are suitable.

**Equipment housing.** For convenience the drum, the traverse and the two motors can be mounted on the top of an instrument case. The space required to produce pictures 21 × 25cm is about 50 × 15cm or so, since room must be left for mounting the bromide paper onto the drum. The electronics can then be built into the space below the mechanical items and the whole presented as one machine. Since the lens, traverse rails and the sticky strip on the drum must be kept clean, and to avoid stray light problems during printing, sides should be built up around the mechanical section and a lid should be fitted. The whole compartment thus formed should then be painted matt black to further reduce reflections. For rigidity it is recommended that the top plate of the instrument case is surfaced with a substantial sheet of metal — say, 5mm thick aluminium. Mountings can then be tapped into this, and it will allow removal and servicing from the top. The electronics drawer underneath should be removable and connected to the section above by multi-way plugs and sockets. Screened cables are recommended for the signal and motor supply lines, and these should be kept separate from each other.

(To be continued)
Transistor arrays

Practical circuits using transistor arrays are given in the latest set of Circards

by J. Carruthers, J. H. Evans, J. Kinsler and P. Williams, Paisley College of Technology

Integrated circuit amplifiers have a different internal structure to those constructed from discrete components. While the earliest i.c.s simply copied or adapted established ideas, more efficient use of the i.c. "real-estate" demanded changes in the design approach. Over the years many brilliant solutions have been found that exploit the characteristics of monolithic i.c. technology - in contrast to the earlier efforts that inevitably tried to get around their apparent disadvantages. We now have access to amplifiers, oscillators, regulators and the like, whose performance in many respects exceed the discrete circuits with which they compete. In cost terms i.c.s dominate over a wide front.

There remains a large number of gaps in this front, perhaps because the number of units needed is not large enough to warrant a separate i.c., but for which existing i.c.s cannot easily be adapted. Often this is because the operating conditions lie outside the range for which the standard i.c.s are designed. Examples include low or high voltages or currents, high or low frequencies, and circuits with non-linear or power law transfer functions. While each of these categories has been successfully tackled using discrete circuit designs, this article looks at a family of devices that using borrowed terminology might be called "naked i.c.s".

These are the transistor arrays which consist primarily of transistors and diodes with at most a few additional resistors. The configurations give a wide choice between flexibility and complexity. In the first category are i.c.s consisting simply of a set of identical transistors, while the last-mentioned is represented by circuits containing a mixture of n-p-n, p-n-p and super beta transistors already interconnected to form the input stage of an operational amplifier. In this article we discuss some of the transistor and diode arrays, outline their common properties and indicate how these properties are exploited. The set of Circards prepared to accompany this article, covers a wide range of practical circuits, from d.c. to high frequencies, linear and non-linear. It also contains a more detailed account of the characteristics, advantages and limitations of presently available arrays.

One of the earlier forms of array contained only diodes as shown in Fig.1. Although the code numbers given are for RCA devices, many manufacturers produce equivalents, particularly for the more popular packages. Others, notably Plessey, have changed the process used, while retaining some of these configurations. Using tighter control, over diffusion depths and doping levels, the transistor bandwidths have been pushed beyond 1GHz. This is particularly important in the design of wideband amplifiers where the improved frequency response need not be at the expense of good matching and low drift as needed for operation down to d.c. This combination of close matching and high speed is equally important in diode ring modulators and diode gating circuits, for which application the device of Fig. 2 is well-suited.

Another specialized area of operation is that of display driving. Using seven
segments to display any number from 0 to 9, the display devices may be filament or l.e.d., and the currents required might be up to 100mA per segment. In addition, the preceding drive circuitry may require common emitter or common-collector configurations. These options are indicated in Figs. 3 and 4 and it is interesting that the transistors can be accommodated in a 16-pin standard package leaving just one spare pin as a separate substrate connection.

This last point is important. From each transistor to its neighbour there is a possible conductive path via the substrate if the p-n junctions become wrongly biased. To avoid this the substrate is normally connected to the most negative potential in the system, leaving all the inter-device p-n junctions reverse biased. There the packing pin-count is insufficient, the substrate may be internally connected to one of the emitters. If a common point between the transistors is undesirable then the number of transistors that can be contained in a package is reduced by about 30%. Thus Fig. 5 shows five independent transistors plus separate substrate connection in a 16-pin package. Any mixture of n-p-n and p-n-p transistors can be similarly accommodated and Fig. 6 shows an example with three n-p-n and two p-n-p types. In early forms of i.c., the p-n-p devices that could be produced were miserable specimens with current gains barely in excess of unity. It took great ingenuity on the part of designers to incorporate the advantages of complementary operation, without destroying the overall performance. In these recent transistor arrays, the p-n-p the current gains are good (> 40) and the only serious limitation is the low gain-bandwidth product: < 10MHz as compared to the 200 to 600MHz range for some of the n-p-n devices.

If more complex functions are to be performed without recourse to larger packages, then a number of internal connections have to be made and Fig. 7 illustrates this point with seven semiconductor devices plus a separate substrate connection in a 14-pin package. The double current-mirror is useful in amplifier circuits, as an active load network for n-p-n transistors, to maximise their gain, possibly coupling the output into the Darlington pair.

As the reverse-biased base emitter junction breaks down around 7.5V with a temperature drift of 3 to 4mV/K, zener diodes based on these junctions offer the possibility of good temperature stability. This can be obtained by adding two forward-biased junctions each with a drift of around -1.9mV/K. A circuit incorporating transistors, zeners and diodes makes a convenient starting point for the design of regulated power supplies and similar power control circuitry. Fig. 8 shows an example of this type.

One of the more complex array i.c.s is shown in Fig. 9. The degree of internal interconnection is such that it might be fairer to describe it as a sub-circuit. It is particularly intended for high input-impedance amplifiers, since \( T_r_1 , T_r_2 \) are so-called super-\( \beta \) transistors having very high current gain. The processes which produce gains well in excess of 1,000 also bring the collector-emitter breakdown voltages to but a few volts. The biasing network must ensure that the p.d. across these transistors is severely restricted and the whole input stage is effectively bootstrapped with \( T_r_3 , T_r_4 \) withstanding the full common-mode input swing.

The i.c.s discussed so far have been bipolar types and it is worth noting that matched pairs of bipolar transistors are widely available and are convenient as low drift and/or gain-boosting input stages for operational amplifiers. The choice with m.o.s. devices is less wide. Again matched pairs and triples are available and these can be of advantage in devising high-input-impedance amplifiers. The best-known array in this area (CD4007) was designed as part of the first family of c.m.o.s. logic i.c.s. Although not characterised for linear applications it has been pressed into service on many occasions, with the result that devices are now available with the same configuration but with specifications more suited to the analogue field (CA3600). Presumably other combinations will be produced, particularly as recent op-amp designs show that the problems of producing m.o.s. and bipolar transistors on a common chip have been overcome.

Transistor arrays offer a challenge to the designer. Though standard i.c.s must reign supreme in the areas for which they are designed there are, and will remain, a number of applications to which they are not suited or for which they would not be an economical

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**Fig. 5**

**Fig. 6**

**Fig. 7**

**Fig. 8**

**Fig. 9**
solution. With care the advantages of both i.c. and discrete techniques can be used by tackling these problems with transistor arrays — combining the close tolerance and matching available from the monolithic process, with the flexibility normally associated with the use of separate transistors.

**Topics in set 32 of Circards**

Device arrays
- Triangular-to-sinewave converter
- Low-voltage square triangle generator
- RC oscillator with automatic amplitude control
- Emitter-coupled voltage-controlled astable
- Sine/cosine to d.c. converter
- Low-voltage astable
- Temperature stabilized chip
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- A.g.c. amplifier

**How to get Circards**

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3. waveform generators
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5. audio circuits (equalizers, etc.)
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7. power amplifiers (classes A, B, C, D)
8. astable multivibrator circuits
9. optoelectronics: devices and uses
10. micropower circuits
11. basic logic gates
12. wideband amplifiers
13. alarm circuits
14. digital counters
15. pulse modulators
16. current-differencing amplifiers — signal processing
17. c.d.s. — signal generation
18. c.d.s.—measurement and detection
19. monostable circuits
20. transistor pairs
21. voltage to frequency converters
22. amplitude modulators
23. reference circuits
24. voltage regulators
25. RC oscillators-1
26. RC oscillators-2
27. linear c.m.o.s.-1
28. linear c.m.o.s.-2
29. analogue multipliers
30. non-linear functions
31. digital multipliers
32. transistor arrays (available shortly)
33. differential amplifiers &c.
34. analogue gate applications — 1
35. analogue gate applications — 2

Continued from page 53

are very difficult to observe, even on a high-speed oscilloscope, he is convinced that there are as many as four sources all transmitting the same, or nearly the same, information, perhaps from different locations. What is equally interesting is that the signals are no longer remaining for periods of hours in one frequency band but are moving up and down the h.f. spectrum in about 100kHz steps, remaining at the chosen frequencies for 30s to 10min.

The use of pulse signals suggests either over-the-horizon (o.t.h.) radar or communications. In either case a complicated signal would be necessary to compensate for propagation variations, and this may involve the use of more than one source. The variations in carrier frequency could either be an attempt at remaining at the most propagatable frequency or they could be a security procedure. It is understandable that the Russians should wish to keep h.f. communications in addition to satellite communications using microwaves because, in the event of a war, the satellite is very vulnerable. However, it is not clear why tens of megawatts would be needed, even for communications to submarines.

Over-the-horizon radar seems to be far more probable. This is not new, the USAF and the Defence Advanced Research Projects Agency (DARPA) have been actively interested in o.t.h. radar for about 15 years and distances of at least 1850km are possible.

It is interesting to note that the frequencies chosen for o.t.h. radar are normally between three and 30MHz. The system would almost certainly use o.t.h.-b. (backscatter) radar which depends upon energy reflected from the target reaching a receiver antenna array via ionospheric reflections. Radar of this kind is often ineffective within a certain skip distance from transmitter. This may explain why an American radio amateur visiting a Soviet amateur organisation as a representative of the ARRL was told that their amateurs were unaware of any high power transmissions from their country.

Systems using more than one radar source are also in existence today. These multiradar tracking systems use some of the signals received to update others so that the best estimate can be made of the target position. Although it is argued that 10p/s is too slow for tracking anything but ships, the higher frequency components within the basic pulse train could surely contain enough information for faster moving, smaller aircraft — especially using multiradar.

If the Russians are really being adventurous they could be testing a four-source system capable of detecting the actual shapes of their targets. Recent results in the study of electromagnetic impulse response of objects have indicated that the information required for the determination of the approximate shape of the objects can be contained in the low frequency range, where the wavelength is longer than the overall dimensions of the object. This means that the h.f. band could be used for targets from 120m down to 10m length or less and this would include the majority of aircraft and rockets. It is also interesting to note that the most troubled frequency (14MHz) corresponds to 20m, about the size of an aircraft.

The study showed that “below four frequencies are sufficient in most cases to provide reliable classification in the presence of substantial amounts of noise”. Using only four frequencies or less, the study showed that four aircraft models (F-104, 18.24m long by 16.6m wingspan, F-4, MiG 19 and MiG 21), scaled to approximately the same size, could be reliably identified. In comparison the distinction between winged rockets and other aircraft would be a simple matter.

Is it feasible that the Russians are testing a system which incorporates both o.t.h. radar and shape recognition by radar returns? The most likely targets for such a radar would be the US B-1 swing-wing bomber and the US Navy and Airforce cruise missiles (only 4 to 6m long). Positive identification of approaching B-1 bombers and cruise missiles would be a valuable asset to the Russian forces and would probably be worth any diplomatic embarrassment caused by interference with Western radio services during preliminary trials.

**References**

1. Intruder Watch is an organisation which monitors the amateur frequency bands and reports to the Home Office any persistent intruders within those bands. In the UK there are currently 22 observers reporting an average of 100 serious intruders per month in the amateur bands alone. Throughout the world the figures are nearer 1200 per month.
Digital angle modulation

2 — Comparison of methods

by R. Thompson, M.I.E.E. and D. R. Clouting, Ph.D., B.Sc.(Eng.)

When selecting a modulation method many factors have to be considered. The most significant of these (though not necessarily in order of importance) are:

- equipment complexity,
- noise performance,
- performance sensitivity to equipment design tolerances,
- the propagation characteristics of the transmission medium.

The equipment complexity required to implement the chosen method is obviously very important, since this will have a significant effect on the cost of the developed equipment. Similarly, to ensure that the equipment is "commercially viable" it is essential that, for a given degradation in performance, the permissible equipment design tolerances are maximized. This will result in equipment which can be manufactured and tested by relatively unskilled labour.

The noise performance, that is the signal to noise ratio necessary at the demodulator input to give the required error rate ($P_e$), is obviously very important since this is a major factor in determining the range of the radio link. In other words, for a given receiver sensitivity it will determine what transmitter power is required. The objective is therefore to select a modulation method which requires the minimum signal-to-noise ratio at the receiver to obtain the required $P_e$.

Due to the introduction of large numbers of new systems in recent years the frequency spectrum is becoming more and more congested. This means that the spectrum available to support new systems is severely restricted. Consequently, spectrum occupancy is likely to have a major influence on the choice of modulation method to be used in future systems. In general, spectrum economy can only be achieved at the expense of noise performance, which means that a compromise must be made.

The last factor, the susceptibility of the modulation method to external interference and the operating environment, is very difficult to quantify. This is primarily due to the fact that, in general, very little quantitative data is available upon which this performance can be compared. Consequently, no attempt is made in this paper to compare quantitatively the methods considered from the operating environment point of view. However, in general it can be stated that all angle modulation methods are likely to perform in a similar manner although four-level systems will be less robust than the equivalent binary systems.

Performance comparisons

During recent years considerable attention has been paid to the performance of digital modulation methods. The performance figures presented in this section are probably the most up-to-date available, having been collected from many sources, primarily by computer simulation.

It is obviously not possible to cover all the large numbers of angle modulation methods. The results included have been restricted to cover the following:

- binary and four-level f.s.k. with and without premodulation shaping,
- binary and four-level d.p.s.k. with and without premodulation shaping,
- four-level d.p.e.k.

In all cases the performance figures related to systems having the optimum design parameters derived in the studies published in references 1 to 4. These are summarised in Table 1.

Noise performance. Fig. 1 shows how the error rate varies with signal-to-noise ratio for each of the methods under consideration. The legends used are those given in Table 1. The signal to noise ratio ($s/n$) is defined as the ratio of the peak signal power appearing at the receiver input and the noise power.

![Fig. 1. Noise performance curves.](image-url)

### Table 1

<table>
<thead>
<tr>
<th>Modulation method</th>
<th>Legend</th>
<th>Receiver bandwidth</th>
<th>Frequency deviation ratio (H)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Binary d.p.s.k</td>
<td>2D</td>
<td>1.1</td>
<td>N/A</td>
</tr>
<tr>
<td>Binary d.p.s.k with premod</td>
<td>2DS</td>
<td>1.1</td>
<td>N/A</td>
</tr>
<tr>
<td>shaping</td>
<td>2DS</td>
<td>0.55</td>
<td>N/A</td>
</tr>
<tr>
<td>4-level d.p.s.k</td>
<td>4D</td>
<td>0.80</td>
<td>N/A</td>
</tr>
<tr>
<td>with premodulation shaping</td>
<td>4DS</td>
<td>0.5</td>
<td>N/A</td>
</tr>
<tr>
<td>4-level d.p.e.k</td>
<td>4DE</td>
<td>1.0</td>
<td>0.65</td>
</tr>
<tr>
<td>Binary f.s.k</td>
<td>2FS</td>
<td>1.0</td>
<td>0.65</td>
</tr>
<tr>
<td>with premodulation shaping</td>
<td>2FS</td>
<td>0.6</td>
<td>0.4</td>
</tr>
<tr>
<td>4-level f.s.k</td>
<td>4FS</td>
<td>0.8</td>
<td>0.5</td>
</tr>
<tr>
<td>with premodulation shaping</td>
<td>4FS</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: All parameters are normalised to the system bit rate.
Fig. 2. Adjacent channel rejection factor.

Fig. 3. Minimum channel spacing versus s/i ratio.

Fig. 4. Effect of filter bandwidth on noise performance.

contained within a bandwidth equal to the bit rate of the digital data being conveyed. The results for the binary and 4-level f.s.k. system have been derived from those published in references 1 and 2 and were obtained by computer simulation. Similarly, the results for the binary and 4-level d.p.s.k. and d.p.e.k. system have been extracted from those presented in references 3 and 4.

The results show that the noise performance of all the binary systems considered are likely to be within 1dB of each other. This tends to lead to the conclusion that, if a binary system is to be employed, noise performance is not an important factor in determining which particular method to use. The performance of the 4-level systems, on the other hand, vary considerably. This is due to the fact that their noise margin is considerably less than that of the binary system, which means that the difference in performance of the various methods is much more pronounced. The results show that the noise performance of a 4-level f.s.k. system is about 6dB worse than that of the equivalent 4-level d.p.s.k. or d.p.e.k. system. They also show that if premodulation shaping is employed in the d.p.s.k. and f.s.k. systems to reduce spectrum occupancy, a degradation in noise performance of 1 to 2dB will result. Whether or not this penalty is cost-effective will be dependent on the relative importance of spectrum occupancy and noise performance. It will be observed that when compared on a peak-power basis 4-level d.p.e.k. and 4-level d.p.s.k. with premodulation shaping give almost identical noise performance. This is to be expected since the two methods are simply variants of 4-level differential phase modulation, the difference being in the technique used to reduce spectrum occupancy. However, in the d.p.e.k. approach spectrum control is achieved by introducing amplitude modulation. This means that if noise performance is compared on a mean power basis d.p.e.k. is superior by almost 2dB. In some cases where mean power rather than peak power is the constraining factor this may be particularly important and make d.p.e.k. very attractive.

Sensitivity to design tolerances. The sensitivity of occupancy of each of the methods under consideration is compared in Figs. 2 and 3. The figures show how the adjacent-channel rejection factor and the permissible signal to interference ratio (s/i) for a given degradation in the P_s vary with the spacing between adjacent channels. The results have been derived from the same sources as the noise performance curves discussed above.

The adjacent-channel interference factor is defined as the proportion of transmitted power which will fall in the passband of a receiver operating on an adjacent channel. As such it is only concerned with the transmitted spec-
tions in the filter bandwidths from the optimum values given in Table 1. The curves have been prepared from results published in references 1 and 3. They show that, in general, the performance degradation is more pronounced if the bandwidth is reduced below the optimum value. The one exception is 4-level d.p.s.k. employing premodulation shaping (4DS). For this system the degradation is slightly more pronounced for increases in bandwidth. This is due to the fact that in a 4DS system a larger proportion of the signal power reaches the detector. The subject is fully discussed in reference 3.

Extrapolating the results given in Fig. 4 to the other systems under consideration (i.e. 4-level d.p.s.k. and 4-level f.s.k.), leads to the conclusion that in a 4-level d.p.s.k. (4DE) system the degradation is likely to be somewhat worse than illustrated for the 4D system. This is based on the fact that the 4D system is simply a 4DE system with no shaping. Since shaping is certain to make the system more critical this must be the case. It is not possible to estimate how much worse this is likely to be however. Similar extrapolations to the 4-level f.s.k. systems (4F and 4FS) indicate that they are likely to behave in a similar way to the 4D and 4DS systems.

Group-delay distortion. A parameter which can seriously affect the performance of any digital modulation system is the overall group delay distortion introduced by the transmission and receiving equipment. To date, few results have been published on this subject. Those available, most applicable to radio systems concern binary f.s.k. systems. These are fully discussed in reference 5.

The curve in Fig. 5 shows the noise performance degradation which can be expected as a function of the peak-to-peak group-delay variation over the receiver 3dB bandwidth. The curve indicates that for binary f.s.k. systems the degradation is not serious (~ 1dB) provided the peak group-delay variation is kept well below a symbol period. This is a much more satisfactory state than was originally anticipated before the results became available. The results of the study described in reference 5 also indicate that there is good correlation between the peak-to-peak variation in group delay and noise penalty. In other words, for a given peak-to-peak group-delay variation, the results show that the same noise penalty will be incurred whatever the group delay profile.

The effects of group delay distortion on binary d.p.s.k. and 4-level systems are more pronounced than for binary f.s.k.

Frequency stability. Fig. 6 shows the effect of system frequency stability on the noise performance of binary f.s.k. and 4-level d.p.s.k. and d.p.e.k. systems. The horizontal axis represents the total frequency offset from all long term causes at both ends of the radio link. The effect of short term stability (i.e. synthesizer phase jitter) cannot necessarily be deduced from the results presented, although an indication of its effect can be obtained if the r.m.s. value of the short-term offset is considered equivalent to a long-term frequency error.

The results for the f.s.k. have been extracted from those published in reference 5, while those for the 4-level systems have been obtained from reference 4. They indicate that the required frequency stability for a binary system is approximately a fifth of that required for a 4-level system. In particular, for systems operating at 100MHz and conveying binary information at 20 kilobit/s, the required, overall long-term frequency stability to keep the noise performance degradation due to this parameter alone below 1dB are 1.2 parts in 10^6 for binary f.s.k., and 2 parts in 10^6 for 4-level d.p.s.k. and d.p.e.k.

Demodulator timing errors. It has been apparent for a very long time that the design of the phase-lock loop in the demodulator is one of the most critical aspects of any digital communications system. For this reason a considerable amount of theoretical and practical work has been carried out in this area. The results of some of this work related to binary f.s.k. and 4-level d.p.s.k. and d.p.e.k. systems are illustrated in Fig. 7. These show the likely noise performance penalties which will be encountered as a function of the timing errors. They indicate that for all three systems the performance degradation will not exceed 1dB provided the timing errors are kept less than a tenth of the symbol period. This may not always be easy to achieve with radio links because of other factors which affect the phase-lock loop design. However, practical results which have recently been achieved indicate that, provided care is taken in the design, no major problem exists.

F.s.k. deviation ratio. Fig. 8 shows how the noise performance of binary f.s.k. systems is degraded when the peak-to-peak frequency deviation ratio varies from the optimum. It will be observed that the degradation is not very great. For example, it is less than 1.5dB for a reduction of H from 0.7 to 0.5 (i.e. a reduction of approximately 30%). This is an interesting fact since by reducing H the spectrum occupancy of the system can also be reduced. It therefore may be possible to reduce the spectrum occupancy so that it is comparable with 4-level systems without degrading the noise performance significantly beyond that possible with 4-level systems. This means that, in many applications,
because of its simpler circuit configuration, binary f.s.k. may be preferred to 4-level systems even though there is a high spectrum occupancy requirement.

**Overall comparisons**

An overall comparison of the modulation methods under consideration is given in Table 2. In this table each method is given a figure of merit for each of the aspects considered. The right hand column gives the sum of the individual figures of merit for each method assuming equal weighting is given to each parameter. In such a case it will be noted that the overall figure of merit of the binary systems are significantly better than those of the 4-level system. The general conclusion can therefore be reached that if spectrum occupancy is not an overriding importance then, of the methods considered, binary f.s.k. and d.p.s.k. appear to be superior. On the other hand, if spectrum occupancy is of overriding importance then it is necessary to employ a more complicated method such as 4-level d.p.e.k. and accept the inevitable equipment implementation and noise performance penalties.

### Table 2

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### References


**Crisis in scientific and engineering education**

In the last six years the number of teachers taking part in the Royal Society's Scientific Research in Schools scheme has fallen from 111 to 47, according to the scheme's 19th annual report. "It is regretted that apparently so few teachers throughout the country are able to use the facilities offered." During the year the Royal Society made grants totalling £2,600 to support schools projects which included: the use of analogue computers and other control engineering techniques for teaching science, especially physics, in schools (Ampleforth College); solar noise at 150MHz (Gipsy Hill College, Kingston-upon-Thames); field emission microscopy of thin metallic layers (Highdown Comprehensive School, Reading, Berkshire); and investigation of the velocity of light from moving sources by an improvement of the method of Kantor (The Queen's School, Chester).

The scheme is supported by the United Kingdom Atomic Energy Authority and six companies, including Mullard and the Imperial Group.

The scheme's committee says in the report that they have tried unsuccessfully to publicise it. They are anxious to see applications of scientific merit which involve the pupils a great deal and which teach them that knowledge is largely gained by empirical enquiry. Less important, they say, is that a teacher may be doing work towards a higher degree. Projects may be suitable even though not fully worked out, not in pure science, and not lengthy. Even though the quality of the work done has been "high" the committee finds the declining numbers of those involved a matter of concern.

The Royal Society's report for the year to August 31 notes that on that date the number of projects was 45, a further reduction of two.

The publication of these reports coincides with a critical report on the training of engineers and scientists from the Select Committee on Science and Technology. The standards among graduates were low, industry told the committee, and they suffered from a "lack of industrial orientation," especially post-graduates. Yet again, industrialists who, two years ago, were calling for pay restraint, drew attention to "lack of incentive" for the best graduates to make a career in industry. More important, research objectives were considerably removed from industry's needs. The Select Committee recommends that the NRDC should become a body supporting high-risk applied research for which no commercial sponsor was available, that universities should be encouraged to set up liaison bureaux and form industrial consultancies, being free to exploit the results of their research wherever they wished, and that employees in industry wishing to co-operate with universities should be given time to do so as part of their normal activities. At the moment, as Wireless World pointed out in November 1975, most consultancy work carried out in universities is done by individual lecturers on a freelance basis who pocket some or all of the proceeds even though they are using equipment paid for from public funds.

**Post Office post**

Professor James Merriman, the Post Office's senior director of development, who retired at the end of 1976, was succeeded on January 1 by Mr John Stuart Whyte, 53. Whyte was vice-president of the Royal Institution for two years and had been the Post Office's director of purchasing and supply since June 1975. Elsewhere that he was director of operational programming and from 1968 to 1971 he planned the modernisation of local telephone exchanges which led to the adoption of TXE4 switches for large local exchanges. He began his career at Dollis Hill's Radio Branch where he worked on data transmission and pulse code modulation, among other things.
Computer-based analysis has led KEF engineers to a significant advance in speaker performance – the acoustic Butterworth (aB) filter network. Now, replacing conventional filter circuitry in the renowned Model 104, it transforms performance with reduced colouration, increased stereo depth and imaging. A difference you can hear. An advance radical enough to justify making the new network available for replacement in existing Model 104’s – see your dealer about this. Power rating is higher too – 100 watts programme – with fuse protection for the tweeter. So KEF engineers have seemingly done the impossible – taken the superb 3 speaker system that reviewers already praised for its clean, uncoloured ‘reference’ sound – and improved it.

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This year's biennial Munich show, claimed to be the world's biggest forum of its kind, had about 1,650 exhibitors from 31 nations housed in 16 halls. The most impressive (or depressive for the less athletic) aspect of the exhibition was its size, around 8½ acres of occupied floor space. This fact alone indicates West Germany's disregard for the "economic recession" scapegoat currently in use by less successful countries. Britain was well represented with 55 exhibitors, which placed us third in the league behind America and the host country.

Instrumentation

Philips were demonstrating several new additions to their range of test gear. The PM3243 storage oscilloscope, an extension of the 3240 family, offers a bandwidth of 50MHz, variable persistence dual trace, and a 40MHz multiplier. The last-mentioned feature can be used to display transient power waveforms by multiplying a voltage and current waveform. Three new timer counters, types PM6652, 24 and 25, are 50MHz, 520MHz and 1GHz instruments respectively with switchable a.c. or d.c. coupling. The 50MHz device features a hold-off facility, variable from 10μs to 100ms. This control is used to prevent false triggering when measuring a signal that suffers from contact bounce or ringing. All three of the counter/timers have several options including four types of internal oscillator, b.c.d. or analogue output boards, and internal rechargeable battery supply. Sensitivity of these counters is 20mV or 200mV and the trigger level is variable from −2.5 to +2.5V or −25 to +25V.

Also on show was the PM5716. This is a new pulse generator which will be available in the UK shortly. The instrument, which is suitable for both t.t.l. and c.m.o.s. circuitry, has a range from 1Hz to 50MHz with a rise time variable between 6ns and 100ms. An interesting facility on the 5716 is an output level clamp. Two vertical slider potentiometers set the upper output level to within ±10V and the lower level to within ±20V.

Systron Donner were exhibiting the 1702 synthesized signal generator which offers a single frequency range from 100Hz to 999,999MHz with a 100Hz resolution. A three digit l.e.d. display is used to indicate f.m. deviation, and modulation modes can be operated internally or externally. Output level is variable from 1V to 0.1μV. Also on the stand was the model 50 microprocessor analyzer. This box of tricks is basically an address and data bus monitor. The manufacturers say that it is functionally equivalent to a 32-channel logic analyzer, with most of the features tailored for microprocessor software/hardware debugging.

National, part of the Matsushita empire, have introduced a low distortion oscillator, type VP-7220B, and a complementary distortion meter, type VP-7702B. The oscillator offers spot and variable frequency signals between 1Hz and 99.9kHz. The distortion content is 0.002% between 50Hz and 50kHz, and the makers say that the typical value at 1kHz is 0.0005%. The 7702B measures total distortion down to 0.01% f.s.d. at any frequency between 5Hz and 150kHz. The frequency range is continuously variable up to 150kHz.

Another interesting exhibit from National was the VP-3702A memory monitor. This instrument looks like a television monitor but is an oscilloscope designed to display and record various electrical signals. The screen can display up to four waveforms simultaneously with a resolution of 8 bits × 512 words for each channel. Input data is plotted from right to left on the c.r.t. with no fade-out in intensity. A freeze button allows a waveform to be examined for one minute, and i.c. memories provide a flicker-free display even with slowly changing signals. The recently launched 7DO1 logic analyzer from Tektronix was publicly demonstrated for the first time in Germany. This unit is a plug in module for use with the 7000 series of oscilloscopes. Data is stored and displayed in three formats, 16 channels × 254 bits, 8 channels × 508 bits, or 4 channels × 1016 bits. Timing and binary information are displayed simultaneously, and the trigger point is marked with an intensified spot on each waveform in the timing display. A built-in word recognizer can also be used to trigger the analogue portion of the oscilloscope by producing an output when the logical states of the input channels match the states of the corresponding word recognizer switches. A filter, variable from 10ns to 300ns, inhibits the recognizer output to prevent triggering.

AEG-Telefunken have introduced a miniature c.r.t. suitable for "pocket" television sets or test instruments. Type DS-100 has a useful screen size of 40 × 30mm and an overall length of 116mm. The tube is equipped with a 35mW directly heated cathode and has a resolution for tv pictures, of 3MHz. Acceleration voltage is 2kV and the deflection coefficients are 53V/cm.

Semiconductors

A particularly interesting device on Toshiba's stand was the TMM142C 1024-bit non-volatile static RAM. This device is organized as 256 × 4 bit words. Each memory cell within the i.c. is composed of a conventional static p-channel m.o.s. flip-flop and a pair of metal nitride oxide semi-conductor (m.n.o.s.) f.e.t.s. This principle of charge storage has been known for some time and adopted in certain r.o.m.s. In conventional r.o.m.s. however, the m.n.o.s. devices suffer severe degradation because of the constant erasure. This problem has been avoided in the TMM142C by using the m.n.o.s. f.e.t.s only when there is a power down situation. The m.n.o.s. devices are in series between the driver and load f.e.t.s of the flip-flop, and in parallel with a p-channel f.e.t. switch. When the device is used in the read write mode the flip-flops act as the memory cells and the m.n.o.s. f.e.t.s are switched out. If the power supply fails, the contents of the memory cells are transferred to the respective pairs of m.n.o.s. f.e.t.s and this information is stored for at least one year. When the voltage returns the data is transferred back to the conventional memory cells.

External circuitry is used to detect the power on and off timing, which is arranged to be a ramp function, and generate pulses to operate the f.e.t. switches. Using the NR input, data

Tektronix's 7DO1 logic analyzer stores and displays data in three formats.
stored in the m.n.o.s. devices can be read out at any time during the normal power-on state. The chip is housed in a 16-pin d.i.i. package and we understand from Toshiba that the device is in volume production.

General Instrument Microelectronics announced the PIC1640 programmable interface controller for use with the CP1600 system. This microcircuit can be programmed to perform the timing, data formatting and control operations for one of several peripherals. The device is basically an eight-bit microcomputer, and any number of the devices can be interfaced to a system bus. Internally, the 1640 is composed of 32 addressable 8-bit registers, an arithmetic logic unit, and a control r.o.m.

Another new device on display was the Ay-3-9880 tone decoder. This device can be used in private PABX tone signalling exchanges for interfacing to Strowger external exchanges. Although not new, the Ay-5-8100 video games chip was also shown. GIM say that they are now the world's largest supplier of these i.c.s and about 5 million of their devices have now been produced since production started about one year ago.

Motorola was able to give Wireless World preliminary details of a new monolithic two-chip 8-bit microprocessor system which will be available around June 1977. The two devices, which are an extension of the standard MC6800 system, will be suitable for large volume usage. The MC6802 has an on-chip clock circuit, and a 128 x 8-bit r.a.m. with the first 32 bytes being retainable in the event of a power failure. The MC6846 contains a programmable timer module, input/output port and a r.o.m. The complete system offers 16-bit memory addressing, two interrupt lines, the option of expanding to 64k words, and t.t.l. compatibility.

Also on the Motorola stand was the new PDS "polyvalent development system", which has been developed in Europe. Basically, this provides a terminal and development system comprising a 5in v.d.u., keyboard, complete microprocessor board, display interface board, and connecting cables. This package is priced at below £1000 and allows the user to develop simple programmes or just gain experience. The only necessary item that is not included is a power supply. The next step is an optional printer which connects directly to the system and is priced at around £800. If the user wants to extend the system still further, larger memories are available, or, for the wealthy, a complete "exorciser" can be added. In this way the initial equipment does not become redundant.

Siemens were showing an interesting alternative to the ultrasonic remote controls currently used with domestic radio and television receivers. The system, known as SIRSYS uses two m.o.s. circuits, the SAB3210 and SAB3209, to transmit and receive an infra-red signal via several i.e.d.s and one photodiode. Binary coded outputs make channel identification via a seven or nine-segment display relatively easy.

A matrix of 8 x 4 buttons is used to select up to 31 instructions by merely combining the lines and columns. The receiver i.c. includes three memories and corresponding digital to analogue converters for variable audio levels like volume, colour-saturation and brightness. Supplementary features such as

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**Sixty Years Ago**

The recent (in February 1917) existence of Wireless World as the Marconi Company's house journal was possibly the reason for the somewhat wholehearted references to products from that source. A vacuum current meter was introduced by Marconi's in February 1971 and an extended "New Product" turned into a complete article on the device.

"The demand for a small, sensitive, robust instrument suitable for use equally on alternating and continuous current circuits is not new, and inventors have made many attempts to satisfy it. It has remained, however, for the Marconi Company to produce just what is required, and a great demand for the new gauge is anticipated.

"The instrument is designed primarily as a maximum current gauge to indicate the condition of sympathy in wireless circuits, and may be employed as a substitute for a thermo-junction and galvanometer combination in the measurement of wavelengths and decrement. The principle involved is that of the bifilar suspension, one pair of the filament ends being fixed, and the other pair attached to, a pivoted arm, the rotation of which is controlled by a spring acting against the tension of the filaments. When a current passes through the filaments, heating them and causing them to elongate, the arm takes up a new position and the angular displacement, as indicated on the scale is a measurement of the current.

"The movement is enclosed in a glass bulb exhausted of air. The sensitiveness is thus greatly increased, and the movement protected against damage and preserved from dust or corrosion.

"The variation in zero which is characteristic of hot wire instruments in general is negligible in this type of instrument, and the natural damping renders the movement especially dead-beat.

"The instrument, suitably calibrated, may also be used as a low reading voltmeter or ammeter, or as a shunted ammeter. The normal resistance of the commercial type of vacuum instrument is approximately 12 ohms.

"The new instrument has been greatly admired for its neat appearance, which can be well judged from the photograph showing one of the gauges standing upright in its silk-lined case.

"In contrast, a device named the "Detectometer" from America, which was a crystal detector and indicator — a "very sensitive form of milliampere-meter" — received a mere two-paragraph mention.

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**Wireless World printed circuit boards**

Due to a change of address, all correspondence concerning p.c.b.s should be sent to M. R. Sagin (assistant editor) at 23 Keyes Road, London N.W.2.
Characteristics and load lines

4 — Linear load lines (continued)

by S. W. Amos, B.Sc., M.I.E.E.

For most transistors the \( L-V_c \) characteristics are more crowded at low values of collector current and thus the two half cycles of a sinusoidal input signal are reproduced with significantly different peak values. As shown in Fig. 15 the peak value of the positive half cycle of current output is greater than that of the negative half cycle. Because of the unequal peak values the area under the positive half cycle is greater than that under the negative half cycle and the mean collector current \( I_{mean} \) in the presence of an input signal is greater than \( I_c \) the no-signal collector current.

Fig. 15 is the form of wave obtained from a device with a parabolic characteristic and it can be analysed into a fundamental component of peak value \( I_1 \) and a second harmonic component of peak value \( I_2 \) as shown in Fig. 16. This diagram also shows that \( I_{mean} \) is greater than the no-signal current \( I_c \) by \( I_2 \) the peak value of the second harmonic component. Thus the increase in collector current for a transistor with a parabolic characteristic is a direct measure of the amplitude of the second harmonic component.

The percentage of second harmonic distortion can be calculated from the values of \( I_{max} \), \( I_{min} \) and \( I_{mean} \) in the following way. The phase relationship between \( I_1 \) and \( I_2 \) is such that they add to form the large-amplitude half cycle \((I_{max}-I_{mean})\) and subtract to form the small-amplitude half cycle \((I_{mean}-I_{min})\). Thus:

\[
I_{max}-I_{mean} = I_1 + I_2 \\
I_{mean}-I_{min} = I_1 - I_2
\]

Adding

\[
I_{max}-I_{min} = 2I_1
\]

Subtracting

\[
I_{max} + I_{min} - 2I_{mean} = 2I_2
\]

Thus

\[
I_2 = \frac{I_{max} + I_{min} - 2I_{mean}}{I_{max} - I_{min}}
\]

The percentage of second harmonic distortion is thus given by

\[
100\frac{I_2}{I_1} = \frac{100(I_{max} + I_{min} - 2I_{mean})}{I_{max} - I_{min}}
\]

This is not a convenient way of calculating the second harmonic content from load line plots because the value of \( I_{mean} \) is not readily obtainable from such graphs. However, the load line does give the value of \( I_c \), the no-signal or quiescent current, and it is a simple matter to recast expression (2) in terms of \( I_c \) in place of \( I_{mean} \). We know that \( I_{mean} \) is equal to \((I_c + I_2)\) and substituting for \( I_{mean} \) in expression (1) above we have

\[
I_{max} + I_{min} - 2I_c = 4I_2
\]

from which

\[
I_2 = \frac{I_{max} + I_{min} - 2I_c}{I_{max} - I_{min}}
\]

Thus the percentage of second harmonic distortion is given by

\[
100\frac{I_2}{I_1} = \frac{50(I_{max} + I_{min} - 2I_c)}{I_{max} - I_{min}}
\]

As an example we can calculate the second harmonic distortion for the output stage represented by Fig. 14. Substituting the appropriate values in the above expression we have

\[
\frac{50(1.22 + 0.24 - 2 \times 0.75)}{1.22 - 0.24} = 2 \text{ per cent approximately.}
\]

\( L-V_c \) characteristics are sometimes more crowded at high currents and low currents than at intermediate values of collector current. The consequent waveform distortion tends to be symmetrical and this is symptomatic of the introduction of odd-order harmonics. It is possible, in fact, to deduce an expression for the percentage of third-harmonics. It is possible to deduce an expression for the percentage of third-harmonic distortion analogous to that just derived for second-harmonic distortion.

**Limiting amplifiers**

In linear amplifiers the crowding of \( L-V_c \) characteristics at low or high currents leads to unwanted harmonic distortion but in other applications the non-uniform spacing of the characteristics is exploited. For example consider,
Forward a.c.

Transformer-coupled load of 6 kilohms (effective primary resistance) and a supply voltage of 6. As a third possibility the diagram could apply to a transistor with a tuned collector circuit, the effective dynamic resistance at the primary winding being 6 kilohms. The quiescent collector current and collector voltage are the same for all three circuits.

The load line enters a region at P where the transistor characteristics are crowded; in fact near zero collector voltage the characteristics all merge into a straight line OP through the origin which is sometimes described as the coalescent characteristic. Fig. 17 shows that any increase in base current beyond 30μA can produce no corresponding increase in collector current or reduction in collector voltage. At this point the transistor is saturated. If, therefore, a sinusoidal signal is applied to the base of the transistor and if the amplitude is increased until the point P is reached on positive half-cycles then further increase in input can produce no corresponding increase in output. The limiting action is illustrated more effectively by plotting base current against collector current as in Fig. 17(b). The curve levels off at a base current of 30μA and a collector current of 2mA. This is the form of input-output characteristic required in a limiting amplifier, e.g. in the i.f. stage of an f.m. receiver. The limiting action helps to make the receiver insensitive to amplitude modulation of the input signal.

Reverse a.c.

Transistors for which the $I_C-V_C$ characteristics are more crowded at low currents can be used for reverse a.c. This is illustrated in Fig. 18 where PQR is the a.c. load line when the transistor is biased back (by a large received signal) to a mean current of 0.4mA. P'Q'R' is the a.c. load line for the same collector load but with the bias adjusted (for a weaker signal) to a mean collector current of 3.1mA. For load line PQR an input current swing of 10μA gives an output current swing of 0.33mA, a current gain of 33. For load line P'Q'R' the same input current swing gives an output current swing of 0.75mA, a current gain of 75. Thus approximately 7dB of gain control is achieved in this example by adjustment of base bias current: by a suitable choice of transistor a greater range of control is possible.

Forward a.g.c.

An alternative method of controlling the gain of a transistor by adjustment of bias is by forward control. In this system the transistor is biased forward for reception of strong signals. The transistor must be specially designed for this form of control and its $I_C-V_C$ characteristics must become more crowded as the collector current increases. This may not be immediately obvious from Fig. 19 but the upper characteristics are plotted for 1 mA base-current increments compared with 0.1 mA increments for the lower characteristics. In spite of this disparity in increment the upper characteristics are more crowded than the lower ones particularly at low values of collector voltage. Thus the quiescent point should be located in the top left-hand corner of the diagram for low gain and in the bottom right-hand corner for high gain. This movement of the operating point is achieved automatically by inclusion of the decoupled collector resistor R in Fig. 20 which is an essential feature of the forward-control circuit.

The d.c. load line for 1 kilohm resistance is shown by QQ' in Fig. 19 and two positions of the a.c. load line (for 600 ohms resistance) are shown at PQR and P''Q'R'. For PQR the base bias current is 0.15mA and an input current swing of 0.1mA yields an output current swing of 3.2mA, a current gain of 32. For P''Q'R' the base bias is 3mA and an input current swing of 2mA yields an output current swing of 2.5mA a current gain of only 1.25. This range of gain control amounts to 28dB but 60dB can be realised in practical circuits.

Load lines on mutual characteristics

The load lines so far considered have been drawn on a graph of output current against input voltage. Fig. 19. $I_C-V_C$ characteristics and typical a.c. and d.c. load lines for forward a.g.c.

Fig. 20. Essential features of circuit for forward a.g.c.
current plotted against output voltage, e.g. a set of $I_d-V_g$ characteristics. Such a load line represents conditions in the output circuit of the active device. Resistors are, however, included in other circuits of active devices and it is sometimes useful to construct load lines for these too. For example consider Fig. 21 which shows a depletion-type f.e.t. biased by a resistor $R_s$ in the source circuit. Conditions in the input circuit of the transistor can be represented on a diagram such as Fig. 22 which shows the $I_d-V_g$ characteristic of the transistor and a load line OA drawn through the origin and with a slope corresponding to the value of $R_s$. The intersection A gives OC as the value of drain current and OB as the gate bias voltage achieved in the circuit. A smaller value of $R_s$ gives a load line such as DE which gives a lower drain current and a higher drain current: a higher value of $R_s$ gives a load line such as DF indicating a larger negative bias voltage and a smaller drain current. Thus this graphical method could be used to determine the value of $R_s$ needed to give a required drain current or the drain current given by a chosen value of $R_s$. However there is a considerable spread in $I_d-V_g$ characteristics for f.e.t.s and so predictions from constructions such as that illustrated in Fig. 22 should be treated as approximate.

The load line concept can, however, be used to suggest a method whereby the effects of the spread in drain current can be reduced. To illustrate this Fig. 23 shows the $I_d-V_g$ characteristics for a particular type of depletion f.e.t. The centre curve is the characteristic for the average transistor and the other two curves show the upper and lower limits of drain current likely to be met in manufacture. For a given gate voltage the drain current can lie anywhere within a range of 3:1 and this is the spread likely to be encountered if the transistor is biased by a simple source resistor as in Fig. 22. Examination of this diagram shows that the current given by a 1-kiloohm source resistor can lie between 0.8 and 2.3mA, the average being 1.6mA. A better performance would be possible by increasing the value of the source resistance, so making the load line more horizontal. This is possible provided the gate is biased positively so as to keep the drain current at the required value. The effect of such a biasing circuit in reducing the effect of manufacturing spreads in drain current can be assessed in a load line diagram in the following way.

In source biasing circuits such as that of Fig. 21 the gate voltage is fixed (at 0V) and bias is achieved by varying the source voltage. Thus the characteristic in which we are interested is that of $I_d$ plotted against $V_g$. This is the same shape as the $I_d-V_g$ characteristic but laterally reversed because the effect of −2V on the gate is the same as +2V on the source. It is, however, quite con-

---

![Fig. 21. A depletion-type f.e.t. biased by a resistor in the source circuit](image1)

![Fig. 22. Load lines on $I_d-V_g$ characteristics showing bias value achieved](image2)

![Fig. 23. The $I_d-V_g$ characteristic is the same as the $I_d-V_g$ with the voltages reversed in sign](image3)

![Fig. 24. Improvement in bias stability by use of positive gate bias and a high-value source resistance](image4)
The new licences
Since January 1, a new comprehensive licence has been introduced by the Radio Regulatory Department of the Home Office and replaces the earlier "sound", "mobile" and "television" licences. Any holder of an Amateur Licence "A" or "B" is now entitled to operate fixed; mobile; teledastrian mobile; r.t.t.; television; slow-scan television; facsimile; data (on 144MHz upwards); and d.s.b.s.c.

Thus at one stroke many of the old requirements to make special applications or obtain special-purpose licences have vanished. Similarly, in logging it is no longer necessary to enter actual transmission frequencies, only the band being used.

New clauses forbid operation from aircraft or public transport vehicles; for high-definition tv it is now necessary that the callsign identification is adjusted to the centre of the video channel.

Separate prefixes for Jersey (GJ) and Guernsey (GU) supersede the former joint GC prefix.

All applicants now have to sign an undertaking that frequency-checking equipment of sufficient accuracy will be used to ensure that all transmissions are within the permitted bands, together with equipment to confirm that harmonic and spurious emissions are "suppressed" (to what degree is not stated). This statement also includes a formal recognition by the applicant that out-of-band-working is a "serious misdemeanour" that could result in withdrawal of the licence.

Annual fee is now £5.50 and the fee for the Post Office Morse Test has recently been raised to £4. Radioteleprinter operation is restricted to International Telegraph Code No. 2 at 45.5 or 50 bauds. Most of the other conditions remain basically the same although some obsolete clauses (for example specifically prohibiting the use of "spark") have been dropped. Only for the 24GHz band for the use of pulse techniques is it still necessary to obtain prior written permission. During data transmissions (144MHz upwards) the station callsign must be given in morse or telephony at least once in every 15 minutes.

This is the first major revision to the UK licence for many years and most amateurs will warmly welcome most of the changes.

US licence problems
The marked differences between the British and American way of amending licence regulations can be detected in some of the questions now facing the FCC. These range from the hint that the FCC may ban the use of separate linear amplifiers for both the amateur service and Citizens’ Band operation to proposals that could eliminate all conventional a.m., d.s.b.s.c., narrow-band f.m. on the h.f. bands and fast-scan tv on 70cm.

As Don Chester, K4KYV/1 points out "there is still a small but substantial minority of amateurs in the USA who wish to continue using conventional a.m. Many of us have built our own transmitters and designed them to minimise distortion. We operate mostly on 1.8, 3.5 and 7 MHz and receive very few complaints of splatter and believe that excessive bandwidths on any mode are often due to distortion products or overmodulation, and that natural sidebands do not cause excessive interference on adjacent frequencies.

"We have used every available means of influence to block the passage of this proposal and there are rumours that the FCC is scraping its plan to put us off the air."

This is not the first attempt to eliminate A3 on the h.f. bands and petitions were made to the FCC on this in 1967. At that time the Commission stated: "While the Commission has, in the interest of spectrum economy, encouraged the use of s.s.b. in other services via the rule making process, it is not believed necessary or desirable in the Amateur Radio Service. One of the unique features of the Service is the wide choice of emissions and operating frequencies . . . continuation of this freedom of choice is considered desirable."

The new handbook edition
The RSGB has just published vol. 1 of its new (5th) edition of its standard book on amateur radio — "The Radio Communication Handbook". In its almost 40 years of publication (originally as "The Amateur Radio Handbook") over 250,000 copies have been printed and found wide use not only by amateurs but also by many with a professional or Services' interest in communications. During World War 2 it was widely used as an approved text book by the RAF.

The new edition has for the first time been split into two separately bound volumes, with volume 2 due this spring.
Rugged oscilloscope range claims low cost of ownership

The Tektronix T900 series of oscilloscopes, first announced over a year ago but only recently available in the UK, fills the gap between their high-cost, high-performance R & D oscilloscopes on the one hand and the low-cost, low-performance Telequipment instruments on the other. The range is aimed at situations where a specific set of measurements on one type of product or process is needed but without the expense of comprehensive triggering and display facilities, such as arise in production and maintenance/service applications.

But Tektronix UK admit that because of high inflation upsetting a general sense of values the traditional division between low and high-cost oscilloscopes isn't very clear. Keith Retallick, UK Sales Manager, says there are now two kinds of potential customer: one is the out-of-date user who still thinks that instruments should cost little more than five years ago, and the other is largely unconcerned, and is prepared to pay almost anything. He sees the T900 range as providing excellent value where low-to-medium performance is required by users who are not forced by economic circumstances to buy only the cheapest. "Most serious buyers are looking not for the lowest price but for value for money," he says.

Main feature of the range is not electrical performance so much as low "cost of ownership", though Tektronix claim that cost/performance ratio is good. Ruggedness, ease of servicing, modular construction, unified sub-assemblies throughout the range, negligible hand wiring, ease of operation (fewer and less critical calibration controls), active device and other tests, and maintenance are the key points. Tests are given in detail in the accompanying documentation.

The T950 model comprises a 3°/div, 1000x deflection factor, 10MHz bandwidth oscilloscope, dual trace (T921, T922)

The T930 model comprises a 3°/div, 35MHz bandwidth oscilloscope, dual trace (T921, T922)

The T940 model comprises a 3°/div, 10MHz bandwidth oscilloscope, one single trace (T921, T922)

The T950 model comprises a 3°/div, 35MHz bandwidth oscilloscope, one single trace (T921, T922)

The T960 model comprises a 3°/div, 10MHz bandwidth oscilloscope, one single trace (T921, T922)

The T970 model comprises a 3°/div, 35MHz bandwidth oscilloscope, one single trace (T921, T922)

The T980 model comprises a 3°/div, 10MHz bandwidth oscilloscope, one single trace (T921, T922)

The T990 model comprises a 3°/div, 35MHz bandwidth oscilloscope, one single trace (T921, T922)

The T900 model comprises a 3°/div, 10MHz bandwidth oscilloscope, one single trace (T921, T922)

The T910 model comprises a 3°/div, 35MHz bandwidth oscilloscope, one single trace (T921, T922)

The T920 model comprises a 3°/div, 10MHz bandwidth oscilloscope, one single trace (T921, T922)

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The T970 model comprises a 3°/div, 35MHz bandwidth oscilloscope, one single trace (T921, T922)

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The T920 model comprises a 3°/div, 10MHz bandwidth oscilloscope, one single trace (T921, T922)

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**Spectrum analyser**
A spectrum analyser covering the range 1MHz to 1GHz has been introduced by Dana Electronics. The Cushman analyser has interlocked controls, to ensure that it is always calibrated, and permits levels from +20dBm to −115dBm to be measured directly from a 70dB-range display. A.m. and f.m. signals, received on its whip aerial, may be monitored audibly and the analyser, which also has frequency and level calibration outputs and a marker input, can be made portable using an optional 12V battery facility. Price is about £360. Dana Electronics Limited, Collingdon Street, Luton, Bedfordshire.

**Pt 100 simulators**
A range of platinum resistance thermometer-element simulators, made by Delristor Limited, is intended for use wherever resistance thermometer values require to be simulated. The instruments are calibrated directly in degrees centigrade and cover the range −200 to +500°C in 25, 50 or 75 discrete steps, depending on the model selected. Two optional accuracies of ±0.5 or ±0.3°C are available and each unit includes a facility for lead resistance simulation. A model is also available for Ni 100 element simulation. Delristor Limited, 21 Windsor Street, Uxbridge, Middlesex.

**Tape-cassette controllers**
Three tape-cassette controllers, suitable for microprocessor and other high-quality recording systems, are available from Tekdata Limited. Model 2, which is a variable-speed controller for 0.4 to 10 i.p.s. recording, is r.t.l., d.t.l. and c.m.os. compatible and has four drive motors. Wow and flutter and jitter are said to be a minimum because the capstan motor is used to drive the capstan only. Other main features include remote-control facilities, less than 30s rewind (C80), and a power requirement of 7V at about 600mA. Model 1 is a fixed speed unit and Model 3, the Superdeck, is a 0.4 to 20 i.p.s variable-speed unit. Tekdata (Trading) Limited, Westport Lake, Canal Lane, Tunstall, Stoke-on-Trent, Staffs ST6 4PA.

**Impulse noise analyser**
An impulse noise analyser, the LEA BAT-1, will count the number of positive and negative pulses having amplitudes which exceed a selected threshold during a pre-determined time interval. The analyser, which has a 600Ω input and a high-impedance (over 60kΩ) input, may be adjusted for thresholds from −50 to 0dB and dead times of less than 100µs, 5ms, 50ms and 125ms. This instrument complies with ITTCC recommendations and includes two plug-in filters. Wessex Electronics Ltd, Stover Trading Estate, Yate, Bristol BS17 5QF.

**Frequency synthesizer**
The PRD 7838 is a programmable frequency synthesizer which covers the range 1kHz to 80MHz in 1Hz steps with an output level of 10mV to 1V r.m.s. into 50Ω. Its stability, when locked to the internal crystal frequency is one part in 10^8 per month, with an optional standard of five parts in 10^8 per day. The spurious output figures are typically 70dB (non-harmonic) and 40dB (harmonic). The unit may be programmed by b.c.d. code, permitting the digital frequency-control functions, which are r.t.l., d.t.l. and t.t.l. compatible, to be performed remotely. Microwave and Electronics Division, REL Equipment and Components Limited, Croft House, Bancroft, Hitchin, Herts.

**Low-cost Variomatrix**
The QSD-2, made by Sansui, is a low-cost Variomatrix decoder capable of decoding both QS and SQ material. This unit, which also permits playback of conventional stereo material via four loudspeakers, gives 20dB separation between adjacent channels, 30dB between diagonal channels and has a frequency response of 20Hz to 30kHz.
with a distortion of up to 0.1% at 1kHz. Price is expected to be well under £100 per unit. (See surround-sound decoder, articles in June-September issues.) Sansui Audio Europe SA, 39/41 Maple Street, London W1.

WW 310 for further details

Cleaners and lubricants

It is claimed that regular use of two aerosols, available from N.S.F. Limited, will prolong the life of rotary wafer-switches. The products, a cleaner and a lubricant, are in 450g cans and are claimed to be harmless to the majority of materials used in present-day components. The cleaner is used first to remove deposits which form after long periods of use or storage and the lubricant is then applied to provide a thin, even film over contacts and other relevant surfaces. N.S.F. Limited, Switches and Controls, Keighley, Yorkshire BD21 5EF.

WW 311 for further details

Psophometer

The type 2429 psophometer is a compact instrument suitable for measurements in accordance with International Standards CCITT-P53 and CCIR-468-1. This meter, which is suitable for both subjective and objective determination of signal-to-noise ratios, has been designed for use with communication systems. Four filters are incorporated in the meter, these being: unweighted, telephone, Radio 1 and Radio 2, and in addition the detector can be set for either quasi-peak or quasi-r.m.s. Amplification is calibrated and is adjustable in 10dB steps, the input impedance can be set to either 600Ω or greater than 10,000Ω symmetrically and a.c., d.c. and earphone outputs are provided. To avoid the possibility of errors an overload detector automatically operates a flashing warning light if an incorrect attenuator setting is selected. B & K. Laboratories Ltd, Cross Lances Road, Hounslow, Middlesex.

WW 312 for further details

Temperature-controlled iron

The Oryx 75 soldering iron is designed for fast production-line work and for applications requiring a carefully-controlled soldering temperature. Fast thermal recovery is achieved by a unit in the handle of the iron, which controls the current pulses to the element, and a temperature sensor close to the element tip. This unit eliminates the need for a cumbersome control box. The tip temperature can be adjusted over the range 300 to 425°C. A wide range of soldering tips is available and the tip may be exchanged in less than two minutes. Electroplan Ltd. P.O. Box 19, Orchard Road. Royston, Herts SG8 5HH.

WW 313 for further details

Stabilized power supply

The Triple-Output Power Supply (TOPS), from Farnell, is designed as a power source for i.e. and op-amp breadboard circuitry, providing 5V at 1A and 15-0-15V at 200mA. Adjustment ranges are 4-6V on the 5V rail and 12-17V on the balanced twin 15V rail. This unit, which contains overcurrent protection and a l.e.d. overload indicator, has a line stabilization of 0.05%, load regulation of 0.1% and a temperature coefficient of 0.02%/°C. Ripple is less than 1mV on the 5V output and 2mV on the twin output. Farnell Instruments Limited, Sandbeck Way, Wetherby LS22 4DH.

WW 314 for further details

Switching power supply

A four-output, 400W switching power supply, designated as the Trio model 674, is designed specifically for microprocessors, memories and other multiple output applications. The unit has a main output for logic, a second output for a memory and two additional outputs for accessory power needs such as ±5V, −9V and ±15V. Mean-time-before-failure is calculated to exceed 30,000h and the unit, which has an efficiency of 60%, measures 127 × 203 × 355mm and weighs only 6.8kg. Trio Laboratories Limited, Grove House, Grayshott, Hindhead, Surrey GU26 8LW.

WW 315 for further details
Solid State Devices

Names or suppliers of devices in this section are given in abbreviation after each entry and in full at the end of the section.

Power Darlington

Complementary Darlington transistors, in the BDX85 to BDX88 and 2N6053 to 2N6056 series', have minimum gains of up to 1000 at 5A and power dissipations up to 120W. The range, from SGS-ATES, includes both p-n-p and n-p-n transistors having $V_{CEO}$ and $I_C$ ratings of up to 100V and 12A respectively.

WW 316 SGS-ATES

U.h.f. dividers

Six two-modulus u.h.f. dividers have been added to Plessey Semiconductors' range. Types SP8740 and SP8745 are 300MHz divide-by-5 or 6 counters with a.c. and d.c. coupled inputs respectively. Types SP8741 (a.c.) and SP8746 (d.c.) are 300MHz divide-by-6 or 7 counters and types SP8743 (a.c.) and SP8748 (d.c.) are 500MHz divide-by-8 or 9 counters. The d.c. devices require PECL 111 inputs and the a.c. devices have a wide dynamic input range of 400 to 800mV pk-pk. Each device, contained in a 16-lead d.i.l. package, is specified for a supply of 5.2±0.25V and consumes typically 50mA.

WW 317 Plessey Semiconductors

Low-power r.a.m.s

Two low-power versions of the 2102A 1k by 1 r.a.m. are now available from Intel. The devices, type 2102AL with an access time of 350ns and type 2102AL4 with a speed of 450ns, have $I_C$ ratings of 33mA and are t.t.l.-compatible on both the inputs and outputs.

WW 318 Intel

Static r.a.m.s

Three static r.a.m.s. from Texas Instruments, are suitable for 4, 8 or 16-bit microprocessor systems and are each available in 1000, 650 and 450ns maximum-access and read-and-write cycle times. Type TMS 4039/2101 has separate input and output enables, an output enable and two chip enables.

WW 319 Texas Instruments

C.m.o.s. multiplexers

Two industrial 16-line to one-line multiplexers are available in c.m.o.s. from National Semiconductor. The devices, type MM74C150 and the tri-state version MM82C19, use four-bit addresses and invert the data from input to output. A strobe pin, which overrides the input data, places the output of the MM74C150 in the logic 1 state, and the output of the MM82C19 in a high-impedance state.

WW 320 National Semiconductor

Teletext character generator

The 1k by 8 m.o.s. r.o.m., designated as type 2608 CN0040, has been programmed to give the fully-approved teletext character font of 7 by 5 upper and lower-case characters. It uses no clocks, has an access time of 650ns and is t.t.l.-compatible on both the inputs and outputs. The r.o.m., which is in a 24-pin package, has tri-state outputs and uses n-channel silicon-gate technology. Maximum power dissipation is 400mW.

WW 321 Mullard

Input-output buffer

The addition of the 10B 1680 input-output buffer microcircuit to GIM's CP 1600 16-bit microprocessor can provide a user with a complete microprocessor system which requires the minimum of additional components. This buffer, in a 40-lead d.i.l. package, is claimed to have all the external data management functions previously performed by about 12 t.t.l. m.s.i. packages.

WW 322 G.I.M.

Bridge rectifiers

Rectifiers in the range 26MB5A to 26MB80A have been introduced as improved versions of International Rectifier's 25A bridge rectifiers. The devices, which are rated from 50 to 800V (maximum reverse repetitive voltages), are claimed to give greater voltage stability and isolation than the superseded ones and will deliver 19A when mounted on a heatsink of 1°C/W.

WW 323 International Rectifier

Multiplier-divider

Differential-input multiplier-dividers in the 4231 range have a claimed noise specification of 120µV r.m.s. from 10Hz to 10kHz; a factor of five improvement over comparably priced units. Three versions are available: type 4231BM providing better than 0.5% accuracy, less than 25mV output offset and less than 0.7mV/sec drift over the range —25 to +85°C, type 4231SM which is a MIL temperature range version of this, and the 4231AM having an accuracy of 1%, offset of less than 50mV and drift of less than 2mV/sec over the working temperature range. Small quantity prices are from £24.00 each.

WW 324 Burr-Brown

Wideband op-amps

Two operational amplifiers, types A970 and A975, are wideband, high slew-rate units in TO-98 packages. The A970 has a typical gain-bandwidth product of 100MHz for small signals, a slew rate of 35V/µs and an open loop gain of 95dB. Type A975 has a typical slew-rate of 120V/µs and a gain-bandwidth product of typically 20MHz. Both units have input impedances of greater than 100MΩ and operate over a temperature range of 0 to 70°C.

WW 325 Hybrid Systems

Suppliers

Burr-Brown International Ltd, Permanent House, 17 Exchange Road, Watford, WD1 7EB.

Hybrid (Component) Systems U.K. Ltd, 12a Park Street, Camberley, Surrey.

General Instrument Microelectronics Ltd, 87/61 Mortimer Street, London W1N 7TD.

Intel Corporation (UK) Ltd, Broadfield House, 4 Between Towns Road, Cowley, Oxford OX4 3NB.

International Rectifier Co. (GB) Ltd, Hurst Green, Oxted, Surrey.

Mullard Ltd., Mullard House, Tarrington Place, London WC1E 7HD.

National Semiconductor U.K. Ltd, 19 Goldington Road, Bedford MK40 3LF.

Perman (Component) Systems Ltd., Cheney Manor, Swindon, Wiltshire SN2 2QW.

SGS-ATES Componenti Elettronici SpA, Via C. Olivetti, 2, 20041 Agrate Br., Milan, Italy.

Texas Instruments Ltd, Manton Lane, Bedford MK41 7PA.
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Eastleigh, Hampshire S05 3ZR. 
Telephone: Chandler’s Ford 2956 
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WORLD LEADERS IN PACKAGING TECHNOLOGY

WW—073 FOR FURTHER DETAILS

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MINIMUM TID POWER AMPLIFIER MODULES
WE BELIEVE OUR MODULES ARE UNEQUALLED IN SOUND QUALITY, OVERALL PERFORMANCE & VALUE FOR MONEY

Due to advances in technology, we are now able to offer

- fully protected 25W-Mk1 £85.50 50W-Mk1 £141.40 
- 2 x 25W-Mk1 £106.50 50W-Mk1 £202.80

It has recently been shown that an amplifier with some traditionally desirable features (veggy feedback with a heavy input) can actually sound worse than one with a 'poorer' bass. This has been attributed to interaction with feedback (Hi-Fi) circuitry, particularly eyelet mounted components, a poor line of sight, wiring, note of bass more obvious and a wilder bass in the midbands. 

Our range has therefore been designed to give a minimum of feedback, minimum capacitance and allow the listener to see the music. This approach has yielded one of the closest sounding amplifiers available, regardless of cost.

35W-Mk1 £79.50 50W-Mk1 £115.00
35W-Mk2 £87.50 50W-Mk2 £143.50

Choose/Pt to CRIMSON ELEKTRIK 467 Freeport Rd, ONEASTON ROAD, LARSHOLT, LEICESTER

WW—024 FOR FURTHER DETAILS

Audio Connectors

Broadcast pattern jackfields, jackcords, plugs and jacks
Quick disconnect microphone connectors
Amphenol (Tuchel) miniature connectors with coupling nut.
Hirschmann Banana plugs and test probes
XLR compatible in-line attenuators and reversers
Low cost slider tasters by Ruf

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90 Wardour Street
London W1V 3LE
01-437 1892/3

WW—027 FOR FURTHER DETAILS

DORAM KITS CONTAIN EVERYTHING DOWN TO THE LAST NUT

De-Luxe FM TUNER £98.50+

BY LARSHOLT

A top quality kit enabling you to construct a highly professional FM Tuner. 

Step-by-step instruction and pre-aligned modules produce a tuner with a higher specification than many other tuners available at more than twice its price! 

SPECIFICATION:

Signal to noise ratio: 67dB typ. (40dB input) 
Sensitivity: 1µV for 25dB quieting 
Distortion: 0.1% (Stereo) typ 
Frequency range: 87.5-106.5 MHz 
Stereo separation: 45dB at 1kHz 

FEATURES—Automatic scan facility. 

£98.50 + VAT (Order Code 991-956)

O seas orders - add 15% for P + P. All items offered for sale subject to the terms of Business as set out in Doram Edition 3 catalogue. 

DORAM ELECTRONICS LTD. P.O. BOX 169 
WELLINGTON RD IND. EST. LEEDS LS12 2UF
An Electrocomponents Group Company

WWW—027 FOR FURTHER DETAILS
Wireless World Dolby™ noise reducer

Trademark of Dolby Laboratories Inc.

We are proud to announce the latest addition to our range of matching high fidelity units.

Featuring:

- Switching for both encoding (low-level h.f. compression) and decoding
- A switchable f.m. stereo multiplex and bias filter
- Provision for decoding Dolby f.m. radio transmissions (as in USA)
- No equipment needed for alignment
- Suitability for both open-reel and cassette tape machines
- Check tape switch for encoded monitoring in three-head machines

The kit includes:

- Complete set of components for stereo processor
- Regulated power supply components
- Board-mounted DIN sockets and push-button switches
- Fibreglass board designed for minimum wiring
- Solid mahogany cabinet, chassis, twin meters, front panel, knobs, mounting screws and nuts

Typical performance

- Noise reduction: better than 9dB weighted
- Clipping level: 16.5dB above Dolby level (measured at 1% third harmonic content)
- Harmonic distortion 0.1% at Dolby level typically 0.05% over most of band, rising to a maximum of 0.12%
- Signal-to-noise ratio: 75dB (20Hz to 20kHz, signal at Dolby level) at Monitor output
- Dynamic range > 90dB
- 30mV sensitivity

PRICE: £37.90 + VAT

Also available ready built and tested

- Calibration tapes are available for open-reel use and for cassette (specify which) ........................................... Price £52.00 + VAT
- Single channel plug-in Dolby™ processor boards (92 x 87mm) with gold plated contacts are available with all components ................................................................. Price £7.20 + VAT
- Single channel board with selected fet ......................................................................................................................... Price £2.20 + VAT
- Gold plated edge connector ........................................................................................................................................... Price £1.40 + VAT

Selected FET’s. 60p each + VAT, 100p + VAT for two, £1.90 + VAT for four

Please add VAT 12½% unless marked thus*, then 8% applies

We guarantee full after-sales technical and servicing facilities on all our kits, have you checked that these services are available from other suppliers?

INTEGREX LTD.

Please send SAE for complete lists and specifications

Portwood Industrial Estate, Church Gresley,
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Burton-on-Trent (0283) 215432 Telex 377106
S-2020TA STEREO TUNER/AMPLIFIER KIT

SOLID MAHOGANY CABINET

A high-quality push-button FM Varicap Stereo Tuner combined with a 24W r.m.s. per channel Stereo Amplifier.

Brief Spec. Amplifier: Low field Toroidal transformer, Mag. input, Tape In/Out facility (for noise reduction unit, etc). THD less than 0.1% at 20W into 8 ohms. Power on/off FET transient protection. All sockets, fuses, etc., are PC mounted for ease of assembly. Tuner section: uses 3302 FET module requiring no RF alignment, ceramic IF, INTERSTATION MUTE, and phase-locked IC stereo decoder. LED tuning and stereo indicators. Tuning range 88—104MHz. 30dB mono S/N @ 1.2µV. THD 0.3%. Pre-decoder ‘birdy’ filter.

PRICE: £53.95 + VAT

NELSON-JONES STEREO FM TUNER KIT

A very high performance tuner with dual gate MOSFET RF and Mixer front end, triple gang varicap tuning, and dual ceramic filter/dual IC IF amp.

Brief Spec. Tuning range 88—104MHz. 20dB mono quieting @ 0.75µV. Image rejection — 70dB. IF rejection—85dB. THD typically 0.4% IC stabilized PSU and LED tuning indicators. Push-button tuning and AFC unit. Choice of either mono or stereo with a choice of stereo decoders.

Compare this spec. with tuners costing twice the price

PRICE: Mono £29.15 + VAT
With ICPL Decoder £33.42 + VAT
With Portus-Haywood Decoder £35.95 + VAT

STEREO MODULE TUNER KIT

A low-cost Stereo Tuner based on the 3302 FET RF module requiring no alignment. The IF comprises a ceramic filter and high-performance IC Variable INTERSTATION MUTE. PLL stereo decoder IC. Pre-decoder ‘birdy’ filter.

PRICE: Mono £26.85 + VAT
Stereo £29.95 + VAT

S-2020A AMPLIFIER KIT

Developed in our laboratories from the highly successful “TEXAN” design. PC mounting potentiometers, switches, sockets and fuses are used for ease of assembly and to minimize wiring.

Power ‘on/off’ FET transient protection.

PRICE: £31.95 + VAT

ALL THE ABOVE KITS ARE SUPPLIED COMPLETE WITH ALL METALWORK, SOCKETS, FUSES, NUTS AND BOLTS, KNOBS, FRONT PANELS, SOLID MAHOGANY CABINETS AND COMPREHENSIVE INSTRUCTIONS

BASIC NELSON-JONES TUNER KIT £14.28 + VAT
BASIC MODULE TUNER KIT (stereo) £16.75 + VAT
PHASE-LOCKED IC DECODER KIT £4.47 + VAT
PUSH-BUTTON UNIT £4.50 + VAT

PORTUS-HAYWOOD PHASE-LOCKED STEREO DECODER KIT £8.00 + VAT
Jack-of-our-trade

Following the success of our range of Bantam Components and Jackfields, we have now introduced on the U.K. market the first-ever 'Jack designed specifically for PCB mounting.

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RADFORD HD250
High Definition Stereo Amplifier

A new standard for sound reproduction in the home! We believe that no other amplifier in the world can match the overall specification of the HD250.

Rated power output: 50 watts per channel into any impedance from 4 to 8 ohms.Both channels driven.

Maximum power output: 90 watts per channel into 4 ohms.

Distortion, preamp: Virtually zero (cannot be identified or measured as it's below 0.01% at 1kHz).

Hum and noise: Disc...83dB measured flat with noise band width 23 kHz (ref 5mV).-86dBV "A" weighted (ref 100V).

Hear the HD250 at SWIFT OF WILMSLOW Dept. WWV, 5 Swan Street, Wilmslow, Cheshire (Tel: 26213)
Mail Order and Personal enquiries: Wilmslow Audio, Swan Works, Bank Square, Wilmslow (Tel: 285999)

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HI-PACK AUDIO MODULES
SA450 tuner £20.95, A100 £4.33, 50W6 Audio Kit £27.20, Tube 60 £10.98, Stereo 30 £16.85, PM90 £24.28, BW100 £3.70, PS4 £1.76, 1358 £2.82. Send for full price list.

SAXON ENTERTAINMENTS
MODULAE
SA120 £20.50, SA120 £19, SA60 £18.95, SA60 £24.60, £10.30, PM120/16 £11.30, PM120/25 £11.30, PM120/4 £16.50, £3.10.

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New integrated circuit 5VW amplifier chip with pcb and data £4.45.

FERRANTI ZN414
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70V with 5 pin DIN plug £1.50 A £1.95.

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Switched 3W £1.75 or 100mA Stereo kit £4.95.

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Make your own printed circuits. Contains everything needed: 100 to 30v of printed circuit board, 1 lb ferric chloride, rubber mat, pen, drill bit and low-cost cutter £2.95.

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Post 30p on orders under £22 otherwise free. Prices include VAT (Overseas customers deduct 7% on remittance, telephone 11p). Official orders welcome.
As these circuits in recent issues of "Wireless World" are capable of such an excellent performance we feel it is not sensible to sacrifice this potential by designing a kit down to a price. We have therefore spent a little more on professional hardware allowing us to design a very advanced modular system. This enables a more satisfactory electrical layout to be achieved, particularly around the very critical input areas of the replay preamps. These are totally stable with this layout and require no extra stabilising components. Many other advantages also come from this system which has separate record and replay amps for each channel plugging into a master board with gold plated sockets. The most obvious is the reduction of crosstalk and interaction which could cause trouble on a single plane board, with our modular system the layout is compact but there is no component crowding. Testing is very easy with separate identical modules and building with the aid of our component-by-component instructions is childishly simple, but the finished result is a unit designed not to normal domestic standards but to the best professional practices.

ALL PARTS ARE POST FREE
Please send 9 x 4 SAE for lists giving fuller details and Price breakdowns.
A suitable Metalwork and Front Plate will be available soon

Penyland Mill, Oswestry, Salop
Personal callers are always welcome, but please note we are closed all day Saturday
Stirling Sound audio modules

for cost-conscious constructors

A NEW 100 WATT r.m.s. POWER AMP

SS.1100

£9.45*

with heatsink-type bracket. Large heatsink - 11' extra

Most recent addition to Stirling Sound's wide range of power amplifiers: the SS.1100 is a solidly constructed heavy duty module, to deliver 100 watts RMS into 4 ohms. Ideal for discos, P.A. and similar applications. With built-in output capacitor and heatsink mounting bracket. Size approx. 140 x 76 x 32mm. A guaranteed Stirling Sound QV Module. Complete with K.V. Factor and built for long unbroken spans of work.

POWER AMPLIFIERS FROM 5 TO 40 WATTS

SS.105

5 watts R.M.S. into 4 ohms using 12V supply. Ideal for use in music entertainment areas. Size - 89 x 51 x 19mm.

£2.25

S.110

Similar in size and design to SS.105: this QV module delivers 10 watts R.M.S. into 4 ohms using a 24V supply. e.g. SS.324. Of great use in domestic applications.

£2.75

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Using a 34 volt supply, such as SS.334: this QV amplifier will deliver 20 watts into 4 ohms load. Same dimensions as above.

£3.25

POWER SUPPLY UNITS SEE BELOW

STIRLING SOUND PRE-Amp/TONE CONTROL UNITS

UNIT ONE


£7.80

SS.100

Active tone control, bass and treble.

£1.50

£101

Pressing for ceramic earthtraps, etc. Passive tone control output available in plate supply.

£1.00

£102 STEREO PRE-AMP

R.A.A. corrected for mag. plus tone controls.

£3.25

POWER SUPPLY UNITS COMPLETE WITH TRANSFORMERS and 13-16V take-off points. Add 50p p/'p for any model.

ALL AT 8% V.A.T.

SS.312 12V/1A £3.75; SS.318 18V/1A £4.15; SS.324 24V/1A £4.60; SS.334 34V/2A £5.20; SS.345 45V/2A £6.75; SS.350 50V/2A £7.95; SS.360 - Power stabilising unit 50-50V, adjustable (no transformer) p/'p £5.35; SS.310/50 Stabilised power supply variable from 10 to 50V/2A £11.55.

The Stirling Sound QV Factor is the symbol of Stirling Sound's guarantee of quality and value which gives you today's best buy all round. It is YOUR guarantee of satisfaction.

TO ORDER add 35p for p/'p unless otherwise indicated. V.A.T. 10% is to be added on all orders unless otherwise shown. Under the age 8%.

Every effort is made to ensure correctness of information at time of going to press. Prices subject to alteration without notice.

O'ceas orders—add 15% for P+P. All items offered for sale subject to the Terms of Business as set out in Doram Edition 3 catalogue. price 60p. The Doram Kit brochure is also available, price 25p. Combined price only 70p which also entitles you to 2 x 25p vouchers, each one usable on any order placed to the value of £5.00 or more (ex VAT). DORAM ELECTRONICS LTD., P.O. BOX 188, WELLINGTON RD. INGEST, LEEDS LS12 2UF. An Electrocomponents Group Company.
20 x 20 WATT STEREO AMPLIFIER
£29.90
(P. & P. 12/10)

 diy speaker kits

EASY TO BUILD WITH ENCLOSURE

Specially designed by RT-VC.
Compact, line-defocused hi-fi enthusiasts, these kits incorporate two twin-
summate enclosures, two EMI 15 x 6.5 (approx) woofers, two tweeters and a pair of matching cross-
overs. Easily constructed using a few basic tools. Superb sound quality, with a low-
follow circuit diagram, and crossover components. Input 15 watts rms, 30 watts peak, per unit.
£25.00 per pair (approx).

15-WATT KIT IN CHASSIS FORM

When you are looking for a good speaker, why not build your own from this kit? It's the unit which we supply with the above enclosures. Size 15 x 6.5 (approx) woofer (EMI), tweeter, and matching crossover. Power handling capacity 15 watts rms, 30 watts peak.
£15.00 per set (approx).

DECCA 20 WATTS STEREO SPEAKER

This matching loudspeaker system is hand-made in only Decca know how, built to a specification, not time to a price. The kit comprises of two 8" diameter approx. base drive unit, with heavy die cast aluminium covers and coincident horns with rolled PVC surround. Two 3½" diameter approx. dome tweeters with crossover networks.
£30.00 per speaker pair (approx)
£60.00 per pair

Wireless World, February 1977

TYRE STEER GRAM CHASSIS

Complete ready to install...Wave bands L/M, VHF STEREO, VHF Mono. Controls for tuning, volume, balance, bass and treble. Power output 7 watts RMS, per channel 14 watts peak into 8 ohms, 2 x 8" approx. speaker cabinets and BSR CI41 auto record player deck.
£49.50

20 WATT STEREO AMPLIFIER KIT

A build-it-yourself stereo power amplifier, complete with integrated circuitry. Include connection cable and mains transformer. £49.50

35-WATT DISCO AMP

Here's the mono unit you need to start off with. Gives you a good solid 35 watts rms, 70 watts peak output. Big features include two disc inputs, both for ceramic cartridges, tape input and microphone input. Level mixing controls fitted with integral push-pull switches. Independent bass and treble controls and master volume.
£27.50

PORTABLE DISCO CONSOLE

with built-in pre-amps

Here's the big-value portable console designed from RT-VC. It features a pair of BSR MP 60 type auto-return, single-play professional series record decks. Plus all the controls and features you need to get the very best disco performance. Simply connects into your existing slave or external amplifier.
£55.00

70 & 100 WATT DISCO AMPS

Brilliantly styled for easy disco performance! Shapely cabinet, so that you can use the controls without fuss or bother. Brushed aluminium fascia and rotary controls. Five smooth-acting, vertically mounted slide controls master volume, tape level, mic level, deck level, PLUS INTER-DECK FADER for perfect graduated change from record deck No. 1 to No. 2, or vice versa. Pre-fade level control (PFL) lets YOU hear next disc before fading it in. VU meter monitors output level 70 watts rms, 140 watts peak output. All the big features as on the 70-watt disco amplifier, but with a massive 100 watts rms, 200 watts peak output power.
£35.00

STEREO CASSETTE DECK KIT

This kit is specially designed for the experienced constructor - for mounting into his own cabinet. Features include solenoid-assisted AUTO-STOP, 3-digit counter, record/repay PC-board mains transformer and input/output controls. AC-3A AND ERASE.
£35.00

DELUXE ACCESSORY KIT

Comprises of a matched pair of dynamic mics and two replacement slider level controls.
£3.95

RTVC

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Closed all day Wednesday and last day Saturday
Sullivan offer you a full range of AC and DC Null Detectors. There is a wide span of ranges available, with battery operation, portability and high quality being common to all.

NEW Model 3336 DC Detector is a versatile production and laboratory instrument offering discrimination of 1µV in 10kΩ and sensitivity of 10µV. This instrument offers low drift, linear or logarithmic response and high stability.

NEW Model 3337 Microvolt Detector has 9 centre zero ranges from 10V to 1µV. It has a resolution of 0.1µV into 10kΩ. Battery operation eliminates mains voltage interference. There are many other features, too, not least of which is a surprisingly competitive price.

Model 4444 AC Detector is a specially designed, battery operated solid state AC detector for the detection of very low level imbalance signals from modern AC bridge and potentiometric measuring systems.

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H.W. Sullivan Ltd., Archcliffe Road, Dover, Kent CT17 9EN
Tel: 0304 202620 Telex: 96283
Thornton Measurement Control and Automation Division

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**The detectors**

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HIGH SPEED RELAYS. Single and Double Pole various resistances. RESISTORS P.O. Type 9 and 12, complete RELAY SELEC-

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This catalogue — Electrovalue Catalogue No. 8. Issue 2, up-dated offers items from advanced opto-electronic components to humble (but essential) washers. Many things listed are very difficult to obtain elsewhere. The company's own computer is programmed to expedite delivery and maintain customer satisfaction. Attractive discounts are allowed on many purchases; Access and Barclaycard orders are accepted.

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**Electrovalue Catalogue No. 8**

144 pages

40p

Post paid

inc. refund voucher worth 40p

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Electrovalue Catalogue No. 8

Electrovalue Ltd

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**FURTHER DETAILS**

94 Wireless World. February 1977
HSR-BI AUTOCHANGER STEREO AND DONO
PLAYS 12", 10" or 7" records. Auto or Manual: A high quality unit backed by HSR-BI, with 2 years guarantee. A C 200/250V. $210.00, 410.00

PORTABLE CABINET

HEAVY METAL PLINTHS
$6.50 or 410.00 per pair.

COMPLETE STEREO SYSTEM
Two full size loudspeakers 13½" X 11". Player units to loudspeakers making it extremely compact; overall size only: 10½" X 8½" X 15". Plays all records 33 1/3 45 and 78 rpm. Separate volume and tone controls. Attractive finish. £22.50. 240V. mains. £1 carriage.

R.C.S. "MINOR" 10 watt AMPLIFIER KIT
This kit is suitable for record players, gramophones, tape playback, electronic instruments or small P.A. systems. Two versions available: Mono £11.25; Stereo £18.00. £4 Post. Specications on request. S.A.E. details. Full instructions supplied. AC mains powered.

E.M.I. 13½" X 8" SPEAKER SALE!
With tweeter and crossover 10 watt 15 watts 20 watts 30 watts 40 watts £5.95 £8.50 £15.00 £21.00 £26.50

Low vol. Electrolytes
2.4V 5A 5V 15A 12V 30A 20V 60A Superised. £5.95 £8.50 £15.00 £21.00 £26.50

BOOKSHELF CABINET
Tape finish, for E.M.I. 13½" x 8" speakers.

THE "INSTANT" BULK TAPE ERASER AND HEAD REGENERATOR. Suitable for all types of cassette, and all sizes of tape reels. A.C. mains powered. Willdemagnize as well. £4.50.

BLANK ALUMINIUM CHASSIS 6½" X 4½"; 8½" X 6½"; 10½" X 7½"; 12½" X 8½"; 13½" X 9½" X 10"; 15½" X 12½"; 16½" X 12½"; 18½" X 16½". All others £4.50, 50p. £2.55

TLoom fittings
7-in-1 PATRIOT TERMINAL £1.10 Post 15p.

R.C.S. LOW VOLTAGE STABILISED POWER PACK KITS
All parts inclusive: (a) 30V, 20A double point solder lugs and miniature transformer. £3.25 Post 15p. (b) 30V, 35A double point solder lugs and miniature transformer. £5.00 Post 15p.
**FAST RESPONSE STRIP CHART RECORDERS**

Made in USSR

**Series H3020**

Basic error 2.5%
Sensitivity 6mV F.S.D
Response 0.2 sec
Width of each channel
Single and three pen recorders
Five pen recorders 50mm

Chart speeds, selected by push buttons: 0.1 - 0.2 - 0.5 - 1 - 2 - 5 - 10 - 25 - 50 mm/sec
Chart drive 200-250V 50Hz
Recording. Syphon pen directly attached to moving coil frames.
Curvilinear co-ordinates.
Equipment Marker pen, timer pen, paper footage indicator, 10 rolls of paper, connectors, etc.

H3020-1 (Single pen): 285mm wide x 384mm deep x 165mm high

**Price £108.00**

H3020-3 (Three pen): 475mm wide x 384mm deep x 165mm high

**Price £160.00**

H3020-5 (Five pen): 475mm wide x 384mm deep x 185mm high

**Price £295.00**

**Series H327**

Polarized moving iron movements with syphon pens directly attached.
Built-in solid state amplifier (one per channel) provides 8 calibrated sensitivity steps. Two marker pens are provided.
Basic error 4%. Frequency response from DC to 100Hz 2dB

Sensitivity: 0.2 - 0.05 - 0.1 - 0.2 - 0.5 - 1 - 2 - 5 volts/cm
Width of each recording channel: 40mm
Chart drive: 220-250V 50Hz
Chart speeds: 1-2-5-10-25-125-250mm/sec

Type H327-1. Single pen: Dimensions: 259 x 384 x 165mm

Weight 15 kilos

**Price £265.00**

Type H327-3. Three pen: Dimensions: 335 x 384 x 165mm

Weight 20 kilos

**Price £520.00**

Type H327-5. Five pen: Dimensions: 425 x 385 x 165mm

Weight 25 kilos

**Price £770.00**

Note: Prices are exclusive of VAT

Available for immediate delivery

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**WW - 448 FOR FURTHER DETAILS**
WIRELESS WORLD, 3.275MHz demodulator £65 carriage £5. 

**PLUMICON TUBE TYPE X0-1071 Mullard** £150.00

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**IDEO TUBE TYPE F 863 B English Electric** £120.00

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</tr>
<tr>
<td>A1911</td>
<td>0.80</td>
<td>0.75</td>
<td>0.50</td>
<td>£5.00</td>
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<tr>
<td>A1910</td>
<td>0.80</td>
<td>0.75</td>
<td>0.50</td>
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<td>Power output</td>
</tr>
<tr>
<td>A1909</td>
<td>0.80</td>
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<tr>
<td>A1908</td>
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<tr>
<td>A1907</td>
<td>0.80</td>
<td>0.75</td>
<td>0.50</td>
<td>£5.00</td>
<td>Power output</td>
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</table>

**TRANSMISSIONS** 12½% Please add VAT 12½% for valves, etc.

<table>
<thead>
<tr>
<th>Type</th>
<th>Description</th>
<th>Price</th>
<th>Description</th>
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<tr>
<td>TF 801D/1</td>
<td>SIGNAL GENERATOR</td>
<td>£250.00</td>
<td>Includes all test equipment for the measurement of valves and circuits.</td>
</tr>
<tr>
<td>TF 801E/2</td>
<td>SIGNAL GENERATOR</td>
<td>£500.00</td>
<td>Includes all test equipment for the measurement of valves and circuits.</td>
</tr>
<tr>
<td>TF 801F/3</td>
<td>SIGNAL GENERATOR</td>
<td>£750.00</td>
<td>Includes all test equipment for the measurement of valves and circuits.</td>
</tr>
</tbody>
</table>

**VALVES AND TRANSISTORS** Telegraph enquiries for valves, transistors, etc. refer 749/1344 trade and export 749/0999.

**PLEASE SEND STAMP WITH ENQUIRIES**

---

**BEST PRICES PAID FOR TEST AND COMMUNICATION EQUIPMENT.** Single items or quantities. Private or Industrial.

**PLEASE NOTE** Unless offered as 'not seen' all equipment is completely overhauled mechanically and electrically in our own laboratories.

**BOONTON** AM/FM SIGNAL GENERATOR, Type C 1000/10. 100 similar channels in 2 ranges £275.00. SIGNAL GENERATOR TS, 497/URS 2.5MHz, 3MHz, 30MHz, 78MHz, 180MHz, 400MHz, 0.1V £150 carriage £3.00.

**COLMER** AM/FM SIGNAL GENERATOR, Type C 1000/10. 100 similar channels in 2 ranges £275.00. SIGNAL GENERATOR TS, 497/URS 2.5MHz, 3MHz, 30MHz, 78MHz, 180MHz, 400MHz, 0.1V £150 carriage £3.00.

---

**Please refer to pages 97-99 and 101 for a full description of valves and circuits.**
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POPULAR SEMICONDUCTORS (A very small selection from our vast stocks, please enquire about devices not listed.)

<table>
<thead>
<tr>
<th>Price</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.95</td>
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<tr>
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<td>74L01</td>
</tr>
<tr>
<td>1.45</td>
<td>74L00</td>
</tr>
</tbody>
</table>

Prices correct at 20th December 1976, but please add V.A.T. Post & Packing 30p

DECLON
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Cost savings can be effected

- Acoustically Transparent
- Wide Design Scope
- Colour Options

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The keys are moulded in Acrylic plastic. A material chosen for its superior wear properties and ideal feel to the touch. They are moulded in two separate pieces, the key face, which has to be perfect in appearance and finish, and the action, which has to be strong and carry the mechanism. The strong section of aluminium extrusion upon which they are mounted is specially designed to take all the pressures of playing. Springs, felt, and contact actuators are supplied ready-fitted.

The contact assemblies are constructed of laminated bakelite, thus giving smooth slot walls and perfectly free movement of the gold-plated contact wires. Types available as follows (Contact pairs normally open):

- GJ-SPCG: 24 pairs
- GB-2 pairs: 27 pairs
- GC-3 pairs: 36 pairs

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**PHONOSONICS**

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B.P.O.

Mail Order and C.W.O. Only — Sorry but No Callers Please

Prices are correct at time of Press. E. & O.E. Delivery subject to availability.
In Hi-Fi News there was published by Mr. Linsley-Hood a series of four articles (November 1972, February, 1973) and a subsequent follow-up article (April, 1974) on a design for an amplifier of exceptional performance which has as its principal feature an ability to supply from a direct coupled fully protected output stage, power in excess of 75 watts whilst maintaining distortion at less than 0.01% even at very low power levels. The amplifier is complemented by a pre-amplifier based on a discrete component operational amplifier referred to as the Linsley which is employed in the two most critical points of the system, namely the equalization stage and tone control stage, purpose where most conventional designs run out of gain at the extremes of the frequency spectrum. Gaussian Nature of the design are the variable transition frequencies of the tone controls and the variable stage of the scratch filters. There is a choice of four inputs, two equalized and twolinear, each having independently adjustable signal level. The attractive slimline units pictured has been made practical by highly compact PCBs and a specially designed Toroidal transformer.

**FREE TEAK CASE WITH FULL KITS**

**KIT PRICE ONLY** £73.90

**NEW KIT!**

**LINSLEY-HOOD CASSETTE DECK**

**SPECIAL PRICE FOR COMPLETE SETS** £81.35

Further details of above given in our FREE LIST 
DEPT WW2
T20+20 and our new T30+30 20W, 30W AMPLIFIERS

Designed by Texas engineers and developed in Practical Wireless, the Texas was an immediate success and now even better. In our laboratories, we have taken the unique performance and technical improvements of the T20+20 and added 20 additional watts per channel at true Hi-Fi at exceptionally low cost. The design is based on a single FET/Glass PCB and features all the normal facilities found on quality amplifiers, including switching and balance filters, available input and output jacks and leads. These follow up articles in Practical Wireless further modifications were suggested and these have been incorporated into the T30+30. These include RF interference checks and a loudness facility.

Power output of this new model is 30W per channel.

SPECIAL PRICES FOR COMPLETE KITS!

<table>
<thead>
<tr>
<th>Kit</th>
<th>PRICE</th>
</tr>
</thead>
<tbody>
<tr>
<td>T20+20 Kit Price only</td>
<td>£31.10</td>
</tr>
<tr>
<td>T30+30 Kit Price only</td>
<td>£35.90</td>
</tr>
</tbody>
</table>

2 NEW TUNERS!

Following the success of our Wireless World FM Tuner kit, we are now pleased to introduce a new FM-Cast model, designed to complement the T30 and T30 amplifiers. The frequency range of our T30, T30, 120 and 130 model, has been limited and the interface simplified. However, the quality of our metal and this new kit offers exceptional value for money. Facilities included are switchable, switchable muting, switchable muting, switchable muting, switchable and pull button channel selection. As with all our new kits, all components are boxed and the last nut and bolt are supplied together with full construction kit details.

POWERTRAN SFMT

This easy to construct tuner uses our own circuit design includes a preamplifier stage and modules. FULL stereo decoder, adjustable muting, switchable muting, switchable and pull button channel selection. As with all our new kits, all components are boxed and the last nut and bolt are supplied together with full construction kit details.

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SQM-1 — 30

KIT PRICE

- £37.15

Wireless World Amplifier Kits. Full kits are not available for these models but we have the PCBs available on request at £0.25 each. Kits are not available for the remaining units shown here.

EXIT NO PROBLEM

Tunisia Germany Nauru Hong Kong Australia Eire Gambia Denmark France Muscat & Oman

New Guinea World, February 1977
The universal system may plugged.

TYPE VCR 13 9A, CV 1526
Price £8.00 P&P 50p add VAT 8% SPECIAL OFFER

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Q: GS Yamanaka and GS Synthesizer are registered trade marks of SANSUI ELECTRIC COMPANY LIMITED OF JAPAN
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Q: GS Yamanaka and GS Synthesizer are registered trade marks of SANSUI ELECTRIC COMPANY LIMITED OF JAPAN
MPS 4001
£120 + VAT (£14.40)
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MASTER SWITCH KIT £8.50 + VAT (£1.06)
All kits are complete with instruction manual. Overseas customers require VAT, but add 1.35 pence per ounce airmail postage.

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or telephone 01-988 8221 on weekdays between 8.30 a.m. and 6 p.m.

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One feeding circuit 10 independent feeding outputs at 830 volts for general studio use. Power is supplied by multiple ideas on amplifiers. Electronic input circuit multiplies the power in four separate circuits.

Stereo Disc Amplifier 2, unit output at +12dB. 750 volts, 0.005%
300 volts, 0.005%.

Parameter indicates, 6000 + 00.4 1 0.05%.
Output +13dB. 7. 0.005%
The unit meets the IBA signal path performance criteria and is available at a competitive price of a set of 10 units, including the case and R/L connections.

STEREO DISC AMPLIFIER 2
PERFORMANCE SPECIFICATIONS
HI-FI DISC MONITORING AND TRANSFER
Mains 230 volt, 50 cycles, 0.002% power hum at 45, 50 and 60 cycles. Mains powered. IBA specification.

PROGRAME METERS
Hi-Fi: Standard performance true circuit order

STABILIZER FOR HOUSE, RADIO AND BALANCED AND UNBALANCED VOLTAGES. URGENT ORDERED.
PUBLIC ADDRESS: SOUND REINFORCEMENT

Wireless World, February 1977
### TRANSFORMERS
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<table>
<thead>
<tr>
<th>Ref.</th>
<th>VA (Watts)</th>
<th>£ (P&amp;P)</th>
</tr>
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<tbody>
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<td>07</td>
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<td>109</td>
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<td>152</td>
<td>250</td>
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<td>153</td>
<td>350</td>
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<td>500</td>
<td>16.48</td>
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<tr>
<td>155</td>
<td>750</td>
<td>25.23</td>
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<td>156</td>
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<td>157</td>
<td>1500</td>
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<td>158</td>
<td>2000</td>
<td>50.70</td>
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### 30 VOLT RANGE
**SPECIAL TAPS 0-15-25-30-40V**

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<td>103</td>
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<td>105</td>
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<td>106</td>
<td>4.98</td>
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<td>119</td>
<td>10.00</td>
<td>20.41</td>
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### 60 VOLT RANGE
**SPECIAL TAPS 0-30-40-50-60-80V**

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<td>127</td>
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<td>132</td>
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### SCREENED MINIATURES

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<tr>
<td>238</td>
<td>400</td>
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### CASED AUTO TRANSFORMERS

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<td>20B</td>
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<td>20C</td>
<td>11.74</td>
<td>1.31</td>
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### POWER UNITS

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<tbody>
<tr>
<td>3360</td>
<td>6.75</td>
<td>0.25</td>
</tr>
</tbody>
</table>

### NEW STERO 30

| Complete chassis: inc. 7+7W m.m. amps., preamp, power supply, front panel, knobs, leads mains (trans) | £115.75 |

**TERMS:**
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**SPECIAL SALE PRICED ITEMS**

<table>
<thead>
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<th>Code</th>
<th>Description</th>
<th>Price</th>
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<td>LED1</td>
<td>1W (Red)</td>
<td>£0.45</td>
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<td>LED2</td>
<td>1W (Green)</td>
<td>£0.50</td>
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<td>LED3</td>
<td>1W (Blue)</td>
<td>£0.55</td>
</tr>
<tr>
<td>LED4</td>
<td>1W (White)</td>
<td>£0.60</td>
</tr>
<tr>
<td>LED5</td>
<td>1W (Yellow)</td>
<td>£0.65</td>
</tr>
<tr>
<td>LED6</td>
<td>1W (Orange)</td>
<td>£0.70</td>
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**FREE SAMPLE ITEMS**

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<th>Code</th>
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<td>FSL1</td>
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</tr>
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<td>FSL2</td>
<td>Ferrite Ferrite</td>
<td>£0.10</td>
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**FREE SAMPLE ITEMS**

<table>
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<tr>
<th>Code</th>
<th>Description</th>
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<tbody>
<tr>
<td>FSL1</td>
<td>Ceramic Ferrite</td>
<td>£0.05</td>
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<tr>
<td>FSL2</td>
<td>Ferrite Ferrite</td>
<td>£0.10</td>
</tr>
</tbody>
</table>

**TRANSMITTERS**

- **C1000 MINI-MULTIMETER**
  - DC/AC 1000V, DC/AC 100V
  - DC/AC 100A
  - Range: £12.50
- **STEREO F.M. TUNER**
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  - £75.00
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  - £19.93
- **Blu-ray**
  - £20.48

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  - WW - 035 FOR FURTHER DETAILS
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Add 12½%
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OA39 6p IN4007 8p
GA41 5p IN4008 9p
6A200/6A201 6p IN4001 10p
6A202/6A201 6p IN4002 11p
6A202/6A216 6p IN4003 12p
6A202 6p IN4004 15p
6A201 6p IN4005 15p
IN4144 5p IN4006 17p
6A202 6p IN4007 17p
6A202 6p IN4008 18p
6A201 6p IN4009 20p

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L.E.D. DISPLAYS
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FLV 117 RED 2" 1.00

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OF 71 Pcs of 5 1.20 1.00

THYRISTORS
Order No
T05 1A 50 PIV
T04 1A 400 PIV
T06 1A 400 PIV
T04 1A 400 PIV
T03 1A 400 PIV

UNJUNCTION
T146 /15 43 18p

PCB MARKER PENS
50P

DIY PRINTED CIRCUIT KIT
CONTAINS 6 pieces copper laminar, box of etchant powder, measure tweezers, marker pen, high quality pump drill, Stanley knife & blades, 6in metal rule. Full easy-to-follow instructions £4.75 £5.50

ORDERING
PLEASE WORD YOUR ORDERS EXACTLY AS PRINTED NOT FORGETTING TO INCLUDE OUR PART NUMBER

PO BOX 6
WARE FIRE, February 1977

POSTAGE & PACKING
Please add 25p Overseas
add extra for airmail
Minimum order
£1.00

BI-PAK SEMICONDUCTORS

74 SERIES TTL ICs

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Devices may be mixed to qualify for quantity price. Data is available for the above series of 1 C.s in booklet form price 35p

LINEAR ICs

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BUY ONE OF EACH Special Price £1.20* the 3

| 16160 24 Ceramic 22 pf 82pf | 16161 24 Ceramic 150pf - 390pf |
| 16162 24 Ceramic 22muluf 330miluf | 16163 24 Ceramic 4700p uf - 047uf |

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| 16203 18 Electronics 100 uf - 680 uf | 16172 24 Ceramic 1300p uf - 3300p uf |
| 16173 24 Ceramic 4700p uf - 047uf | 16160 24 Ceramic 22 pf 82pf |

RESISTOR PAKS

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NEW HIGH QUALITY MODULAR AMPLIFIER SYSTEMS

STEREO FM TUNER

Fitted with Phase Lock-loop Decoder

OUR PRICE ONLY £20.45

The 450 Tuner provides instant program selection at the touch of a button ensuring accurate tuning of 4 pre-selected stations, any of which may be altered as often as you choose, by simply changing the settings of the pre-set controls.

Used with your existing audio equipment or with the Bi-KITS STEREO 30 or the MK60 Kit, etc. Alternatively the PS12 can be used if no suitable supply is available, together with the Transformer T538.

The SA450 is supplied fully built, tested and aligned. The unit is easily installed using the simple instructions supplied.

STEREO PRE-AMPLIFIER

A top quality stereo pre-amplifier and tone control unit. The push button selector switch provides a choice of inputs together with two really effective filters for high and low frequencies, plus tape output.

MK 60 AUDIO KIT: Comprising 2 x AL60's 1 x SMP80 1 x BM60 1 x PA100 1 front panel and knobs. 1 kit of parts to include on/off switch, neon indicator, stereo head phones plus instruction booklet. COMPLETE PRICE £29.55 plus 85p postage.

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SPECIFICATION:

- Harmonic Distortion Po = 3 watts f = 1kHz 0.25 %
- Load Impedance 8-16ohm
- Size: 255mm x 63mm x 255mm
- Sensitivity for Rated O/P — Vs = 25v, RL = 8ohm f = 1kHz 75v.RMS

AL20 5w R.M.S. £2.95
AL30 10w R.M.S. £3.25

MPA 30

Enjoy the quality of a magnetic cartridge with your existing ceramic equipment using the new M.P.A. 30. A high quality pre-amplifier enabling magnetic cartridges to be used where facilities exist for the use of ceramic cartridges only. It is provided with a standard DIN input socket for ease of connection. Full instructions supplied.

OUR PRICE £2.85

STereo 30 COMPLETE AUDIO

7 + 7 WATTS R.M.S.

UNIT PRICE £16.25

New PA12 Stereo Pre-Amplifier completely redesigned for use with AL 20-30 Amplifier Modules. Features include on/off volume, balance, bass and treble controls, complete with tape output.

OUR PRICE £6.70

PS12 Power supply for AL20/30, PA12, SA450 etc.

OUR PRICE £1.30

P.O. BOX 6, WARE, HERTS.

HIGH QUALITY MODULATED AUDIO POWER SUPPLY TYPE SPM80

SPM80 is especially designed to power 2 of the AL60 Amplifiers, up to 15 watts (R.M.S.) per channel simultaneously. With the addition of the Mini Transformer BM780, the unit will provide outputs of up to 15a at 35v. Size 63mm x 105mm x 30mm. Incorporating short circuit protection.

Transformer BM780 £2.80 + 62p postage

BI-PAK

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MARCONI TEST EQUIPMENT
TF329G circuit magnification meter.
TF455E Wave analyser.
TF801D RF signal generator.
TF858 Universal bridge.
TF995A/2 AM/FM generator.
TF1041B V T Voltmeter.
TF2200 Oscilloscope.
TF1100 Sensitive v/voltmeter.
TF1152A/1 RF power meter.
TF2145 Q-meter.
TF147 200MHz frequency counter.
TF1342 Low capacitance bridge.
TF3170 Wide-range RC oscillator.
TF2163 UHF attenuator DC-1GHz.
TF2200 Al power meter.
TF2600 Sensitive v/voltmeter.
TF2604 Electronic voltmeter.
TF2606 Differential DC voltmeter.
TF2660 Digital voltmeter.

MARCONI TF995B/2, AM/FM GENERATORS.
200kHz-220mHz in 5 bands. 0.1 uV-200mV. Continuously variable FM in two ranges to 75kHz. Price and full spec upon request.

MUIRHEAD DECADE OSCILLATORS type 890A. 1kHz-1.1kHz in four decade ranges. Scope monitored output for high accuracy of frequency. Excellent generator. £135.

ROHDE & SCHwarz EQUIPMENT
Midget crystal clock type XSZ BN15221.
Selective UHF v/meter, bands 4&S. USVF Selectomat RF Voltmeter. USV BN15221.
Standard attenuator 0-100db 0-300mHz.
DPR.
UHF Signal generator type SCR.
UHF Test receiver type USVD.

P. F. RALFE ELECTRONICS
10 CHAPEL STREET, LONDON, NW1.
TEL: 01-723 8753.
NOTICE. All the pre-owned equipment shown has been carefully tested in our workshop and reconditioned where necessary. It is sold in first class operational condition and most items carry our three months' guarantee. Calibration and certificates can be arranged at cost. Overseas enquirers welcome. Prices quoted are subject to an additional 9% VAT.

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AIRMAN 210A Multi-function meter 3.7Inch-view.
APT 504 Power supply 0-500V at 25mA £35
BPL Capacitance decade (6) Cd133 10pF-1uf £45
BRANDENBURG High voltage generators, type 0530/10 £200kV and 0510 type 0.5kV.
BRASILMAG 44428 Potentiometric set £85
DM Model 2001M II Digital voltmeter £275
FLUKE RM504 Memory multimeter £250
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GR Standard sweep generator 400kHz-230mHz £485
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Hewlett-Packard type 432A power meter £350
HEWLETT PACKARD 6010 sweep meter £350
MEDIOTOR type A75A Potentiometric microvoltmeter £115
PYE EHT scallop voltmeter 0.4KV £125
RACAL 1 MHz counterحسن £4 Digital S9536 £85
RADIOMETER Wave analyser type FRA28 0.1kHz-1MHz £150
SCHNEIDER type C25 100MHz frequency counter £235
SCHOMANDL Frequency meter type F01 £400
SOLARTRON Pulse generator type G01101 £65
TEKTRONIX type 575 Transistor curve tracer £40
TEKTRONIX 586A Oscilloscope with 82 P 1 DC 500MHz £250
TEKTRONIX C27 Printed Oscilloscope camera £50

ADVANCE RF SIGNAL GENERATORS
E1 100kHz-60Hz £30
G1 7-50MHz £35
H2 60kHz-7.2Ghz £30
P1 100kHz-100MHz £35
S98TA 7.5-250MHz FM £75

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500V TRANSISTORIZED INSULATION TESTER
Lightweight, small size (13x7x4.5cm). Reads insulation from 0.2-2000MΩ at 500V. Price list standard 9V PP3. Brand new £16.50

FRACMO Glass meters. 24V AC 5.9PM. 88A. £80

CENTRIFUGAL TYPE Blowers. 12V DC输出. £10.50

CENTRALIZED TYPE Blowers. 230V AC Output. £12.50

500V TRANSISTORIZED INSULATION TESTER
Lightweight, small size (13x7x4.5cm). Reads insulation from 0.2-2000MΩ at 500V. Price list standard 9V PF3. Brand new £16.50

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CENTRALIZED TYPE Blowers. 230V AC Output. £12.50

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TEAC A3340(S) 4-CHANNEL RECORDER
REVOX A-770 SERIES
The new big Revox ideal for all studio requirements. Highly sophisticated design features include servo tape tension, full deck logic crystal controlled servo electronics. 3 speeds, tape, cassette.

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Carriage extra

INPUT 230 V. A.C. 50/60
OUTPUT VARYABLE 0/260 V.A.C.
BRAND NEW. All types.
200V (1 Amp) Input / A.C. 

0.5 KVA (Max. 2.75 Amp.) 

$11.50

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4 KVA (Max. 20 Amp.) 

$60.00

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Step up step down units 110-220 to 230-240 volts.

1kVA 3-phase 240 V.A.C. X 5 units $85.00.

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300 V.A. ISOLATING TRANSFORMER

12/24 V. (10 steps) 15 steps. 

Price: $25.00.

GENTS 4" ARMAL BELLS.

$2.00 each D.C.

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250W, 200W and 100W available also.

250W, 200W and 100W available also.

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A bank. 25 way. 9.5 mm. 25A. 0.3 amp. Price: $2.00. 30A. 0.5 amp. Price: $3.00.

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BLOWING UNIT


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At all voltages. Price: $1.50.

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<th>Sensitivity</th>
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<td>20 – 50</td>
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**FEATURES:**
- Complete pre-amplifier in single pack
- Multi-function equalization
- Low noise
- Low distortion
- High overload
- Low cost combined for series

**APPLICATIONS:**
- Time delay
- Mixers
- Disco
- Guitar and Organ
- Public address

**SPECIFICATIONS:**
- **INPUTS:**
  - Magnetic Pick-up 3mV
  - Ceramic Pick-up 30mV
- **OUTPUT:**
  - Vacuum 100mV
  - Microphone 10mV
- **ACTIVE TONE CONTROLS:**
  - Treble: +2dB at 1kHz
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**DISTRIBUTION:**
- 0.1% at 1kHz
- Signal/Noise Ratio 68dB

**OVERLOAD:**
- 3dB at 1kHz
- Magnetic Pick-up
- **SUPPLY VOLTAGE:**
  - 14.5V

Price £6.75 + 58p VAT P&P Free.

HY5 mounting board £1.40 + 60p VAT P&P Free.

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**HY30**

15 Watts into 8Ω

The HY30 is an exciting New kit from I.P. It features a virtually indistinguishable I.C. with short output and thermal protection. The kit consists of a I.C. heatsink P.C. board, 4 resistors, 6 capacitors, input resistor kit, together with easy to follow instruction and operating instructions. This amplifier is ideally suited to the beginner in audio who wishes to use the most up-to-date technology.

**FEATURES:**
- Complete kit
- Low Distortion
- High Quality
- Open and Thermal Protection
- Easy to Build

**APPLICATIONS:**
- Updating audio equipment
- Guitar practice amplifier
- Test amplifier
- Audio education

**SPECIFICATIONS:**
- **INPUT POWER:**
  - 15W RMS into 8Ω
- **DISTORTION:**
  - 0.1% at 15W
- **INPUT SENSITIVITY:**
  - 500mV
  - **FREQUENCY RESPONSE:**
    - 10Hz - 16kHz
    - 3dB
- **SUPPLY VOLTAGE:**
  - 7.5V

Price £6.20 + 37p VAT P&P Free.

---

**HY50**

25 Watts into 8Ω

The HY50 reads I.P.’s total integration approach to power amplifier design. The amplifier features an integral heatsink together with the simplicity of no external components. During the past three years the amplifier has been refined to the extent that it is one of the most reliable and robust high fidelity modules in the World

**FEATURES:**
- Low distortion
- High Quality
- Thermal Protection
- No external components

**APPLICATIONS:**
- Medium Power Hi-Fi systems
- Low power disco
- Guitar amplifier

**SPECIFICATIONS:**
- **INPUT SENSITIVITY:**
  - 500mV
- **OUTPUT POWER:**
  - 25W RMS into 8Ω
- **DISTORTION:**
  - 0.04% at 25W at 1kHz
- **OUTPUT NOISE RATIO:**
  - 90dB
- **FREQUENCY RESPONSE:**
  - 10Hz - 45kHz
  - 3dB
- **SUPPLY VOLTAGE:**
  - 15V

Size 194 x 50 x 85mm

Price £14.40 + £1.16 VAT P&P Free.

---

**HY120**

60 Watts into 8Ω

The HY120 is the baby of I.P.’s new high power range designed to meet the most exacting requirements including load line and thermal protection; this amplifier sets a new standard in modular design.

**FEATURES:**
- Very low distortion
- High Quality
- Low noise
- High power input in power supply module
- No external components

**APPLICATIONS:**
- Hi-Fi
- High quality disco
- Public address
- Monaural amplifier
- Guitar and organ

**SPECIFICATIONS:**
- **INPUT SENSITIVITY:**
  - 500mV
- **OUTPUT POWER:**
  - 60W RMS into 8Ω
- **DISTORTION:**
  - 0.04% at 60W at 1kHz
- **OUTPUT NOISE RATIO:**
  - 90dB
- **FREQUENCY RESPONSE:**
  - 10Hz - 45kHz
  - 3dB
- **SUPPLY VOLTAGE:**
  - 15V

Size 194 x 100 x 85mm

Price £21.20 + £1.70 VAT P&P Free.

---

**HY200**

120 Watts into 8Ω

The HY200 is a new and improved version of the HY120, providing an output of 120 Watts. It has been designed to meet the most exacting requirements of professional and domestic applications. It is designed to be used in commercial or domestic audio environments with output levels of 240W. The HY200 is a complete kit, together with easy to follow instruction and operating instructions. The amplifier features an integral heatsink together with the simplicity of no external components.

**FEATURES:**
- High Quality
- Thermal Protection
- No external components

**APPLICATIONS:**
- Hi-Fi
- High quality disco
- Public address
- Monaural amplifier
- Guitar and organ

**SPECIFICATIONS:**
- **INPUT SENSITIVITY:**
  - 500mV
- **OUTPUT POWER:**
  - 120W RMS into 8Ω
- **DISTORTION:**
  - 0.05% at 120W at 1kHz
- **OUTPUT NOISE RATIO:**
  - 95dB
- **FREQUENCY RESPONSE:**
  - 10Hz - 45kHz
  - 3dB
- **SUPPLY VOLTAGE:**
  - 15V

Size 194 x 100 x 85mm

Price £29.25 + £2.34 VAT P&P Free.

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**HY400**

240 Watts into 4Ω

The HY400 is a new version of the HY200, providing an output of 240 Watts. It has been designed to meet the most exacting requirements of professional and domestic applications. It is designed to be used in commercial or domestic audio environments with output levels of 240W. The HY400 is a complete kit, together with easy to follow instruction and operating instructions. The amplifier features an integral heatsink together with the simplicity of no external components.

**FEATURES:**
- High Quality
- Thermal Protection
- No external components

**APPLICATIONS:**
- Hi-Fi
- High quality disco
- Public address
- Monaural amplifier
- Guitar and organ

**SPECIFICATIONS:**
- **INPUT SENSITIVITY:**
  - 500mV
- **OUTPUT POWER:**
  - 240W RMS into 4Ω
- **DISTORTION:**
  - 0.1% at 240W at 1kHz
- **OUTPUT NOISE RATIO:**
  - 94dB
- **FREQUENCY RESPONSE:**
  - 10Hz - 45kHz
  - 3dB
- **SUPPLY VOLTAGE:**
  - 15V

Size 194 x 100 x 85mm

Price £29.25 + £2.34 VAT P&P Free.

---

**POWER SUPPLIES**

<table>
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<tr>
<th>I.P. Electronics Ltd</th>
<th>Crossland House</th>
<th>Nackington, Canterbury</th>
<th>Kent CT4 7AD</th>
<th>Tel (0227) 63218</th>
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4 x 4/c each Bank £2.25 P.20p
6 make each way linking 60p P.10p
Bank of 4 x 4/each way: 1 bank £1.25 P.15p
MULTICORE CABLES
6 CORE RAINBOW CABLE
8 x 14/76 Forming 9vn wide strip
10m—£1.15 20m—£4.50 50m—£10.25 £12.00 100m—£22.50 P.10p per metre
5 CORE H.D. CABLE 5 x 70/76 P.V.C.
10m—£1.50 25m—£4.25 50m—£8.50 £10.00 100m—£22.50 P.20p per metre
5 CORE ARMOURED 4 x 40/50 P.V.C. INS.
Outer Smooth-Flexible Galvanised Tubing, O.D. 9mm
10m—£3.50 25m—£8.25 50m—£15.10 100m—£22.50 P.25p per metre
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10m—£1.50 25m—£3.50 50m—£5.25 100m—£12.50 P.20p per metre
36 CORE SCREENED 36 x 7/76 (36 colours) O.D. 1mm
VARIABLES
E.M.T. MULTIMETERS
Input 100-260k 50 Hz. Output 13kV
F.P. @ 500m a. (150 x 150 x 75mm) L12, P.P. £1.
AIR PRESSURE SWITCH 0-100 Vacuum
Switch Contacts 15 amp. Control EACH £1.50 P.25p
10.7 MHz CRYSTAL FILTERS (I.T.T. 1901) 25 Cent £6.00
H.D. THYRISTORS 65 amp 100 P.V.
On deep finned heat sink £2.50 P.50p
BYPASSING AUDIO ALARMS
12 v C.D. £5.00 P.10p
GEARED MOTORS 230 A.C. (150rpm)
120 m. £2.50 240 m. £2.50
MAGNETIC COUNTERS
8x2g 45c D.C. (Non-Reset) 92 x 22 x 22 m.m.
New/Revo £1.25
UMRICATORS 0.9 D.C. (Non-Reset)
Light conductive foam isolated 12 bulla contacts onto display
Character size 20 x 10 overall size 25 x 60 x 68 mm £1.50 P.25p
D.C. POWER SUPPLIES
Input 240 V.A.C.
TYPE 1 200 watt regulated £2.50 P.25p
TYPE 2 200 watt D.C. at 500 m.a. stabilized on open chassis 170 x 100 x 25mm £2.50 P.25p
PHILIPS MOBILE RADIO P.S.U.
Input 240 V.A.C. Output 32v at 1.5 Amp D.C. £5.25 P.75p
TELEPHONE HANDSET with "Press to Speak" switch £1.50 P.25p

Please ask for VAT.
J. B. PATRICK
191/193 LONDON ROAD
ROMFORD, ESSEX.
R90F. 44473.
Radio Officers—now you can enjoy the comforts of home.

Working for the Post Office Maritime Services really makes sense. You still do the work that interests you, but with all the advantages of a shore-based job: more time to enjoy home life, job security and good money. To qualify, you need a United Kingdom Maritime Radiocommunication Operator’s General Certificate or First Class Certificate of competence in Radiotelegraphy, or an equivalent certificate issued by a Commonwealth Administration or the Irish Republic.

Starting salaries, at 25 or over, are £2905 rising to £3704 after three years service. Between 19 and 24, the starting salary varies from £2234 to £2627 according to age. In addition, a supplement of £312 p.a. is payable. You’ll also receive an allowance for shift duties which at the maximum of the scale averages £900 a year and there are opportunities to earn overtime. There’s a good pension scheme, sick pay benefits and prospects of promotion to senior management.

Right now we have a few vacancies at some of our coastal radio stations, so if you’re 19 or over, preferably with sea-going experience, write to: ETE Maritime Radio Services Division (L690), ET17.1.1.2., Room 643, Union House, St. Martins-le-Grand, London EC1A 1AR.

Post Office Telecommunications
ELECTRICAL/ ELECTRONICS ENGINEERS

a consultancy/managerial/designer role

The Government Communications Headquarters has a constant demand for specialised complex equipment and systems designed by its own engineers, as well as readily available commercial equipment.

The successful candidates will undertake engineering project officer duties. These will include interpreting non-technical briefs; advising clients on the best method of approach; preparing specifications and designs; costing; and managing projects right through to implementation.

Currently there are vacancies in the following fields: Radio Communication Systems across the range from VLF to microwaves and the millimetric bands; Line and Data Communication Systems including computer application; and Main Computer Systems together with a wide range of peripherals.

Candidates must have a degree in electrical or electronic engineering or be academically qualified for corporate membership of the IEE or IERE. They must have general appreciation of project officer responsibilities and had at least 2 years' appropriate training and experience.

Starting salary between £3,760 and £5,030, depending on qualifications and experience. Prospects of promotion. Non-contributory pension scheme.

GCHQ
Cheltenham

UNIVERSITY OF DURHAM
ELECTRONICS TECHNICIAN

For the DEPARTMENT OF MUSIC

Applications are invited from suitably qualified Electronics Technicians for the above post, starting March / April 1977. Duties will include servicing and maintenance of the existing analogue electronic music system; candidates should have an aptitude and enthusiasm for undertaking the design and development of both analogue and digital sound-processing circuits in collaboration with the Senior Experimental Officer and have relevant experience. Salary at a point on the University's Grade 5 scale (£2,884 - £3,867) dependent upon education, qualifications and experience. Applications in writing giving full details of age, education, qualifications and experience, together with names and addresses of 2 referees, to the Personnel Office, Old Shire Hall, Durham, by 28th February, 1977, from whom further particulars are available.

LONDON BOROUGH OF HOUNSLOW COLLEGE OF TECHNOLOGY
DEPARTMENT OF ELECTRICAL ENGINEERING

Applications are invited as soon as possible for:

LECTURER

Grade 1 posts with specialism in one of the following fields: Electronic Installation; Electronic Craft Practice; Electronic Technician.

SALARY SCALE:

Lecturer Grade 1 £2,469 to £3,777 plus £402 London Allowance, plus £312 Supplement at all points. Increments above the minimum may be given for relevant industrial experience and degree qualifications.

Application forms may be obtained from the Chief Administrative Officer at the College (Denis Road, London NW10 2XU. Tel. 01-439 0147) and should be returned within two weeks from the appearance of the advertisement.

The Authority has a scheme for assistance with removal expenses including legal fees, etc., travelling and lodging allowances.

EAST MIDLANDS AIRPORT
RADIO TECHNICIAN

TECHNICAL OFFICERS GRADE 4

Applications are invited from men and women of the above age at East Midlands Airport intending applicants should possess either a City & Guilds qualification and/or Service qualifications and/or have relevant experience.

The post involves the installation and maintenance of Navigational Aids and other electronic equipment.

Applications are to be returned to the Technical Officer, East Midlands Airport, Castle Dairies, Ducksby, Donington, Derby, DE7 2SA, to whom they should be returned by 17th January 1977.

Mrs. M. R. Jennings
Park Air Electronics Limited
Northfields, Market Deeping, Peterborough PE6 8LG
Telephone: Market Deeping (0778) 345434

DESIGN/DEVELOPMENT ENGINEER

PARK AIR ELECTRONICS LIMITED, a subsidiary of International Aeradio Limited Group, seeks to appoint an Engineer to assist in the design and development of the Company's range of VHF communications equipment.

The successful applicant will be a self-motivated engineer capable of working alone or as part of a small team responsible for design and development from conception through to production. He/she will have formal qualification to HNC/Degree standard with relevant experience in the VHF communications field. Familiarity with modern stripline techniques and receiver front end design would be an advantage.

The Company offers an attractive salary package which includes a Contributory Pension Scheme, subsidised canteen and concessional fare rebates on holiday air fares for his or her family.

Applicants who are keen to join a small, stable Company with excellent growth prospects should apply in the first instance for an Application Form to:

PAE

Wireless World, February 1977
Wireless World, February 1977

ELECTROSONIC
S.E. LONDON

DEVELOPMENT ENGINEERS
PROJECT ENGINEERS
PRINTED CIRCUIT DESIGNER
TEST ENGINEERS
INSTALLATION ENGINEERS

C £4500
C £3800-£4500
C £3800
C £3000-£3600
UP TO £3200

Electrosonic Ltd. is a leading company in the rapidly expanding fields of lighting control, audio and audio-visual systems situated in South-East London within easy reach of rural Kent.

DEVELOPMENT ENGINEERS

Senior Development Engineer (audio visual products). A professional engineer is sought having wide experience of electronic control circuit design both analogue and digital (CMOS). Minimum qualifications HNC or equivalent. The applicant will be expected to carry the development through from initial design and breadboarding to final production including development or programming of the associated test equipment. This is a challenging position and will appeal to those engineers who enjoy combining both their theoretical and practical abilities.

PROJECT ENGINEERS

Engineers are required with experience of planning and detailing special projects. They will be required to handle medium sized projects from the order/specification stage to final on-site commissioning, also assisting with major projects. The work involves the integration of the company’s standard products into systems, the design of special equipment as part of the system, the preparation of detailed information for production and contractors, also close liaison with production, contractors and the customer. Applicants should be qualified to HNC standard and have at least three years’ experience in system engineering in relevant fields.

PRINTED CIRCUIT DESIGNER

An experienced and creative engineer is required to design and layout printed circuit boards from logic and circuit diagrams. The work will entail the preparation of artwork, component reference masters and other essential P.C.B. documentation. The ability to produce fast and accurate results is essential. This will be a new appointment.

TEST ENGINEERS

Electronic engineers are required for testing and fault finding on a wide range of electronic control and audio equipment employing digital and analogue circuitry. On-the-job training will be given in the company’s products. Applicants should have at least two years’ continuous experience in industry additional to industrial training periods, academic training to ONC/HNC level or equivalent qualification is desirable.

INSTALLATION ENGINEERS

The hire department requires an engineer to set up equipment in the factory and install and operate on site. The equipment is principally for exhibition and audio presentation and includes lighting and audio systems. Essential requirements are attention to detail with a mature and a presentable manner. The job will appeal to young engineers with an interest in electronics and travel. A clean driving licence is desirable. Salary according to age and previous experience up to £3200 plus overtime and allowances.

The company offers an attractive working environment and excellent conditions of employment

Applications to: Mr. R. D. Naisbitt, Personnel Director
Electrosonic Ltd., 815 Woolwich Road, London SE7 8LT
Telephone: 01-855 1101

AUDIO TEST ENGINEERS

Allen & Heath Ltd., and Brenchell Engineering are expanding their production of mixers and tape recorders in North London.

Test Engineers with a good understanding of basic audio circuits are required for PCB and finished product test. This is an opportunity for capable test workers to join a young team.

Bonus scheme in operation. For interview call Ted Rook on 01-607 8271.
ELECTRONICS SERVICE ENGINEERS

An early challenge for 1977

S.E. Labs is an expanding Company within the highly successful EMI Group manufacturing a wide range of Electronic and Electro Mechanical equipment. The high standard of our products and our commitment to investment and further development means more and more orders — as a result of which we can offer the following four challenging opportunities.

1. Field Service Engineer (Feltham, Middlesex) — to service a range of digital tape systems and computer display terminals. Previous experience of servicing computer peripherals is essential.

2. Inside Service Engineer (Feltham, Middlesex) — to service a range of analogue magnetic tape systems. A thorough knowledge of analogue techniques is required.

3. Field Service Engineers (Oldham, Lancs.) — to service a wide range of electronic instrumentation equipment. Previous experience in a service environment and the ability to communicate with customers would be an advantage.

4. Inside Service Engineers (Stapleford, Notts.) — to service a range of Electromechanical and Turbo-driven recorders, signal conditioning equipment and oscilloscopes. Previous experience in a service environment would be an advantage.

For each of the above vacancies candidates should be qualified to at least ONC level or have equivalent in-depth experience. Applicants should preferably reside in or near to the locations quoted. A company car will be provided in the two Field Service Posts.

Salary will take full account not only of experience but also ability and qualifications. You will be entitled to the full range of EMI group employees benefits.

To apply please telephone or write to: Ray Flower, Personnel Manager, S.E. Labs (EMI) Ltd., North Feltham Trading Estate, Feltham, Middlesex. Telephone 01-890 1477.

SE LABS

A member of the EMI Group of companies.
International leader in electronics and record.

Electronics Engineers

You can bank on all these with Radiomobile

If you have a good qualification in electronics plus some years of design experience in communications or consumer radio or TV phone or write to: John Lawrence (Design Manager), Radiomobile Ltd. Eaton Road, Hemel Hempstead, Herts. Telephone 63511 ext. 24.

If you don't, you'll never know what you might have missed!

Radiomobile is a subsidiary of Smiths Industries.
TEST TECHNICIAN
To carry out all aspects of testing on a wide range of electrical-electronic apparatus and components used in the manufacture of modern X-ray equipment. General testing experience is essential, although not necessarily in this particular field.
Write in the first instance to The Personnel Officer, G.E.C. Medical Equipment Limited, 14 Progress Way, Waddon, Croydon, Surrey. Telephone: 01-688 7495

VHF SERVICE engineer required to work on Pye, GEC ITP, etc. Mobile radio and base stations experience preferred. Excellent prospects with ample opportunity for overtime if wanted. Well equipped and bus work shops in Croydon. Friendly atmosphere. London Car Telephone: 01-680 1018. (£87)

DESIGN ENGINEER
Thorn Consumer Electronics Limited, the leading manufacturer of television, radio and audio equipment in the U.K. wish to appoint an experienced Design Engineer for their research and engineering centre at Enfield.

He/she will be of degree or equivalent standard, preferably under 35 years of age with at least 2 years background of television design and some digital design capability.

He/she will join a team investigating new ideas and systems and be required to work on his/her own initiative leading with internal development departments and outside suppliers.

Applications in writing giving details of age, experience and qualifications to:

The Personnel Manager (DE/WW)
Thorn Consumer Electronics Ltd.
Great Cambridge Road, Enfield, Middlesex EN1 1UL

Lowestoft, Suffolk
ELECTRONICS ENGINEER
To develop advanced Radio-Telemetry for Ecological Studies

The post involves developing and improving radio-telemetry equipment for tracking the movement of vertebrate pests, particularly foxes, badgers, rats, coyote and polecats, in a variety of habitats. The work has important implications regarding the prevention of health hazards, both to humans and animals, particularly the spread of rabies by foxes and bovine tuberculosis by badgers.

There is considerable scope for research and development and it is envisaged that multi-channel telemetry will play an important part in future studies. The successful candidate will be based at Lowestoft, at an outer station of the Pest Infestation Control Laboratory. The headquarters are at Worpleston, Surrey.

Candidates (normally aged under 27) must have a 1st or 2nd class honours degree or equivalent in Electronics Engineering or Physics and a good knowledge of radio wave propagation. Final Year students will be considered considered.

Appointment will be as Scientific Officer (£2460-£3840). Starting salary according to qualifications and experience. Non-contributory pension scheme. Good promotion prospects.

For further details and an application form (to be returned by 2 February, 1977), write to Mr. Geoffrey E. Wilson, Ministry of Agriculture, Fisheries and Food, Pest Infestation Control Laboratory, Lowestoft, Lowestoft, Suffolk.

INSTRUMENT TECHNICIAN (preferably aged under 25) needed for 2 years at the Institute of Scientific Instrumentation in Bangladesh to set up a small instrument servicing and repair laboratory, advice on the maintenance and repair of electronic/electrical equipment and train local technicians in this work. The volunteer terms of service include a modest allowance accommodation, fares and expenses. Gain experience of a lifetime helping to develop the country. Further information from Jan Davis, Voluntary Service Overseas, (DE/WW) 14 Bishop's Bridge Road, London W2 6AA (Tel: 262 2871). (£81)

ENGINEER who has had considerable experience in the manufacture of small magnetrons. We have an interesting situation for the right person which could be very rewarding, according to skills both in business and manufacturing abilities. Write in confidence giving details of experience, etc. to Box No. W/W 5903

AUDIO VISUAL COMPANY requires electronic engineers with digital and analogue experience for challenging work on teletext decoders advanced audio systems and microprocessor video games. Salary negotiable. Also required are copywriters/women for interesting work with overtime, in pleasant surroundings. All enquiries to Miss Manzi. Tel: 01-750 1801. (£609)

Ministry of Agriculture, Fisheries and Food Pest Infestation Control Laboratory

E296.

(£609)
Gilbert Islands
Telecomms
Technicians
If you have a C & G (Telecomms) Certificate or equivalent and have specialised in either marine electronics or radio with a minimum of two years' relevant experience, you can apply for one of the following posts in these beautiful and friendly Pacific islands.

Marine Electronics
You will be responsible for the installation, maintenance and repair of ships' stations on locally registered vessels, and for advising ship owners on spares requirements and holdings. You may have to undertake similar land work. Supervisory and training duties are also involved. (MX/11125/WD)

Telecomms
You will be responsible for the installation, maintenance and repair of telecomms equipment in commercial, marine coast and aeronautical services, and for the supervision and training of local staff. (MX/11126/WD)

Starting salary is equal to £4000 pa to £5925 pa and includes a substantial and normally tax-free allowance paid under Britain's overseas aid programme. Basic salary attracts a 25% tax-free gratuity.

Benefits include free passages, generous paid leave, children's holiday visit passages and education allowances, outfit allowance, subsidised housing, appointment grant and interest-free car loan.

For full details and application form write, quoting appropriate reference to:

Crown Agents
The Crown Agents for Oversea Governments and Administrations, Appointments Division, 4 Millbank, London SW1P 3JD.

Fluke International urgently require Service Engineers to work in their Customer Service department. Experience of D.V.M.s, Counters and Calibration equipment is essential as is a good all-round knowledge of Digital and analogue techniques.

Fluke are an International Corporation and leaders in their field. Our well equipped Service Laboratory is located at our UK Headquarters in Watford.

A good salary will be paid commensurate with experience, plus a pension and Bonus Scheme, plus three weeks' annual holiday.

Please send your résumé to:

Mr. Bob Coton, Service Manager
Fluke International Corporation
Garnett Close
Watford
WD2 4TT

WIRELESS TECHNICIANS

There are a limited number of vacancies in the Home Office Wireless depots at Bishops Cleeve, Gloucestershire; Bridgend, Glamorgan; Crayke, Kent; Harrow, Middlesex and Taplow. Bucks for Wireless Technicians to assist with the installation and maintenance of VHF and UHF Systems. Applicants must be able to drive a car and be in possession of a current United Kingdom driving licence.

Salary
is £2,010 (at 17), £2,450 (at 21) and £2,905 (at 25) rising to £3,385, plus a pay supplement of £313.20 a year and an Outer London Weighting allowance of £275 a year at Harrow.

A Secure Future
with a non-contributory pension scheme, good prospects of promotion and a generous leave allowance. There are opportunities for day release to gain higher qualifications.

Qualifications
Candidates, male and female, must hold a City and Guilds Intermediate Telecommunications Certificate or equivalent qualification and have had good experience in Telecommunications.

Interested?
Then write or telephone for further details and an application form to: Mr. C. B. Constable, Directorate of Telecommunications, Home Office, 60 Rochester Row, London SW1P 1JX. Telephone 01-828 9848 Extension 734.

SERVICE ENGINEERS

Sound Logic require an ENGINEER

with Prototype Wiring Experience

The appointment offers scope for Project Engineering, Technical Drawing, Installation and Servicing work, but of prime importance is the ability to achieve high standards in 'one off' wiring of light duty relay and control circuitry including Audio equipment. Applicants should be prepared to travel and hold a current driving licence. Salary commensurate with experience and ability.

Sound Logic is a young, expanding company producing Audio, Communications and Control equipment for a variety of venues.

Apply in writing to: Chris Taylor
SOUND LOGIC LTD.
17 Fingal Street, Greenwich, London SE10 0JL
Iran Telecommunications

OSCO—The Oil Service Company of Iran, a Consortium of International Oil Companies engaged in the exploration and production of oil and gas for the National Iranian Oil Company have the following vacancies:

Head Telecommunications Special Projects

(US $30,000 per annum nett)

Responsible for the planning, co-ordinating and management of the telecommunication projects which include microwave, UHF, VHF and HF radio systems, trunk line and cable carrier systems, telegraph networks, telephone exchanges and local telephone line distribution.

Candidates should be graduates in Electronics/Telecommunications and have at least 10 to 12 years experience in telecommunication engineering and administration with at least 5 years at supervisory level.

Head Telecommunications Services

(US $25,000 per annum nett)

Responsible for all-over supervision and control of the drilling radio operation, maintenance of exchange and line, trunk telephone/telegraph network and all radio and electronic systems throughout the area of operations.

Candidates should be graduates in Electronics/Telecommunications with at least 10 years experience in all telecommunication engineering aspects including administration with at least 5 years at supervisory level. Must additionally have experience relating to radio band/frequency and a good background of radio, exchange and line maintenance.

Both appointments will be located in Ahvaz in South-West Iran and the tour of duty will be for two years with a possibility of extension.

In addition to a generous salary free of local income tax, the following benefits will apply:

1. Married accommodation available after short initial period of single status.
2. Free medical attention in Iran for staff and families.
3. Home leave earned at the rate of 4 days per month of foreign service.
4. Primary schooling available locally.
5. Financial assistance towards boarding school costs.
6. Additional school children's passages for children at boarding school in the country of origin.
7. Substantial terminal bonus on satisfactory completion of contract.

Iranian applicants will be considered under the regulations existing for the employment of Iranian staff.

Please forward full details of experience and qualifications to Brian Doyle, Selection Consultant, Ref. 8381/WW, Whites Recruitment Limited, 72 Fleet Street, London EC4Y 1JS.

Saudia, the airline of the Kingdom of Saudi Arabia, is seeking, as part of a planned programme of expansion, two thoroughly experienced technicians, aged under 45, to sustain the existing level of operations and also to work on new communications equipment which is currently being installed.

SENIOR TELEPRINTER TECHNICIAN

Starting salary c. £7,600 (income tax free)

Duties will include:

- Routine and complex maintenance and repair of teleprinter equipment
- The installation of circuits and teleprinter machines
- Conducting periodic tests to check the quality of the teleprinter circuits
- Routine preventative maintenance on equipment and machinery
- The maintenance of service records for equipment in use
- Maintenance and revision of technical manuals

Applicants should hold a certificate of training in the field of teleprinter/system maintenance and have 3-5 years practical experience. (Please quote reference A-504-762 when applying for this job).

SENIOR RADIO TECHNICIAN

Starting salary c. £7,600 (income tax free)

Duties will include:

- Routine maintenance and troubleshooting on radio equipment—eg. UHF/VHF/HF mobile communications equipment, public address systems, etc.
- Work on communications system installations including antennas, feeder lines, power lines and cables
- The maintenance of technical journals
- The maintenance of service records for equipment and logs of the utilisation of spare parts
- Participation in on-the-job training of Saudi National employees

Applicants should have completed a trade school course or have equivalent experience. 3-5 years experience of electronics equipment servicing is essential. (Please quote reference A-504-762 when applying for this job).

These jobs, which are for a 2 year (renewable) contract period, are based in Jeddah. Saudia offer excellent (income tax free) salaries together with free furnished accommodation for you and your family, free and reduced air tickets, 40 days leave per annum and a relocation allowance.

Please write, with full personal and career details, to telephone for an application form, quoting the appropriate reference, to:

Miss Connie Mulshaw, Saudia's U.K. Personnel Representative, Saudia Arabian Airlines, Room 216, 93, Regent Street, London W.1. Tel. 01-439 1661.

Closing date for completed applications 2nd January 1977.
Avery Hill College
Bexley Road, London SE3 2PQ

Closed Circuit Television Studio Engineer

Required as soon as possible a CCTV Studio Engineer. The person appointed will be responsible to the Head of the Television and Film Section for the efficient operation and maintenance of a small but well equipped television studio and its distribution system. There will be opportunities to take part in programme production. The present engineer is leaving to take up a new post. Salary £4393 - £5191. Appointment may be made above the minimum where appropriate.

ilea

Application forms, obtainable from the Senior Administrative Officer at the College, should be returned within 14 days.

Teledcommunications Engineering

These vacancies are in the Telecommunications Division of the Central Computer Agency, London, which supplies a consultancy service to Government Departments on all technical aspects of the use and procurement of non-telephony telecommunications equipment and services. One post is mainly concerned with assisting in the design and evaluation of data transmission networks including those using packet switching. The second post is concerned with audio and video teleconferencing, facsimile, closed circuit television and all aspects of telegraphy including message switching. The work also includes exploration of the available field in order to advise on, and satisfy, the telecommunication requirements resulting from dispersal of Government Departments.

Candidates must have HNC, or equivalent, in Electrical or Electronic Engineering, and several years' relevant experience.

Starting salary between £4700 and £5500 depending on qualifications and experience. Prospects of promotion. Non-contribution pension scheme.

For further details and an application form (to be returned by 10 February, 1977) write to Civil Service Commission, Alencon Link, Basingstoke. Hants RG21 1JB, or telephone Basingstoke (0256) 6851 (answer service operates outside office hours). Please quote T/9455.

Civil Service Department

PROGRAMMER

A programmer is required with experience of DEC equipment as Assembler level and preferably a real-time applications background to undertake the software development of a number of interesting products.

TEST/SERVICE TECHNICIANS

These positions require a background of digital systems testing or maintenance and would suit men or women with a practical rather than academic bias. A current driving licence is essential and candidates must be prepared to travel within the United Kingdom.

Please reply giving a resume of experience and salary requirements to the Project Manager.

Isca Electronics Limited
Crosskeys
Newport, Gwent NP1 1PX

Tel: Crosskeys (0495) 27061

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SOWTER TRANSFORMERS FOR SOUND RECORDING AND REPRODUCTION EQUIPMENT

We are suppliers to many well-known broadcasting, recording organisations, and music groups, and hold large stocks of new, and second-hand equipment, parts, accessories, coaters, pumps, etc. Specialise in television equipment. Large group of small components etc. All work done to order. Prices reduced. Available immediately.

NATIONAL PRICE. FULL DETAILS ON REQUEST.

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16mm BELL HOWELL 631 750/100w lamp, separate speaker and transformer. £150 + VAT. Hilton's Stock, hill, Dartford, K.R.E. Tel: 20009.

VALVES RADIO - T.V. Industrial. Transmitting. We dispatch valves to all parts of the world by return of post, air or sea mail. 2,000 types in stock. 1930 to 1976. Obsolete types a specialty. List 25p. Wholesale South S.A.E. Open to callers Monday to Thursday inclusive except Closed Wednesday 1200. We wish to purchase all types of new and boxed valves. Cox Radio (Surrey) Ltd., Dept WW, The Parade, Horsell, Surrey, Post Box 130 DSB, West Wittering 2023 (STD Code 024368).

CAPACITORS, mixed bags of electrolytics, approximately 1000 pieces, tested for EL. Multifield metallised polyester, mixed bags of 50 1µF, 2.2µF and 2.5µF (250v d.c.), cosmetic imperfections so EL. Add 40p P&P to all orders. R. Wardle, 5 Ermington Road, SW15 1BE.


Situations Vacant

Classified

Wireless World, February 1977

S.E.10

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Modern language teaching equipment - little used, at one tenth of today's cost. This offer cannot be repeated. Ring Mr Wright, 091-194 2361.

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For fastest, best CASH offer, phone

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RADIO GEAR, fixed mobile, commercial, military or amateur; also surplus new electronic components wanted. 81-820-2869. 29A Waddington Road, Croydon. (6734)

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SURPLUS COMPONENTS, Equipment and Computer panels wanted for cash. Ring Southamptom 773201. (16)

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WE BUY new valves, transistors and clean new components, large or small quantities, all sorts, always quotations by return. — Walton's, 55 Worcester St., Wolverhampton. (62)

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**BATCH**
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**PRODUCTION WIRING**
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