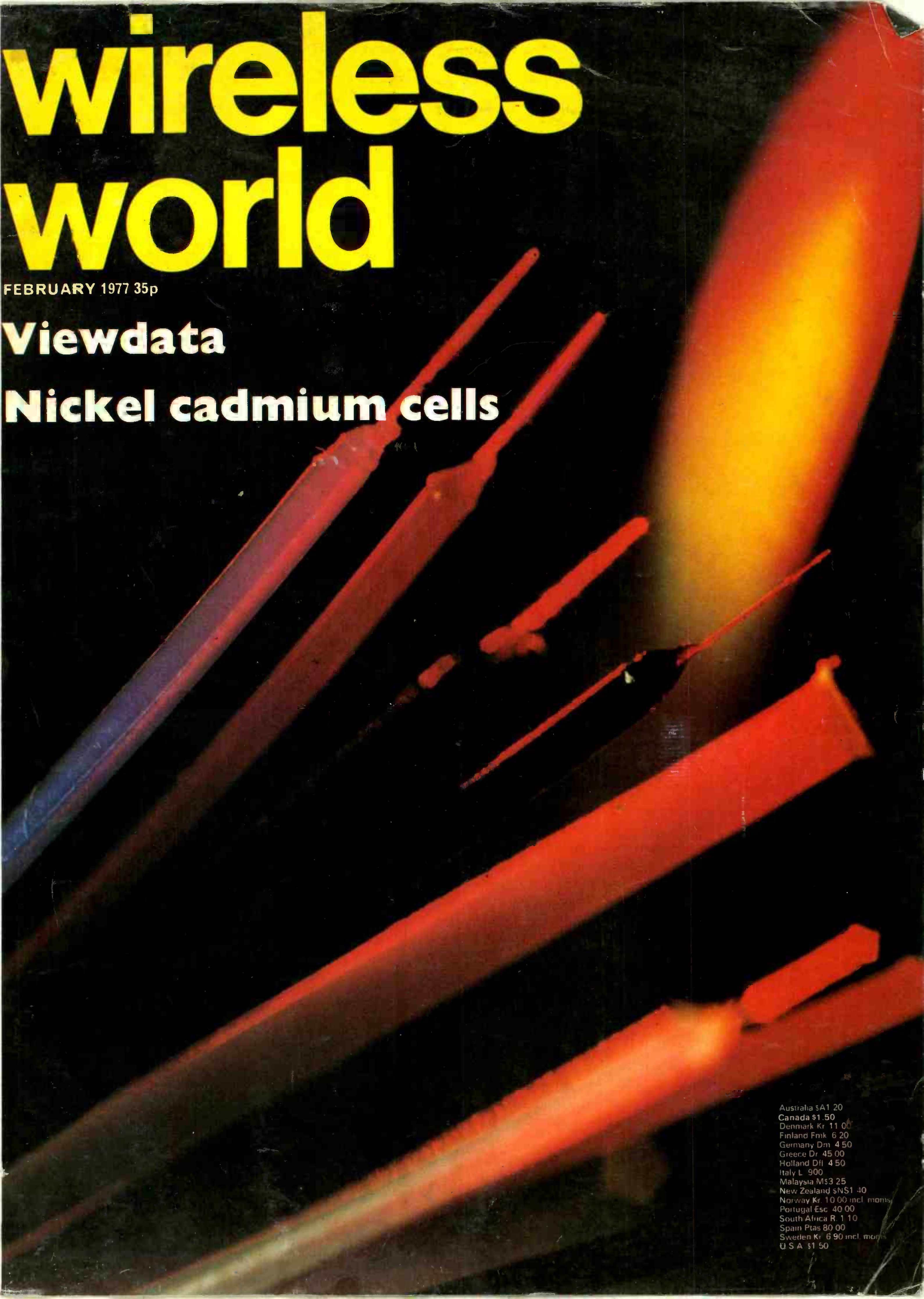
wireless world

FEBRUARY 1977 35p

Viewdata

Nickel cadmium cells



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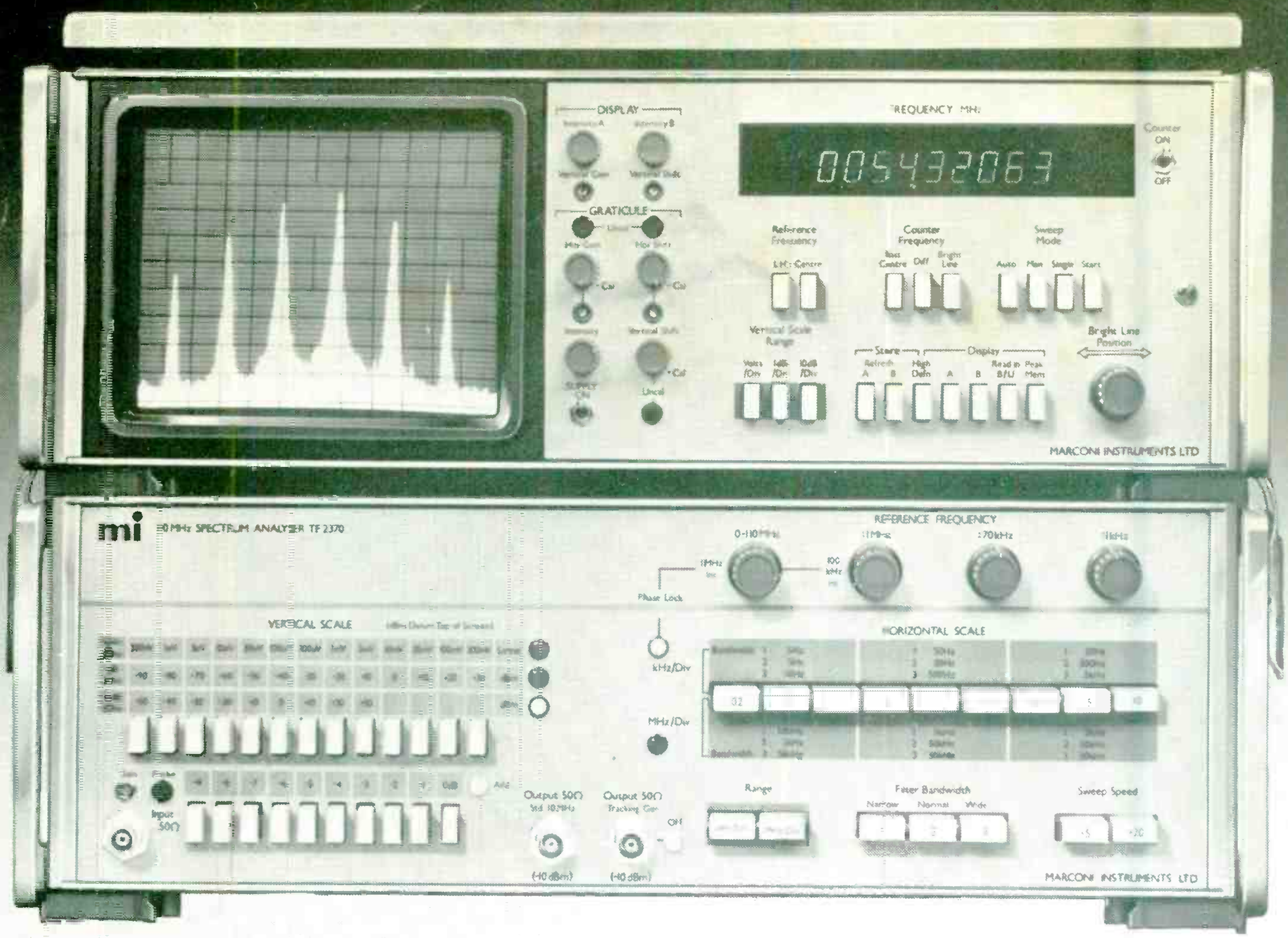

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You've never seen a faster, more accurate way of measuring frequency response from 30Hz to 110MHz

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:

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* 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!

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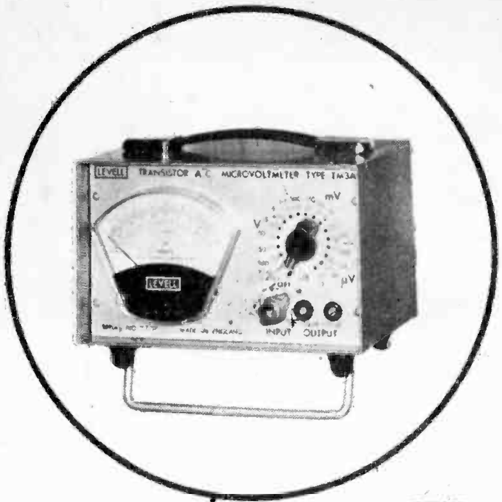

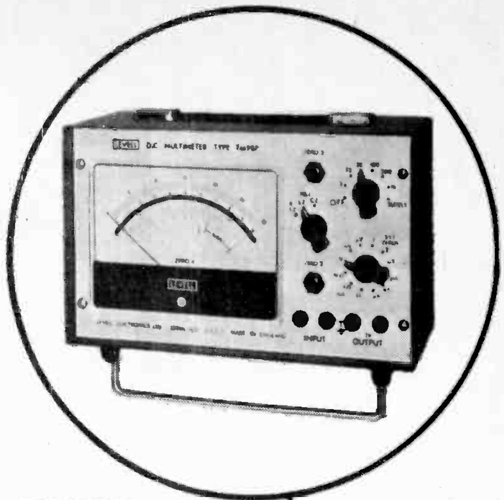

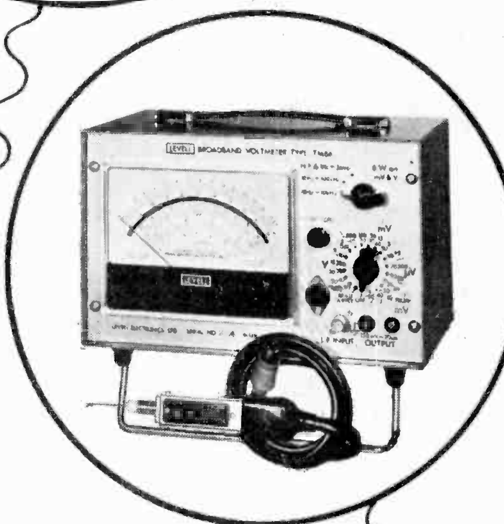

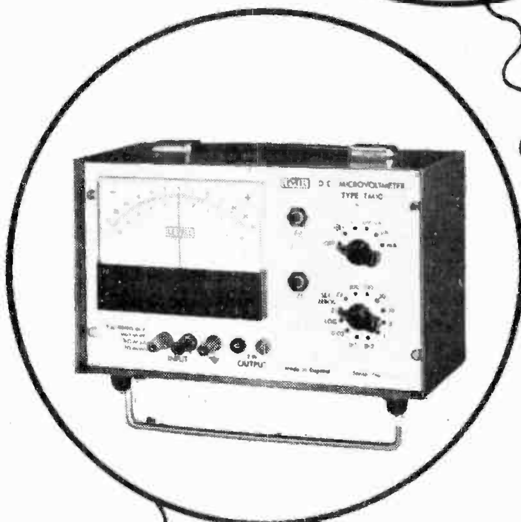

A.C. MICROVOLTMETERS

VOLTAGE & dB RANGES: 15µV, 50µV, 150µV . . . 500V.
Acc. ± 1% ± 1% f.s.d. ± 1µV at 1kHz — 100, — 90 . . . +50dB
Scale — 20dB/ + 6dB rel. to 1mW/600Ω.
RESPONSE: ± 3dB from 1 Hz to 3MHz, ± 0.3dB from 4Hz to 1MHz above 500µV. Type TM3B can be set to a restricted B.W. of 10Hz to 10kHz or 100 kHz.
INPUT IMPEDANCE: Above 50mV >4 3MΩ<20pf. On 50µV to 50mV: > 5MΩ < 50pf.
AMPLIFIER OUTPUT: 150mV at f.s.d.

type TM3A **£85** type TM3B **£95**

D.C. MULTIMETERS

VOLTAGE RANGES: 3µV, 10µV, 30µV . . . 1kV.
Acc. ± 1% ± 1% f.s.d. ± 0.1µV. LZ & CZ scales.
CURRENT RANGES: 3pA, 10pA, 30pA . . . 1mA (1A for TM9BP).
Acc. ± 2% ± 1% f.s.d. ± 0.3pA. LZ & CZ scales.
RESISTANCE RANGES: 3Ω, 10Ω, 30Ω . . . 1 GΩ linear Acc. ± 1% ± 1% f.s.d. up to 100MΩ.
RECORDER OUTPUT: 1V at f.s.d. into > 1kΩ on LZ ranges.

type TM9A **£125** type TM9BP **£135**

BROADBAND VOLTMETERS

H.F. VOLTAGE & dB RANGES: 1mV, 3mV, 10mV . . . 3V.
Acc. ±4%±1% f.s.d. at 30MHz. — 50dB, — 40dB, — 30dB to + 20dB. Scale — 10dB/ + 3dB rel. to 1mW/50 Ω ± 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.

type TM6A **£135** type TM6B **£145**

D.C. MICROVOLTMETERS

VOLTAGE RANGES: 30µV, 100µV, 300µV . . . 300V.
Acc. ± 1%, ± 2% f.s.d., ± 1µV. CZ scale.
CURRENT RANGES: 30pA, 100pA, 300pA . . . 300mA.
Acc. ± 2%, ± 2% f.s.d., ± 2pA. CZ scale.
LOGARITHMIC RANGE:
± 5µV at ± 10% f.s.d., ± 5mV at ± 50% f.s.d., ± 500mV at f.s.d.
RECORDER OUTPUT: ± 1V at f.s.d. into >1kΩ.

type TM10 **£77**

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.

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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!

Fill in this coupon for your copy of the data sheet on the 8030 and 8040 and send it to:
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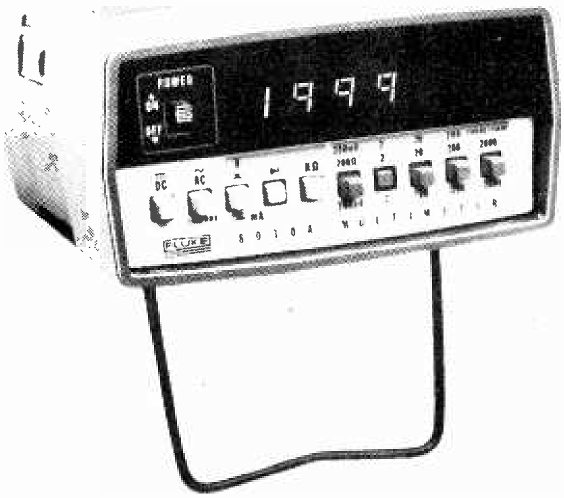

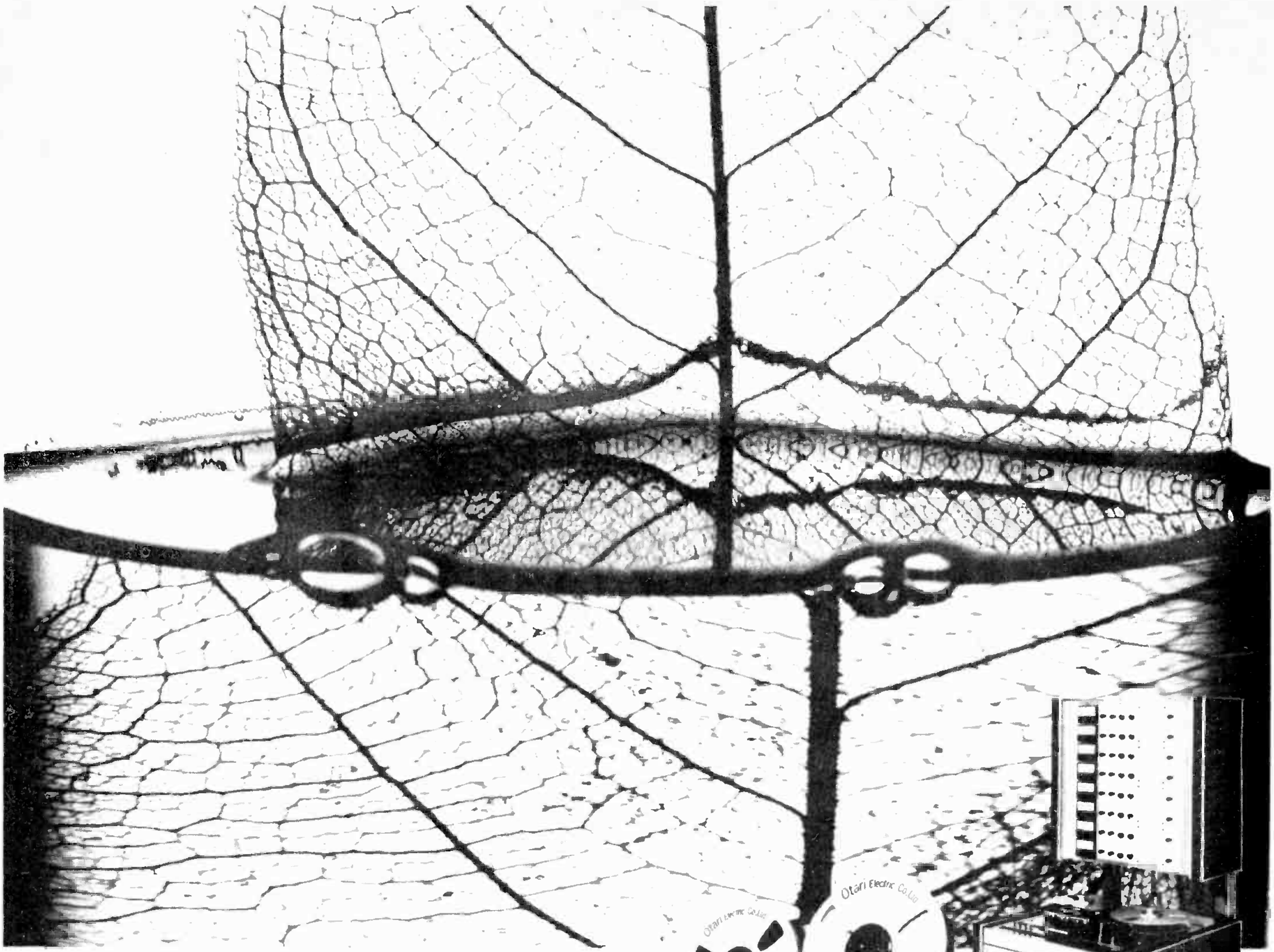

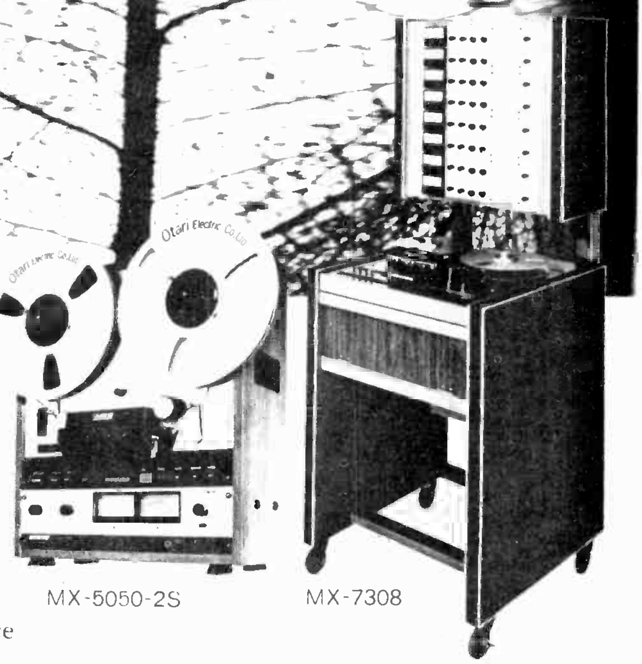
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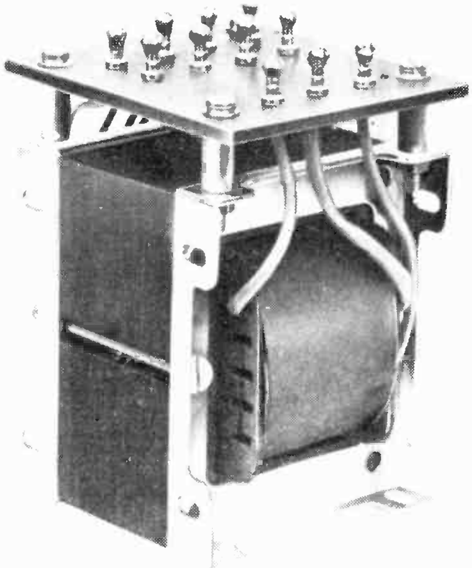
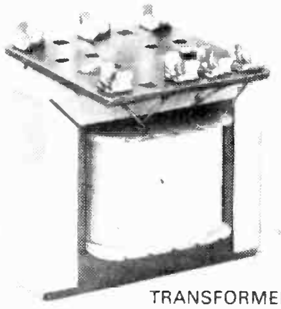


MICROPHONE TRANSFORMER IN MUMETAL CAN



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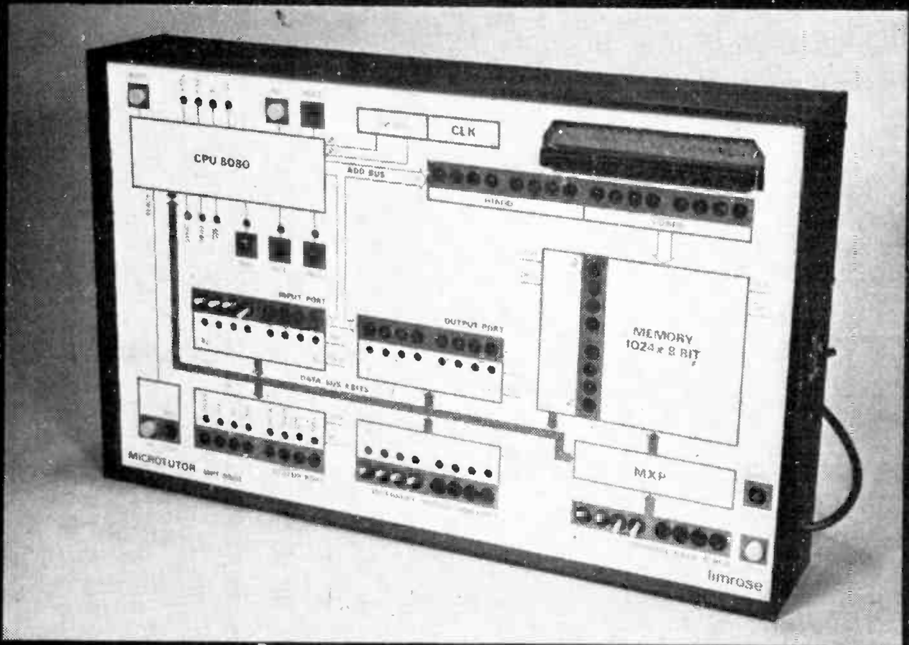
New low cost microcomputer for learning the 'how' of microprocessors ....



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

It comes ready to use. Nothing else to buy, debug or assemble. Just plug it in and you have a powerful microcomputer ready to use. No need for a Teletype, but if you have one, it can be hooked on using a plug-in card.

The comprehensive instruction manual is so straight-forward 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:

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Our Radio/TV Programme

If you service radio or television receivers, Avo has Signal Generators to meet your requirements.
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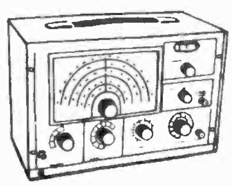
One of these units, incorporated into your re-equipment programme, could increase your throughput and optimise the use of your skilled manpower.
If you would like to know more about our AM and AM/FM Signal Generators, get in touch.
We will gladly put you in the picture.



Avo Limited,
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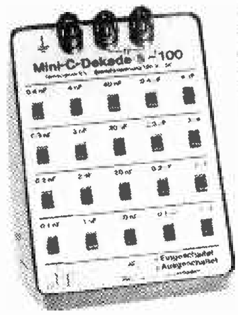
THORN Thorn Measurement and Components Division.

WW — 059 FOR FURTHER DETAILS

ESP Mini-C-Dekade

NEW



Mini-C-Dekade Type 5-100
Range 100pF to 11 uF
Accuracy 2%
Rating 100V DC
Size 10 × 15 × 4 cm
Fits neatly in to the palm of the hand

Price £74
EX VAT

ESP Mini-T-Dekade

NEW

Universal Timer
1 μsec 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

Time range—1. 1 μs to 9.999999 secs II. 01 μs to 999999 9 secs Ranges are switched in 7 decades using BCD code.

Output — 25mA, 30V and 10W, 0.5A, 200V DC

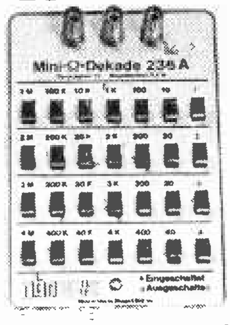
Quartz crystal—2 MHz. Stability : 50 ppm

Power supply—N. Cd cell 12V 225m Ah

Price £195 EX VAT

ESP Mini-R-Dekade

NEW



Mini-R-Dekade Type 236A
Range 1 ohm to 11 Mohm
Accuracy 1%
Max Dissipation 0.5 W
Size 10 × 15 × 3 cm
Fits neatly into the palm of the hand.

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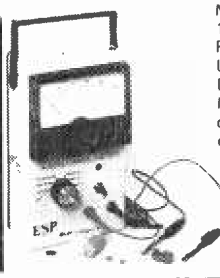
AUTO RANGING

Mini DVM Type 3201
Functions

DC V	200 2000 mV	
	20 200 V	
	1000 V	
	200 mV	
AC V	2000 mV	
	20, 200 V	
	500 V	
DC A	200 2000 μA	
	20 200 mA	
	200 μA	
AC A	2000 μA	
	20 200 mV	
OHM	2, 20 KΩ	
	200, 2000 KΩ	

Price £84 EX VAT

ESP Mini C-Meter



Mini C-Meter 100a
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Portable
Linear Scale
Direct reading
Measures any type of capacitor including electrolytics

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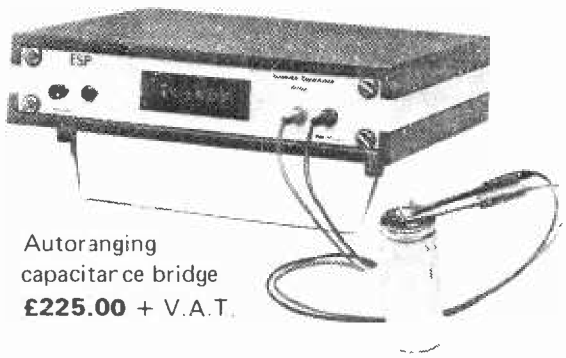

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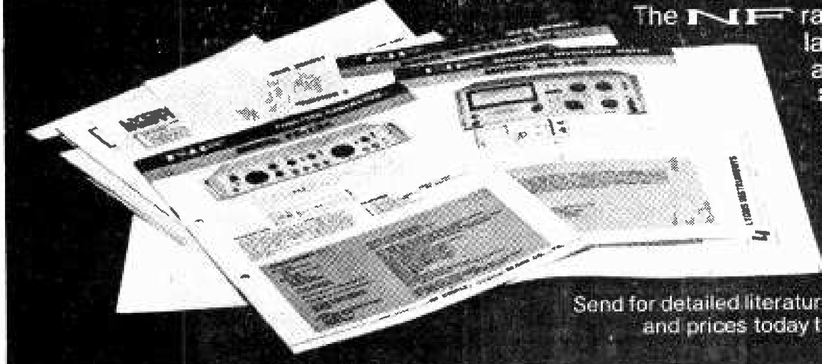

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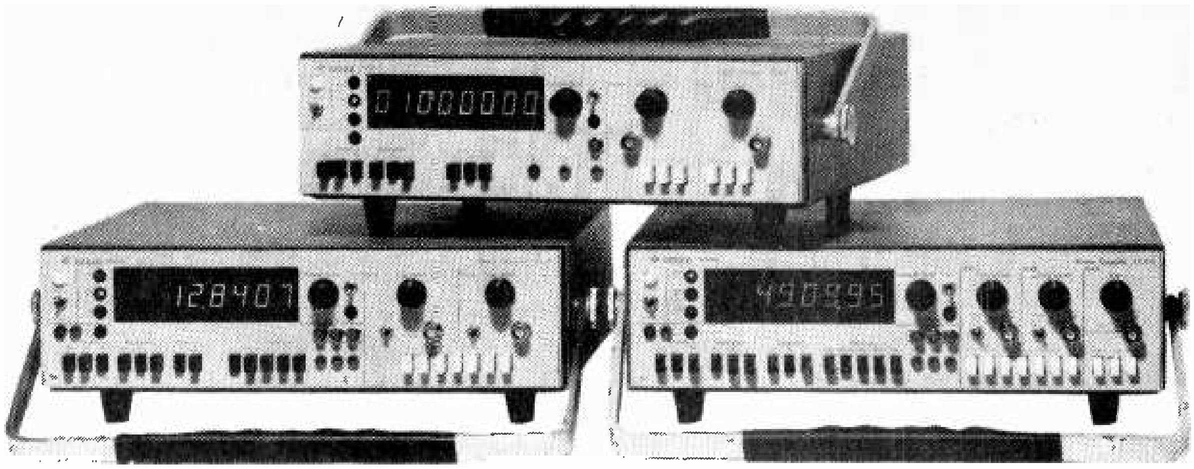

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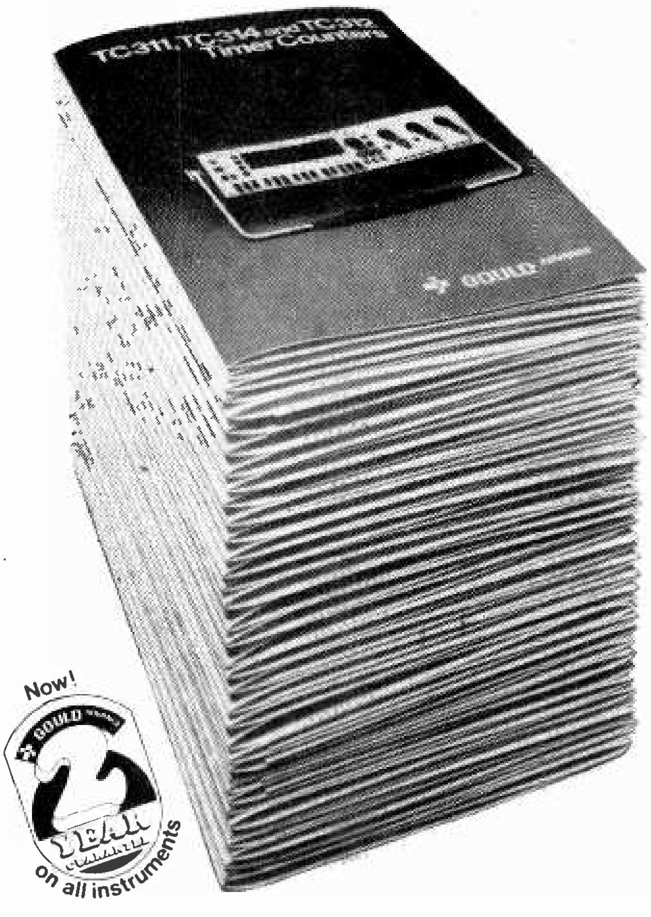

Try our specs.

Browse through the specification. You'll find all the normal requirements plus extras not normally found at this price. There's a wide range of functions including frequency, time, period, count, totalise and ratio. And of course, every instrument is fully guaranteed for 2 years, another cost saving. But don't just take our word for it, read all about it for yourself – and see how the advantages stack up.

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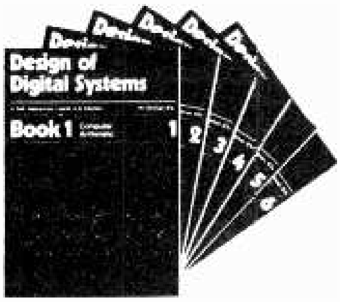

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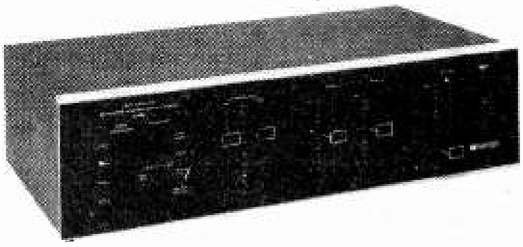

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Characteristics as ZD100 amplifier but provides an output of 250 watts per channel into 4 ohms and 150 watts per channel into 8 ohms.

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Uses ZD22 pre-amplifier with a power amplifier having a power output in excess of 50W per channel into 4-8 ohms. Distortion: less than 0.02% at rated power, typically less than 0.01%. True complementary symmetry output. Headphone output. Inputs: Disc, tuner, and two tape machines. Sensitivities: Disc 1mV. Auxilliaries 50mV for 20W output.

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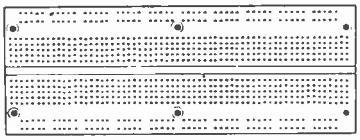

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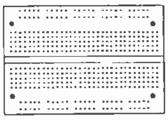

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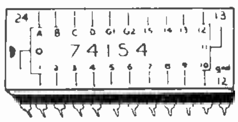

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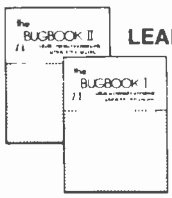

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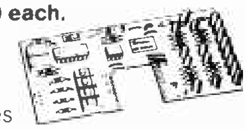

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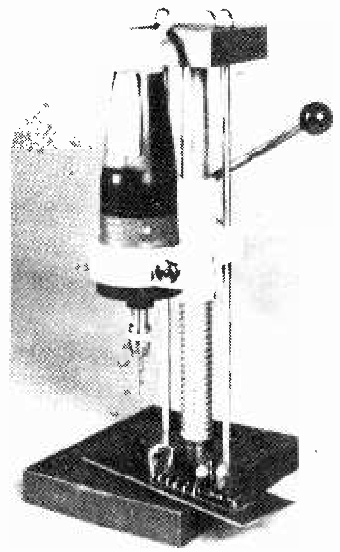

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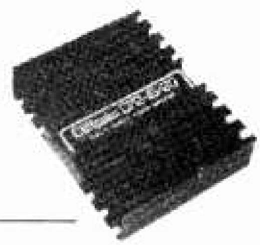

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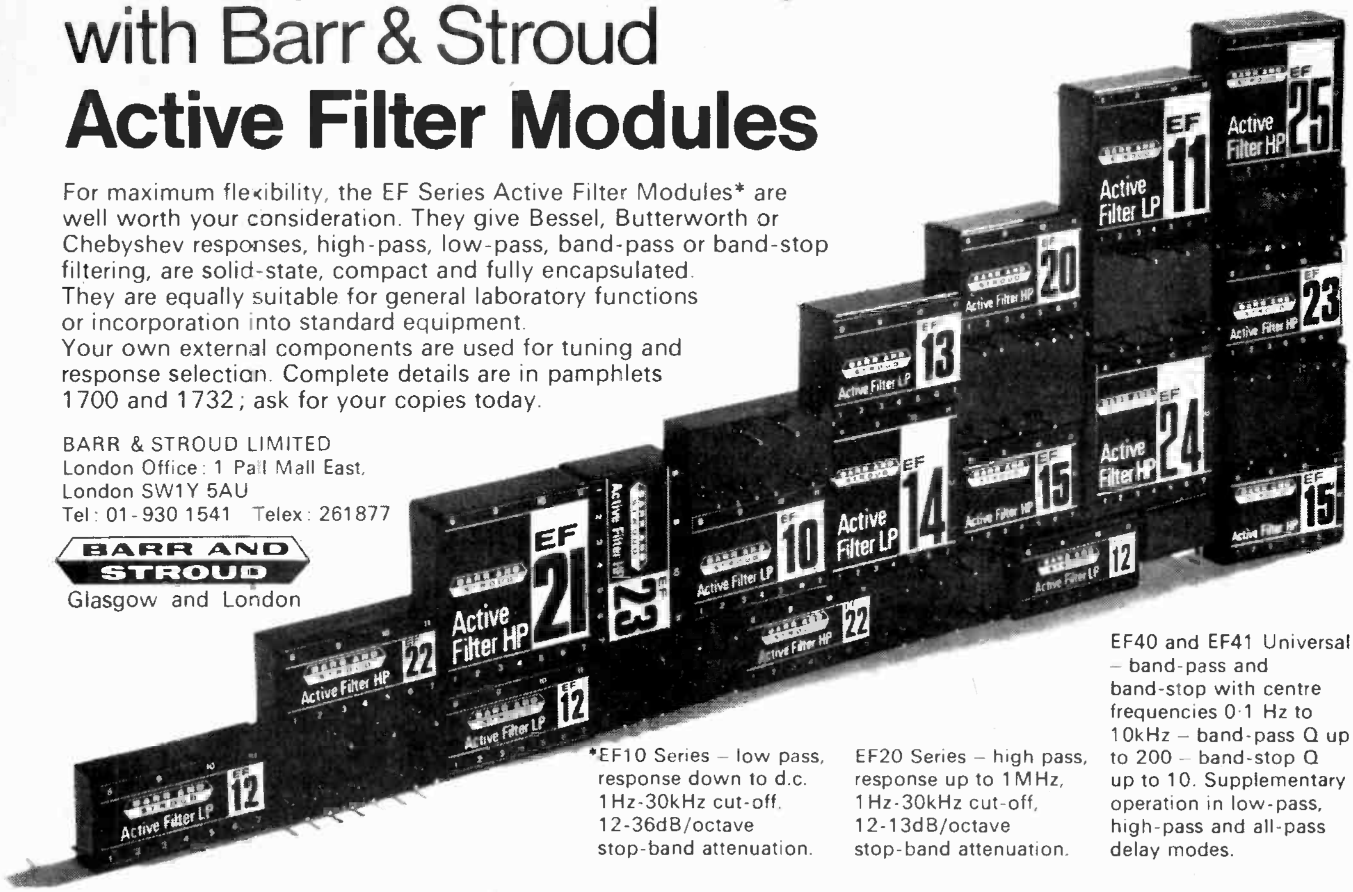

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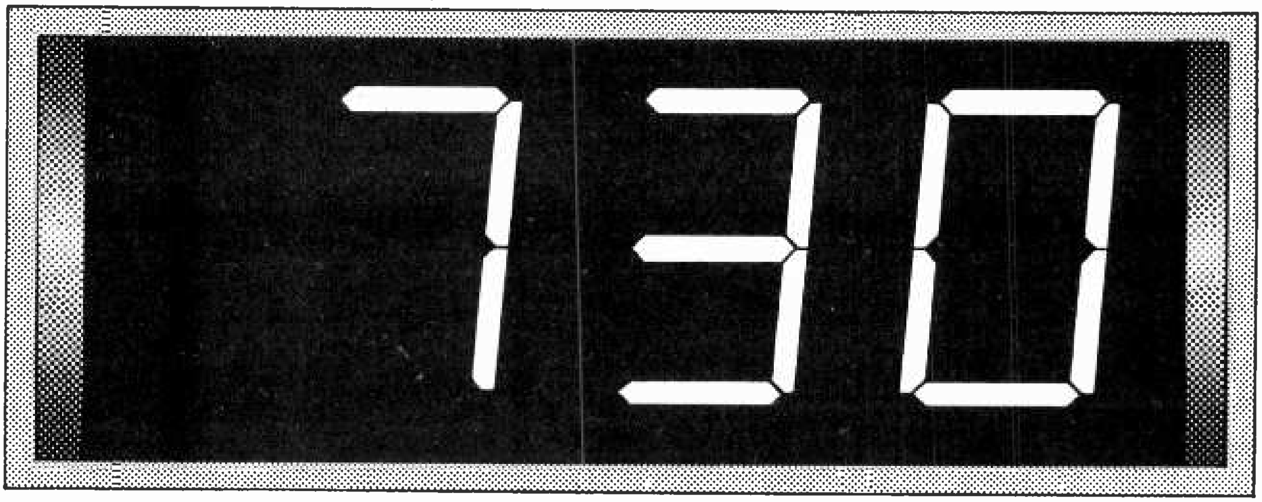
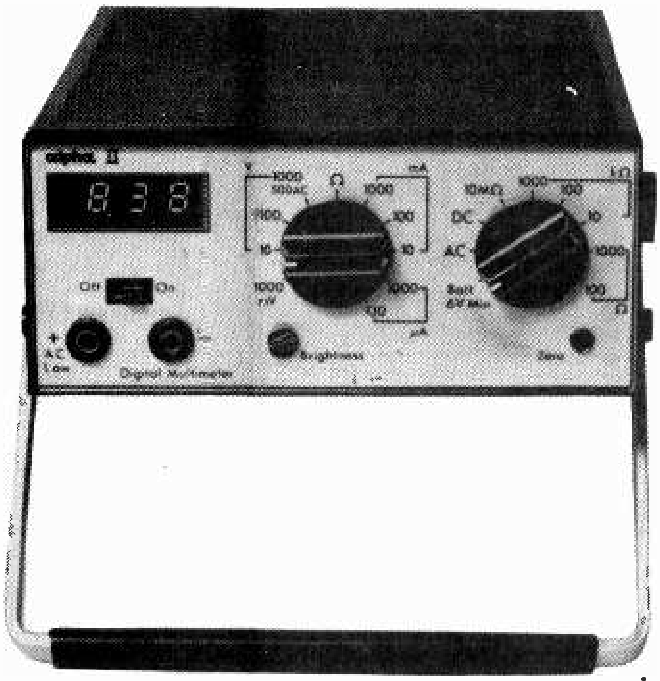


Take a look at the Alpha II Multimeter, and the first thing you'll notice, apart from the surprisingly low price, is the display. Big, bright and clear, — even in high ambient light conditions.



Use the instrument for a little while, and something else will impress you: its accuracy. The Alpha II is accurate to within 0.2% – better than many a more expensive instrument.

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Unique full-function 8-digit wrist calculator... available only as a kit.

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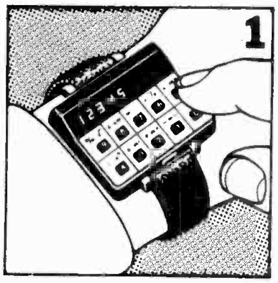
But a wrist-calculator is only worth having if it offers a genuinely comprehensive range of functions, with a full-size 8-digit display.

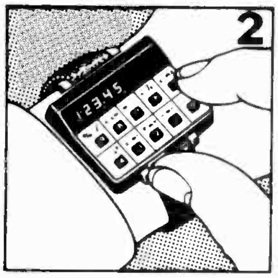
This one does. What's more, because it *is* a kit, supplied *direct* from the manufacturer, it costs only a very reasonable £9.95 (plus 8% VAT, P&P). And for that, you get not only a high-calibre calculator, but the fascination of building it yourself.

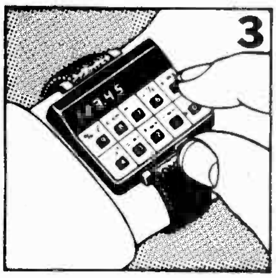
How to make 10 keys do the work of 27

The Sinclair Instrument wrist calculator offers the full range of arithmetic functions. It uses normal algebraic logic ('enter it as you write it'). But in addition, it offers a % key; plus the convenience functions $\sqrt{x}$, 1/x, x^2; plus a full *5-function memory.*

All this, from just 10 keys! The secret? An ingenious, simple three-position switch. It works like this.







1. The switch in its normal, central position. With the switch centred, numbers – which make up the vast majority of key-strokes – are tapped in the normal way

2. Hold the switch to the left to use the functions to the left above the keys...

3. and hold it to the right to use the functions to the right above the keys.

The display uses 8 full-size red LED digits, and the calculator runs on readily-available hearing-aid batteries to give weeks of normal use.

Assembling the Sinclair Instrument wrist calculator

The wrist calculator kit comes to you complete and ready for assembly. All you need is a reasonable degree of skill with a fine-point soldering iron. It takes about three hours to assemble. If anything goes wrong, Sinclair Instrument will replace any damaged components *free:* we want you to enjoy assembling the kit, and to end up with a valuable and useful calculator.

Contents

Case and display window.
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The wrist-calculator kit is available only direct from Sinclair Instrument. Take advantage of this 10-day money-back undertaking.

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Name ____________________

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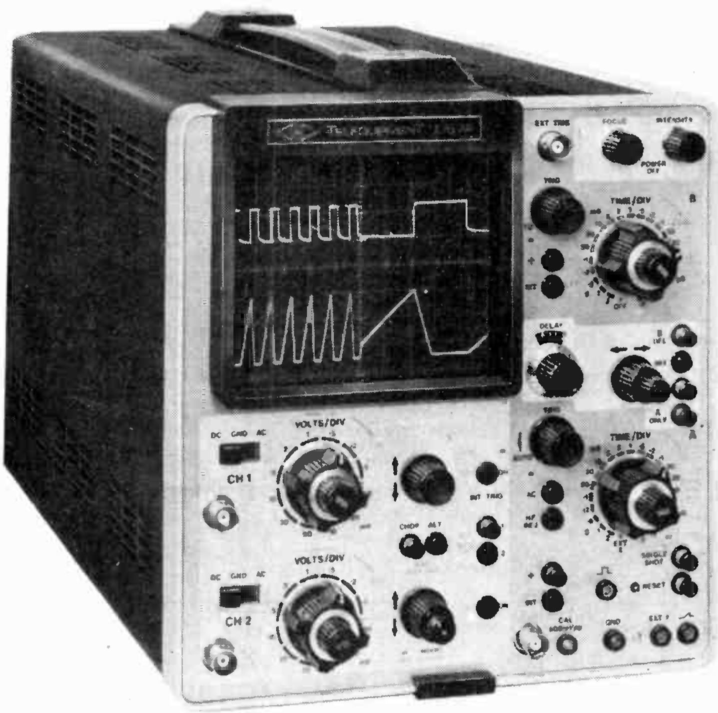

wireless world

Electronics, Television, Radio, Audio

FEBRUARY 1977 Vol 83 No 1494

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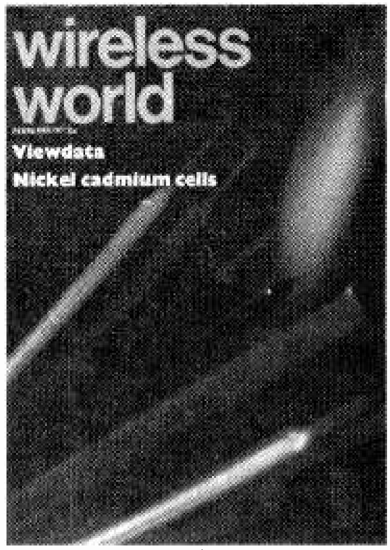

Front cover shows a group of silica optical fibres made by Standard Telecommunication Laboratories for use in optical communication systems. *Photographer Paul Brierley*

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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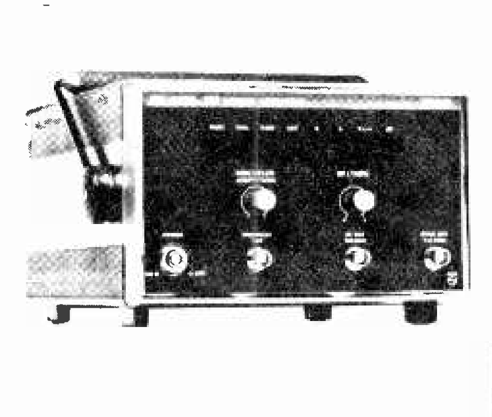

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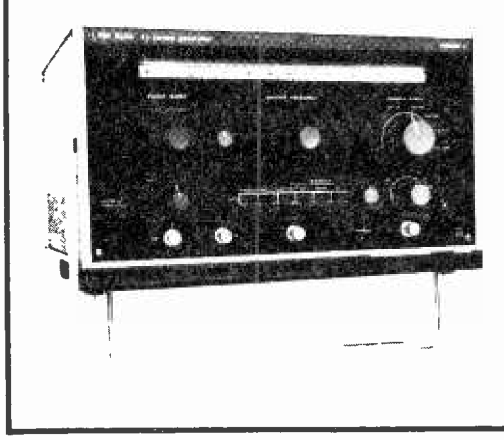

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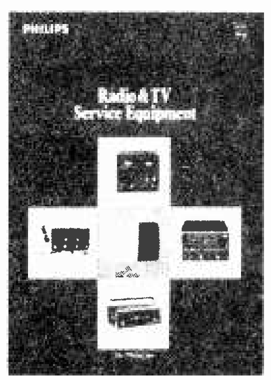

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wireless world

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.

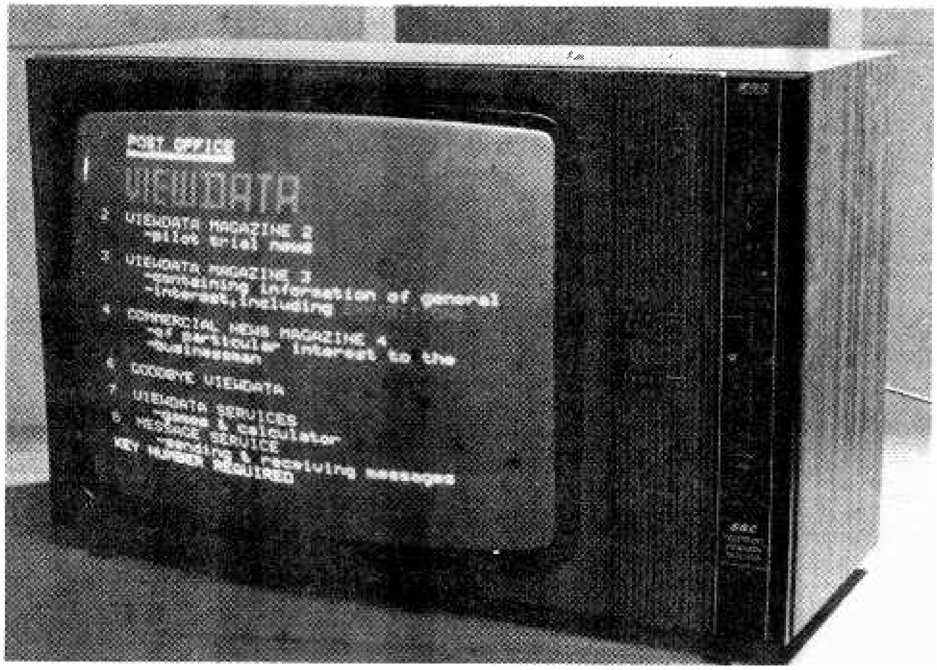
Clearly there is a strong subjective element in forecasting the future. Both reports are biased by the priorities of the organizations that produced them. The truth may lie somewhere between. What we need now is a public conference, perhaps run by one of the engineering institutions, that would allow 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.



Viewdata index displayed on a commercial teletext/Viewdata receiver.

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[1] 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[2] 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[3] 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. Thus the terminal equipment is minimal. The main problem of course is to so organise the service that 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 so 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[4] 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 +, −, ×, ÷, $\sqrt{}$ 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×(3+5)−6.2"

is transmitted as

4*7*13*05*2*86*52**:

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.

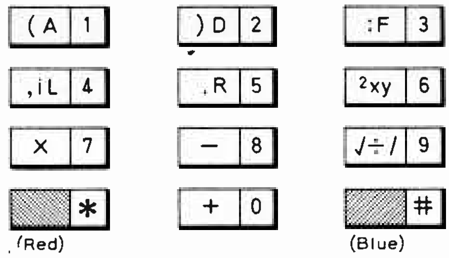


Fig. 1. Overlay template attached to push-button telephone used in DIALS calculation service

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.[5]. 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, which is sited 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 standard 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 communications 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.

* American Standard Code for Information Interchange.

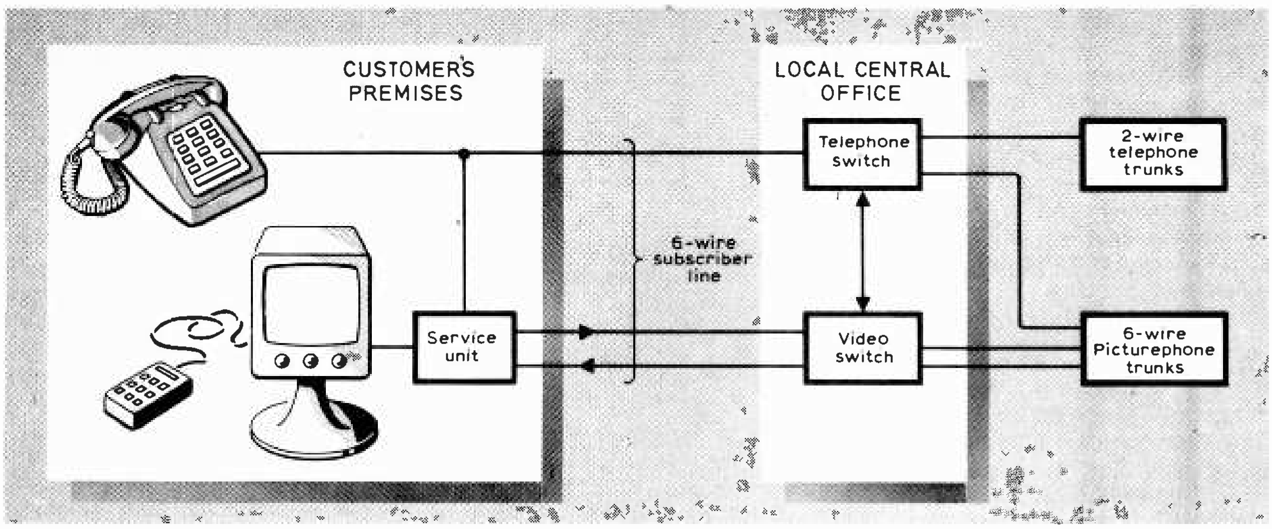
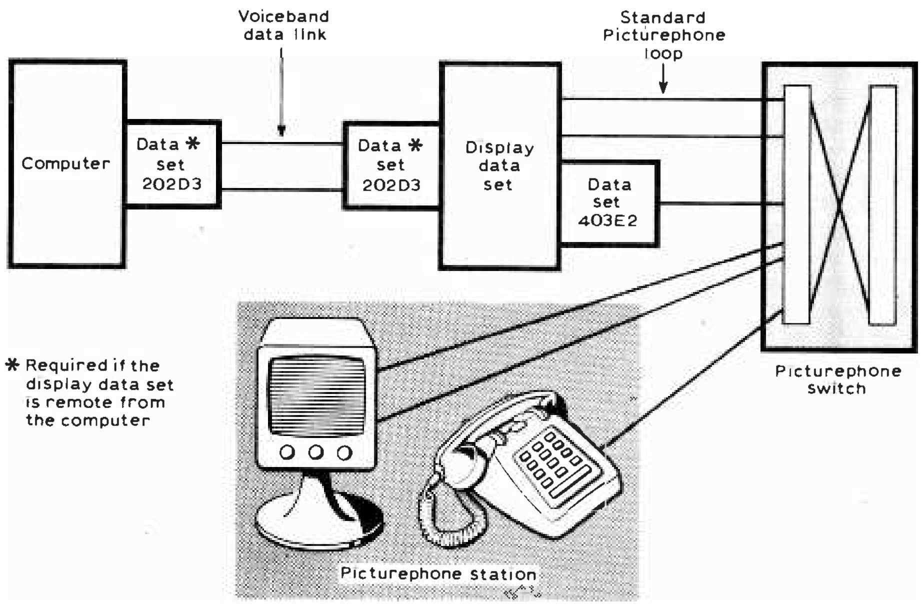


Fig. 2. (above). Basic local arrangement used in the Picturephone system developed by Bell Telephone; (right) Picturephone computer access system



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.

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[6].

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.

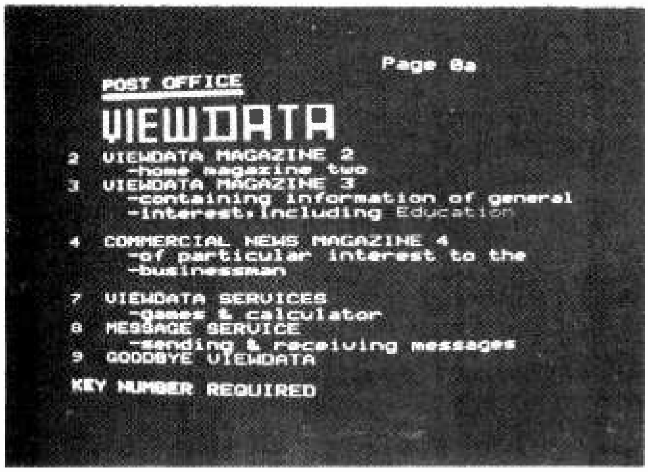
The computer relationship. In Viewdata as in the other systems noted earlier, the problem of how to enable users with no special computer training to access and instruct a computer loomed large, mainly because computer programming had developed from the very beginning, and with very few exceptions, into 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.

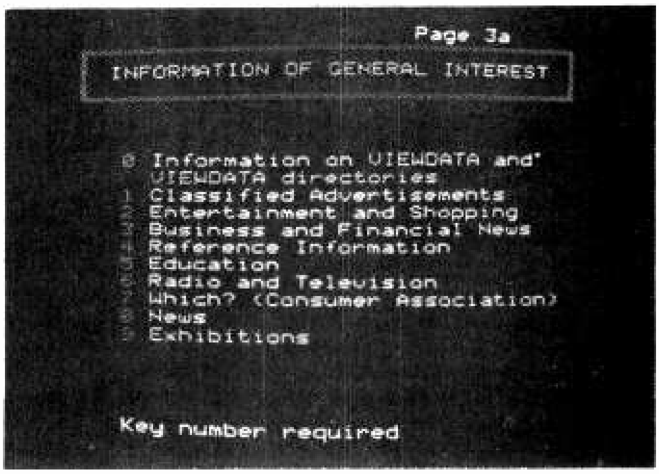
In a sense the computer programmer is a designer of a logic system, who uses logical instructions instead of using logical circuit interconnections like his colleague who designs hardware logic systems. But whereas we do not expect the *user* of a piece of logic hardware to be able to design it, in the 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

Fig. 3. (below). Displayed index from which the user selects the topic he requires. Fig. 4 (right). Index to magazine 3 as listed on the Fig. 3 display, showing the progressive nature of the Viewdata index.





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

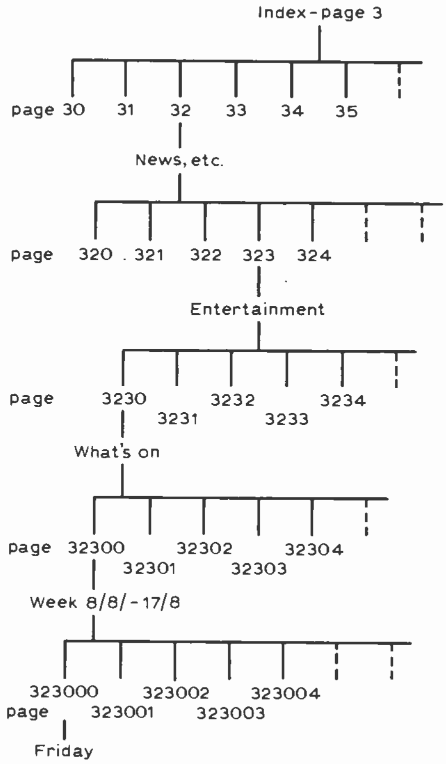


Fig. 5. Information in Viewdata is sub-divided in a tree structure. This gives an example of main topics (at the top) being sub-divided down to sub-topics (at the bottom).

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 lump. 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 simplfying 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)

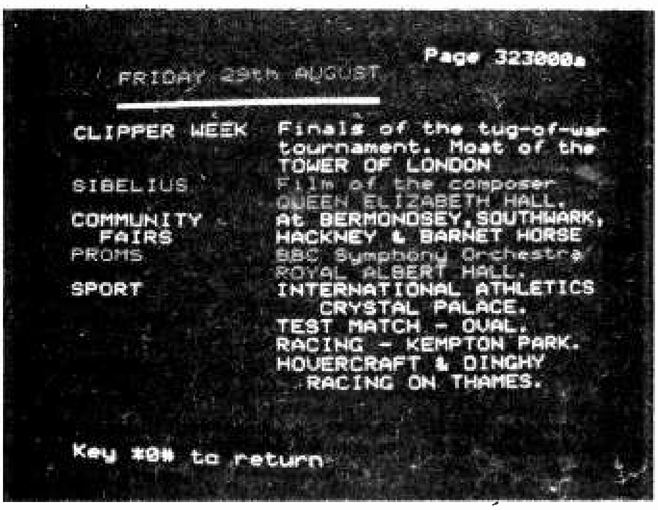


Fig. 6. Some information is presented in considerable detail, with page numbers being a correspondingly large number of digits

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Transient intermodulation in amplifiers

Simpler design procedure for t.i.m.-free amplifiers

by Bert Sundqvist

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

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

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[1-5] 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 bandwith. It is basically an overload phenomenon, giving an audible result that resembles crossover distortion. Transient intermodulation can be avoided by careful design[1-3] 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. Whe 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[4, 6]. 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[3,6] 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[4,5]; 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.

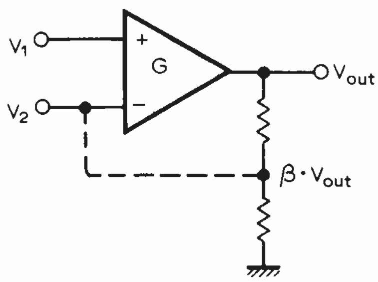

Fig.1. Single stage amplifier.

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 $V_{out} = G(V_2 - V_2)$ where $G = Aa/(a+s)$, with $s = j\omega$; we have a low frequency gain of $G = A$ and an upper cut-off frequency $2\pi f_a = a$. If we now apply the input signal V_{in} to input 1 and a feedback signal βV_{out} to input 2 we get $V_{out} = V_{in}G/(1+\beta G) = V_{in}Aa/(s + a(1+\beta A))$.

From this equation the low-frequency gain with feedback is $A/(1 + \beta A) \approx \beta^{-1}$, and the upper cut-off frequency is now $2\pi f_c = a(1+\beta A)$. 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 $G = G_1G_2 = ABab/(a+s)(b+s)$, see Fig. 3. If we now apply feedback in the same way as before we obtain

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

$$= V_{in}\frac{ABab}{s^2 + s(a+b) + ab(1+\beta AB)}$$

The non-inverting configuration has

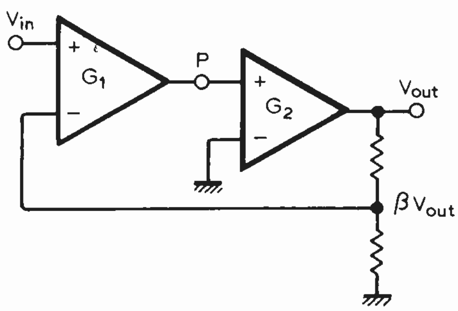

Fig.2. Two-stage amplifier with overall negative feedback.

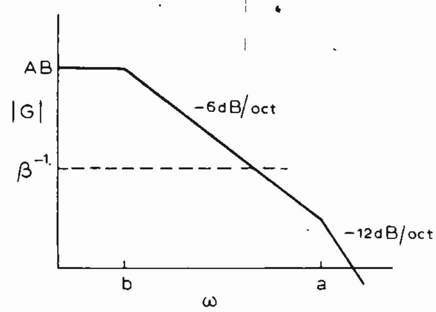

Fig.3. Gain vs frequency plot for the amplifier in Fig.2; both axes logarithmic.

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

$$V_p = V_{out}/G_2 = G_1(V_{in}-\beta V_{out}) = V_{in}\frac{Aa(b+s)}{s^2+s(a+b)+ab(1+\beta AB)} \qquad (1)$$

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 $p_{1,2}=-0.5(a+b)\pm 0.5[(a-b)^2-4ab\beta AB]^{1/2}$. We then find, for p_1 and p_2 both real and $t\geqslant 0$:

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

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

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

$$t=t_o=(p_1-p_2)^{-1}\log_e((b+p_2)/(b+p_1)) \qquad (2)$$

This means that for $t_0\geqslant 0$ 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_{pmax}) 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 $V_{pmax}/V_p(t\to\infty)$ versus a for $b=10^3$ and $b=10^4$ and for different values of βAB. The value of $V_{pmax}/V_p(t\to\infty)$ is approximately equal to βAB if a is large. To see why, let $a\to\infty$ in equation 1:

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

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

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

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

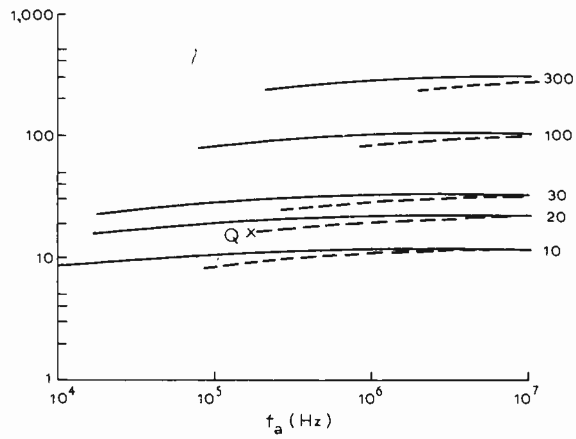

Fig. 4. Plots of V_{pmax}/V_p $(t\to\infty)$ vs $f_a=a/2\pi$ (in Hz) for $\beta AB=10, 20, 30, 100,$ and 300. Broken lines: $b=10^4$, solid lines: $b=10^3$.

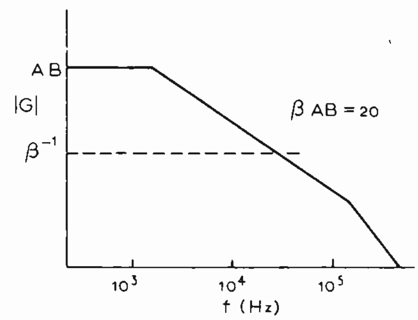

Fig. 5. Gain vs frequency plot for the amplifiers in the example (logarithmic axes).

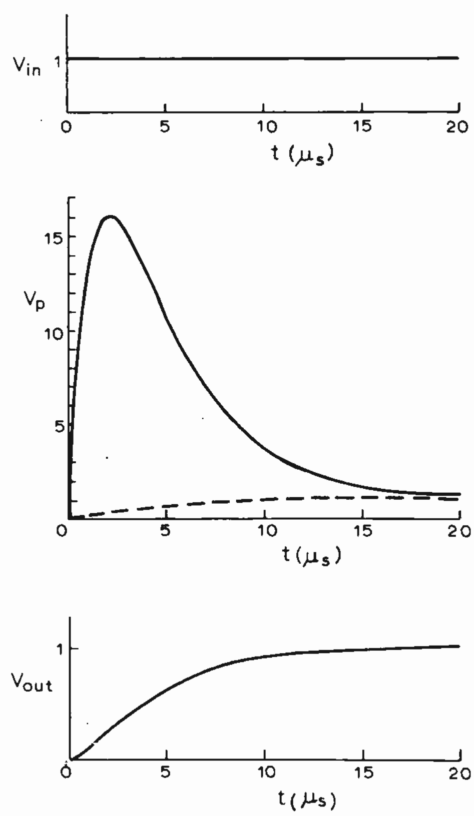

Fig. 6. Plot of $V_{in}(t)$, $V_p(t)$, and $V_{out}(t)$ for two amplifiers with a step voltage input signal. V_{in} and V_{out} are the same in both cases; for V_p we have: solid line: case 1, broken line: case 2 (see text).

ref.1, for $\gamma = 0$). Thus for $a \gg b$ we always get, for a step input, a maximum voltage V_p that is approximately $(1+\beta AB)$ 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 βAB. By limiting the bandwidth of the pre-amplifier we can then decrease the overshoot still further or even eliminate it by slowing down the rise of the input voltage[1], and in this way it is thus possible to design an amplifier with very low t.i.m.

There is, however, another way. If $t_0 \leq 0$ we see that V_p rises monotonically towards its final value and no overvoltage blocking is possible. From equation 2 we see that $t_0 < 0$ is equivalent to $(b+p_2)/(b+p_1) < 1$, which is equivalent to $a\text{-}b < ((a\text{-}b)^2 - 4ab\beta AB)^{1/2}$. 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.

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 $a = 10^6$, $b = 10^4$ (this resembles those studied in refs 1 and 4; it is shown as point Q in Fig. 4) and case 2 $a = 10^4$, $b = 10^6$. In both cases $1+\beta AB = 21$. The gain *vs* 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 $10^4/2\pi \approx 1.6$kHz this amplifier might give rise to appreciable values of t.i.m., even if preceded by a pre-amplifier with 20kHz bandwidth[1].

Fig.6 plots what happens if we apply a unit step voltage V_{in} to the amplifier input. (All voltages have been normalized to give $V_{in} = V_p = V_{out} = 1$ at infinite time). In both case 1 and case 2 we have the same $V_{in}(t)$ and $V_{out}(t)$, if the amplifiers have infinite voltage capabilities. $V_p(t)$, 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 1Hz 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[2], 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[2].

The stages following the first can be designed using accepted "rules"[2,3,6]. 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!

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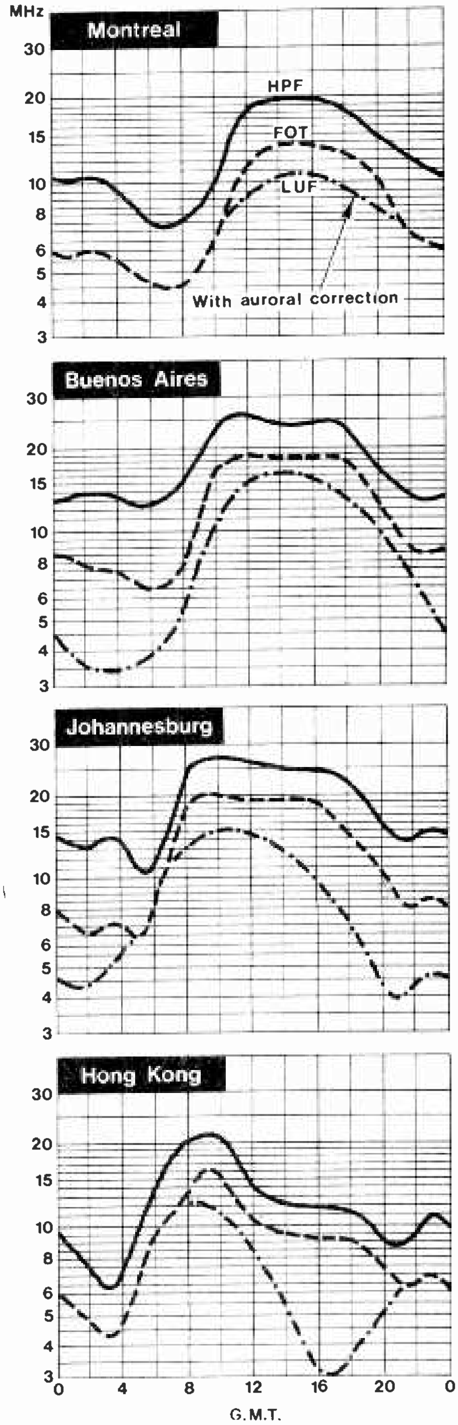
HF predictions

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.



News of the Month

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 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 avilable 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 12.2GHz 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 12GHz 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 yet 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 8.9MHz carrier system using then current components. Because microbending 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 l.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. Receiver used a H-P p-i-n diode and cascode preamplifier circuit with the low noise level of 0.9pA/$\sqrt{}$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.p.ds on account of their inherently higher noise level. (A p-i-n diode and bipolar preamp can give 5dB lower noise with 2μW 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. Deaf-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, Deaf-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.

Deaf-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 in 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* teletext 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 Institute for the Deaf and the National Deaf Children's Society may put their weight behind efforts to persuade the government to support a captioning service. The NRDC has put the organisers in touch with the inventor of CHIT, a method of conveying freehand drawings over telephone lines now commercially 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, according 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 were it not for Philips's explanation that their facility allowed one to fade "post" the recording process, one might be driven to conclude that they had picked up a half-understood recording studio term with which to overawe prospective 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 2/15s before the mistake and at the lowest speed 4/7s. The only accurate 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 appointment of a programme manager, a 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 television has now become increasingly used for non-tv applications. According to a report in the American trade paper *Electronic News*, land mobile communications (470-512 MHz and 806-890 MHz, the so-called 900 MHz region); offshore telecommunications and industrial (488-499MHz, 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 bureaux, 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 harmonic suppression may be increased from 60dB to 100dB. Television interference 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.

the FCC to delay the introduction of the 40 channel service for further studies, and the AMST and the ABC to ask for suppression regulations to be tightened to exclude television interference completely. But no amount of filtering on the receivers will block out the interference from the second harmonic on American television's channel two, and the FCC has maintained that a lot of the interference complaints stem rather from poor receiver design than noisy c.b. equipment.

Band II ferrite rod aerials

One reason why so few people in Britain listen to sound radio on v.h.f/f.m.—18% of the population say the BBC – is thought to be the inconvenience of the telescopic aerial on portable sets. It has to be pulled out and re-adjusted for each new position of the set in the house. An answer to this problem was demonstrated by the BBC's director of engineering, James Redmond, in his Appleton Lecture to the IEE on January 6. This was an internal ferrite rod aerial for v.h.f. developed by the BBC Research Department. The aerial coil is tuned by a varactor diode. At least one set manufacturer will be introducing a receiver incorporating this type of v.h.f. aerial at the spring trade shows this year. Mr Redmond also said, "we now impatiently await the push-button portable v.h.f. radio."

●In the evening only about 7 per cent of the population settles to listen to a fixed installation stereo receiver which may do justice to the quality of the v.h.f./f.m. transmission, said Mr Redmond.

● Another BBC Research Department development mentioned by Mr Redmond was a technique to improve the BBC's proposed "dedicated" motoring information service that uses a network of m.f. transmitters in a single-frequency t.d.m. system (see News, May 1976, p.41). For the motorist to get the most effective briefing it is necessary to ensure that only the transmission of the nearest station which will be carrying the relevant information is reproduced. In the new technique "the control signals to activate the car receiver to reproduce a message (and then return it to standby when the message is completed) are conveyed by frequency modulating the medium-wave transmitter carrier. The message itself may be by conventional amplitude modulation of the same carrier, or it could employ any one of the alternative systems of modulation. The well-known capture effect of f.m. transmissions, applied here to the control signals, enhances the discrimination between wanted and unwanted messages by some ten to twenty times."

Electronic systems syllabus approved

The proposed 'A' level syllabus in electronic systems, which has formed the basis 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 G. B. B. Chaplin 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 experiment 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 concentrate equally 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, Iliffe 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 cancelled 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 5m × 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 station set up 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 individuals 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 Corporation funds. It should be noted 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 causes 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. Crompton 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 Ambisonics 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 "extremely 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 decoder but using Sansui'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 trade between 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 360° range of source angles and 2dB in stereo. The Ambisonic 45J gives slightly more variation in mono and slightly less in stereo. In stereo, H is slightly less wide 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; they are different for pair-wise mixed material).

But the differences between Ambisonics 45J and other codes doesn't just centre on the 2→2½→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 similarly augmented. The technology 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-to-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 directions as opposed to a selection of a few of those directions).

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 (so much so 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 is about to have its i's dotted and t's crossed and interest is being shown by other broadcast organisations.

● The 4-4-4 and 4-3-4 configurations studied by the BBC are "of no interest since they could not be broadcast satisfactorily through the three nation-wide v.h.f. networks operated by the BBC." The BBC would naturally wish 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 band-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 proposal, is that the extra channel can be deleted anyway and still maintain a surround performance, arguably better than matrix H.

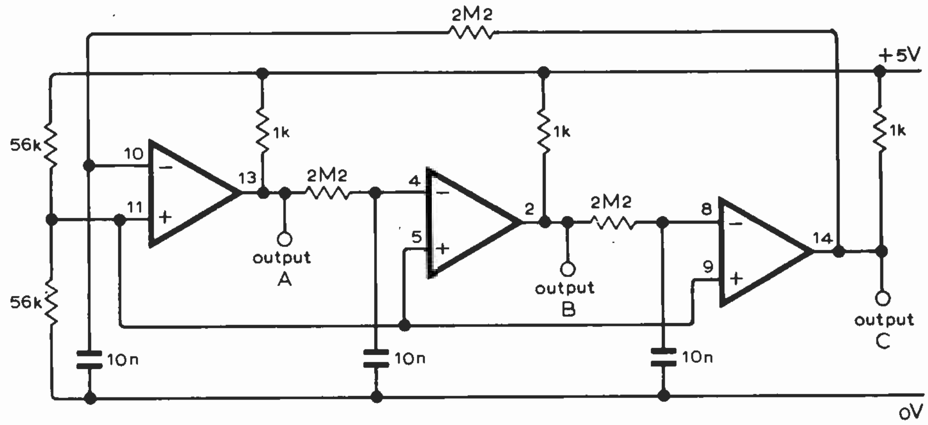
Circuit Ideas

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 R_1, $_3$ and $_5$ are adjusted so that the peak-to-peak amplitude of the three output waveforms are equal. Resistor R_4 is adjusted to give a symmetrical waveform and R_2 is adjusted to give minimum distortion of the sine wave output. Output amplitude is set by R_6, and a d.c. level of between ±14V may be added to the output by R_7. Frequency of the waveform is switched in decades by S_1. The power supply should be rated at 150mA.

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



Three coupled astables

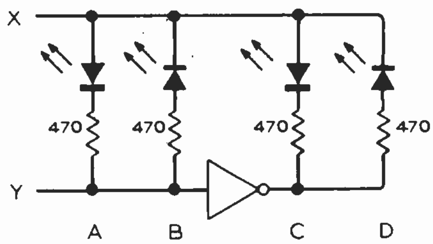
This circuit produces three symmetrical square waves at 120° to each other. By inverting these, outputs at 60° can be produced. Three comparators from the MC3302P are used, and the device can be operated from 4 to 12 volts. With the component values shown, output frequency is approximately 17Hz.

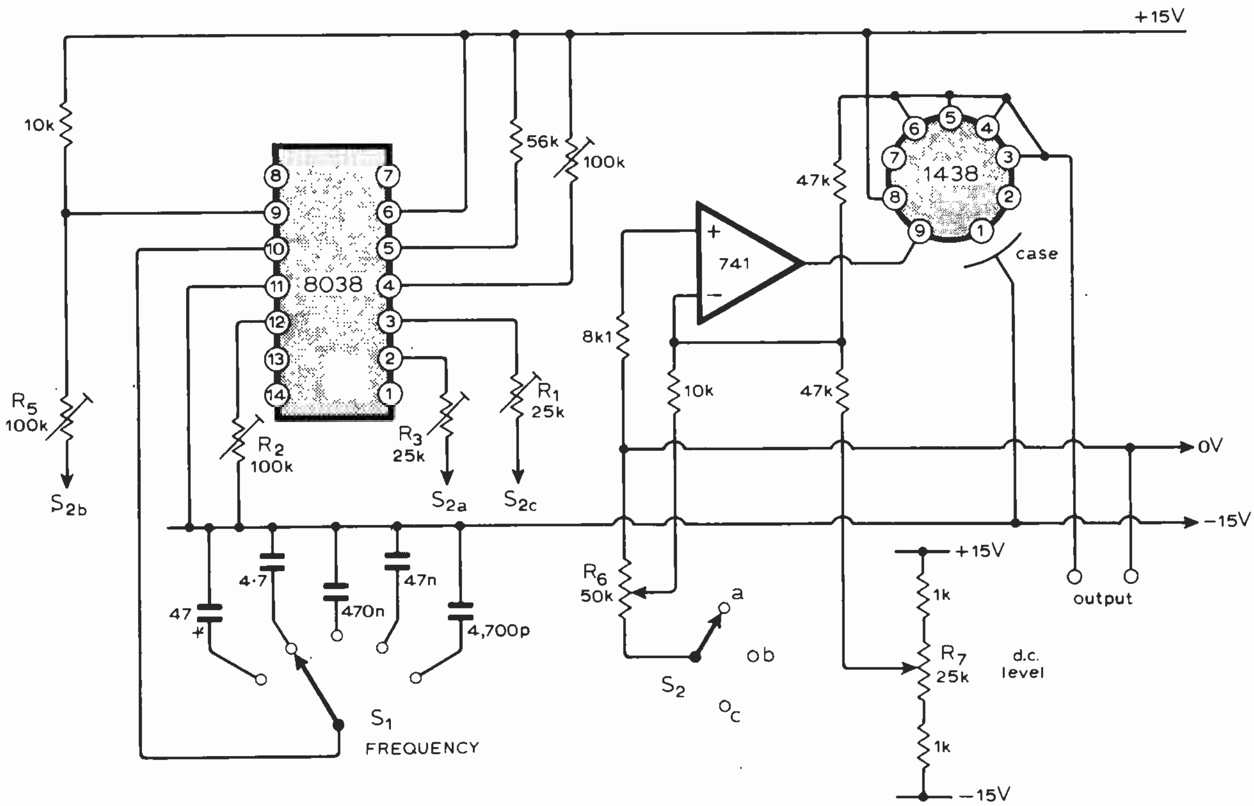
L. J. Bell,
Evesham,
Worcs.

Binary state indicator

A simple circuit for displaying the four possible states on two binary lines uses four l.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 l.e.d. will be turned on. When x is opposed to y the reverse situation occurs.

David Straker,
Dwyran,
Gwynedd.



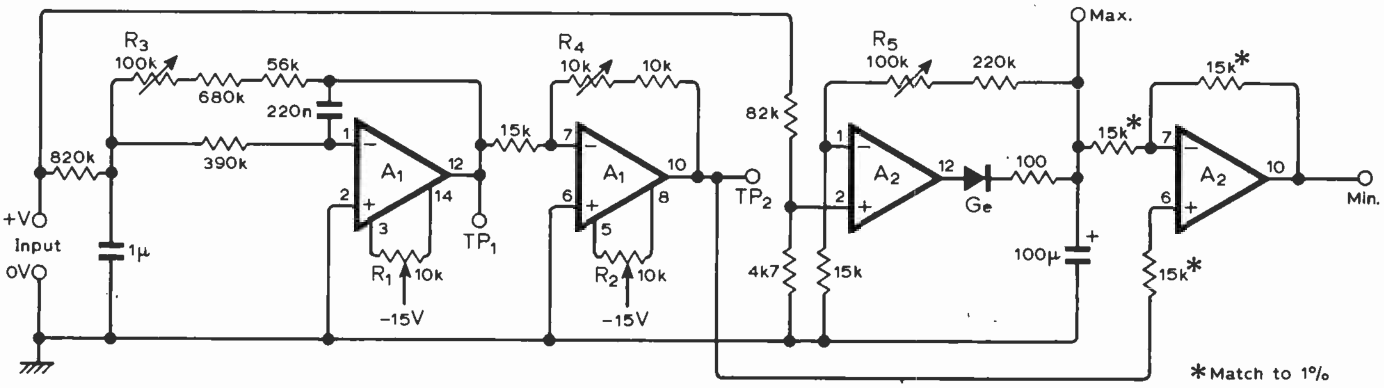


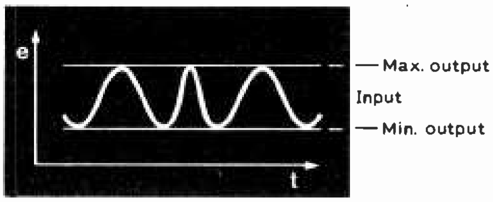
Peak and trough detector

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.cs 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 R_1 until 0V ± 1mV appears at TP1. Resistor R_2 is then adjusted so that 0V also appears at TP2. With +5V ±1mV applied to the input, R_3 is adjusted until TP1 measures +5V ±1mV, and R_4 is adjusted until TP2 measures −5V ±1mV. Finally, R_5 is adjusted until +5V ±1mV appears at the "max" output.

K. R. Brooks,
University of Bristol.



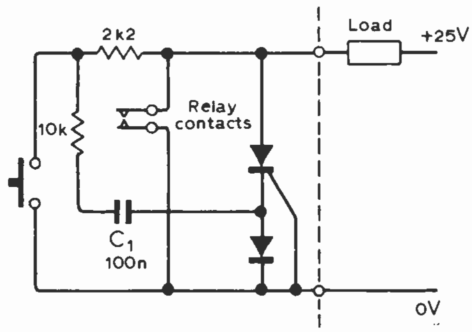


A1 and A2 I.c. type LM747CN (dual 741)

Small signal amplifier

There are two basic types of small signal amplifier, the virtual earth type as shown in Fig.1 (Linsley 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.

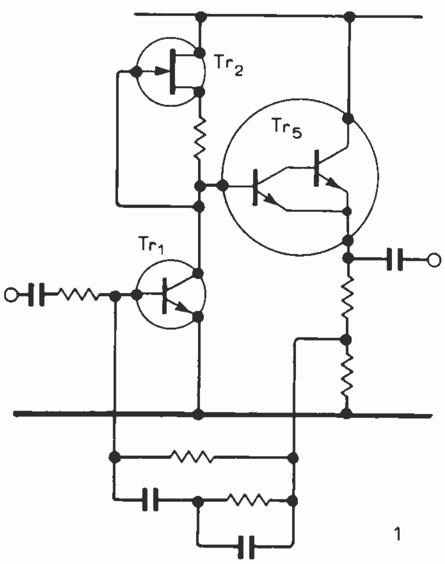
D. Rawson-Harris,
Ferranti Ltd,
Manchester.



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, C_1 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.

R. V. Hartopp,
Saffron Walden,
Essex.



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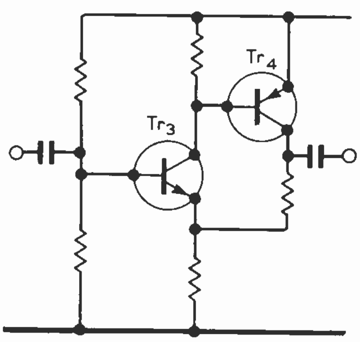

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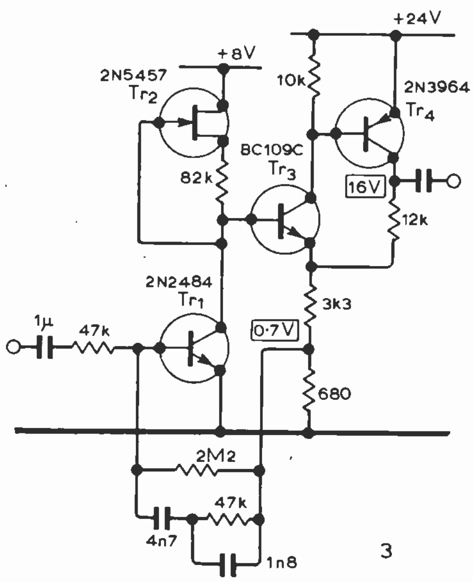

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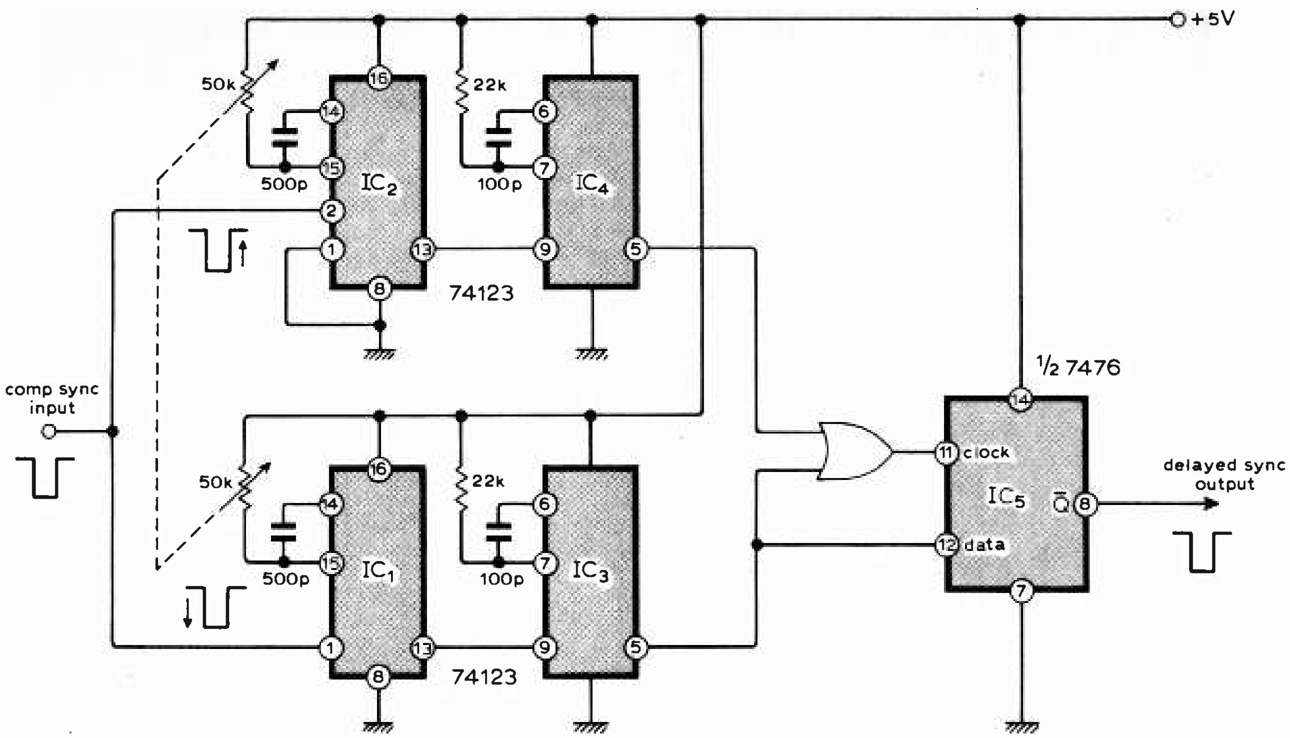


Sync-pulse delay

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 blurr 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 become 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 1.25V, 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 overcharge state must be limited to about 0.1C, the ten hour rate.* A voltage of about 1.30V 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 0.1C (ten hour rate) charge current to it. Watch the voltage with a meter, but there is no need to worry if

* See Appendix

no significant amount appears at this stage. Arrange to be able to add a very much larger charge current, 10C (six minute rate) perhaps, to just one cell at a time. A connection across the headlamp switch of a car might be suitable, or two charged healthy cells in series with an appropriate resistance. Arrange also a dummy load that will discharge a normal voltage cell at about the 10C rate. This may well be a metre or so of quite thick copper wire and will get fairly warm in use. Use this dummy load to make sure that the cell under treatment is in fact flat before starting to charge it.

Now add the heavy charge current to the low one for bursts of about five seconds, allowing intervals of perhaps fifteen seconds between the bursts to avoid undue heating. Don't worry too much about the voltmeter reading while the heavy current is flowing — remember that you were going to throw the cell away — but notice the voltage to which the cell settles between bursts. This may start at zero, but even the most obstinate cell will "come unstuck" after a few bursts and will reach a value of around 1.25 volts. After perhaps twenty bursts the cell ought to be a little more than a quarter full and it is unwise to go much further at the heavy current as the cell will lose electrolyte and be permanently damaged if it reaches full charge. Use the dummy load then to discharge the cell completely, again working in bursts to avoid undue heating.

The theory behind this rough treatment is that the heavy charge current will melt any whiskers causing short-circuits, thus destroying their crystal structure or fusing them altogether, while depositing cadmium metal back on the plate to give a useable amount of charge. The heavy discharge will then oxidize the metal in any remaining whiskers first, despite the lower activity of the crystalline material, simply because the metal offers a much lower electrical resistance path than the electrolyte.

Now recharge the cell to the quarter full state with a further twenty bursts of the heavy current. Then leave it on just the low current for ten hours or more, and if the treatment has been successful it will go through to the oxygen regeneration state. It is difficult to establish for sure when this has been achieved, but measure the voltage carefully and then, without disturbing the charge current, discharge the cell with the dummy load for about 30 seconds and compare the voltage to which it recovers in a minute or so. If this is significantly lower, say 50mV, then the cell was probably fully charged and will be so again after a further hour on charge. In any case it seems that this sort of discharge will probably do the cell good, and it is certainly a good thing to leave a cell which has had short-circuit trouble on low current overcharge for at least another 24 hours.

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 it 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:

Cell size	Capacity	0.1C current
AA, R6 or U7	500 mAH	50 mA
C, R14 or U11	1500 mAH	150 mA
D, R20 or U2	3500 mAH	350 mA

Announcements

Ritro Electronics (UK) Ltd has been formed as a fifty-fifty partnership between Ritro Electronics bv, component suppliers of Holland and Belgium, and Tahold Investments Ltd to distribute electronic components in the UK. Tahold 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 Maidenhead, Berks.

Syston-Donner have appointed Electroplan of Royston UK distributor for four of their range of pulse generators, the model 99, 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 and reverse programme sound, forward and reverse communications, vision and sound cueing and synchronising pulses. The system used 60kbits of p.r.o.m. and 5kbits of c.m.o.s. store which memorises the routing if the power fails.

An unnamed Arabian country has placed a £7million order for a microprocessor-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 base and 13 h.f. and v.h.f. 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 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 1950. 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. Lecturers will be from Decca Navigator, Marconi-Elliott 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. W. Leach, Training Manager, ACE Training Centre, Roxby Houses, Station Road, Sidcup, Kent. The only qualification needed to enter courses is conversational ability in English. The centre specialises "in the 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 Conor Cruise O'Brien, has now 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 £200,000 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 telephone, telegraph 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 satellite. The first earth station was installed in Kigali, Rwanda, late in 1976, where it is relaying programmes from Cologne.

Awards

Derek Tilsley, marketing director of Rupert Neve & Co, the Energy Services and Electronics Ltd subsidiary, has been elected vice president, International, of the Audio Engineering Society.

Sir Karl Popper has been elected a Fellow of the Royal Society.

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 imput 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 curcuits using all of the above elements but such circuit configurations are not, at present, common. Circuits composed entirely of NAND or entirely of NOR 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 $\bar{B}$ 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 $\bar{B}$, as indicated by the entries in the top two rows of the truth table.

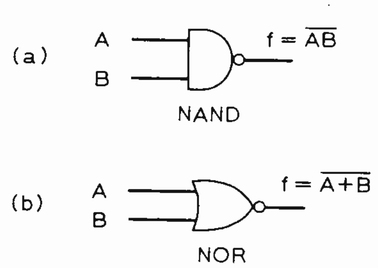
NAND and NOR gates can also be used to generate the OR and AND functions. For example, the output of a NAND gate driven by signals $\bar{A}$ and $\bar{B}$ is $\overline{\bar{A}\,\bar{B}}$. which may be written as A + B, as shown in Fig. 2(a). The AND function can be generated by connecting two NAND gates 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 $f = A\bar{B} + \bar{A}B$, 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 $f = A(\bar{A} + \bar{B}) + B(\bar{A} + \bar{B})$ requires one gate less, as shown in Fig. 3(c).

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

$$P = (\bar{A} + BC) \qquad R = F$$
$$Q = E \qquad S = (\bar{G} + \bar{H})$$

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 $\bar{G} + \bar{H}$ to gate 3 is the output line of a two-input NAND gate, whose inputs are found by inverting the variables $\bar{G}$ & $\bar{H}$. Similarly, the input line $\bar{A}$ + BC to gate 2 is the output line of a two-input NAND gate, whose inputs are found by inverting the variable $\bar{A}$ and the product BC, as



A	B	f
0	0	1
0	1	1
1	0	1
1	1	0

A	B	f
0	0	1
0	1	0
1	0	0
1	1	0

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

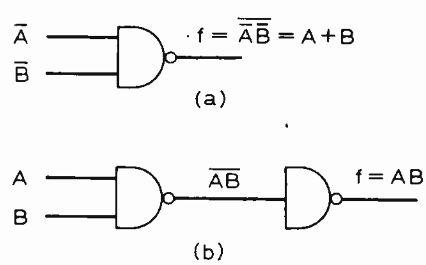


Fig. 2. The OR function using a NAND gate at (a) and the AND using NANDs at (b).

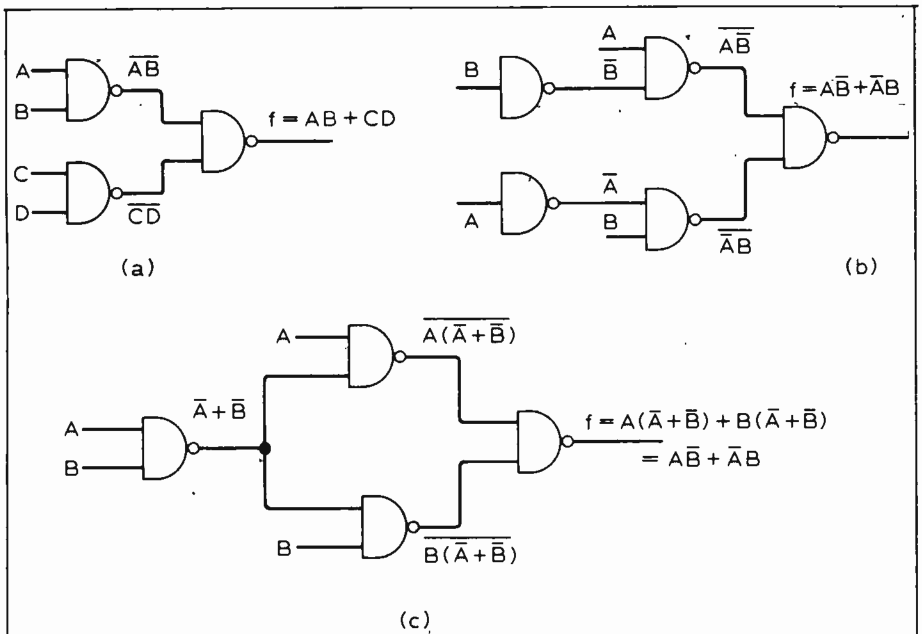


Fig. 3. The use of NAND gates to obtain a sum-of-products function (a). The minimal form of expression need not give a minimal circuit; minimal expression $f = A\bar{B} + \bar{A}B$ in (b) needs one more gate than non-minimal expression $f = A(\bar{A} + \bar{B}) + B(\bar{A} + \bar{B})$ at (c).

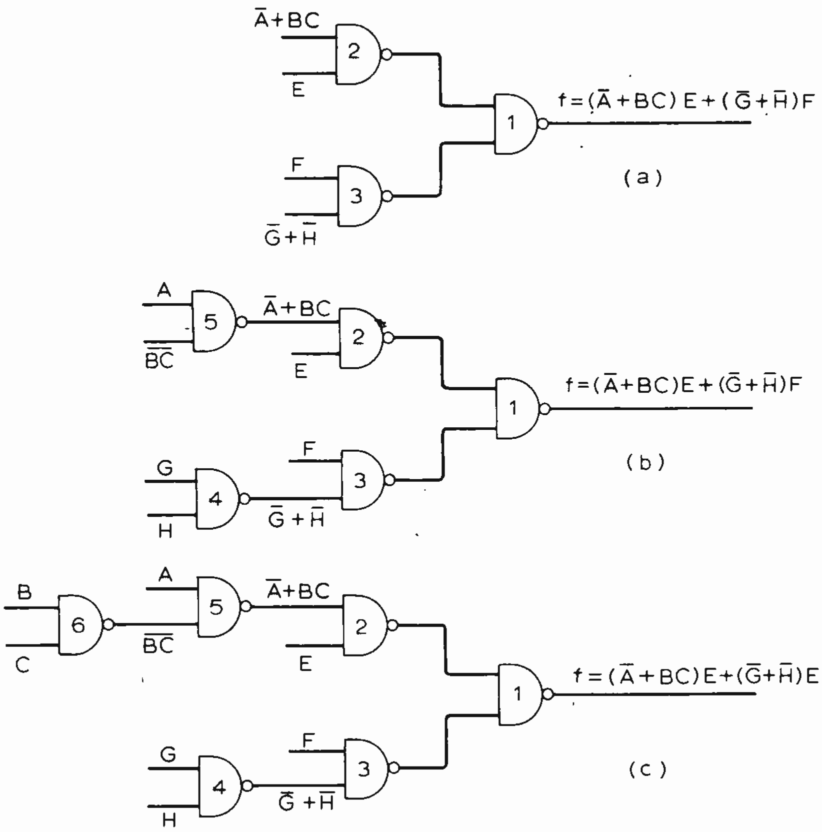


Fig. 4. Building up the expression $f = \bar{A} + B\,C)E + (\bar{G} + \bar{H})F$ from the output end in three levels.

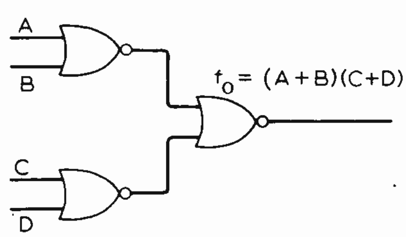


Fig. 5. Dualizing $f = A\,B + C\,D$ with NOR gates.

shown in Fig. 4(b). For the final stage in the implementation it is only necessary to precede gate 5 with a two-input NAND gate whose input variables are B and C as shown in Fig. 4(c).

If the NAND gate in Fig. 3(a) were replaced by NOR gates as shown in Fig. 5 the output function, which the reader can check for himself, will be

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

which is the dual of the output function of the circuit shown in Fig. 3(a). Hence to implement the NOR circuit of a Boolean function first derive the NAND-circuit of the dual function and replace the NAND gates by NOR gates.

Example. Implement the function

$$f = \bar{A}\bar{B}\bar{C} + ABC.$$

Dualise:

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

Express in Sum-of-Products form:

$$f_D = \bar{A}B + \bar{A}C + A\bar{B} + \bar{B}C + A\bar{C} + B\bar{C}$$

minimising using the method of Part 1:

$$f_D = \bar{A}B + \bar{B}C + A\bar{C}.$$

The NAND circuit of this function is shown in Fig. 6(a) and the NOR function $f = \bar{A}\bar{B}\bar{C} + ABC$ 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, $A = \bar{A}$ = either 0 or 1. Hence if a Boolean expression of a signal in a circuit reduces to either $A + \bar{A}$ or $A\bar{A}$, a race-hazard exists at the output of the corresponding gate, otherwise the signal is hazard-free.

In the example shown in Fig. 7, $f = AB + \bar{A}C$ 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 $A\bar{A}$. This is achieved by the application of the theorem of race-hazards in Part 1. Hence

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

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

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

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

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 $f = AB + A\bar{C} + A\bar{D}$ 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

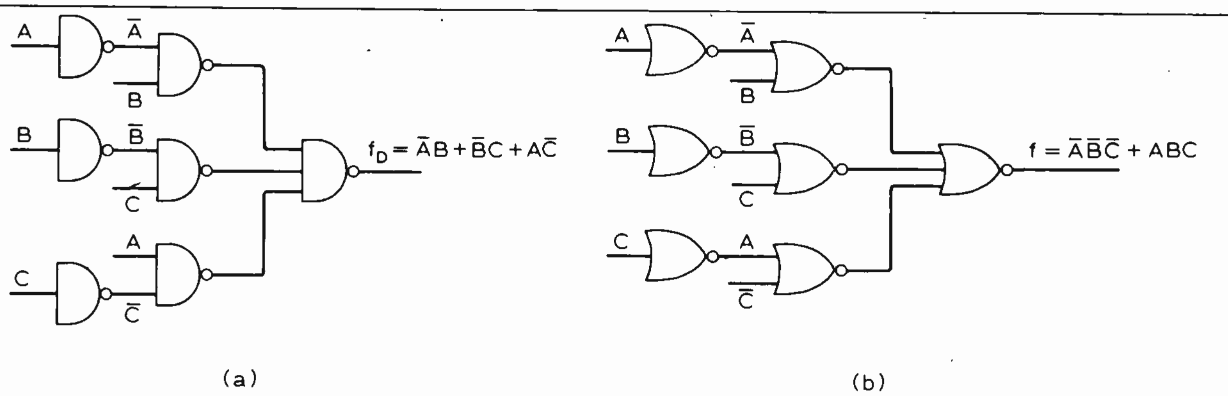


Fig. 6. Generating a function using NOR gates. Function $f = \bar{A}\,\bar{B}\,\bar{C} + A\,B\ \ C$ is first dualized, minimized and implemented in NAND logic, as at (a). This circuit is then converted to NOR gates to provide the required output.

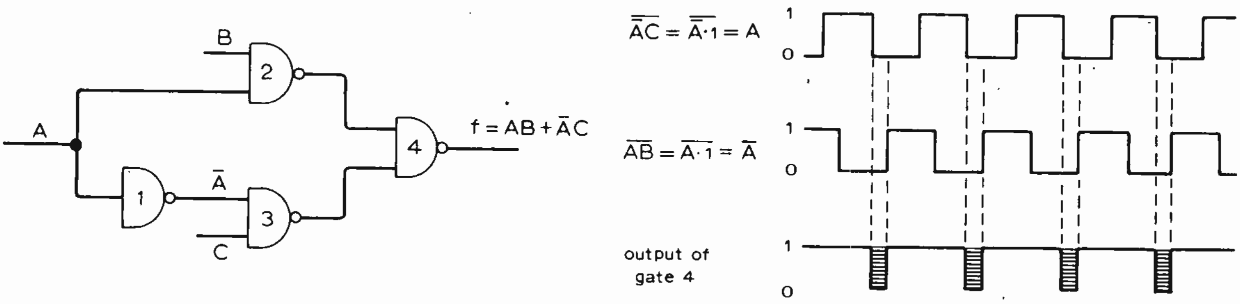


Fig. 7. Mechanism of "spike" generation.

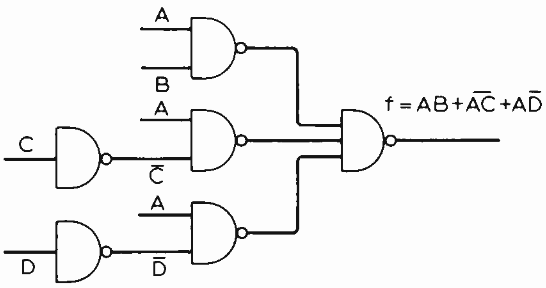


Fig. 8. "Direct" generation of $f = A\,B + A\,\bar{C} + A\,\bar{D}$ when 3-input gates can be unused.

rearranging the given function to satisfy this restriction.

Method 1: bracket two of the three products.

The function is $f = AB + A\bar{C} + A\bar{D}$

bracketing: $f = (AB + A\bar{C}) + A\bar{D}$.

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

Method 2: remove a common factor:

The function can then be written

$$f = AB + A(\bar{C} + \bar{D}).$$

The realisation 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

$$f = A(B + \bar{C}) + A\bar{D}.$$

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

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

but this function has the same form as $f = A(B + \bar{C}) + AD$ and can be implemented with six NAND gates, the same number as in Fig. 8. Obviously the optimal implementation is given when the function is written in the form $f = AB + A(\bar{C} + \bar{D})$ even if a 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 [1,2].

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

$$f = AB + A\bar{C} + A\bar{D}$$

The function is dualised and the brackets numbered:

$$f_D = (A + B)^1(A + \bar{C})^2(A + \bar{D})^3$$

Next the change in the gate count ΔN, 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 ($\Delta Z = 0$) 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.

$$(H_1 + T_1)(\bar{H}_1 + T_2) = H_1T_2 + \bar{H}_1T_1$$

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 ΔN 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.

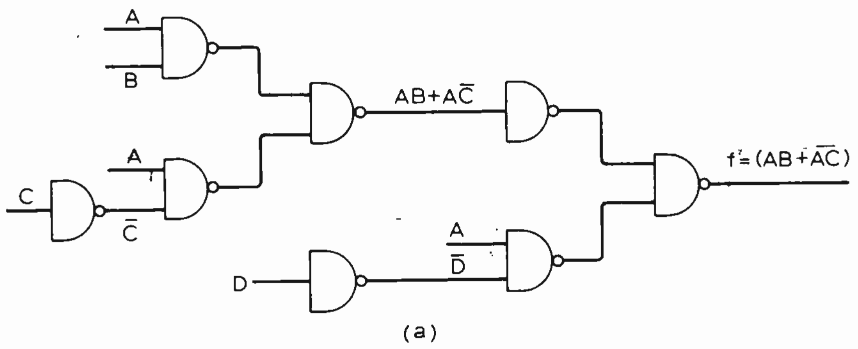
r = the number of terms in the head section of the smaller bracket.

$n = 1$ if a group of terms in one bracket, called the head, is the complement of a group of terms in the other, otherwise $n = 0$.

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.



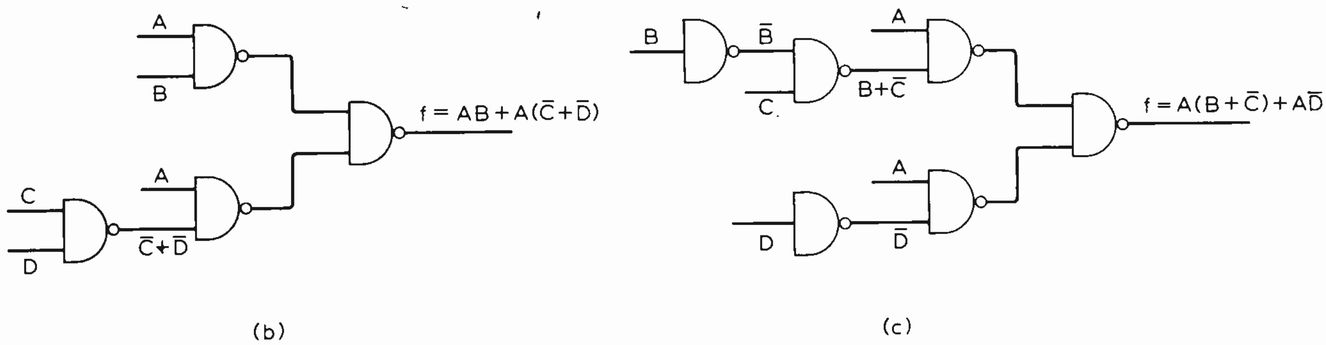


Fig. 9. Bracketing two products in $f = AB + A\bar{C} + A\bar{D}$ enables use of 2-input gates but requires eight instead of six, as in (a). Removing a common factor again meets fan-in restriction to 2 inputs, with varying savings in number of gates, as seen in (b) and (c).

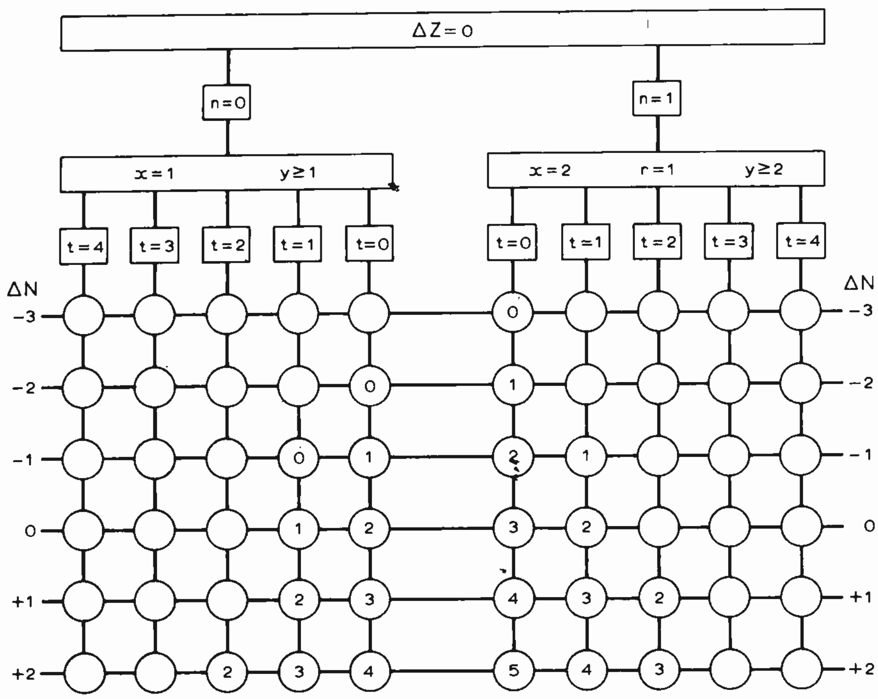


Fig. 10. Merging table for $\Delta Z = 0$.

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

i = the number of inverted variables such that for each

(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 ΔN 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, ΔN being obtained from the table of Fig. 10.

$$f_D = (A+B)^1(A+\bar{C})^2(A+\bar{D})^3$$

b/p	n	x	y	r	t	l	i	l-i	ΔN
1/2	0	1	1	–	1	2	1	1	0
1/3	0	1	1	–	1	2	1	1	0
2/3	0	1	1	–	0	2	2	0	–2

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 $f_D = (A+B\bar{C})(A+\bar{D})$
redualising: $f = A(B+\bar{C})+A\bar{D}$
see Fig. 9 (c)
Merging 1/3 gives $f_D = (A+BD)(A+\bar{C})$
redualising: $f = A(B+\bar{D}) + A\bar{C}$
Merging 2/3 gives $f_D = (A+\bar{C}\bar{D})(A+B)$
redualising: $f = A(\bar{C}+\bar{D})+AB$
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.

$$f = AB+\bar{A}\bar{C}+C\bar{D}$$

This equation is already in its minimal form.

Dualise: $f_D = (A+B)^1(\bar{A}+\bar{C})^2(C+\bar{D})^3$

Attempt merging:

b/p	n	x	y	r	t	l-i	ΔN
1/2	1	2	2	1	2	4–2=2	+1
1/3	cannot be merged						
2/3	1	2	2	1	1	4–3=1	–1

Merging 2 and 3 will result in a

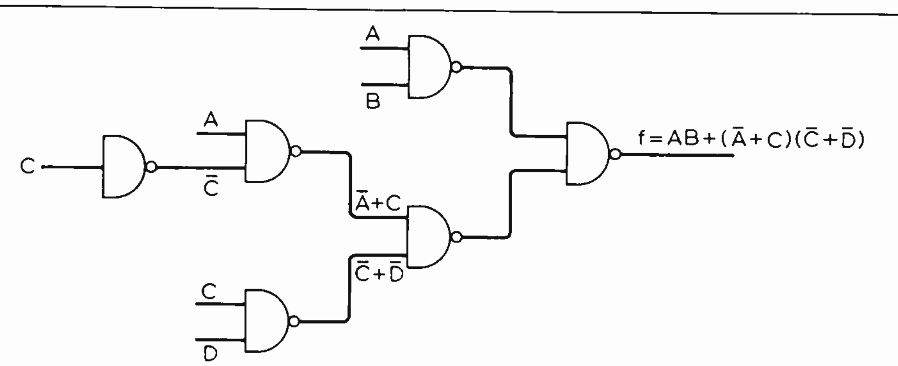


Fig. 11. Minimal circuit for $f = A\,B\,(\bar{A} + C)(\bar{C} + \bar{D})$, *using the merging operation.*

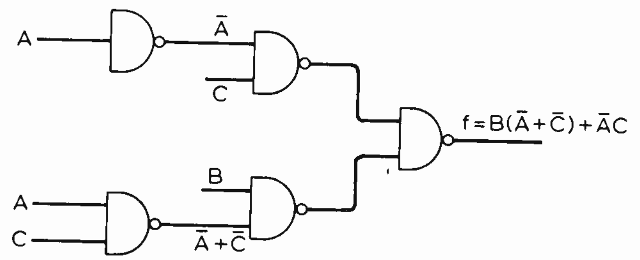


Fig. 12. Two-input NANDS used to realise $f = B(\bar{A} + \bar{C}) + \bar{A}C$, *which is hazard-free form of* $= \bar{A}C + B\bar{C}$.

reduction of the gate count by 1
Merge 2, and 3: $f_D = (A+B)(\bar{A}C + C\bar{D})$.
Redualise: $f = AB + (\bar{A}+C)(\bar{C}+\bar{D})$
Implement as in Fig. 11.

Example 2. Under what circumstances will a spike be generated at the output gate if a direct NAND implementation of the function $f = \bar{A}C + B\bar{C}$ is made? Derive an equivalent hazard-free expression that can be implemented minimally using two-input NAND gates.

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

The hazard-free expression is $f = \bar{A}C + B\bar{C} + \bar{A}B$
Dualise: $f_D = (\bar{A}+C)^1(B+\bar{C})^2(\bar{A}+B)^3$

Attempt merging:

b/p	n	x	y	r	t	l-i	ΔN
1/2	1	2	2	1	2	4–1=3	+2
1/3	0	1	1	–	1	2–0=2	+1
2/3	0	1	1	–	0	2–1=1	–1

Merge 2 and 3: $f_D = (B+\bar{A}\bar{C})(\bar{A}+C)$
Redualise: $f = B(\bar{A}+\bar{C}) + \bar{A}C$
Implement, as in Fig. 12.

References

1. Logic Design Algorithms, D. Zissos, Oxford University Press, 1972.
2. "Fan-in Restrictions in Logic Circuits," D. Zissos and F. G. Duncan, Proc. I.E.E., Vol. 118, No. 2, Feb. 1971.

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 G5XB of Intruder Watch[1] told *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

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Letters to the Editor

RE-INVENTION — HOW OFTEN?

The article on re-invention by F. G. Canning[1] exemplies his own thesis — that early inventions can be overlooked. He supposes that the Stentorphone of 1921 may have been the first loudspeaking gramophone. But the Hon. Charles Parsons in 1903 patented[2] the Auxetophone, which reproduced gramophone records audible "over the whole village"; and Parsons refers to an Edison patent[3] of 1877 of a similar, though complicatedly 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[4] 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[5]. It is reported that an auxetophone-cello gave orchestral quality.

J. M. Little,
Welwyn Garden City,
Herts.

References

1. *Wireless World*, December 1976.
2. Patent 10468, 1903.
3. Patent 2909, 1877.
4. *Musical Opinion*, Dec. 1938.
5. Patent 10469, 1903.

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 secrecy 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 are not prepared 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 telex, the loss 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, or for disc seal triodes. 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 on 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 who may wish to comment. 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" — "Conférence Européenne des PTTs" 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 sideband receivers 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 unpopular 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 which, since it represents a compromise for a continent, may be somewhat inflexible. Secret formulation of a national policy makes the life of a WARC delegate much easier, he 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 EEC 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 the 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 desirable end.

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 it is being used by people* may be better used than a frequency kept, for example, for defence use, that is only used on the odd exercise. Moreover, is only used in such a case in an artificial environment that assumes no opposition will have the ill grace to use it or jam it. It is also worth remembering, as was said only a few days ago by Professor Gosling of Bath University, the spectrum comes up as bright as ever when it is abandoned by one user in order to be taken over by another.

J. D. Parker,
Buckhurst Hill,
Essex.

AURAL SENSITIVITY TO PHASE

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 by partial quotation — 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".

Mr Driscoll's subsequent strictures on my attempt to define reference phases in terms of a "synchronising time" suggest that he, like Mr Moir (December letters), is not aware that a waveform of finite duration can be represented through its Fourier transform as the sum (strictly the integral) of a set of sine-wave components whose phases and amplitudes are all constants, independent of time. The waveform may be produced by anything from a single harpsichord note, with its starting transient and subsequent decay, to a performance of a complete symphony. It is this pure frequency domain description of an input waveform which must be married with the frequency response of an amplifier or loudspeaker to obtain the pure frequency domain description of the output waveform.

The mixed time and frequency description adopted by Messrs Moir and Driscoll is the commonsense one, which when it works is usually simpler to follow than the pure frequency description, for example in most applications of frequency modulation. In dealing with sine-wave tone bursts, however, one must remember that the edges of the burst can shock-excite circuit components whose response bands are far removed from the frequency of the carrier sine-wave. Tone bursts which differ in the framing or "phase" of the sine-wave with respect to the burst envelope have spectra of different shapes, thus invalidating Mr Driscoll's third paragraph interpretation of his own observations.

The pure frequency domain description always works, provided one is dealing with a linear system, but is usually much more difficult to apply. Fortunately Gabor's Acoustical Uncertainty Principle makes it possible to determine when the mixed description can safely be used, and when the pure frequency description must be employed instead.

C. F. Coleman,
Wantage,
Oxfordshire.

Only rarely, during the many years I have read *Wireless World*, has a subject aroused so much interest, correspondence and heat, as that of phase distortion in audio signals. In spite of your voluminous postbag there are some relevant points that still have not been made. May I therefore at this late stage add further to your correspondence?

Firstly, allow me to horrify some, at least, of your correspondents by categorically stating that phase distortion *is* quite audible. Its audibility does depend on the circumstances and on the degree of distortion. Phase distortion is *not* normally audible in complex continuous tones which the ear assesses in a manner essentially similar to Fourier analysis, only the frequencies and levels of any harmonics being significant. With transient signals of less than about 200 milliseconds duration, however, the situation is very different. The ear seems to assess such sounds by analysing the signal envelope shape and the phase relationships are then very important. Anyone who wishes to prove my statement for himself should tape record a continuous complex note and also a slowly repeated transient note (e.g. piano) and then play the tape in reverse (admittedly a little difficult without a suitable recorder). The continuous note will sound unaltered. The transient note will sound entirely different. 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 audibility 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 a different 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 phase v. 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 over some portions 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 distortion.

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. Measurement of the filter performance showed frequency response 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 achieved. Every single note produced by a piano or guitar, as well as by some other musical instruments, is frequency modulated. The rate of modulation is high and a number of 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 frequency shifted to a different but noticeable extent, then various inharmonic relationships might become apparent. Further, theory tells us that frequency cannot be modulated 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 point 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.

ADVANCED PRE-AMPLIFIER DESIGN

If that was an "Advanced preamplifier design" in your November 1976 issue then I can only hope that when it is fully developed it will look different from the circuit published.

First a few fundamentals:

1. Magnetic cartridges give output voltages dependent on the velocity of the needle; keeping the recorded amplitude fairly constant with frequency, the record makers therefore force the output of the cartridge to rise at +6dB/octave.
2. Normal cartridges today, because of development in magnetic materials (stronger, smaller magnets), give outputs of much more than 2mV, around 10mV at 1kHz for 5cm/s velocity.
3. If the disc is cut with an overhead of +20dB (peaks of 50cm/s) and the frequency is 20kHz not 1kHz, giving another rise in output of +20dB, then you can see the signal at 20kHz can be 1V.

Reality is not as bad as this since the spectral density of music is not constant with frequency and falls off at high frequencies. However, outputs from cartridges do rise to 200mV peaks and do have fast slew rates.

Mr Self's talk of overload margins is a little confused when he compares amplifier performance. If the normal operating (0dB) level of an amplifier is 10mV input then to cope with 1V inputs there must be no limiting of distortion anywhere before a gain control for signals of +40dB above normal. This is best known as an overhead of 40dB and *is required at 20kHz* relative to 1kHz.

Now RIAA amplifiers have some peculiar problems coping with the high transient signals from magnetic cartridges just because the output does rise with frequency: this rise causes a high spectral density of high frequency signals and high slew rates. The prime requirements in the input stages are therefore wide bandwidth (to give fast slew rate) and low transient distortion when handling the excess high frequency spectral density.

Mr Self's preamplifier does little for either of these: the open loop bandwidth is not clearly defined. If the second stage is guessed at 100 then the stage has a —3dB point of 3kHz. The bandwidth of the amplifier is further limited by the input capacitor (1n5) and by the output loading network R_1/C_1 on the output: in fact what can the amplifier drive into C_1 at 20kHz to give a respectable overhead margin?

More problems!

The input impedance will fall rapidly to high frequencies because the output signal is fed back via 10nF to the emitter of Tr_1 then by 1.5nF to the input itself. Therefore the magnet won't be given a chance to generate the correct h.f. signals, for to do so it must have a resistive load right up to 20kHz.

More problems!

The first two transistors are connected in a classic phase shift oscillator configuration. I have often had this configuration burst into l.f. oscillations when fed from a low impedance (which a cartridge has at l.f.). The reason is simple: there are two phase shift networks, first the r_e of Tr_2 and the decoupling capacitor 22μF ($\phi = 90°$ below 10Hz), the second the resistor 220k and the input capacitor 1μF ($\phi = 90°$ at 0.1Hz). Thus towards l.f. even if the circuit has insufficient loop gain to oscillate (it fortunately has by a factor of about four) it will have a characteristic l.f. peak of a few dB.

All amplifier designs of this type have some sort of l.f. peak; it could be suppressed by increasing the 22μF to 2200μF, thus reducing the feedback by 100 times, or best of all don't use this configuration.

Actually the component values don't seem to have been chosen consistently: the input capacitor of 1μF has a f−3dB point of about .1Hz but the decoupling capacitor has a f−3dB point about 100Hz which is rather the wrong way round to achieve a proper control of the l.f. 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 l.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 it is over 65dB at maximum bass boost. No matter how good the noise performance of Tr_4/Tr_5 some l.f. hum and noise will be present at the output *all* the time. By all means vary the input preset gain to allow for high output cartridges but the system volume control must be later on in the chain, or does Mr Self have another control on his power amplifier? The l.f. boost amplifier is a nightmare: why not use any one of the perfectly good op-amps available (L148T1, 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 h.f. 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 h_{FE}s (very variable).
2. The open loop compensation is not calculated to ensure good transient response and/or stability. Is it calculated?
3. The response of the network 270k + 22k + (1n5//12nF) does not give anything like the correct l.f. response for RIAA. This should start to fall at 50Hz, all 20dB at 6dB/oct. to 500Hz then go flat to >20kHz. Mr Self's circuit, if he wants to know, starts to fall at 37.4Hz 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 10dB? 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 frequencies alongside completely unknown and variable bass roll 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,
SGS-ATES (United Kingdom) Ltd,
Aylesbury,
Bucks.

Mr Self replies:

To deal with Mr Watts' main points in the order that 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 disc input stages. 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 gain means that the signal the stage puts out 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 820Ω resistor, forms an r.f. attenuation network to prevent breakthrough 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 as at the base, due to the high open-loop again; 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 raises 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 combination of the 68k and 220k 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 l.f. hump, if the d.c. 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 persuading the stage to give less than unity gain at the highest extremes of the RIAA curve. The extra treble cut network (560Ω and 6n8) does not alter the overall phase response, as its extra phase lag is compensated for 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/frequency 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 assertion 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 one usable 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

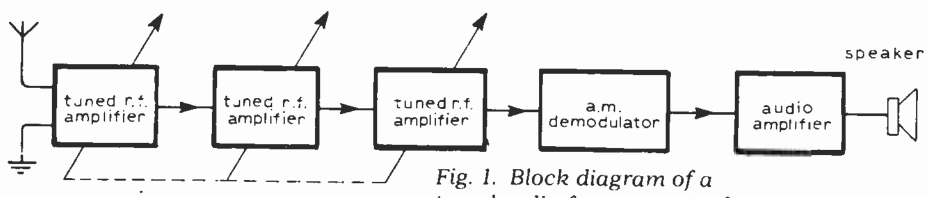


Fig. 1. Block diagram of a tuned-radio-frequency (t.r.f.) receiver.

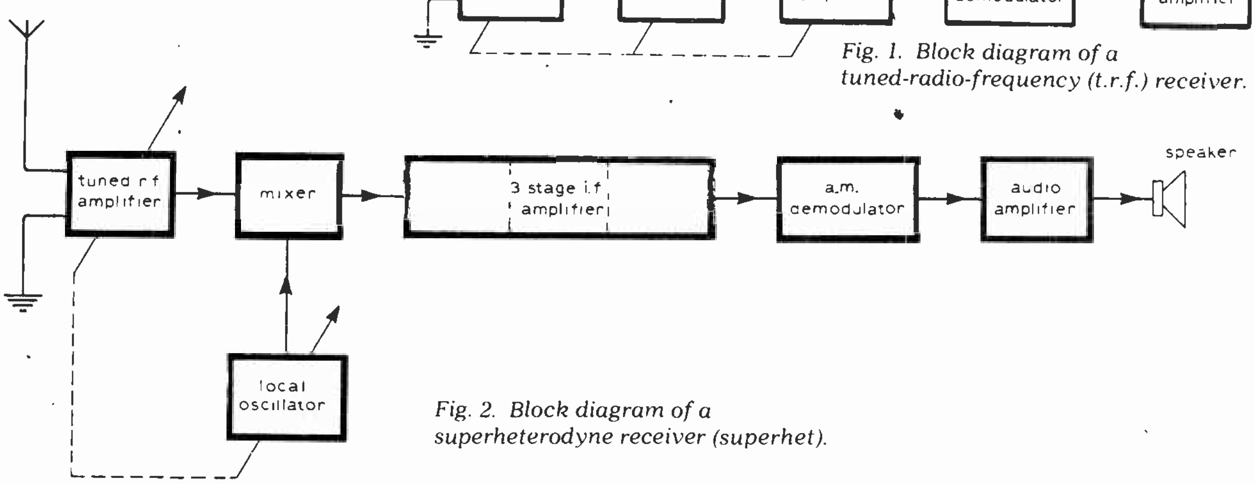


Fig. 2. Block diagram of a superheterodyne receiver (superhet).

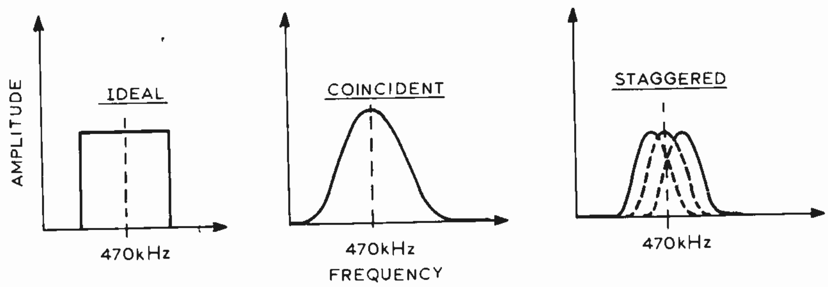
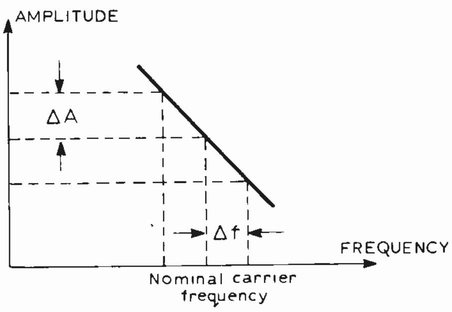


Fig. 3. Frequency responses for an intermediate frequency (i.f.) amplifier showing the ideal case and the coincident and staggered responses expected in practical circuits.

Fig. 4. Ideal response curve for an f.m. demodulator.



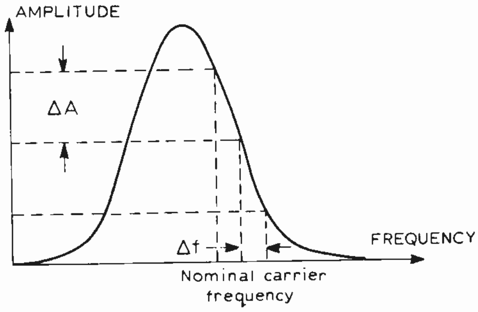


Fig. 5. The f.m. demodulator characteristic, shown in Fig. 4, can be approximated by operating on the flank of a tuned circuit's response curve, as shown. Demodulator is tuned so that the nominal frequency is halfway down the response curve

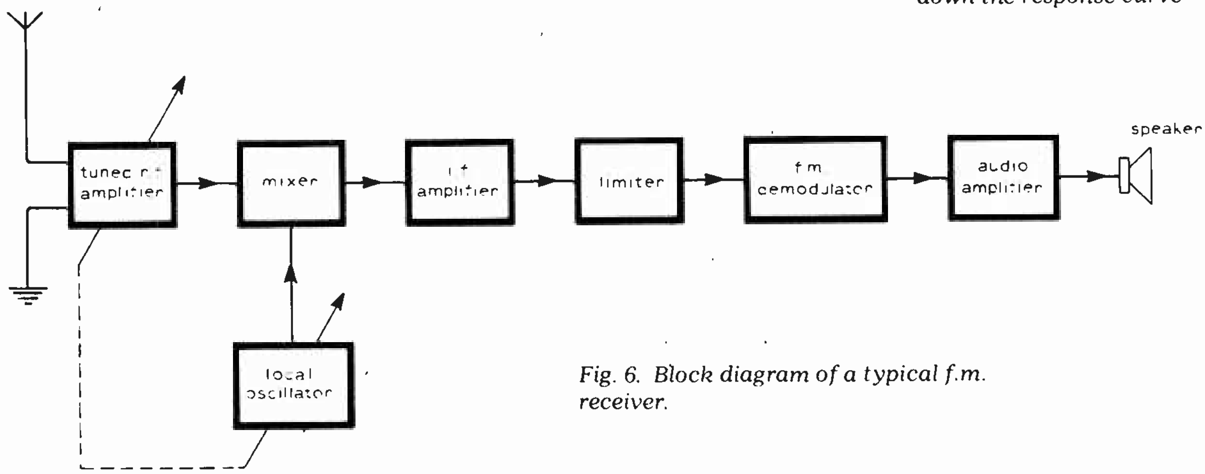


Fig. 6. Block diagram of a typical f.m. receiver.

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. Conseqeuently 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 1 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 IC_6, pin 3 (Jan, Fig. 1), due to too many volts being dropped across R_3. The fault is simply cured by reducing the value of R_3 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 C_{10} (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 R_{16} 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 IC_{42} (Jan, Fig. 6) causing incorrect loading of the row number information into IC_{20} (Jan, Fig. 1). The spikes are somewhat variable and will depend to some extent on the delay time through IC_1 (Jan, Fig. 6). (It is best to use a 7493A in this position.) A very simple solution to the problem is to feed IC_7 pin 9 (Jan, Fig. 6) from a different output of IC_{42}, 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 IC_{42} since this will also determine the start of the line blanking waveform and if a later output of IC_{42} 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 IC_1 for a synchronous counter such as a 74161. This cures any spikes on the outputs of IC_{42} 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't's 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.l. 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 $IC_{57}/_{58}$ (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 IC_9 (Jan, Fig. 5) pins 13 and 14 are shorted together thus eliminating the effect of VR_2 (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 IC_{17} (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 problems 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 after 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.

Finding 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 set and put a 75 ohm resistor in series with the coaxial cable leading to the decoder. This will reduce any chance of interference from the decoder getting back into the i.f. strip of the receiver, and also enable a longer coaxial lead to be used to feed the decoder without impairing the video signal too much. The actual point of connection in the receiver should be after any 6MHz sound traps but before any 4.43MHz chroma filters. The signal fed to the decoder should not be less than 1 volt peak-to-peak, and marginally better results will be achieved if the signal is somewhat larger than this: up to about 4 volts peak-to-peak.

Modifications

I think the above points cover most of the more common queries I have received and I will now move on to describe a few possible modifications. The only change in the specification which may cause the decoder to actually malfunction concerns the transmission of "interleaved" magazines. This allows for rows of different magazines to be transmitted during the same field blanking interval, i.e. magazine 1 may be transmitted on lines 17 and 18, and at the same time magazine 2 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.

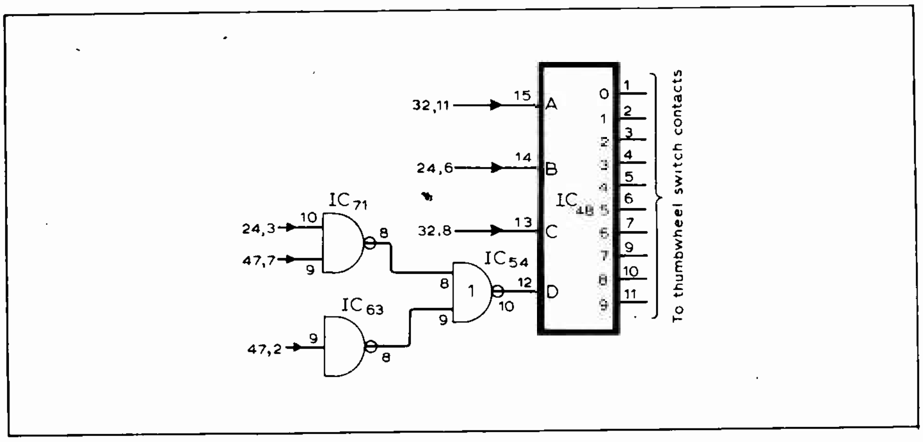


Fig. 1. Modification to cope with transmission of interleaved magazines.

(1) Break the tracks leading to IC_{45} (March, Fig. 1) pin 10 and IC_{63}, pin 13, joining both these i.c. pins to IC_{79}, pin 8.
(2) Break the track to IC_{79}, pin 3 and connect this pin to IC_{80}, pin 4.
(3) Break the tracks at IC_{63}, pins 8 and 9. Connect IC_{47}, pin 2 to IC_{63}, pin 9 and connect IC_{63}, pin 8 to IC_{54}, pin 9.
(4) Connect IC_{54}, pin 10 to IC_{48}, pin 12 and IC_{54}, pin 8 to IC_{71}, 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 out 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 only allow the page headers of selected magazines to be displayed, as follows.
(1) Break the track leading to IC_{46}, pin 5 (March, Fig.1).
(2) Connect IC_{46}, pin 5 to IC_{71}, 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.cs, 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 "roll on" contact of the switch should be connected to IC_{57}, 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. different character locations on the screen can have somewhat different address set-up times) and the other is that being an m.o.s. device, a relatively long write pulse is desirable. I originally tested over 200 r.a.ms and found them all to work perfectly satisfactorily with the write pulse specificied 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 IC_{70}, pins 10 & 11 (March, Fig.1).

(2) Connect the above two pins to IC_{42}, 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 blast 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 as 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 invisible!) 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, newsflashes 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 black background to be restored during a display row.

Corrections to circuit diagrams.

Jan. Fig. 5: Pin 1 of IC_{11} is CLR not CLK

Feb. Fig 1: Data input B to IC_{21} is pin 2 fed from (81, 9).

Feb. Fig. 4: Pin 13 of $IC_{33\text{-}39}$ (chip enable) should be grounded.

March Fig. 1: Connection to roll switch from (71, 6) is omitted.

March Fig. 4: Pins 9 and 10 on IC_{57} should be interchanged.

March Fig. 4: IC_{44} pin 2 is fed from output blanking edge connector.

April Fig. 3: IC_{83} pin 12 is fed from IC_{3} pin 1.

April Fig. 2: IC_{85} pin to +5V should be pin 24.

May Fig. 1: Inputs to CD4016 switches (IC_1, and IC_2) reading from top of diagram are: pins 11, 11, 1, 1, 4, 4, 8, 8.

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 microphone transmitters and receivers 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 hand-held or pocket type. EDC are at Leweston, Organford Road, Holton Heath, Poole, Dorset BH16 6JY .... WW 401

Toroidal transformers from Avel-Lindberg are described in a new brochure. The transformers are rated from 15 to 130 VA at up to 40V and are contained in resin-filled plastic cases. The toroidal construction is said to reduce the stray magnetic field by up to eight times. Avel-Lindberg Ltd, South Ockenden, Essex RM15 5TD .... WW 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 .... WW 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, Burslem, Stoke-on-Trent ST6 3AT............................ WW 404

We have received from Advance a leaflet on the OS3300B 50MHz, dual-trace oscilloscope, which is a portable instrument with a full complement of display facilities. Main and delayed sweeps can be mixed. The leaflet is available from Gould Advance Ltd, Roebuck Road, Hainault, Essex..... WW 405

A catalogue from Electronic Brokers lists and describes a range of used test equipment, computers and their peripherals and a new section on multimeters, function generators, stroboscopes and recording equipment is included. The publication is obtainable from 49-53 Pancras Road, London NW1 2QB............................ WW 406

The use of s.s.b., a.m. and f.m. modes enables the use of the Harris AN/URC-94(V) transceiver at long and short range. The frequency coverage is 1.5 to 80MHz in 100Hz synthesized steps. A leaflet describing the equipment can be obtained from the Marketing Dept, Harris RF Communications Division, 1680 University Avenue, Rochester, N.Y., 14610, U.S.A.......................... WW 407

A brochure from RCA Solid State gives basic characteristics of six c.m.o.s memories. Five r.a.ms and a r.o.m. are described, including three silicon-on-sapphire r.a.ms. RCA Solid State — Europe are at Sunbury-on-Thames, Middx. WW 408

Helical aerials for u.h.f. and v.h.f. mobile transceivers and boot-mounting, whip aerials and bases are briefly described in two leaflets from the Panorama Radio Company Ltd, 73 Wadham Road, London, SW14 2LS .... WW 410

Weather-satellite picture facsimile machine — 3

Drive amplifier, motors, light source and constructional details

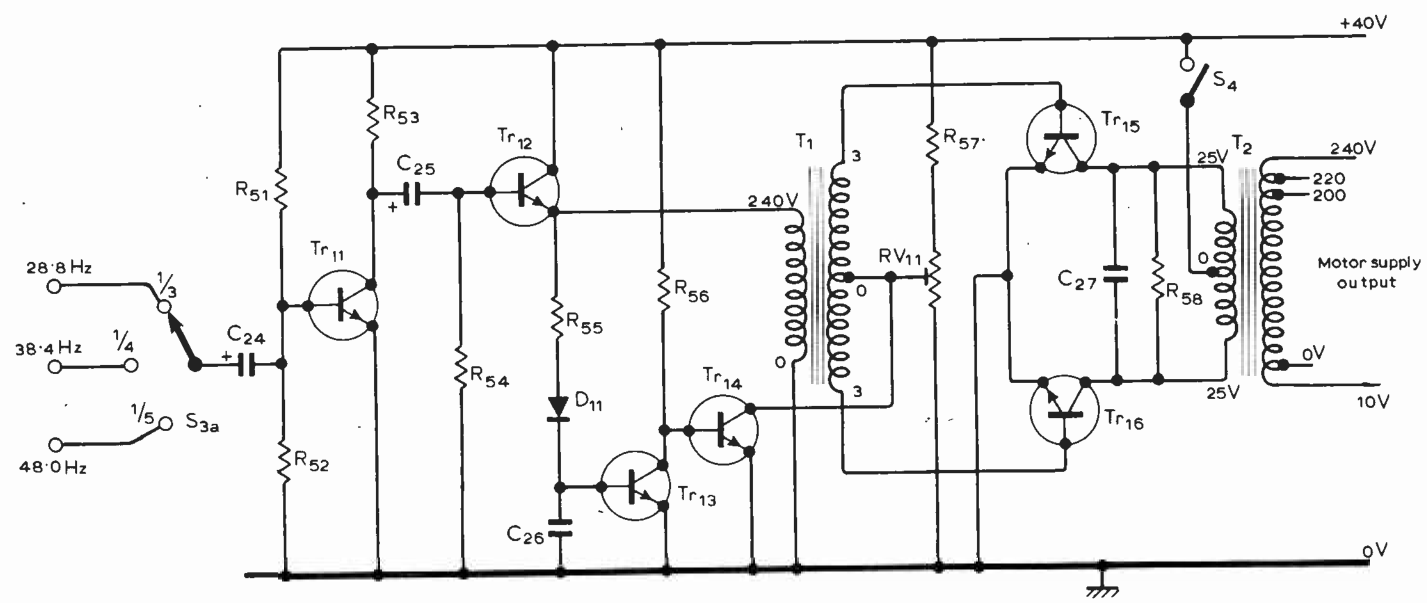
by G. R. Kennedy

The square wave signal from the SR line divider is selected by S_{3a} 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 Tr_{11} and a.c. coupled to the emitter follower Tr_{12} which feeds the primary of a small mains transformer, T_1, used here as a phase splitter. The centre-tapped secondary paraphase feeds output transistors Tr_{15} and Tr_{16}. The bias is set by RV_{11}, and the collectors are connected in push-pull by transformer T_2, which is a mains transformer reverse connected. The d.c. supply to the output transistors is switched by S_4, the drum motor on/off switch. To obtain a near-sinusoidal output, the centre-tapped winding of T_2 is broadly tuned to 38Hz or so by means of the non-electrolytic capacitor C_{27}; 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 R_{58} is placed across C_{27}.

Clamp. In Fig. 12, if the drive into C_{24} should fail for some reason while S_4 is made, the output stage could be damaged due to excessive current flowing through T_2 and the output transistors. A clamp circuit is included to prevent this. A small portion of the current drive from the Tr_{12} emitter is taken via R_{55} and D_{11} to charge C_{26}. When the potential on this rises, Tr_{13} turns on and shorts the base of Tr_{14} to ground, thus turning it off. Since the off resistance of the silicon transistor Tr_{14} 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 Tr_{11} and hence Tr_{12} fails, no current flows from the Tr_{12} emitter and C_{26} discharges through the Tr_{13} base-emitter junction. Tr_{13} turns off, its collector potential rises and turns on Tr_{14}. The wiper of RV_{11} is effectively shorted to ground, and the output transistors Tr_{15} and Tr_{16} 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^{-3}Nm working torque (approximately 3.7gcm). The starting torque is 32.5 × 10^{-3}Nm, 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^{-3}Nm. 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 600Ω 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 Tr_{17} and Tr_{18} is set by RV_{12} and the output is taken to an external socket from the emitter follower stage Tr_{19} via C_{32} and via R_{66} to the light-emitting diode D_{12} to give a visible indication of drum rotation. The unstabilized supply is tapped from the +40V supply and smoothed by R_{67} and C_{33}.

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 C_{34}, shunt rectified by D_{13} and applied to the trigger input of monostable IC_{22}. The on-period is selected according to the line division in use by S_{3b}, R_{69}, C_{35} and one of RV_{13}, RV_{14} or RV_{15}. This output is taken via R_{70} to limit the output current. A simple semi-stabilised +5V rail is derived from the +12V line by R_{71}, D_{14} and C_{36}.

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 laser 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

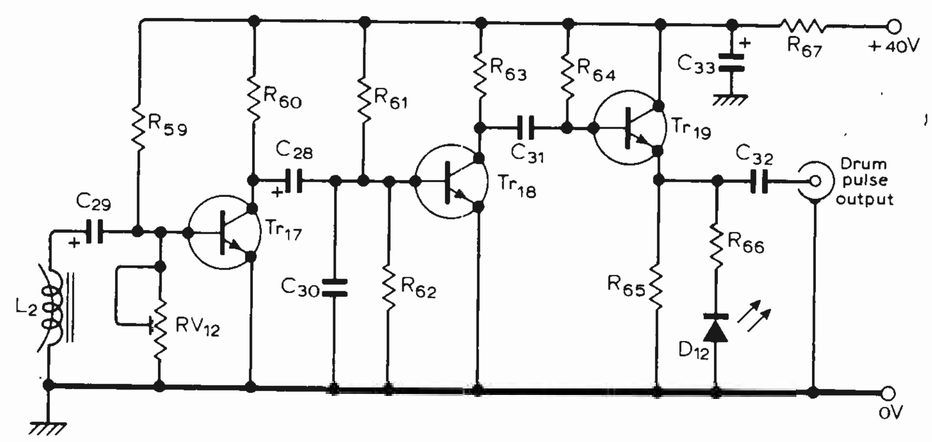


Fig 13. Drum-pulse amplifier

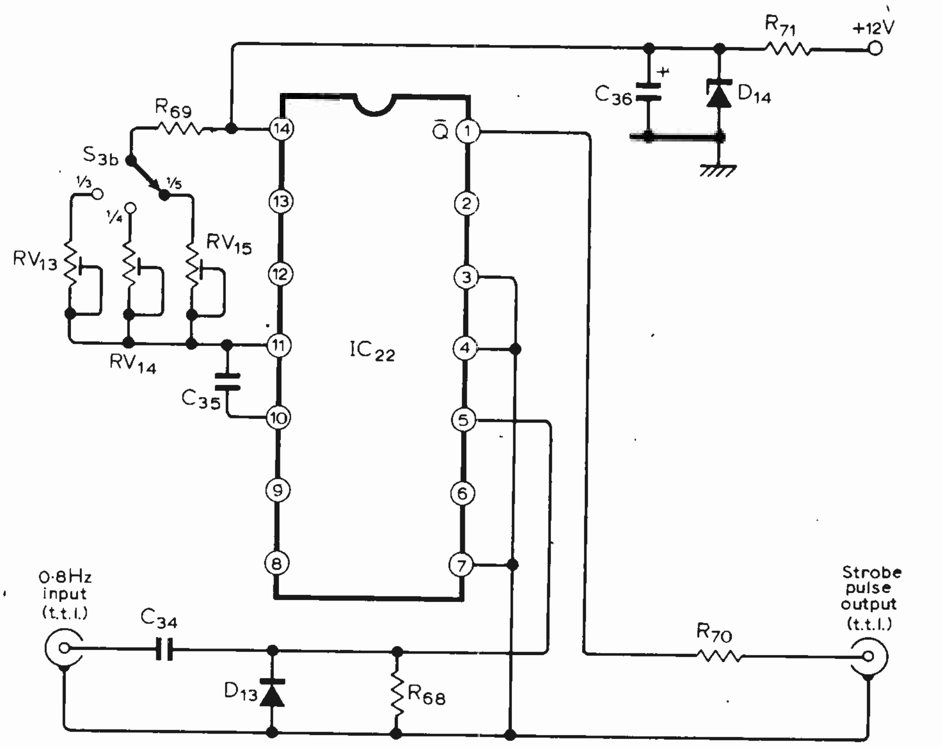


Fig 14. SR strobe-pulse generator

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 (2870°K colour temperature) and has an average life at 30mA of 250h. It is also inexpensive, being available in small quantities for about £15. 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 refs 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

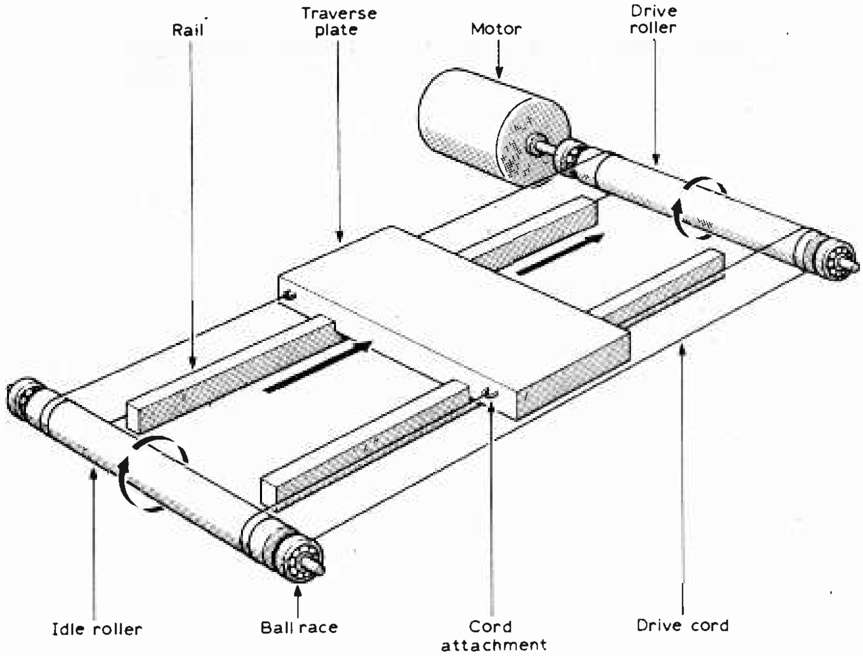


Fig 15. Traverse-drive scheme.

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 1½ 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 plummer 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.

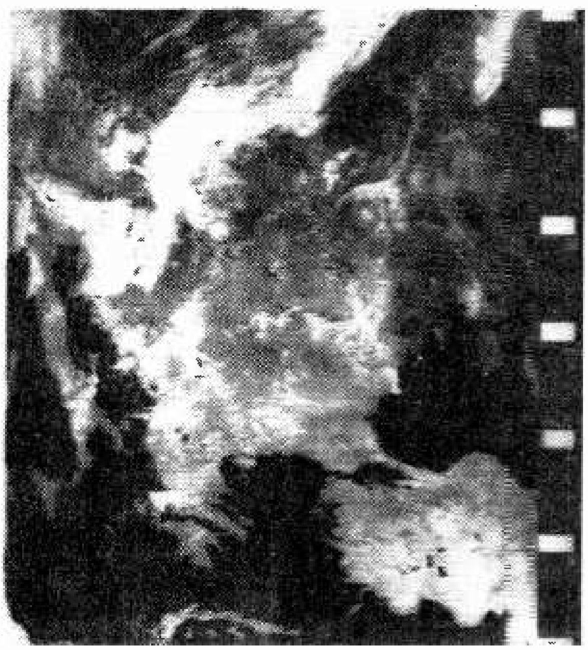
The **traverse** comprises a sledge block running on two straight rails. The prototype used a heavy Paxolin plate approximately 18 × 8 × 2cm thick with two square-section slots 1.0 × 0.7cm milled across the width. The rails are 1.8 × 1.0cm rectangular-section brass rods, selected for straightness and surface planed for smooth running. The slots were milled approximately 0.15mm over width and the Paxolin was oil impregnated, 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 end rollers. 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 200s, 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 diametrical 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 × 45cm 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)

Meteor 25 Satellite Pictures

11 September 1976, 09.19z, revolution 1671, *printed live using the linear detector. Facsimile was set for a high contrast to show coastlines. Numbers down edge of the picture are transmitted by satellite and are timing, calibration and housekeeping data. SR distortion can be seen by the elongation of Italy at low left. Greece is lower centre, the Black Sea is right.*



11 September 1976, 09.19z revolution 1671, *printed from a tape recording of the live signal. Logarithmic detector was used giving a larger dynamic range to the picture. Cloud patterns are more easily seen, as are some geographical features such as mountains and rivers, compared with the picture produced using the linear detector. Black lines on the picture are due to oxide drop-outs on the recording tape. Crete and Turkey can be seen at the bottom of this picture.*

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.cs 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.cs 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.cs cannot easily be adapted. Often this is because the operating conditions lie outside the range for which the standard i.cs 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.cs".

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.cs 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

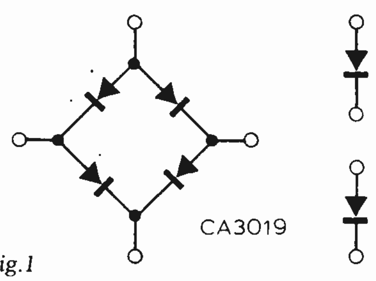


Fig.1

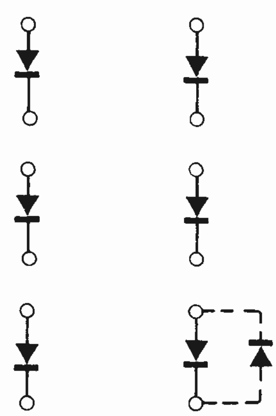


Fig.2

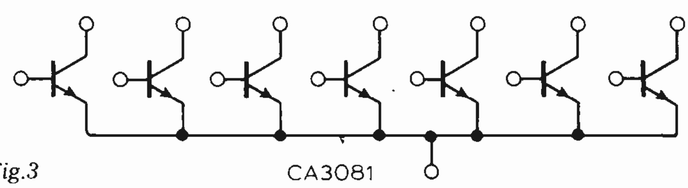


Fig.3

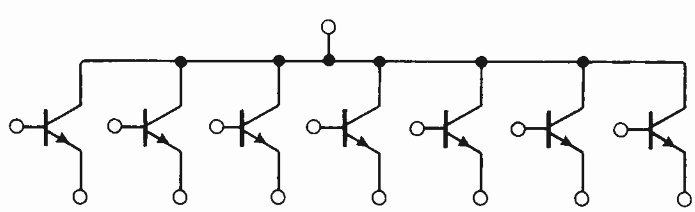


Fig.4

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 connnected 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.

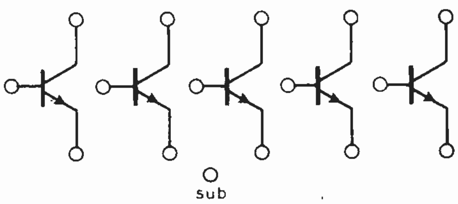
If more complex functions are to be performed without recourse to larger packages, then a number of internal connections have to be made and Fig.7 illustrates this point with seven semiconductor devices plus a separate substrate connection in a 14-pin package. The double current-mirror is useful in amplifier 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.cs 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 Tr_1, Tr_2 are so-called super-β 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 bootstraped with Tr_3, Tr_4 withstanding the full common-mode input swing.

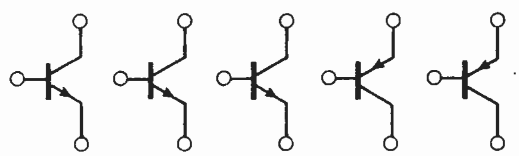
The i.cs discussed so far have been bipolar types and it is worth noting that matched pairs of bipolar transistors are widely available and are convenient as low drift and/or gain-boosting input stages for operational amplifiers. The choice with m.o.s. devices is less wide. Again matched pairs and triples 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.cs. 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.cs 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



CA3083

Fig.5



CA3096

Fig.6

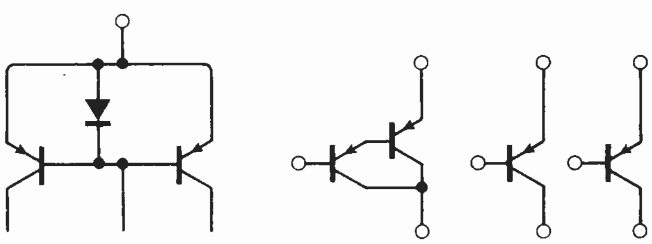


Fig.7 CA3084

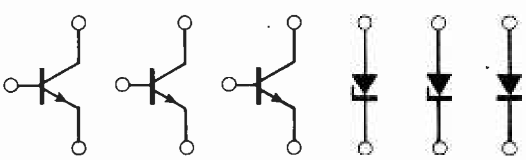


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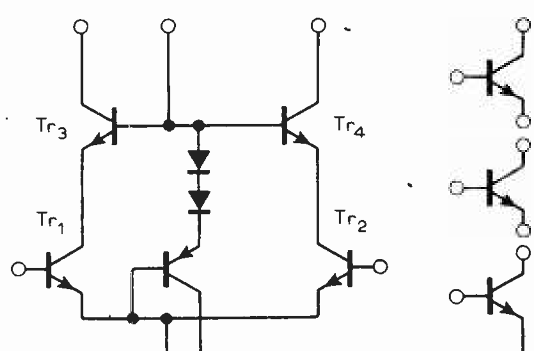
Fig.8



CA3095

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.

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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 multiplers
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 system 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,[2] 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.[2] Radar of this kind is often ineffective within a certain skip distance from transmitter.[2] 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[3] 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[4] 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[4] 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 organization 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.
2. Janes Weapons Systems.
3. Tracking in a multiradar environment, H. W. Thomas, G. Maignan and J. T. Storey, *Proc. IEE*, vol. 123, No. 3, March 1976.
4. Identification of complex geometrical shapes by means of low frequency radar returns, Y. T. Lin and Professor A. A. Ksienski, *The Radio and Electronic Engineer*, vol. 46, No. 10, October 1976.

Digital angle modulation

2 — Comparison of methods

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

Part 1 of this article reviewed various methods of generating and detecting angle-modulated signals carrying digital information. This part discusses the comparative performances of types of modulation.

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.

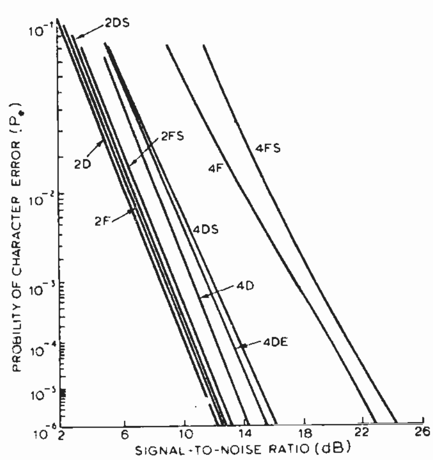

Fig. 1. Noise performance curves.

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 number 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

Table 1

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

Note: All parameters are normalised to the system bit rate.

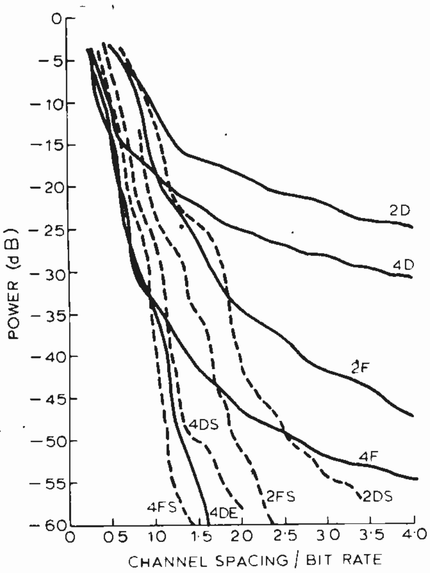

Fig. 2. Adjacent channel rejection factor.

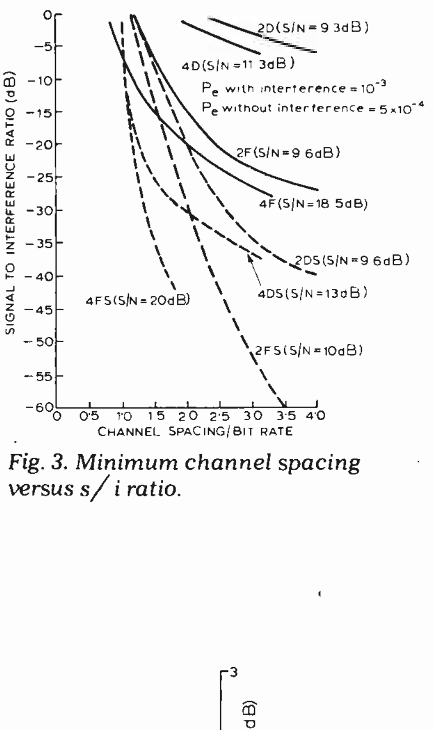

Fig. 3. Minimum channel spacing versus s/i ratio.

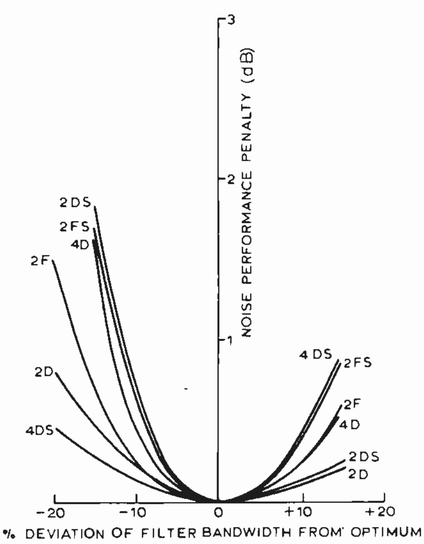

Fig. 4. Effect of filter bandwidth on noise performance.

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 importance and make d.p.e.k. very attractive.

Spectrum occupancy. The spectrum 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_e 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 spectrum and does not take into account the performance of the receiving end of the radio link. The curves included in Fig. 2 clearly indicate the advantages to be gained in terms of spectrum occupancy by the use of premodulation shaping, 4-level coding or f.s.k. rather than d.p.s.k. They also clearly show that the advantages gained increase significantly with channel spacing. The 4-level d.p.e.k. shows that this method is theoretically very attractive from the spectrum usage point of view. However, it should be pointed out that for this method the adjacent channel rejection factor is highly dependent on the linearity that can be achieved in the transmitter. This is because its amplitude modulation component will cause spectrum spreading to occur in the transmitter, the amount being dependent on the degree of linearity achieved. The curve presented is the best which it is considered can be achieved with present day transistor r.f. power amplifiers.

As stated above, the adjacent-channel rejection factor does not take into account the performance of the receiving end of the radio link. The curves presented in Fig. 3 overcome this shortcoming by indicating how the maximum permissible level of an interfering like signal at the input to the receiver varies with channel spacing. The curves show the same general trends as those of adjacent-channel rejection.

Sensitivity to design tolerances

So far the paper has considered the comparative performance of the various modulation methods with their design parameters optimized. We now attempt to quantify the performance degradations which can be expected if the parameters deviate from their optimum values. This gives an indication of how critical the various parameters are and hence how difficult it is to achieve near theoretical performance in practice. The parameters considered are:

- filter bandwidth,
- group delay distortion,
- frequency stability,
- demodulator timing errors,
- f.s.k. deviation ratio.

In each case, the performance degradation is expressed in terms of the noise-performance penalty incurred as a function of the deviation of the parameter from its optimum value. In many cases figures for all the methods under consideration are not available. In such cases the likely degradation is discussed in qualitative terms by extrapolation of the available results.

Filter bandwidth. The effect of the filter bandwidth on the noise performance of the binary f.s.k. and the binary and 4-level d.p.s.k. systems is illustrated in Fig. 4. In this figure the noise penalties are plotted as functions of the deviations 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.e.k. and 4-level f.s.k.), leads to the conclusion that in a 4-level d.p.e.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 the effects of this parameter and, of the results available, those 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 distorition 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 stabilities to keep the noise performance degradation due to this parameter alone below 1dB are 1.2 parts in 10^5 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,

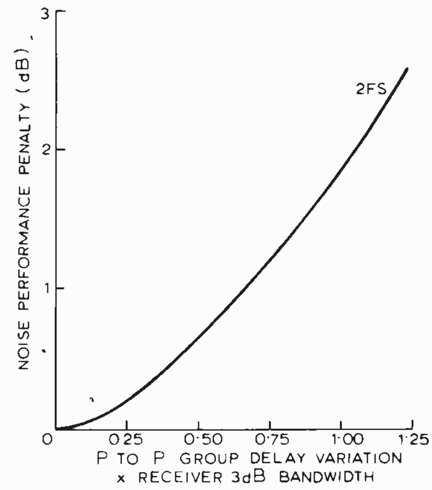

Fig. 5. Effect of group delay distortion on noise performance.

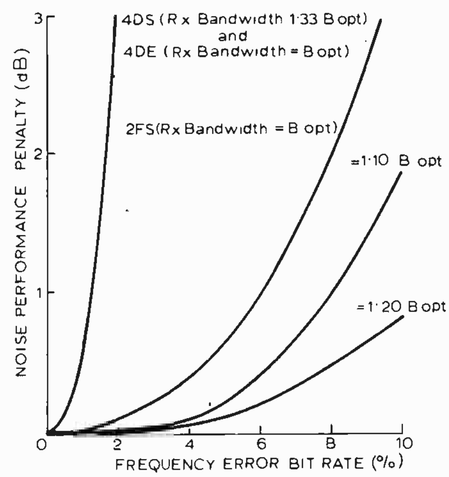

Fig. 6. Effect of system frequency stability on noise performance.

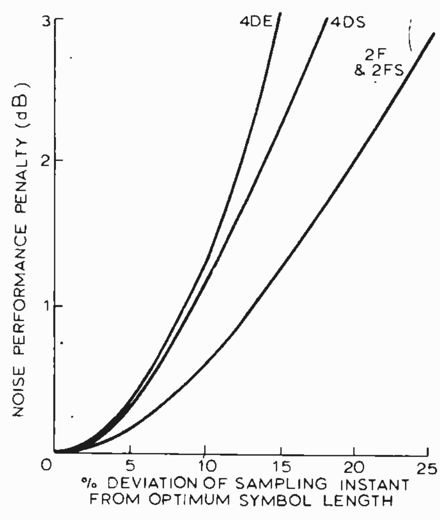

Fig. 7. Effect of demodulator sampling instant errors on noise performance.

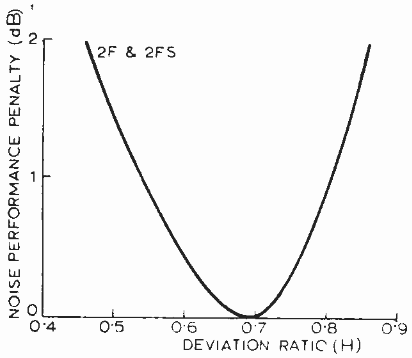

Fig. 8. Effect of f.s.k. deviation ratio on noise performance.

TABLE 2

Modulation method	Parameter: Equipment complexity	Noise performance	Spectrum occupancy	Sensitivity to equipment tolerances	Propagation characteristics	Overall (Assuming equal weighting)
2D	1	1	3	1	1	7
2DS	2	1	3	1	1	8
4D	2	2	3	2	2	11
4DS	3	2	1	2	2	10
4DE	3	2	1	2	2	10
2F	1	1	3	1	1	7
2FS	2	1	2	1	1	7
4F	2	3	2	2	2	11
4FS	3	3	1	2	2	11

because of its simpler circuit configuration, binary f.s.k. may be preferred to 4-level systems even though there is a tight 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 of 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.

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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 on 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. Before 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.

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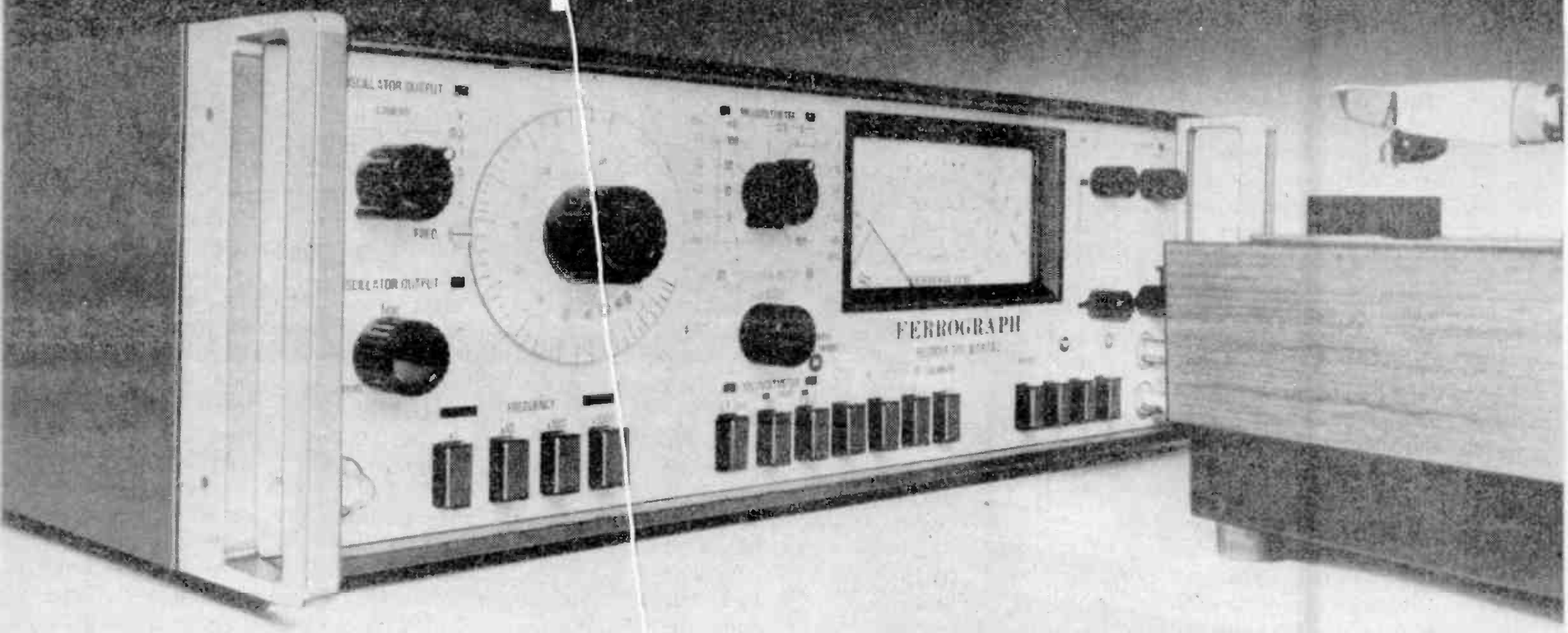

The Ferrograph RTS 2 is a complete, single-unit audio analyzer. Used by leading manufacturers and dealers throughout the world, it is the only single equipment available that can run exhaustive checks on hi-fi – including amplifiers, tape recorders, equalisers and mixers – making it an invaluable aid to sales and service.

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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 PM6622, 24 and 25, are 80MHz, 520MHz and 1GHz instruments respectively with switchable a.c. or d.c. coupling. The 80MHz 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.

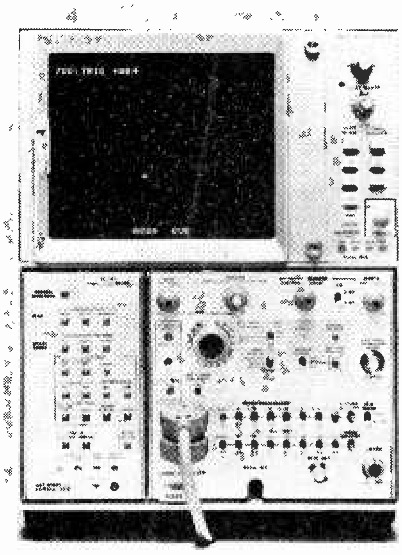
Also on show was the PM5716. This is a new pulse generator which will be available in the UK shortly. The instrument, which is suitable for both t.t.l. and c.m.o.s. circuitry, has a range from 1Hz to 50MHz with a rise time variable between 6ns and 100ms. An interesting facility on the 5716 is an output 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 999.9999MHz with a 100Hz resolution. A three digit l.e.d. display is used to indicate f.m. or a.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 logic 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 false triggering.

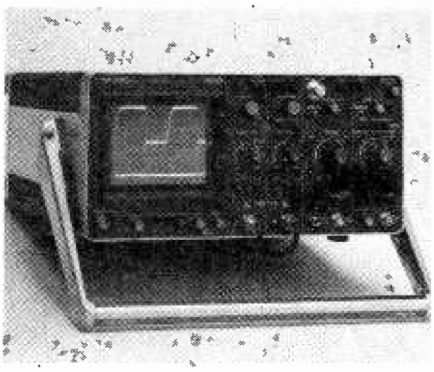


Tektronix's 7DO1 logic analyzer stores and displays data in three formats.

AEG-Telefunken have introduced a miniature c.r.t. suitable for "pocket" television sets or test instruments. Type D5-100 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 r.a.m. 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.ts. This principle of charge storage has been known for some time and adopted in certain r.o.ms. In conventional r.a.ms. 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.ts. only when there is a power down situation. The m.n.o.s. devices are in series between the driver and load f.e.ts 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.ts 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.ts 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



Philips type PM3243 storage oscilloscope has a bandwidth of 50MHz.

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.l. 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 formating 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-3-9800 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.cs 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 × 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, one 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 £600. 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 l.e.ds and one photodiode. Binary coded outputs make channel identification via a seven or nine-segment display relatively easy.

A matrix of 8 × 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 controls like volume, colour-saturation and brightness. Supplementary features such as

Philips type PM6622 timer / counter operates up to 80MHz.

instant sound muting, and standard-setting are also included in the devices. Another interesting exhibit, although announced prior to the show, was Siemens "T^{3}LS" family of high-speed, high noise immunity logic. This is similar to conventional t.t.l. but offers an immunity to static noise, for both logic states of roughly 40% of the swing. In this family the switchover threshold is typically 2.1V. At the moment the range comprises four devices. FLY971 is an expander with 1 × 5, 1 × 4, and 1 × 3, inputs. FLH961 is two AND-OR/NOR gates with 1 × 2 and 1 × 3 inputs. FLH981 is two NAND gates each with two inputs, and two AND/NAND gates also with two inputs. FLH951 is an AND-OR/NOR gate with 2 × 2, 2 × 3 and expander inputs. These devices can be used with standard t.t.l. by inserting a 2.5kΩ resistor between the interface and operating voltage.

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 syntony 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.

Wireless World printed circuit boards

Due to a change of address, all correspondence concerning p.c.bs 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 I_c-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_0 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_0 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

$$I_{max}+I_{min}-2I_{mean}=2I_2 \qquad (1)$$

Thus

$$\frac{I_2}{I_1}=\frac{I_{max}+I_{min}-2I_{mean}}{I_{max}-I_{min}}$$

The percentage of second harmonic distortion is thus given by

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

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_0, the no-signal or quiescent current, and it is a simple matter to recast expression (2) in terms of I_0 in place of I_{mean}. We know that I_{mean} is equal to (I_0+I_2) and substituting for I_{mean} in expression (1) above we have

$$I_{max}+I_{min}-2I_0=4I_2$$

from which

$$\frac{I_2}{I_1}=\frac{I_{max}+I_{min}-2I_0}{2(I_{max}-I_{min})}$$

Thus the percentage of second harmonic distortion is given by

$$\frac{100I_2}{I_1}=\frac{50(I_{max}+I_{min}-2I_0)}{I_{max}-I_{min}}$$

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

percentage of second harmonic distortion

$$=\frac{50(1.22+0.24-2\times 0.75)}{1.22-0.24}$$

$=2$ per cent approximately.

I_c-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, in fact, 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 I_c-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 Fig. 17: this shows a linear load with a slope corresponding to 6 kilohms superimposed on a set of I_c-V_c curves for a bipolar transistor. This diagram could apply to a circuit with a direct-connected collector load resistor of 6 kilohms and a supply voltage of 12. It could equally apply to a stage with a

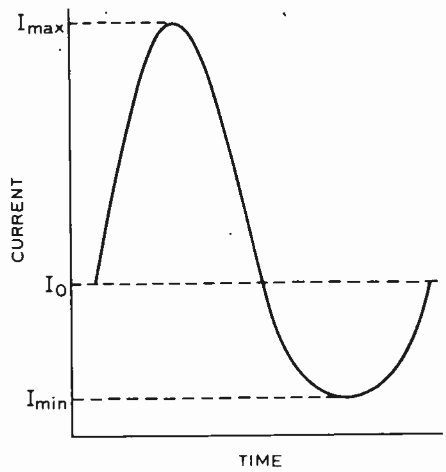


Fig. 15. Type of waveform distortion given by a device with a parabolic characteristic

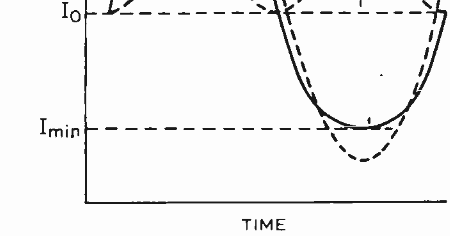
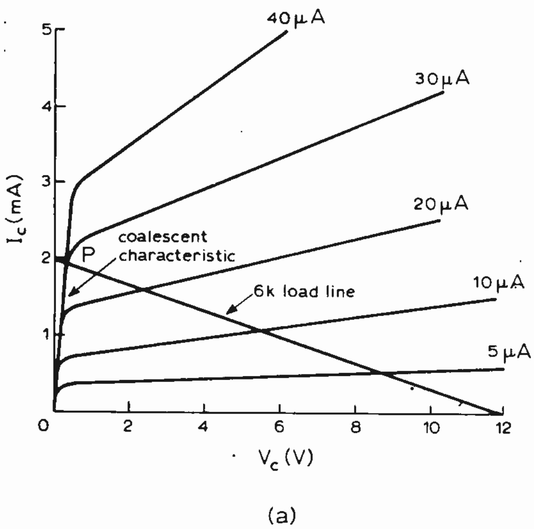


Fig. 16. Fundamental and second-harmonic components of the waveform of Fig. 15



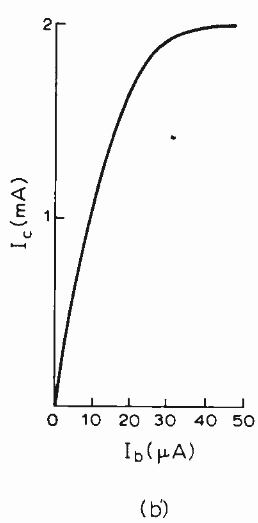


Fig. 17. (a) Load line exhibiting limiting characteristic and (b) the input-output characteristic for the 6kΩ load line of Fig. 17(a)

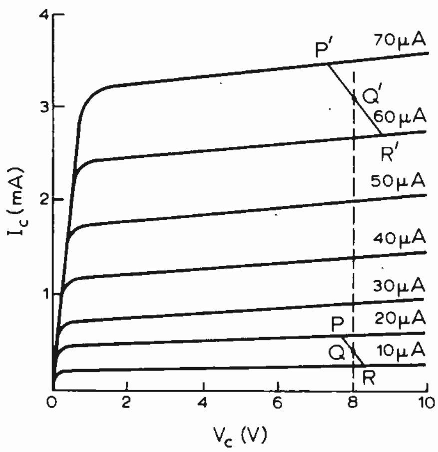


Fig. 18. $I_c - V_c$ characteristics and load lines showing the action of reverse a.g.c.

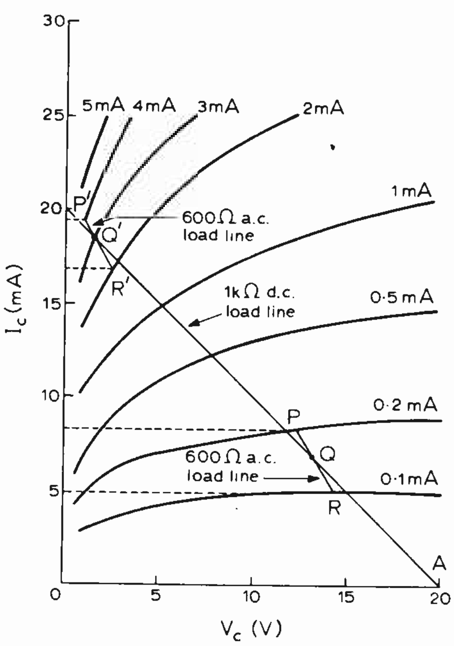


Fig. 19. $I_c - V_c$ characteristics and typical a.c. and d.c. load lines for forward a.g.c.

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.g.c.

Transistors for which the $I_c - V_c$ characteristics are more crowded at low currents can be used for reverse a.g.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

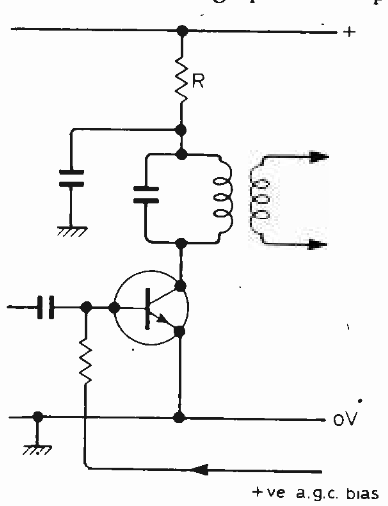


Fig. 20. Essential features of circuit for forward a.g.c.

current plotted against output voltage e.g. a set of I_c-V_c 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 smaller negative bias voltage and a higher drain current: a higher value of R_s gives a load line such as DF indicating a large 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.ts and so predictions from constructions such as that illustrated in Fig. 22 should be treated as approximate.

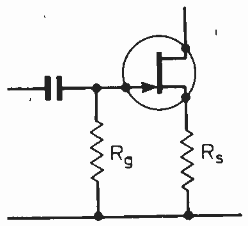


Fig. 21. A depletion-type f.e.t. biased by a resistor in the source circuit

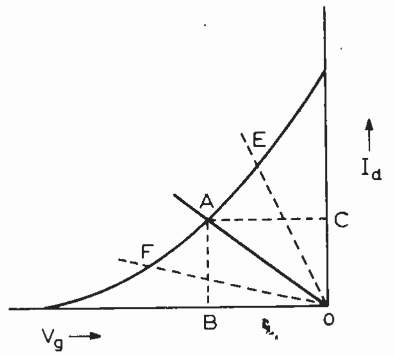


Fig. 22. Load lines on I_d-V_g characteristics showing bias value achieved

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-kilohm 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.

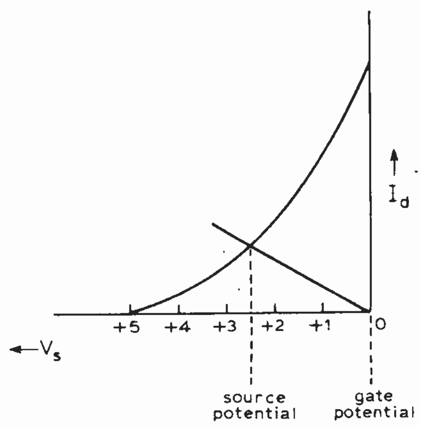


Fig. 23. The I_d-V_s characteristic is the same as the I_d-V_g with the voltages reversed in sign

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_s. 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 $+2$V on the source. It is, however, quite convenient to retain the familiar shape of the I_d-V_g characteristic and to reverse the signs on the voltage axis as in Fig. 23. The intersection with the load line gives the source and gate potentials as indicated. On this diagram we can now show the effect of biasing the gate positively and using a high-value source resistor. As an example suppose the gate is biased to $+10$V. Then the load line should meet the voltage axis at -10V as shown in Fig. 24 which shows the load line giving the same value of drain current as for the 1-kilohm resistor considered earlier. The slope of the new load line shows that the resistance is approximately 7 kilohms. Fig. 24 shows that the drain current for limit transistors does not greatly differ from that of the average specimen: in fact the total variation in drain current is from 1.5 to 1.75mA, the average being 1.6mA as before. The penalty to be paid for the increased stability of the operating point is that a higher value of supply voltage is required. If the gate voltage is $+10$V, the source voltage is nearly $+12$V as shown in Fig. 24 in the lower voltage scale. To give a reasonable voltage across the transistor itself and the drain load a supply of at least 20V is desirable.

The author would like to thank Mullard Ltd for supplying the transistor characteristics on which Figs. 19 and 24 were based.

The next article in this series, Part 5, will examine the forms of non-linearity of load lines that can occur and the effect this has on circuit performance.

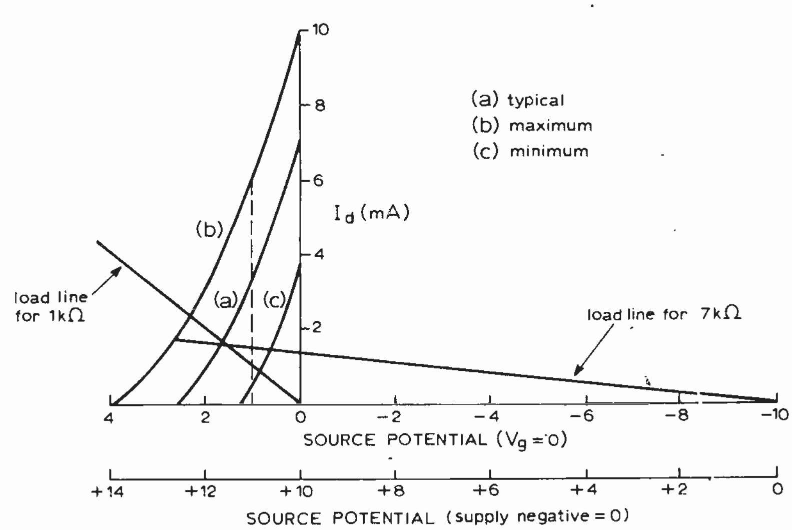


Fig. 24. Improvement in bias stability by use of positive gate bias and a high-value source resistance

World of Amateur Radio

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; pedestrian mobile; r.t.t.y.; 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 and 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 (Docket 20777).

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 scrapping 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."

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. Vol. 1 covers: fundamental principles; valves and semiconductors; h.f., v.h.f. and u.h.f. receivers; h.f., v.h.f. and u.h.f. transmitters; keying and break-in; modulation systems; and r.t.t.y.

A foreword by M. Mili, Secretary-General of the ITU, states: "The role of radio amateurs in technical training seems to be little known for all its great importance. The ITU is engaged on a vast programme of technical co-operation to aid developing countries to expand their telecommunication services. In this programme training plays a vital role. There is no doubt that the development of an amateur radio service makes a substantial contribution to the execution of this immense task, and a contribution moreover that costs the community so little."

In brief

European amateurs have abandoned hope of obtaining an allocation around 220MHz at the 1979 World Administrative Radio Conference although the RSGB and some other European societies are continuing to press for a small allocation at 50MHz, as currently available to amateurs in Regions 2 and 3 . . . CT2BB in the Azores has heard both British and American 144MHz amateurs during Sporadic E openings and may soon provide a beacon signal on 144.1MHz, raising hopes once again of an eventual spanning of the Atlantic on 144MHz . . . Durham beacon, formerly GB3DM, is now operational as GB3NEE on 144.935MHz . . . "Some of the things I hear through GB3LO make me ashamed to be associated with it. There have been suggestions that GB3LO should be closed down completely, and more specifically that it should be closed in the evenings" states Chris Roberts, G4EVA, chairman of the UK FM Group (London). A meeting of the Group has debated a motion that "the continued 24-hour operation of GB3LO is detrimental to the original aims and objectives of the UK FM Group and to the aims of Amateur Radio in general" . . . A fully automatic telecommand system for use with Oscar 6 has been commissioned at the University of Surrey. For the past 1½ years this station has had the responsibility of ensuring that the amateur satellite is switched off when the internal batteries are being recharged, and to switch it on for European activity and for the news bulletins sent via Oscar from HG5BME at Budapest Technical University. Oscar 6 should complete its 20,000th orbit during February . . . The GB2RS news bulletins now go out on Sunday mornings on 3650kHz instead of 3600kHz; the two-metre frequency remains 144.5MHz . . . The British Amateur Television Club has recommended to the RSGB the use of 144.230MHz as an sstv calling frequency, 144.750MHz as a fast scan calling frequency, and 144.70MHz for facsimile.

PAT HAWKER, G3VA

New Products

Programmable calculator

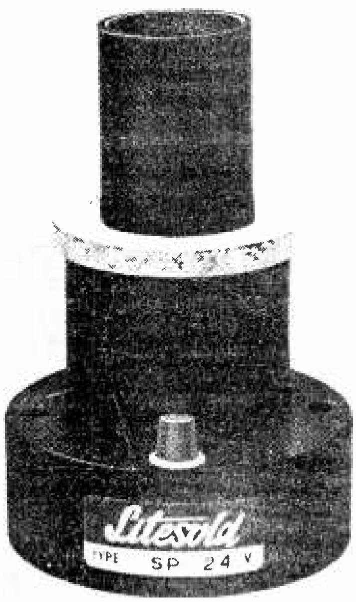
In addition to over 30 pre-programmed functions and ten independent memories, using full memory arithmetic, the PR100 scientific calculator can store 72 programme steps. The instrument has a ten-digit calculation accuracy with an eight-plus-two digit l.e.d. display. This calculator, which also has parenthesis, algebraic notation and seven pre-programmed conversions, is supplied with an adaptor/charger and carrying case and is priced at £49.95. Commodore (UK) Limited, 446 Bath Road, Slough, Berks.

WW 302 for further details

Solder pot

The Litesold LSP solder pot, which is designed for improved operator safety and longer element life, will run on existing 24V soldering-iron power units or low-voltage power supply systems. Its 130g-capacity crucible is machined from fine-grain cast iron and has a tinning depth of 31mm. At normal ambient temperatures the 48W element gives a soldering temperature of approximately 300°C. Light Soldering Developments Ltd, 97-99 Gloucester Road, Croydon, Surrey.

WW 303 for further details

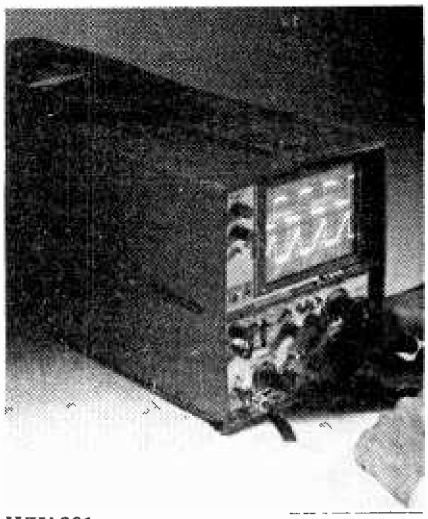


Rugged oscilloscope range claims low cost of ownership

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,



WW 301

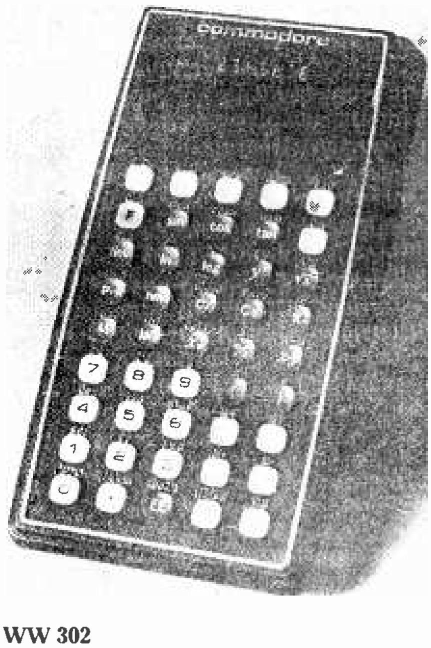
and maintenance of accuracy are the aims that Tektronix have set themselves.

The models, costing from £500 to £1000 (plus v.a.t.) are

- two 15MHz units, one single and one dual trace (T921, T922)
- two dual trace 35MHz units, one with delayed timebase (T932, T935)
- 10MHz storage oscilloscope, dual trace (T912)
- rack-mounted version of T922.

Five of the models use an 8 × 10cm 12kV c.r.t., with post deflection acceleration to keep power low in the deflection circuits, and measure only 18 × 25 × 48cm, with a weight of around 7 or 8kg. Smallest vertical deflection factor is 2mV/div, input impedance the standard 1MΩ plus 30pF, and rise time 10ns. Phase difference between x and y amplifiers is quoted at 3° at 50 kHz. Z input bandwidth is 5MHz.

WW 301 for further details



WW 302

Ferrite cross-over chokes

Research into ferrite characteristics by Aladdin Components, in conjunction with a loudspeaker manufacturer, who for commercial reasons wishes to remain anonymous, has resulted in the development of a range of ferrite-cored cross-over chokes which are claimed to give up to 40% less harmonic distortion than is normally associated with conventional ferrite cores. Actual test figures are still to be released. The chokes, which use a ferrite called LDC, are available to customers specifications and, because of copper savings achieved, can be made economically — i.e. from 50p, depending on quantity and current rating required. Aladdin Industries Ltd, Western Avenue, Greenford, Middlesex UB6 8UJ.

WW 304 for further details

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 £3600. Dana Electronics Limited, Collingdon Street, Luton, Bedfordshire.

WW 305 for further details

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 centrigrade 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.

WW 306 for further details

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 t.t.l., d.t.l. and c.m.o.s. 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 (C60), 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.

WW 307 for further details

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 5QP.

WW 308 for further details

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 10^6 per month, with an optional standard of five parts in 10^9 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.

WW 309 for further details

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

WW 305

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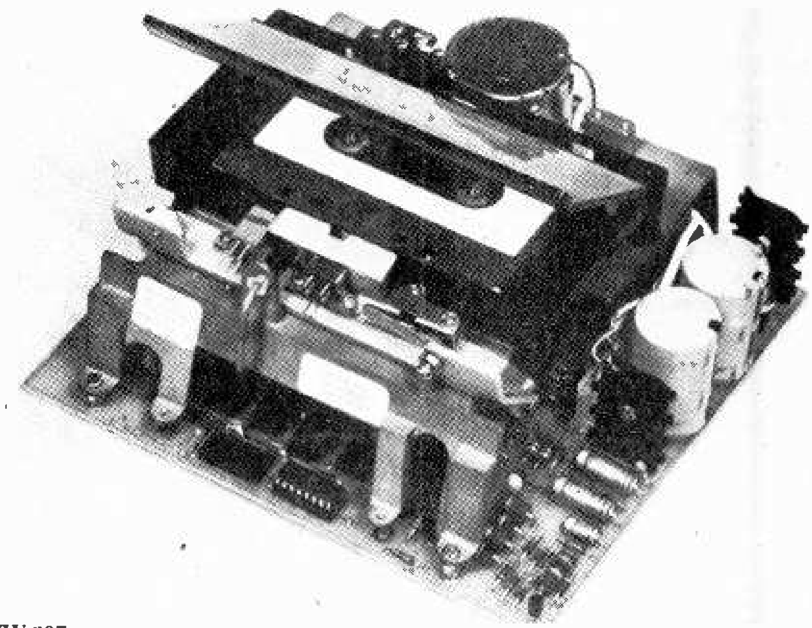

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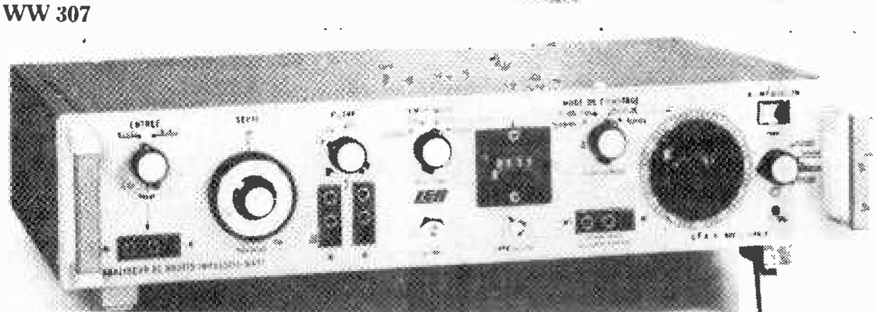


WW 308

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

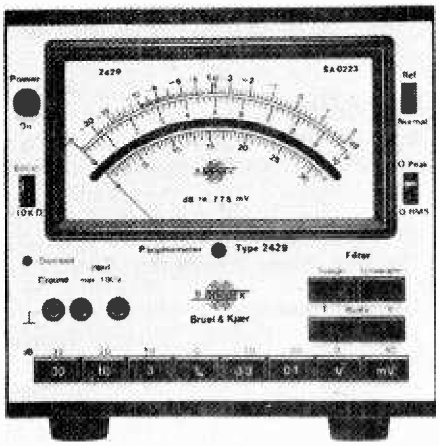
The Oryx 75 soldering iron is designed for fast production-line work and for applications requiring a carefully-controlled soldering temperature. Fast thermal recovery is achieved by a unit in the handle of the iron, which controls the current pulses to the element, and a temperature sensor close to 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 or element may be changed 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.c. 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 6LE.
WW 315 for further details



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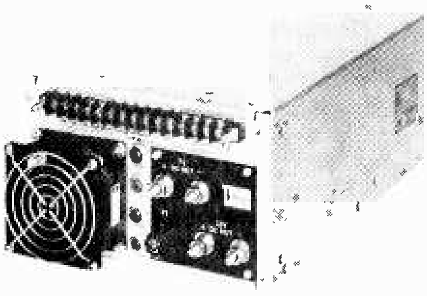
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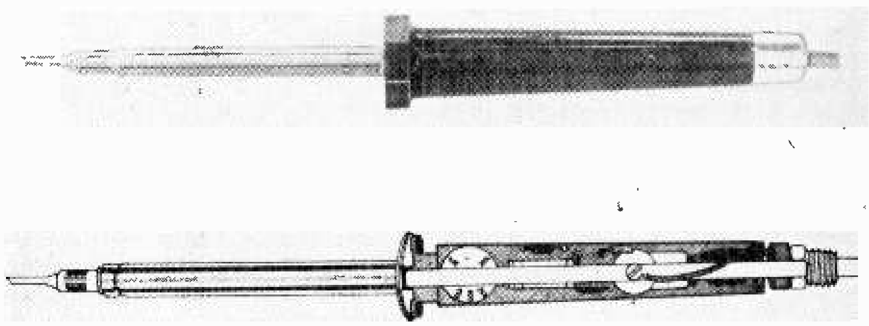
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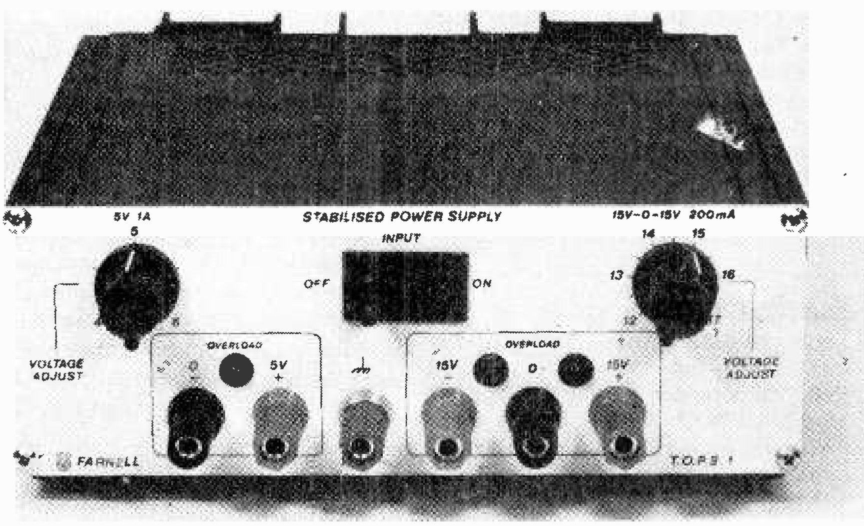

WW 314

Solid State Devices

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

Power Darlingtons

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 rantge 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.ms

Two low-power versions of the 2102A lk 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_{CC} ratings of 33mA and are t.t.l.-compatible on both the inputs and outputs.

WW 318 **Intel**

Static r.a.ms

Three static r.a.ms, 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. The TMS 4042/2111 is the same but has bus-oriented common input and output enables. Type TMS 4043/2112 has common input and output enables and a chip enable. The t.t.l.-compatible devices have typical power dissipations of 175mW.

WW 319 Texas

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 lk by 8 m.o.s. r.o.m., designated as type 2608 CN0040, has been programmed to give the fully-approved teletext character fount 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

Rectifers 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/°C 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/°C 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 **A**975, are wideband, high slew-rate units in TO-99 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, 57/61 Mortimer Street, London W1N 7 TD.

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, Torrington Place, London WC1E 7HD.

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

Plessey Semiconductors, Cheney Manor, Swindon, Wiltshire SN2 2QW.

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

Texas Instruments Ltd, Manton Lane, Bedford MK41 7PA.

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Vero offer an outstanding range of small enclosures and cases of high quality, attractive appearance and economic prices with immediate delivery.

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Verobox (R) extruded aluminium enclosures – a range of low cost small boxes, supplied in kit form in 36 different sizes from stock.

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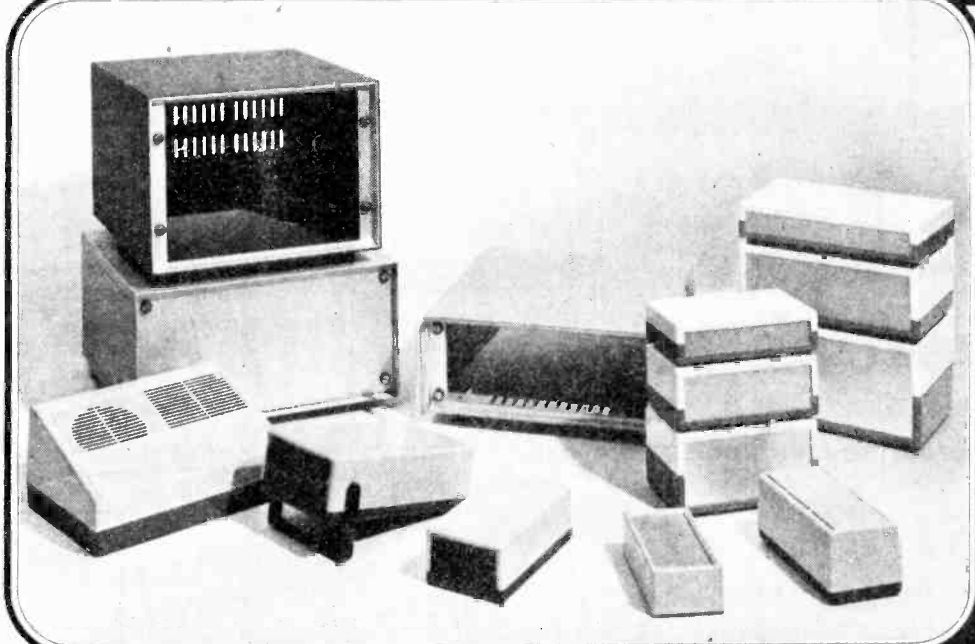
Telephone: Chandler's Ford 2956
Telex: 47551

Section 13 in our catalogue

vero



WORLD LEADERS IN PACKAGING TECHNOLOGY

WW—073 FOR FURTHER DETAILS

Crimson Elektrik

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

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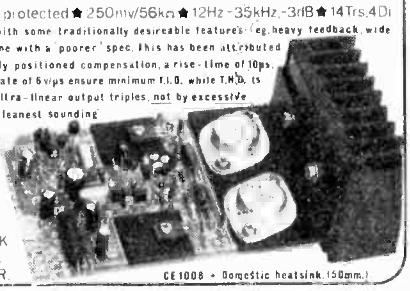

CE1008 + Domestic heatsink (150mm.)

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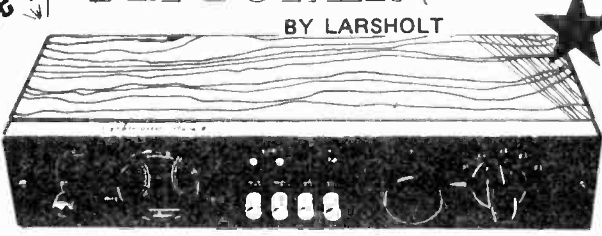
De-Luxe FM TUNER £98·50 +H

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. (400μV input)
Sensitivity:	1μV for 26dB quieting
Distortion:	0.1% (Stereo) typ.
Frequency range:	87.5—104.5 MHz
Stereo separation:	45dB at 1KHz 36dB at 10KHz

FEATURES—Automatic scan facility.
£98.50 + H 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, 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

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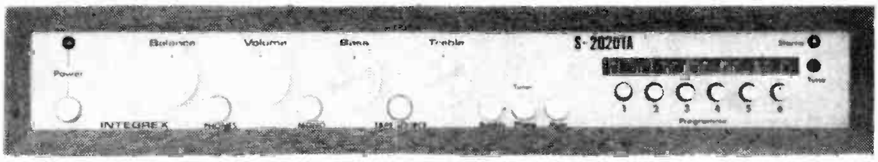
WW — 029 FOR FURTHER DETAILS

INTEGREX

S-2020TA STEREO TUNER/AMPLIFIER KIT

SOLID MAHOGANY CABINET



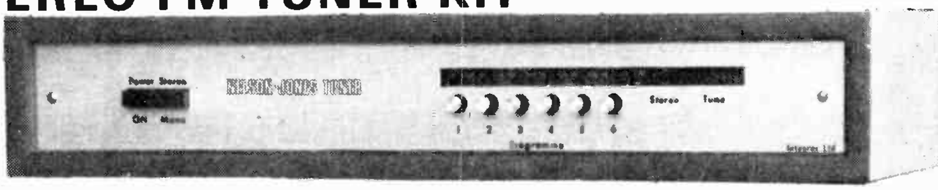
A high-quality push-button FM Varicap Stereo Tuner combined with a 24W r.m.s. per channel Stereo Amplifier.

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

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

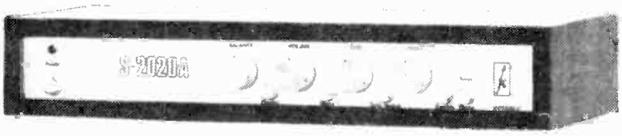
STEREO MODULE TUNER KIT

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

Sens. 30dB S/N mono @ 1.2μV
THD typically 0.3%
Tuning range 88—104MHz
LED sig. strength and stereo indicator

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.

Typ Spec. 24+24W r.m.s. into 8-ohm load at less than 0.1% THD. Mag. PU input S/N 60dB. Radio input S/N 72dB. Headphone output. Tape In/Out facility (for noise reduction unit, etc.). Toroidal mains transformer.

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
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PHASE-LOCKED IC DECODER KIT	**£4.47**+VAT
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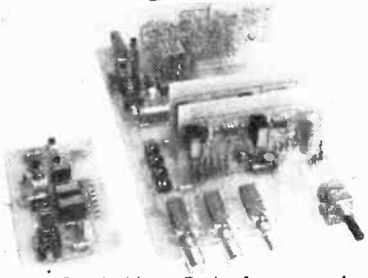
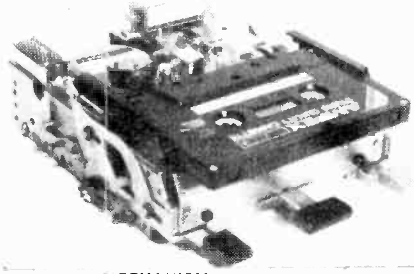


Master Board with one Replay Amp removed



As these circuits in recent issues of "Wireless World" are capable of such an excellent performance we feel that 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 in to 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 practice.

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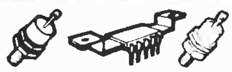

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TRIACS

1.6 AMP PLASTIC ●

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NAS 0161x	100V	.31
NAS 0162w	200V	.34
NAS 0162x	200V	.32
NAS 0164w	400V	.45
NAS 0164x	400V	.43
NAS 0166w	600V	.56
NAS 0166x	600V	.53

6 AMP ISOLATED TAB

NAS 0651w	100V	.68
NAS 0651x	100V	.68
NAS 0652w	200V	.72
NAS 0652x	200V	.72
NAS 0654w	400V	.80
NAS 0654x	400V	.78
NAS 0656w	600V	.97
NAS 0656x	600V	.86

10 AMP ISOLATED TAB

NAS 1001w	100V	.80
NAS 1001x	100V	.80
NAS 1002w	200V	.86
NAS 1002x	200V	.84
NAS 1004w	400V	£1.19
NAS 1004x	400V	£1.14
NAS 1006w	600V	£1.49
NAS 1006x	600V	£1.47

3.5 AMP CLIPPED TAB

NAS 0351w	100V	.58
NAS 0351x	100V	.57
NAS 0352w	200V	.64
NAS 0352x	200V	.61
NAS 0354w	400V	.75
NAS 0354x	400V	.74
NAS 0356w	600V	.95
NAS 0356x	600V	.92

8 AMP ISOLATED TAB

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15 AMP ISOLATED TAB

NAS 1501w	100V	£1.15
NAS 1501x	100V	£1.05
NAS 1502w	200V	£1.14
NAS 1502x	200V	£1.12
NAS 1504w	400V	£1.66
NAS 1504x	400V	£1.63
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Oevices with internal trigger have "W" suffix. "X" Oenotes Standard Triac

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NAS 006q	100piv	.31
NAS 006r	200piv	.34
NAS 006s	400piv	.44
NAS 006t	600piv	.57

4 AMP ISOLATED TAB

NAS 106p	50piv	.29
NAS 106q	100piv	.33
NAS 106r	200piv	.40
NAS 106s	400piv	.63
NAS 106t	600piv	.99

6 AMP ISOLATED TAB

NAS 206p	50piv	.40
NAS 206q	100piv	.46
NAS 206r	200piv	.55
NAS 206s	400piv	.85

8 AMP ISOLATED TAB

NAS 306p	50piv	.45
NAS 306q	100piv	.52
NAS 306r	200piv	.65
NAS 306s	400piv	.93

16 AMP TO 48

16A	50V	.60
16A	100V	.64
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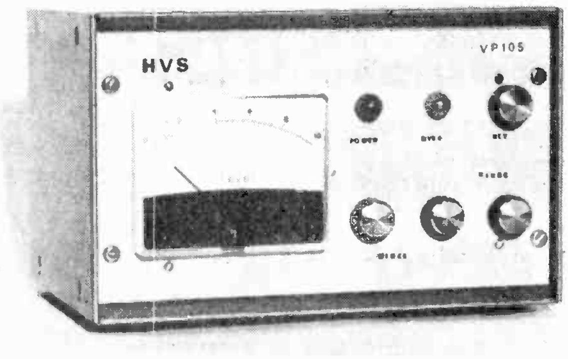

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WW—065 FOR FURTHER DETAILS

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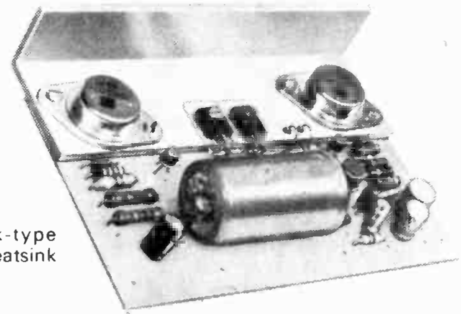
QV audio modules

for cost-conscious constructors

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



SS.1100
£9.45*

with heatsink-type bracket. Large heatsink — £1* extra

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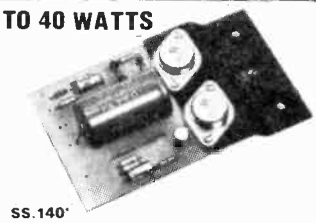

SS.140*
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Combined pre-amp with active tone-control circuits. 200mV output for 50 mV in. Runs on 10 to 16V supply. Treble ±15 dB at 10KHz. Bass ±15 dB at 30Hz. Stereo Balance, vol., treble and bass controls. **£7.80**

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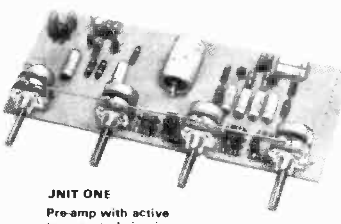
SS.102 STEREO PRE-AMP
R.L.A.A. corrected for mag., plus tape, radio, etc. **£2.65**



JNIT ONE
Pre-amp with active tone control circuits.

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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 **£6.25;** SS.350 50V/2A **£6.75;** SS.300 — Power stabilising unit 10-50V. adjustable (no transformer, p/p 35p) **£3.25;** SS.310/50 Stabilised power supply variable from 10 to 50V/2A **£11.95.**

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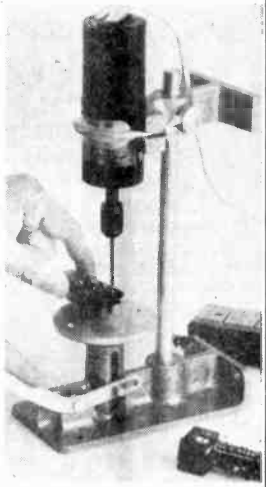

TITAN DRILL
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£9.61 + 35p p & p inc. VAT

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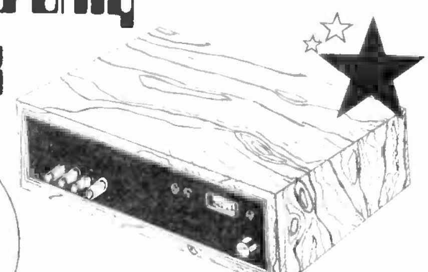
WW — 060 FOR FURTHER DETAILS

Doram kits

DORAM KITS CONTAIN EVERYTHING DOWN TO THE LAST NUT

TV sound only TUNER



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£36.95
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(5-pin DIN) LED tuning indicator
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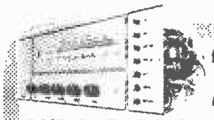

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DIY SPEAKER KITS

EASY-TO-BUILD WITH ENCLOSURE

Specially designed by RT-VC for cost-conscious hi-fi enthusiasts, these kits incorporate two teak-simulate enclosures, two EMI 13"×8" (approx.) woofers, two tweeters and a pair of matching cross-overs. Easily constructed, using a few basic tools. Supplied complete with an easy-to-follow circuit diagram, and crossover components. Input 15 watts rms, 30 watts peak, each unit. Cabinet size 20"×11"×9½" (approx). £25.50 PER PAIR + p & p £5.50

'COMPACT' FOR TOP VALUE

How about this for incredible bookshelf value from RT-VC! A pair of high efficiency units for only £7.50 – just what you need for low-power amplifiers. These infinite baffle enclosures come to you ready mitred and professionally finished. Each cabinet measures 12"×9"×5" (approx.) deep, and is in wood simulate. Complete with two 8" (approx.) speakers for max. power handling of 7 watts. £7.50 per pair + p & p £1.70

15-WATT KIT IN CHASSIS FORM

£8.50 PER SET + p & p £1.70

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 13"×8" (approx.) woofer (EMI), tweeter, and matching crossover. Power handling capacity 15 watts rms. 30 watts peak.

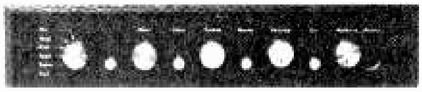
DECCA 20 WATTS STEREO SPEAKER

This matching loudspeaker system is hand-made, as only Decca know how, built to a specification, not down to a price. The kit comprises of two 8" diameter approx. base drive unit, with heavy die cast chassis laminated cones with rolled PVC surrounds. Two 3½" diameter approx. domed tweeters complete with crossover networks.

Our price per stereo pair £30.00 + p & p £4.00

20 x 20 WATT STEREO AMPLIFIER

£29.90 + p & p £2.10



Superb Viscount IV unit in teak-finished cabinet. Black fascia with aluminum rotary controls and pushbuttons, red mains indicator and stereo jack socket. Function switch for mic, magnetic and crystal pick-ups, tape, tuner, and auxiliary. Rear panel features two mains outlets, DIN speaker and input sockets, plus fuse. 20 + 20 watts rms, 40 + 40 watts peak.

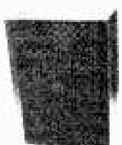
HOW YOU CAN SAVE

SYSTEM 1B For only £80, you get the 20+20 watt Viscount IV amplifier, a pair of our 12-watt-rms Duo Type IIb matched speakers; a BSR MP 60 type deck complete with magnetic cartidge, de luxe plinth and cover. £80.00 + p & p £6.50

SYSTEM 2 Comprising our 20+20 watt Viscount IV amplifier: a pair of our large Duo Type III matching speakers which handle 20 watts rms each, and a BSR MP 60 type deck with magnetic cartridge, de luxe plinth and cover. £92.00 + p & p £7.60

Carriage surcharge to Scotland System 1B £2.50 System 2 £5.00

SPEAKERS Two models – Duo IIb, teak veneer, 12 watts rms, 24 watts peak, 18½" × 13½" × 7¼" approx. £34 PER PAIR + p & p £6.50

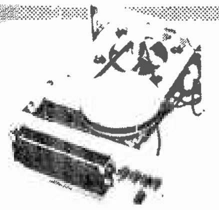


Duo III, 20 watts rms, 40 watts peak, 27" × 13" × 11½" approx £48 PER PAIR + p & p £7.50

TURNTABLE Popular BSR MP 60 type, complete with magnetic cartridge, diamond stylus, and de luxe plinth and cover. £24.00 + p & p £3.50

30 x 30 WATT AMPLIFIER KIT

Specially designed by RT-VC for the experienced constructor, this kit comes complete in every detail. Same facilities as Viscount IV amplifier. Chassis is ready punched; drilled and formed Cabinet is finished in teak veneer. Black fascia and easy-to-handle aluminium knobs. Output 30+30 watts rms, 60+60 peak. £29.00 + p & p £2.10

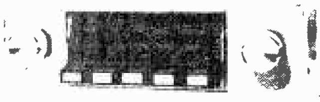


BSR T145 8-TRACK CARTRIDGE PLAYER MECHANISM

SPECIAL OFFER

Requires some attention. Complete with built in pre-amp, A.C. 240V £6.95 + p & p £1.50

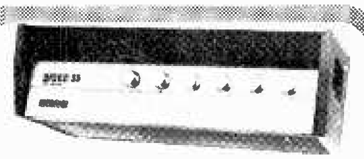
TOURIST IV PUSH BUTTON CAR RADIO KIT



MOTOR TOP 10 AWARD

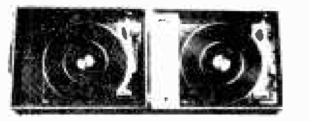
Complete with speaker, baffle and fixing strip. The Tourist IV for the experienced constructor only. The Tourist IV has five push buttons, four medium band and one for long wave band. The tuning scale is illuminated and attractive small aluminium control knobs are used for manual tuning and volume control.

The modern style fascia has been designed to blend with most car interiors and the finished radio will slot into a standard car radio aperture. Size approx 7" × 2" × 4½". Power Supply Nominal 12 volts positive or negative earth (altered internally). Power Ouptut 4 watts into 4 ohms £10.50 + p & p 1.50



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 + p & p £1.50



PORTABLE DISCO CONSOLE

with built-in pre-amplifiers

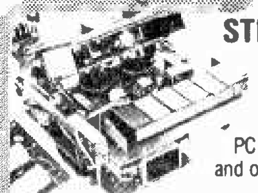
Here's the big-value portable disco console from RT-VC! It features a pair of BSR MP 60 type auto-return, single-play professional series record decks. Plus all the controls and features you need to give fabulous disco performances. Simply connects into your existing slave or external amplifier. £55.00 + p & p £6.50

70 & 100 WATT DISCO AMPS

Brilliantly styled for easy disco performance! Sloping fascia, 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.

70 WATT £49.00 + p & p £3.00

100 WATT £65.00 + p & p £4



STEREO CASSETTE DECK KIT

Again, 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/replay PC board, mains transformer and input and output controls. AC BIAS AND ERASE. £32.50 + p & p £1.50

DELUXE ACCESSORY KIT Comprises of a matched pair of dynamic mics. and two replacement slider level controls. £3.95 + p & p £1.00

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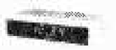

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Also available less crystal control and battery backup Order as **GCK £14.40**

THE SINTEL CAR CLOCK KIT
Four 0 5" red digits ● Neat white case ● Crystal control ● Battery backup ● Suitable for all 12v negative earth cars 154mm x 83mm x 40mm Kit complete less battery
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BC109	0.14	BDY95	2.14	CRS3 20	0.50	2N3053	0.15
BC109C	0.12	BDY96	4.63	CRS3 40	0.60	2N3054	0.40
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BC237	0.16*	BT1D7	1.60	TIP31A	0.54	2N5062	0.30*
BC238	0.16*	BT108	1.60	TIP32A	0.64	2N5064	0.35*
BC300	0.34	BT109	1.00	TIP34	1.05	2N5496	0.65

DIGITAL DISPLAYS & LEDs

DL704	99p	DL728	£1.85	2 RED LED ONLY	13p
DL707	99p	DL747	£1.80	GREEN	20p
DL727	£1.85	DL750	£1.80	TL209	10p

THYRISTORS

	0 8A (TO92)	1A (TO5)	3A (C106 type)	4A (TO220)	6A (TO220)	8A (TO220)	10A (TO220)
50	0.25*	25	35	38	41	42	47
100	0.28*	25	40	42	47	48	54
200	0.30*	35	45	51	58	60	68
400	0.35*	40	50	60	87	88	98
600		65	70	89	1.09	1.19	1.26

TRIACS (PLASTIC TO—220 PKGE ISOLATED TAB)

	4A		6 5A		8 5A		10A		15A	
	(a)	(b)	(a)	(b)	(a)	(b)	(a)	(b)	(a)	(b)
100V	0.60	0.60	0.70	0.70	0.78	0.78	0.83	0.83	1.01	1.01
200V	0.64	0.64	0.75	0.75	0.87	0.87	0.87	0.87	1.17	1.17
400V	0.77	0.78	0.80	0.83	0.97	1.01	1.13	1.19	1.70	1.74
600V	0.96	0.99	0.87	1.01	1.21	1.26	1.42	1.50	2.11	2.17

N B Triacs without internal trigger diac are priced under column (a) Triacs with internal trigger diac are priced under column (b) When ordering please indicate clearly the type required

TTL 74 SERIES PLASTIC

7400	0.16	7420	0.16	7447	0.81	7483	1.12	74119	1.92	74163	1.20
7401	0.16	7422	0.38	7448	0.81	7484	0.85	74121	0.34	74164	0.93
7402	0.16	7423	0.40	7450	0.85	7485	1.25	47122	0.47	74165	0.93
7403	0.16	7425	0.30	7451	0.16	7496	0.32	74123	0.40	74167	3.70
7404	0.18	7427	0.48	7453	0.18	7489	2.92	74125	0.79	74174	1.06
7405	0.18	7428	0.53	7454	0.18	7490	0.45	74141	0.75	74175	0.94
7406	0.51	7430	0.16	7460	0.18	7491	0.68	74145	0.74	74176	0.86
7407	0.18	7432	0.37	7470	0.32	7492	0.57	74150	1.20	74180	1.23
7408	0.18	7433	0.49	7472	0.26	7493	0.45	74151	0.77	74181	3.20
7409	0.18	7437	0.35	7473	0.30	7494	0.85	74153	1.09	74190	1.33
7410	0.16	7438	0.35	7474	0.32	7495	0.67	74154	1.62	74191	1.33
7412	0.25	7440	0.16	7475	0.47	7496	0.78	74155	1.32	74192	1.39
7413	0.25	7441	0.76	7476	0.36	7497	4.32	74157	0.78	74193	1.39
7414	0.72	7442	0.65	7480	0.55	74100	1.15	74160	1.20	74196	1.64
7416	0.43	7445	1.50	7484	1.26	74107	0.35	74161	1.20	74197	0.81
7417	0.43	7446	2.56	7482	0.75	74118	1.16	74162	1.20	74198	2.74
										74199	2.74

LINEAR ICs

LM307	0.55*	709	0.35	MC1307P	1.17*
LM380	0.90*	741	0.28	MC1352P	0.91*
NE555	0.45	748	0.35	TAA550	0.45*
NE565	2.00*	3900	0.70	TAA300	1.61
NE566	1.50*	CA3045	0.85*	TAA310	1.38
NE567	2.00*	CA3046	0.50*	TAA611B12	1.25*
711	0.61			TBA530	1.85*

TO-3 Transistor mounting kits
50 kits for **65p**

Fully Tested but unmarked TO-3 NPN Power Transistors Similar to 2N3055 type except
BVCEO>50V
HFE>20 @ 3Amps
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10 pcs for £1.80
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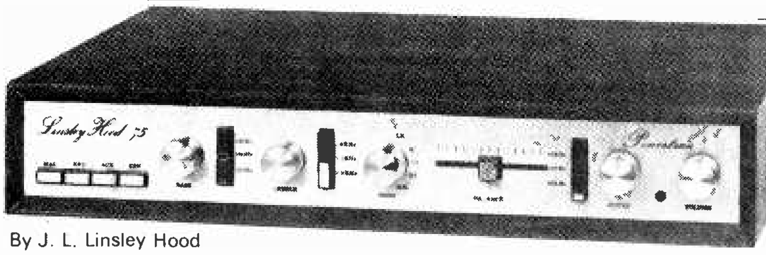
INCORPORATING AMBIENTACOUSTICS

HI-FI NEWS 75W/CHANNEL AMPLIFIER



By J. L. Linsley Hood

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 power amplifier is complemented by a pre-amplifier based on a discrete component operational amplifier referred to as the Liniac which is employed in the two most critical points of the system, namely the equalization stage and tone control stage, positions where most conventional designs run out of gain at the extremes of the frequency spectrum. Unusual features of the design are the variable transition frequencies of the tone controls and the variable slope of the scratch filter. There is a choice of four inputs, two equalized and two linear, each having independently adjustable signal level. The attractive slimline unit pictured has been made practical by highly compact PCBs and a specially designed Toroidal transformer

Pack	Price
1. Fibreglass printed-circuit board for power amp	£1.15
2. Set of resistors, capacitors, pre-sets for power amp	£2.15
3. Set of semiconductors for power amp	£6.50
4. Pair of 2 drilled, finned heat sinks	£1.10
5. Fibreglass printed-circuit board for pre-amp	£1.75
6. Set of low noise resistors, capacitors, pre-sets for pre-amp	£3.40
7. Set of low noise, high gain semiconductors for pre-amp	£2.40
8. Set of potentiometers (including mains switch)	£3.15
9. Set of 4 push-button switches, rotary mode switch	£4.50
10. Toroidal transformer complete with magnetic screen/housing primary: 0 117-234 V; secondaries: 33-0-33 V, 25-0-25 V	£10.95
11. Fibreglass printed-circuit board for power supply	£0.85
12. Set of resistors, capacitors, secondary fuses, semi-conductors for power supply	£4.60
13. Set of miscellaneous parts including DIN skts, mains input skt, fuse holder, inter-connecting cable, control knobs	£5.35
14. Set of metalwork parts including silk screen printed fascia panel and all brackets, fixing parts, etc.	£7.30
15. Handbook	£0.30
16. Teak cabinet 18.3" x 12.7" x 3.1"	£9.85

2 each of packs 1-7 inclusive are required for complete stereo system. Total cost of individually purchased packs £83.75

FREE TEAK CASE WITH FULL KITS

KIT PRICE ONLY **£73.90**

WIRELESS WORLD FM TUNER

Designed in response to demand for a tuner to complement the world-wide acclaimed Linsley Hood 75W Amplifier, this kit provides the perfect match. The Wireless World published original circuit has been developed further for inclusion into this outstanding slimline unit and features a pre-aligned front end module, excellent a.m rejection and temperature compensated varicap tuning, which may be controlled either continuously or by push button pre-selection. Frequencies are indicated by a frequency meter and sliding LED indicators, attached to each channel selector pre-set. The PLL stereo decoder incorporates active filters for "birdy" suppression and power is supplied via a toroidal transformer and integrated regulator. For long term stability metal oxide resistors are used throughout

Pack	Price
1. Fibreglass printed board for front end IF strip, demodulator, AFC and mute circuits	£2.15
2. Set of metal oxide resistors, thermistor, capacitors, cermet preset for mounting on pack 1	£4.30
3. Set of transistors, diodes, LED, integrated circuits for mounting on pack 1	£5.25
4. Pre-aligned front end module, coil assembly, three section ceramic filter	£8.50
5. Fibreglass printed circuit board for stereo decoder	£1.10
6. Set of metal oxide resistors, capacitors, cermet preset for decoder	£2.60
7. Set of transistors LED, integrated circuit for decoder	£2.90
8. Set of components for channel selector switch module including fibreglass printed circuit board, push-button switches, knobs, LEDs, preset adjusters, etc.	£8.80
9. Function switch, 10 turn tuning potentiometer, knobs	£5.30
10. Frequency meter, metar drive components, fibreglass printed circuit board	£9.45
11. Toroidal transformer with electrostatic screen. Primary: 0—117V—234V	£4.45
12. Set of capacitors, rectifiers, voltage regulator for power supply	£2.95
13. Set of miscellaneous parts, including sockets, fuse holder, fuses, inter-connecting wire, etc.	£1.50
14. Set of metal work parts including silk screen printed facia panel, acrylic silk screen printed tuning indicator panel insert, internal screen, fixing parts, etc.	£7.50
15. Construction notes (free with complete kit)	£0.25
16. Teak cabinet 18.3" x 12.7" x 3.1"	£9.85

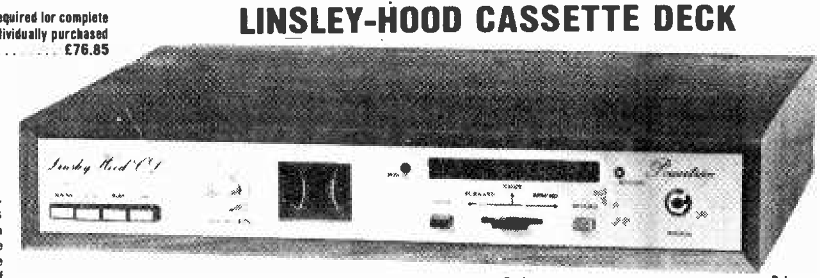
One each of packs 1-16 inclusive are required for complete stereo FM tuner. Total cost of individually purchased packs £76.85

FREE TEAK CASE WITH FULL KITS

KIT PRICE only **£66.75**

NEW KIT!

LINSLEY-HOOD CASSETTE DECK



Published in Wireless World (May, June, August 1976) by Mr. Linsley-Hood, this design, although straightforward and relatively low cost nevertheless provides a very high standard of performance. To permit circuit optimization separate record and replay amplifiers are used, the latter using a discrete component front-end designed such that the noise level is below that of the tape background. Push button switches are used to provide a choice of equalization time constants, a choice of bias levels and also an option of using an additional pre-amplifier for microphone use. The mechanism used is the Goldring-Lenco CRV, a unit distinguished in its robustness and ease of operation. Speed control and automatic cassette ejection are both implemented by electronic circuitry. This unit which is powered by a toroidal transformer and uses metal oxide resistors throughout offers an excellent match for the Wireless World Tuner and the Linsley-Hood 75 Watt Amplifier

Pach	Price
1. Stereo PCB (accommodates 2 rep. amps, 2 rec. amps, 2 meter amps, bias/erase osc. relay)	£3.35
2. Stereo set of capitors, M.O. resistors, potentiometers for above	£9.80
3. Stereo set of semiconductors for above	£8.90
4. Miniature relay with socket	£2.45
5. PCB, all components for solenoid, speed control circuits	£3.20
6. Goldring Lenco mechanism as specified	£21.95
7. Function switch, knobs	£1.60
8. Dual VU meter with illuminating lamp	£7.20
9. Toroidal transformer with E.S. screen prim. 0-117V, 234V, Sec. 15V	£4.45
10. Set of capacitors, ractifiers, I.C. voltage ragulater for power supply (Powertran design)	£2.80
11. Set of miscellaneous parts, including sockets, fuse holder, fuses, interconnecting wira, atc.	£2.50
12. Set of metalwork including silk screened facia panel, internal screen, fixing parts, etc.	£7.10
13. Construction notes	£0.25
14. Teak cabinet 18.3" x 12.7" x 3.1"	£9.85

One each of packs 1-14 inclusive are required for compete stereo cassette deck. Total cost of individually purchased packs £85.40

SPECIAL PRICE FOR COMPLETE SETS £81.35

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OUR PRICE ONLY **£20.45**

Fitted with Phase Lock-loop Decoder

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 S450 is supplied fully built, tested and aligned. The unit is easily installed using the simple instructions supplied.

- ★ FET Input Stage
- ★ VARI-CAP diode tuning
- ★ Switched AFC
- ★ Multi turn pre-sets
- ★ LED Stereo Indicator

Typical Specification:
Sensitivity 3μ volts
Stereo separation 30db
Supply required 20-30v at 90 Ma max.

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. **£2.85**

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STEREO PRE-AMPLIFIER PA100

OUR PRICE **£13.75**

A top quality stereo pre-amplifier and tone control unit. The six push-button selector switch provides a choice of inputs together with two really effective filters for high and low frequencies, plus tape output.

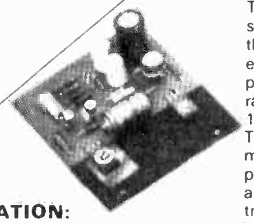
Frequency Response + 1dB 20Hz 20KHz. Sensitivity of inputs:
1. Tape input 100mV into 100K ohms
2. Radio Tuner 100mV into 100K ohms
3. Magnetic P.U. 3mV into 50K ohms

P.U. Input equalises to R1AA curve with 1dB from 20Hz to 20KHz.
Supply — 20-35V at 20mA.
Dimensions 299mm x 89mm x 35mm.

MK. 60 AUDIO KIT: Comprising 2 x AL60's, 1 x SPM80, 1 x BTM80, 1 x PA100, 1 front panel and knobs, 1 Kit of parts to include on/off switch, neon indicator, stereo headphone sockets plus instruction booklet. **COMPLETE PRICE £29.55** plus 85p postage.

TEAK 60 AUDIO KIT: Comprising Teak veneered cabinet size 16¾"x11½"x3¾", other parts include aluminium chassis, heatsink and front panel bracket plus back panel and appropriate sockets etc. **KIT PRICE £10.70** plus 85p postage.

AL-20-30 AUDIO AMPLIFIER MODULES



The AL20 and AL30 units are similar in their appearance and in their general specification. However, careful selection of the plastic power devices has resulted in a range of output powers from 5 to 10 watts R.M.S.
The versatility of their design makes them ideal for use in record players, tape recorders, stereo amplifiers and cassette and cartridge tape players in the home.

SPECIFICATION:
- **Harmonic Distortion Po=3 watts f=1KHz 02.5%**
- **Load Impedance 8-16ohm**
- **Size: 75mm x 63mm x 25mm**
- **Frequency response ±3dB Po=2 watts 50Hz-25Hz**
- **Sensitivity for Rated O/P — Vs=25v. RL=8ohm f=1KHz 75mV.RMS**

AL20 5w R.M.S. £2.95 AL30 10w R.M.S. £3.25

STEREO 30

COMPLETE AUDIO

7+7 WATTS R.M.S.

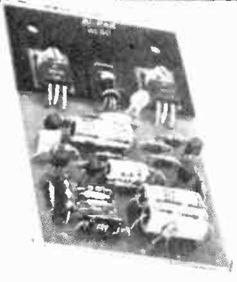
P & P 45p

£16.25

The Stereo 30 comprises a complete stereo pre-amplifier, power amplifiers and power supply. This, with only the addition of a transformer or overwind will produce a high quality audio unit suitable for use with a wide range of inputs i.e. high quality ceramic pick-up, stereo tuner, stereo tape deck etc. Simple to install, capable of producing really first class results, this unit is supplied with full instructions, black front panel knobs, main switch, fuse and fuse holder and universal mounting brackets enabling it to be installed in a record plinth, cabinets of your own construction or the cabinet available. Ideal for the beginner or the advanced constructor who requires Hi-Fi performance with a minimum of installation difficulty (can be installed in 30 mins).

TRANSFORMER £2.45 plus 62p p &p
TEAK CASE £5.25 plus 62p p & p.

AL 60 25 Watts (RMS)



★ Max Heat Sink temp 90C. ★ Frequency response 20Hz to 100KHz ★ Distortion better than 0.1 at 1KHz ★ Supply voltage 15-50v ★ Thermal Feedback ★ Latest Design Improvements ★ Load — 3,4,8, or 16 ohms ★ Signal to noise ratio 80db ★ Overall size 63mm. 105mm. 13mm.

Especially designed to a strict specification. Only the finest components have been used and the latest solid-state circuitry incorporated in this powerful little amplifier which should satisfy the most critical A.F. enthusiast.

£4.35

NEW PA12

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.

Frequency Response 20Hz-20KHz (—3dB). Bass and Treble range 12dB. Input Impedence 1 meg ohm. Input Sensitivity 300mV. Supply requirements 24V .5mA. Size 152mm x 84mm x 33mm.

£6.70

PS12

Power supply for **AL20/30, PA12, SA450** etc.

Input voltage 15-20v A.C. Output voltage 22-30v D.C. Output current 800 mA Max. Size 60mm x 43mm x 26mm.
Transformer T538 £2.30

OUR PRICE £1.30

Stabilised 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 Mains Transformer **BMT80**, the unit will provide outputs of up to 1.5A at 35V. Size 63mm. 105mm. 30mm. Incorporating short circuit protection.
Transformer BMT80
£2.60 + 62p postage

£3.75

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TF1342 Low capacitance bridge.
TF1370 Wide-range RC oscillator.
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TF2500 Af power meter.
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TF2660 Digital voltmeter.

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200kHz-220mHz in 5 bands. 0.1 uV-200mV. Continuously variable FM in two ranges to 75kHz. Price and full spec upon request.
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1Hz-110kHz in four decade ranges. Scope monitored output for high accuracy of frequency. Excellent generator. £135.

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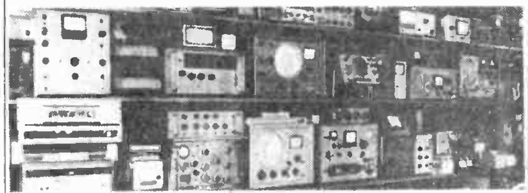

ADVANCE TCD500 Frequency dividers to 500mHz £100
AIRMEC 210A Modulation meter 3-300mHz
APT 504 Power supply 0-500V at 250mA £35
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BRANDENBURG High voltage generator type S.0530/10 0-20KV and MR50 type 0-50KV.
CAMBRIDGE 44228 Portable potentiometer £85
DM Model 2001 Mk II Digital voltmeter
FLUKE 891A DC Differential voltmeter
GERTSCH Frequency meter and deviation meter 20-1000mHz £250
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Hewlett-Packard 208A Battery powered oscillator 5-500kHz
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MEDISTOR type A-75A Potentiometric microvoltmeter £115
PYE EHT scalamp voltmeter 0-40KV £125
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E1 100kHz-60mHz	£30
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Type Multi-minor Mk4. Light, small size instrument (14x9x3½ cms). Measures volts AC/DC to 1KV. DC.I from 0.1mA-1A. Resistance ranges 10KΩ/V.DC.1KΩ/V.AC. Tested, and in excellent condition **£8.90**

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Type 898 Drive unit. All complete with unmarked scale plate, flywheel, knob, pointer, etc. This is a horizontal slide-rule type. Brand new, boxed, with panel cutting template. List price is over £15. **OUR PRICE ONLY £8.50**

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Miniature type (22mm diam.) Counting up to 15 turn 'Helipots'. Brand new with mounting instructions. Only **£2.50 each**

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New **£95**
Westrex 8-hole paper-tape punches **£95**
Sound-proof case available **£15**

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Made by Rotron, Holland. These are very high quality, quiet running fans specially designed for the cooling of all types of electronic equipment. Measures 4.5x4.5x1.5". 115V AC. 11 Watts. The list price of these is over £10 each. We have a quantity available brand new for only **£4.50 each**

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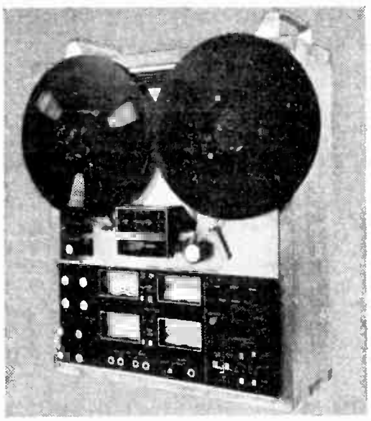
Lightweight, small size (13x7x4cms). Reads insulation from 0.2-100MΩ at 500V pressure. Runs from standard 9V PP3. Brand new **£16.50**

FRACMO Geared motors. 24V AC 0.5RPM. 68A Torque 40lb in. Price including starting capacitor **£10.50**

CENTRIFUGAL TYPE Blowers. 12V DC. Outlet diam. 7 cms. Overall diam. 15 cms and 17 cms deep. Very powerful fans **£9.50**

TEAC

TEAC A3340(S) 4-CHANNEL RECORDER



Industrial version upgraded to studio requirements, with increased signal to noise performance and improved reliability. Four totally independent channels each with sel sync, input mixing, switchable VU's and all the facilities for easy multitracking. This industrial model is in more studios than any other version.

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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 footage counter.

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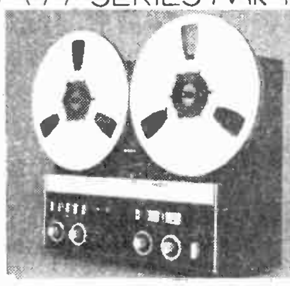

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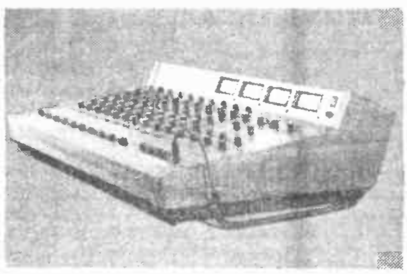

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7437	36p	74161	120p
7438	36p	74162	120p
7440	19p	74163	120p
7441	75p	74164	120p
7442	70p	74165	220p
7443	140p	74166	160p
7444	140p	74167	340p
7445	120p	74170	250p
7446	100p	74173	160p
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7470	36p	74182	82p
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7476	36p	74192	120p
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7481	95p	74194	120p
7482	90p	74195	95p
7483	90p	74196	120p
7484	110p	74197	120p
7485	120p	74198	250p
7486	34p	74199	250p
7489	320p	74221	160p
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2107 RAM	1000p
2112 RAM	450p
2513 ROM	850p
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OP. AMPS

1458	Dual Op Amp Int Comp	8 pin DIL	70p
301A	Ext Comp	8 pin DIL	36p
3130	COSMOS/Bi-Polar MosFet	8 pin DIL	100p
3900	Quad Op. Amp.	14 pin DIL	70p
536T	FET Op Amp	TO-99	275p
709	Ext Comp	8/14 pin DIL	30p
741	Int Comp.	8/14 pin DIL	22p
747	Dual 741	14 pin DIL	70p
748	Ext Comp	8/14 pin DIL	36p
776	Programmable Op Amp	TO-5	140p

LINEAR I.C.s

CA3080E	Op Transcond Amp	8 pin DIL	90p
*CA3028A	Diff Cascade Amp	TO5	95p
ICA3046	5 Transistor Array	14 pin DIL	80p
*CA3048	Quad Low Noise Amp	16 pin DIL	200p
*CA3053	Diff Cascade Amp	TO5	70p
*AY-1-0212	Tone Generator	16 pin DIL	600p
*CA3089E	FM IF System	16 pin DIL	225p
*CA3090	FM stereo Multi Dec	16 pin DIL	400p
ICL8038CC	VCO Fun Gen	14 pin DIL	340p
*LM380	2W Audio Amp	14 pin DIL	99p
*LM381	Stereo Preamp	14 pin DIL	175p
*LM389N	Aud Amp +3 Trs Array	18 pin DIL	160p
*M252	Rhythm Generator	16 pin DIL	800p
*MC1310P	FM Stereo Dec	14 pin DIL	190p
*MC1351P	Lim/Det Aud Preamp	14 pin DIL	97p
MC1495	Multiplier	14 pin DIL	300p
*MC1496L	Bal Mod/Demod	14 pin DIL	100p
*MC1596	Bal Mod/Demod	TO/DIL	300p
*MC3340P	Electronic Attenuator	8 pin DIL	160p
*MFC4000B	1/4W Audio Amp	PCB	90p
*NE540L	Audio Pwr driver	T099	140p
NE555	Timer	8 pin DIL	40p
NE556	Dual 555	14 pin DIL	100p
NE561	PLL with AM Demod	16 pin DIL	425p
NE562	PLL with VCO	16 pin DIL	425p
NE565	PLL	14 pin DIL	200p
NE566	PLL Fun Gen	8 pin DIL	200p
NE567	PLL Tone Dec	8 pin DIL	200p
2567	Dual 567	16 pin DIL	370p
SN72710	Diff Comparator	14 pin DIL	50p
*SN72733	Video Amp	14 pin DIL	120p
*SN76003N	Pwr Aud Amp with int HS	16 pin DIL	245p
*SN76008	10W Amp in 4 ohms	5 pin Plastic	250p
*SN76013N	Pwr Aud Amp with int HS	16 pin DIL	140p
*SN76018	10W Amp in 8 ohms	5 pin Plastic	250p
*SN76023N	Pwr Aud Amp with int HS	16 pin DIL	140p
*SN76033N	Pwr Aud Amp with int HS	16 pin DIL	230p
*TAA621A	Aud Amp for TV	QIL	225p
*TAA661B	FM IF Amp-Limiter/Det	QIL	120p
*TBA641B	Audio Amp	QIL	250p
*TBA651	Tuner & IF Amp	16 pin QIL	200p
*TBA800	5W Audio Amp	QIL	90p
*TBA810	7W Audio Amp	QIL	100p
*TBA820	2W Audio Amp	QIL	80p
*TDA2020	20W Audio Amp	QIL/DIL	325p
XR2240	Prog Timer/Counter	16 pin DIL	370p
*ZN414	TRF Radio Receiver	TO-18	110p

Basic data sheets on above at **20p** each + S A E

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Phototransistors		L.D.Ro	
OCP70	50p	ORP12	70p
OCP71	120p	ORP60	75p
2N5777	54p	ORP61	75p

LEDS		0.2"	
TIL209 Red	16p	Red	18p
TIL211 Green	36p	Green	36p
TIL32 Infrared	75p	Yellow	36p

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		Xciton:	
3015F 0.3" Red	160p		
DL704 0.3" Red	140p	0.3" Green	160p
DL707 0.3" Red	140p	0.3" Green	160p
DL747 0.3" Red	225p	0.6" Green	225p

Drivers: 75491 84p 75492 96p

TRANSISTORS

AC125	25p	BFY51	15p	2N3439	67p
AC126	20p	BFY52	16p	2N3442	140p
AC127	20p	BFY90	120p	*2N3565	30p
AC128	16p	BRY39	45p	*2N3702	12p
AC141	20p	BSX19	20p	*2N3703	12p
AC142	20p	BSX20	20p	*2N3704	12p
AC176	20p	*BU105	140p	*2N3705	12p
AC187	20p	BU108	250p	*2N3706	12p
AC187K	25p	*MJE340	45p	*2N3707	12p
AC188	20p	MJ2955	120p	*2N3708	12p
AC188K	25p	MJE2955	120p	*2N3709	12p
AD149	49p	MJE3055	70p	2N3773	250p
AD161	36p	*MPSA06	30p	2N3866	90p
AD162	36p	*MPSA12	50p	*2N3903	18p
AF114	20p	*MPSA56	32p	*2N3904	16p
AF115	20p	*MPSU06	62p	*2N3905	20p
AF116	20p	*MPSU56	78p	*2N3906	16p
AF117	20p	OC28	75p	*2N4058	15p
AF127	25p	OC35	75p	*2N4059	10p
AF139	43p	OC36	75p	*2N4060	13p
AF239	48p	*OC71	20p	*2N4123	22p
BC107/B	9p	*R2008B	200p	*2N4124	22p
BC108/B	9p	*R2010B	200p	*2N4125	22p
BC109/B	10p	*TIP29A	40p	*2N4126	22p
BC109C	12p	*TIP29C	55p	*2N4289	20p
*BC117	22p	*TIP30A	48p	*2N4401	27p
*BC147	9p	*TIP30C	60p	*2N4403	27p
*BC148	9p	TIP31A	52p	2N4427	90p
*BC149C	10p	TIP31C	52p	*2N5089	27p
*BC157	11p	TIP32A	58p	2N5296	55p
*BC158	10p	TIP32C	82p	*2N5401	50p
*BC159	11p	TIP33A	90p	2N6034	160p
*BC169C	12p	TIP33C	115p	2N6107	55p
*BC172	11p	TIP34A	115p	2N6247	190p
BC177	18p	TIP34C	160p	(Comp to 2N3055)	
BC178	17p	TIP35A	225p	2N6254	130p
BC179	18p	TIP35C	290p	2N6292	65p
*BC182	10p	TIP36A	270p	40360	40p
*BC183	10p	TIP36C	340p	40361	45p
*BC184	11p	TIP41A	65p	40362	45p
BC187	30p	TIP41B	70p	40364	120p
*BC212	11p	TIP41C	78p	40409	65p
*BC213	10p	TIP42A	70p	40410	65p
*BC214	14p	TIP42B	76p	40411	300p
BC478	30p	TIP42C	82p	40594	88p
BCY70	18p	TIP2955	78p	40595	97p
BCY71	22p	*TIS93	30p		
BD124	130p	*ZTX108	10p		
BD131	36p	*ZTX300	13p		
BD132	40p	*ZTX500	15p		
*BD135	48p	*ZTX502	18p		
*BD136	50p	2N457A	190p		
*BD139	52p	2N697	22p		
*BD140	58p	2N698	45p		
BDY20	125p	2N706	20p		
BDY56	200p	2N708	20p		
BF115	22p	2N918	40p		
BF167	23p	2N930	18p		
BF170	23p	2N1131	18p		
BF173	25p	2N1132	18p		
BF177	26p	2N1304	45p		
BF178	28p	2N1305	45p		
BF179	33p	2N1306	45p		
BF180	33p	2N1307	45p		
BF184	22p	2N1308	40p		
*BF194	10p	2N1309	40p		
*BF195	9p	2N1613	25p		
*BF196	14p	2N1711	25p		
*BF197	15p	2N1893	30p		
BF200	32p	2N2102	55p		
BF257	32p	2N2219	20p		
BF258	36p	2N2222	20p		
*BFR39	30p	2N2369	14p		
*BFR40	30p	2N2484	30p		
*BFR41	30p	2N2904/A	25p		
*BFR79	30p	2N2905/A	25p		
*BFR80	30p	2N2906/A	24p		
*BFR88	30p	*2N2926R	7p		
BFX30	34p	*2N2926B	7p		
BFX84	30p	*2N2926O	9p		
BFX85	30p	*2N2926Y	9p		
BFX86	30p	*2N2926G	9p		
BFX87	30p	2N3053	18p		
BFX88	30p	2N3054	50p		
BFY50	16p	2N3055	50p		

FETs

*BF244	25p
*MPF102	40p
*MPF103	40p
*MPF104	40p
*MPF105	40p
*2N3819	25p
*2N3820	50p
2N3823	57p
*2N5457	40p
*2N5458	40p
*2N5459	40p

MOSFETs

3N128	85p
3N140	85p
3N141	85p
3N187	180p
3N202	120p
40603	58p
40673	58p

UJTs

*TIS43	34p
2N2160	95p
2N2646	45p
*2N4871	45p

PUJT

*2N6027	48p

DIODES

***SIGNAL**

OA47	9p
OA70	9p
OA81	15p
OA85	15p
OA90	7p
OA91	7p
OA95	7p
OA200	8p
OA202	10p
IN914	4p
IN916	9p
IN4148	4p

RECTIFIER

*BY100	25p
*BY126	12p
*BY127	10p
IN4001	5p
IN4002	5p
IN4004	6p
IN4005	6p
IN4007	7p
IN5401	13p
IN5404	18p
IN5407	23p

ZENER
2.7V to 33V*

*400mW	9p
*1W	18p

NOISE

*Z5J	110p

BRIDGE RECTIFIERS

*1A 50V	22p
*1A 100V	24p
*1A 200V	28p
*1A 400V	30p
*1A 600V	36p
*2A 50V	30p
*2A 100V	35p
*2A 200V	40p
*2A 400V	45p
*3A 200V	60p
*3A 600V	72p
*4A 100V	84p
6A 50V	90p
6A 100V	96p
6A 200V	108p
6A 400V	120p

TRIACS

Amp	Volts	Price
3	400	120p
6	400	150p
6	500	180p
10	400	185p
10	500	195p
15	400	210p
15	500	250p
40430		120p
40669		120p
DIAC		
BR100		30p

VOLTAGE REGULATORS — FIXED — PLASTIC

1 Amp Positive			1 Amp Negative		
5V	7805	140p	5V	7905	200p
12V	7812	140p	12V	7912	200p
15V	7815	140p	15V	7915	200p
18V	7818	140p	18V	7918	200p
24V	7824	140p	24V	7924	200p

LM309K 1 Amp 5V TO3 140p LM323K A5V 700p
LM309H 100mA 5V TO5 75p

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1468 ±15V 100mA 16 pin DIL 300p.
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VARIABLE VOLTAGE REGULATOR
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TL430 3V to 30V 100mA TO92 85p

SCR-THYRISTORS

1A 50V	TO5	40p	
1A100V	TO5	42p	
1A400V	TO5	45p	
1A600V	TO5	70p	
3A100V	Stud	65p	
3A400V	Stud	75p	
7A100V	TO5+HS	84p	
7A400V	TO5+HS	90p	
8A 50V	Plastic	130p	
12A400V	Plastic	160p	
16A100V	Plastic	160p	
16A400V	Plastic	180p	
16A600V	Plastic	220p	

BT106	1A/700V	Stud	110p
C106D	4A/400V	Plastic	63p
*MCR101	0.5A/15V	TO-92	25p
2N3525	5A/400V	TO-66	120p
2N4444	8A/600V	Plastic	185p
*2N5060	0.8A/30V	TO-92	34p
*2N5062	0.8A/100V	TO-92	37p
*2N5064	0.8A/200V	TO-92	40p

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DIABLO Model 31 DISC DRIVE with 12 MBit capacity, £495.
IBM Model 1056 CARD READER with logic, etc., £68.00.
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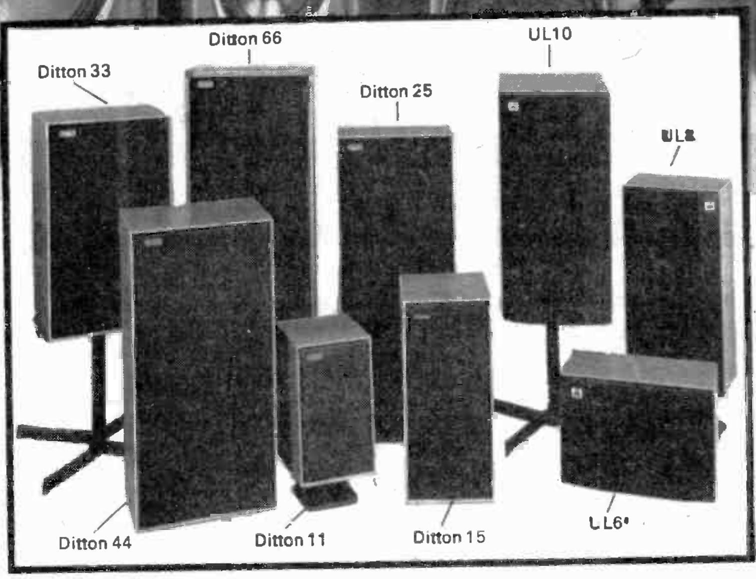

The magnificent nine... an open and closed case for selecting Celestion.

Model	Measurements		Sensitivity Pink Noise W at 1M=90 dB	Power Handling Peak Music	Suggested Amp Watts RMS		Frequency Response
	Centimetres	Inches			Min	Max	
Ditton 11	35 × 20 × 25	14 × 8 × 10	9.9	25 W	15	30	35 Hz – 28 KHz
Ditton 15	53 × 24 × 23	21 × 9½ × 9½	4.2	30 W	10	30	30 Hz – 15 KHz
Ditton 33	61 × 35 × 26	24 × 14 × 10½	5.5	40 W	20	50	40 Hz – 23 KHz
Ditton 44	76 × 37 × 25	30 × 14½ × 10	4.0	44 W	20	50	30 Hz – 40 KHz
Ditton 25	81 × 36 × 28	32 × 14 × 11	2.9	60 W	15	60	20 Hz – 40 KHz
Ditton 66	100 × 38 × 29	40 × 15 × 11½	4.8	80 W	20	80	16 Hz – 40 KHz
UL 6	29 × 41 × 22	11½ × 16 × 8½	13.0	40 W	20	40	35 Hz – 28 KHz
UL 8	58 × 28 × 23	23 × 11 × 9½	8.4	50 W	15	50	30 Hz – 28 KHz
UL 10	67 × 31 × 38	26½ × 12½ × 15	18.0	100 W	25	100	20 Hz – 40 KHz

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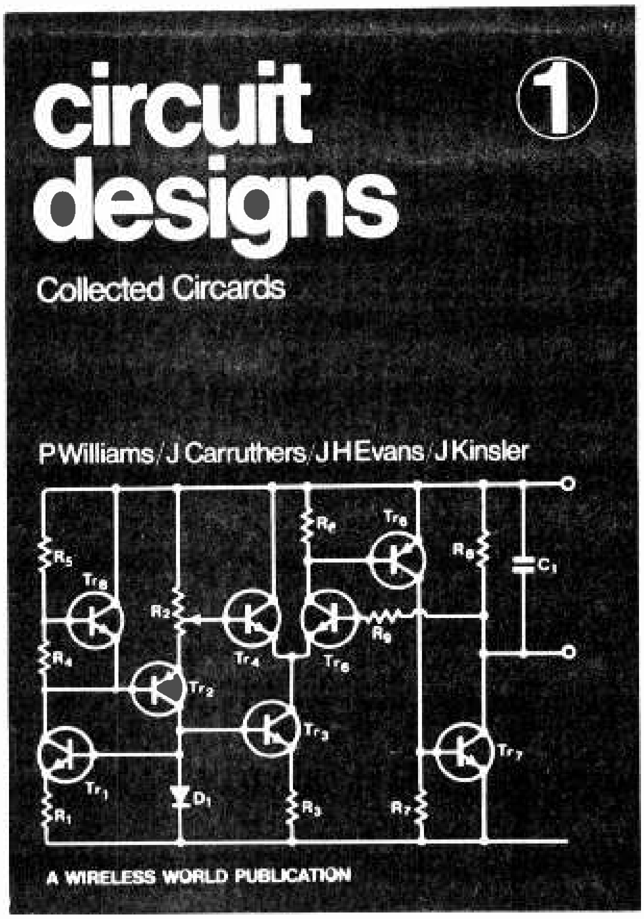

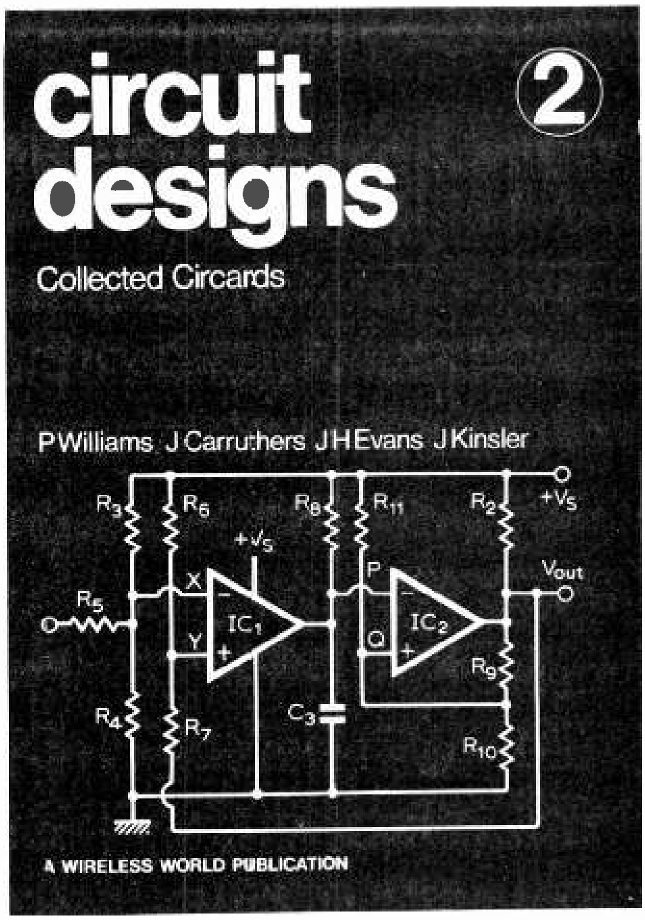

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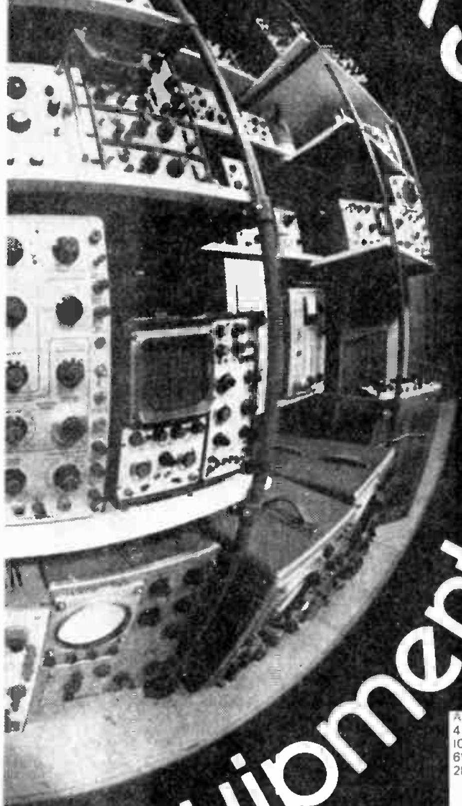

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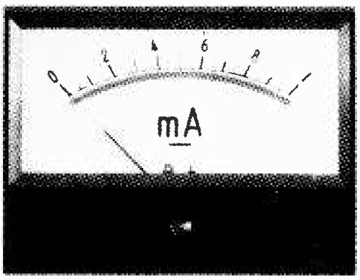

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TIP31A	57
TIP31B	64
TIP31C	79
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TIP32B	76
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TIP36C	4 10
TIP41	60
TIP41A	67
TIP41B	75
TIP41C	94
TIP42	72
TIP42A	80
TIP42B	90
TIP42C	1 10
TIP2955	97
TIP3054	50
TIP3055	48
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†ZTX300	15
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†ZTX342	22
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†ZTX503	21

†ZTX504	25
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†ZTX530	23
†ZTX531	23
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IN914	06
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IN4007	11
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IN5403	18
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2N2222	20
2N222A	21
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2N2647	85
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2N29[illegible]A	26
†2N2923	22
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†2N2926 Red	12
†2N2926 Org	13
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2N3440	55
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2N3576	20
2N3611	1 30
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2N3613	1 50
2N3614	1 60
2N3615	1 70
2N3616	1 80
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2N3789	3 00
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†2N3820	48
2N3821	73
2N3822	64
2N3823	58
†2N3823E	26
2N3824	52
2N3866	95
†2N3903	13
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2N4030	46
2N4031	46
2N4032	48
2N4033	40
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†2N4410	50
2N4416	70
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2N549D	65
2N5492	68
2N5494	65
2N5496	60
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3N141	90
40361	50
40362	50
40363	1 14
40411	2 60
CMOS	
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4001	20
4002	20
4006	1 90
4007	20
4008	1 08
4009	80
4010	80
4011	20
4012	20
4013	56
4014	1 86
4015	1 00
4016	56
4017	1 00
4018	1 40
4019	60
4020	1 10
4021	1 00
4022	1 00
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4024	80
4025	20
4026	1 90
4027	60
4028	90
4029	1 30
4030	65
4031	2 40
4032	1 00
4033	1 60
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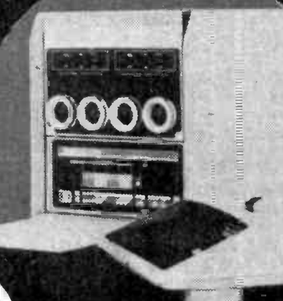

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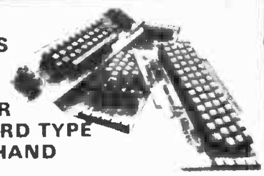

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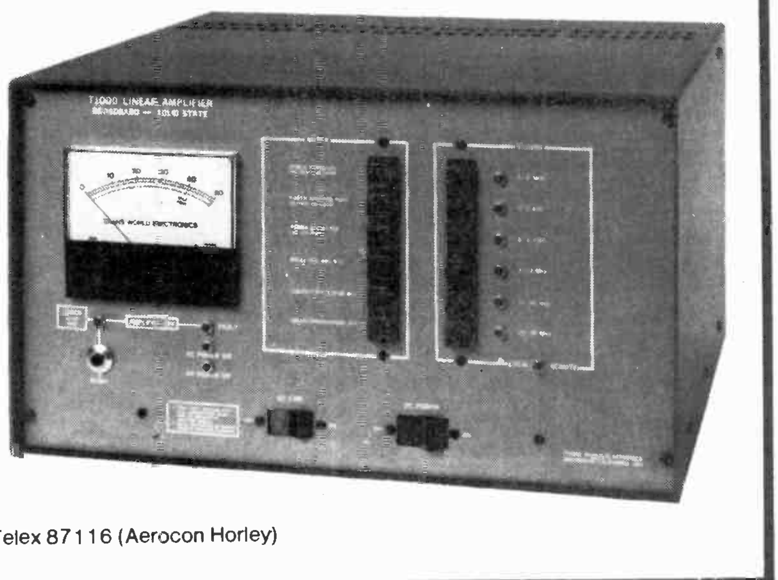

Full technical information is available on request from the sole distributors in the UK

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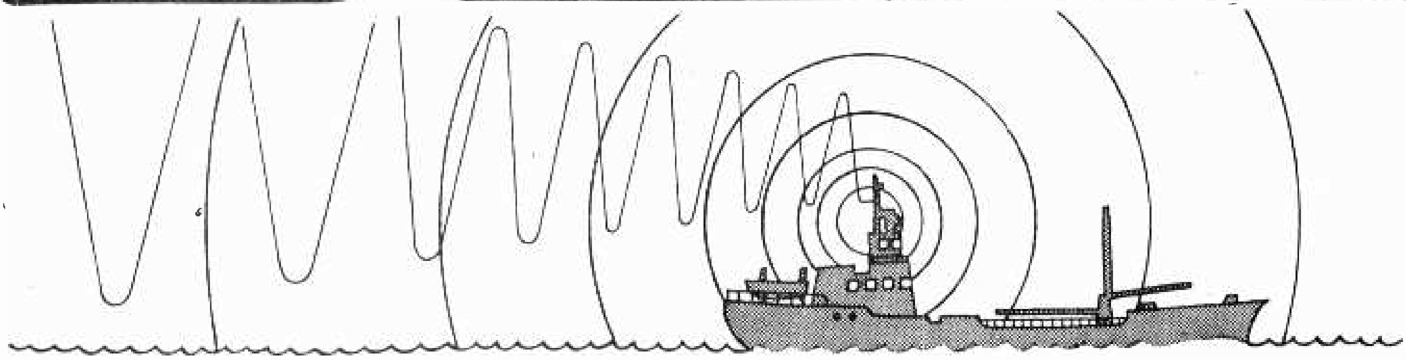

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The successful candidates will undertake engineering project officer duties These will include interpreting non-technical briefs; advising clients on the best method of approach; preparing specifications and designs; costing; and managing projects right through to implementation.

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Starting salary between £3,760 and £5,030, depending on qualifications and experience. Prospects of promotion. Non-contributory pension scheme

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Telephone: Market Deeping (0778) 345434

(6751)

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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 circuitry in collaboration with the senior Experimental Officer and have relevant experience. Salary at a point on the University's Grade 5 scale (£2,889-£3,367) 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.

(6764)

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WILLESDEN COLLEGE OF TECHNOLOGY
DEPARTMENT OF ELECTRICAL ENGINEERING

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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 (Denzil Road, London NW10 2XD. Tel. 01-459 0147) and should be returned within two weeks from the appearance of the advertisement.
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(6775)

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RADIO TECHNICIAN

TECHNICAL OFFICERS GRADE 4

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The post involves the installation and maintenance of Navigational Aids and other electronic equipment.

National Joint Council Conditions of Service apply Salary £3366-£3702 pa + £312 Government Supplement An alternating shift system is in operation for which a shift allowance of 14% of basic salary is paid Enhanced pay for weekend work and a standby allowance of £158.60 pa is payable

The cost of telephone rental is reimbursed by the Authority

Application forms are obtainable from the Airport Director, East Midlands Airport, Castle Donington, Derby DE7 2SA, to whom they should be returned by 17th January 1977

(6813)

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S.E. LONDON

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TEST ENGINEERS	**C £3000-£3600**
INSTALLATION ENGINEERS	**UP TO £3200**

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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 combing both their theoretical and practical abilities.

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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.

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Applicants should be qualified to HNC standard and have at least three years' experience in system engineering in relevant fields.

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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.

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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.

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The hire department requires an engineer to set up equipment in the factory and instal 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.

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Telephone: 01-855 1101

(6765)

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(6810)

AUDIO TEST ENGINEERS

Allen & Heath Ltd. and Brenell 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 fast workers to join a young team

Bonus scheme in operation. For interview call Ted Rook on 01-607 8271

(6771)

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.
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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 EMI

A member of the EMI Group of companies. International leader in electronics and leisure. (6801)

THOMSON FOUNDATION TELEVISION COLLEGE

PROFESSIONAL BROADCAST TELEVISION ENGINEER

required to join a team specialising in training broadcast technicians and Senior Engineers from overseas television stations in studio / transmitter / communication techniques.
Desirable qualifications: Degree, HND or equivalent, with several years' experience in television studios and/or transmitters. Salary: £4,266-£5,997 incremental. Starting salary dependent on experience. Contributory pension scheme.

The post is based in Glasgow with occasional trips abroad.

Applications in writing to the Principal, Thomson Foundation Television College, Kirkhill House, Broom Road East, Newton Mearns, Glasgow, G77 5RH. (6795)

ROYAL COLLEGE OF ART

The Department of Environmental Media

TECHNICIAN

Applications are invited from candidates with a thorough knowledge of the following equipment to fill the post of full-time TECHNICIAN in the Department.

16mm cine projector. ½" Sony video recording and editing facilities multi-screen encoder/decoder and cross-fade unit: sound recording mixing and synthesising equipment.

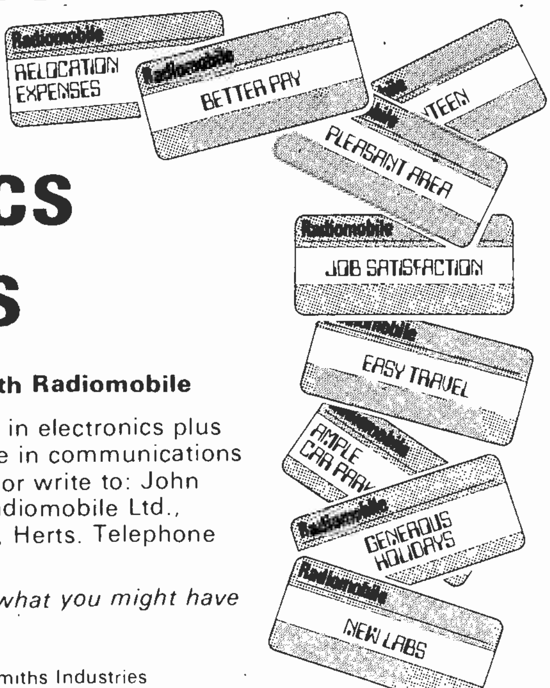
The successful candidate will be required to assist and advise in the creative use of the equipment in the design and building of "one off" pieces of equipment, to interface or modulate the standard departmental facilities and to maintain the equipment.

The starting salary will be in the range £3024-£3405 + 4½% under Stage II of the government pay policy.

Please write giving full details of age qualifications and previous experience to **Mr H W Denyer, Royal College of Art, Kensington Gore, London SW7 2EU.**

(6781)

Electronics Engineers



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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!

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(6811)

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(S & W SERVICES)

For Electronic Engineers, Technicians & TV Service Engineers.
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(6552)

ELECTRONICS Mail Order Company requires Manager who has some design and development experience with amplifiers and instrumentation, opportunity for directorship and investment. N. London. — Box No. EW 6785.

YOUNG ELECTRONICS TECHNICIANS required for assembly and testing work on Electronic equipment, very varied work. Qualifications ONC or CNG (or studying) or ex apprentice or similar desirable. Excellent opportunity for right person with a small expanding company. Application forms from Young Electronics Ltd., 184 Royal College Street, London NW1. Tel: 01-267 0201. (6796

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 eqiupment. 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

(6802)

VHF SERVICE engineer required to work on Pye, GEC ITT, 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 1010. (6767

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 liaising with internal development departments and outside suppliers.

Applications in writing giving details of age, experience and qualifications to:

THORN

The Personnel Manager (DE/WW)
Thorn Consumer Electronics Ltd.
Great Cambridge Road, Enfield, Middlesex EN1 1UL

(6761)

TSR SYSTEMS

EXPORT PROJECT ENGINEERS

TSR SYSTEMS are expanding their Hotel Systems Division.

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We have a rapidly increasing commitment in the export market, a fast-developing order book and continued success in obtaining overseas contracts.

We require additional technicians and engineers with practical experience in industrial communications. They will have a proven capability in successful systems project work and their background will include all or most of the following:

Audio; PA; HF & VHF MATV, CATV, CCTC; and modular data communications, although other similar areas of expertise will be considered.

These positions are specifically concerned with export business and an ability and willingness to take the opportunity for travel and make overseas project and site visits when required is essential.

Applications to:

B. Boswell
Television Systems & Research Ltd.
Station Field Industrial Estate
Kidlington, Oxford
Telephone Kidlington (08675) 4190

(6804)

INSTRUMENT TECHNICIAN (preferably single) needed for 2 years at the Institute of Scientific Instrumentation in Bangladesh to set up a small instrument servicing and repair laboratory, advise 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 the experience of a lifetime helping this developing country. Further information from Mr Jan Davis, Voluntary Service Overseas, (WW) 14 Bishop's Bridge Road, London W2 6AA (Tel: 262 2611). (6805)

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 6808.

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 copywiremen/women for interesting work with overtime, in pleasant surroundings. All enquiries to Miss Manzi. Tel: 01-730 1801. (6809)

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, coypu 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 Worplesdon, 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 Civil Service Commission, Alencon Link, Basingstoke, Hants, RG21 1JB, or telephone Basingstoke (0256) 68551 (answering service operates outside office hours).

Science Group Civil Service

Ministry of Agriculture, Fisheries and Food
Pest Infestation Control Laboratory

(6780)

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 Ahwaz 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:

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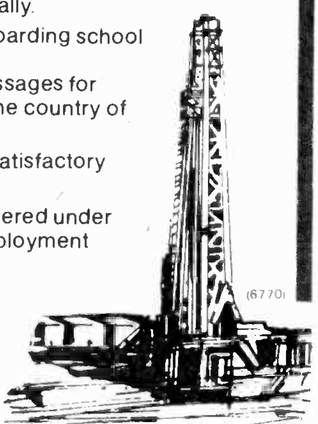
4. Primary schooling available locally.
5. Financial assistance towards boarding school costs.
6. Additional school children's passages for children at boarding school in the country of origin.
7. Substantial terminal bonus on satisfactory completion of contract.

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.



(6770)

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Duties will include:

- routine and complex maintenance and repair of teleprinter equipment
- the installation of circuitry and teleprinter machines
- conducting periodic tests to check the quality of the teleprinter circuitry
- 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-503-762 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
- keeping up-to-date regarding state of the art procedures in electronics maintenance
- field trips
- the maintenance of service records on equipment and logs of the utilisation of spare parts
- participation in on-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 unfurnished accommodation for you and your families, free and reduced air tickets, 40 days leave per annum and a re-location allowance.

Please write, with full personal and career details, or telephone for an application form, quoting the appropriate reference, to:

Miss Connie Mulshaw,
Saudia's U.K. Personnel Representative,
Saudi Arabian Airlines,
Room 216, 93, Regent Street,
London W.1. Tel: 01-439 1661.

Closing date for completed applications 24th January 1977.

saudia
SAUDI ARABIAN AIRLINES

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Bexley Road, London SE9 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.

(6762)

Telecommunications 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-contributory 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) 68551 (answering service operates outside office hours). Please quote T/9455.

Civil Service Department

(6787)

Due to continued expansion ISCA ELECTRONICS LTD. has vacancies for a wide range of electronics engineers. The Company's activities are primarily associated with electronic weighing machines, mini-computers, micro processors and digital systems. Excellent opportunities are available within the ISCA group of Companies for further growth, overseas travel, etc. The positions offer varied and interesting work in a modern purpose built facility located in pleasant surroundings, seven miles North of Newport, South Wales.

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A programmer is required with experience of DEC equipment at 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 résumé of experience and salary requirements to the Projects Manager.

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(6772)

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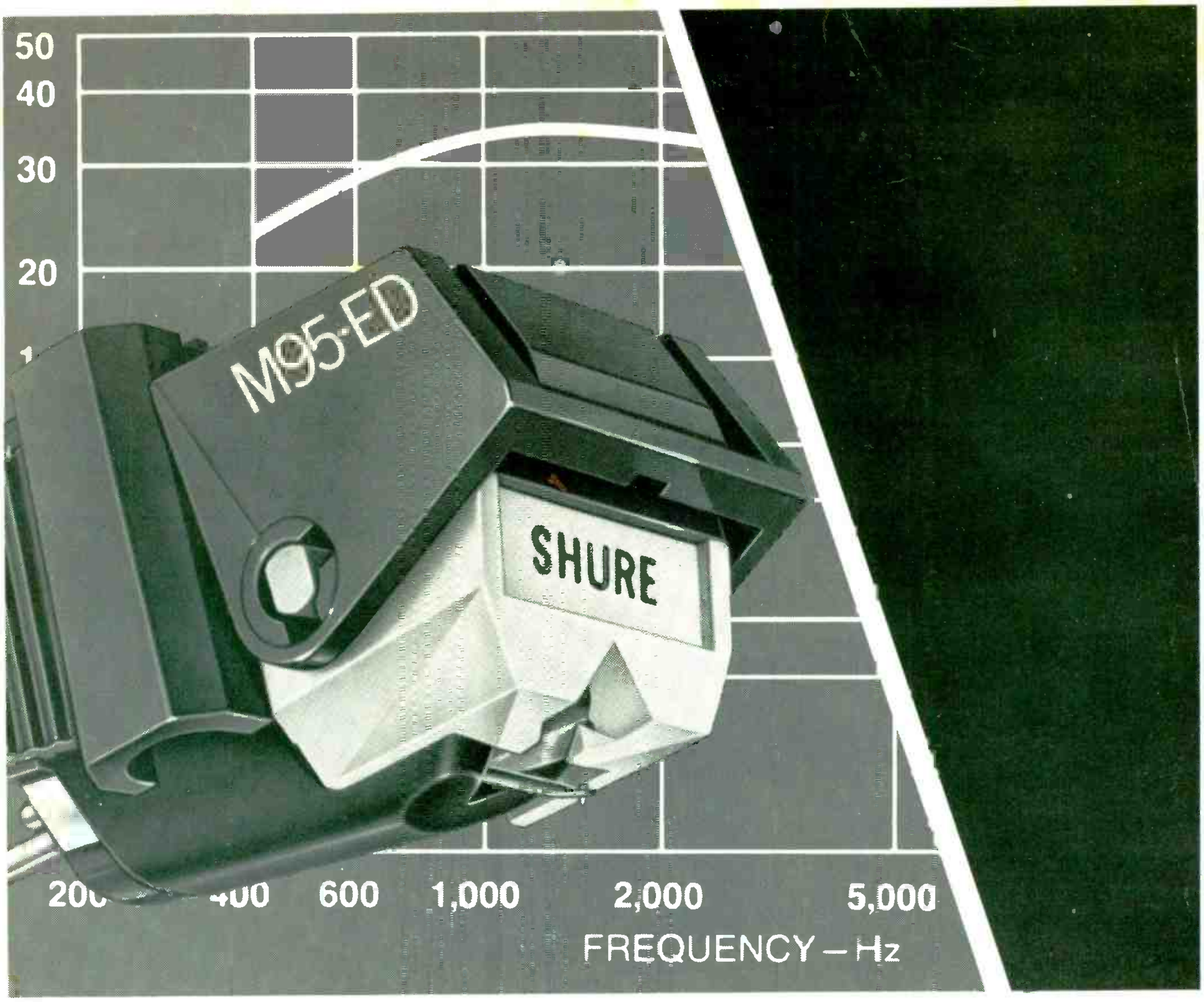
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