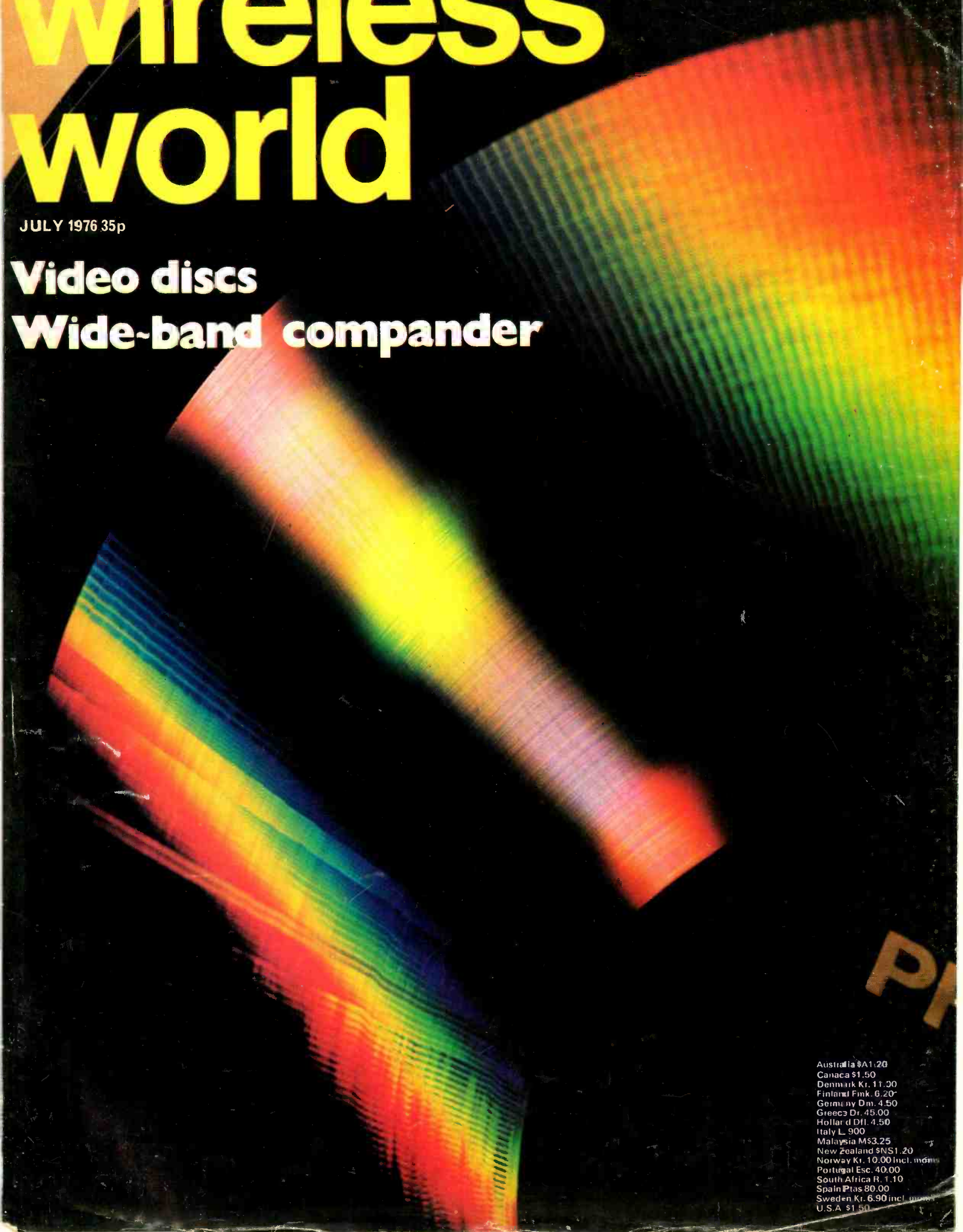
wireless world

JULY 1976 35p

Video discs
Wide-band compander



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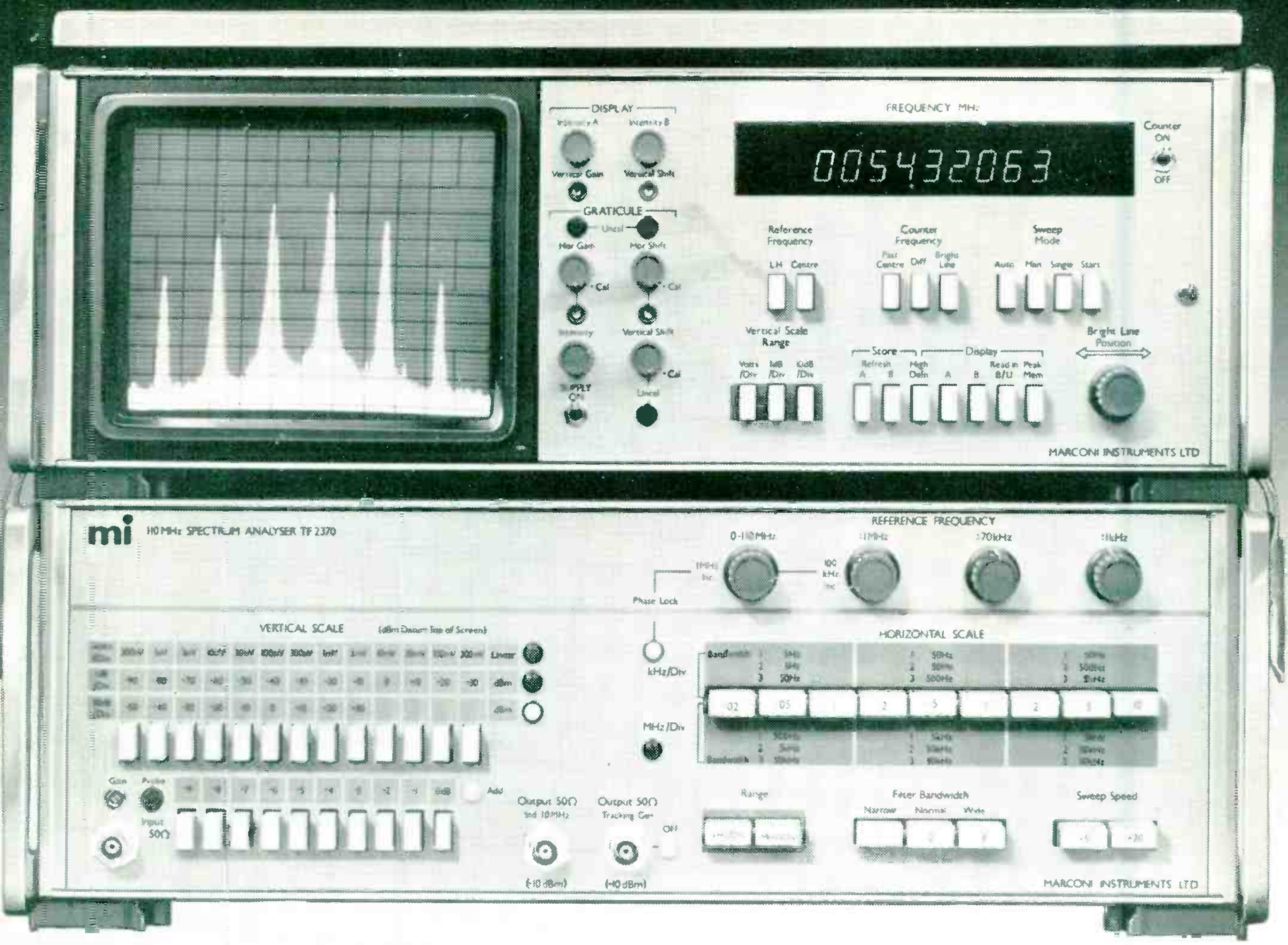


The Most Advanced Spectrum Analyser

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

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

* Flicker-free 100 dB display of frequency response from 30 Hz to 110 MHz on a high brightness c.r.t.
* Electronic graticule, with a ±15% variation of horizontal divisions for pin-point positioning against waveform display.
* Three amplitude scales: one linear and two logarithmic with expansion to 1 dB/div. with an accuracy of ±0.1 dB/dB.
* 9-digit electronic counter automatically gives centre frequency, reads any other frequency corresponding to manually-adjusted 'bright line' position on display, or the difference frequency between the two, at the press of a button. All to an accuracy of ±2Hz ± reference frequency accuracy on high resolution and manual. Internal reference frequency provided with setting accuracy of 1 in 10^7.
* Internal generator supplies synchronous signal source for measuring such items as networks and filters.
* For comparative measurements, unique memory storage system will retain one display indefinitely as required, for simultaneous display with response produced by items under test.
* Automatic adjustment of amplifier gains to give optimum lowest-noise performance with full protection against input overloading.
* Automatic selection of optimum sweep speed.
* With the 5 Hz filter, signals 100 Hz from a response at 0 dB can be measured to −70 dB.

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

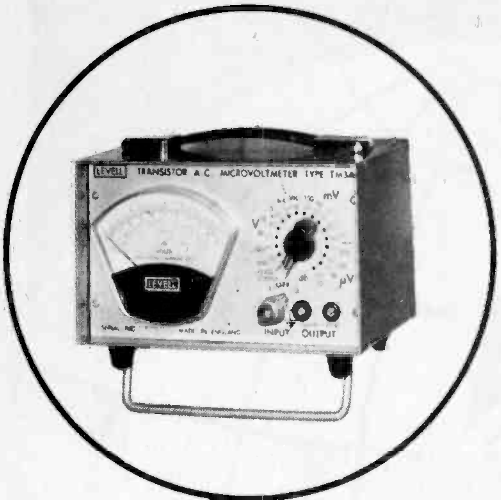
mi: THE INNOVATORS

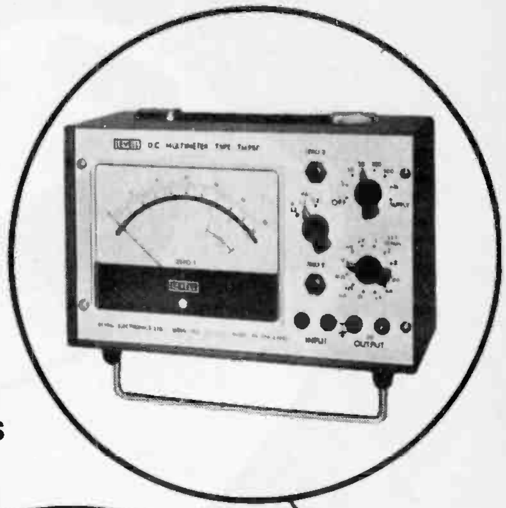
MARCONI INSTRUMENTS LIMITED,
Longacres, St. Albans, Hertfordshire, England, AL4 0JN. Telephone: St. Albans 59292 Telex: 23350.
A GEC-Marconi Electronics Company

WW—001 FOR FURTHER DETAILS

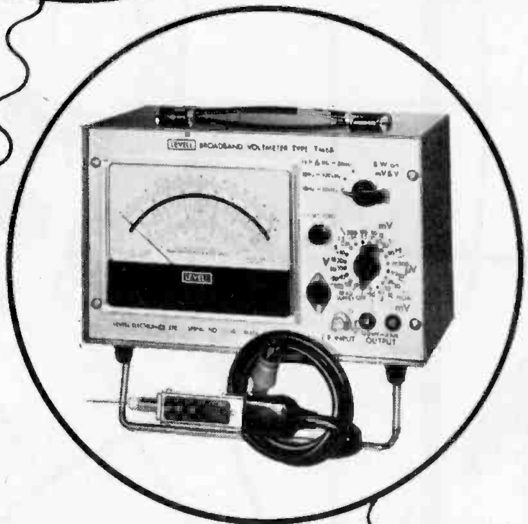
LOW COST VOLTMETERS from the range of

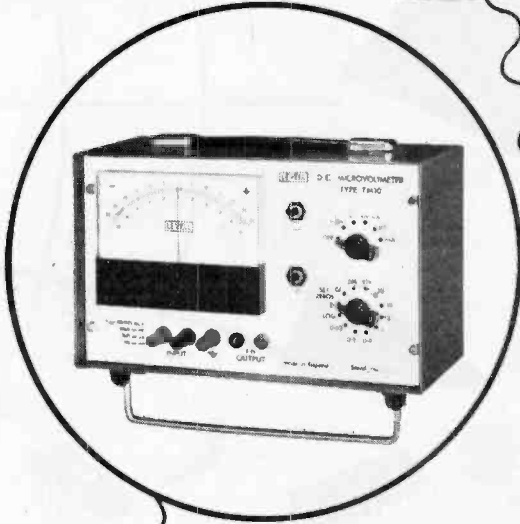
LEVELL
PORTABLE INSTRUMENTS





SEE US AT THE LEEDS ELECTRONICS EXHIBITION 29/30th June, 1st July





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 **£77** type TM3B **£88**

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 **£110** type TM9BP **£125**

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 **£125** type TM6B **£135**

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 **£73**

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

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

Prices include batteries and U.K. DELIVERY. VAT extra. Optional extras are leather cases and mains power units. send for data covering our range of portable instruments.

WW—057 FOR FURTHER DETAILS

Not a win on the pools, a trip to a Pacific paradise, or a reduction in income tax, but distortionless "current dumping".

Z's 1 to 4 are the four passive components which interconnect the current dumpers, (the output transistors which supply the power), to the small high quality amplifier which provides the error signal, so that when the above condition is met the current in the load, the loud-speaker, is independent of the current in the dumpers and hence distortion is solely dependent on the quality of the error amplifier, which because it is small can be very good.

Wonderful indeed.

For further details on current dumping and other Quad products write to Dept. WW
The Acoustical Manufacturing Co. Ltd., Huntingdon, Cambs., PE18 7DB Telephone (0480) 52561

"Something wonderful happens when $Z_1Z_3=Z_2Z_4$" *

* Elektor Electronics Magazine No. 8. Dec. 1975

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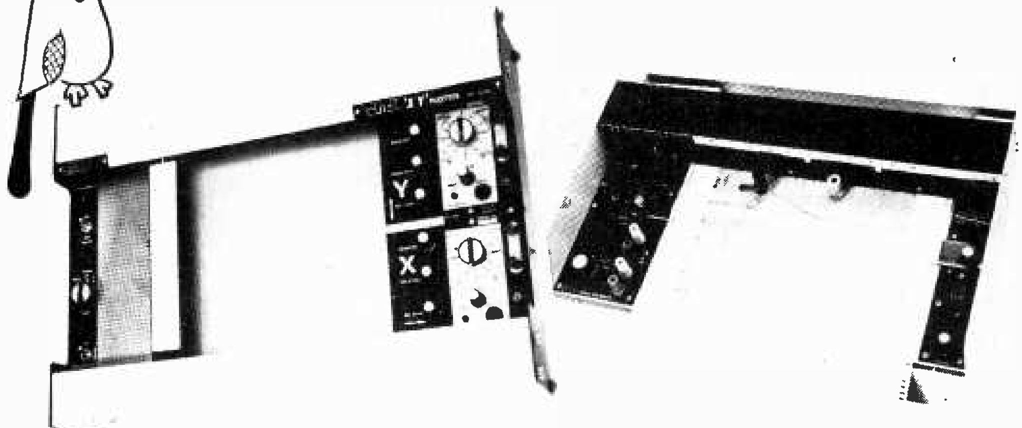
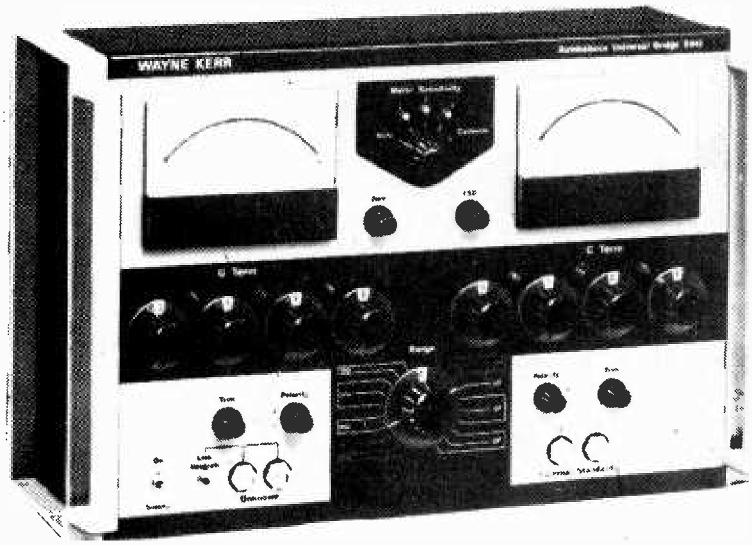
QUAD *is a Registered Trade Mark*

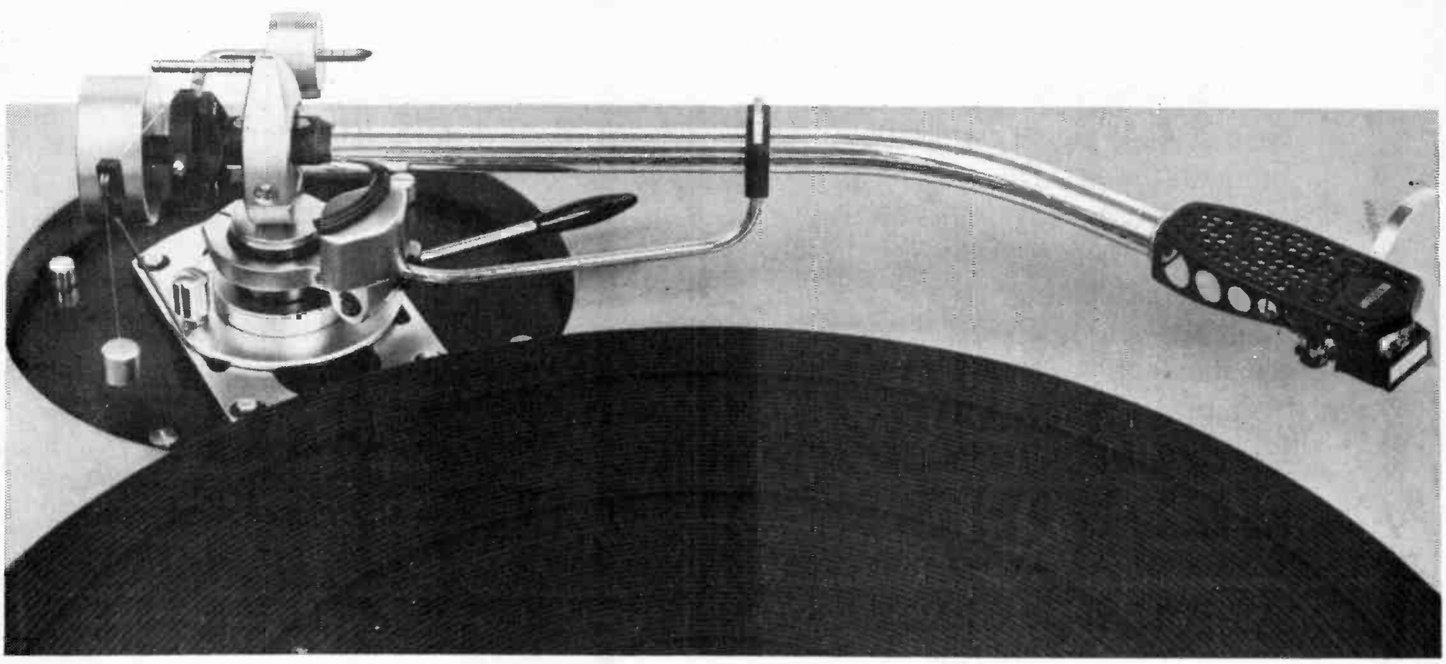
WW—074 FOR FURTHER DETAILS


Y
X


WAYNE KERR

3009+SL120

This turntable offers the mechanical excellence of the SL110 in a more compact form. Ideally suited to our precision pick-up arms, its use is detailed in information sheet No. 15, a copy of which will be sent to you on request.



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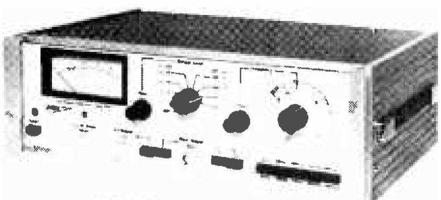
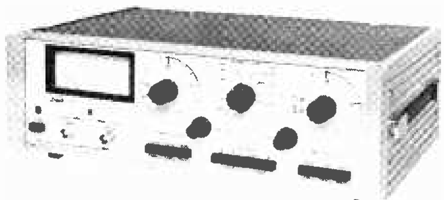
The best pick-up arm in the world

WW—064 FOR FURTHER DETAILS

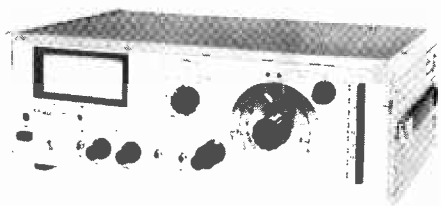
Now over to the Test Match



Type 2041



Type 2045



Type 2065

Three new additions to the Dymar communications instruments team make a perfect match. They are:

Type 2C41 AF signal generator.
Frequency range 3Hz to 300kHz. Maximum output 3W into 3 ohms. A combination to cover the field from audio applications to vibration analysis. Calibrated and stepped 600 ohms attenuator gives adjustable output levels from 1mV to 3V (fsd). Auxiliary output from oscillator for frequency monitoring.

Type 2045 AF two-tone signal generator.
Full audio range, 30Hz to 30kHz, with two simultaneous but independently adjustable AF tones of high stability and purity. For intermodulation testing, or for evaluating communications circuits. Constant source impedance of 600 ohms and output levels adjustable from 1mV fsd to 1V emf (3V for a single tone).

Type 2065 AF distortion factor meter.
Accurate measurement of noise and harmonic distortion of AF waveforms in the frequency range 6.4Hz to 64kHz. Handles distortion measurements down to 0.03% and can be used as a tuneable bandstop filter. Sensitivity: 300mV to 10V.

Naturally, all three operate on mains or optional internal rechargeable batteries – for classic home or away performance. Ask Dymar for details or use the Reader Reply Service.

DYMAR
instruments for communications

Dymar Electronics Limited, Colonial Way,
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Telephone: Watford 37321. Telex: 923035.
Cables: Dymar Watford.

WW — 073 FOR FURTHER DETAILS

(Gardners)

The Best of British

Where performance is paramount, professionals prefer Gardners...

We, at Gardners, have been in the communications business for many more years than we care to remember — so have our Audio Transformers. Used throughout the world by leading broadcasting and recording companies or wherever only the highest technical standards and levels of reliability are good enough our products are still preferred by professionals who know . . .

From microphone to tape (or film), speakers or headphones, studio consoles, manpacks, amplifiers, modems, we at Gardners have tried to anticipate your needs. Miniaturisation (yes!) plus good performance (yes!) through to exceptional performance (of course!). Impedance changing, coupling, isolation, bridging, low and high power, with or without D.C. Choose from our standard range of 95 models! Every one an example of sheer professionalism.

All have low loss, low distortion, low phase-shift, low pick-up, BUT wide frequency range.

Cat. No.	Impedance (OHMS) Input	Output	Turns Ratio Sec/Pri	Operating Level dBm at 50Hz	Frequency Response
MU 7501	0 3 15	100k	83/188 1		
MU 7503	0 200 600	100k	13/23 1	8	± 1 dB
MU 7514	600	600/2.4k	1 + 1 1		50Hz – 10kHz
MU 7518	10k CT	10k	1.1 CT		
MU 7521	3.75/15	600 CT	6.32/12 64 1		
MU 7522	3.75/15	100k*	82/164 1		
MU 7524	150/600	600 CT	1/2 1	16.5	± 0.5 dB
MU 7525	600 CT	300/1.2k	1 + 1 1.41 CT		30Hz – 20kHz
MU 7530	10k CT	10k	1 1 CT		(* ± 1dB at 20kHz)
MU 7534	50/200	100k*	22.4/44 8 1		
MU 7566	600 CT	10k/2.5k	4.08/2 04 1	12	
MU 7567	600/150	50k	9.13/18.26 1		
MU 7582	200/50	600 CT	1 73/3 46 1	20	± 0.5dB 10Hz – 100kHz
VM 7461	15/3.75	600	6.35/12.7 1		
VM 7464	600/150	600	1/2 1		± 1dB 30Hz – 22kHz
VM 7466	600	10k/2.5k	4.14/2 07 1	4.75	
VM 7468	50/12.5	50k	32/64 1		± 1dB 30Hz – 12kHz

We would emphasise that the above is a representative selection only. Send for Brochure GT5 for complete listings.
All units described are normally AVAILABLE FROM STOCK.

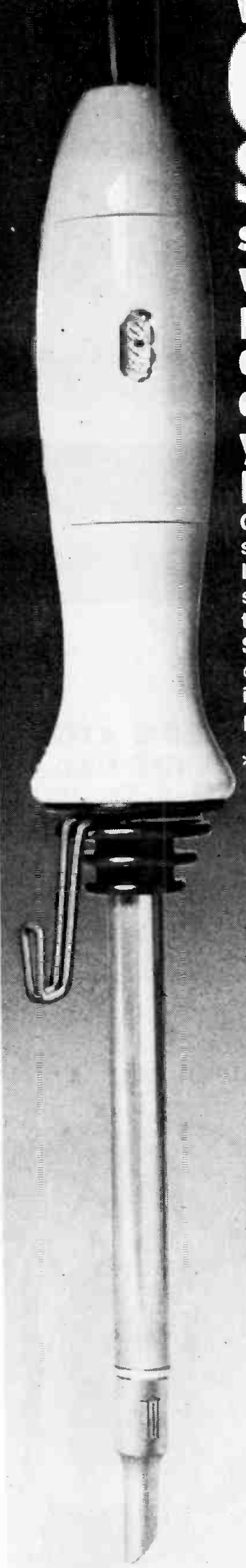
SPECIAL DESIGN SERVICE
If your requirements cannot be met by our standard range, then we will gladly design for your production needs.

(Gardners)

Gardners Transformers Ltd.
Christchurch Dorset BH23 3PN
Telephone 02015-2284
Telex 41276 Gardners XCH

Approved manufacturers of electronic transformers, modular power supplies, inverters and converters to Defence Standard 05-21

WW — 044 FOR FURTHER DETAILS



With our New ORYX SUPER 30

soldering iron we have a slight problem at £2.95* how do we convince you that it is a precision tool.

Our reputation for professional soldering equipment has been built on our precision products, so we have taken extreme care to see that our new ORYX Super 30 iron at, *dare we repeat it*, only £2.95, is going to be the best at its price.

** plus VAT at 8%*

Here are some of the features you get as standard:

A neon Safety Light,
A long life element,
Iron coated screw-on tip,
Stainless steel shaft,
Styled handle,
A two-minute element change, and a Stainless steel clip-on hook.

You can have further technical information, or by ordering one now you will see why we call it the Super 30.

Illustration actual size.

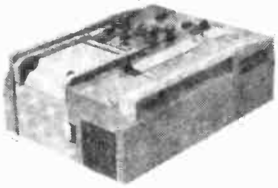
Greenwood Electronics

Greenwood Electronics, Portman Road, Reading, RG3 1NE
Telephone: 0734-595844. Telex 848659

WW — 027 FOR FURTHER DETAILS

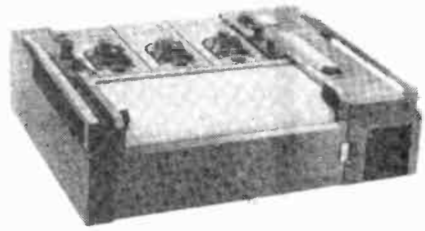
FAST RESPONSE STRIP CHART RECORDERS

Made in USSR



Type H3020-1
Single pen

Type H3020-3
Three-pen



Specification

Basic error	2.5%
Sensitivity	8mA F.S.D.
Response	0.2 sec.
Width of each channel	80mm
Chart speeds, selected by push buttons	0.1—0.2—0.5—1—2.5——5—12.5—25mm/sec.
Chart drive	200-250v 50Hz

Recording: Syphon pen directly attached to moving coil frame, curvilinear co-ordinates

Equipment: Marker pen, Timerpen, Paper footage indicator, 10 rolls of paper, connectors, etc.

Dimensions: H320-1: 285x384x16.5mm
H320-3: 475x384x16.5mm

PRICE: H320-1 £108.00
H320-3 £160.00
Exclusive of VAT

Available for immediate delivery

Z & I AERO SERVICES LTD.

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Farnell offer the only
DIGITAL MULTIMETER
with all these features

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★ LARGE DISPLAYS ★ A.C. & D.C. VOLTS & CURRENTS
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DM 131 (mains powered) **£147** | DM 131/B (mains/battery) **£173**

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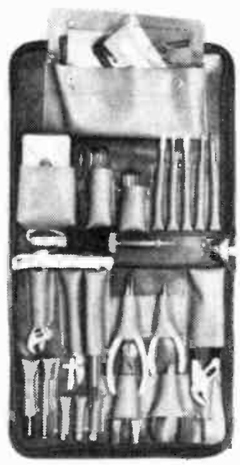
keep your tools handy in case...



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NEAL 3 CHANNEL AUDIO VISUAL
NEAL 4 CHANNEL RECORDERS

CASSETTE RECORDERS FOR THE PROFESSIONAL USER

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NEAL Range includes:		102AV, 103AV	STEREO AV DOLBY
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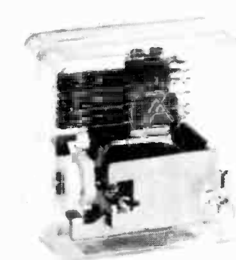
Our product range comprises:
Low profile (flatform) · Timing · Miniature · Low contact capacity · Hermetically sealed · Stepping · Mains switching · Latching Contact stacks · Solenoids



Stepping Relay AZ 170
Contacts are mechanically latched and thus unaffected by supply interruption.
Regular contact configurations from 1 make up to 3 changeovers.
Heavy duty version with 1 make or 1 changeover. Switching capability: 3 A at 125 V AC.
Coil voltages: 6 to 110 V DC.

We resolve your switching problems rapidly and expertly. Please contact us for further details.

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Please look us up at
Leetronex, Leeds, 29 June-1 July, 1976
A member of the worldwide ZETTLER electrical engineering group, est. 1877

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TRANSISTORISED INVERTERS

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SOME TYPICAL TYPES ARE:
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We also manufacture Frequency Changers, Power Supplies and Standby Systems, and we are always happy to quote for your special requirements. All prices plus VAT

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Tel. 01-890 4242/4837

WW—036 FOR FURTHER DETAILS

MOTOROLA
IN-LINE WATTMETER

Measures power output from transmitter and reverse power from antenna.

Compact and light weight (approx. 1 lb)

Frequency range 2MHz to 19Hz.

Measures RF power from 1W to 1KW.

System includes a series of wide range RF elements which can be left permanently in-line in the transmission cable—measurements can then be taken without disconnecting the antenna.

MOTOROLA ELECTRONICS LTD.,
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TELEPHONE: BURNHAM 62427 TELEX: 847121.

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Alice Broadcasting

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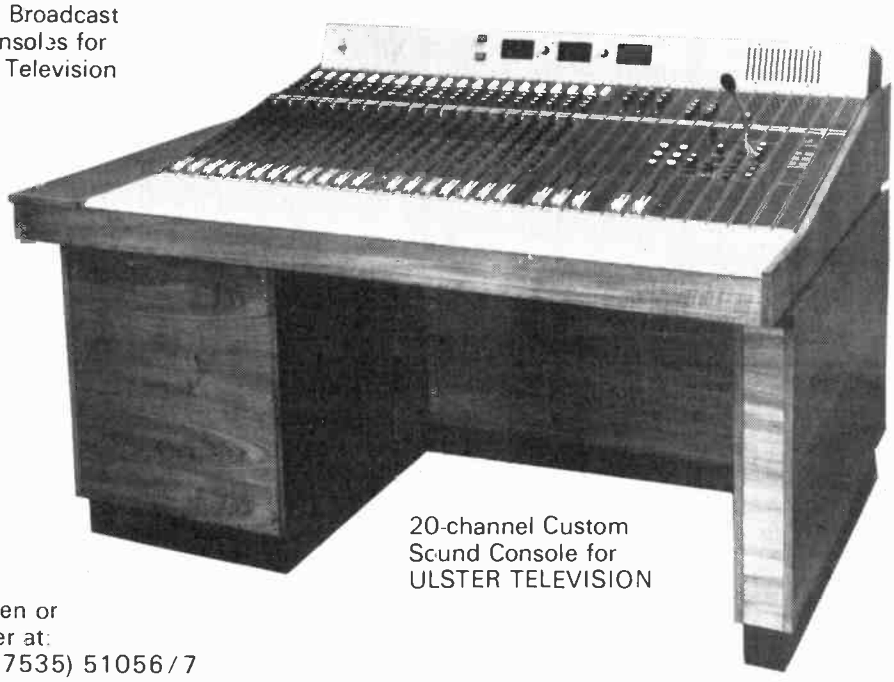
TORONTO
TELEX 06-963645

AM Series Broadcast
Mixing Consoles for
Radio and Television



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20-channel Custom
Sound Console for
ULSTER TELEVISION

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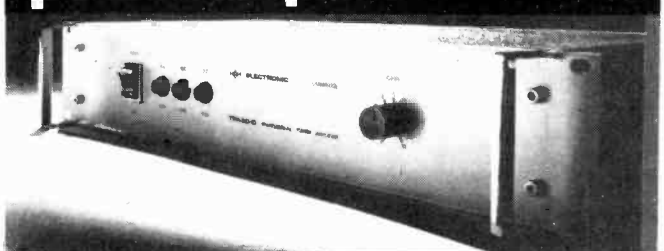
Alice **(Stancoil Ltd.), Alexandra Road, Windsor, Berks. Telex 849323 AEGIS G**

TPA SERIES – D
integrated circuit power amplifier



TPA 50 - D Specification

Power Output	100 watts rms into 4 ohms 65 watts rms into 15 ohms
Freq Response	±0·1dB 20Hz to 20KHz into 15 ohms. -1dB at 150KHz
Total harmonic distortion	Less than 0·04% at all levels up to 50 watts rms into 15 ohms
Input sensitivity	OdBm
Noise	-100dB
Rise time	2 u seconds
Price	£77 plus V.A.T.

100V Line (C.T.) and balanced inputs available.
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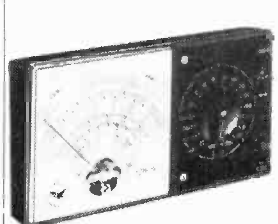
Test Equipment



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The Eagle range of multimeters covers every possible need of the electrical or electronic engineer. They cost from about £6 to £58 (inc V.A.T.). There's at least one which suits your job precisely.

We have a lot of other test equipment too. Send the coupon and we'll send you our complete catalogue.

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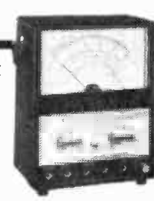

NAME ....
ADDRESS ....
....
....

Eagle International Ltd., Precision Centre, Heather Park Drive, Wembley HA0 1SU
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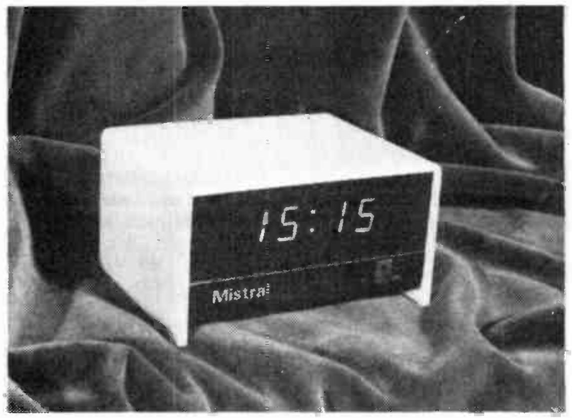
Eagle

WW — 030 FOR FURTHER DETAILS

THE 'MISTRAL' 1 DIGITAL CLOCK

★ COMPLETE KIT ★



- Pleasant green display · 12/24 Hour readout
- Silent Synchronous Accuracy · Fully electronic
- Pulsating colon · Push-button setting
- Building time 1 Hr. · Attractive acrylic case
- Easy to follow instructions · Size 10.5x5.7x8 cm
- Ready drilled PCB to accept components

KIT PRICE £10.25
+ 82p VAT P&P inc.

THE 'MISTRAL' 2 DIGITAL ALARM CLOCK

★ Fully Built, Tested and Guaranteed ★

WITH SLEEP-OVER FEATURE

- Soft Green Display
- 24 Hour Alarm
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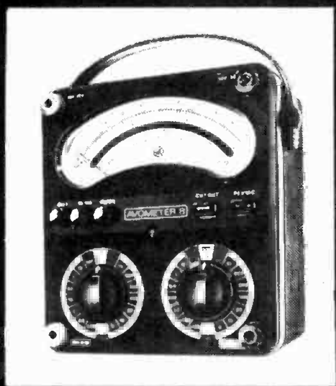

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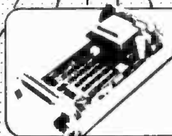

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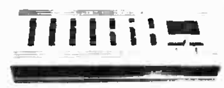

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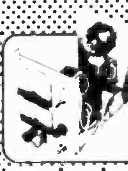

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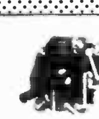

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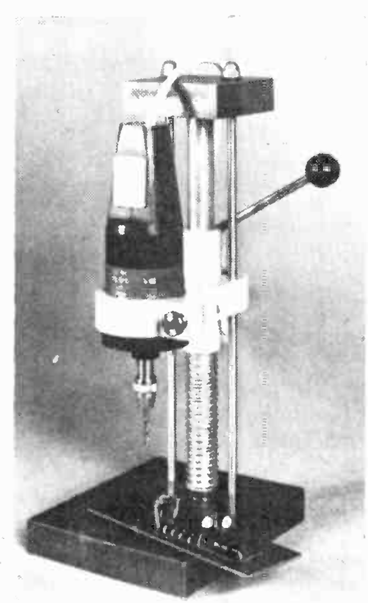

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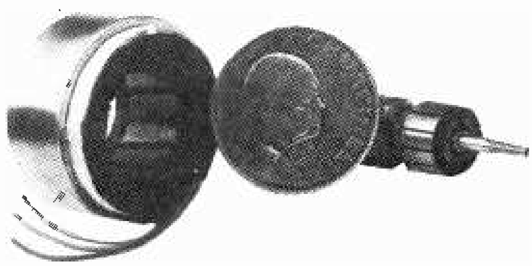

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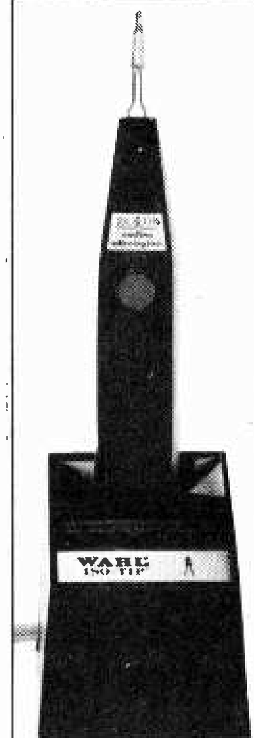

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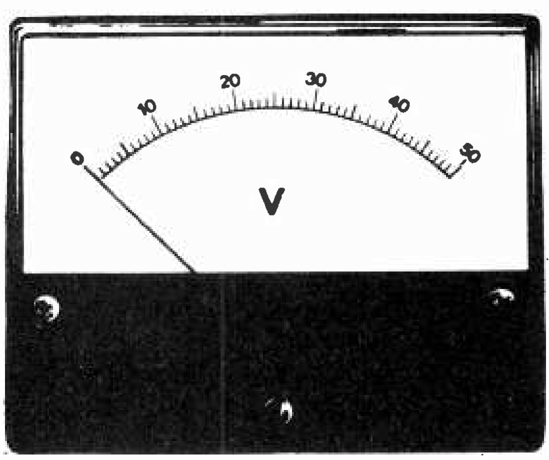

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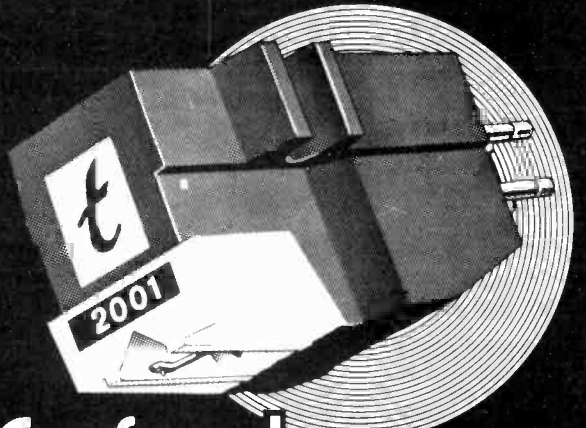

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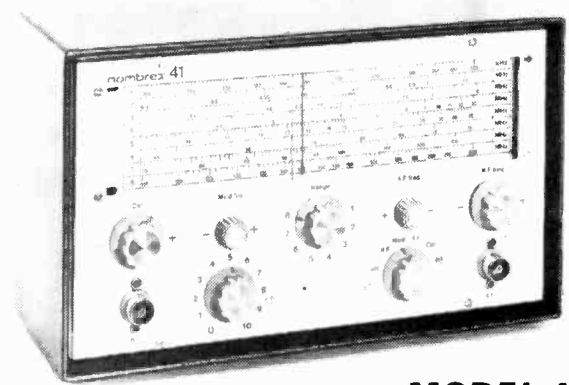

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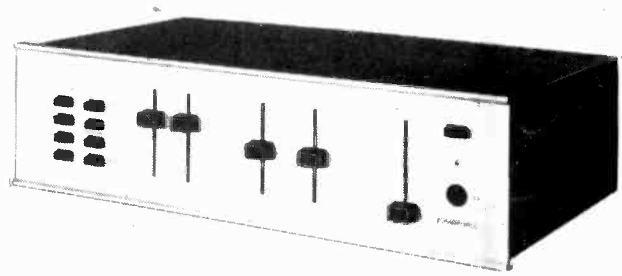

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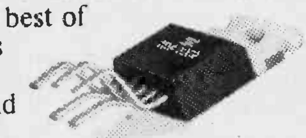

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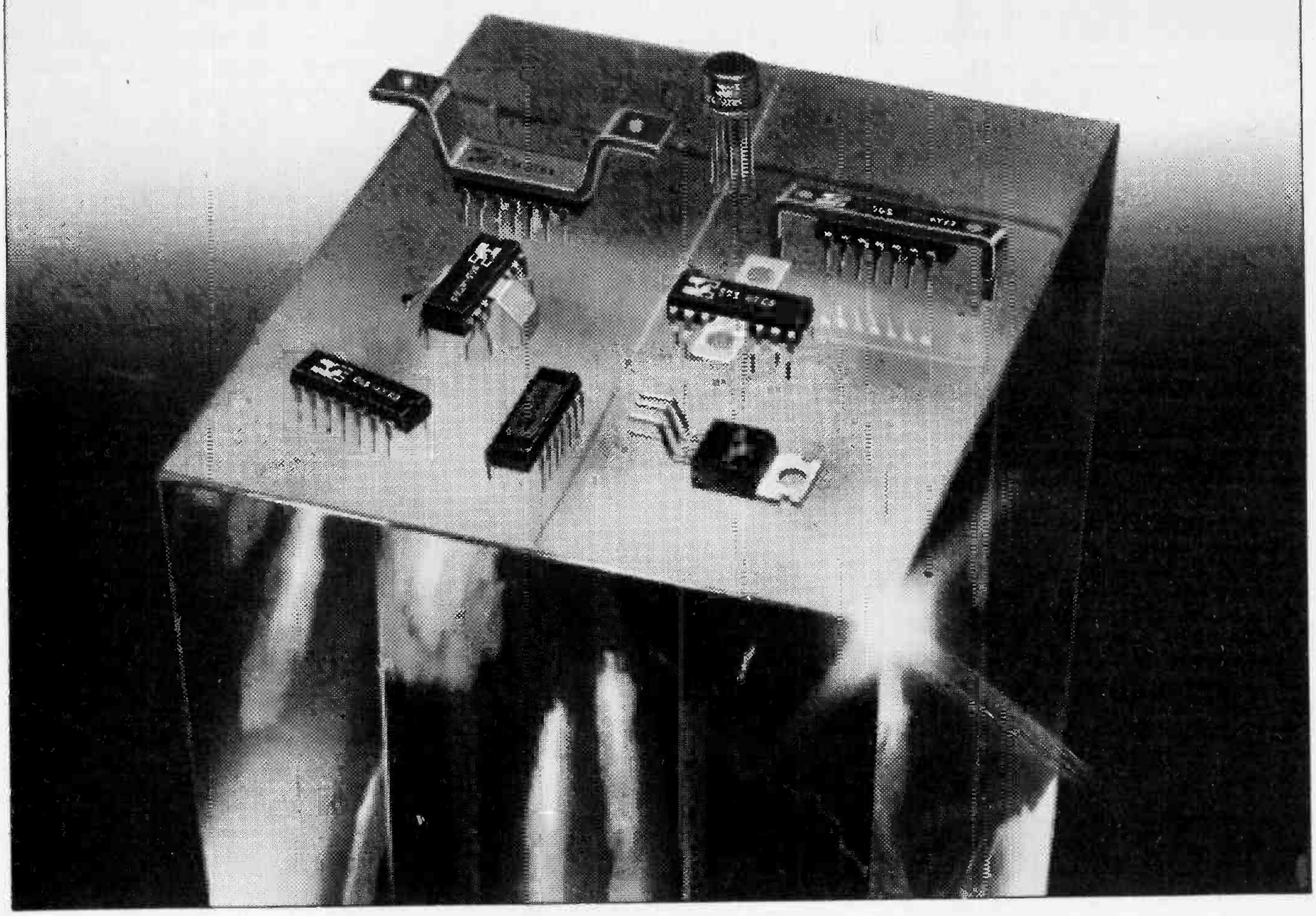

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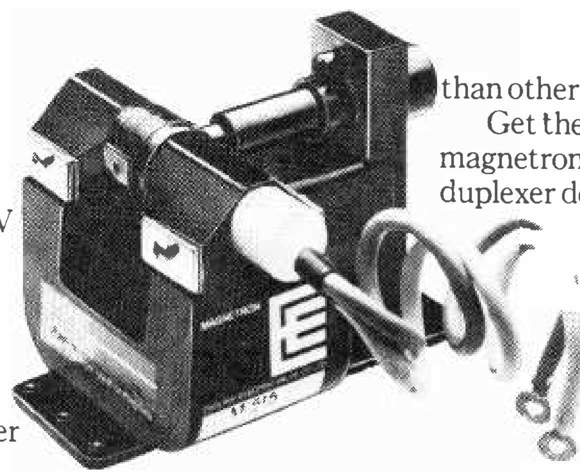

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JULY 1976 Vol 82 No 1487

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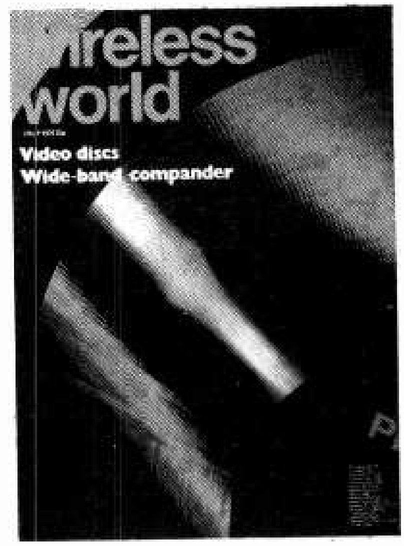

Photographer Paul Brierley

Front cover introduces the article on video discs in this issue and shows colour patterns produced by light interference effects on the surface of a Philips VLP video disc.

IN OUR NEXT ISSUE

The inventors. An examination of the difficulties of inventors in the electronics field in getting their ideas accepted by the Establishment — some revealing interviews.

Accurate digital clock. First part of a design for a self-setting clock controlled by radio using the time-of-day code transmitted by MSF, Rugby.

Linear characteristics. First article of a tutorial series on linear and non-linear characteristics and load lines in electronic circuits.

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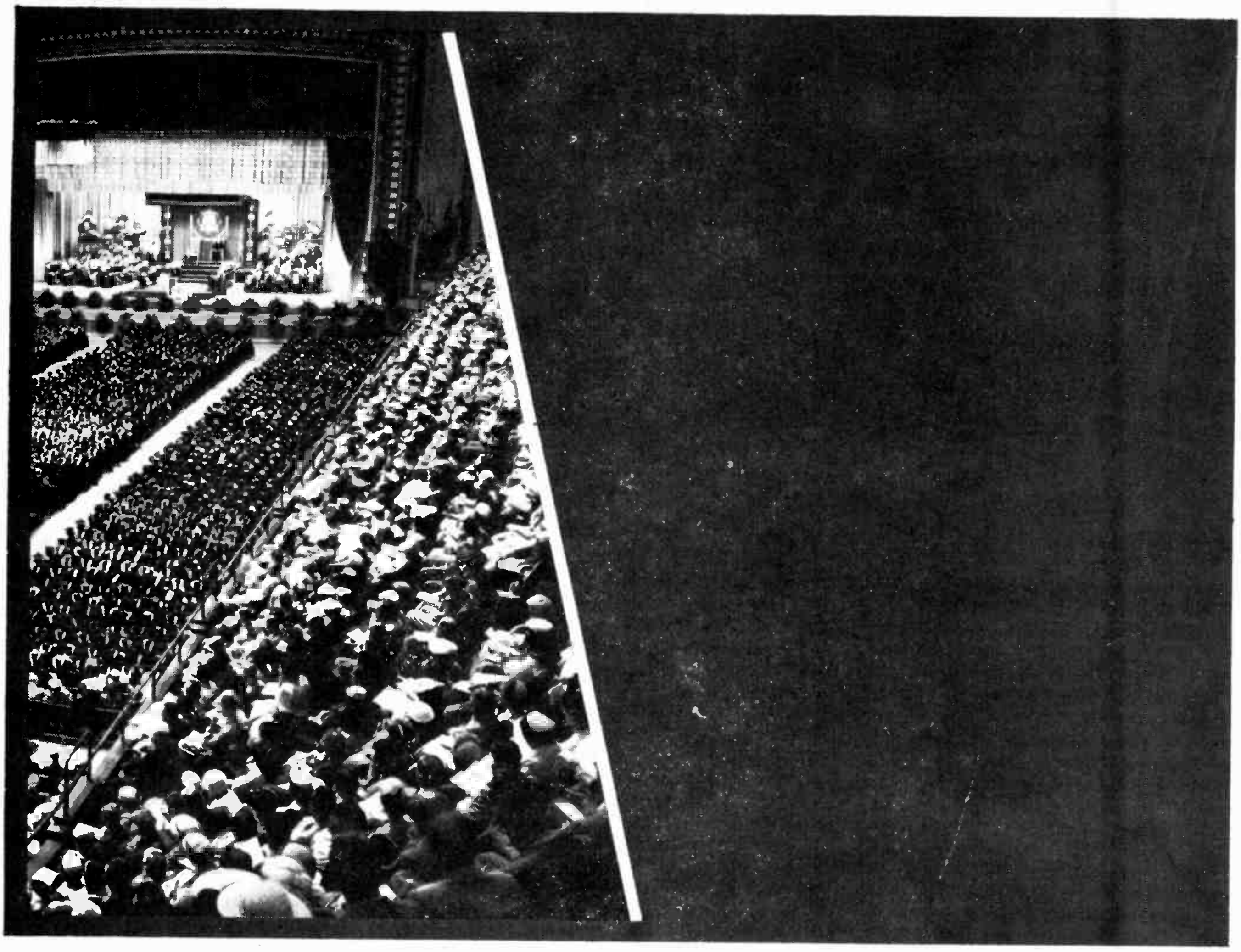

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Editor:
TOM IVALL, M.I.E.R.E.

Deputy Editor:
PHILIP DARRINGTON
Phone 01-261 8435

Technical Editor:
GEOFFREY SHORTER, B.Sc.
Phone 01-261 8443

Assistant Editors:
BILL ANDERTON, B.Sc
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Alien audio

We were recently talking to a man who takes published designs for audio equipment (among other things), collects the components together and, after attending to the mechanical design of the instrument, sells kits of parts. The finished appearance of the equipment was mentioned and he was of the opinion that an extra few decibels of s/n ratio or another order of magnitude less on the t.h.d. figure were as nought compared with a multitude of "facilities" and a satin-finished front panel. Not that his kits reflect this point of view — they are extremely well done — but he is beginning to think in terms of a spurious "technical" appearance, quite apart from high quality, to sell his products. The conversation made us think about the imbalance in the hi-fi shops in favour of foreign equipment and why it exists.

There are at least two main reasons for this imbalance. The first is advertising: in a recent check in one of the high-fidelity magazines we counted 30 pages (full-page, single-name ads) for foreign, mainly Japanese equipment, against 12 similar pages for British products. And that didn't include the discount companies who handle a very high proportion of foreign equipment. It is also evident that the use of English-sounding names for many of these foreign products is widespread. Secondly, the appearance of most foreign equipment is designed to project a "scientific" look, often with superfluous controls and indicators. The performance of these products is good, but is not better than that of home-grown equipment, whose appearance is less deliberately contrived. However, if the "mission-control" category of product is what the average person likes and therefore buys, why not let him have it? It could pay British designers to take more notice of the preferences of their customers. Or perhaps a foreign name might help!

British sound reproduction equipment has always been in the lead for sheer high quality and it seems stupid to let foreign companies take over the market by means of high-pressure saturation advertising through their distributors. Loudspeakers and electronics made in Britain have no peers anywhere, except perhaps in presentation, and that shouldn't present too much of a problem to a competent industrial designer who is prepared to cater for the demonstrated taste of the equipment-buying public.

Video *discs?*

"Without doubt the video disc is not the end of the story"

The quotation is how we ended our June 1975 view of the video disc scene. That view made the point that everyone seems to have taken for granted the use of the domestic television receiver for display of video records. It is of course the existence of a huge number of tv sets that prompts industrial and commercial concerns to think in terms of selling a home video unit to set owners. The return on investment could no doubt be enormous if things turn out right for them. But it does bring into focus the question of whether the currently-promoted video disc systems are the best way to achieve this end; not to mention the more fundamental question of priority about whose needs are to be met in the first place.

If an attraction for the electronics giants is the sheer volume of production, can it be achieved with the precision mechanisms, by domestic standards, that so far appear to be needed? Video players are not like other domestic products of the electronics industry, many of which can almost be thrown together and sold in millions at rock-bottom prices. Not yet anyway. They are precision machines, made from close-tolerance and hence costly components, and clearly fall into a different category from the low production-cost things we see around the home. Cost reduction by quantity production has its limits for such instruments and unless price can be reduced to amounts within the pocket of the ordinary citizen where is the one-video-player-per-family market? Teldec are not finding it easy to sell TeD players at DM1500.

It is doubtful that the tv-type display will be optimum for many applications. All manner of new display devices are currently being dreamed up, and it seems unlikely that the television line-by-line scanning system would be optimum to these. (If scanning is at all appropriate, a variable scanning rate, depending on changes in information density, may offer advantages.) Together with developments in the newer kinds of storage methods – for example photochromic, photoplastic and thermoplastic materials, possibly linked with holography – and possibilities for spatial information processing, it would seem unwise to limit the options now.

So we hope engineers will take a broad view of the possibilities for video records. The commercial pressures will be there; but let's continue to question our priorities and ask whether we need video disc players in our homes so soon. The present situation could easily produce a "bandwagon" effect – a tendency for the pace to quicken for fear of either being left behind in the market place or of writing off large R & D investments. Let's take our time and get it right, for everybody's sake.

If we had rushed into a standardized format at the outset for surround-sound records, for instance, we might conceivably, commercial interests aside, have got the best of the available systems at the time. As it became clear only a short time later, the initial attempts at providing surround-sound codings fell short of what was optimum – that is, of making the best use of channel capacity to portray sound direction.

THERE ARE SIGNS of consolidation among those who were first in the (optical) field. Following the collaboration of Philips and MCA it now seems that if Zenith opt for an optical system it will be based on the same broad specifications i.e. 1800 rev/min (NTSC) to give one tv frame per disc revolution and allowing "stop action", spiral track with direct NTSC coding by frequency modulation, two sound channels with subcarriers at 2.3 and 2.8MHz, and 8 or 12in reflective discs, either 1mm rigid or 0.2mm flexible. (See *WW* 1973, pages 541-3 for details of European version.)

Thomson-CSF, who with Zenith have developed aerodynamic stabilization of discs, have put in some effort to reduce player cost. This stabilization means that a focusing servo mechanism can be eliminated. In addition, the method used to correct radial tracking error doesn't require a separate motorized mirror; the error signal is derived instead from the photodetector array.

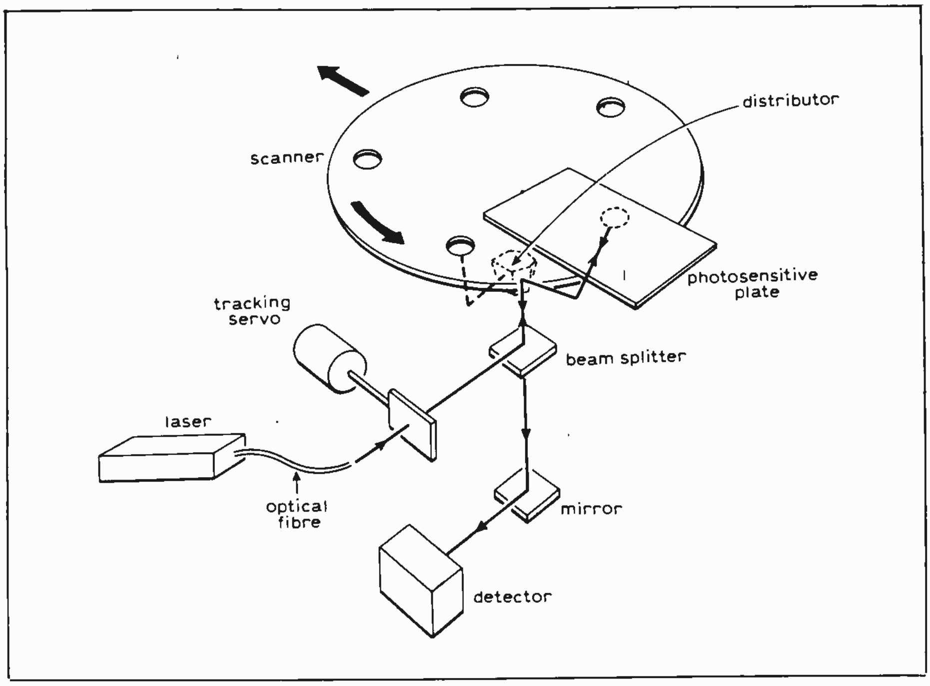
Bosch have developed a system along similar lines to these optical systems (*WW* August 1975, pages 364-5); with its higher resolution – the disc spins at 3000 rev/min – application is in the professional television and archival areas. RCA too have a synchronous optical disc for picture storage though this, like the Ampex magnetic ESS (electronic still store) and the Sony magnetic card, is for broadcast use.

By adopting a mechanical guidance method for the pickup, RCA avoid the need for servo tracking in their Selectavision system. But more significant in terms of cost saving is the use of a capacitance pickup from a metallic electrode deposited on the stylus. RCA claim the stylus is easy and inexpensive to fabricate compared to other pickups, and that it is capable of resolving signal elements smaller than the wavelength of visible light, permitting high density recording with an electron beam.

A further point of difference is the choice of speed, 450 rev/min. According to RCA, effects of vibration due to unbalance of rotating parts are reduced compared to a rotational speed of 1500 or 1800 rev/min. Errors in signal timing that result from warp or eccentricities of the disc occur at a lower frequency, making it easier for the synchronizing circuits of the television receiver to follow. More important, a simple and inexpensive transducer can be used to reduce time-base errors, permitting playback into receivers with relatively slow horizontal sync circuits without requiring circuit modification. This consists of a small moving coil element which drives the stylus arm back and forth along its long dimension, parallel to the record groove. If the record runs too slowly, the stylus is pulled toward the transducer to increase the relative speed, and if the record runs too fast, the stylus is pushed away from the transducer to reduce the relative speed. Error signals are derived from the colour burst frequency as the record is played.

Luminance, chrominance and audio signals are encoded on carriers and recorded on the disc as variations in the width or spacing of slots in the bottom of the grooves on a master disc. Colour information is encoded to give spectrum peaks at odd multiples of half line frequency to conserve bandwidth.

The master recording is made with an electron beam to record the signal slots in a material similar to photo-resist, but optimized for sensitivity to electron beam exposure. Replication is similar to conventional processes. After discs are pressed, they are coated with three 40nm layers. First, a conductive metallic



In the digital video record system, the 5×7in record is stationary and the scanner moves. A distributing prism acts to switch the beam from the end of one track to the start of the next.

coating is applied which serves as one electrode of a capacitor. Then an insulating coating is applied to act as the dielectric, and finally a thin layer of oil is added as a lubricant to prolong the life of the disc and stylus. The tip of the sapphire stylus is triangular in shape, and a metal electrode is deposited on the back surface. Signals are recovered by detecting the variations in electrical capacitance between the tip of the electrode on the stylus and the metal coating on the disc as the stylus passes over the slots in the bottom of the groove. Apart from the stylus, RCA say the components are conventional and have been used for years in consumer products.

Whilst this electrostatic system may be able to provide low-cost players, the film-based systems claim the advantage of potentially low-cost duplication. The I/O Metrics system is f.m. and based on synchronous disc speeds, whereas the DRC system, see below, is digital with non-circular records. Full details of the French SEPO technique aren't available, but in 1974 they quoted a disc production cost of one franc!

Perhaps replication cost of the MDR magnetic disc is being quietly forgotten, as the system lends itself to home recording. MDR say they will market this year at DM2000. It started with the aim of low-speed recording and replay to allow the use of ordinary turntables, but a speed of 156 rev/min has had to be accepted. We do not know how much of a problem disc-head contact is going to be.

High-density optical system is digital

It is perhaps surprising that of all the video disc systems announced not one has been truly digital. Most are analogue systems relying on frequency modulation of a carrier. Recently, we learned of a video record system that uses, in effect, photographic plates digitally encoded. Developed originally by a division of the Battelle Memorial Institute, work on the system is now sponsored by the Digital Recording Corporation of Scarborough, New York, whose president recently told *Wireless World* of the system.

Applications for the digital technique are seen in wide variety of situations. In information storage and retrieval, costs are expected to be lower than any other storage technique and much lower than any other system with automatic access. In this application, four possible information handling schemes can be adopted depending on the nature of the material to be stored. For continuous tones the material would be scanned with an 800-line resolution system to digitize the image. The digitized data can then be stored by differential binary coding, giving a linear reduction of 150 times. A two-level (black or white) image e.g. line drawings or text can be stored with a linear reduction of 270 times or, by storing changes only, 460 times. Computer coding could allow a reduction of 1700 times. On this basis, a reduction of storage area can be about three million times, compared with 400 times for conventional microfilm or microfiche techniques. In an archival system, a storage unit of 1000 plastic 4×5in records is envisaged with an access time of five seconds or so (milliseconds on the same record). Between 5 and 600 million frames could be stored in the space of a four-drawer file, depending on storage mode. Storage size could be increased by a factor of ten if speed can be sacrificed.

As a device for playback on home TV receivers, a unit could cost $150 to produce. It could make use of 5×7in records loaded singly or automatically from a stack. The storage medium could equally well be a film cassette, automatically wound-on. And according to the company a playback unit can be modified to provide a home recording unit, the optics and mechanics being the same. Replication cost is said to be low and a production cost of "much less than 25 cents" has been mentioned.

As with other video storage techniques, it would lend itself to audio records. Use of a digital technique allows a greater dynamic range, elimination of various distortions, an unwearable and more compact record. An audio player, possibly small enough to fit into a car, could store 30 to 60 minutes of surround sound on a 3×3in record. There could also be applications in the professional or studio television area, especially for advertising spots. Variable delay can be provided for monitoring and editing, and loss-free stop and start, stop-action, frame indexing and computer-controlled editing are a few of the more obvious facilities. Freedom of jitter and of errors in colour, together with high signal-to-noise ratio come with the digital format.

Although the patents held by DRC cover a wide compass of configurations, one type is described to illustrate the approach. Information on the records is in the form of spots and spaces distributed along a curved path on a photosensitive glass plate. In recording such a plate, the data are scanned in serial order on to the plate by a rotating scanning head with several scanning apertures around its perimeter (see diagram). An optical distributing prism placed on-axis switches the light beam so that when a scanning aperture reaches the end of a track, the light beam is cut off and reinstated at the start of the next track. Thus the track pattern is a series of arcs, rather than the popularly used spiral. To produce sequential tracks, the scanning components are translated in the direction of the arrow. The fixed-plate approach is claimed to result in a simpler and less expensive mechanism.

In playback, the light beam is reflected from the dark '1' spots, but not from the clear '0' bits. Because the same machine would not generally be used for both recording and playback a tracking servo (not operative on recording) is provided to deflect the beam slightly as required. This feature,

● *Continued on page 36*

Schmitt trigger design with op-amps

Graphical technique eases design procedure

by R. D. Tuthill

The common form of a Schmitt trigger design using discrete components as shown in Fig. 1 has several disadvantages. If V_{in} is 0V, transistor Tr_1 is switched off and Tr_2 will therefore be switched on. It can be seen that V_{out} has a minimum voltage level, set by the ratio of R_5 and R_6 values, which is the first disadvantage. If the potential of V_{in} is raised, Tr_1 will start to conduct and the potential at the collector will fall. This starts to switch off Tr_2 which causes the voltages across R_6 to fall and Tr_1 to switch on. Although the change of state is now complete, there is now a current flowing into the base of Tr_1 which changes the input impedance of the circuit. This is also a disadvantage. The basic Schmitt trigger in Fig. 1 is a non-inverting type, and this can also be a disadvantage.

Using integrated circuit op-amps these disadvantages can easily be overcome. From Fig. 2(a) and (b) the only apparent difference between inverting and non-inverting configurations is the reversal of functions at the two inputs. However, for the same specified input and output conditions, different values of R_i, R_f and reference potential are required. Note that when using op-amps, switching always occurs when there is virtually no potential difference between the two inputs. Secondly, because the input impedance of an op-amp is high, virtually all of the current in the feedback resistor also flows through the input resistor. Therefore, the potential at the amplifier input can be calculated by knowing the voltage applied to R_i, the output voltage, the values of R_i and R_f or just their ratio.

The design procedure relies on the last-mentioned point. In the non-inverting configuration V_{IH} is the upper input voltage limit, V_{IL} the lower limit, V_{OH} the positive output voltage, V_{OL} the negative output and V_R the reference voltage. When the voltage ranges have been selected, a suitable voltage scale as shown in Fig. 3, can be chosen. A vertical line is drawn through Q and using the same scale as that on the left-hand side, V_{OH} and V_{OL} are marked. For the example shown V_{OH} is + 10V,

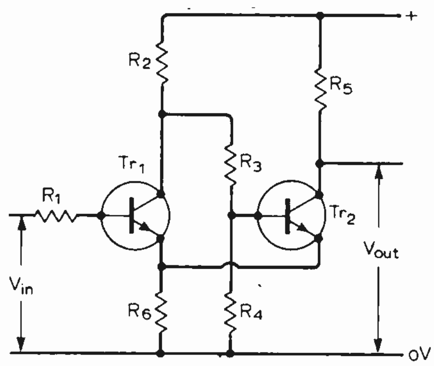


Fig. 1. Common form of non-inverting Schmitt trigger.

V_{OL} −10V, V_{IH} 8V, and V_{IL} −1V. This gives hysteresis of $V_{IH}-V_{IL}$ which is 8−(−1)=9V. At the left-hand end of the 0V line, point P is chosen and a vertical line through P is marked with V_{IH} and V_{IL}, again using the same voltage scale. Referring now to Fig. 2(a), the inverting input of the op-amp is connected to the reference voltage. Note that the non-inverting input must also be at potential V_R for switching to occur. This potential is not yet known but a line from V_H to V_{OL}, the conditions which exist just prior to switching, can be drawn. If the length of this line represents the impedance $R_i + R_f$, then, by knowing their ratios or values, the value of R_F can be found. Unfortunately neither of these are known but a second set of conditions is, and this may have the same reasoning applied to it, i.e. just prior to the output switching from V_{OH} to V_{OL} the voltage at the non-inverting input is also V_R. Therefore, a line from V_{OH} to V_{IL} can be drawn. The intersection of the two lines gives the value of V_R when scaled vertically from the 0V line.

The ratio R_f:R_i can be found as well as the value of R_i if a suitable value for R_f already exists. Using the scale of resistance, R_f is marked on the horizontal axis, in this case 100kΩ, and a line is constructed from this point through R to interset the vertical line at point X. Using X as a starting point a second line is constructed through W to finish at Z.

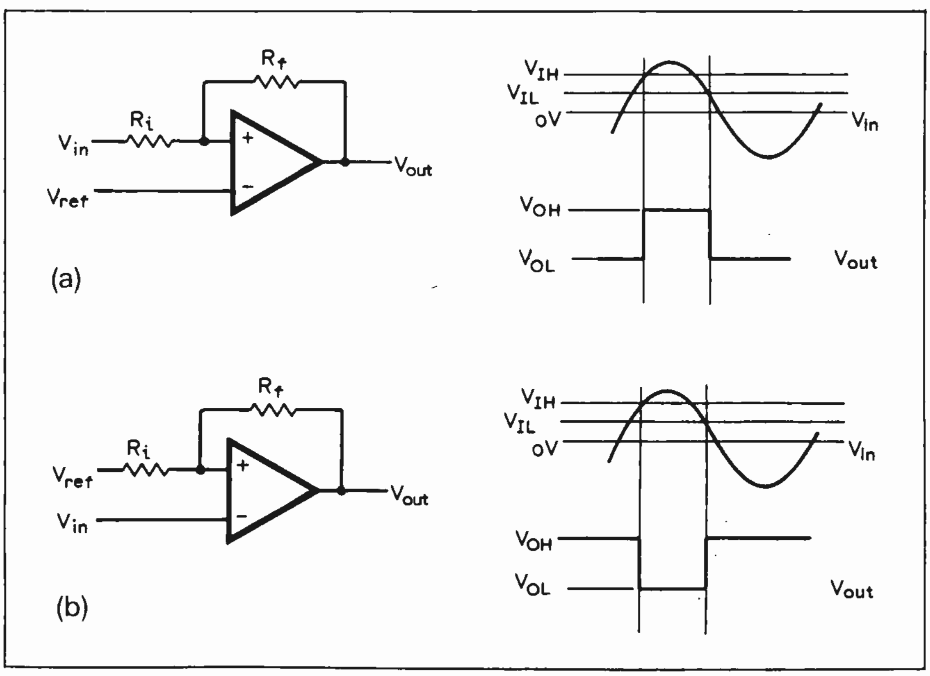


Fig. 2. (a) Non-inverting and (b) inverting Schmitt trigger both using a single op-amp.

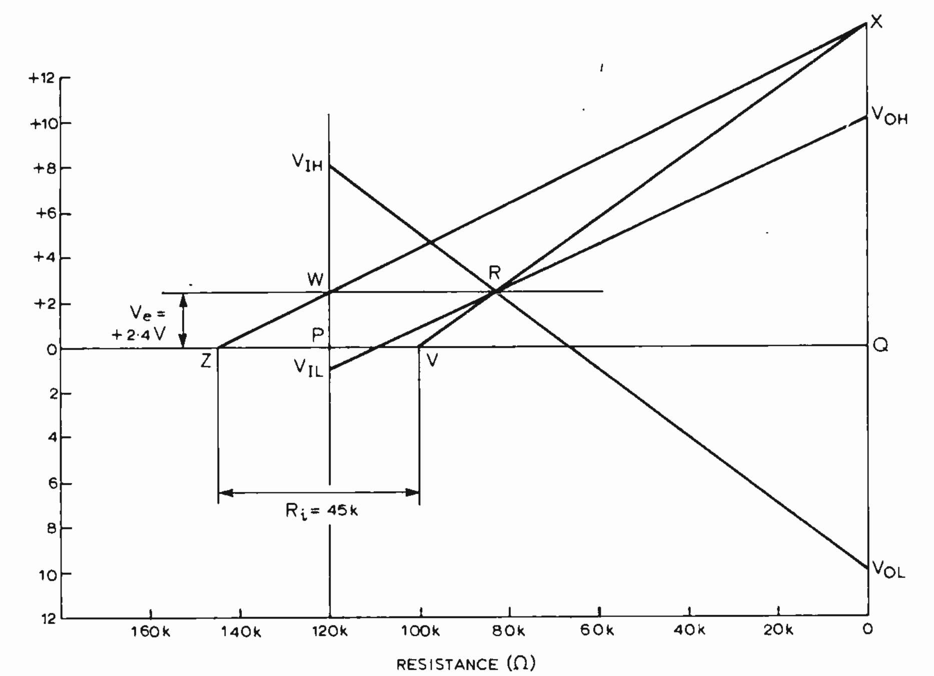


Fig. 3. Graphical method for calculating R_i in the non-inverting Schmitt trigger mode.

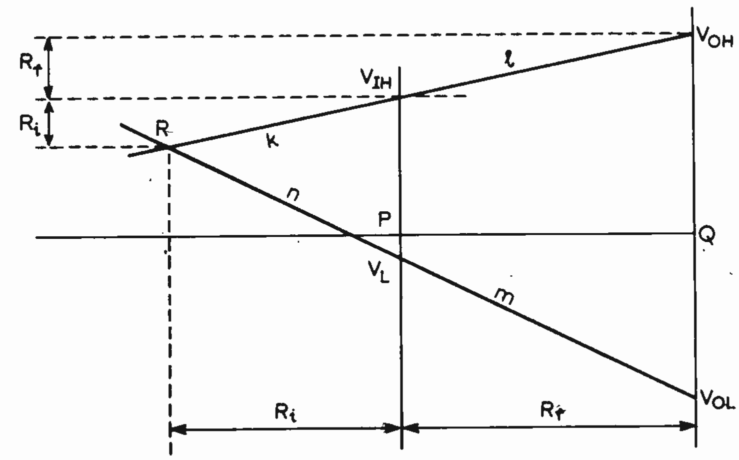


Fig. 4. Graphical method for calculating R_i in the inverting Schmitt trigger mode.

On the same resistance scale the distance V–Z gives the value of R_i.

If necessary a resistance scale in the horizontal axis can be used to begin with. In this case, values for R_i and R_f are marked off as point P and Q accordingly, and the distance from Q to the line vertically dropped from R is measured to obtain R_f, and from this point to P for R_i. The only disadvantage of this method is that there may be two awkward values of resistance rather than one.

This covers the graphical technique. For the trigonometrically minded it can be proved that $k/l = n/m$ and from this a mathematical formulae can be deduced. The vertical component of k is $V_{IH} - V_R$, l is $V_{OL} + V_R$ (where V_{OL} is negative), n is $V_{IL} + V_R$ (where V_{IL} is negative), and m is $V_{OH} - V_R$

Therefore:

$$\frac{k}{l} = \frac{n}{m} \text{ becomes}$$

$$\frac{V_{IH} - V_R}{-V_{OL} + V_R} = \frac{-V_{IL} + V_R}{V_{OH} - V_R}.$$

Solving for V_R gives

$$V_R = \frac{V_{IL} \cdot V_{OL} - V_{IH} \cdot V_{OH}}{(V_{IL} + V_{OL}) - (V_{IH} + V_{OH})}$$

It is also true that $k/l = R_i/R_f$, therefore

$$R_i = R_f \cdot \frac{k}{l} = R_f \frac{(V_{IH} - V_R)}{(-V_{OL} + V_R)}.$$

Once R_f has been selected it is a simple matter to evaluate R_i

For the inverting configuration more care has to be taken in positioning point P because the lines of construction may be well to the left of this point. From Fig. 2(b) the voltage on the non-inverting input of the op-amp changes every time the output changes state. However, the inverting and non-inverting inputs must be virtually at the same potential for a change in output voltage to occur.

A line can be constructed from V_{OH} to V_{IH} with its length representing only the potential across R_f, and not $R_f + R_i$ as in the non-inverting case. A similar state exists for V_{OL} and V_{IL}. The intersection produces a point from which the ratio R_f:R_i can be obtained. Also, the value of V_R is, as before, the vertical separation of point R from the 0V line. Resistors R_f and R_i can also be marked off as before. From Fig. 4 it can be trigonometrically proved that $k/l = n/m$, therefore $k/k+1 = n/n+m$ and, from deduction

$$\frac{V_{IH} - V_R}{V_{OH} - V_R} = \frac{-V_{IL} + V_R}{-V_{OL} = V_R}$$

Solving for V_R gives

$$V_R = \frac{V_{IH} \cdot V_{OL} - V_{IL} \cdot V_{OH}}{(V_{IH} + V_{OL}) - (V_{IL} + V_{OH})}$$

Also $k/l = R_i/R_f$, therefore

$$R_i = R_f \frac{(V_{IH} - V_R)}{(V_{OH} - V_{IH})}$$

Once R_f has been selected it is again a simple matter to evaluate R_i.

Linsley Hood cassette deck

The final part of this article, containing details of the motor-control circuit, will be published in the next issue. Readers who have used Garrard mechanisms will find that the motor-control unit is supplied but we will provide the information for the convenience of readers who have obtained the Goldring CRV mechanism.

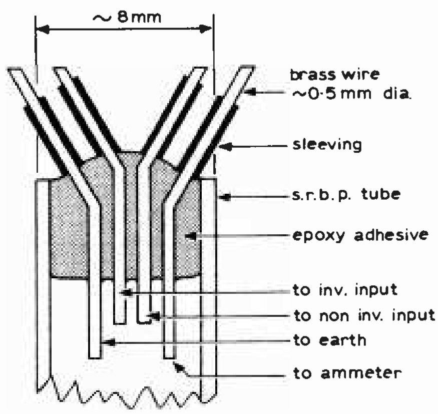
Circuit Ideas

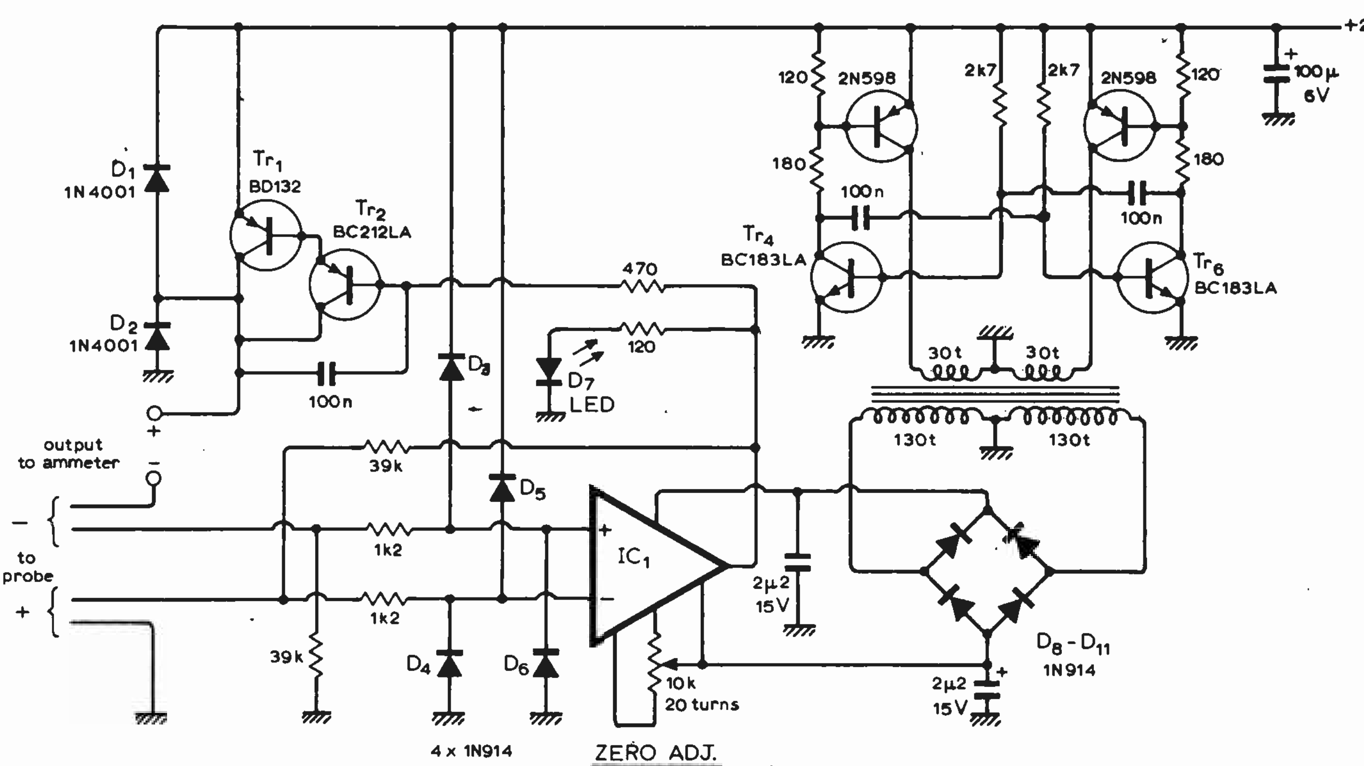
P.c.b. ammeter

This circuit allows measurement of current in a single printed circuit conductor, without the necessity of breaking the track. The device uses a probe of four wires and when all the wires are in contact with a conductor a p.d. appears at the input of a differential amplifier. The two outer wires carry a current of opposite polarity via an ammeter. Because there is a negative feedback loop in the conductor, the differential amplifier input voltage will return to zero when the outgoing current is equal to that of the unknown current, the former being read from the ammeter. The differential amplifier offset voltage must be maintained to as near zero as the twenty-turn preset potentiometer will permit. An advantage would be to use a 725C instead of the 741 which was chosen for the merit of low cost.

The l.e.d. shown in the circuit has a twofold use. Firstly, when there is an offset voltage at the input, on shorting all four wires of the probe on a dead conductor, it will light or, alternatively, the ammeter will show a reading. Secondly, when the probe input is reversed the l.e.d. will again light. Diodes D_{1-2} and D_{3-6} provide protection to the circuit which may be floated from voltage to voltage when in use. Finally, the d.c. converter enables the circuit to use a single battery.

F. Andrews,
Southampton College of Technology.

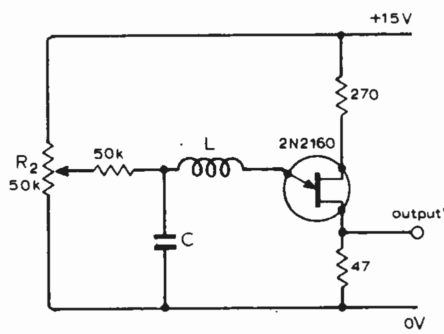




Simple sine-wave oscillator

This circuit provides a simple a.f. sine-wave oscillator by using a unijunction transistor as a negative resistance in a RLC circuit. The potential divider R_2 sets the peak point of the emitter and should be adjusted for maximum output consistent with a good sine wave. The output is about 200mV and the circuit operates from 1kHz to 50kHz by using suitable values of L and C.

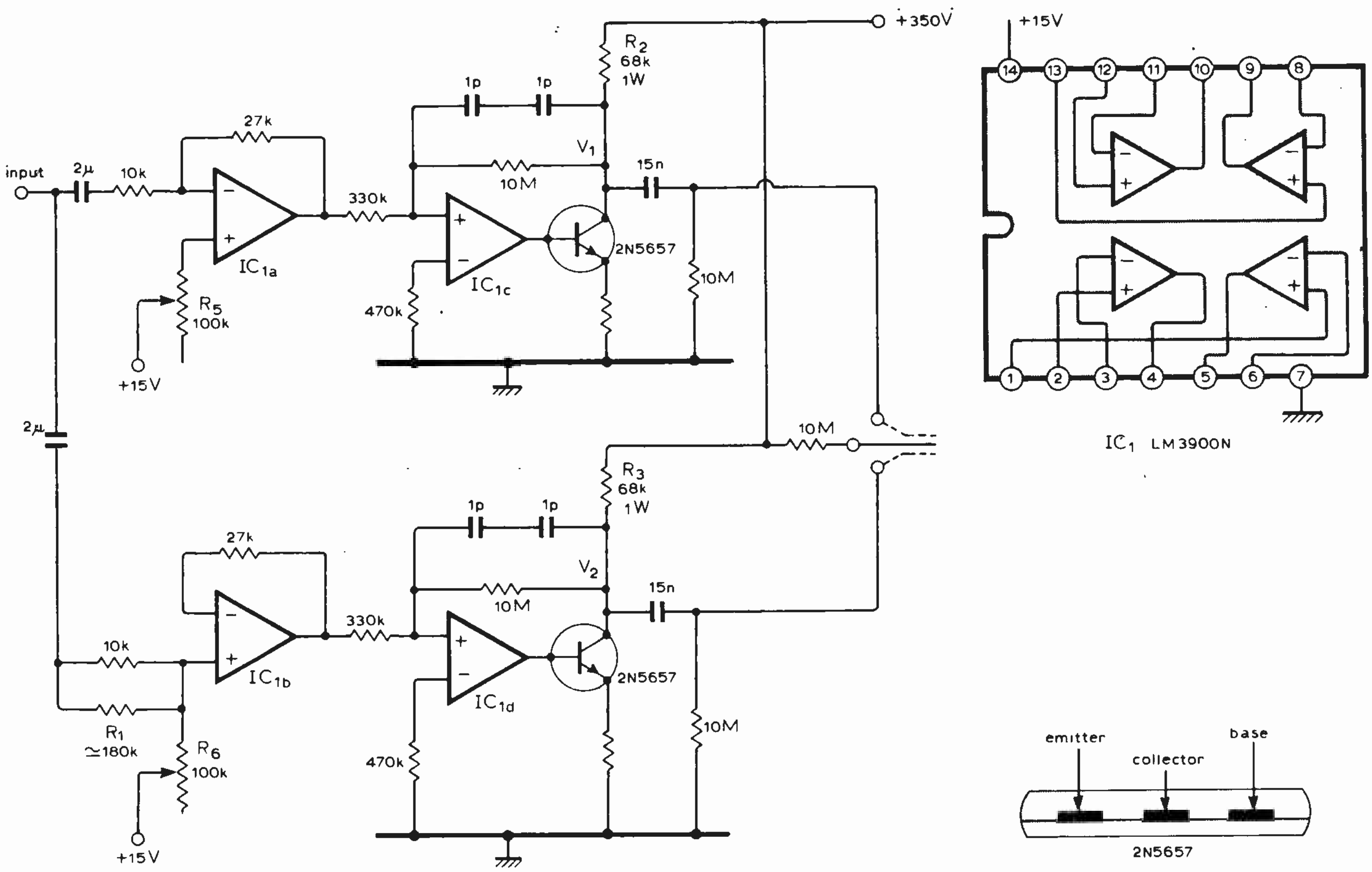
R. P. Hart,
Hadlow,
Kent.



Electrostatic headphone amplifier

This circuit has been used successfully with a pair of headphones based on the W.W. design Dec. 1968. The amplifier can be driven from the headphone output of most power amplifiers. Potentiometers R_5 and R_6 are used to set V_1 and V_2 at half the supply voltage. Resistor R_1 is required to compensate for the small signal resistance of a diode in the non-inverting input of IC_{1b}. If headphones of greater capacitance than 150pF are used it is necessary to reduce R_2 and R_3 to maintain the power bandwidth. It may then be necessary to heat sink the power transistors. The +15V bias supply for IC_{1a} and IC_{1b} must be well filtered. The amplifier has a small signal frequency response of (−3dB) 10Hz to 40kHz, a power bandwidth of 10Hz to 15kHz, and a total harmonic distortion at 1kHz (almost entirely second harmonic) of 0.1% at 50V pk-pk and 1.0% at 300V pk-pk output.

N. Pollock,
Sandringham,
Australia.

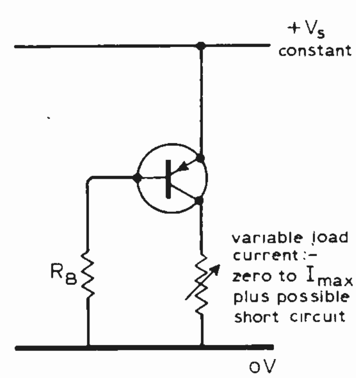


Short-circuit protector

The short-circuit protector shown is fast and cheap. The transistor is biased to saturation and the collector-emitter voltage is therefore less than a volt. If a short-circuit occurs, the collector is pulled along the constant current line of its output characteristic corresponding to the base bias current I_B. The short-circuit current is therefore restricted to some value say I_{max}. Suppose that a maximum load current of I_{max} is to be made available from a supply of V_s, and the transistor has a current gain of h_{FE}, then the base resistor is calculated as follows. As $I_B = I_{max}/h_{FE}$, and because V_{BE} is small, $R_B \approx V_S/I_B$. Therefore $R_B \approx V_S h_{FE}/I_{max}$. If the precise current gain of the transistor is not known, or if a variable I_{max} is necessary, R_B may be made partly variable and adjusted on test. For a +15V supply from which at least 100mA may be drawn, suitable components for the short circuit protector would be a silicon p-n-p transistor with h_{FE} 100 (e.g. BC327) and a base resistor of 12kΩ. The output voltage will then be 14.5V and the value which I_{max} reaches will exceed 100mA.

Under normal operation very little power is dissipated in the protection transistor. Under a short-circuited load condition the power developed is $V_s I_{max}$ watts. For negative supplies a n-p-n transistor may be used in the same configuration.

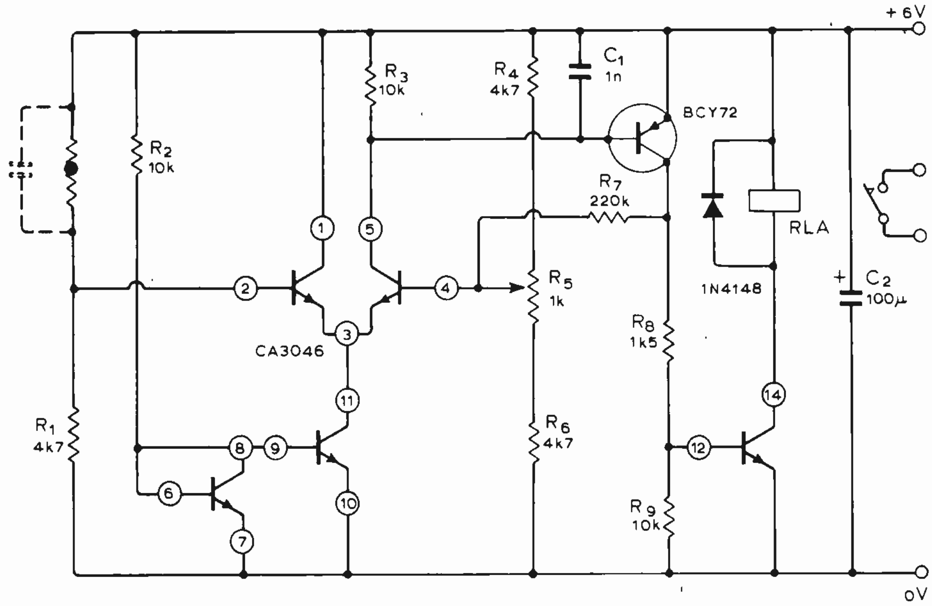
M. C. Hately,
Robert Gordon's Institute of Technology,
Aberdeen.



Thermistor controlled thermostat

Essentially the circuit is a bridge formed by the thermistor, R_1, R_4, R_5 and R_6 with an amplifier for sensing the unbalance. The circuit switches a relay on when the temperature is below a chosen level, and by altering R_1 the operating temperature can be changed. If the opposite function is required the positions of the thermistor and R_1 are reversed. The sensing circuit uses a CA3046 which supplies two matched pairs of transistors in addition to the output transistor. Tr_1 and Tr_2 act as a voltage comparator, the tail current being provided by the current mirror Tr_3 and Tr_4. The base voltage of Tr_2 can be adjusted using R_5 which allows the switching temperature to be set precisely. Positive feedback via R_7 prevents chatter when the switching point is reached. If the thermistor is separate from the amplifier, a 0.1μF capacitor should be connected across R_1 to minimize pick-up effects.

D. E. O'N. Waddington,
St. Albans,
Herts.



Video discs *(continued from page 31)*

common to most analogue optical disc systems, allows some tolerance on record positioning and on hole alignment in the scanning disc.

An interesting point concerns the limiting spot size. According to classical diffraction theory the focused spot produced by a lens passing monochromatic light shows an intensity distribution in which the bright central area contains 84% of incident energy. The diameter of the first dark ring surrounding this area determines, at first sight, the maximum achievable bit density. But in practice, the spot size on a photographic emulsion will be smaller due to the gamma effect of the emulsion. (Gamma is the maximum slope of the log of exposure versus density.) The intensity distribution of the diffraction pattern is not "mirrored" by the photographic density distribution, and the slope of the central peak in the diffraction pattern is sharpened on the emulsion – in effect a sharpening of the spot size, allowing greater spot density. Spot sizes of 1μm are produced on silver halide emulsions at 633nm wavelength and a focal length-to-aperture ratio of two, allowing a bit density of 10^8 bit/cm.

Because of possible variations in emulsion depth and position depth of focus must be adequate. A technique that avoids the expense of servo-controlled focusing is to blank off the central portion of the lens, in playback if not in recording. This has the effect of increasing the depth of focus, but at the expense of more energy appearing in the secondary rings of the diffraction pattern. This is not very important in playback because of the way the detector electronics respond to sharp modulation represented by the central spot. Depth can be increased from 20 to 40μm by occulting three-quarters of the lens. (Actually, DRC say 10μm is adequate for rigid records in commercial form.)

For flexible records an holographic lens – made by replacing the lens by a transmission hologram after exposure by sending monochromatic light backwards through the system which can compensate for errors in the optical system – could yield up to 120μm depth.

An advantage of a digital method is that emulsion noise is much less noticeable than in an analogue method – only extreme fluctuations of grain density and size would show. In certain applications, error-correcting codes could be built into the system.

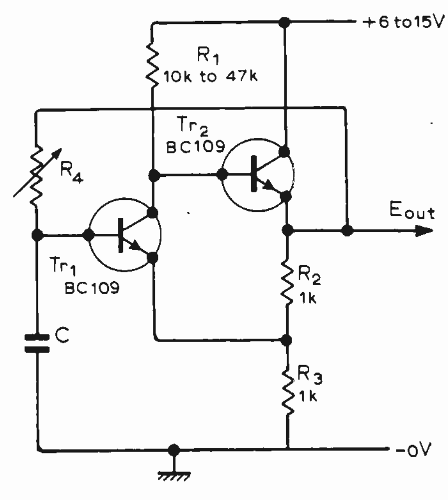
In demonstration apparatus, differential encoding has been used to remove some of the redundancy in normal tv pictures. Each picture element is recorded as a four-bit word, three bits for luminance and one bit for colour. Instruction codes are recorded instead of the usual blanking signals so that audio signals can be digitized and time multiplexed into the horizontal blanking periods.

Square-wave generator with single frequency-adjustment resistor

When the circuit shown is switched on C is uncharged and Tr_1 is non-conducting. Transistor Tr_2 is therefore fully on and its emitter is at a potential near V_{cc} Capacitor C therefore charges until Tr_1 begins to conduct which causes Tr_2 to rapidly cut-off, by regenerative action. The emitter of Tr_2 falls to a level determined by the ratio of R_1 to R_3, and C discharges through R_4 until Tr_1 cuts-off and the cycle repeats.

The transition times of the circuit are rapid and it will work with small-signal silicon transistors up to at least 0.5MHz, and down to a frequency determined by CR. The output is almost an equal mark-to-space ratio over a wide frequency range, though this can be trimmed if required by the ratio of R_2 to R_3, or by a small resistor in Tr_1 base.

J. L. Linsley Hood,
Taunton.



IRCAM

Electronics at the Paris Institute for Research and Coordination in Acoustics and Music

Under construction, just off the boulevard de Sebastopol in the heart of Paris is the new Centre Beaubourg research institute which is to form part of a major contemporary art centre. The Centre Georges Pompidou will house a museum of modern art, a centre for industrial design and an extensive public library in which space will be reserved for displays on current events and for the operation of audiovisual facilities. The centre, to be officially opened in April 1977, will also include a fourth department, IRCAM – Institut de Recherche et Coordination Acoustique/Musique, built underground next to the Centre Beaubourg.

IRCAM is to provide research facilities for developing future aspects of music. To do this the aid of digital electronics has been enlisted as an important tool in the processing of real time electronic sound reproduction. At the heart of the technical facilities will be a Computer Automation PDP10 with its associated 24k bit core store and a peripheral number of interlinked visual display units and input/output keyboards. Nothing out of the ordinary to those already involved in the use of computer facilities, but the application is unique and likely to cause initial scepticism. Computers for making music? What then will happen to the composer and instrumentalist and the essence of *human* expression? In the words of Pierre Boulez, Director of the research programme "The musician must assimilate a certain scientific knowledge, making it an integral part of his creative imagination. As to the scientist, we are of course not asking him to compose, but to conceive with precision what the composer, or instrumentalist, expects of him, to understand the direction contemporary music has taken, and to orient his imagination along these lines. At educational meetings, scientists and musicians will become familiar with one another's point of view and approach. In this way we hope to forge a kind of common language that scarcely exists at present, while traning a staff who will be basically oriented towards musical creation."

Computer aided design

It has become clear that with the appearance of synthesized sound, traditional instruments no longer determine the limits of perception and comprehension of music. The aim of the research at IRCAM is to determine in which direction these limits should be pushed in widening the available scope for composition and performance. A computer programme, Musik V, has been developed over the last few years to assist these aims. Its initial application is in the examination of the waveforms produced by musical instruments in order to determine the parameters relevant to their accepted perception. This is not as simple as it sounds. For instance, a waveform of say a trumpet can be reproduced easily enough, but it was found that the result still did not sound like a trumpet. Further investigation showed the reason to be that the decay of harmonics was dependent on their frequency. In other words harmonics of high frequency decayed at a different rate to those of lower frequency.

Using computer facilities to analyse results such as this should be applicable to the development of new instruments. For instance a composer could stipulate the range and timbre of the sound he requires by simulating them on the computer, analyzing their component parts and developing an individual instrument that can produce them. Another application is in 'bending' the sound of a standard instrument so that its range of timbre can be increased or completely altered. It was demonstrated at the centre how the waveform from a violin could be fed to a computer which gradually reshaped the signal to that produced by a trumpet, the startling result being a sound emanating from the same instrument which gradually changed from one type of known instrument timbre to that of another.

Such flexibility provided by the computer can be coupled in the IRCAM centre with its 'Espace de Projection'. This area of the underground building will be used for transmitting any sound produced in the studios, for acoustic measurements and also for direct participation of concert audiences in sound experiments. The acoustics of the Espace de Projection will be mechanically variable so that reverberation time will depend on the position of moveable absorption elements in the walls and ceiling. Also it will be possible to lower and raise the ceiling and a system of curtains across the area will provide even more flexibility of the acoustic environment. Other facilities in the building will include two acoustically isolated studios with 'ideal' reverberant conditions and a department for the study of psychoacoustic effects. Finally, it will be the job of the 'Diagonal department' (le departement Diagonal) to coordinate the different branches of research and instigate the transplanting of techniques from one department to another. It will also undertake research work on the transmission, projection and perception of sound as well as on pure acoustics, music theory and their relationships with other disciplines.

Common effort

Two aspects of the centre which it was surprising to find were not being considered in depth were the use of video in composition and the use of a computerised system for multichannel sound recording. Lack of video applications was surprising as there is a lot of interest in its use by many contemporary artists in both the fields of music and the visual arts. More importantly however it was felt that recording techniques are as complex in their execution as the basic research of the institute already mentioned. If results of the work produced from IRCAM in years to come are to be communicated to as wide a public as possible then it would be a pity if the subtleties of compositions using new acoustic effects were lost because recording equipment was not developed to an equivalent degree of flexibility . . . "Contemporary music has at the moment less need of individual souls and their vagaries than of common effort to explore its own innermost nature, to explore sound itself, both with instruments and artificially, in order to unlock new sonorous possibilities for composition, to explore musical perception, in order to understand why some tools function better than others, to explore relationships between music, performance and listeners. This adventure will take place in many ways: through the severity of scientific analysis, through experimental testing of hypotheses, through all manner of public presentation, and through composition itself" – Gerald Bennett.

WEA

F.m. adaptor for a.p.t. tape recording

P.l.l. design overcomes replay amplitude variations

by J. B. Tuke

Many earth stations receiving automatic picture transmissions from satellites use a tape recorder as an intermediate link between the radio receiver and picture printing equipment. This system has advantages because some picture printers need to be operated in complete or semi-darkness, and many aerial systems are manually tracked which requires the operator's full attention during satellite transit.

The 2400Hz amplitude-modulated signal which carries the picture information can be recorded and reproduced on a domestic type of tape recorder, preferably running at 7½ in/s. However, the picture produced on replay shows dark horizontal streaks, caused by fluctuations in the replayed signal level. These variations of about a decibel are in the most critical part of the picture level, where minute changes of intentisy produce appreciable changes in the shades of grey. If infra-red data is being displayed using the intensification process, deterioration can become severe.

To overcome the amplitude variations a frequency modulated signal can be used. This technique is well known and the Signetics NE565 phase-locked loop i.c. is used, as shown in Fig. 1(a). The v.c.o. frequency-determining components are chosen to produce the required carrier frequency, and the modulation is applied to pin 7. The v.c.o. output on pin 4 is then passed to the recorder as shown in Fig. 1(b). On replay, the f.m. signal from the tape recorder is fed to pin 2 of the i.c., which is connected in the conventional p.l.l. demodulator mode and the demodulated output appears on pin 7, see Fig. 1(c).

Choice of v.c.o. frequency is important. The upper frequency limit of the v.c.o. is set by the tape recorder and experiments have shown that a carrier frequency of 11kHz is quite satisfactory. Remember that the f.m. sidebands on both sides of the carrier must be reproduced. For this type of recording, using limited deviation and where fidelity of the replayed signal is not of primary importance, it is adequate to consider the required bandwidth as being twice the modulating frequency either side of the carrier. With an 11kHz carrier and 2.4kHz modulation, the tape recorder should be able to deal with a frequency band between about 6 and 16kHz.

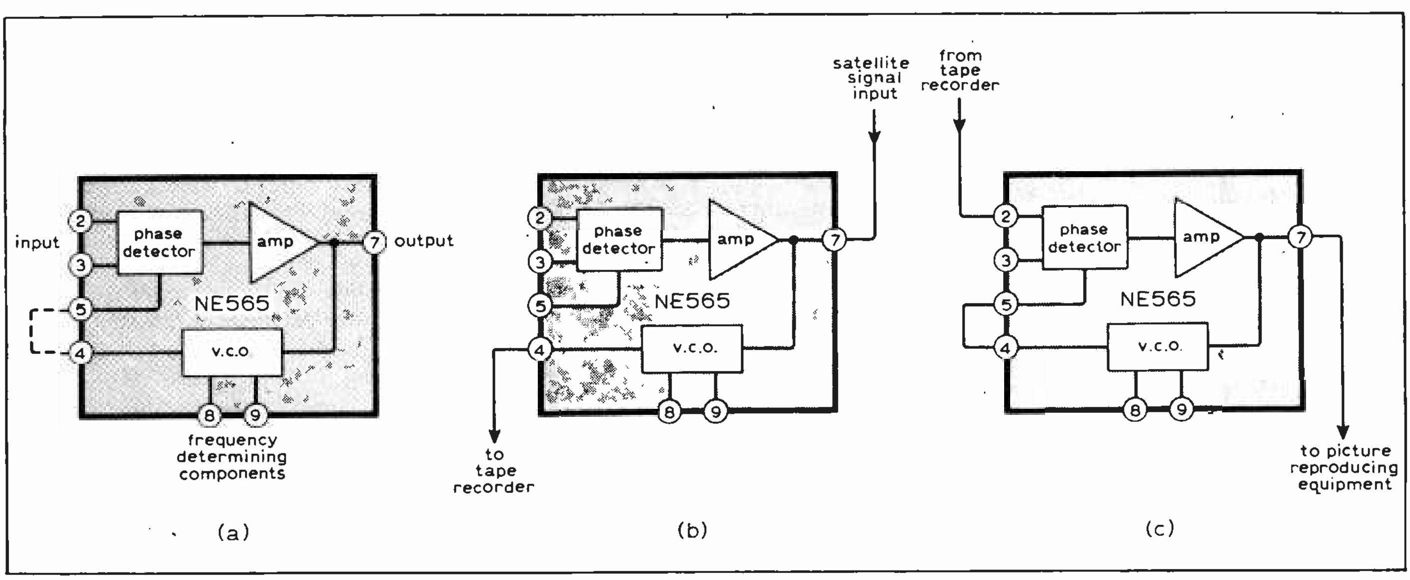
As replay is only concerned with an f.m. signal, this band does not have to be replayed at the same level as long as there is sufficient signal from the tape recorder to lock the p.l.l. A carrier frequency which is an exact multiple of 2400Hz should be avoided to prevent patterning on the finished picture.

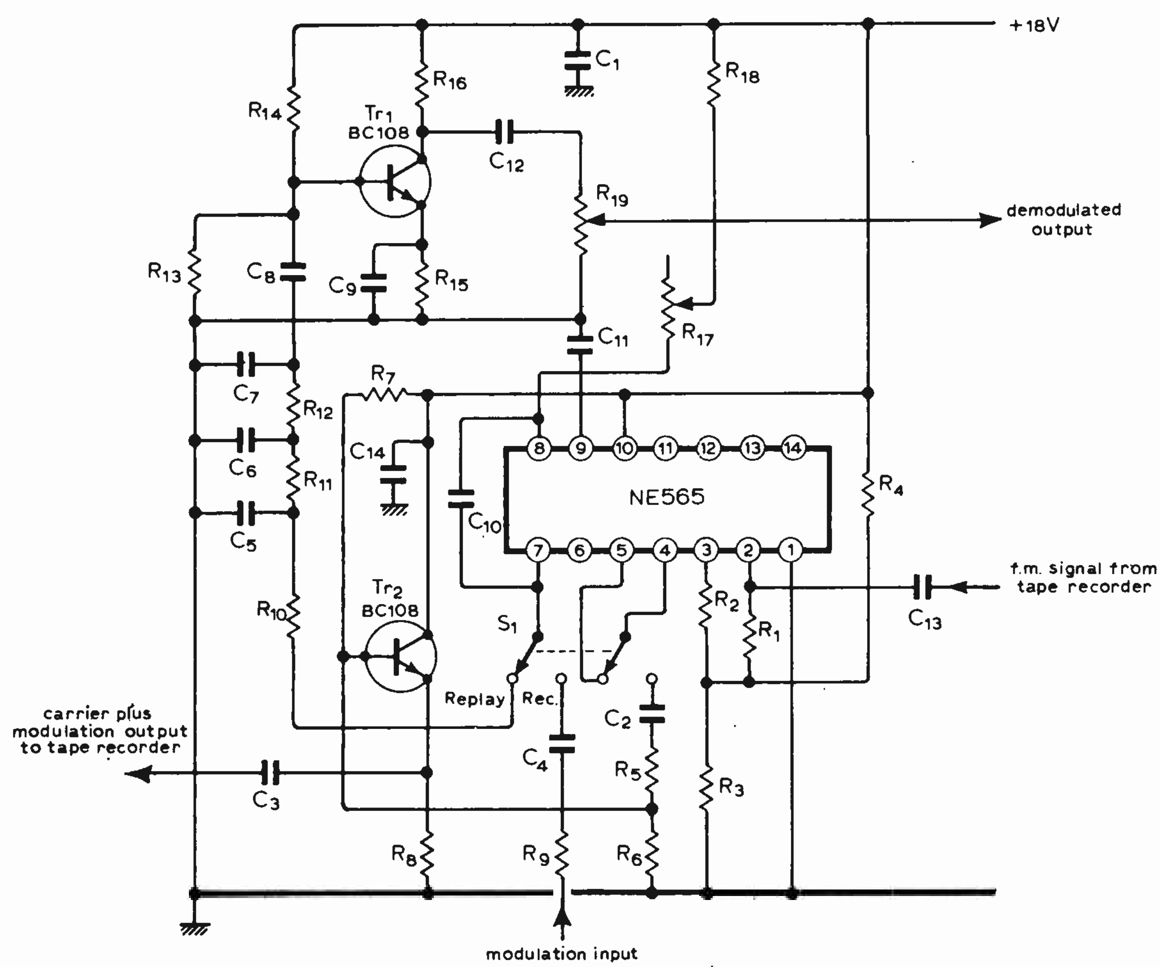
Measurements of input amplitude against output signal have shown an almost linear relationship within the dynamic range of the system. The signal to be recorded may have a value up to —3dBm. Higher values than this cause excessive carrier deviation and loss of lock on replay. If the weakest signal (full black) is recorded at —30dBm, the worst signal-to-noise ratio is 15dB and the dynamic range is nearly 30dB which is ample for a.p.t. signals.

When setting the record level remember that in NOAA spacecraft signals, peak-white occurs at the edges of the picture and not in the picture itself. Due to the global position of the U.K., picture content rarely exceeds 80% of the peak value. Consequently the input must be adjusted so that signal peaks do not exceed —3 dBm otherwise the circuit will momentarily drop out of lock. Although this may not be part of the line scan carrying picture data, lock takes a few milliseconds to recover and causes a large black streak.

If the 2.4kHz signal were first rectified to produce the video (f_{max} is 1.8kHz) and

Fig. 1. (a) Block diagram of phase locked loop, (b) signal path for the modulating mode, (c) connections for the demodulating mode.





then applied to the NE565, the resultant f.m. signal would be of a simpler nature and a lower carrier frequency could be used. This system presents no problems in the record mode but when amplification is required on replay, the d.c. component would have to be preserved right through to the picture printing device. Infra-red NOAA pictures indicate temperature by the relative intensity of black and white. A typical read-out from near the north pole to

Fig. 2. Practical circuit for modulator / demodulator using one p.l.l. and a d.p.d.t. switch. Tr_1 provides an overall gain of 0dB in the replay mode, and Tr_2 isolates the v.c.o. output in the record mode.

north Africa shows a steady darkening of the picture from north to south as the surface temperature increases. This may be referred to calibration charts for exact temperatures and therefore the d.c. levels must be maintained. This complication is removed by retaining the 2.4kHz portion of the signal.

A practical circuit as in Fig. 2 consists of the NE565 together with two simple transistor amplifiers. In the record mode the v.c.o. output is isolated from the tape recorder by an emitter follower. In the replay mode a transistor amplifier is used to produce an overall gain of 0dB. A d.p.d.t. switch enables one i.c. to be used in both modes, although two devices can be used.

The unit may be built on Vero-board and powered by an 18V regulated supply. Using this adapter, which can be built for around £10, pictures can be recorded which are almost indistinguishable from the original.

Component list

C1	100µF 25V	**R1,2**	7.5k
2,3	100n	3,16	4.7k
4,8	470n	4	10k
5,6,7	47n	5	22k
9	25µF 6V	6	3.3k
10	1n	7	33k
11	10n	8,-9, 10,	
12	50µF 25V	11,12,	1k
13	200n	15	1k
14	100n	13	6.8k
		14	68k
		17	20k
		18	2.2k
		19	10k

Correction

The following apply to 'Weather satellites ground station – 3' by G. R. Kennedy, January 1975: capacitors C_{77-79} and C_{85-87} should be 1,800pF and R_{94} is a 5kΩ ten-turn pot; in Fig.23, IC_7 output is from pin 12, IC_6 should have pin 10 grounded; Tr_{27} should be 2N4061, 2N3702 or similar; S_4 is labelled in reverse; on page 25 for S and S read S_5 and S_6 and in the appendix for R_{53} read R_{57} for C_{67} read C_{68}; in the parts list add R'_{105} – 390Ω, for REL65 read REC65 and C_{93} should be 1.5µF.

Wireless across space

2 — Proximity of communicating civilizations in the Milky Way

by Tong B. Tang, M.Tech

St John's College Cambridge

That communication with extraterritorial intelligence (sometimes abbreviated to CETI) is possible with today's radio technology was postulated in Part 1. As further support of the thesis, we will now consider an order-of magnitude calculation of the most probable distance separating a civilisation from its nearest neighbour, using today's knowledge and opinions.

There are at least 10^{10} galaxies, some containing more and some less stars than the Milky Way, in the part of the universe so far observed. But for our present purpose we need only to consider our own galaxy, the Milky Way (Fig. 5), which from statistical star counts has some 10^{11} stars. (On the scale of galaxy diameters intergalactic distances are two orders of magnitude higher.) After Drake[5], the number of civilisations which have the capacity for interstellar communication can be analysed as

$$N^* = Rf_p n f_l f_h f_c T$$

Here R is the average rate of star formation. The age of the Milky Way is about 1.5×10^{10} years, and thus the overall R will be seven stars per year. However, the actual R in earlier times must have been larger, and in later times smaller, while those stars formed in the earlier periods are likely to be lacking in heavy chemical elements and should be excluded because in their absence advanced civilisations or perhaps even life itself cannot arise. In view of this, a reasonable value of R will be one star per year.

f_p is the fraction of stars possessing planets. For a long time it has been observed that stars whose temperatures are similar to or less than that of our sun – and nine out of ten stars belong to this category – are usually rotating much less rapidly than the remaining stars; the observation is deduced from the much smaller amounts of the Doppler broadening in their spectral lines. The interpretation is that they have planets to which most of their rotational energies have been transferred. Furthermore, in particular, the motions of some nearby stars, "Bernard's Star" for instance, have been seen to "wobble," and this almost certainly shows that they have dark companions (planets) in orbit around them.[26] The mechanism of planet formation is not yet well-established theoretically [27] but in all possibilities it is consistent with that of star formation, viz. the self-gravitational collapse of a nebula of gas and "dust" into a state where it is hot and dense enough for the start of nuclear reactions and the birth of the star. We shall be conservative by taking f_p as 0.5.

n is the mean number of planets in each planetary system which have environments suitable for life; or, in astrobiologists' jargon, which lie within the ecosphere of the local sun. The most important factor here is whether the planet in question acquires by outgassing its crust an atmosphere which initially contains hydrogen but not oxygen (where complex molecules when formed will not be at once oxidised) and a hydrosphere of water. In our solar system Earth and Mars satisfy the conditions, and we shall use 2 as the value of n, by the "assumption of mediocity"[11] (that what is true for us cannot be unique and is likely to be the average for the whole galaxy).

f_l is the percentage of these planets in which life does develop. It looks to us that the abiogenic (spontaneous) synthesis of probionts (self-replicating molecular assemblies) is, given the boundary conditions of a primitive hydrosphere containing hydrogen, methane and ammonia, forced by the laws of physics and chemistry and therefore a certainty. Given, in addition, sufficient time and an environment which is not entirely static, self-reproducing organisms are bound to appear later. (Incidentally, I mention the speculation that the properties of matter or even the physical laws change, until they are such that the appearance of life in the universe becomes inevitable. We should therefore not be surprised that everything seems to just fit in, so that in particular we exist on earth, because when it is not so we do not exist to know. We are here, hence the world is being such that life can exist – the "anthropic principle"; and hence there is life "out there" as well – the assumption of mediocity.) It follows that f_l is very nearly 1 and as a close estimation is taken as 1.

f_h is the fraction of inhabited planets in the biospheres of which life advances to a high level, during the lifetime of the local sun. A high-level life form means one which will not become an evolution cul-de-sac. It is, I think, one which can form an internal analytical model of the external environment, *and* which relies mainly on this ability for the survival of its species (or, more exactly, its genes). On earth this occurred when the first truly erect walking species, *Sinanthropus pekinensis*, appeared; that was 1.5 million years ago, according to the very recent fossil dating by R. E. F. Leakey. Ample artefacts have been uncovered to show that they were tool-using and relied more on manipulative skill than on structural adaptations of the body for species survival. We have, or at least think that we have, reasons to suppose that, given certain broad and fairly general initial conditions, the appearance of such species in due course is again a certainty. Of course, there are many hurdles to jump before its superiority over other species, many of which are splendidly adapted to specific environments so long as they do not change, becomes established (as is so for us, *Homo sapiens*). Some species (e.g., the *Neanderthal man*) failed and went extinct. However, eventually one species would succeed. This is not so only if, for example, the planet is covered entirely by water, so that there is no land for life to invade from the sea and to develop stronger interactions with the environment. From these considerations a guess of f_h will be 0.5.

f_c is the fraction of planets populated by higher forms of life, on which civilisations develop to the stage of participating in interstellar communication. That is, they change from "planetary" civilisations (civilisations whose activities and modes of thinking are restricted in their scopes to their own planets) to extra-planetary civilisations. This is precisely the threshold over which we are about to step, and it is difficult to imagine that we will somehow regress. My considered belief is that similar laws of technological and social evolution apply in different planets, except where the natural conditions differ fundamentally. Lower life forms can be very unalike on different planets or even on different regions of a planet, because of the multiplicity of planetary initial conditions and of evolutionary accidents. However, as they evolve further, the influences of these boundary conditions decrease in proportion to those dictated by the universal laws of nature. Accordingly, the "psychologies" of different intelligent races should in general converge. With the conservative assumption that the development of a technological civilisation requires that things like low melting-point alloys and easily accessible fossil fuels are naturally existing, we take f_c as 0.2.

Finally, T is the lifetime of the communicative stage of these civilisations. In our view the *continued* development and progress of a technologically advanced civilisation depend on its social system, which is a matter of experimenting and choice, so that they are not only possible but probable because presumably they are its intentions. We then judge that, say, one out of ten civilisations lasts as long as the local sun remains "healthy." The averaged value of T will be 10^9 years.

With these values, N^* comes to be $(1\,\text{year}^{-1}) \times 0.5 \times 2 \times 1 \times 0.5 \times 0.2 \times (10_9$ years$) = 10^8$. In other words, on average one out of a thousand stars will possess on average one planet where there is a civilisation in the interstellar communicative stage. The main uncertainties in this estimation of N^* lie with the last three factors, namely f_i, f_c and T.

Using the mean density of stars in the Milky Way, which is 1 star per 200 cubic light-years, the mean minimum separation of communicating civilisations (i.e., the most probable distance between the nearest neighbours) will be the radius of the sphere of volume 2×10^5 light-years, or roughly 40 light-years. In general, the distance is $2 \times 10^4 / \sqrt[3]{N^*}$ light years.

If direct radio contact is considered, the civilisations have to exist in the same epoch. A slightly more complicated procedure gets $23 / \sqrt[3]{T_G/T}$ light-years as the likely minimum separation between 'contemporary' civilisations, [28] in which T_G is the galaxy time-scale, i.e. 10^{10} years. In our estimation therefore it will be about 50 light-years. This is not much greater than the previous estimation of 40 light-years, because we have taken T to be not much smaller than T_G. A more exact assessment will have to take into account the length of time required in biological evolution [29] but being much less than 10^9 years it can be taken as zero.

The chance that a randomly selected star is sending interstellar signals is 0.001. If and when the synchronisation problem referred to previously has been solved, we can be sure that, when we look at it, its signals are beamed towards us. In this case, the probability of achieving at least one contact after

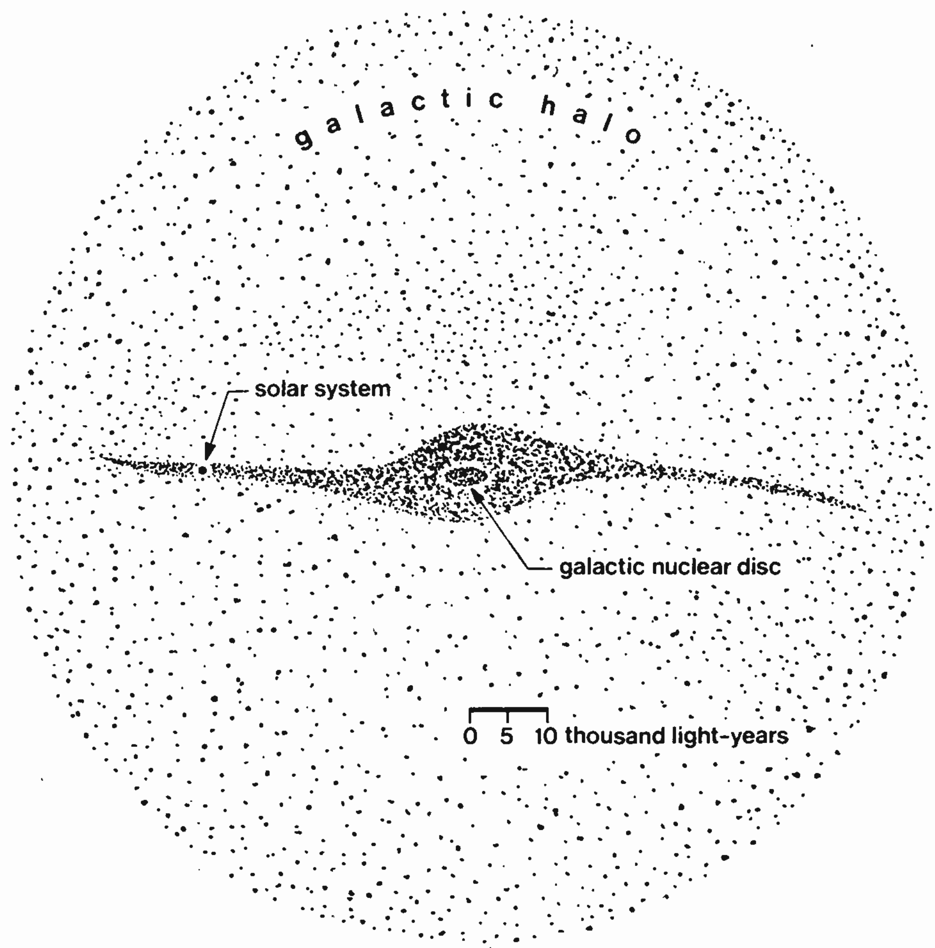


Fig. 5. Schematic picture of the galaxy, showing its shape and size and the relative position of our solar system.

searching N stars is $1-(1-0.001)^N$ or approximately $1-\exp(-0.001N)$. A search of a thousand stars will, assuming perfect synchronisation, give us a 63% success.

Inevitability of participation in interstellar communication

The feasibility of intentionally achieving communication by radio contact with extra-terrestrial civilisations has been shown. By way of conclusion I would point out one more consideration. We have been using u.h.f. radio communication for some fifteen years. Also, there must be now a few thousand television stations on our planet which transmit in channels 14 to 83 at a power of something like 20kW on average, and a lot of u.h.f. transmitters such as maritime radio beacons and satellites' telemetry and tracking. Earth is then radiating nearly a tenth of a watt per hertz into space at centimetre wavelengths. By the equation for L, we see that these radiations can be detected, over a distance of 50 light-years, by a radio telescope of effective area 40km^2 and listening to a bandwidth of one hertz. If there is such a telescope on a planet within this distance, the discovery of our presence in due course, whether we intend it or not, is highly probably.

To build this telescope does not necessitate fantastic technological sophistication. In fact, as investigated in the Project Cyclops [30], the construction by us of a phased antenna array of ten thousand parabolic reflectors, each 30m in diameter, is feasible (it would cost six to ten thousand million dollars but this is less than half the cost of the Apollo space programme.) Such an antenna system would have an effective area of 20km^2, and there appears to be no technological limitation to its expansion, to a size of 100km^2 or more. If we do build this colossal telescope, we will be able to eavesdrop on our neighbours. (A further feasibility study after Project Cyclops is being undertaken, and should be completed by summer 1976.) The Cyclops concept is already the basis of a very-large-array telescope now under construction in the plain west of Socorro in New Mexico. When completed, it will have 27 parabolic dishes, each 30m in diameter, and an estimated sum of seventy-six million dollars will have been spent. Scheduled for general radio-astronomical observations at 1.3, 2, 6 and 18-21cm wavelengths, it will be partially operating by the winter of 1977.

I have not discussed the rationality or even necessity of communicating with extra-terrestrial civilisations. Everyone will form his or her own opinion, and it seems out of place to argue here. However, it does appear obvious to me that it is wiser to devote our labours and resources to seeking out life outside Earth, than to building things which potentially destroy life on Earth and which are no less expensive.

The table [31] published last month listed projects to detect radio signals from extra-terrestrial intelligence which are still in progress. The complete projected programme in the USSR has been published [32]; it is perhaps at present the country where (mainly for political reasons) such work is taken on most seriously.

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Some readers interested in CETI and related subjects may like to read, among other magazines and journals, Spaceflight and the Red Cover issues of *J.B.I.S.*, both published by the British Interplanetary Society.

Sixty Years Ago

The following piece was printed, without much comment, in our issue of July, 1916. It was in the section "Digest or wireless literature", which contains a couple of fairly imaginative accounts of inventions and development, including a description of a wireless-controlled boat of 30 tons, which carried a torpedo at 50 mph and would turn upon and destroy any jamming transmitter!

Radium and aerials

"The following abstract of an article by E. Leimer in the Elektrotechnische Zeitschrift, printed recently by the *Electrician*, will be of special interest to our readers as it contains a report of some experiments on new lines.

On the results of Szilard with radium-coated lightning conductors becoming known to the author he was led to consider the possibility that radium might exert some effect upon the reception of radio-telegraphic signals.

The first experiments were made with an indoor antenna consisting of a wood rod closely wound throughout its length with wire, the rod being directed towards a sending station, FL, about 300 km distant from it. This antenna was suspended in a room. The receiving set used comprised a galena detector, 4,000 ohm telephones, and a tuning coil 50mm in diameter, and having 800 turns of enamelled wire. No signals were audible from FL at any position on the tuning coil. Signals were, however, at once distinctly audible as soon as a sealed glass tube containing radium bromide of 50,000 units (and thus very weak) was brought near.

Literature Received

Television sound, off-air, is provided by the Ambit 7700 tuner, which contains a u.h.f. tuning head and therefore requires no pickup coil. The tuner is compatible with 6MHz, 5.5MHz and 4.5MHz intercarrier frequencies at aerial input levels of 10μV or more and is provided with a four-channel selector and indicator. A leaflet is obtainable from Ambit International, 25 High St, Brentwood, Essex WW401

Multiway circular connectors, type 602GB, are described by Amphenol in a new catalogue. The connectors are intended for military and civil aerospace use and are resistant to most solvents and fluids likely to be encountered, including salt spray. They also meet the requirements of BS 2G 100 P2 C11. Amphenol Ltd, Thanet Way, Whitstable, Kent...................... WW402

Rare-earth cobalt alloys in powder form, for the making of permanent magnets, are made in a new process by T, H. Goldschmidt Ltd, which is discussed in issue 4/75 No.35 of Goldschmidt Informiert, available from the company at York House, 353a Station Road, Harrow, Middx.................. WW403

Aerials for domestic radio and television are dealt with in a publication from the British Aerial Standards Council. The booklet describes methods of measurement, together with the relevant electrical and mechanical requirements. Available from the council at 27 Ingorsby Lane, Houghton on the Hill, Leicestershire, the booklet costs £1.

Heathkit's new catalogue supplements, containing the latest exotica, are now available. Introductions are a pre-amplifier (£94), an equalizer (£88), a 200W power amplifier at up to £340, a 10MHz oscilloscope at £270 and a digital i.c. tester at £49. But the real mind-boggler is, we are informed, a Digital AM/FM Stereo/Quadraphonic Tuner/Preamplifier at £550. The only thing we couldn't spot on the front panel was a handle to wind it up. The supplements can be obtained from Heath (Gloucester) Ltd, Bristol Road, Gloucester WW404

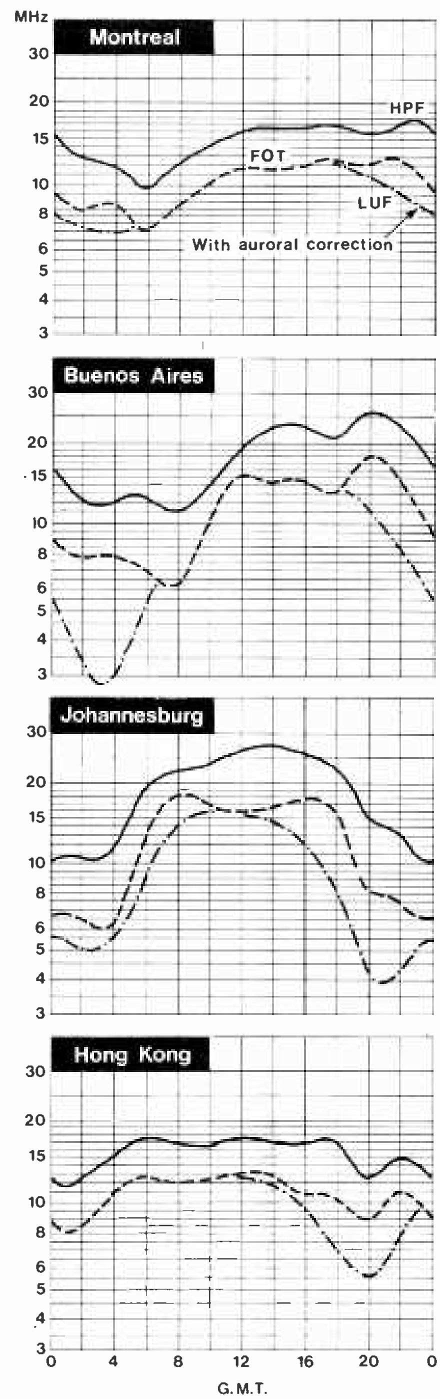
Precision metal pressing by Latham Manufacturing Co Ltd is briefly described and illustrated in a brochure, now available from Latham at Croxstalls Road, Bloxwich, Walsall, Staffs WW405

Audio accessories are listed by Ross Electronics in their enlarged catalogue, which includes tape, headphones, microphones, test meters and connecting leads. The catalogue can be obtained from Ross Electronics, 32 Rathbone Place, London W1P 1AD (Trade only.)

An X-Y recorder, the HR2000, is the subject of a brochure from Gould Advance. The instrument takes the form of a mainframe with inputs and pen controls, with a range of input modules to provide a choice of sensitivity and speed. The brochure is obtainable from Gould Advance Ltd, Roebuck Road, Hainault, Essex....... WW406

HF predictions

HPF (highest probable frequency) is the frequency above which the probability of ionospheric reflection is less than 10% and FOT (from the French optimum working frequency) is the frequency below which reflection probability is greater than 90%. Thus the skywave probability of any given frequency can be found from the charts. Although a skywave path may exist signals can be below noise level and LUF (lowest usable frequency) is the 90% probability contour of signal level exceeding noise level by a certain amount. Best operating frequencies for consistent day to day working will lie between FOT and LUF and this applies when LUF is higher or lower than FOT. The latter condition implies that the certain amount referred to above cannot be realised.



Unfamiliar forms of temperature compensated voltage reference

The Widlar diode and others

by K. C. Johnson, M.A.

It is almost universal, at the present time, to use zener diodes whenever a constant voltage is required in an electronic circuit. These devices depend on the breakdown of a reverse-biased junction between two semiconductors and the characteristic voltage can be varied over a wide range by controlling the abruptness of the junction (width of the depletion layer) during manufacture. If a very abrupt junction is made, breakdown occurs at a low voltage, while less abrupt junctions give higher voltages. In low-voltage devices the temperature coefficient is negative, since the breakdown is predominantly by the true zener action, while in higher-voltage devices, where breakdown is due to avalanche action, the coefficient is positive. In silicon, the two effects compensate at about 5.6V; consequently a silicon diode with this breakdown value has an almost zero variation with temperature. At 3.3V the variation matches that of an ordinary forward-biased junction such as the base-emitter of a transistor. Both of these types of diode, together with others where compensation is obtained by connecting junctions in series, are in very wide use and will be familiar to readers.

There are, however, two other ways in which temperature-compensated reference voltages can be obtained, using only the forward conduction characteristics of semiconductor junctions. These arrangements are very much less known, but offer advantages in that they work at lower voltages and do not require such precise control of the abruptness of the junctions. In order to understand their action one must first consider the effect of temperature on conduction under forward bias.

Forward-biased junctions

The usual Schottky formula for the current flow i at an applied voltage V is

$$I = I_0[\exp(qV/kT) - 1]$$

where I_0 is the leakage current, q the electronic charge, k Boltzmann's constant, T the absolute temperature.

From its appearance, this formula should also predict the changes of current with temperature, as it clearly contains T, but in fact any results it gives will be wildly wrong. The trouble is that I_0 is not constant but changes rapidly with temperature.

To improve matters we must alter the formula into the form

$$I = I_G[\exp(q(V-V_G)/kT) - \exp(qV_G/kT)]$$

and choose a value for V_G so that I_G really is essentially constant irrespective of temperature changes within the working region. When this is done it turns out that V_G is approximately equal to the energy gap of the semiconductor material (1.2V for silicon) while I_G has a value far larger than any real working current.

Suppose now that such a diode is made to carry a constant current while its temperature is allowed to change. The second exponential term in the formula represents the insignificant leakage current only and so the first term must remain virtually constant. It can only remain constant if $(V-V_G)$ changes in direct proportion to T, and this is what happens in practice.

If, for example, a particular type of silicon diode requires 0.65V to carry 1mA at 25°C, the formula predicts a temperature variation of

$$\frac{0.65-1.2}{25+273} = -0.00185\ \text{V/°C}$$

which clearly agrees well enough with the normally accepted figure of −1.8mV/°C.

This behaviour can be represented graphically as in Fig. 1. A diode behaves as if cooling to absolute zero temperature would make it insulate at all

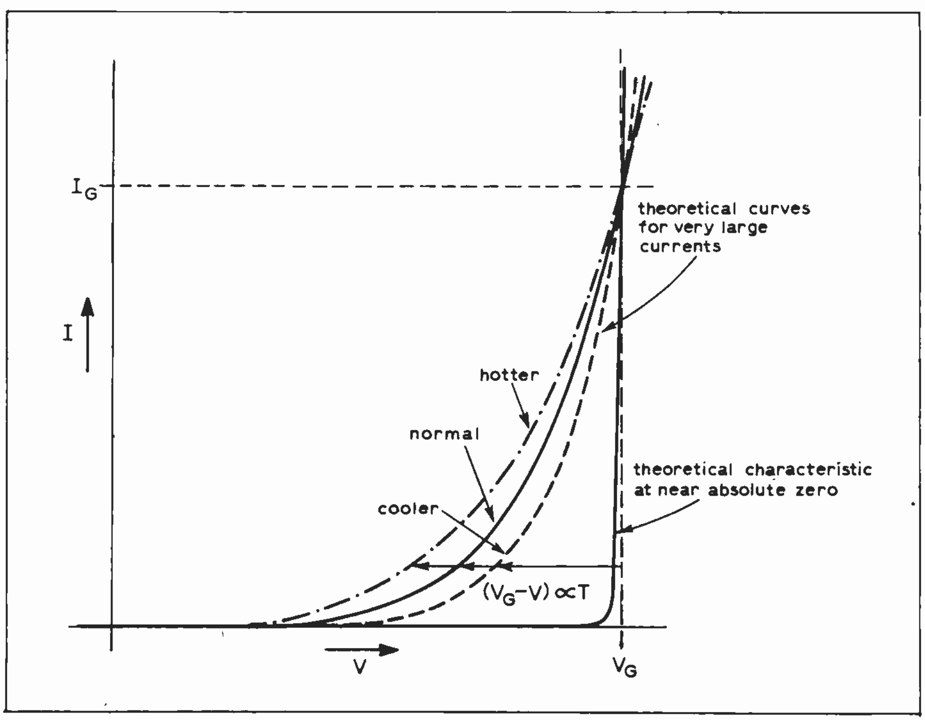


Fig. 1. Zener diode characteristics indicating how the difference between the voltage (V) across a diode at any given current and the energy gap (V_G) of the semiconductor expands in direct proportion to the absolute temp. (T).

voltages below V_G and then turn on unlimited forward current, with an almost superconducting slope resistance, at that voltage. As the temperature is increased, the familiar exponential characteristic appears and expands linearly away from the V_G ordinate.

The Widlar diode

The Widlar diode is really an assembly of three transistors and three resistors, as shown in Fig 2. All the junctions are of the same semiconductor material and are essentially at the same temperature, but the circuit behaves as a compensated voltage reference as seen at the two terminals. Temperature compensation is obtained by exploiting the fact that a forward-biased junction, carrying less current in the same area, has a working voltage further away from V_G and hence has a greater temperature coefficient. In silicon, the effect is roughly a 10% increase for every reduction by a factor of 10 in the current. This can be verified from the formula given.

The three resistors in the circuit are selected so that Tr_1 and Tr_3 each carry 1mA, while Tr_2 carries 0.1mA (all three transistors being of the same type) when the voltage applied is at some value near 1.2 volts. Typically, the values might be 540Ω, 575Ω and 5.4kΩ respectively for R_1, R_2, and R_3. Therefore the whole assembly carries 2.1mA at 1.2 volts.

If the applied voltage is increased slightly, the current in Tr_1 will, of course, increase. The stabilizing effect of R_2, however, makes the corresponding increase at Tr_2 very much less, even as a proportion. The voltage across R_3 therefore remains almost constant and a large part of the original voltage increase is passed to the base of Tr_3, which is consequently turned on. The overall effect is that the slope resistance at the terminals is in the region of 30Ω while the intercept resistance is nearly twenty times this value. The circuit clearly gives a constant voltage action.

Suppose now that the temperature rises slightly. The voltage at the base of Tr_1 will fall, since the junction conducts more easily, and the base of Tr_2 will fall with it. The emitter junction of Tr_2, however, was carrying less current and so has a greater temperature coefficient. The voltage across R_2 therefore rises and increased current flows in Tr_2 and R_3. If R_3 is large enough the resulting fall of voltage at the base of Tr_3 can be sufficient to cut the current in that transistor by an amount greater than the combined increase in Tr_1 and Tr_2, despite the warming of the emitter junction.

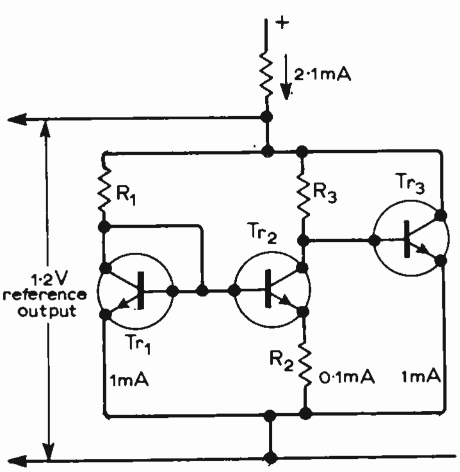


Fig. 2. The Widlar diode circuit.

The magnitude of R_3 depends directly on the value selected for the voltage when the resistor values were determined. Selection of a large voltage would therefore have given over-compensation, while a small voltage would have under-compensated. The value for an exact balance depends on the precise properties of the components used, but is in the region of the figure of 1.2V already quoted.

The fact that this arrangement uses only standard transistors operating in the normal way makes it much more attractive than a zener for use in integrated circuits. The lower voltage is also more convenient if the incoming power is from batteries or a standard 5V supply. Many integrated circuits rely on Widlar diodes for their voltage references, but the three transistors are often hidden in a complex circuit diagram without any clear explanation of their function.

The l.e.d. as a reference

Another, simpler, form of temperature-compensated voltage reference can be obtained using the forward conduction characteristic only. If two junctions of different semiconductor materials both obey the theoretical formula reasonably well then it is possible to select the devices and adjust their current levels so that the values of $(V-V_G)$ match to give equal variations with temperature, while the actual values of forward voltage are appreciably different. If the two voltages are arranged to subtract in a circuit the required effect can be obtained.

Silicon and germanium could obviously be used in this way but the resulting difference in voltage would be rather small and might not be very stable. A more attractive alternative, which has only recently become possible, is silicon and gallium phosphide or arsenide phosphide. Diodes made from these new materials are now in large scale production for use as l.e.ds and are already no more expensive than zener diodes. In spite of the fact that they are designed primarily for making visible light these devices have a surprisingly low series resistance and obey the Schottky formula well at currents in the milliampere region.

A great many different types of device are being made and the values of $(V-V_G)$ can be expected to vary accordingly, but some measurements of a few

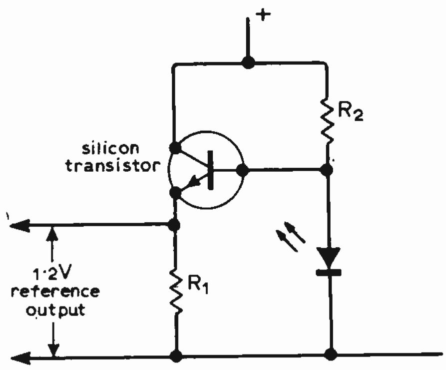


Fig. 3. A reference voltage using a gallium phosphide l.e.d.

commercial l.e.ds of various colours were made by Mr S. G. Hale and all showed values of temperature variation within 10% of that of a typical silicon transistor. There would appear to be little difficulty in selecting devices to match more accurately than this. The value of V_G for this material is about 2.4V, so the compensated reference output will again be in the region of 1.2V.

The kind of circuit shown in Fig. 3 can be used to obtain the necessary subtraction. The resistors R_1 and R_2 fix the levels of current in the two junctions and can be adjusted to give a fine control of the compensation, since a larger current gives a reduced variation. If a really stable output is required the l.e.d. should be shielded to avoid any photo-cell action, but for most practical applications this refinement is unlikely to be needed and the device might even do double duty as an indicator lamp.

If a constant current rather than a voltage is required, then this can be obtained from the collector of the transistor in Fig. 3. Once the basic principle is understood, there is no great difficulty in arranging circuits for multiplication of the voltage or any other of a vast range of requirements. This second system may well prove the more useful to readers on account of its simplicity, but it is unlikely to find application in integrated circuits due to the mixing of semiconductors.

Gravitational radiation — a fruitless search

Another disappointment in the search for gravitational radiation: the Glasgow University team working on the subject report a negative result from further test runs. This latest work was designed to test the possibility that a series of short pulses of gravitational radiation might produce a cumulative response in a detector, big enough to account for reported detections elsewhere. This now seems likely.

Wideband compander design

Simple square-law circuit gives 100dB dynamic range

by John Vanderkooy

University of Waterloo, Ontario

The wideband compander described can preserve the dynamic range of virtually any input signal when recorded by a normal tape recorder. Operational amplifiers and matched photocells allow accurate compansion with no necessity for calibration or care in recording levels. The unit can be used in compression mode for recording or playback in noisy environments, and for speech signals.

The dynamic range of tape recorders has never been adequate for high quality reproduction. If a high input level is used in an attempt to decrease the effects of tape noise, distortion results on loud passages and transients are severely distorted. Reducing the level to allow even moderate transients to be captured with little distortion means that small signals will be lost in noise. A good quality half-track reel-to-reel machine can expect a signal-to-noise ratio of about 60dB and because normal audio signals vary more than this, most recording is caught in the compromise between noise and signal distortion.

Several commercial devices are available to solve these noise problems. Dolby A systems are compressor-expanders that work in a number of frequency bands in the audio spectrum. They are very virtuous but are beyond the stage where home construction can be contemplated. The Burwen compressor-expander[1] is a device that works over the whole audio spectrum, using cube-root compression and cubic expansion, along with some equalization. Circuits for this compander were not available to the author, but the appeal of the basic system was such that a design suitable for home construction was sought and finally achieved. A recent advertisement from DBX indicates their companders may be similar to the one described here. Recently, Self[2] has detailed a circuit for compression only. Stuart[3] has described several other active systems but not the power law compander so its basic merits will be given below.

If a compressor is designed to take an input audio signal I of large dynamic range and compress it to an output θ in accordance with the law

$$\theta = k_1 I^{1/n}$$

where k_1 is a constant and n is a positive integer (it could be fractional, but the electronics is more complicated), then the dynamic range of θ can be such that a tape recorder can faithfully record this signal. We assume that the playback signal P is equal to θ for a unity gain recorder. (There will be some error and its effect will be discussed later). Then if an expander is made which gives a final output signal S given by

$$S = k_2 P^n,$$

then
$$S = k_2\theta^n = k_2(k_1 I^{1/n})^n = k_2 k_1^n I$$

and hence except for the constants, which will vary if level controls are altered, the signal S is a scaled version of the original input I. For domestic use it is argued that $n=2$ is a good choice. An input signal of 100dB variation will be compressed to 50dB at the tape, thereby achieving a good performance with modest recorders. The $n=3$ system used by Burwen[1] shows deficiencies when used with domestic recorders having considerable variations in response with frequency. If the recorder has a response error of XdB then the final expanded signal will have an error of nX dB. A wide spectrum signal such as normal audio will relieve these difficulties, but if a 6dB variation in response exists, the cubic system is impractical.

Recent articles by Shorter[4] on the Wireless World Dolby B noise reducer give much useful information on compansion in general and prompt a comparison between wideband compansion and Dolby B. I have always preferred the transmission of programme material by simple 2:1 logarithmic compression, rather than Dolby B methods, because the frequency response is then not altered by receivers not equipped with standard decoders. I fear the extra top will become so enticing to people that the Dolby decoders will hardly find use. In essence it boils down to a preference for distortion in level as opposed to distortion in frequency response. An interesting view of Dolby methods from the BBC recently appeared in a letter to the editor[5].

A real advantage of the Dolby B approach is that only high frequencies are altered, and gain changes can be made so quickly that no noticeable noise modulation and breathing exist. Present-day wideband companders can partially solve these problems as well. Firstly, the attack time can be very short, so that extra pre-emphasis can be used with a consequent reduction in noise. This however, creates more incompatibility with existing components and pre-emphasis is not used in the present design. Secondly, by using special filters to eliminate self-modulation distortion, but still retaining a rapid decay-time, the effects of noise modulation and breathing are subjectively reduced. This concept is used in this design. A definite advantage of wideband compansion is the much greater degree of noise reduction for low-level signals, as will be evident later. Professional assessments of companders and Dolby systems are given in recent reviews[6]. For the moment it is to be appreciated that wideband compansion prevents overloading the recorder, reduces the effects of noise at low signal levels, and virtually makes recording level controls unnecessary. In addition an accurate power law device will reproduce faithfully irrespective of the settings of the level controls. No reference levels are necessary as in Dolby systems or other non-linear companders.

Requirements

The heart of a compander is a gain-controlled amplifier which can divide or multiply the gain by means of a control voltage. It must be capable of 50 or 60dB gain variation with an accurate characteristic. A good audio bandwidth must be maintained over the whole variation, and the distortion should not exceed 1%. The gain variation must be rapidly programmable as well. A servo system driving a potentiometer would be accurate but too slow. A good figure to shoot for in response time is several milliseconds. This allows even transients to be respectably dealt with.

A well-built transconductance multiplier will satisfy the above characteristics, but it has too much wideband noise. This is due to the necessity of small signal levels at the bases of the multiplying transistors to prevent distortion.

As well as an accurate multiplier-divider, the circuits which caliper the audio level and produce a smooth rectified signal proportional to the amplitude must be accurate and have an attack time less than a few milliseconds. The release time should be rapid to prevent pumping but not rapid enough to cause distortion by "self modulation" of a low-frequency signal.

Experiments

Early experimental attempts at making the multiplier-divider centred on f.e.ts and their source-drain characteristics near the origin. Distortion is high if the f.e.t. is used in a straightforward way. It can be greatly reduced if the gate is driven not only as a control voltage but as an alternating voltage which is midway between that of the source and the drain as in Fig. 1(a). This gives the device a drain characteristic of odd symmetry. Thus all even harmonics are entirely

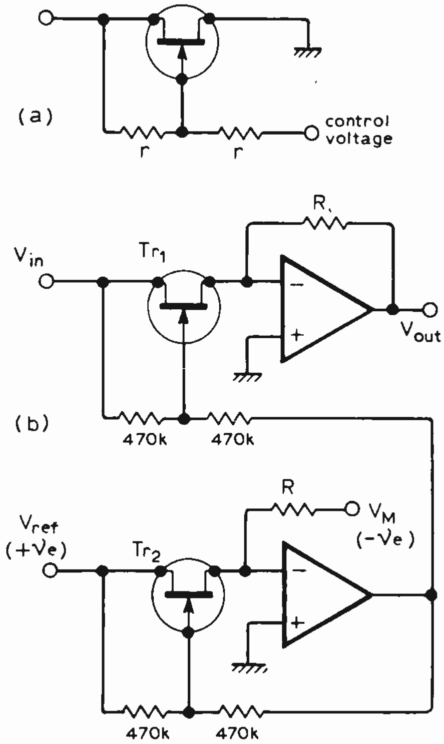


Fig. 1 (a) The distortion of the f.e.t. as a voltage-controlled attenuator can be reduced by driving the gate with an alternating voltage midway between the source and drain voltages. (b) by using a second matched f.e.t. the variation of the gain can be made proportional to V_m/V_{ref}.

removed by this "push-pull" technique, and only odd harmonics, mainly third, occur at higher signal levels. The problem still remains that a large gain variation of greater than 30dB is difficult to achieve, and the gain is not a simple function of the control voltage. The last-mentioned problem can be alleviated by using one of a matched pair of f.e.ts (a dual) to generate a specific resistance using an operational amplifier.

In Fig. 1(b), Tr_2 has a resistance which is determined by setting the input current of the op-amp equal to zero with due respect for the virtual earth, i.e. $V_{ref}/R_{f.e.t.} = V_m/R$. Transistor Tr_1 will have the same resistance and the upper circuit, which handles both polarities for audio, will obey a law $V_{out}/R = V_{in}/R_{f.e.t.} = V_M V_{in}/V_{ref}R$. Thus $V_{out} = V_{in}V_M/V_{ref}$. Division and multiplication have both been accomplished! This circuit technique must be remembered for the multiplier to be described later. It is not suitable in the present form since not enough gain variation is available.

Another method attempted was to make a transconductance multiplier using f.e.ts as the input active elements. They would not be as linear as transistors on a relative basis but since the voltage scale on which they turn on is about a volt as opposed to the 25mV for a transistor, much less attenuation of the input signal is necessary and this together with lower f.e.t. noise would reduce the noise to small values. Disadvantages of the design are the difficulty of obtaining division and the requirement of four well-matched f.e.ts.

Photoconductive cells were also considered as possible gain control elements for the multiplier-divider. Initial experiments indicated that when a light-emitting diode was suddenly turned on the coupled photocell would respond with approximately two time constants, one a fast but rather small relative behaviour, the other a slower rise of about 10ms to a final conductance level. This is not suitable for a fast-acting gain control circuit. Also the final conductance value was not properly proportional to the l.e.d. current. Fig. 2 shows the characteristic of resistance versus current for a CL904N photocell coupled to an l.e.d. A straight line of slope −1 would represent ideal behaviour.

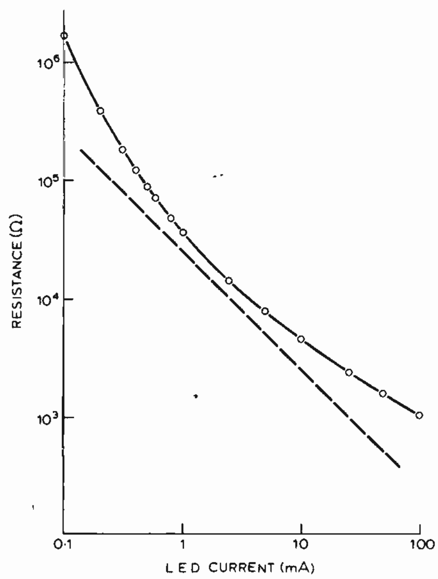


Fig. 2 Curve of photocell resistance versus l.e.d. current for a Clairex CL904N photocell when illuminated by a red l.e.d. The unbroken line is drawn through the experimental points. The dashed line represents ideal behaviour.

It was decided to employ op-amps to linearize the cells using the technique mentioned earlier. Fig. 3 shows the basic idea for a multiplier. A divider can be constructed by interchanging the resistor and the photocell as gain-determining elements for the amplifier A_1. The l.e.d. shines equally onto both photocells. Tracking of the photocells is essential for an accurate power law compansion, but an error does not significantly affect the overall characteristic, see later. From five photocells at least two would track well over factors of 100 change in the resistance.

Experiments with this multiplier-divider

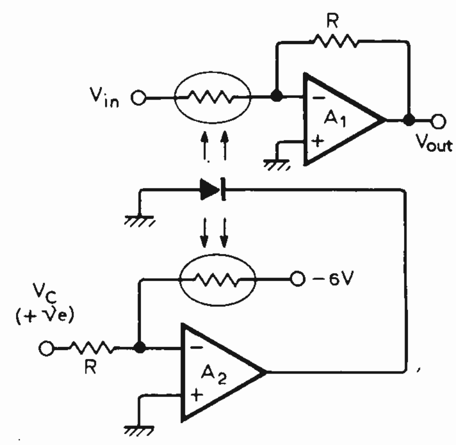


Fig. 3 Photocells and a controlling l.e.d. are used here as a multiplier using a concept similar to that shown in Fig. 1 (b). For this circuit $V_{out} = V_c V_{in}/6$.

showed that a 60dB range was possible and the attack time for a large step increase in the control voltage was about one millisecond. The feedback has thus considerably reduced the sluggishness of the cell. At low light levels the cell seems to have a longer time constant and a nonlinear network placed in series with the l.e.d. maintains good control stability over all voltage levels.

Fig. 4 shows the rectifier circuit that was adopted to produce a direct control voltage for the multiplier-divider. Amplifier A_2 has circuitry which creates an absolute value circuit with a gain of 2/3. Diode D_2 is used to create a virtual earth at the inverting input for positive input signals so that the upper 5k and 10k resistors can form a simple attenuator. This diode also prevents op-amp saturation and hence allows accurate response up to the highest audio frequencies, a feature which many precision rectifier circuits do not have.

Amplifier A_3 is a peak detector in which D_4 prevents saturation of the op-amp when the input voltage from the absolute value rectifier is lower than the voltage on C_1. Another advantage of this diode is more subtle. If a rectified sine wave of constant amplitude is fed into the peak detector, the

Fig. 4 Schematic of the circuit used to obtain an absolute value of the audio signal and produce a control voltage proportional to the peak of the waveform.

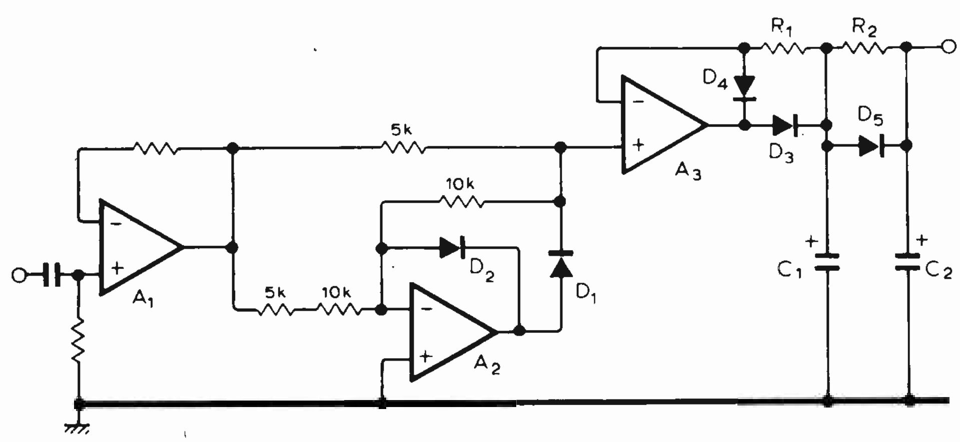
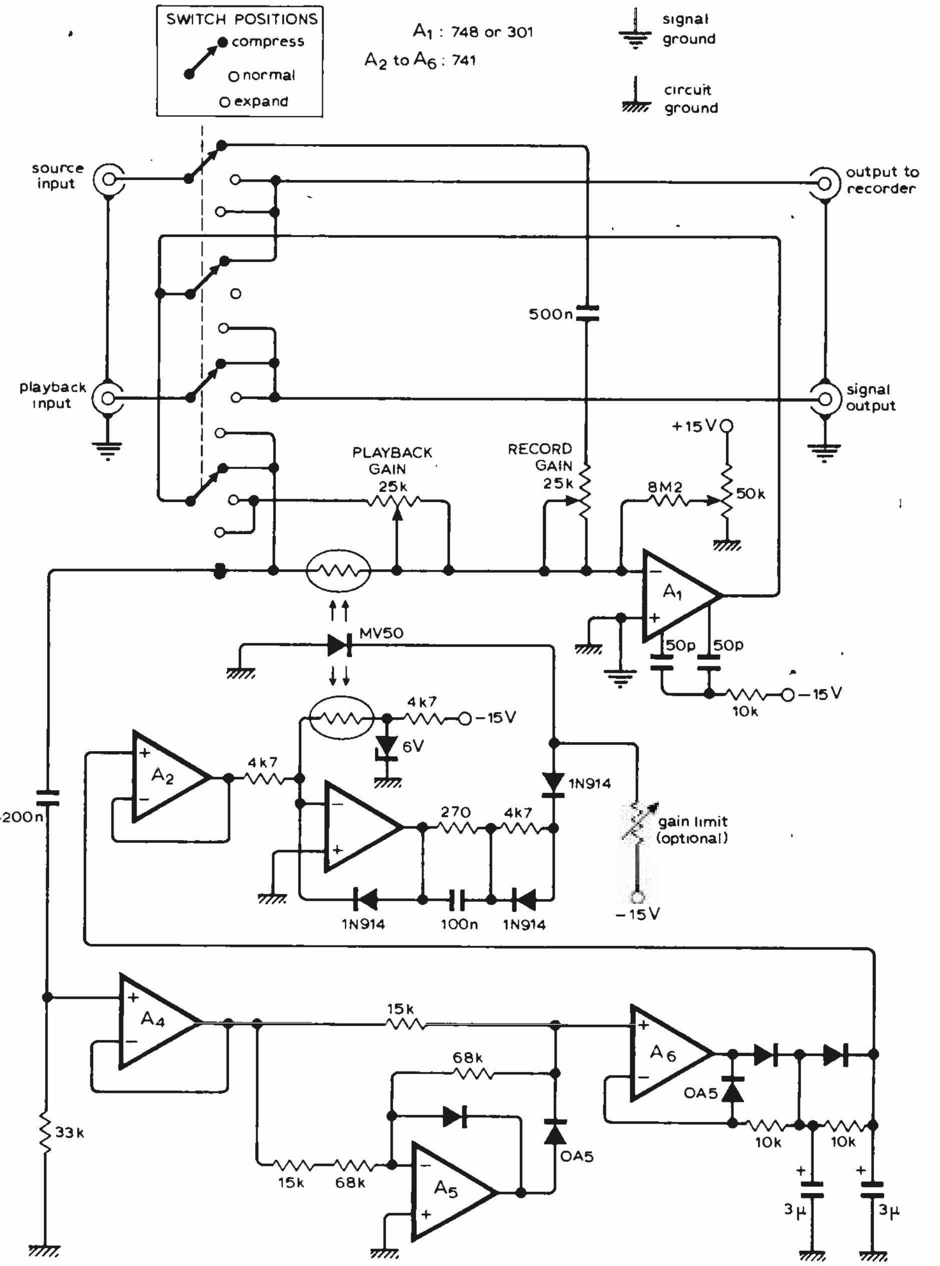


Fig. 5 Complete schematic of the compander. Op-amps are assumed to have ±15V power supplies. For best performance amplifier A_1 should have separately decoupled supplies. The 10kΩ resistor in the compensation should be referred to the negative supply.



droop at C_1 is much less than in a circuit in which R_1 is returned to ground rather than the inverting input terminal. This is so because the negative input terminal follows faithfully the input signal on the non-inverting input terminal. However, if the audio signal dissappears, then R_1 is effectively returned to ground and the decay time constant is short. For audio frequencies $>1/2\pi R_1C_1$, the droop is only $1-(2/\pi)\approx 0.36$ as large in this circuit as when R_1 is returned to ground. Components R_2 and C_2 provide extra filtering and D_5 allows the control voltage to rise quickly in the presence of audio transients. The input follower A_1 is necessary because the input impedance of the absolute value circuit changes with signal polarity.

Circuit description

The complete compander circuit diagram is shown in Fig. 5. Switching allows the circuit to be used as a compressor during recording, and as an expander during playback. In the compression mode, the control voltage acts to decrease the audio gain as a divider. Hence the output θ will be related to the input by the relations $\theta \propto I/V_c$. But V_c is derived from the amplitude of the output signal, hence $V_c \propto \theta$. Thus $\theta \propto I/\theta$ or $\theta \propto \sqrt{I}$, a square-root compressor. When in the expansion mode, the audio gain is precisely proportional to the control voltage. Hence the final output signal S is related to the playback signal by the relation $S \propto PV_c$ but V_c is derived now from the audio signal P, hence $V_c \propto P$. Thus $S \propto P^2$ and a square-law expander results.

If the photocells do not track well, the division or multiplication factor must still be the same function of control voltage, say $f(V_c)$, because of the way the photocell is switched in the compress and expand modes. Hence $\theta = I/f(V_c)$, and if we assume again that $P=\theta$ (for a good recorder) then

$$S=Pf(V_c)=\theta f(V_c)=I.$$

Thus a perfectly complementary system still results. Careful analysis shows that this is true only if the recorder has unity gain, because otherwise the playback signal would produce a different control voltage than that used during recording. Only a power-law behaviour of the function $f(V_c)$ will preserve the relative level differences. In the present circuit $f(x)=x$, a simple function indeed.

The major circuit blocks in Fig. 5 can easily be recognised from the earlier discussion, but several features warrant special consideration. The operational amplifier A_1 used in the multiplier is used in a circuit in which the gain is varied by up to 60dB. At unity inverting gain, a compensation capacitor of about 15pF between pins 1 and 8 (half of that for a voltage follower) is necessary for stability. But this is detrimental to the frequency response when the gain is high (a small amount of feedback), as for example during small signal levels in compression. Pin 8 comes from the output circuit of the op-amp. Pin 1 is a high impedance point which has a signal referred to the negative supply line. The difficulty occurs when the high level signal from pin 8 is injected into pin 1 through the normal compensation capacitor. The gain is drastically reduced at high audio frequencies. But there is no problem with op-amp stability at these frequencies; instability only occurs near 1MHz. The 10kΩ resistor between the two 50pF capacitors shunts the gain reducing signal to the negative supply line thus restoring the gain at audio frequencies while not materially affecting stability considerations at megahertz frequencies.

An important point is the selection of photoconductive cells. Impedances of 1kΩ are ideal for op-amp gain determining resistors. Lower values might tend to cause current limiting at high signal levels. It is therefore recommended that the photocells have resistances of not much less than 1kΩ when illuminated by an l.e.d. carrying a current of 10mA. The l.e.d. can be glued to the two matched photocells (or dual photocell) with clear epoxy.

In a stereo system one has a choice of building a compander for each channel (the best solution) or of combining functions together. In a combined system it will be necessary to control three photocells with one l.e.d. If matched l.e.ds are available then two double units can be used. But they are not easily matched. Some require a threshold current before they start to emit light. In any event the right and left channels should be summed before peak detection. The voltage follower in the rectifier circuit can easily be rewired to act as an inverting summer. Of course two separate op-amps will be necessary with compensation as described earlier.

Due to the switching in the rectifier and peak detecting circuits, it is recommended that separate decoupling be used for the supply lines to the signal op-amp. All input and output connectors should have their signal ground connected to the non-inverting input of A_1. You may wonder why a low-noise audio op-amp such as the Fairchild 739 was not used in the signal circuits. This is because these do not have adequate reserve gain for the multiplier – divider action necessary here. They also draw more input current, causing greater offsets when the gain is high. It is wise to include the input offset current adjustments for the signal op-amps as shown in Fig. 5. The offset is adjusted to provide zero direct output voltage with a very low signal input in the compress mode. If this is not done a low frequency thump will occur when the gain

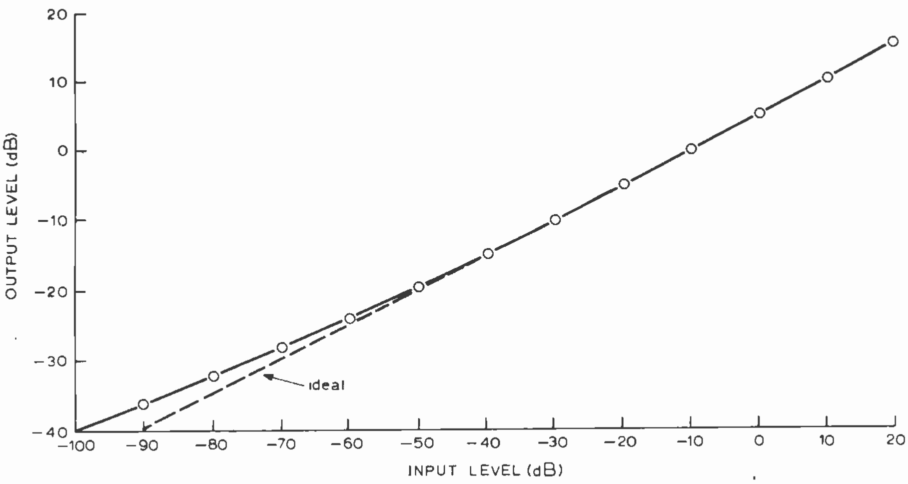


Fig. 6 Curve indicates output level versus input level when the compander is in the compression mode. Note that a 60dB input variation is compressed to 30dB of output variation to be recorded on the tape.

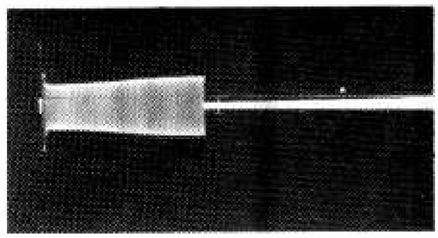


Fig. 8 Oscillograph of the compressor output when the 1kHz input signal is suddenly increased by about 30dB by a mercury wetted relay. (20ms/div horizontally, 2V/div vertically.)

changes quickly.

Another point is that for no signal level in the compress mode, the gain is very large and is limited mainly by the rectified output noise. This is not usually a problem since most sources for recording in the home such as discs and microphone arrangements have enough background noise. An easy way to eliminate such problems is the inclusion of a resistor shown dotted in Fig. 5 which limits the maximum gain, by preventing the l.e.d. current from becoming zero.

As shown, the compander responds to very low frequency signals and has low phase shift. Sometimes a turntable can have a large low frequency rumble which can modulate the compressor gain. In such cases a filter should be used to remove such low frequencies. A simple solution is to decrease the value of the 0.5μF record input coupling capacitor to give an appropriate cut off frequency. If a recorder with restricted bandwidth is used, it is wise to restrict the input to the compander to the same extent. This ensures that the rectifier circuits will see similar signals on compression and expansion.

The power supplies should be well regulated for optimum performance, but unregulated supplies with good ripple filtering are acceptable. The transformer should supply 11V a.c. on open circuit and allow 70mA of current drain.

All diodes can be silicon signal diodes, such as 1N914, 1N4148, 1S44; only D_5 in Fig.4 should be a germanium signal diode as this will help reduce overshoots in compression.

Input impedances are simply given by the values of the record and playback preset potentiometers. The outputs are low impedance, and perhaps 560Ω resistors should be added in series with these outputs to prevent damage if high signal levels are inadvertently applied to these outputs.

Performance

The most important characteristics are the compression and the accuracy of the whole process. Fig. 6 shows the graph of output level versus input level in the compression mode of operation. The deviation of the curve at very low input levels is due mainly to photocell tracking error, and partially from the amplified noise of the 748 op-amp. The input voltage is not measured at these low levels; it is inferred from the settings of an accurate low impedance attenuator. Deviation from a square root behaviour is never more than 1dB for well over 80dB of dynamic range. All levels are in dBm (0dBm = 0.775V r.m.s.).

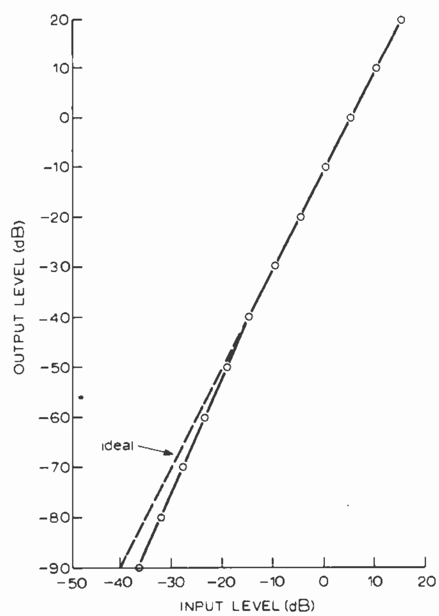


Fig. 7 Output level versus input level in decibels for the expansion mode. A 30dB input variation from the recorder on playback would be expanded to an output of 60dB to be fed to a power amplifier.

Fig. 7 shows the output level versus input level in the expansion mode. The curve again shows almost no discernable deviation from a square law. Output levels are difficult to measure with standard a.c. voltmeters below about −90dB. The complete characteristic from recording input to final signal output is linear to much better than 1dB because of the exact complementarity discussed earlier.

Even the dynamic characteristics are precisely complementary, because the audio signal used to produce the control voltage is derived from the output in compression mode, and from the playback input signal in expansion mode. These two signals should be the same for a good tape recorder. An overshoot in the compression mode, which is very difficult to suppress completely because of the time constants of the photocells and the peak rectifier, will not be problematic because it will be exactly undone in the expansion mode. Only the leading edge of a transient sound will perhaps not be faithfully recorded, but the ear will forgive severe distortion for periods of several milliseconds. Fig. 8 shows the output signal to the recorder in compression mode when the input signal is suddenly increased by about 20dB. The signal frequency is 1kHz. Notice that there is a slight overshoot in the compression that lasts about 10ms. The transient edge dies away with a time constant of about a millisecond. There is some dependence in Fig. 8 on the phase of the input signal at the moment of switching in the higher level. One would expect this in fast-acting circuits. A real audio transient is likely to be less severe than the instantaneous switching used here as a test signal.

The release time constant is less than a tenth of a second, giving a fast enough action that even on a rapid reduction in signal level, no noise is noticeable on replay. The rapid release time is also advantageous if the compressor is used on the output of an automobile radio. The normally large variations in signal level will be reduced so that low levels are not masked by the ambient noise. (I have often wanted something akin to an engine-speed dependent volume adjustment on my automobile radio.)

For high fidelity purposes the compander must have low distortion. Fig. 9 shows the measured second and third harmonic distortion versus frequency in compression mode for an input level of +10dB. The rise at low frequencies is due to the ripple from the peak rectifier. The wideband distortion is due to the photocell characteristic and is mainly third harmonic.

Fig. 10 shows the second and third harmonic distortion versus the output signal level (the voltage across the photocell) at a frequency of 1kHz. Except at high output level, the distortion quickly falls near the noise limit of the wave analyser. There is approximately 0.05% of residual third harmonic distortion in the oscillator which may slightly raise or lower the measured third harmonic, depending on phase relationships. Distortion level is low enough because it does not represent a crossover distortion, only a gently curving transfer characteristic. However, it would be unwise to be too defensive

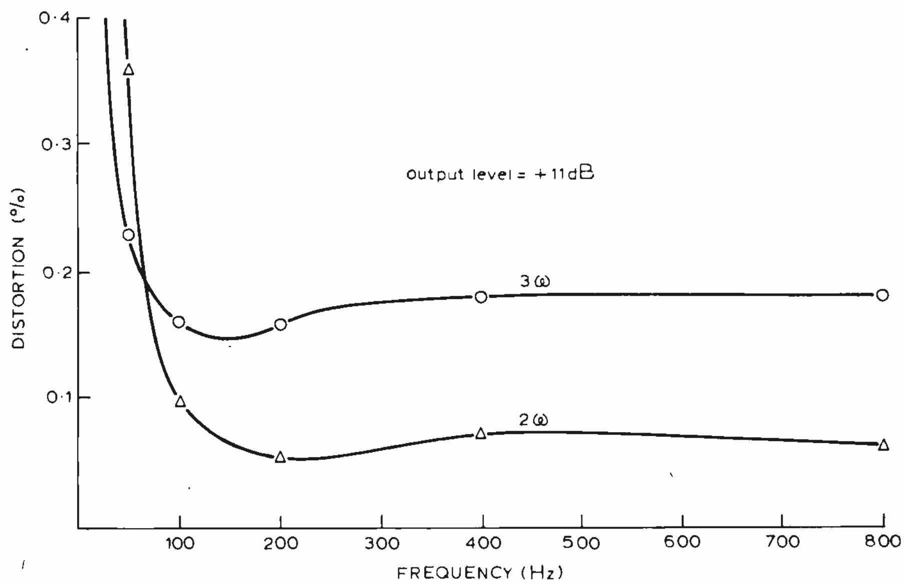


Fig. 9 Distortion of the compressor versus frequency for an input level of +10dB. Curves are substantially constant beyond 800Hz with a small increase beginning beyond 10kHz.

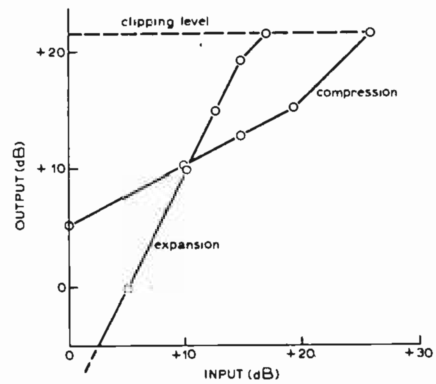


Fig. 11 Characteristics of the compander for high level signals. Clipping level in the compression or the expansion mode is determined by the supply voltage of the operational amplifiers. Deviation from square-root compression and square-law expansion results from the current limiting of the amplifier A_3 driving the l.e.d. These levels were obtained by setting the record and playback present potentiometers to 10kΩ. Altering these values will alter the point at which the behaviour saturates.

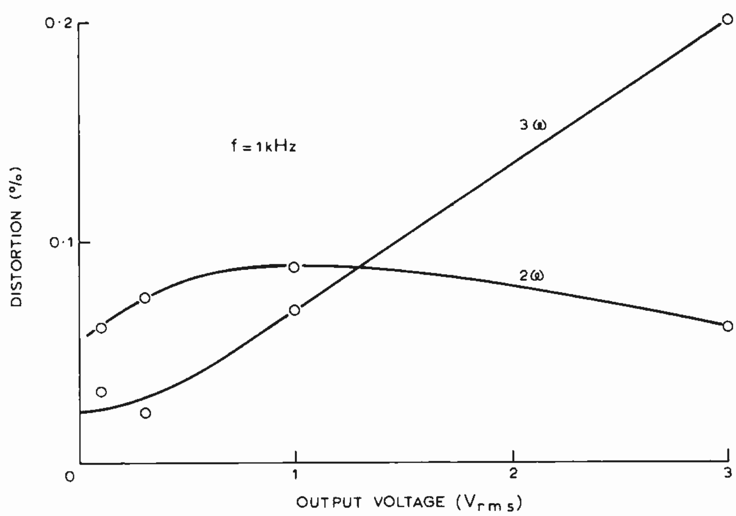


Fig. 10 Distortion of the compressor versus output voltage level at a signal frequency of 1kHz. There is a residual distortion of about 0.05% third harmonic in the oscillator which may alter the third harmonic results somewhat at low levels.

about distortion levels in photocell circuits. Some cells have much larger distortion than others. A number of different types were tried. I admit I could not *hear* the difference, but measured distortions of up to 2% at high level were occurring for some cells. The circuit whose measured low distortion is shown in Fig. 9 and 10 uses quite inexpensive cells, type VT-833, manufactured by Vactec Incorporated.*

Any reasonably fast CdSe photocell could be used with resistance characteristics as described earlier. A quick check on distortion can be made by applying 10V r.m.s. at 1kHz to a divider made up of 10kΩ resistor and the cell, illuminated to a resistance of about 10kΩ. If no appreciable curvature exists on an X-Y oscilloscope display or cell voltage versus oscillator voltage, the cell has suitable characteristics.

In Fig. 11 the clipping characteristics of the compander are shown in compression and expansion modes. The break point is due to current limiting of the amplifier A_3 in Fig. 5 which drives the l.e.d.

The final test of performance of an audio circuit must be the human ear. In microphone arrangements using the compander there is dead quiet at no signal level. This is far from true without the compander. Replay sounds natural and the settings of the level controls on either recording or playback are unimportant as long as overload is prevented. Using good discs as a source there is no noticeable difference in the dynamics even on piano music when the compander is used. This is impressive performance for such a simple circuit.

How can the audio enthusiast use the compander? If his tape recorder has a signal-to-noise ratio not much worse than the sources at his disposal, then it is hardly worthwhile using it to preserve dynamic range. However, modern stereo cassette recorders have signal-to-noise ratios of around 50dB, whereas a live f.m. broadcast can have 70dB. Then 20dB of increased dynamic range will result. In a live microphone setup with a low noise preamplifier the increase in dynamic range is greater than 40dB, and here the compander allows almost complete disregard of the level controls.

If master tapes and discs were made with a square root compressor and radio stations would broadcast these directly, then an expander in the receiver could bring back the full dynamic range of the original signal. Another use for the compander occurs whenever there is a high background noise level, such as in an automobile, workshop, or a home with children. The unit can be used to process a signal using compress mode, so that the dynamic range of the signal stays sensibly above the noise level. It is wise to include the dotted resistor of Fig. 5 in such setups to reduce the noise output when the signal level is very low.

*U.K. agents Teknis Ltd, Teknis House, Meadrow, Godalming, Surrey GU7 3HQ. The cells cost around £1.

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1 Burwen R. S. Design of a noise eliminator system *Audio Eng. Soc.* Vol 19 December 1971.

2 Self, R. G. High-quality compressor printer, *Wireless World*, Dec. 1975 p.587-90.

3 Stuart, J. R. Tape noise reduction, *Wireless World* March 1972.

4 Shorter, G. Wireless World Dolby noise reducer, *Wireless World*, May 1975, p.200

5 Dolby f.m. broadcasting (letter), *Wireless World*, Sept 1974, p.344.

6 See, for example, *Studio Sound*, March 1974.

Printed circuit boards

Wireless World has arranged a supply of glass fibre p.c.bs. The board is a stereo version but using a common control circuit. (Two boards are needed for a two-channel version with separate control circuits.) Provision has been made for board-mounted l.e.ds and photocells, and connections are brought to one edge. One-off price is £3.50 inclusive from M. R. Sagin, 11 Villiers Road, London NW2.

News of the Month

Video-plus-data recording

The Japanese are using a teletext type of method to record simultaneously on video tape pictures and measurement data from industrial or other processes. The idea is that in investigating certain processes it is useful to be able to correlate pictures of events with measurements of the variables (e.g. temperature, pressure) that are significant in these events. At the 7th IMEKO congress held in London in May, H. Soga and co-authors described a system for multiplexing television pictures and data that has been applied to blast furnace operation and human body movement patterns. It uses an ordinary closed-circuit television camera and magnetic-tape video data coder.

The c.c.t.v. camera signals are sent by coaxial cable to the video data coder, and at the same time measurement signals from transducers on the process are fed in via an analogue-to-digital converter. The a-d converter produces the measurements as 10-bit digital signals, and after storage in a register the successive pulses of these data signals are fed out sequentially from the register and combined with the camera's video signal. Each data pulse is accommodated in an extended blanking period, following the line sync pulse and colour burst and before the video signal proper. Addressing is done by means of an additional identifying pulse, called a "group bit pulse", inserted at intervals also into the blanking period. Finally the composite video-and-data signal is recorded by the video recorder. On playback the data pulses are picked out of the composite signal by gating, converted back to analogue signals by a d-a converter and passed to pen recorders or other display instruments.

This process monitoring technique is said to be particularly useful when an experiment cannot be artificially repeated, or is expensive, time consuming or dangerous, or when a fully explanatory record is required for educational purposes.

Brake regulator eliminates locking

A new brake regulator system which allows car drivers to brake hard at high speed without risk of the wheels locking has been developed in Sweden. Many accidents are caused by cars going out of control because the wheels have become locked as a result of abrupt brake application at high speed, especially on icy or wet roads. The new system has a toothed rim mounted inside each wheel hub. The rim's rate of rotation is continuously monitored by a photocell which feeds data on every change in speed to an electronic control unit. When the brakes are applied and a wheel is about to lock, the electronic unit actuates a valve mechanism which causes the brakes to be released for a short time and then to be applied again. This process can be repeated up to 15 times per second and the brakes retain full effectiveness without locking the wheels. The inventors, two Linkoping technicians, believe that, if the new system can be manufactured on a sufficiently large scale, it could be supplied at "reasonable cost" either as a spare part or as a component for installation during manufacture.

Microwaves for Ireland

The Republic of Ireland is to be provided with a new microwave communication system that will replace the country's existing television distribution network and provide additional TV coverage to new areas. The system will utilise 22 repeater stations over approximately a 750-mile route and will provide two main television channels which will each have an 1800-channel capacity. Originating from Dublin, the system will provide high-quality television broadcasting to Ireland's most populated areas which include Cork and the south coast, Galway and the west coast, Donegal, Athlone and Dundalk.

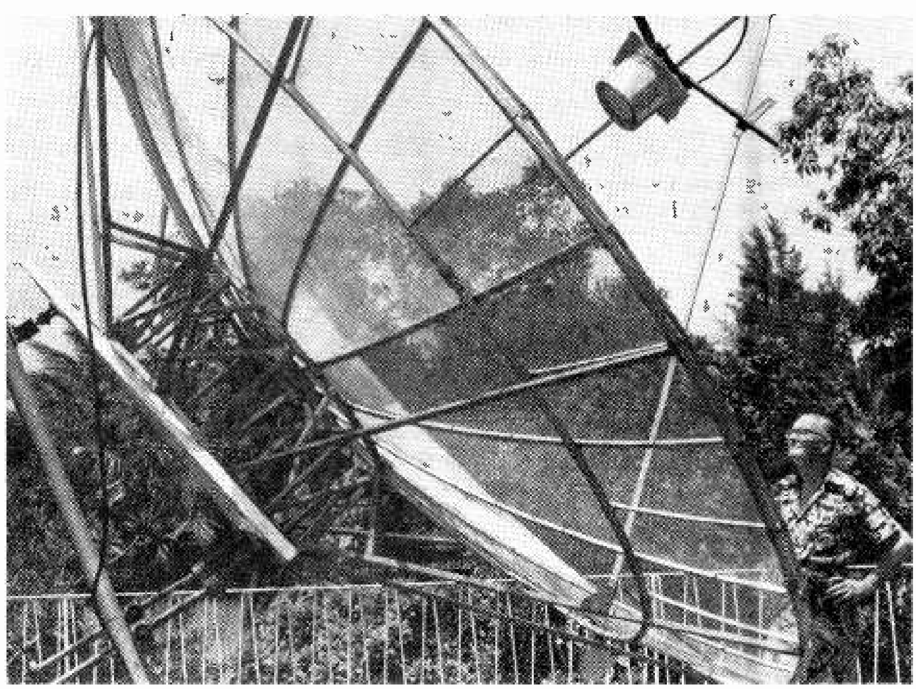
The 3.5m dollar contract to provide and install microwave equipment was awarded to GTE Telecomunicazioni S.p.A., Milan, GTE International's Italian subsidiary, by Ireland's Department of Post and Telegraphs. The system is expected to become operational in early 1977.

Tributes to Arthur C. Clarke

Arthur C. Clarke may not have received the first L. M. Ericsson prize for his significant contribution to telecommunications (see "Who thought up the synchronous satellite?, April issue, p.68) but he did get an appropriate material tribute for his work from the Indian Space Research Organisation. A party of their engineers arrived at his home in Colombo, Sri Lanka, one day and fitted up a complete installation for receiving the Indian television programmes now being broadcast from the ATS-6 satellite (March issue, p.68). The 15ft antenna, mounted on a balcony, is shown in the picture. The 22-inch monochrome set was made in India.

Also, Dr Harold Rosen of Hughes Aircraft, on receiving the Ericsson prize

Arthur C. Clarke and the 15ft paraboloid of the ATS-6 television satellite receiving station presented to him by the Indian Space Research Organization. The feed unit contains an 860MHz three-stage low-noise pre-amplifier (see news item).



in Stockholm in May, made a graceful reference to Arthur Clarke in an address on the history of geo-stationary communications satellites. Earlier this year Mr Clarke was awarded an Honorary Fellowship of the American Institution of Aeronautics and Astronautics in New York. In fact he made history by being promoted from Member to Fellow and then to Honorary Fellow all in the same year.

Radio relay above 13GHz

A radio relay system has been developed to operate in the frequency range above 13GHz and to transmit information by means of digital phase modulation. Modern radio relay systems using frequencies up to 13GHz fulfil their functions in analogue long-range communication networks, Nevertheless, factors such as the increasing digitization of communications traffic, future transmission capacity requirements and economic considerations have made the new relay system necessary.

The PSK 120-240/15000, developed by Siemens, operates with differential four-phase shift keying of the carrier, information being contained in the phase shifts at 0°, 90°, 180° and 270°. This type of modulation permits a good compromise between immunity to interference, bandwidth requirements and technical complexity. On the basis of rainfall figures for Germany, radio path lengths of 22 to 28km were found advisable, so that the system is suitable for dense radio relay networks whose nodes have several links radiating from them and which have relatively short transmission paths of between 25 and 50km. Such network structures and corresponding transmission capacities can be found for instance at the short-haul level of the Federal German communication networks. This is where the PSK radio relay system (see photo) will probably be used first when it becomes necessary to transmit large numbers of digital signals such as p.c.m. speech bands or coded videotelephone signals.

Open University's telecommunication course

An understanding of technical advances and their practical application for the present and future, form the basis of a one-year course 'Telecommunication Systems' being offered by the Open University. With over 55,000 students spread throughout the UK, improved communication systems have a special interest for the University. A part of the course which is therefore of particular interest is a case study of the use of tutorials by telephone and an examination of current developments in the transmission of graphical information over telephone lines with visual displays at remote terminals.

The course which is part of the University's 'Post-experience' programme for 1977, deals mainly with the way in which various elements of telecommunication systems are selected and combined, the functions they serve, the way they interact and the effects which inherent imperfections have on the overall system performance. Application and further information on the course can be obtained from the Post-experience Student Office, the Open University, PO Box 76, Milton Keynes, MK7 6AA.

Clean room at Mullard Hazel Grove, a Philips Industries semiconductor components factory. Instead of having large open areas serviced with cleaned and filtered air, the working stations are fitted into modules that can be put together to form an open-ended tunnel.

TV deliveries down

Deliveries to UK distributors of UK made and imported colour television receivers reached 109,000 in March, a fall of 22 per cent on March 1975 (139,000), according to the latest statistics compiled by the British Radio Equipment Manufacturers' Association. This brought the total for the year to 309,000, a fall of 35 per cent compared with the same period in 1975 (475,000). Total monochrome TV deliveries for March were 96,000, an increase of 55 per cent compared with March 1975 (62,000), bringing the year's total to 244,000 compared with 212,000 last year. These figures include deliveries to rental and relay companies.

IBA's 300th transmitter opened

The opening of a local television relay station at Beacroft Hill near Leeds, which came into full service on April 30, 1976, brings the number of IBA television and radio transmitting stations to 300. Of these, 200 have been opened in the four years since April 28, 1972, when a television relay at Brighton, Sussex, brought the IBA's total to 100. There are now 213 u.h.f. 625-line television transmitting stations, including 46 high-power 'main' stations, serving just over 96 per cent of the population of England, Scotland, Wales and Northern Ireland; 39 v.h.f. and medium-wave sound transmitting stations for the 19 independent local radio companies; and 47 v.h.f. television transmitting stations which continue to provide television services for viewers with older 405-line receivers or who are not yet in range of the u.h.f. services.

The introduction by the IBA of unattended transmitters at all power ratings has meant that the 300 existing transmitting installations are operated and maintained by approximately the same number of field engineering staff as were needed before 1969 for the original ITV v.h.f. television network of under 50 transmitting stations.

World of Amateur Radio

More u.h.f. repeaters

During April the Home Office licensed 20 u.h.f. "talk through" repeaters in England, Scotland and Wales and within a week or two the installations at Corby, Manchester, North Wales and some near London were operating. The introduction of these repeaters between 433 and 435 MHz has, however, caused some consternation in amateur television circles and it is to be hoped that arrangements will be worked out to enable both services to operate without mutual interference. Many other amateurs are perturbed at the deliberate interference to and abuse of the 144 MHz repeaters (particularly the GB3LO repeater in London) and the whole subject of repeaters is still creating a highly charged atmosphere.

Some 40 u.h.f. repeaters are planned, conforming to a 33km square grid covering the UK. There are now some 2,000 amateur repeaters in the United States and the FCC has recently authorised repeaters in the 28 MHz band, between 29.5 and 29.7 MHz with a suggested 100 kHz separation of input and output frequencies.

Experimental retransmission of 625-line amateur television vision and sound signals through a u.h.f. repeater has been reported from Adelaide, South Australia, with 441 MHz input and 579 MHz output. Pictures from the 1.5W repeater transmitter can be received on standard u.h.f. domestic TV sets.

Interference suppression

Both amateurs and broadcast listeners have learned how difficult it can be to cope with two intractable sources of electrical interference: car ignition systems and domestic TV.

A team at Stanford Research Institute have come up with a suggestion that could do much to reduce ignition problems: a modified form of sparking plug that by increasing capacitance between the centre electrode and the resistive lead to about 10 pF provides, in effect, a built-in low-bass filter. In *IEEE Transactions on Vehicular Technology* (February 1976) the team – R. A. Shepherd, J. C. Gaddie and D. L. Nielson – report that such plugs, if a manufacturer would produce them, could result in 13 to 20 dB additional suppression, compared with conventional techniques, over the range 30 to 500 MHz. Earlier research by the same team drew attention to the wide variation in ignition noise radiated by different vehicles and even between different firings of the plugs. Some "super-noisy" vehicles were found to radiate 40 dB more interference than others.

Interference radiated by television sets (sometimes called reverse-tvi or "ivt") seems to have risen with the increasing use of switched-mode power supplies and greater deflection power in colour receivers, often ruining broadcast reception below about 800 kHz and producing whiskery signals at line-frequency separation throughout the h.f. spectrum. While various "braid-breaker" high-pass filters in the aerial leads of the TV sets can sometimes reduce radiation from individual sets, urban areas appear to be increasingly heavily polluted during popular TV viewing hours.

ARRL and Citizens' Band

Although one still finds among American amateurs a deep dislike of many aspects of the CB scene, a notable attempt to heal the breach has been made by Richard Baldwin, W1RU, general manager of ARRL and secretary of IARU. He admits, in a *QST* editorial, the widespread interference caused by CB to television but also pays tribute to "some fine public work" by CB operators. He believes that the big expansion has now brought into existence "a new breed of CBers interested in CB because it is a way of talking to someone – not because it is radio – to relieve the boredom of long trips and to keep posted on traffic conditions". No longer, he suggests, is the bulk of CB operation from frustrated would-be radio amateurs who wanted to be on the air because of a hobby interest in radio but who did not want to learn the Morse code or pass examinations. He feels, however, that there are still some CB enthusiasts who become interested in radio communication as radio and who should be encouraged.

This distinction between amateur radio and CB communication is something not always appreciated in the UK. The Council of the RSGB has stated that the Society will give no support to a 27 MHz communications band, partly because the press does not differentiate between licensed radio amateurs and the 27 MHz users.

In the United States CB has reached the stage where the radio stores carry large stocks of mobile and hand-held 27 MHz transceivers and the bookshops carry more CB publications (including dictionaries of CB slang) than books on amateur radio. It has become very big business but clearly both CB and amateurs would gain from keeping the two types of activities entirely distinct. FCC are to attempt to move very low power CB hand-held operation to frequencies around 50 MHz.

In brief

One little known fact about that supreme recluse — the late Howard Hughes: at one time he held the amateur callsign W5CY . . . The revival of an RSGB Radio Communications Exhibition this year in the London area has already been promised considerable trade support: it is to be held at Alexandra Palace from 10 a.m. to 8 p.m. on July 30 and 31, and 10 a.m. to 4 p.m. on August 1 . . . For the first time in its 63-year history, the membership of RSGB has exceeded 20,000 . . . The 1976 convention of the British Amateur Television Club will be held on Saturday, September 18, at Parkinson Court, Leeds University . . . ARRL are appealing for 100,000 new US amateurs by 1979, now that those who graduate from training courses held by affiliated clubs and societies will be able to obtain licences without the usual issuing delays . . . Combined operational life of the Oscar 6 and Oscar 7 satellites now exceeds five years with Oscar 6 clocking up 3½ years in service in April and Oscar 7 1½ years in May . . . Total of UK amateur licences had reached 22,789 (class A 15,819; class B 5,843; class F (mobile only), 21; and television, 306) by the beginning of March . . . Novice and Technician licences first came into force in the United States 25 years ago on July 1, 1951. A current proposal for novice licences in Canada would provide c.w. only between 3700 to 3725, 7100 to 7150, 21,100 to 21,200, 28,100 to 28,200 kHz with 150-watts input. Licences would be issued for two years only and require 5 w.p.m. morse, knowledge of regulations, adjustment, operation and care of radio apparatus; tests would be administered by Advanced Class amateurs not related to the applicant. . . A German international "hamfest" is being held this year in a new location at Friedrichshafen on Lake Constance between June 25 and 27 (details DARC, PO Box 1155, D-3507, Baunatal, Federal Republic of Germany) . . . The "National Wireless Museum" has opened, under the auspices of the Wireless Preservation Society at Arreton Manor, near Newport, Isle of Wight, with early radio and television receivers, crystal sets, early loudspeakers, etc (10 a.m. to 6 p.m. on weekdays, Sunday afternoons) . . . In the USA a new electronic-communications museum at East Bloomfield, New York, contains over 25,000 pieces of equipment, including 7,000 valves (with an original 1905 Fleming diode given by The Marconi Company) and including a number of replicas of early amateur stations (including a 1923 station, W2AN, which operates on 1.8 MHz); early ship and coast stations are also reproduced. It is run by the Antique Wireless Association.

PAT HAWKER, G3VA

Analogue to digital meter

Circuit using l.e.ds or 1½-digit display

by G. Kalanit, B.Sc., M.I.E.E.
Rediffusion Engineering Ltd

In level measurements such as signal strength in communication, an accuracy of about ± 10% and a resolution of about 5% may be sufficient. For such a requirement an l.e.d. array may replace a conventional meter. The level is displayed as a moving bright dot, calibrated with an appropriate scale. The advantage of such a circuit is its clarity and its instantaneous display of varying levels. Mechanically it is robust. Its main characteristics are a resolution of half a digit, and a minimal consumption of supply power. The current drain is almost constant and used mostly (about 80%) to illuminate the array l.e.ds. For applications where a digital display or level warning is also required, an output from the meter is described.

Initially when the d.c. input level is low, Fig 1(a), transistors Tr_1 Tr_2 and Tr_3 are cut off and transistors Tr_{01}, Tr_{02} and Tr_{03} are in a saturated state. Hence the l.e.d. for 0 is illuminated. Because of the voltage drop across Tr_{01} base-emitter junction, there is not enough voltage drop across l.e.d. 1, and therefore it is not switched on. By the same reasoning l.e.d. 2 is also off. When the input direct voltage is raised sufficiently to switch transistor Tr_1 on, Fig. 1(b), transistor Tr_{01} cuts off and l.e.d. 0 is switched off This results in l.e.d. 1 being on. With a further increase of input voltage, Fig. 1(c), transistor Tr_2 comes into saturation and cuts off transistor Tr_{02} and l.e.d. 1. This results in l.e.d. 2 being switched on. Hence, in the final state transistors Tr_1, Tr_2 and Tr_6 are switched on, and only l.e.d. 2 is illuminated. The circuit may be described as a column of transistor pairs.

The switching from one l.e.d. to another is not a snap action, and illumination from 0 to 1 to 2 is continuous. This means that halfway between 0 and 1, both l.e.d. 0 and l.e.d. 1 are lit together. Similarly halfway between 1 and 2, l.e.d. 1 and 2 are lit together. Because of the constant-current feed, the level of the illumination is halved for each l.e.d; however, the total level remains constant and the visual effect is to give a resolution of half a digit.

A complete meter circuit is given in Fig. 2 for an eleven-l.e.d. array. A constant-current source of 20mA gives a fairly bright display. Fig. 3 gives a calibration curve of the circuit in Fig. 2. The curve slope is the meter sensitivity which may be defined as the increase in input voltage required to change one digit, i.e. $i \times R_n + V_{ce(sat)}$ (Tr_n), where i, is the constant current through R_n, and $V_{ce(sat)}$ (Tr_n) is the saturation voltage drop across transistor Tr_n. In the circuit, Fig. 2, for n values 1 to 10, sensitivity is

$$20\text{mA} \times 15\Omega + 0.15\text{V} = 0.45\text{V}$$

The fact that the sensitivity of each

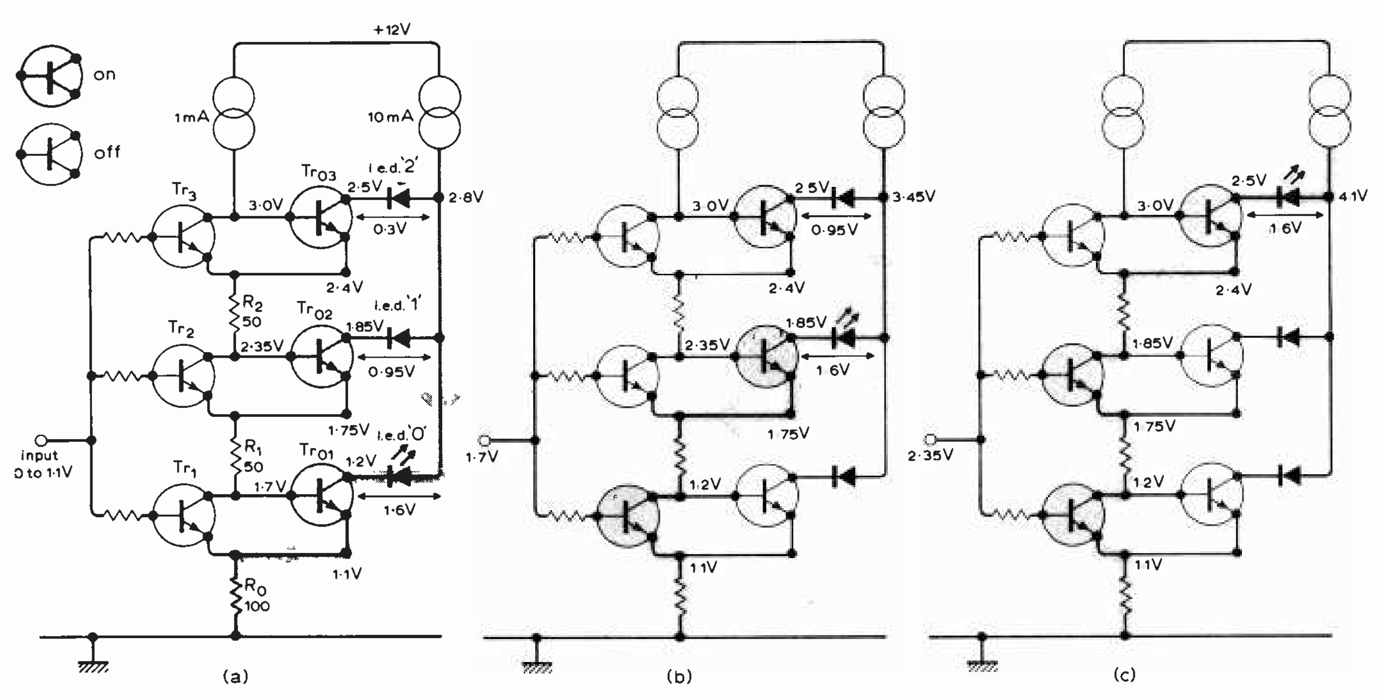


Fig. 1 Circuit for an l.e.d. array display for use as an output level meter, e.g. signal strength meter, showing how the l.e.ds switch on in sequence as the input voltage is increased. Voltage conditions assume V_{be} of 0.6V and V_{ce} of 0.1V.

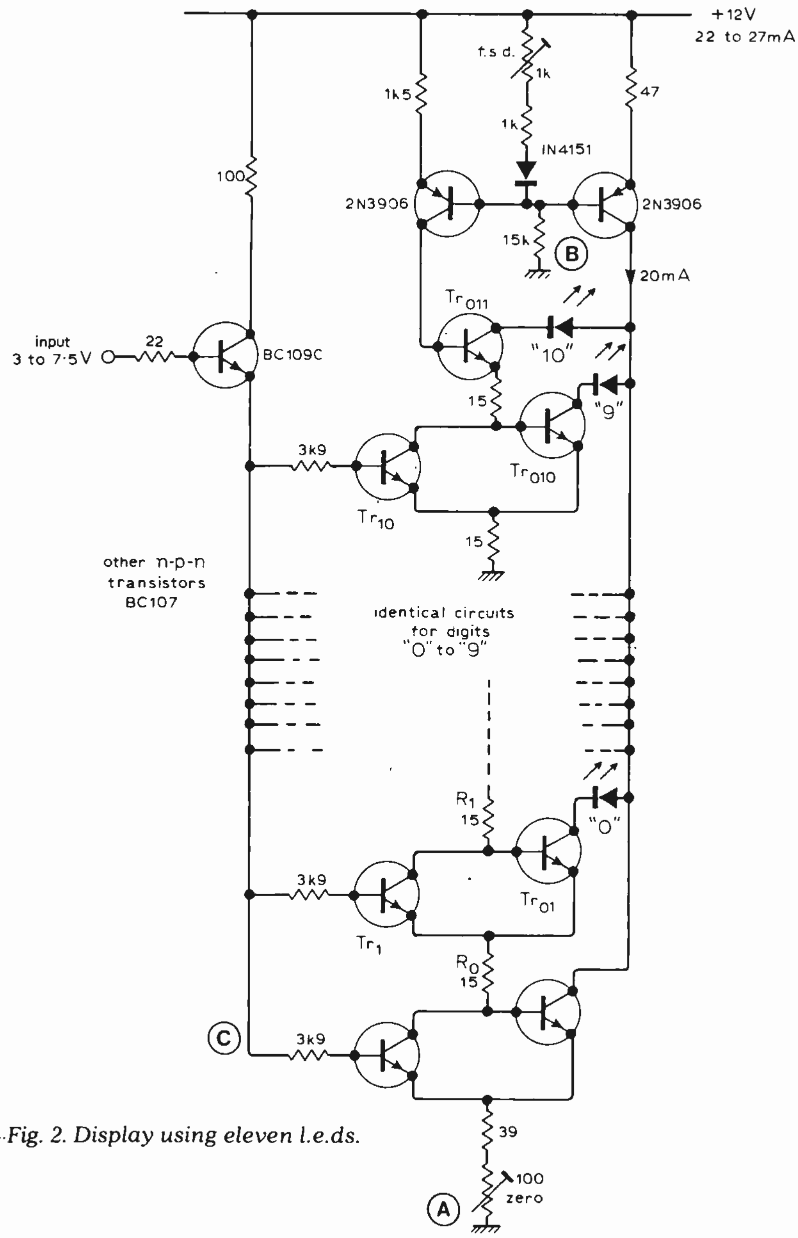
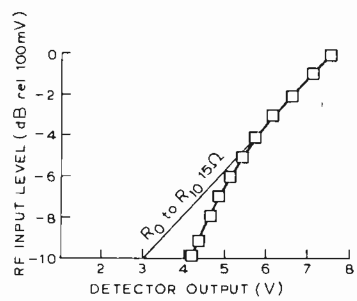


Fig. 2. Display using eleven l.e.ds.

digit can be controlled with the value of the corresponding resistor, means that the meter may be easily employed in non-linear requirements. It was adapted to a newly developed r.f. calibrated level receiver. Response of the receiver detector output was plotted against a decibel varied input, shown in Fig. 4. The slope of Fig. 2 circuit was then adjusted with a new set of R_0 to R_{10} resistors, values of which are given in the table (see Fig. 4). Fig. 5 shows the total response of the receiver input r.f. level against the l.e.d. meter display. Hence the meter reads decibels with a resolution of ½dB. The l.e.d. display array is shown in Fig. 6. Adjacent to the 10dB scale are the voltage level scales.

Each display l.e.d. requires two n-p-n transistors. The circuit of Fig. 2 requires a total of 24 n-p-n transistors. Arrays of n-p-n transistors are the obvious solution for a reduction in number and cost of active elements in the circuit. RCA type CA3086 is a suitable example, containing 5 n-p-n transistors. Because one of the transistors in the array has to be wired to the earth rail, only four out



R_{10}	16·5
R_9	16·5
R_8	15
R_7	15
R_6	15
R_5	7·5
R_4	7·5
R_3	5·6
R_2	3
R_1	0
R_0	0

Fig. 4. Graph showing how the selection of the resistors R_0 to R_{10} allows the circuit in Fig. 2 to be used for a non-linear application; in this case an r.f. calibrated receiver.

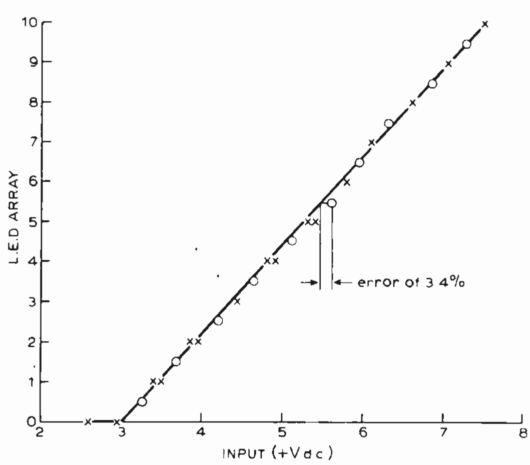


Fig. 3. Calibration curve for the display in Fig. 2 showing the input voltages required to light l.e.ds numbers 0 to 10. Points X represent a single l.e.d. when lit, points 0 represent two adjacent l.e.ds when equally bright; e.g. at an input of 5.6V both l.e.ds 5 and 6 are equally on and the error is about 0.12V. Full scale is 3.5V d.c. therefore error at full scale is 0.12 x 100/3.5 = 3.4%

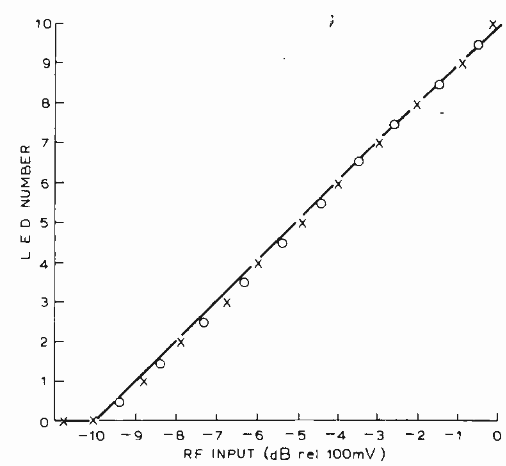


Fig. 5. Graph showing the response of the receiver input r.f. level against the l.e.d. display when using the parameters described in Fig. 4.

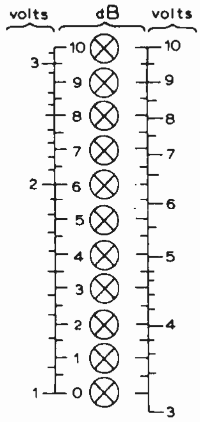


Fig. 6. Typical display array for l.e.ds showing 0 to 10dB and equivalent voltage levels.

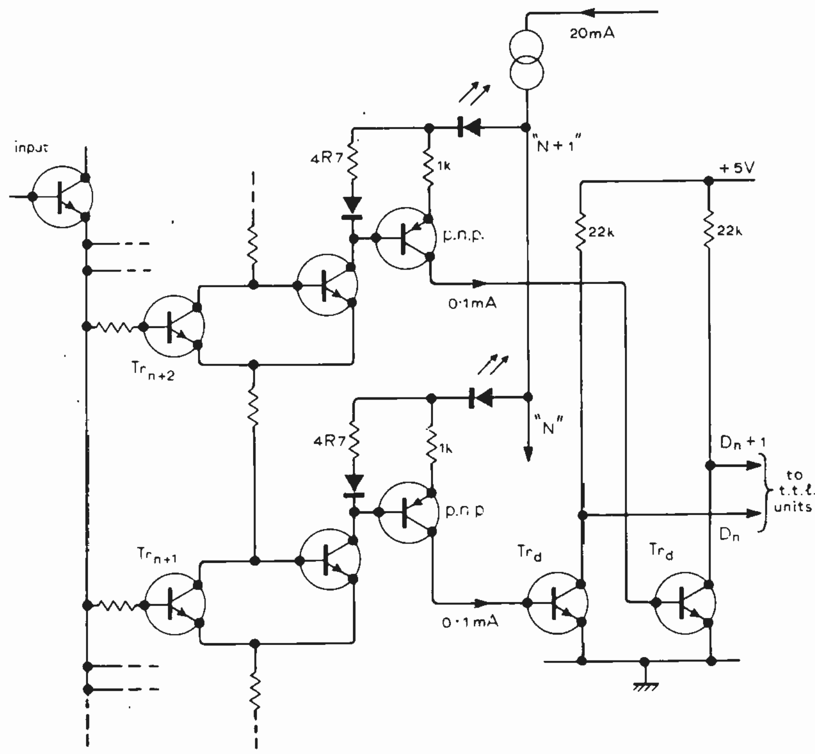


Fig. 7. Modifications to Fig. 2 to provide digital outputs. $D_n = 0$ when l.e.d. "n" is on.

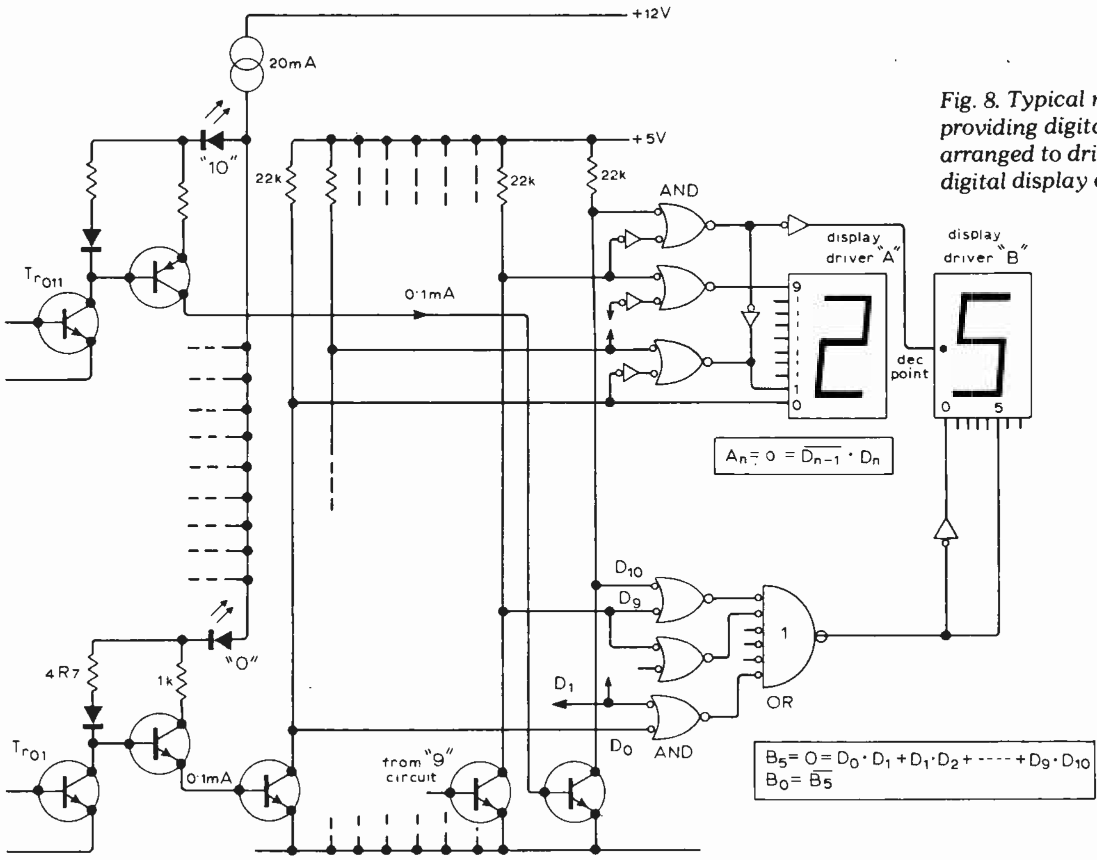


Fig. 8. Typical modification to Fig. 2 providing digital outputs arranged to drive a digital display of 1½ digits.

of the five transistors can be used. Hence, six units of CA3086 must be employed, making a worthwhile reduction in number and cost.

The meter can be arranged to have digital outlets for systems which require level limits warnings. The basic circuit is given in Fig. 7. The 4.7-ohm resistor in series with the diode, together, sense the l.e.d. current, and develop a voltage which switches on the p-n-p transistor. The 1k Ω resistor in series with the p-n-p transistor emitter limits the transistor current to 0.1mA, and therefore does not load the 20mA current source and disturb the l.e.d. chain switching action which depends on constant current, i.e. only 0.5% (0.1mA/20mA) of the constant current is drained away by the p-n-p transistor. In the circuit, the p-n-p collector current switches on a t.t.l. drive transistor (Tr_d).

Fig. 8 demonstrates the use of the outlets to drive a display of 1½ digits. A drive transistor is on when the corresponding l.e.d. number n is on, hence output $D_n = 0$ for l.e.ds being on. As the digit display units may also require a zero voltage to drive them on, it is convenient to use negative logic for the Boolean expressions of logic requirements, as follows: The 0.5 digit B is on only when two adjacent l.e.ds are on together, otherwise 0.0 is displayed. Hence for zero input into B_5

$$B_5 = 0 = D_1 + D_1.D_2 + \ldots + D_9.D_{10}$$

also $B_0 = \overline{B}_5$. For the A digit, the requirement is that, number A_n is on only when $\underline{A_{(n-1)}}$ is switched off. Hence $A_n = 0 = \overline{D_{(n-1)}}.D_n$. For the 10 display, A_{10} is fed via a buffer to A_1 input i.e. digits 1 and 0 are on, and the decimal point is switched off.

Automatic brightness control

The light emitting diodes, in the meter example of Fig. 2, are driven with a constant current of 20mA to give a bright display suitable for outdoor use. Indoors, however, it would be desirable, to reduce the l.e.ds' current consumption to improve their life span. Also, the power of the battery source, in the case of portable equipment, may be saved.

Truth table (negative logic)

input	L.E.D. 'D' 0	1	2	9	10	input driver A A_0	A_1	A_2	A_9	decimal point	input driver B B_0	B_5	display
<0	1	1	1	1	1	1	1	1	1	0	0	1	.0
0·0	0	1	1	1	1	0	1	1	1	0	0	1	0.0
0·5	0	0	1	1	1	0	1	1	1	0	1	0	0.5
1·0	1	0	1	1	1	1	0	1	1	0	0	1	1.0
1·5	1	0	0	1	1	1	0	1	1	0	1	0	1.5
2·0	1	1	0	1	1	1	1	0	1	0	0	1	2.0
⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮
9·0	1	1	1	0	1	1	1	1	0	0	0	1	9.0
9·5	1	1	1	0	0	1	1	1	0	0	1	0	9.5
10·0	1	1	1	1	0	1	0	1	1	1	0	1	1 0

The earth rail of the meter circuit (Fig. 2) is lifted and re-connected to earth via a saturated transistor Tr_6 (Figs. 9 & 10) which acts as an on/off switch. Transistor Tr_6 is switched on/off by astable multivibrator Tr_3, Tr_4, at a rate of 66Hz to 630Hz. The on time is fixed to 1.5ms duration (see waveforms in Fig. 9). The off time is variable and is inversely in proportion to ambient light. Thus, we have a pulse-width-modulated multivibrator controlled by ambient

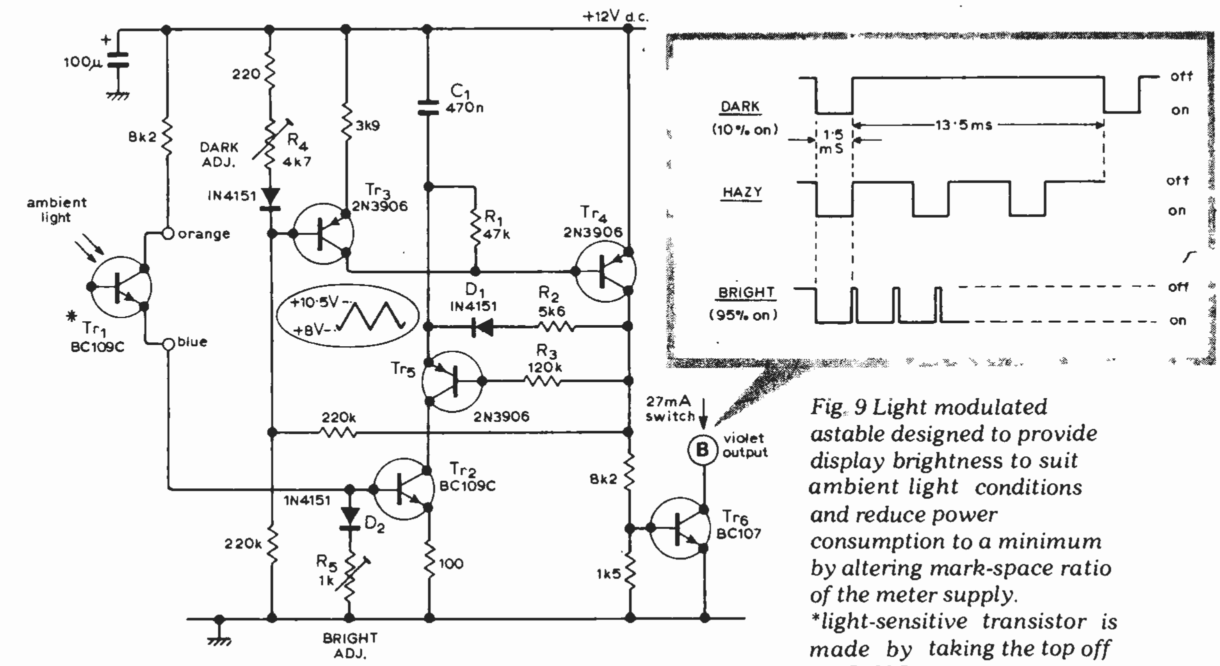
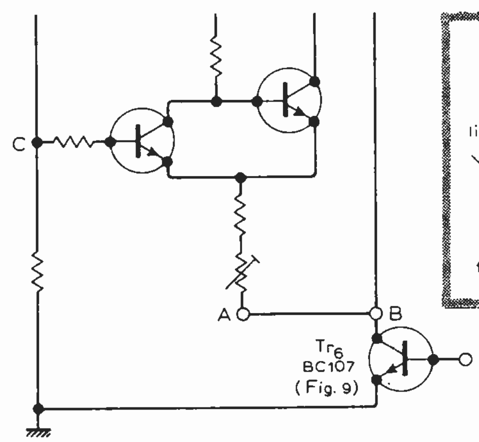


Fig. 9 Light modulated astable designed to provide display brightness to suit ambient light conditions and reduce power consumption to a minimum by altering mark-space ratio of the meter supply. *light-sensitive transistor is made by taking the top off a BC109C.



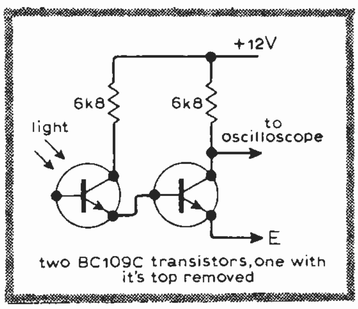


Fig. 10. Modification to Fig. 2 to include supply switching for power saving.

light with a variable mark to space ratio from about 5% to 98%. In practice it was found that a ratio range of 10% to 95% was adequate.

Transistors Tr_3, Tr_4 are connected d.c. wise as a Schmitt trigger with input at junction C_1, R_1. The off/on switching voltages at C_1, R_1 are approximately +8V and +10.5V. The timing of the sawtooth which occurs at C_1, R_1 is controlled by C_1 and the independent mark and space charging and discharging circuits. The mark time is determined by the discharge resistor R_2 only, and lasts 1.5ms. The space time is controlled by the charging current through Tr_5 and Tr_2. The current amplitude depends on the ambient light affecting the light sensitive transistor Tr_1. The brighter the light, the larger the charging current and the shorter is the space time. The space 'dark' charging current is determined by R_3 to be 13.5ms (Tr_2 is cut off).

During the mark time, when Tr_4 is on, D_1 is on and Tr_5 is off. During the space time, when Tr_4 is off, D_1 is off and Tr_5 is on, giving complete independence of mark and space time control. Potentiometer R_4 controls the direct voltages at which the on/offs occur; this it controls the 'dark' mark-to-space ratio. Potentiometer R_5 controls the d.c. gain of transistor Tr_2; thus it controls the 'bright' mark-to-space ratio.

The astable current consumption is 0.4mA indoors at 10% duty cycle and 2mA outdoors at 95% duty cycle. The total meter circuit consumes only 2.6 to 3.3mA indoors at 10% duty cycle, and 23 to 27mA outdoors at 95% duty cycle.

The lowest frequency of the astable was chosen to be 66Hz to avoid flicker effect. The cycle length is 15ms, therefore the maximum mark time of 10% duty cycle is 1.5ms.

To see how well the l.e.ds follow the input waveform, a photosensitive probe (see inset in Fig. 10) was placed in front of an illuminated l.e.d. in the meter array. The waveform was then displayed on a double-beam 'scope together with Tr_6 collector waveform. The waveform from the probe was delayed by about 0.1ms with a rise and fall time of about 0.1ms.

Acknowledgment. The astable circuit was suggested by Messrs. H. L. Baker and J. W. Sinclair of Rediffusion Engineering Ltd., who used an op-amp type LM3900. The above design follows the basic circuitry of the LM3900 but consumes less current. A similar circuit employing an op-amp is also shown by A. Cantori in *Electronics Letters* vol. 9 1973 no. 7, p.158.

FM tuner designs

Further details of construction and alignment

by D. C. Read, B.Sc.

As the result of experience gained in building what might be termed production models of the f.m. tuners described recently in *Wireless World* (March and April), the following information on construction and alignment is given, together with suggestions for possible modifications and component alternatives, and some corrections to details already published.

As a board layout was arranged to take specific capacitor types, further details are:

C_1, C_6, C_{15} – polystyrene 2 per cent types were used originally but disc ceramic capacitors are also suitable;
C_{20}, C_{21a}, C_{21b} – polystyrene;
C_{24}, C_{25}, C_{26} – polystyrene (these low-pass filter components need to be as accurate in value as possible);
C_4, C_{32}, C_{33} – 10 per cent polyester, e.g. Mullard type 334.

On the p.c. board supplied for the tuner there are two positions marked for each of C_{32} and C_{33}. This provides for additional components to be installed so that the theoretical 75µs de-emphasis time-constant can be obtained very accurately if necessary. Unless otherwise specified, the remaining capacitors are either disc ceramic or tantalum types, the last-mentioned being marked with polarity on the circuit diagrams.

Push-button assemblies

Push-button switch assemblies may be used, but remember that as these are generally equipped with high-value adjustment resistors (100kΩ per section), the reservoir capacitors, C_{42} to C_{48} in Fig. 1, would not then be suitable because tantalum capacitors are subject to considerable variation of leakage current with change in temperature. They are unsuitable for use in a high-resistance circuit within an a.f.c. loop; given a modest change in temperature, the resulting frequency bias created by the consequent change in the tantalum characteristics could so offset the a.f.c. system as to prevent it giving satisfactory overall control.

As a compromise, disc ceramic capacitors of, say, 220nF could be used in these positions to provide a small but useful reservoir effect. Note, however, that without the decoupling action of the 22µF components, the tuning-voltage feed to the LP1186 module is more liable to pick up hum and noise interference and hence allow spurious modulation of the received signal. Thus, if a push-button unit remote from the tuner is installed, it is good practice to screen this feed and/or ensure that it is kept well away from possible sources of interference, e.g. mains wiring. When loaded with the high-resistance selection circuit, the tuning voltage regulator diode, D_4, may be fed with much more current than is needed to carry out its control function. In this event, R_{44} could be increased, say to 100Ω.

AFC circuit

In Fig. 5 (April issue) a 3.3µF capacitor was specified for C_6 in the a.f.c. line from pin 7 of the CA3089E demodulator. This is an unnecessarily large value because the feed only carries an appreciable audio component under off-tune conditions. A smaller, and hence cheaper, component, say a 470nF disc ceramic or polyester capacitor, would suffice.

Too large an a.f.c. range can be a disadvantage because of station-jumping. If four diodes, arranged as two series pairs connected back-to-back in parallel, are placed across points 1 and 2 in the a.f.c. circuit, the positive and negative voltage excursions are limited each to about 1.2 volts so that the maximum possible tuning frequency change under a.f.c. action is always less than the minimum channel separation.

The other modification concerns extension of the a.f.c. sensitivity control as a front panel facility. This can be done by making R_9 a variable component, still connected between points 1 and 2, but with R_8 taken to the slider. Such an arrangement then enables reduction in sensitivity to be carried out manually whenever necessary but does not prevent the voltage changes appearing across R_9 from being used to operate the l.e.d. indicator circuit detailed in Fig. 4 of the March issue.

Muting circuit

In at least one of the advanced tuners so far built and aligned, the CA3089E muting output from pin 12 took the form of amplitude-clipped noise instead

Filter type	3dB bandwidth	±300kHz rejection	stopband loss
Vernitron FM4	235kHz	30dB	40dB
Toko CFSA	300kHz	20dB	30dB

of varying d.c. The interconnecting circuit feeding the muting input on pin 5 then produced an average of this output which was not sufficient to operate the mute when required. As the i.c. gave a satisfactory performance in all other respects, it was worthwhile making a suitable circuit change to correct for the abnormality. The circuit published in the April issue was therefore modified to give an increased output by disconnecting the existing circuit between pins 12 and 5 and connecting a 1N914 and 50kΩ potentiometer in series between pins 12 and 5 (anode to pin 12). Connect C_{21} between pin 5 and the zero-volt line.

Aerial coil

The aerial coil, L_1, used to feed incoming signal to the tuned r.f. stage in the advanced version is constructed as shown below. Note that the total number of turns on this coil is 7, not 8¼ as stated on page 50 of the April issue.

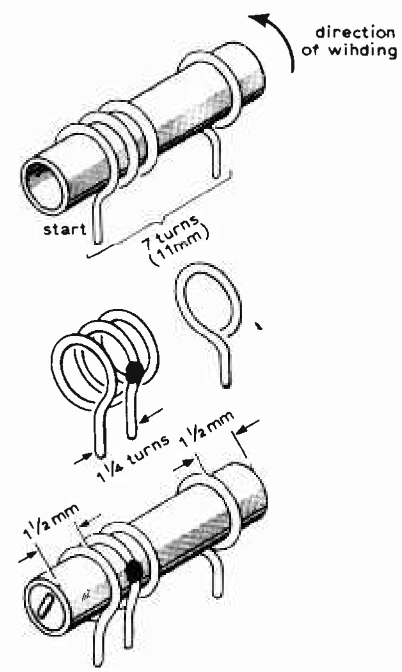
Cut Neosid 6mm former to about 14mm.

Wind on 7 turns 22 s.w.g. tinned copper wire, equally spaced out to 11mm.

Remove former, tap at 1¼ turn from start, open turns adjacent to tap to avoid shorting.

Re-insert former and centralise. Screw in core together with p.t.f.e. tape. Coat with Denfix or nail varnish.

In some examples of the advanced version, C_1 may not be required because stray capacitance and the input capacitance of Tr_1 added together are sufficient.



Ceramic filters

Difficulty has recently been found in obtaining the Vernitron filters specified for F_1 and F_2 in both versions. Fortunately, ceramic filters from the Toko type CFSA 10.7 range are readily available. These replacement components offer a performance which is not quite as good as that of the Vernitron FM4, but it is generally adequate for the tuners described. The Toko units are also cheaper – about half the cost.

If these alternative filters are used, a small change in Fig. 1 circuit values would be required because the amount of overall phase response correction given by C_{28} and R_{27} in the Tr_2/Tr_3 amplifier is no longer suitable. The values should be changed to 3.3nF and 2.4kΩ. Resistor R_{27} can be adjusted on test to obtain up to 38dB channel separation from 1 to 5kHz.

Adjustment of L_3

The quadrature-phase signal derived for both demodulators, TAA661B in the simple version and CA3089E in the advanced version, could optionally be produced by means of a double-tuned coil at L_3. When setting the two cores of L_3 so as to take the best possible advantage of the linearizing effect of current in the dummy coil, it is essential that the cores be kept as far apart as possible in the former, thus minimising changes in coupling between the coils when adjustment is made. The lower core is used to tune the mail L_3 coil; it should initially be screwed in just enough to give as symmetrical an S-curve as possible. When this has been set satisfactorily, the upper core is added and screwed in enough to straighten the bend in the transfer slope as in the left hand trace of Fig. 2. More precise adjustment would require the use of a wave analyser or distortion meter.

Corrections

In Fig. 1 of the March article, R_2 should be 1k not 100kΩ and R_{65} should be 10k, not 12kΩ. The switch shown in broken line at pin 14 of IC_3 is an optional component which operates as a cancel-stereo shorting contact when closed. Note also that the common-circuit line mainly joining Tr_2, Tr_3 and IC_3 should be labelled '0V' — it is not a continuation of the +4.5V line in the tuning selector circuit. In Fig. 5 of the April article R_{37} should be 47Ω not 470Ω. In the p.c. board/layout diagram, R_{18} (top, centre) should be shown as R_{13} and the unmarked component immediately to the left of R_{43} (centre, toward r.h.s.) should be marked D_4.

Receiving weak TV signals

by W. H. Jarvis,

Rannoch School, Perthshire

With the aid of a grant from the Royal Society, we have been studying for years various approaches to the problem of weak TV reception in a remote, mountainous area of Scotland.

Some years ago, two licensed amateurs (one pupil and one teacher) set up a 10W f.m. transmitter operating on 145MHz at a local beauty spot known as Queen's View, and showed that it gave good signal levels to about 800 potential listeners or viewers who at present have little or no signal.

In tackling the problem of using the existing very weak signals, we have until recently been without a calibrated signal strength meter, so we modified a 12V portable dual-standard TV receiver to give a meter indication of relative strengths (*Physics Education*, vol. 16 No 2, p86). We bought a 44-element J-Beam for channels 10 and 11, and, whilst we failed to get an "enjoyable" IBA signal from either Kirk O'Shotts or Angus (Dundee), we did get consistent enough results to show that in highly wooded areas, the average signal falls in spring when foliage begins to appear, and rises in autumn when the leaves fall. In a separate experiment on amateur v.h.f. bands, we showed that horizontally polarised signals travel better through woods than do vertically polarised signals, and we attribute this to a greater average conductivity in the vertical direction when one is surrounded by damp trees.

Intermittent work on trying to improve reception for local residents led to the installation of 3-channel colour through a piped system using 7 in-line amplifiers; unfortunately only one householder benefited, and no-one connected with the school could be served.

In establishing a v.h.f. TV relay at the school (*School Science Review*, Sep '71), we found that even high-grade low-loss coax deteriorates rapidly as damp diffuses through the coating and dielectric.

We are now experimenting with a Signetics NE561 p.l.l. i.c, hoping to find a demodulating circuit which will give a higher signal-to-noise ratio with existing signals (about 15μV).

In addition to thanking the Royal Society and Professor Lamb of the University of Glasgow, we would gratefully acknowledge the help of the BBC and the Post Office, and the loan of a signal strength meter from the local firm of K. Atter and Partners.

Earthquakes examined

A satellite which looks like a giant golf ball has been launched by NASA into a 5,900-km high orbit to obtain information on the Earth's polar motion and crustal movements. The Laser Geodynamic Satellite (Lageos) will use laser satellite tracking techniques to make extremely accurate measurements which include minute movements of large land masses, called tectonic plates.

Lageos carries an array of 426 prisms called cube-corner retroreflectors, giving it the dimpled appearance of a golf ball. Retroflectors are three dimensional prisms that reflect light (in this case a laser beam) back to its source, regardless of the angle of incidence. A laser pulse beamed from a ground tracking-receiving station to Lageos initiates a timing signal at the ground station that continues until the pulse is bounced back from the satellite and received at the station. By measuring this length of time, the distance between the station and the satellite can be calculated and in this way movements detected of the Earth's surface.

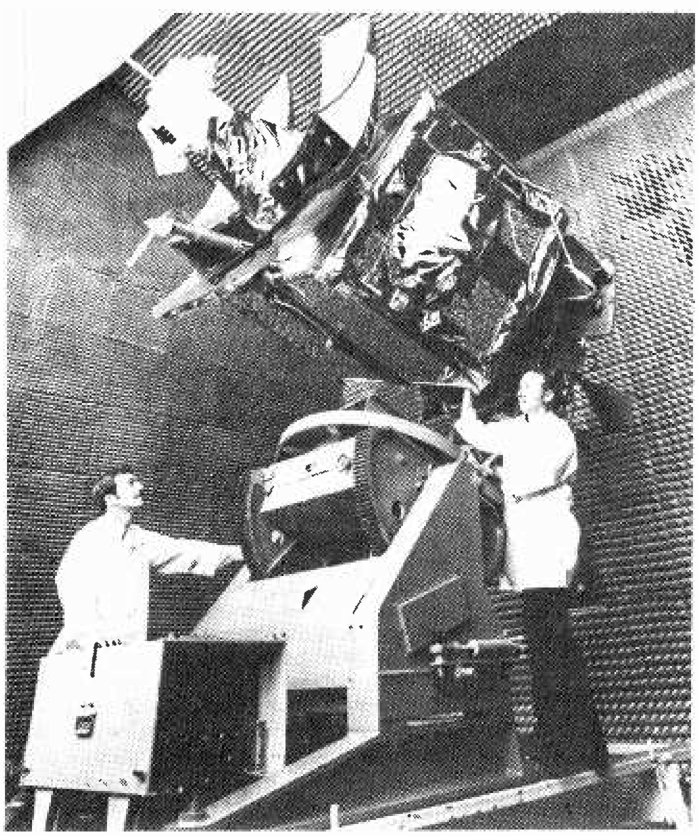
New ESA ground stations network

The European Space Agency ground stations network, controlled by the European Space Operations Centre is now composed of two types of station; the v.h.f. stations (Redu and Fairbanks) and the "specialized" stations (Odenwald, Fucino and Villafranca del Castillo). The Redu (Belgium) and Fairbanks (Alaska) stations form part of the network set up by ESRO in 1966 in relation to the orbits of the first European satellites which were mainly low and polar. The stations at Ny Alesund (Spitsbergen) and Port Stanley (Falkland Islands) which also formed part of this network, are now closed.

At present Redu is performing tracking, telemetry and v.h.f. telecommand operations for COS-B, launched in 1975, and ANS, a Dutch satellite also launched in 1975. This will be the main v.h.f. station for GEOS tracking and telecommand (due for launch in 1977) and back-up v.h.f. for Meteosat (1977), OTS (1977) and Marots (1978). Fairbanks is also participating in support operations for COS-B.

The Odenwald station (Michelstadt, Germany) will acquire S-band data from GEOS. It will also collect, process and disseminate raw meteorological data from Meteosat.

The Villafranca del Castillo station near Madrid will perform the acquisition, scientific processing and control as well as the main support of the in-orbit operations of the maritime satellite, Marots (1978) and the aeronautical satellite, Aerosat (1979). The Fucino station near Rome, which is to perform the control of the operations of the telecommunications satellite OTS (1977), is already equipped with its main antenna and will be operational in 1977.



Satcom II during tests of the antenna system at RCA's Astro-Electronics Division, Princeton, New Jersey. The domestic communications satellite has recently joined Satcom I in orbit. It is capable of providing a communications service to 50 North American states.

First Comstar in orbit

The first Comstar 1 communication satellite that will relay telephone and television traffic within the United States, Alaska, Hawaii and Puerto Rico was launched from Cape Kennedy at the beginning of May. Each Comstar 1 will be able to handle approximately 14,400 telephone conversations or about twice the capacity of the satellites presently operating. This has been achieved by a cross polarization technique which allows re-use of the same frequency bands and therefore more efficient use of the r.f. spectrum. The British Aircraft Corporation has manufactured a large part of the structure, solar arrays, cable harnesses and battery packs for these massive satellites which stand 20ft tall. Cylindrical solar panels, covered with nearly 17,000 solar cells, provide the satellite with primary power of 570W.

International magnetospheric study underway

An international magnetospheric study is now underway which is to last several years and is expected to help scientists understand more about the magnetic field surrounding the Earth. Geos, the first geostationary research satellite of the European Space Agency is due to be launched this autumn and will contribute information to the study. The antenna of the Earth station for this project was erected near Michelstadt, Odenwald by Siemens and was recently handed over ready for service to ESA.

Letters to the Editor

TRAFFIC BROADCASTING

I have read your very interesting article in News of the Month *(Wireless World* May 1976) concerning the BBC traffic service proposal. I should like to amplify a statement made in the final sentence, which deals with international aspects.

The European Broadcasting Union, through both its Technical and Programme Committees, has been studying the use of broadcasting in helping the motorist for some time. The requirements vary considerably from country to country, and lack of precise knowledge on this aspect has so far precluded a firm recommendation for any particular system. However, their technical sub-group (of which I am a member) regards the West German v.h.f. system as suitable in the short term. They have also said that in the longer term where a dedicated service is required, the t.d.m. (BBC) system might be feasible. The BBC has now demonstrated that, technically, this solution is feasible. It also represents a cheaper and more efficient approach for the United Kingdom, although the full technical implications of international operation have not yet been examined.

The proposal has clear advantages, but obviously to be successful it depends upon the organizations which obtain and process traffic information. This aspect and the interface with the broadcasting network are now being examined by the authorities concerned. This will, one hopes, lead to a public experiment.

R. S. Sandell,
BBC Research Dept.,
Kingwood Warren,
Surrey.

OUR DAILY BREAD

The pay and status of engineers has been an issue – amongst engineers – for some time, but no amount of criticism of employers, or of railing at an unjust world, can alter the fact that we are paid what we are *worth*, at least in the eyes of the world. The unpalatable truth is that the supply of engineers balances the demand at the prevailing rates of pay: we are not, in general, seen as demonstrating any particular sense of responsibility, and we must face the fact that the standard of education necessary to function to a satisfactory level is not particularly high, in spite of pious attempts by our own establishment to make people believe so. If the pay demanded by a chartered engineer is too high, then his job can, and will, be done by someone else, with very few exceptions.

I believe we have not accepted sufficient responsibility for the end uses to which our products are put, we tend to be too short sighted, too involved in the immediate problems of how to make something work, to worry about implications for the future. The engineering profession is very inward looking; we seem to split into two camps which seldom meet. The one camp concentrates on the job in hand, meeting the employer's specification, cost and delivery, but never worrying about the use of the end product; and the other camp sits on committees, in institutions, universities and colleges, considering the engineering profession; its status, training and qualifications, occasionally handing down a sermon: "the engineer must be broadly educated", which is done by the addition of a class on "the engineer in society" or some such pretence: or perhaps "the engineer should join a trade union", the latest edict!

I suggest that we shall gain nothing from joining a trade union since we shall still be over-ruled by the giant manual unions, the power of which will continue to grow. They will not allow themselves to become the dog, wagged by the professional engineers' "tail".

The true answers, I submit, are two-fold. Firstly, we shall raise our status by demonstrating our responsibility and concern at the purpose and uses of those things *which would not exist* were it not for engineers; and secondly, we shall raise our pay, relative to the unskilled, only if we enter the political arena and join the battle to reduce the power of the unions, to get us out of the terrifyingly unstable situation we are now in. After all, if the pay of manual workers continues to increase at the expense of the professional engineer, we shall reach the stage where we simply refuse to become professional engineers and all become manual workers, and our civilisation cannot exist in those conditions.

J. C. Taylor, M.I.E.R.E.
Heywood,
Lancs.

CURRENT DUMPING AUDIO AMPLIFIER

I have had many enjoyable discussions with P. J. Walker, M. P. Albinson, P. Blomley and R. C. Bowes in the quest for the ideal audio amplifier which would be totally free from audible distortion, have no adjustments of any kind, and be economical and straightforward to manufacture. Numerous fascinating schemes have been considered, and assessing their overall relative virtues has been quite difficult – and indeed, at times, very perplexing.

When the Quad 303 circuit was first evolved, it was evident that the very good linearity of the individual triples, resulting from their internal feedback, was, in a sense, being partially wasted, because the existence of some residual crossover distortion in the transfer of current from one triple to the other necessitated a large amount of overall feedback in addition. A superb performance is, of course, thus obtained, but one was left feeling that if only a circuit could be devised that would sense when both triples were on together and apply extra negative feedback to prevent the gain from increasing, then a more economical design, preferably free from preset adjustments, might be possible. Countless hours were spent scratching around trying to solve this and related problems, and there were moments of elation when it was thought that an answer had been found. But then it turned out that the proposed solution, to work ideally, involved the concept of infinite loop gain – camouflaged, maybe, as a requirement for a zero source impedance at some internal point in the circuit. In other words it turned out merely to be an example of Mr Halliday's "familiar assertion that the distortion can be made negligible by huge amounts of feedback".

Then Peter Blomley's fundamental and excellent new idea came along[1] – a class B amplifier in which both halves of the output stage retained their full mutual conductance throughout the whole audio cycle. This seemed to me at first to be the total answer to the problem of an adjustment-free amplifier with first-class performance, and I did a good deal of very encouraging experimental work leading to simplified circuit designs. It became evident, however, that though the technique is basically absolutely sound, the major practical problem is to ensure that, in the absence of any kind of adjustments or selection of transistors, the quiescent current will fall within reasonable practical limits, albeit quite uncritical ones, without wasting too much output power in highish-valued output-stage emitter resistors, or requiring, somewhere in the circuit, transistors having closely-matched V_{be} values at a given current. Circuits using dual transistors, or i.cs, in the quiescent-current-determining circuitry, were inclined to become undesirably complex, though excellent results were obtainable.

I tried to persuade Peter Walker, at an early stage, that Quad would do well to develop an amplifier based on the Blomley idea, but he and Michael Albinson, with remarkable intuitive wisdom, sensed that the economics of such an approach might well be less than ideal, and they continued to investigate other techniques. The current-dumping scheme as conceived and developed by them seems to me to have an impressive elegance and economic "rightness" about it. Much of the practical success of the 405 design is due to the master-stroke of making the class A amplifier into an integrator, with an inductor elsewhere in the circuit, but there is also the ingenious economy of making the integrator output transistor (Tr_7 in Fig. 4, page 562, December 1975 issue) function in addition as the driver for one of the dumper transistors. (For practical reasons the dumpers-off regime is displaced to one side of the zero-load-current state.)

For the record, it may be mentioned that R. C. Bowes independently put forward a proposal for a current-dumping amplifier circuit, in which the current fed by the dumpers to the load was monitored not by a resistor directly in series with the load, but by small resistors in the collector leads of the dumpers. A negative-feedback voltage was derived from the sum of the voltage drops across these resistors, and values were so chosen that the gain of the system was independent of whether or not the dumpers were in action. So far as I can recollect, however, nothing comparable with the integrator-and-inductor scheme was envisaged.

Having just completed a chapter on amplifiers for the forthcoming Butterworths publication "Radio, TV and Audio Technical Reference Book", I thought some *Wireless World* readers might be interested in the simple explanation there given of the Quad current-dumping technique. It seems to me that this rather different approach has the virtues (a) that it is more directly related to very familiar ideas and (b) that it provides a simple and convincing physical argument that the scheme must work, without recourse to any algebra. I believe that it is always very much worthwhile to seek the simplest possible, sound, non-mathematical explanation of any circuit, to supplement the algebraic analysis which may already have been done.

Consider first diagram (a). In the absence of overall feedback via R_1, and assuming for convenience a resistive load, the transfer characteristic will be as at (b), giving gross distortion. With overall feedback, the transfer characteristic is much better, as shown at (c); but however much feedback is applied, it can never be quite perfect. Clearly what is wanted is to apply a little more negative feedback in the AB and A'B' regimes than in the AA' regime, thus equalizing the slopes in the three regimes. This is achieved with the (d) arrangement, in which R_1 receives a small extra voltage component (the voltage drop in R_4) only when the dumpers are in action. If R_4 is made too large, there will evidently be too much extra feedback, and the gain will then be *less* in the AB and A'B' regimes than in the AA' regime. The correct value of R_4 will thus give exactly equal slopes, and there is clearly no need for infinite gain to exist anywhere in the circuit for this result to be obtained.

If R_2 is made very large, the system will have a large forward gain and there will then be a lot of overall feedback. Consequently, even with $R_4=0$, the characteristic shown at (c) will have nearly equal slope everywhere, so that a very small value of R_4 is all that is then required for perfect slope equalization. Thus, if R_2 is replaced by a capacitor, giving high forward gain at low frequencies only, the impedance element replacing R_4 needs to have an impedance which is very small at low frequencies but which increases in proportion to frequency to offset the effect of the falling forward gain introduced by C. An inductor is therefore required, as shown in (e).

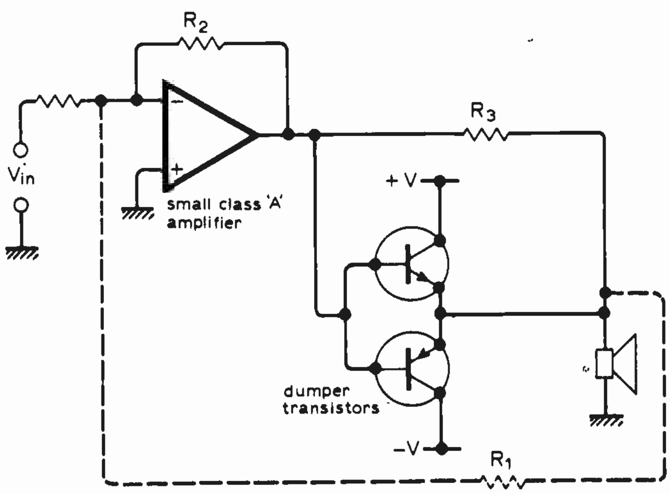
When the circuit shown at (e) is handling a high-level sine-wave signal, the voltage waveform at 'P' is, of course, very non-sinusoidal, and it is therefore necessary for the class A integrating amplifier to have a clean performance up to much higher frequencies than the upper limit of the audio band. A very simple circuit is capable, however, of giving the required performance.

One way to arrive at the correct choice of values for distortionless results with circuit (e), assuming a perfect integrator, is as follows. Consider first the ideal limiting case that the dumper stage is not only on, but that it has infinite mutual conductance. Then the incremental output impedance of the complete circuit is clearly that of R_3 and L in parallel, for at the left-hand side of both of these elements we see the zero output impedance of an ideal feedback circuit. Now consider the other limiting case, where the dumpers are completely off, and work out the output impedance (or, more conveniently, admittance) of the circuit which then applies. It will be found that if L is made equal to R_1R_3C, this output impedance is equal to that of L and R_3 in parallel, as before. Now any system with a distortionless no-load output voltage, and an output impedance independent of loading, must be distortionless.

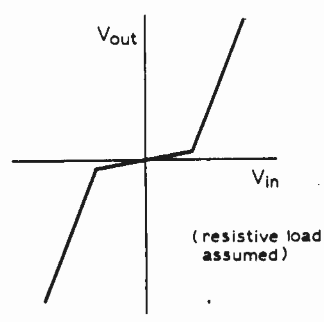
P. J. Baxandall,
Malvern,
Worcs.

1. Blomley, P., "New Approach to Class B Amplifier Design", *Wireless World*, Feb. 1971, pp. 57-61 and March 1971, pp. 127-131. (Also in *Wireless World* "High-Fidelity Designs" book.)

In the April issue of *Wireless World*, Mr P. G. Walker tries to prove that the feed-forward is linear, referred to the input. It would then be possible for the *A* gain (or G_{m1}) to be arbitrarily low and the current dumping to be linear at the same time. This is not the case. The error in the top figure on p. 55 is that it does not show the interaction between G_{m1} and G_{m2}. If G_{m2} is nonlinear it is impossible for G_{m1} (or *A*) to have a linear voltage *and* current gain consistent with linear load current. During the cross-over instant, when the power-section is cut-off, the total gain is only $A\cdot R_L/(Z_3+R)$. During the remainder of the cycle the gain is *A*, because the power-section has approximately unity voltage gain. This causes some cross-over distortion if the gain of *A* is not infinite. No



(a)



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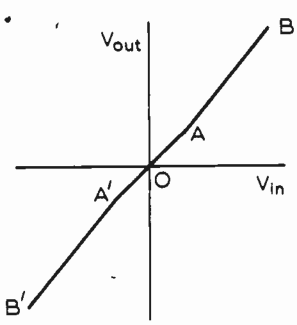

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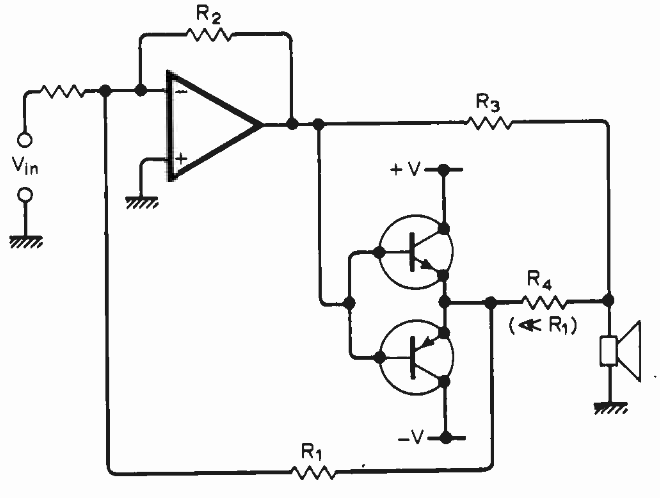
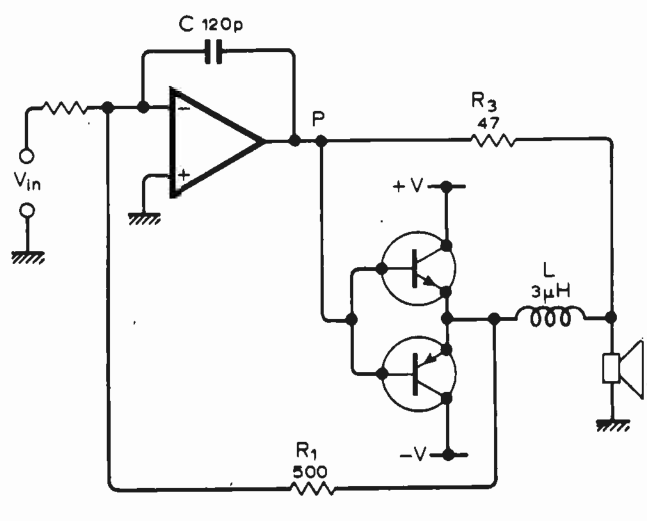


(d)



(e)

more proof is needed to show that the feed-forward is not linear, referred to the input terminals.

One may look a little closer at the non-linear feed-forward, or shall we say, non-linear *gain*, assuming the existence of one of the following extremes of *A* and the power-section. Independent of how the amplifier *A* is fed back, it may have one of the extremes of voltage or current feedback or no feedback at all. Amplifier *A* may thus, by design, have a constant-voltage or constant-current output.

Constant-voltage output in series with Z_d gives a constant G_m – as long as Tr_1 and Tr_2 take no input current. But when they draw a base current comparable to the current in Z_d the G_m is no longer constant. Constant current generated by *A* has the same error. The conditions for constant G_m do not exist as long as Z_d is connected in parallel to the variable input impedance of Tr_1 and Tr_2. In other words there is no way to make *A* linear, which was required to make term I_d disappear from the equations. Since there is no linear relationship between the output voltage and the output from amplifier *A*, the "rigidity of interconnection" is missing, as pointed out by Mr A. Sandman.

The current dumping method acquires a linear *feedback* current, i.e., it is proportional to the total output current, but this goal can with the same merit by arranged by common voltage feedback (assuming constant load) as shown by Mr J. G. Bennett. The feedback from each output path is made proportional to the output current in that path. This holds both statically (feedback resistors only) and dynamically (feedback resistors, capacitors and inductors are used) because of the design rules suggested by P. J. Walker:

$$\frac{\text{feedback current}}{\text{output current}} = \frac{Z_3}{Z_2} = \frac{Z_4}{Z_1} = k.$$

That is: 1 mA of output current (or 1 mA/μs) causes $k \cdot 1$ mA feedback current, whether the current is sensed by Z_3 or Z_4. In addition, there is only one summing point. The audio amplifier can not sense from where the feedback signal originates – all the output current branches being equally weighted by the rule of design. The *forward* linearity will not be changed by the divided feedback loops, since the same input voltage differential *V* is needed to drive the current I_d and the base current of Tr_1 and Tr_2 *irrespective* of how the feedback is taken.

The current dumping method would be unique if the feedback network could separate the different output paths. But it cannot, and the mode of operation is not different from one feedback resistor sensing the output current or output voltage or parts of both. The use of reactances, as in Fig. 2 in Walker's first paper, causes the feedback to increase with the frequency in the same way as if the single feedback resistor is shunted by a small capacitor. There is one implicit feature – that of current continuity, accomplished by Z_d. If Z_d has a low impedance, any non-linear amplifier would be less non-linear. The existence of Z_d causes an improvement, but not a change of nature of the amplifier.

One arrives inevitably at the conclusion that the current-dumping scheme has the same forward nonlinearity and identical feedback collection of output current information, as an ordinary amplifier with zero bias current and with the same amount of feedback. In fact there is no difference at all.

Bengt G. Olsson,
Xelex AB,
Stockholm.

THE WALLTENNA

Any reader who is offended by unsightly roof-top TV antennae should consider another alternative before starting to strip the wallpaper (The "Walltenna", *WW* May 1976 pp 57-59) – the screened loop. This gives me excellent colour TV reception in conditions where a commercial wide-band Yagi array (folded dipole, reflector, and 21 directors) gave excessive ghosting, and gross deterioration of the picture in bad weather. My house is about 50 km east of Crystal Palace, on high ground but surrounded by tall trees, which clearly provided most of the multiple-path interference. A two-turn screened loop mounted horizontally in the loft below the ridge-beam of the roof solved all my problems, and was very easy to make. The last two metres of the coaxial cable to the receiver were coiled to form two turns, and lashed with adhesive tape. A short length of the outer insulating sheath adjoining the loop was removed to expose the braided screen, and a copper-foil clip clamped round it: the free end of the cable was stripped and the screen cut back, the centre conductor being connected to the clip. The result is a loop antenna, having two turns fully electrostatically screened from each other and from interfering sources. The improvement in picture quality was sensational, and my chimney stack is now unadorned. The feeder to the receiver was dropped inside a cavity wall to a flush socket in the living-room, so the installation could not be neater. It is baffling that screened-loop antennae are not more widely used: in areas reasonably close to a transmitter they offer a far tidier roofscape, and less chance of ghosting from mutual interference.

David T. Broadbent,
Chatham,
Kent.

PHASE AND SOUND QUALITY

I hesitate to proliferate the correspondence on phase distortion, but there were letters published in the April issue worthy of comment.

Analogies between eye and ear can be interesting, although I am not sure that they are always constructive; specifically, the suggestion that parallels may be drawn between colour perception and the analysis of chords (even "broadly speaking") is quite wrong. I assume that when Mr Gamble refers to the presentation of a harmonic interval, such as a major third, he means that the tones are to be played simultaneously, otherwise the analogy will bear even less resemblance to the mixing of primary colours. If two notes, reasonably separated in frequency, are played simultaneously, the ordinary observer can pick out the two components making up the chord. If he cannot do this he will most easily hear the upper note, but there is certainly no perception of some kind of average frequency, half way between the two. In vision the situation is entirely different. With suitable choice of intensities a mixture of red and green light, of wavelengths around 600 nm and 540 nm respectively, will look indistinguishable from a pure yellow of intermediate wavelength and the spectral components will be invisible.

A far better analogy is to be drawn between the way in which we hear auditory frequencies and see spatial frequencies, such as a region covered by stripes. There is strong evidence (e.g. Campbell and Robson, *Journal of Physiology*, 1968) that the visual system analyses such stimuli in a manner equivalent to Fourier Analysis and it has been shown that a visual square wave (i.e. alternating dark/light stripes of equal width and with no merging through grey) invokes sensations at the third harmonic, as if there are stripes present three times as close. If stripes of high spatial frequency, with brightness varying sinusoidally, are displayed on a c.r.t. the contrast can be amplitude modulated at a lower frequency. This is exactly equivalent to amplitude modulating a high pitched tone with a lower frequency. In both cases, although the fundamental is not physically present, the low frequency, whether visual or auditory, is perceived.

In the same issue Mr Hodgkinson points out the many other sources of phase distortion that modify the wave form of a signal, apart from the loudspeaker. One that he does not mention is the outer ear flap or pinna. The little folds of the pinnae produce delays and echoes in the sound, particularly at higher frequencies, where the wavelength is comparable to the fold size. Far from being a nuisance to the auditory system the distortion of the waveform is a valuable direction-finding cue, since the effect varies with source/head angle. To extract a clear signal, when it is followed by multiple reflections, we use both ears. If readers care to listen to sounds in a fairly reverberent room and then cover one ear they will observe an increase in "boomyness." However, they will still be able to judge source direction fairly well. If those keen enough now fill in the folds of their exposed ears with plasticine they will find a marked decrease in localising ability! Some listeners to dummy-head recordings do not at first find them particularly convincing, but with continued listening the reality grows. This occurs as the listener learns to hear with a new set of pinnae. Of course, surroundings will modify the spectrum of a sound too, but the distortion remains constant for a given frequency and source direction and the auditory system seems very quickly to cope with this, learning to treat it as a constant. As long as the phase distortions introduced by loudspeakers do not fluctuate arbitrarily over short time intervals, then there is no reason to suppose that we cannot listen comfortably to the results, which is not to say that, given the opportunity to make fairly quick alternate comparisons, we cannot hear a difference between two loudspeakers of differing phase linearity.

Peter Naish,
University of Reading,
Berks.

Being a hi-fi enthusiast myself I have followed the arguments for and against the audibility of phase distortion in audio program material with much interest. To some extent I was hoping that this illusive but controversial effect may explain the differences in sound from systems which are not borne out by differences in specifications. The case for phase linearity in loudspeakers is obviously dubious by virtue of the preceding stages in the process from recording to the output terminals of the amplifier, none of which (with possible exception of the amplifier) are performed with phase linearity as a subject of cause.

However it has intrigued me as to whether, given phase linear material applied directly to a loudspeaker, any phase difference gave rise to a difference in overall sound experience of the listener. In the absence of any phase linear material it is possible to obtain a signal source from two sine wave generators and feed these directly into a loudspeaker via a mixer network whilst monitoring the waveform on a c.r.t. It must be realized that this configuration obviates any of the negative arguments put forward by linear phase optimists that the effects are masked by the use of phase distorted program in subjective tests. It must be accepted that the sine waves from both generators, however pure or impure, are constant and phase distortion in a loudspeaker cannot exist (relative to constant listening position) when it is fed by a single sine wave without any fixed reference.

If the levels of both generators are the same and they are set at 1kHz adjustment of generator B will cause enhancement and cancellation effects at a critical point on the scale. If generator B is then increased to 2KHz and is offset sufficiently to allow it to drift gently in and out of phase with respect to generator A, the tone remains constant and apparently absent of aberations due to the constant drift of phase between signals! I have carried out this experiment at all harmonic multiples and at various levels and ratios of level with various loudspeakers and have so far failed to hear any relationship between the relative phase of the generators and the actual sound of the resultant waveform.

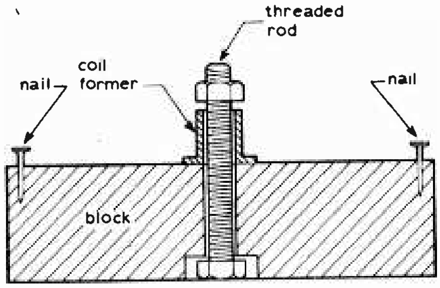
However, if the resultant signal is seriously distorted by introducing a diode across the loudspeaker terminals, regular changes in sound, at the rate of changes in phase, can be heard at a few apparently arbitrary harmonics of the fixed generator A. It seems, therefore, that phase relationships of signals is only audible when the resultant composite signal is wildly distorted! This leads me to believe that, since all musical waveforms are made up of a complex combination of a wide range of sine waves, phase linearity cannot be heard or appreciated unless the output stages of the amplifier are clipping or half waving. And that the sound is then produced by the effect of the waveform meeting an insufficient threshold and is consequently incomplete?

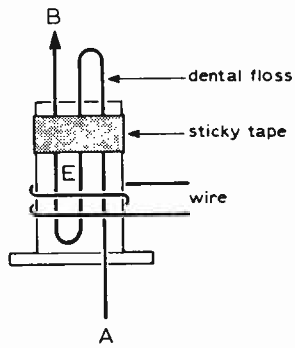
Paul A. Furindle,
Norwich.

Television tuner design

Just a few points about the coil winding for D. C. Read's TV tuner. With regard to the pile wound centre-tapped coils, I presume it is best to wind them with a double strand of wire and make the centre tap the start.

Secondly, I would like to mention ways of making a single layer unframed coil very firm. Of course one winds on a simple jig, as in Fig. 1. To give the coils extra firmness either double-sided sticky tape folded back over the coil or a double looped technique using dental floss can be used. Wire is started through loop E and wound over the 3 strands of floss and to finish passed through loop F.





Then pulling end A will tighten the finish of the coil and pulling end B will tighten the start. It may help to attach the dental floss to the end with double sided sticky tape to start the coil. This makes a very firm coil.

J. Rankin,
Harpenden,
Herts.

Mr Read replies:

I thank Mr Rankin for his helpful coil-construction hints, particularly the one given for making secure winding ends. The double-loop, draw-through process will be well known and perhaps fondly remembered by any ex-Scout (or ex-Guide, for that matter) as the means to produce tidy 'whipping'; the extension of this technique to coil-winding, especially with dental floss as the draw string, is a very useful idea.

I must, however, correct Mr Rankin's wrong supposition regarding the winding of centre-tapped coils. As the tuner circuit diagram (Fig. 2 Part 1) shows, the sense of winding in each instance is 'series-aiding', and for such an arrangement it is necessary to have the centre tap at a finish/start point (assuming the coiling sense to be the same on both sides of the tap). It would be possible to use bifilar winding on these coils much as Mr Rankin suggests, but the double start could not be used as a centre tap because the two halves would then be in series opposition. In fact, with the coils parallel wound like this, the centre tap must be formed by cutting the double start and joining one of the resulting free ends to a winding finish.

But as most of the centre-tapped coils are used in the group-delay equalizer and this circuit is operating at an unusually high impedance of 750 ohms, this is not a satisfactory winding method because it results in excessive self-capacitance, with the danger of in-band self-resonant coils.

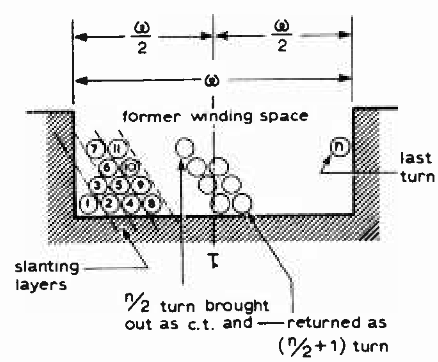
As explained in the follow-up article (*Wireless World*, April, page 83), pile winding is the best way to reduce coil capacitance and can be used for tapped as well as single coils. The diagram shows how the winding order is modified to enable the tap to be brought out.

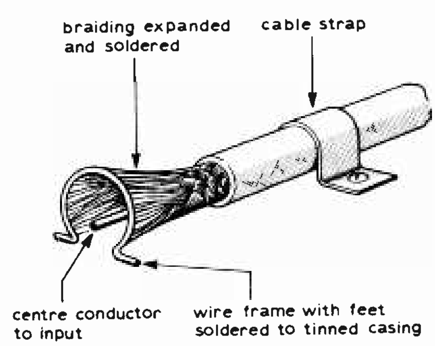
The tuned circuits L_{10}(110μH) – C_{13} and L_{11} (14μH) – C_{31} should resonate at 3MHz and L_{12} (39μH) – C_{32} and L_{13} (12μH) – C_{33} should resonate at 5.5MHz. Wind L_{13} with 23 turns, and not 31 as given in the parts list. The correct tuning for these inductors should obtain when the cores are turned back between 1 and 4 turns from the fully-in position. In case of difficulty in resonating L_8, L_9, the shunt capacitors can be reduced.

The group delay network, L_{10} – L_{13}, may add a small amount of stray shunt capacitance and cause a slight droop of the video characteristic – between 1 and 2dB – which can be compensated by adjustment of the optional equalizer circuit in parallel with R_{25} (see broken lines at Tr_5 in Fig. 2, October issue page 450).

A pack containing all the parts required for the tuner inductors is available from Manor Supplies (excepting the rubber cushion shown on page 83. Cut this from rubber 1-2mm thick to a size of 13mm square).

Finally, a small but important aspect of reception inadvertently not covered in the earlier articles should be mentioned. It concerns the high-order vision and sound carrier harmonics generated by carrier clipping diodes in the MC1330 demodulator and the discriminator circuit. Some of these harmonics, specifically from the 12th to the 20th, fall in bands IV & V, and, if picked up on the aerial input, could cause considerable interference. Obviously, it is good practice to have efficient screens at all low-level circuit points, especially at the ELC1043 aerial input connection. For this particular purpose, a Mullard accessory – called an immunity shield (part number 4313 132 01910) – is available. A satisfactory home-made alternative can be constructed, however, by suitably stretching the screening braid of the incoming aerial co-ax so as to form a hood over the connection. As illustrated in the diagram below, this is most easily done by





bending a small piece of wire (about 20 s.w.g.) into an omega-shape and soldering this to the tinned cover. The braid end is then pulled over and round the frame as shown and then soldered, allowing small amounts of solder to run over the braid to strengthen the hood.

Digital multipliers and dividers

Summary of circuits in set 31 of Circards

by J. Carruthers, J. H. Evans, J. Kinsler & P. Williams

Paisley College of Technology

Many transducers used in the measurement, or as a monitoring function, of physical processes deliver digital signals in the form of a pulse-rate. This sort of information is usefully processed by rate-multipliers which are available as m.s.i. circuits, both in t.t.l. and c.m.o.s. Their range of application is wide, covering numerical control, digital filtering and frequency synthesis, to name a few. When combined with up-down counters, rate-multipliers may perform arithmetic functions such as multiplication, division, square-rooting and integration.

Basically, a rate-multiplier generates an output pulse-rate or frequency which is proportional to the product of two inputs, one of which is a clock frequency f_c, and the other, an n-bit binary or binary-coded-decimal integer. M is the programmed number, with $N=2^n-1$, and the output pulse rate is $f_c.M/N$ where $N>M$, so that the output rate is always less than the input pulse rate. Usually the rate-multiplier produces a train of unevenly-spaced pulses, but this is not too critical when the output rate is time-averaged to the correct fractional rate of the input pulse train.

This type of multiplier is useful under conditions where variable input pulse rates are to be multiplied or divided on-line. For example, an unknown input frequency can be compared against a rate-multiplier output and on the result of the comparison, a counter can be made to count up or down until a stable result is acquired, which will relate to the unknown quantity. This is usually a counter/multiplier closed loop which allows fairly straightforward implementation. Discrete and m.s.i. forms with applications are covered in three of the cards of this set.

Card 8 considers a simpler frequency ratio ratemeter to provide an analogue output signal proportional to the ratio N_1/N_2, where N_1 and N_2 are the average rates of two input pulse trains, but this requires additional constraints on the ratio that can be recognized. Normal frequency division with m.s.i. counters provides output pulse trains which are not symmetrical, whereby with fairly simple external gating, card 7 summarises techniques for obtaining a range of dividers which always produce symmetrical outputs.

Stochastic multiplication is reviewed in card 4, with a novel delta-sigma modulation technique using probabilistic principles being discussed on card 6. The specific application arranges for squared and cubic outputs proportional to an analogue input, but demanding a synchronous clock-drive. Another m.s.i. package for implementing cellular-array structures provides for 2 bit by 2 bit multiplication, and is shown to be extendable to increased bit manipulation by straightforward interconnection of the i.c. packages. To conclude this short summary of Set 31, a digital/analogue monolithic 8-bit d-a converter is shown to provide a fairly simple technique for multiplying two-binary numbers and giving an analogue output voltage or current proportional to the result.

Titles of cards in this set are:

1 monolithic d/a multiplier
2 2 x 2 bit binary multiplier
3 binary rate multiplier
4 stochastic multiplication
5 dual-slope a/d multiplier
6 $\Delta\Sigma$ modulator probability multiplier
7 symmetrical programmable divider
8 pulse ratio measurement
9 applications of rate multipliers/ dividers – I
10 applications of rate multipliers/ dividers – II

Surround sound decoders — 2

Assembly, setting-up CD-4 unit, cartridge notes

David Heller, B.Sc.(Eng.)

This article includes performance details of a CD-4 decoder using the QSI i.c., which includes preamplifier, phase-locked loop demodulator, a.n.r.s. expander and muting circuits. Spectrum analyser traces show performance of record-cartridge-decoder system for various extended-response cartridges. Subsequent articles by the same author will give circuits for QS and SQ surround sound decoders.

The construction of the demodulator is straightforward, but note the following points. Solder the link wires whose positions have been silk-screened on top of the board after soldering resistors into position, but before soldering the remaining components. Do not apply too much heat to the polystyrene capacitors; these 30 volt devices are closely wound and excessive heat will short the layers together.

The 12mH, 15mH and 18mH inductors are variable inductors which have been preset. They are either marked with their values or colour coded with paint (red — 12mH, green — 15mH and grey — 18mH). On no account should the pot cores be adjusted and each coil should only be handled by its case so as not to disturb the core.

Use insulated wire to connect remaining links (marked A to A, B to B, C to C, D to D, E to E, F to F, G to G and H to H on the board). These connections are best made on the copper side of the board.

In connecting the signal input to the board (points h and i on the switches to points h and i on the board), use screened cable but only earth one side of the lead. To stop possible r.f. breakthrough, loop small ferrite beads with three to four turns of wire and solder one end of this wire to the points on the board (marked h and i) with the other end going to the audio lead.

Connect the points on the switch positions to the similarly marked points on the board using insulated wire. Again it is preferable to make the connections on the underside of the board. (The positions to be connected are b to b, o to o, c to c, x to x, d to d, m to m, e to e, l to l. Points f, k, a and p are left unconnected.) The signal input leads to the selector switches are: tuner input to v (left) and w (right); auxiliary input to s (left) and t (right); tape input to g (left) and r (right), and disc input to g (left) and j (right).

Care must be taken not to create an earth loop; in particular the input socket earth must not touch the chassis. A separate earth line should be run from the mains socket earth to the earth of the power supply. And the board should only be earthed in one position i.e. an earth wire is run from the earth point on the board to the power supply earth. A 100nF capacitor should be soldered between the input socket earth and chassis. Run an earth wire from the chassis to the power supply earth terminal.

Connections for switches S_1 are best "hard-wired", depending on whether a magnetic or semi-conductor cartridge is used. (Note that on the p.c. board, the marking "S1E" correspond to S_{1b} in the circuit diagram. S4 on the board corresponds to S_2 in the circuit.)

When wiring is completed (do not forget the l.e.d. — anode to supply rail) mount the board in its box and connect up a regulated 13 to 14 volt supply line to the supply rail, but do not turn on. (A power supply is included in the kit available from Compcor; a circuit will be given with the next part and is suitable for the CD-4, QS and SQ decoders.)

Setting-up procedure

Connect the record player fitted with extended-response cartridge to the input jacks of the demodulator using low-capacity TV cable of approximately 50pF/metre. Limit the cable length to maintain a total capacitance of 100pF or less. Run a separate earth wire from the chassis of the demodulator to a screw or chassis of the turntable.

Switch on the equipment and place the pickup on band 2 of side 2 of the test record. If the demodulator is functioning and either of the two phase locked loops are in-lock, the l.e.d. should glow. Adjust the 4.7kΩ v.c.o. potentiometers so that the l.e.d. glows brightest. By turning the v.c.o.-adjust potentiometer ($R_{57,157}$) to either of the extreme positions, the l.e.d. will either go off or vary in intensity depending whether the other v.c.o. is in lock or out of lock.

Turn the test record to side 1, band 3. This gives the same music played sequentially out of each speaker. Turn down the front volume controls of your amplifier. Adjust the 1kΩ separation potentiometer ($R_{9,109}$) of the preamplifier for minimum loudness out of the respective rear channels when the announcer states the front channel sound. The announcer will state "left front channel" and music will follow. Adjust the left separation adjust to get minimum loudness from the left rear channel. Disregard the announcement of the rear channel music. Repeat the process for the right front channel announcement, this time tuning for minimum right rear channel loudness.

Alternatively, the white noise source on band 2 can be used. This is fully explained on the test record. Return to side 2 of the test record and place the cartridge anywhere from band 2 onward. Turn the balance control first to the left side and adjust the left hand side v.c.o. control for minimum distortion. Repeat the process with the balance control set for the right hand side.

Extended-response cartridges

The following nine cartridges were tested: Tenorel 2001SD, Audio Technica 12S, Nagaoka JT322, JVC 4MD20X, B & O MMC5000, B & O MMC6000, JVCX1, Pickering UV152400 and Pickering XUV4500. Each cartridge was tested in an SME arm with detachable headshell. Tracking weights between 1gm and 3gm were chosen depending on the various manufacturers' recommendations. Using side 1, band 3 of the test record, the separation control was adjusted for minimum level out of each of the rear speakers.

Side 1, band 2 of the test record contains CD-4 encoded white noise. With the aid of an audio spectrum analyser, kindly loaned by Hewlett-Packard, the spectrum level of the front channel was measured and stored on the display. The analyser was then connected to the rear channels and the same passage of white noise was replayed and the spectrum level recorded on the lower trace.

The accompanying photographs, Fig. 11, show the relative levels between front and back for the left hand channels only, the top trace being the front channel and the lower trace being the rear channel. The difference in level is thus the separation obtained from the disc encoded material through the cartridge and demodulator.

Performance

Input level	0.7 to 14mV
Input impedance	
magnetic	100kΩ
semiconductor	2.2kΩ
Output level	300mV
Output impedance	less than 200Ω
Amplitude response	
baseband system	30Hz to 15kHz, −3dB
carrier system	30Hz to 12kHz, −3dB
Harmonic distortion	
baseband	less than 0.2%, at 150mV output (typically 0.05%)
carrier channel	less than 1%, at 150mV output, 1—10kHz
Power supply	12 to 15V, 130mA max

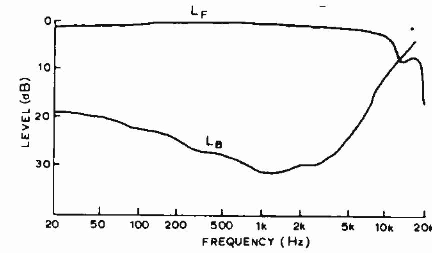


Fig. 13. Front-back separation measured using test bench generator. Sum signal delayed by 45μs with reference to the carrier signal.

Separation	
front-back	>30dB at 1kHz. See Fig. 13 for system separation
left-right	60dB at 1kHz
S/n ratio*	>60dB

*Measured using a virgin test record, containing an unmodulated and modulated (1kHz) carrier together with 1kHz baseband signal.

Components

Resistors All ¼W 5% carbon film

$R_{1, 101}$	47k
$R_{2, 102}$	100k
$R_{3, 103}$	10k
$R_{4, 104}$	150k
$R_{5, 105}$	15k
$R_{6, 106}$	15k
$R_{7, 107}$	15k
$R_{8, 108}$	2.2k
$R_{9, 109}$	1k pot
$R_{10, 110}$	20
$R_{11, 111}$	2.2k
$R_{12, 112}$	20
$R_{13, 113}$	330
$R_{14, 114}$	3.3k
R_{115}	150k
R_{16}	100k
$R_{17, 117}$	6.8k
$R_{18, 118}$	8.2k
$R_{19, 119}$	7.5k
$R_{20, 120}$	15k
$R_{21, 121}$	4.7k
$R_{22, 122}$	4.7k
$R_{23, 123}$	4.7k
$R_{24, 124}$	8.2k
$R_{25, 125}$	4.7k
$R_{26, 126}$	1k
$R_{27, 127}$	27k
$R_{28, 128}$	4.7k
$R_{29, 129}$	15k
$R_{30, 130}$	220k
$R_{31, 131}$	15k
$R_{32, 132}$	4.7k
$R_{33, 133}$	10k
$R_{34, 134}$	220k
$R_{35, 135}$	3.3k
$R_{36, 136}$	4.7k
$R_{37, 137}$	4.7k
$R_{38, 138}$	4.7k
$R_{39, 139}$	4.7k
$R_{40, 140}$	470k
$R_{41, 141}$	1.8k
$R_{42, 142}$	4.7k
$R_{43, 143}$	4.7k
$R_{44, 144}$	4.7k
$R_{45, 145}$	47k
$R_{46, 146}$	4.7k
$R_{47, 147}$	4.7k
$R_{48, 148}$	4.7k
$R_{49, 149}$	47k
R_{50}	1.8k
$R_{51, 151}$	560k
R_{52}	330
$R_{53, 153}$	2.7k
$R_{54, 154}$	1k
$R_{55, 155}$	330
$R_{56, 156}$	56k
$R_{57, 157}$	4.7k preset
$R_{58, 158}$	10k
$R_{59, 159}$	10k
$R_{60, 160}$	10k optional
$R_{61, 161}$	10k

Capacitors

Types E are electrolytic. PC Siemens B32540 polycarbonate, PE polyester, PS 30V polystyrene, and DC disc ceramic.

$C_{1, 101}$	3.3μ	16V	E
$C_{2, 102}$	200μ	10V	E
$C_{3, 103}$	4.7n	PS	
$C_{4, 104}$	22n	PC	
$C_{5, 105}$	0.47μ		E
$C_{6, 106}$	33n	PS	
$C_{7, 107}$	2.2n	PC	
$C_{8, 108}$	2.2n	PC	
$C_{9, 109}$	8n	PE	
$C_{10, 110}$	450p	PS	
$C_{11, 111}$	1.4n	PS	
$C_{12, 112}$	1.6n	PS	
$C_{13, 113}$	10n	DC	
C_{114}	3.3μ	16V	E
$C_{15, 115}$	2.7n	PS	
$C_{16, 116}$	2.1n	PS	
$C_{17, 117}$	960p	PS	
$C_{18, 118}$	3.9n	PS	
$C_{19, 119}$	6.8n	PS	
$C_{20, 120}$	3.3μ	16V	E
$C_{21, 121}$	7.2n	PS	
$C_{22, 122}$	10n	DC	
$C_{23, 123}$	3.3μ	16V	E
$C_{24, 124}$	100p	PS	
$C_{25, 125}$	100p	PS	
$C_{26, 126}$	0.47μ	16V	E
$C_{27, 127}$	2.2n	PC	
$C_{28, 128}$	0.68	PC	
$C_{29, 129}$	4.7μ	16V	E
$C_{30, 130}$	960p	PS	
$C_{31, 131}$	3.9n	PS	
$C_{32, 132}$	3.1n	PS	
$C_{33, 133}$	3.3μ	16V	E
$C_{34, 134}$	3.3μ	16V	E
C_{135}	100μ	10V	E
$C_{36, 136}$	10n	DC	
$C_{37, 137}$	6.2n	PS	
$C_{38, 138}$	800p	PS	
$C_{39, 139}$	3.3μ	16V	E
$C_{40, 140}$	68p	DC	
$C_{41, 141}$	10n	DC	
$C_{42, 142}$	6.2n	PS	
$C_{43, 143}$	800p	PS	
$C_{44, 144}$	3.3μ	16V	E
$C_{45, 145}$	68p	DC	
$C_{46, 146}$	10n	DC	
C_{147}	100μ	10V	E
$C_{48, 148}$	100μ	16V	E
$C_{49, 149}$	33μ	10V	E
$C_{50, 150}$	6.8n	PS	
$C_{51, 151}$	10μ	16V	E
$C_{52, 152}$	100n	DC	
$C_{53, 153}$	68p	DC	
$C_{54, 154}$	10n	DC	
$C_{55, 155}$	10n	DC	
$C_{56, 156}$	68p	DC	

Semiconductor devices

IC_1, IC_{101} Signetics QS5022
Tr_1 — Tr_4, Tr_{101} — Tr_{104} BC208A
D_1, D_{101}, D_2, D_{102} 1N4148
light-emitting diode TIL209, MLED650, or similar

Inductors

$L_{1, 101}$ 15mH Toko 80016
$L_{2, 102}$ 18mH Toko 80016
$L_{3, 103}$ 12mH Toko 80016
$L_{4, 104}$ 15mH Toko 80016
$L_{5, 105}$ 100mH TDK 104J

A 10kHz bandwidth is displayed because, in all but one case, the separation fell below 5dB after 10kHz. The only exception was the B & O MMC5000 where 10dB of separation extended to 13kHz Fig. 12.

In addition listening tests were carried out using difficult CD-4 records. The following is a brief assessment of each cartridge.

Tenorel 2001SD. Separation of 18dB was attained at about 2kHz, but disappeared totally at 9kHz and reversed at 9.25 kHz. In the listening tests, carrier dropout occurred frequently with annoying results. Playing weights of close on 3gm were required with the result that the cartridge base nearly touched the record.

Audio Technica 12S. Peak separation of 18dB occurred at about 2kHz, decreasing to 5dB at about 8kHz and remained at such to 13kHz, where the low-pass filter in the demodulator started to take effect. A tracking weight of 1.8gm gave good results with little carrier dropout. This cartridge is available at discount stores for about £17 (including v.a.t.) and is the low cost cartridge I would recommend for the system.

Nagaoka JT322. This cartridge displayed 15dB separation at 2kHz, but this disappeared at about 9kHz. Its output at 2gm tracking weight was on the low side and it did not track difficult passages as well as the AT12S. This cartridge is available from its distributor in The Netherlands at a cost of about £22. The AT12S is a better bet.

JVC 4MD20X. This cartridge gave essentially similar results to the AT12S, but is about twice its cost. I would go for the AT12S in preference as I found little to choose between the two in performance.

B & O MMC6000. The MMC6000 has a recommended tracking weight of 1gm. I tried three of these cartridges and none functioned satisfactorily. The devices suffered from carrier loss particularly in the left channel. The latest sample I tried was found to be defective when played through B & O's own demodulator. I believe the cartridge should only be used in the tangential player for which it was designed; the SME arm has too much mass for such a delicate cartridge.

B & O MMC5000. The MMC5000 gave excellent separation results, as the extended separation trace of Fig. 12 shows. However, the maximum practicable tracking weight was 1.5gm and this was inadequate for an SME or similar type arm. The cartridge is ideally suited for the B & O 3400 unit which has a low-mass arm and can thus track at a lower weight more effectively. A pity, because this cartridge showed signs of excellence, but carrier breakup was too frequent for comfort. On consulting B & O they agreed that a low-mass arm would be needed to ensure effective tracking.

JVC X1. This cartridge gave 20dB

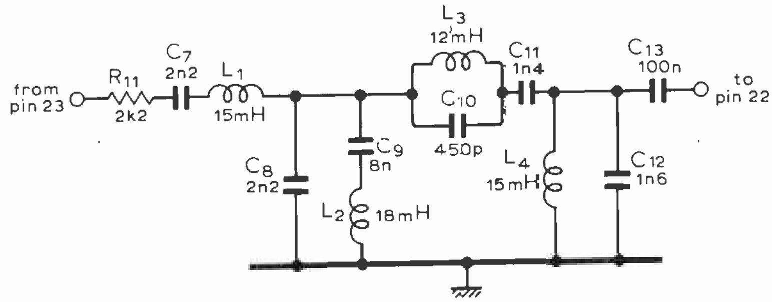


Fig. 10. Linear phase filter with delay of 32μs, 19-45kHz. Two of these filters are used in the circuit of Fig. 9.

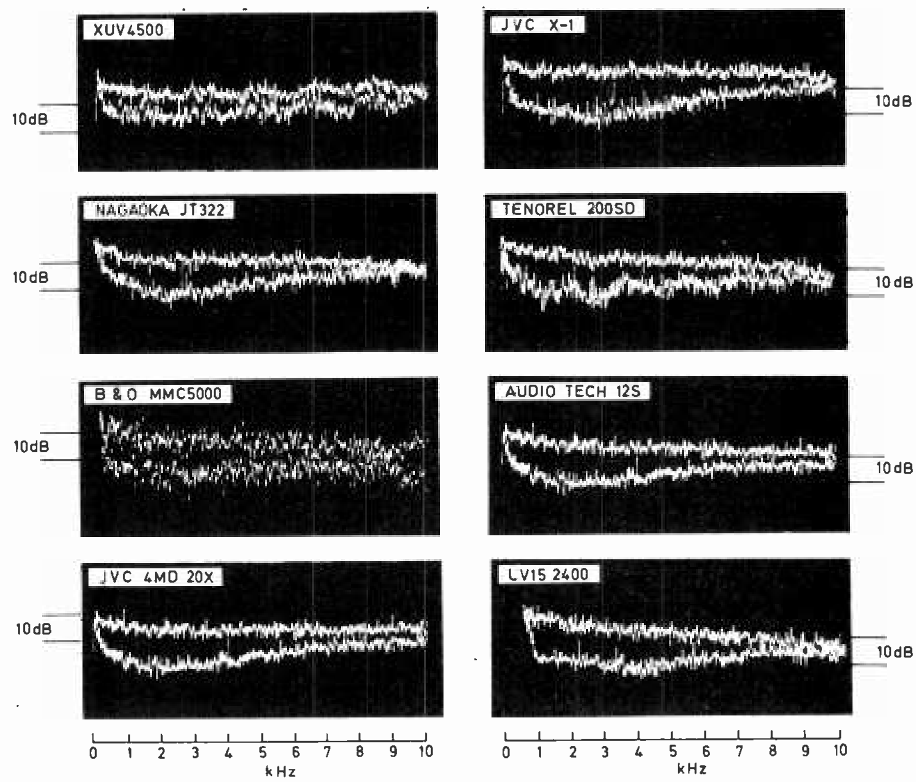


Fig. 11. Spectra of the left front and left back demodulated signals from a white noise CD-4 encoded disc through selected cartridges and the demodulator.

separation between 2 and 5kHz, settling to about 5dB at 9kHz. Its tracking of CD-4 records at 1.8gm was excellent and its clarity was unequalled by any other cartridge except Pickering's XUV4500. This is indeed an excellent CD-4 cartridge and is available at some discount stores at about £50. For those who have the money, this represents very good value.

Pickering UV152400 and XUV4500. Both of these cartridges are very expensive. The UV152400 displayed similar separation characteristics as the AT12S but was clearly superior in tonal quality. However, it is more expensive than the JVC X1.

The XUV4500 was an excellent cartridge. Admittedly the separation exhibited in the photograph looks poor (about 10dB over the bandwidth displayed), but it is likely that this is

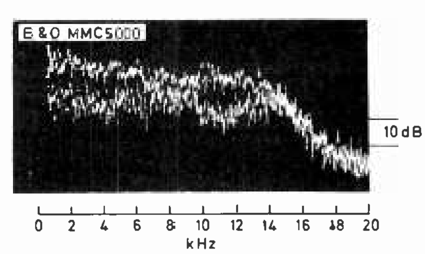
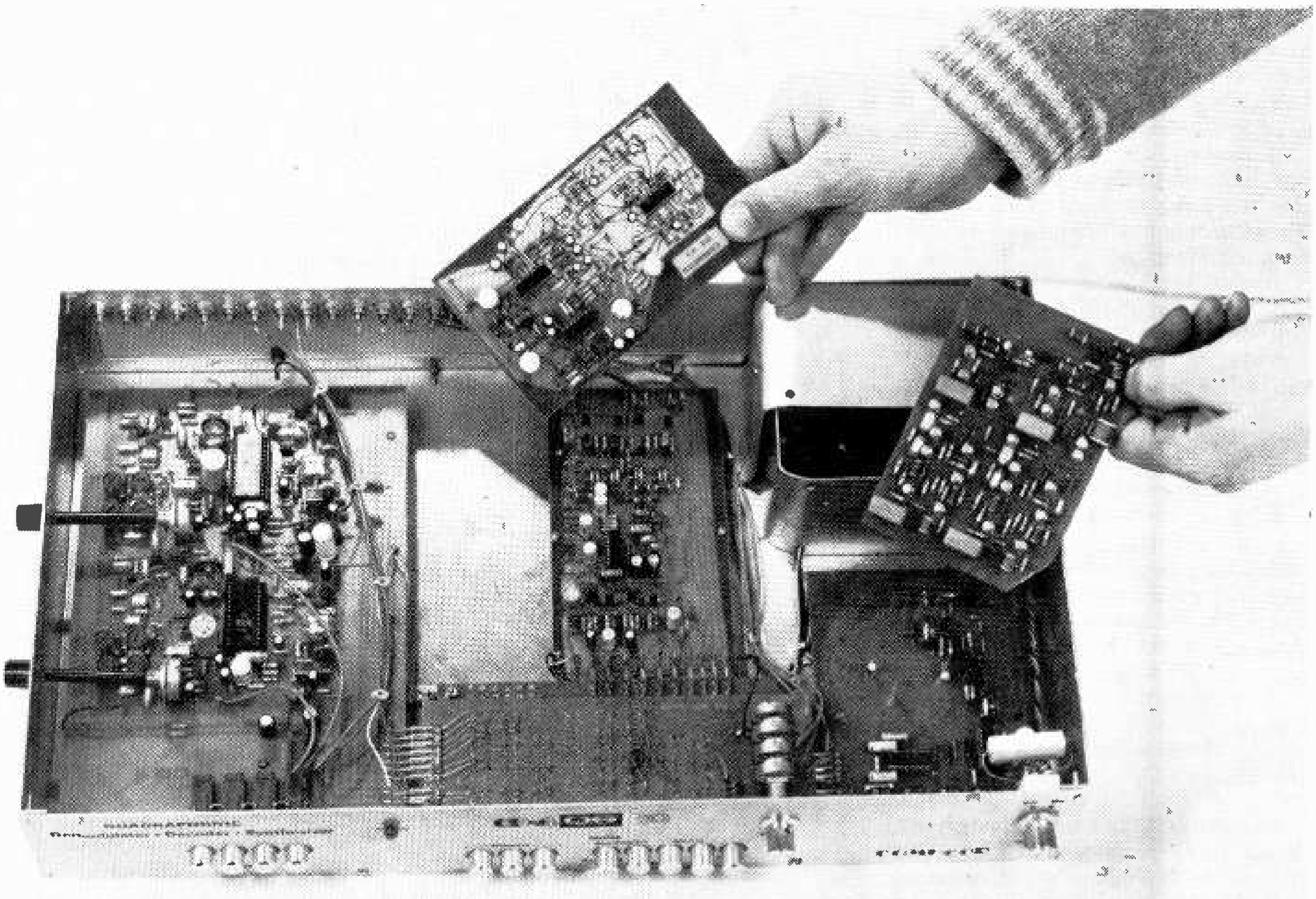


Fig. 12. Separation of 10dB or more extends to 13kHz in the case of the B&O mmc5000 cartridge.

because the delay time of this cartridge is shorter than that of the other cartridges tested (12μs for the XUV4500 against 25μs for the majority of the others). The demodulator is designed for a 25μs delay through the cartridge and any deviation from this will reduce separation. In listening tests I was not



able to perceive any less separation through this cartridge when compared to the JVC X1. It performed equally as well as the X1 and proved superior on stereo discs to the X1. Both cartridges were tested using the difficult band of the Hi-Fi Sound 75 test record. The XUV4500 tracked this band perfectly, while the JVC X1 displayed some slight mistracking.

After carrying out extensive tests on the cartridges named, I would recommend the AT12S for budget systems and the JVC X1 for those who can afford it. In both cases a tracking weight of between 1.8 and 2.0gm proved optimal.

Correction. On page 45 of the June issue, the reference to C_{38} should be to C_{33}.

One format of the surround-sound decoder incorporating CD-4 unit (left). A two-board SQ decoder is shown right, and a two-board QS decoder middle. There is space for a rear-channel, preamplifier and tone control, above the switchboard.

Acknowledgement. I should like to thank Lou Dorren of Quadracast Systems Inc. for the valuable help and guidance given in the preparation of this CD-4 project. Thanks too to Hewlett Packard for the loan of the audio spectrum analyser.

A kit of parts (except metalwork) may be obtained from Compcor Electronics Ltd, 9 Dell Way, London W13 8JH for £37 inclusive of v.a.t., packing, postage and insurance. The same price applies to overseas readers, and covers the cost of airmail postage. A test record produced by Quadracast Systems Inc is available for £4.20 inclusive from the same supplier.

A specially constructed case is available from Bazelli Instrument Cases, St. Wilfred's, Foundry Lane, Halton, Lancaster LA2 6LT for £10 (including v.a.t. and carriage) with fully punched panels or £8 unpunched. This case will house CD-4, QS and SQ decoders and power supply. A suitable case for the CD-4 module only is type B304, available from the same company for about £5 (unpunched) inclusive of delivery and v.a.t.

Announcements

Panduit Ltd of Sittingbourne, Kent, manufacturer of cable ties and DIN connectors, has announced the appointment of Vero Electronics Ltd, Chandler's Ford, Eastleigh, Hants, as the UK stockist and distributor for the Panduit range of DIN 41612 and 41613 one-piece and two-piece connectors.

Gould Advance Ltd has appointed J. Sinclair Ltd, 8 Dixon Place, College Milton North, E. Kilbride, Glasgow, G74 5JF, as the Scottish agent for Gould Advance power supplies and Gould Brush oscillographic recorders.

Ferrograph, Ferrograph Professional, Rendar and Wayne Kerr, formerly operating as separate companies within the Wilmot Breeden (Holdings) Ltd, are to trade collectively as **Wilmot Breeden Electronics Ltd.** Manufacturing facilities for the various product groups will remain at South Shields, Burgess Hill and Bognor Regis.

Laskys, one of Europe's leading hi-fi retailers, has announced a new service. All of Laskys' 35 branches will offer a **repair service for** any **hi-fi equipment,** provided that spare parts are available. You do not need to have purchased the equipment from Laskys.

Boosey & Hawkes Ltd has formulated a new subsidiary **Boosey & Hawkes (Electrosonics) Limited.** This follows the acquisition earlier this month of 50 per cent of Hammond Organ UK Ltd. Hammond will continue to be run by its existing management team who will also manage Boosey & Hawkes (Electrosonics). Boosey & Hawkes (Electrosonics) will market a range of electronic musical products both in the UK and overseas. It will be exclusive distributor of Leslie Speakers in the UK and will operate from new premises at St Albans, Herts.

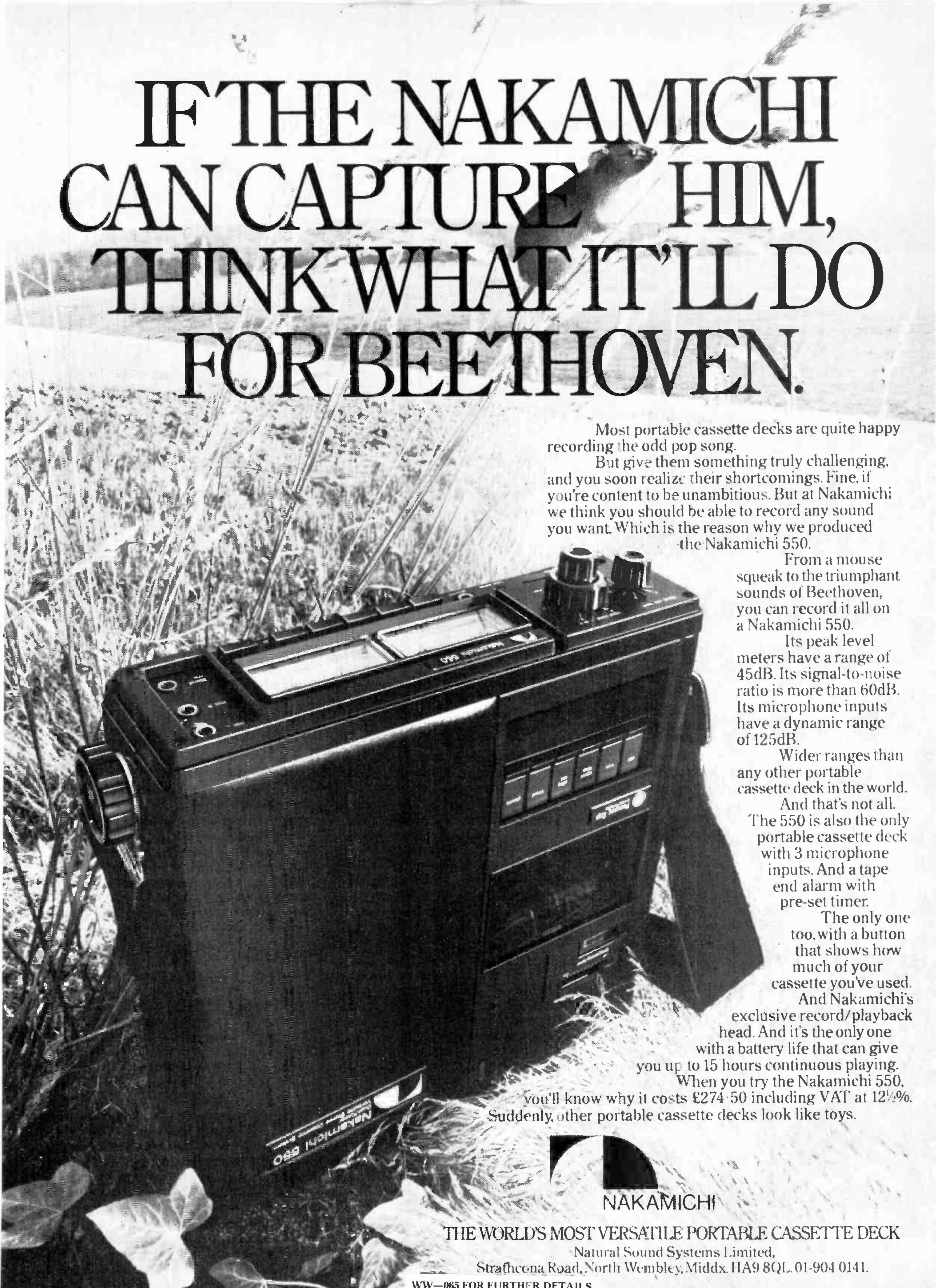
Steatite Insulations Ltd, Hagley House, Hagley Road, Birmingham, B16 8QW, have announced their entry into the field of semiconductor devices in co-operation with **Toshiba (UK) Ltd.** The aim of the agreement is to broaden the UK penetration of Toshiba's semiconductors and to enable this by forming a semiconductor marketing department at the Steatite Group's headquarters in Birmingham.

In keeping with their involvement with the military electronics industry, **Sealectro Ltd,** Walton Road, Farlington, Portsmouth, PO6 1TB, manufacturers of precision coaxial connectors, insulated terminals and programming devices, have received approval by the Ministry of Defence to the recently introduced standard 05-21.

The UK agency for **Fuki Film magnetic tape** has been given to Belmont A/V Ltd, a member of the Pyser Group, at Fircroft Way, Edenbridge, Kent, TN8 6HA. The range of Fuki Film cassette and open reel tapes is available to the public from mid-May, 1976.

Uher Werke Munchen have announced that with effect from April 1st, 1976, a wholly owned subsidiary company, namely Uher Ltd, 24 Market Place, Falloden Way, London, N.W.11, will transact all business in the UK and Channel Islands under a distribution agreement.

Jermyn Industries, Vestry estate, Sevenoaks, Kent, will programme all National p.r.o.ms free of charge, providing the memories are purchased from them. They will also consider programming memories of other manufacture free of charge dependent on type of memory, application and complexity.



WW—065 FOR FURTHER DETAILS

Binary counting

Explanations of terms used in today's techniques

by C. Jones

As digital techniques continue to spread to increasingly diverse applications so the ranks of those obliged to keep abreast of developments in logic design are swelling accordingly. It is lamentable that this area of most rapid change is also surrounded by the heaviest element of mystique, perpetuated to a large degree by excessive and often cynical use of jargon in much of the associated literature.

While it is true that current trends in logic design are quickly reflected in additions to the integrated circuit lists, there is a tendency for the various manufacturers to favour differing terminology when referring to what are, in fact, identical circuit types and functions. This is particularly marked in the case of the binary counter which, as the most versatile of the digital building blocks, has spawned so many variations.

Counters now attract such terms as "programmable", "variable-modulo", "parallel access", and "carry lookahead" while clocking arrangements are described as synchronous, asynchronous or even semisynchronous.

The implications of these and many other circuit descriptions are certainly of more than just academic interest and are considered in this review of current binary counting techniques.

Basic counting and the JK flip-flop. The basic counter arrangement Fig.1, which is included for the sake of completeness, consists of a chain of four JK edge-triggered bistables with the count pulse, or "clock", applied to the first stage only. Each successive stage accepts the (Q) output of the preceding one as a clock pulse input and will change stage each time this preceding stage is reset.

Note that the leading (least significant) stage does not change state until the trailing edge of the clock pulse — this is a feature of the JK class of flip-flop which is the bistable most favoured in integrated logic design. The adoption of the JK flip-flop as the preferred micrologic bistable is based on the versatility obtained by combining the best features of alternative configurations to form one multipurpose design suitable for all applications.

Functional differences between the more familiar RS (set/reset) flip-flop and the JK type are illustrated by comparison of the truth tables (Tables 1 and 2). The troublesome indeterminate condition resulting from a "1" level being presented to both R and S inputs simultaneously is overcome in the JK arrangement by "back-priming" connections (Fig. 2) which force a straightforward change of state for the double "1" input condition. However, as the changeover will normally take place well within the width of the clock pulse the effect of simple back-priming connections will be to allow the circuit to tumble between one state and the other until the clock pulse ends. This problem is overcome by adopting the slightly more complex arrangement (Fig. 3) in which two RS flip-flops are connected in cascade with clock pulse inversion and gating in such a way that the second flip-flop (slave) is prevented from following the first (master) until the trailing edge of the clock pulse. In effect, a delay has been introduced on the back-priming lines to prevent unstable operation.

It is this characteristic two-stage transfer action that has added the term "master/slave" to the JK flip-flop description in which J and K have been

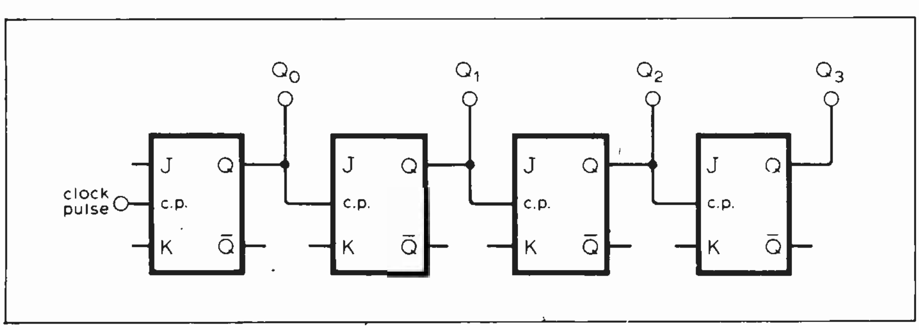


Fig. 1. Basic JK count chain.

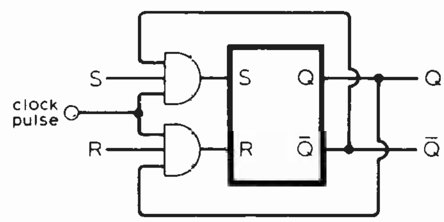


Fig. 2. Simple back-priming of RS flip-flop.

R	S	$\bar{Q}'$	Q'	$\bar{Q}$	Q
0	1	$\bar{Q}'$	Q'	0	1
1	0	,,		1	0
0	0	,,		$\bar{Q}'$	Q'
1	1	,,		*	*

Table 1. RS flip-flop.

K	J	$\bar{Q}'$	Q'	$\bar{Q}$	Q
0	1	$\bar{Q}'$	Q'	0	1
1	0	,,		1	0
0	0	,,		$\bar{Q}'$	Q'
1	1	,,		Q'	$\bar{Q}'$

* indeterminate
$\bar{Q}'\ Q'$ outputs before clock
$\bar{Q}\ Q$ outputs after clock

Table 2. JK flip-flop.

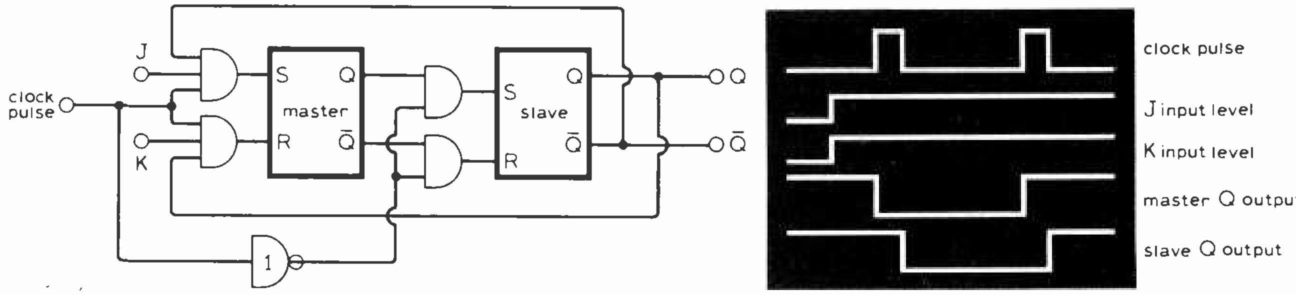


Fig. 3. *JK (master/slave) flip-flop.*

taken to correspond to S (set) and R (reset) respectively. In the binary counting application the J and K inputs of each stage are internally tied to the logic "1" level so that the required binary sequence is followed.

Reduced counts. When the internal organisation of the various counter types is studied it becomes evident that certain basic configurations have been generally preferred, mainly to ensure that each device meets the widest possible field of applications.

To this end it will be found that standard four-bit counters have no internal connection between the first and second stages and separate access is provided to the clock input of the second stage (Fig.4).

By splitting the count chain into two distinct parts, three count modes are made available with an external connection required for the full division by sixteen. When operating in the split-count mode, the first and final three stages are able to function quite independently of each other in the divide-by-two and divide-by-eight modes, even when working at widely differing clock rates. However, as the reset-to-zero facility has not been similarly split the dual count mode is restricted to those applications which either do not use a reset or those that can tolerate common resetting.

The split-count method of providing for shortened counts is purely organisational and cannot be regarded as a true reduced count in the same way, as, for example, the decade counter which involves a premature reset-to-zero. Retaining the split-count format will now result in separate divide-by-two and divide-by-five modes or a full count which is held-down to ten.

The divide-by-twelve counter, although apparently similar to the decade format, has important functional differences which show clearly when the count patterns are compared. The output lines of the decade counter are allowed to follow a true binary coded decimal (b.c.d.) progression from 0 to 9. By comparison, the method used to produce the divide-by-twelve count is a combination of premature resetting and count knock-on logic which, in effect, causes two count states to be skipped.

This forcing-on technique inevitably results in count patterns appearing at the output pins which do not accurately relate to the true count. The sequence diagram (Fig. 5) shows that this occurs during the second half of the count cycle with counts 6 and 7 being skipped and the reset being forced at the appearance of 14. The divide-by-twelve counter is therefore unsuitable for the direct driving of count displays any further than the 50% duty cycle point.

Synchronous working. The counting scheme so far outlined (Fig. 1 and 4) in which the clocking pulse is applied to the first stage only is generally known as ripple or asynchronous counting and is only acceptable provided that speed of operation is not of primary importance. If, however, the total count length has been greatly extended by a stringing together process, then the time taken for a resetting edge to "ripple" through the entire counter length could well prove to be prohibitive. This would apply particularly to uses in which various processing steps are initiated or otherwise controlled by the count sequence, and would therefore need to be inhibited for a period at least equal to the worst-case settling time following each clock pulse.

The time penalty involved in avoiding the effect of spurious counts during settling is largely overcome by the technique of synchronous counting, in

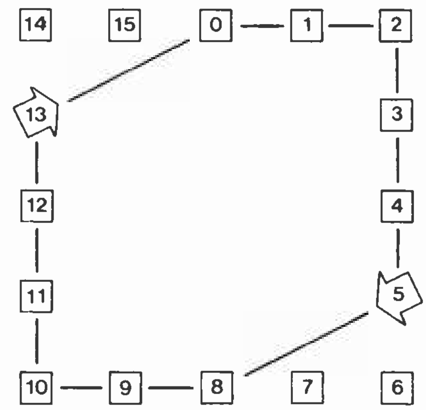


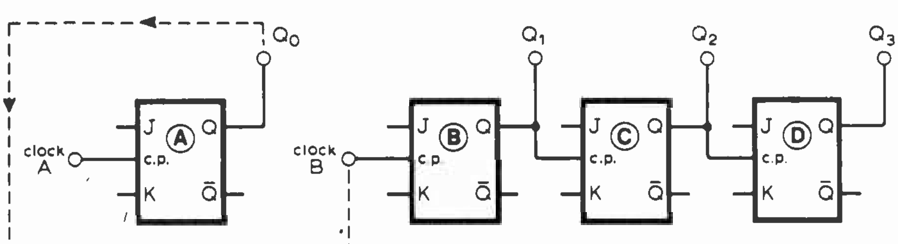
Fig. 5. *Divide-by-twelve sequence diagram.*

which all stages are clocked simultaneously but via interstage gating (Fig. 6). The steering gates ensure that the clock pulse only reaches those stages having a full count in the preceding (less significant) positions. By this method all change-of-state switching is synchronised with the trailing edge of the clock pulse with no false count patterns appearing between one condition and the next.

Semisynchronous format. The split-count configuration in which the first and second stages are not internally coupled cannot be combined with fully synchronous working but results in a hybrid action classed as semi-synchronous (Fig. 7). With the external link in place the second, third and fourth stages do not receive the clock pulse direct but are simultaneously clocked by the output of stage A. The only difference, therefore, between full and semi-synchronous working is the switching time of the first stage.

Group carries in synchronous counting. Providing for synchronous operation over a four-bit counter is perhaps deceptively simple due to the functionally straightforward nature of the clock steering logic. In fact, a problem still exists in providing a system arrangement which will allow something approaching true synchronous operation when a number of packages are cascaded to form an extended chain. Although functionally straightforward, the clock gating commitment for synchronous working rapidly becomes unwieldy as the number of stages

Fig. 4. *Split count chain.*



increases so that even the improved package count lengths of l.s.i. do not provide an altogether effective answer.

Advancing the count state from one package to the next is referred to as a "group carry" and the design requirements of the synchronous counter will always include additional gating to generate the group carry signal for use by the following counter group(s). The group carry output will be typically labelled by different manufacturers as "terminal count", "ripple clock" or simply "carry", but in each case will be the product of a full (terminal) count condition plus the group carry level from the preceding counter.

The resulting scheme (Fig. 8) provides a reasonable compromise in counting speed but one which still imposes a heavy restriction on the maximum count rate possible. The restricting factor hinges on the series enabling line only being held active for the time that the first (least significant) counter is actually holding a full count. This allows only one clock period for the group carry to propagate (trickle) through to the final group(s) as the total count reaches the full reset point. Any carry operation not completed before the arrival of the next clock pulse will, of course, result in a false count.

Greater group carry speed is possible using a modified version of the trickle method (Fig. 9) but one that requires each counter to include an additional enable input which controls only the clock pulse and not both clock and carry output. The least significant counter is now only permitted to control the clock enabling of the remaining counters via this additional input, which is usually labelled "parallel enable" as distinct from the trickle (series) enable. It is now the full count of the second package that has the longest trickle path forward but with the complete count cycle of the least significant counter effectively acting as a time buffer.

To remove the remaining restriction on count rate would require external "look ahead" logic, probably in the form of carry look-ahead packages which are actually intended for the generation of fast carries in parallel adding schemes and can operate in a similar manner across blocks of four counter packages.

Reversed counting and parallel access. As the counting down process is invariably concerned with the reduction of a preset count level to zero rather than with a repetitive count cycle, it would be most unusual for the reverse count feature to be incorporated into the design of a counter without a parallel loading facility also being included. The resulting combination offers the convenience of being able to force the count to any desired state independently of the clock style (asynchronously) and for the count to then continue up or down from this point.

A reducing count sequence will be obtained if the "reset" output of each flip-flop is used as the clocking line (ripple), or clock controlling influence (synchronous) in place of the "set" outputs. The reversible, or up/down counter, must therefore include both types of interstage connection with either one or the other enabled to decide the direction of count.

Two types of direction control logic are used: the dual clock method in which separate clock inputs control the count direction, or the single clock scheme with direction being selected by a separate up/down control line (Fig.

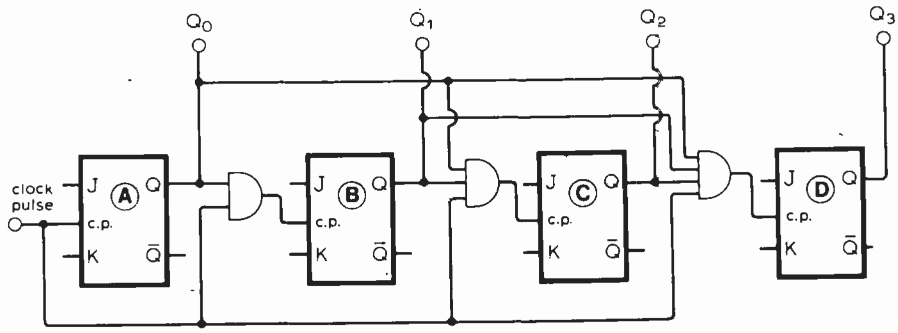


Fig. 6. Four stage synchronous clocking.

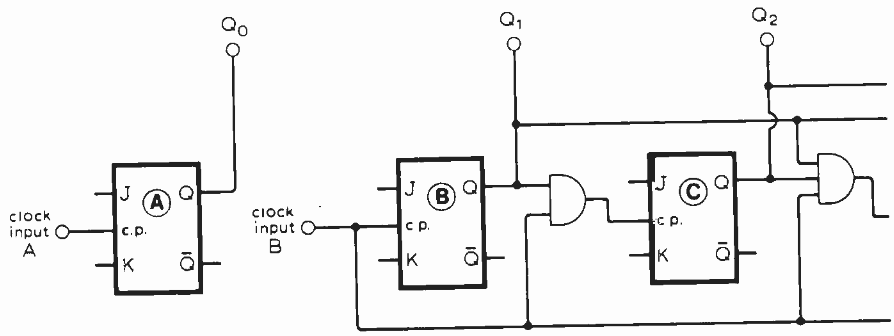


Fig. 7. Semi-synchronous format.

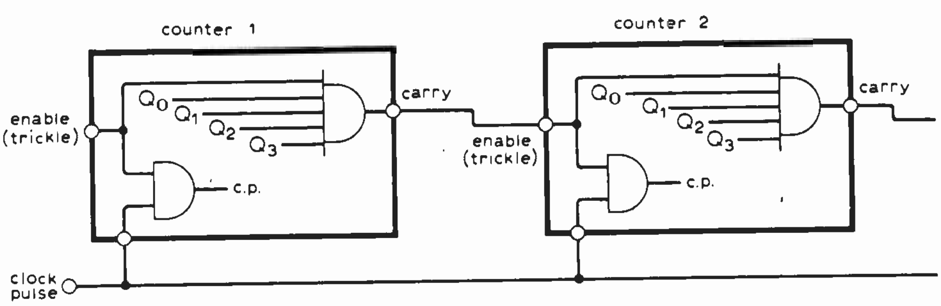


Fig. 8. Trickle group carry scheme — skeleton logic.

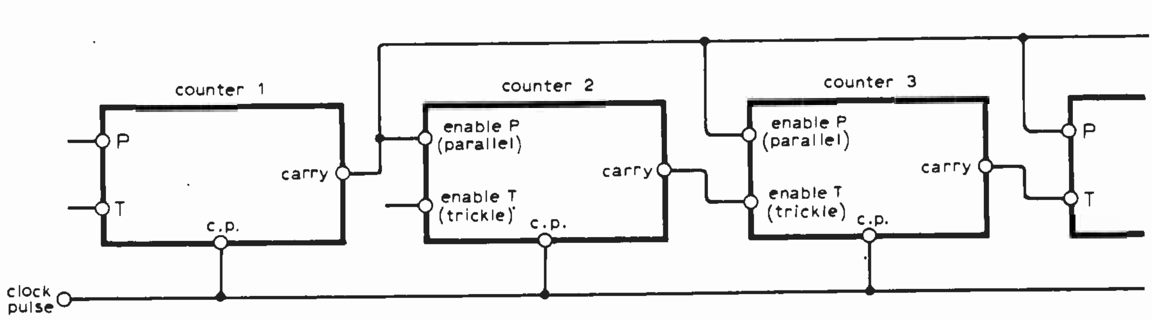


Fig. 9. Group carry scheme — fast.

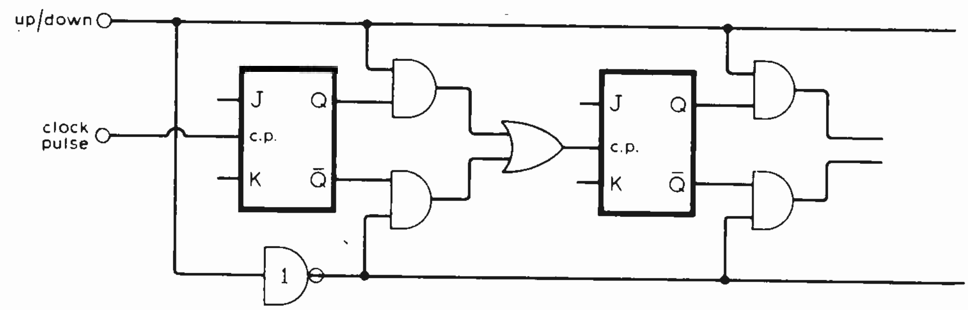


Fig. 10. Reversible count logic—single clock.

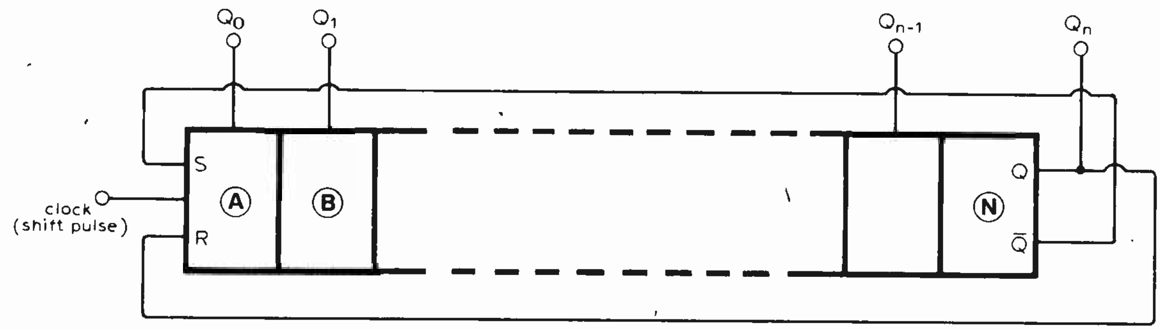


Fig. 11. Basic Johnson counting.

TABLE 3

count	stage outputs				two input octal decode
	Q_0	Q_1	Q_2	Q_3	
0	0	0	0	0	$\bar{Q}_0 \cdot \bar{Q}_3$
1	1	0	0	0	$Q_0 \cdot \bar{Q}_1$
2	1	1	0	0	$Q_1 \cdot \bar{Q}_2$
3	1	1	1	0	$Q_2 \cdot \bar{Q}_3$
4	1	1	1	1	$Q_0 \cdot Q_3$
5	0	1	1	1	$\bar{Q}_0 \cdot Q_1$
6	0	0	1	1	$\bar{Q}_1 \cdot Q_2$
7	0	0	0	1	$\bar{Q}_2 \cdot Q_3$

Table 3. Four-bit Johnson count sequence.

10). Both methods are straightforward in operation but result in slightly different cascading arrangements.

The cascading requirement for a reducing count is virtually identical to that of the forward count but the group carry function now becomes a "group borrow" and must reflect zero count states rather than the full counts of a carry line. Use of the dual clock method of direction control dictates separate carry and borrow lines which are controlled by the appropriate up or down clock input. Alternatively, the single clock system allows both carry and borrow functions to share a common "max/min" output which is quite independent of the clock line and which signals the full or zero condition as selected by the count direction (up/down) input.

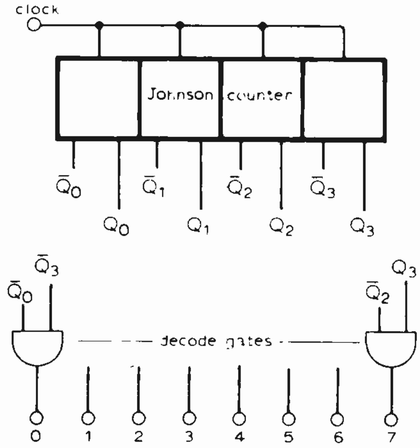
In addition to the max/min output it is common to have a "ripple clock" output which allows the equivalent of the trickle group carry scheme, while fast operation is possible by using the max/min output in conjunction with external look-ahead logic.

From the crop of exotic-sounding circuit descriptions used to refer to the parallel loading facility, those most likely to be encountered are the terms "parallel entry", "parallel access", "side-loading", "programmable" or "presettable". All are used to describe the arrangement in which a set of inputs, under the control of a "data load" line, may over-ride an existing bit pattern by forcing each count stage to follow its appropriate parallel data input. This load function can be referenced to the clock cycle for synchronous working or be left to operate in the more flexible asynchronous mode.

Variable modulo. The terminal (full) count output of the synchronous counter is especially useful in serving as the data load input when forming a variable count length without the need for external sensing logic. The count length of the resulting variable-modulo configuration is equal to the normal full count, minus the bit pattern set up on the parallel data lines and to which the counter resets. In this manner, a continuously variable count length is possible by manipulation of the data input lines.

Purpose designed variable-modulo counters use various methods of modulo selection and often no individual stage outputs are provided, particularly when the maximum count length is extremely long. In these instances output information is limited to a single divide-by-N pin which flags the terminal count condition.

Fig. 12. Johnson-based counter/divider (octal).



Johnson counters. Octal and decade counter/dividers in which a four or five stage Johnson format is used as a basis for obtaining a set of linear spike-free outputs are now quite common. Basically a ring counter, the Johnson sequence follows the bit pattern of a back-primed shift register with the clock input acting as the shift pulse (Fig. 11). Decoding each count state of the Johnson sequence (Table 3) to produce a linear one-of-eight or one-of-ten output is particularly straightforward and involves a simple two input gating function for each linear output line (Fig. 12).

The advantages of this type of counter are the high speed operation resulting from not having to follow true binary 1,2, 4, 8 code and the spike-free outputs taken via decoding gates.

Unlike standard binary counters, the Johnson counter must be guarded against unwanted codes which, once established, lock "holes" into the sequence with the inevitable output errors. It is also possible for certain types of Johnson logic to lock up completely in some circumstances and anti-lock logic is necessary to ensure that only valid codes can exist.

Tomorrow's counters. As fuller use is made of the high density logic families so the present building-block approach to digital system design will take on a more concealing blackbox character. For the counter, this trend will not be restricted to extending package count lengths but will result in much decoding and look-ahead logic being included as part of the counter packaging. A current forerunner to this level of inclusive counter logic is the full four decade counter with a single time-shared b.c.d. output, and the variable modulo concept has now been taken to the stage where the maximum divide-by-N factor equals 16,000.

As the existing logic families expand and new lists appear so the task of technical monitoring becomes more unmanageable but at the same time even more vital. Hopefully, keeping tabs on state-of-the-art counting techniques will at least go some way in maintaining a foot in the door of the digital skyscraper.

Commercially available i.c. counters grouped under general function headings

BASIC ASYNCHRONOUS COUNTERS (RIPPLE CLOCK)

	TEXAS	MULLARD
4 bit binary	SN7493	FJJ211
decade	SN7490	FJJ141
divide by 12	SN7492	FJJ251

SYNCHRONOUS COUNTERS (PRESETTABLE)

	TEXAS	MULLARD
4 bit binary	SN74161 SN74163	FJB9316
decade	SN74160 SN74162	FJB9310

REVERSIBLE COUNTERS (SYNCHRONOUS)

	TEXAS	MULLARD
4 bit binary	SN74191 SN74193	FJB9366
decade	SN74190 SN74192	FJB9360

ASYNCHRONOUS PRESETTABLE COUNTERS

	TEXAS	MULLARD
4 bit binary	SN74177	FJB93177
decade	SN74176	FJB93176

VARIABLE MODULO COUNTERS

	RCA	MULLARD
4 bit binary	——	FJB9305
four decade	CD4059 (cmos)	——

JOHNSON-BASED COUNTER/DIVIDERS (CMOS)

	MOTOROLA	NATIONAL
octal	MC 14022	MM 4622A
decade	——	MM 4617A

Semiconductor developments

Power f.e.t. and improved bi-polar transistor

Audio power f.e.ts were first reported in *Wireless World* in June 1974. These devices were developed by Yamaha under a commission by Japan Technology Development Foundation. At the same time, Sony started a separate line of development concerned with power f.e.ts and as a result produced versions which differed in detail from the Yamaha device. Interestingly, Yamaha produced only one polarity of f.e.t., the n-type f.e.t., whereas Sony developed complementary pairs. The structure of the Sony f.e.t. is shown in Fig. 1 and consists of a drain of n^+ doped silicon mounted on a substrate, a grid of p^+ gates diffused into n^- drain area and a source also selectively diffused through the inner silicon oxide layer between the grid of the gate. The structure is completed by a metal connecting bridge to the gate and the source. The complete chip of the power f.e.t. is 3mm square and has approximately 1500 rectangular source areas. The complementary version of this f.e.t. is produced by reversing the polarity of the impurities used in each layer.

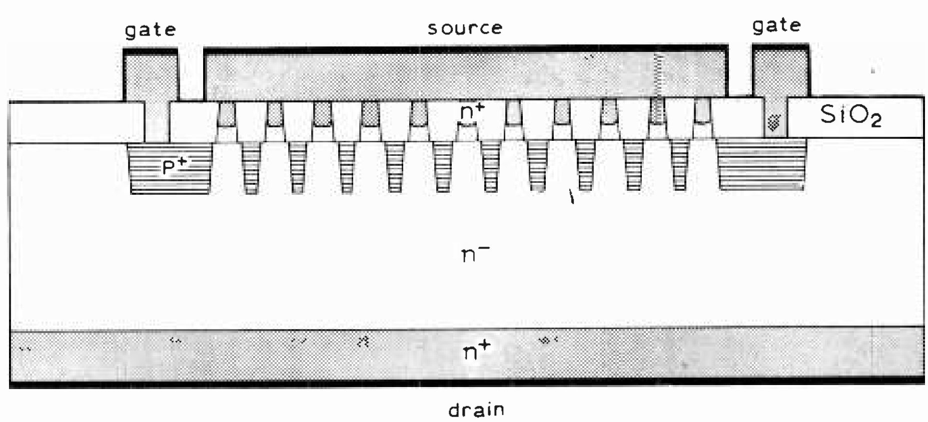
The difference between this device and the Yamaha device reported earlier appears to be largely one of detail design, and also of power dissipation. The Sony devices are rated at considerably lower powers than the Yamaha versions, the former having a total dissipation of 63 watts for both types.

Fig. 2 shows the output characteristics of two power f.e.ts, showing a strong resemblance to the characteristics of a triode valve. These devices are known as vertical f.e.ts (v-f.e.t.) because current flows from the substrate area through the thickness of the chip to the metal connections at the top. The advantages to be obtained through this form of construction are a greater current density, coupled with a high input and low output impedance characteristic. Other advantages claimed for the v-f.e.t. are a fast pulse response originating from the low capacitance due to the thick insulating layer separating the source from the drain, and a voltage rather than a current controlled response.

In a paper presented to the AES at the recent 50th Convention, a speaker reported on the characteristics of two devices developed and used by Sony, the 2SK60 and the SJ18. These are complementary power devices with a voltage amplification factor μ = 4-5, a mutual conductance, g_m = 250mS, and an output resistance R_D = 16Ω. Unlike its bi-polar counterpart, the v-f.e.t. has no area of second breakdown and this, coupled with its extremely fast switching response, indicated to the equipment designers that it was particularly suitable for a Class B or similar power output stage.

Several power amplifiers have been designed by Sony using these v-f.e.ts. However, only two have appeared here in the UK, these being mentioned above. The version described in the AES paper mentioned is not available yet in the UK, though it is believed that the design techniques described are similar to the models now available. The model described is the TAN-8550 power amplifier which utilises three n-channel and three p-channel devices in parallel, complementary arrangement to produce a 100 watt per channel output into an 8Ω load at any frequency in the audio

Fig. 1. A cross-section of the Sony v-f.e.t.

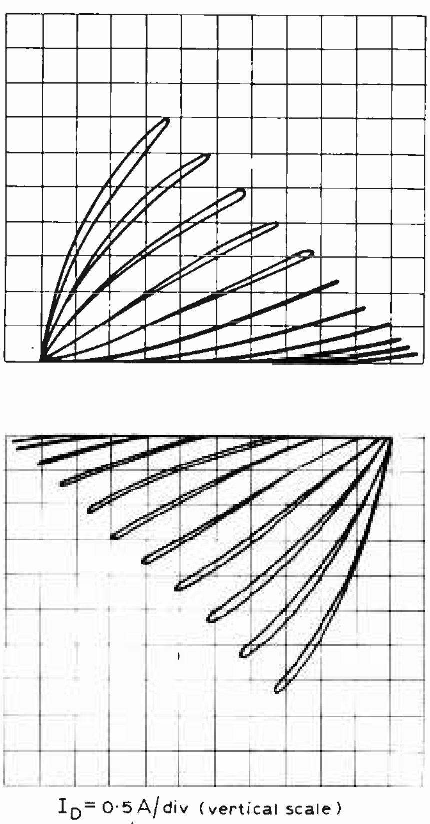


spectrum. The output stage is driven from a Class A stage consisting of three direct coupled differential amplifiers. The total open loop gain of this circuit is approximately 82dB with a distortion that has been held to below 1% over the audio spectrum, before negative feedback is applied.

In designing the v-f.e.t. power stage, two alternatives offered themselves, the first of which was a source follower, the second being a drain follower. The source follower suffers from a gain loss by the mount of the offset bias potential; the drain follower circuit provides a gain proportional to the amount of the actual amplification factor μ_R. The main disadvantage of the drain follower is that the power supply voltage needs to be rather higher than that for source follower. A simplification of the bias circuit is obtained by using the source follower design and this in fact is a version used in the Sony TAN-8550 amplifier. The open-loop frequency response extends to a roll-off point of about 35kHz before negative feedback is applied. This initial wide frequency response is said to bring an improved transient intermodulation performance, an improved stability and a reduced high order harmonic distortion, compared with a similar bi-polar output stage.

There appeared to be some disadvantages to the use of v-f.e.t., these being principally associated with the values of voltage required from the power supplies. In the case of the Sony

Fig. 2. Output characteristics of two complementary v-f.e.t. devices.



I_D = 0·5 A/div (vertical scale)
V_{DS} = 5V/div. (horizontal scale)

amplifiers at least three supply rails are provided, and, in addition, the idling current in the output stage produces a high order of power dissipation in the static, no-signal condition. In one amplifier designed by Sony, the static dissipation is in the order of 65 watts for a 100 watt amplifier.

A further disadvantage of the type of design approach utilising the parallel arrangement of output devices is that should one break down and require replacement, the complete six need replacement since the six v-f.e.ts are matched in characteristics.

Sony have also produced a lower powered version of the v-f.e.t. which is used elsewhere in voltage amplification stages in at least one of their v-f.e.t. amplifiers.

A second semiconductor device developed by Sony and used in some of their v-f.e.t. integrated amplifiers is known as the l.e.c. bi-polar transistor. The abbreviation l.e.c. stands for low emitter impurity concentration, which describes in elementary form the structure of the emitter area of what is otherwise a conventional bi-polar transistor. In a recent paper the Sony engineers described the general design of the l.e.c. device, which appears to have arisen from a study designed to investigate the noise characteristics of small signal transistors.

Conventional transistors, in order to obtain a high emitter efficiency have a higher emitter impurity concentration than that of the base region. The reason for this is to keep the value of the injected minority carrier current from the base into the emitter as low as possible. Any attempt at reducing the emitter impurity concentration below that in the base results in a reduced emitter efficiency because there is an increase in the ineffective minority carrier current being injected into the emitter which is inversely proportional to the emitter concentration.

The l.e.c. transistor does not suffer from this disadvantage because the emitter region is double diffused to produce a secondary junction. This junction divides an area of high emitter impurity concentration from an area of low emitter impurity concentration and thus is an n^+n or a p^+p junction. The purposes of this barrier is to reflect unwanted minority carriers injected into the emitter and thus retain higher high emitter efficiency.

The n^+n junction is not the only type of barrier which is capable of reflecting injected minority carriers. Other barriers listed in the original paper are as follows; surface barrier, m.i.s. (*sic*) barrier, p-n junction barrier, hetero-junction barrier and the Schottky barrier. An example of one application of the m.i.s. barrier application is where a metal gate device with such a structure, is designed to control the surface recombination velocity and thus the gate so formed can change the amplification factor by changes in its bias.

However, the l.e.c. transistor described has the singular advantage of having high current gain with very low noise and in particular the flicker noise and burst noise is reduced below that normally found in conventional bi-polar devices.

Doppler shifts analyse Chinese ceramics

The aesthetic appeal of ancient Chinese ceramics is enhanced by their coloured glazes which are found in a variety of forms with names such as Tea Dust, Coral Red, and Mirror Black. It would be of interest to know how the potter produced these effects — without destroying the specimens in the course of finding out.

A step in this direction has been made at the Research Laboratory for Archaeology and the History of Art at Oxford. R. E. M. Hedges reports some preliminary work on measurements based on Mössbauer spectroscopy. This applies an effect, discovered by Mössbauer in 1957, concerned with the way in which very short electromagnetic waves (gamma rays) are emitted and absorbed by crystalline substances. The processes of emission and absorption are tremendously frequency-dependent, and each element has characteristic frequencies. For iron, the selectivity of the effect corresponds to a Q-factor of about 3 million million. The frequency of emission is slightly different from the frequency of absorption, and because of the high Q the emission frequency falls outside the absorption passband. The emission and absorption frequencies can however be made to coincide by moving the emitter relative to the absorber, so that the emission frequency is Doppler shifted by the right amount. This is the basis of Mössbauer spectroscopy. If a specimen is believed to contain a certain element, its absorption of the gamma rays from a moving emitter is measured. By changing the velocity of the emitter different absorption peaks can be tuned in. The interest to the physical chemist lies in the fact that the shape of the frequency response is modified by the way in which the element is chemically bound in a crystal. This enables the structure to be deduced and, in the case of the Chinese glazes, makes possible intelligent guesses about the original production processes.

The work done at Oxford so far used iron-containing glaze ground off the surface of pieces of broken china (sherds) but an improved instrument, now under construction, based on reflection rather than absorption should enable non-destructive measurements to be made, and with luck reveal the secrets of the potters' techniques.

Electronic systems — 4

More about modulation and transmitting signals

by W. E. Anderton *Assistant Editor, Wireless World*

Further considerations in an amplitude modulation system include the depth of modulation. We must not over modulate the carrier as this would be like asking for more than full output or less than no output and the effect would be to distort the transmitted and thus the received signal. Fig.1 illustrates this principle with examples of the waveforms expected for 0%, 50%, 100% and more than 100% modulation.

Figure 1 also shows the quantities which must be measured in order to calculate the depth of modulation. The amplitude labelled b represents the mean carrier level, i.e. the unmodulated carrier amplitude. The quantity labelled a is the peak modulation amplitude on the resultant modulated carrier. Depth of modulation is given by the relationship depth of modulation = $(a/b) \times 100\%$.

If we examine the case where $a = b$ then we can see that the carrier will be 100% modulated.

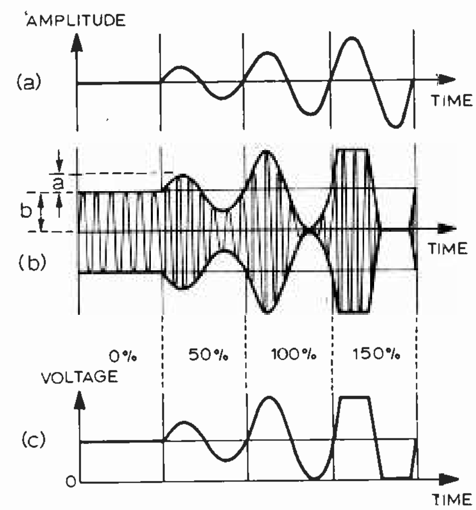


Fig. 1. Illustrating the meaning of modulation depth in an amplitude modulated system with examples of the waveforms expected for 0%, 50%, 100% and more than 100% modulation.

Spectrum of an a.m. signal

The transmitted signal involves multiplication of the carrier and modulating signals. The multiplication process produces a complex output signal which contains the sum and difference frequencies of the two input signals. If we are to transmit the baseband speech signal previously described, the sum and difference components will form two bands of frequencies on either side of the carrier frequency. These bands of frequencies are known as "sidebands", each of them having a bandwidth equal to the bandwidth of the modulation signal.

If our a.m. system is to transmit baseband signals up to 4kHz, then each sideband will have a bandwidth of 4kHz. The total bandwidth of the transmitted signal (accounting for both the upper and lower sidebands) will be 8kHz. The spectrum of such a system is shown in Fig.2.

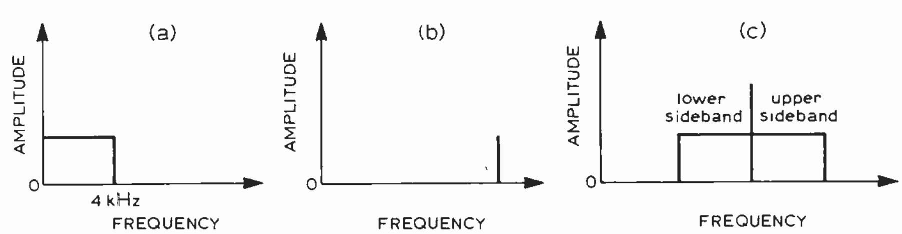


Fig. 2. Spectrum of an a.m. system which is to transmit baseband signals up to 4kHz.

Channel allocation

The long-wave and medium-wave amplitude-modulated broadcast bands have all been split into 9kHz channels.

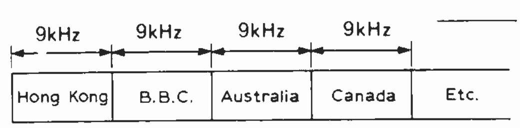


Fig. 3. Type of allocation of channels one might expect over a small portion of the medium wave band.

Each radio station is allocated a channel in which it is allowed to transmit so that each of these stations is located at an allocated frequency in each band. Now, because the channel bandwidth is only 9kHz, each station can only transmit baseband signals up to the maximum of 4.5kHz. If a station were to transmit outside its allocated channel, the people receiving adjacent channels would experience interchannel interference. In an attempt to alleviate this problem, adjacent channels are allocated to stations as far removed geographically, from one another as possible. Figure 3 indicates the type of allocation of channels one could expect over a small portion of the medium wave band.

Advantages and disadvantages of am.

One of the main advantages of an a.m. transmission system is that it is simple both in design and implementation at both the transmitter and the receiver, making the system relatively cheap to operate and maintain.

The disadvantages of the a.m. systems are all concerned with quality of reception. We started this section by describing how early experiments were conducted using spark transmitters (now illegal, incidentally). All sparks cause propagation through space on a wide range of frequencies and hence amplitude-modulated systems are subject to impulsive, wideband noise. Impulsive noise can be generated by car ignition systems, electric motors, arcing switch contacts, etc. The received impulsive noise is so intrusive in some locations as to make concentration on the received programme extremely difficult.

The second disadvantage is again concerned with quality; this time it is the low bandwidth which is considered an impairment. Two sidebands are accommodated within a narrow channel and transmitted bandwidth is necessarily limited.

Frequency modulation

Frequency modulation (f.m.) was developed in an attempt to overcome the limitations of an a.m. system. The transmitter again supplies a sinusoidal voltage to an aerial, but this time the frequency of the sinewave varies in sympathy with the modulation signal, the amplitude of the transmitted signal being kept constant (see Fig.4, part 3, April issue). The receiver is designed in such a way that the demodulated output is insensitive to impulsive amplitude changes of the carrier wave.

When there is no modulation signal, the carrier wave is at a fixed frequency. The modulation signal causes a frequency deviation of the carrier and this deviation is proportional to the instantaneous amplitude of the modulation signal.

The spectrum produced by this f.m. signal is extremely complex. Mathematical analysis shows that there exists an infinite number of sidebands, each one of less amplitude than the previous one. To achieve full modulation in the receiver one can argue that you would require to transmit and receive a signal of infinite bandwidth, but in practice, it is found that the bandwidth required is given by $2(f_d + f_m)$ where f_d is the maximum deviation frequency and f_m is the maximum modulation frequency. If we remember that lack of baseband available bandwidth was one of the criticisms of an a.m. system, then our f.m. system must attempt to improve this situation. Very high frequency f.m. transmissions can be modulated at up to at least 15kHz and achieve a quality comparable to hi fi record reproduction.

This series of articles is based on a proposed Advanced Level course for schools and is prepared in consultation with Professor G. B. B. Chaplin, University of Essex. The next article will deal with reception and demodulation.

The bandwith required to transmit a broadcast f.m. signal is greater than 100kHz; consequently f.m. stations are only found on the v.h.f. band where these large bandwidths can be accommodated. (The v.h.f. f.m. band, known as Band II, is from 87 to 10MHz). The v.h.f. transmissions have a disadvantage in that the transmitters and receivers are complex and thus relatively expensive. Coupled with this disadvantage is also the fact that v.h.f. transmitters have a limited range, often no more than about 50 miles. Thus more transmitters are required to provide national coverage than would be the case with an a.m. system.

Contrast of a.m. and f.m.

In a.m. the amplitude of the carrier is varied, whereas in f.m. the carrier frequency is varied. Frequency modulation gives a much better signal-to-noise ratio than a.m. under similar operating conditions. Frequency-modulated systems are usually more sophisticated and expensive than a.m. systems.

Appendix 1

Derivation of a.m. sidebands. Let the modulation signal be represented by

$$V_{mod} = \cos A$$

and the carrier be represented by

$$V_c = \cos B.$$

Modulation will be the product of the two input signals plus a function representing the carrier itself. Thus the output (the transmitted signal) is

$$V_{out} = \cos B + k\cos B\cos A$$

where k is a constant chosen to ensure that the expression $1 + k\cos A$ never becomes negative. Alternatively,

$$V_{out} = \cos B + (k/2)(\cos(A-B) + \cos(A+B)).$$

Appendix 2

Representing the f.m. carrier wave. To obtain an expression for an f.m. wave, let the instantaneous carrier wave be represented by

$$v_c = V_c\sin\omega_i t = V_c\sin 2\pi f_i t$$

where f_i is the instantaneous frequency. For a positive increase in frequency we have

$$f_i = f_c + \Delta f_c \sin\omega_m t$$

where f_c is the carrier frequency and Δf_c is the frequency deviation of the carrier wave due to the modulating signal of frequency f_m.

If the instantaneous carrier phase is Φ_i then

$$\frac{1}{2\pi}\frac{d\Phi_i}{dt} = f_i = f_c + \Delta f_c \sin\omega_m t$$

$$\text{or} \quad \frac{d\Phi_i}{dt} = 2\pi f_i = \omega_c + 2\pi\Delta f_c \sin\omega_m t.$$

By integration and a correct choice of the phase angle, we obtain

$$\Phi_i = \omega_c t - \frac{\Delta f_c}{f_m}\cos\omega_m t$$

or

$$\Phi_i = \omega_c t - m_f\cos\omega_m t$$

where $m_f = \Delta f_c / f_m$ is called the modulation index. Since $v_c = V_c \sin\phi_i$ we obtain

$$v_c = V_c\sin\omega_c t - m_f\cos\omega_m t$$

which represents an f.m. carrier wave.

This article was prepared in consultation with Professor G.B.B. Chaplin, University of Essex.

Further reading

Obtainable from Mr. R. A. Smith, Department of Electrical Engineering Science, Universtiy of Essex, Wivenhoe Park, Colchester CO4 3SQ, Essex, are the teaching texts for the electronic systems pilot A-level course, price £4.50; communication systems section only, £2.00; computer systems section only, £2.00; feedback systems section only, £2.00; basic electronics section only, £1.50.

Teletext at Birmingham

Our demonstration of teletext at the IEA/Electrex exhibition during May was not an undiluted success and for this we apologize to those people who went to the exhibition for the express purpose of seeing the decoder. We were rendered *hors de combat* by an obscure fault in the television receiver and were unable to either rectify it or obtain another, modified receiver in time to go on with the demonstration, in spite of rapid assistance from the set makers.

Correction

In the article "Some factors in loudspeaker quality" by H. D. Harwood, May 1976, reference 8 should be accredited to D. E. L. Shorter and A. Gee.

New Products

IEA New Products

Seen at the IEA/ Electrex exhibition, Birmingham 1976

Digital counter

A range of low-cost digital frequency meters was one of the highlights of the Marconi Instruments stand. The meters, designated TF2430, TF2431 and TF2432, cover the ranges 10Hz to 80MHz, 10Hz to 200MHz, and 10Hz to 560MHz respectively. Large-scale-integration component design and automatic production methods have enabled the instruments to be manufactured for reliability, and at low cost. Frequency measurements are made directly, requiring no prescaling, and switching allows a maximum resolution of 0.1Hz. A feature of this range of meters is the simplicity of design. Each instrument has as few controls as possible and incorporates automatic gain control on the input channel, which will accept from 10mV to mains voltage, to cut out the need for a sensitivity control. The readout, which is in the form of a l.e.d. display, is operated from a memory so

that only the last measured value is displayed and the blur of the digits during counting is avoided. This facility, together with an in-built leading-zero suppression, ensures that the meter is easy to read. Attention has been paid, during design, to the construction and layout of the meters to give good servicing accessibility. Marconi Instruments Ltd, Longacres, St Albans, Herts AL4 0JN.

WW 301 for further details

WW 301 for further details

Programmable power supply

Two digitally programmable power supplies, types GXP25/25 and GXP10/50, were among the major items displayed by Gresham Lion Ltd. These power supplies provide outputs which may be controlled by a binary-coded-decimal logic input. Type GXP25/25 has a range up to 24.975V and 2.475A, and minimum settings of 25mV and 25mA. The GXP10/50 covers a range up to 9.99V providing up to 4.95A. Minimum settings for the GXP10/50 are 10mV and 10mA. The input, which can accept up to 50V without damage, is by standard p.c.b. connector. Gresham Lion Ltd, Twickenham Road, Feltham, Middlesex TW13 6HA.

WW 302 for further details

Low cost oscilloscope

The model 4S6-LS oscilloscope has a vertical amplifier sensitivity of 10mV/cm with a 6MHz bandwidth and an accuracy of ±5% A major difference between the 4S6-LS and previous models is in the timebase sweep range which has been extended to 1s/cm at ±5% accuracy. To ensure that the oscilloscope produces a good display with the low-speed sweep a P7 long-persistance cathode ray tube is fitted as a standard. As an optional extra the c.r.t. graticules may be treated with Glarecheq, a non-reflective acrylic

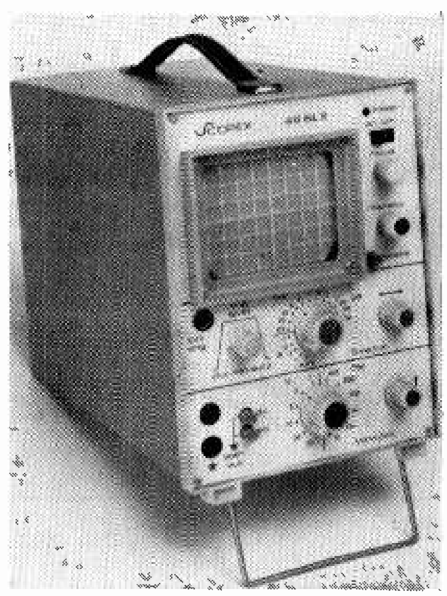
IEA

coating which helps to reduce the amount of reflection from the screen. At the time of release the oscilloscope, treated with Glarecheq, was priced at £106. Scopex Instruments Ltd, Pixmore Industrial Estate, Pixmore Avenue, Letchworth, Herts SG6 1JU.

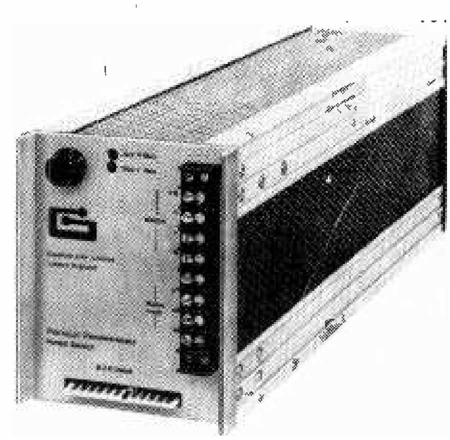
WW 303 for further details

Programming aids

A collection of programming aids for microprocessor systems design were exhibited by Osprey Electronics Ltd. The aids, produced by Stag Electronic Designs Ltd, offer a system which, it is claimed, avoids the problems of time consumption and inconvenience resulting from the large number of changes and trial runs inevitable in software development. Each system may consist of a range of r.o.m. and p.r.o.m. simulators, a simulator programmer, a p.r.o.m. eraser, and a p.r.o.m. programmer. Pin-compatible simulators are available for the 1702, 2704 and 2708 series of ultra-violet erasable p.r.o.m.s,



WW 303 for further details



WW 302 for further details

as well as an equivalent of the Motorola MCM6830L mask programmed r.o.m. The SP2 simulator programmer is a manually operated data entry device capable of programming any of the Stag range of p.r.o.m. or r.o.m. simulators. This programmer can be used to modify individual locations or load complete programmes – by keyboard for data entry and by thumbwheel switches for address selection. Two p.r.o.m. erasers suitable for electronically programmable r.o.ms are available, the SE4 which will take four p.r.o.ms and the SE15 with a capacity for 15 p.r.o.ms. The p.r.oms are placed in a tray, within the eraser, and are then exposed to high intensity ultra violet light for a prescribed time, preset on a timer dial. Two p.r.o.m programmers exist, the PP2 for the 1702 series and the PP8 for the 2704 and 2708 series. These programmers are suitable for electrically programmable r.o.ms and are capable of transferring master p.r.o.m. or simulator data directly into a p.r.o.m. Stag Electronic Designs Ltd, Northaw House, Potters Bar, Herts EN6 4PS.

WW 304 for further details

Multimeters

The **Dolomiti** has 39 ranges and measures current, voltage, resistance, capacitance and decibels. This meter has a sensitivity of 20kΩ/volt, with an accuracy of ±2.0% on d.c. ranges and ±2.5% on a.c. and resistance ranges. Operating frequencies on the a.c. ranges are from 20Hz to 20kHz. The meter, which measures 130 x 125 x 40mm, requires two 1.5V batteries and one 22.5V battery and incorporates diodes, a cutout and a fuse for automatic overload protection. Optional extras include a 30kV probe and a signal injector. Carlo Gravazzi (U.K.) Ltd, North Crawley Road, Newport Pagnell, Bucks, MK16 9HF.

WW 305 for further details

Avometer model 73 is a pocket sized multimeter measuring up to 750V and up to 3A on both a.c. and d.c. ranges. On resistance ranges the meter will measure up to 20MΩ using internal batteries. This meter has a sensitivity of 20kΩ/volt d.c. and 1kΩ/volt a.c. and an accuracy of ±2.5% on direct voltage and current ranges. On a.c. ranges the **model 73** will operate on frequencies up to 75kHz. Fuse protection allows the application of up to 250V r.m.s. for 10 seconds on any range. Avo Ltd, Archcliffe Road, Dover, Kent CT17 9EN.

WW 306 for further details

Sanwa N-501 has a 2μA movement, enabling resolutions of 0.05mA or 1mV, and measures current, voltage, resistance and decibels. This meter has current ranges up to 12A a.c./d.c. and voltage ranges up to 1.2kV a.c./d.c. with an accuracy of ±2.0% on the d.c. ranges and ±2.5% on the a.c. ranges. Operating frequencies on the a.c. ranges are from 20Hz to 50kHz. The **N-501,** which measures 252 x 191 x 107mm, is protected by diodes and a fuse. Quality Electronics Ltd, 24 High Street, Lydd, Kent TN29 9AJ.

WW 307 for further details

Miselco Tester 20 is a 20kΩ/volt, 40 range meter measuring current, voltage, resistance and decibels. This general-purpose unit can measure d.c. current up to 10A, has an accuracy of 2.0% on the d.c. and resistance ranges and 3.0% on the a.c. ranges. Operating frequencies on the a.c. ranges are from 20Hz to 20kHz. The **Tester 20** measures 105 x 130 x 35mm and requires two 1.5V batteries. Optional extras include a 15kV/30kV d.c. probe. Alcon Instruments Ltd, 19 Mulberry Walk, London SW3 6DZ.

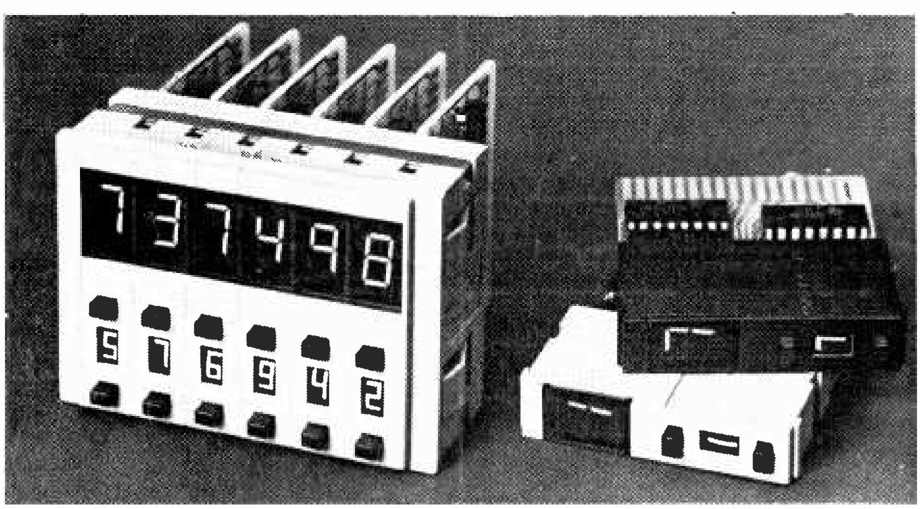
WW 308 for further details

Display modules

Compact 7-segment l.e.d. display modules, with integral push-button decade switches for preset counting, were featured by Contraves Industrial Products Ltd. The displays, called Multicount modules, may be assembled into multi-decade display and switching banks, for instrument and control panel mounting. Each module occupies 10mm x 50mm of panel space, and end brackets, for push-in front-of-panel mounting, add a further 10mm to the width. A variety of functions are available in the Multicount range; these include a built-in-memory, an up or down counter, a comparator and a sign display. Dummy modules can be supplied for incorporating additional functions such as push-buttons, keyswitches or electronic circuits. The bidirectional decade switches have binary-coded decimal outputs which can either function independently from the digital display, or may be connected to the display logic. Contraves Industrial Products Ltd, Times House, Station Approach, Ruislip, Middlesex, HA4 8LH.

WW 309 for further details

WW 304 for further details



WW 309 for further details

Base stations for f.m. systems

Burndept Electronics have introduced two f.m. base station transceivers, the BE454 for u.h.f. and the BE458 for v.h.f. The u.h.f. station operates within the range 420 to 470MHz, with channel spacings of 25kHz, and has a transmitter output of 5 watts with a spurious output of less than 2.5μW. The v.h.f. station operates in the bands 68 to 108MHz and 132 to 174MHz with channel spacings of 12.5 or 25kHz. Receiver sensitivity for both transceivers is 0.35μV for 20dB quieting. Crystal stability is ±5 parts in a million over the temperature range −10 to +60°C. The transceivers, which can also be used for repeater operation, are designed to be operated either locally or remotely in a communications network. Remote control is achieved by tone or d.c. signalling over two or four wire systems. A range of quick-change modules are available allowing both versatility and ease of maintenance. Both transceivers can be used in single or two frequency simplex, or duplex modes and are available in single or multichannel versions. Optional extras include tone squelch and selective calling controls. Burndept Electronics (E.R.) Ltd, St Fidelis Road, Erith, Kent DA8 1AU.

WW 310 for further details

Cam switch

Adjustable cam switches, suitable for up to 700 rev/min, have been introduced by Barden Corporation. These miniature switches, in the PA1 and PA2 series, give infinitely adjustable shaft and dwell angles between 3° and 357°. The units, which can be adjusted while the shaft is fixed or rotating, can be mounted in series to provide from 1 to 10 independently adjustable switches. Features include precision ball bearings and low inertia and operating torque for fast and accurate switch operation at minimum power. Operating characteristics are: 115/230V a.c. for 5A inductive and restive load, 30V d.c. for 5A resistive load or a 3A inductive load with an inrush capacity of up to 24A. The Bardon Corporation (UK) Ltd, Western Road, Bracknell, Berks, RG12 1QU.

WW 311 for further details

Digital cassette recorder

A digital cassette recorder, known as the Raycorder, is claimed by its makers, Raymond Engineering Inc., to be a highly reliable instrument suitable for minicomputer, telecommunications, and research applications. The recorder is designed primarily for use in data terminals and data logging systems, but may also serve as a digital interface. A number of versions are available, including single or dual-channel machines with either read-write or read-while-write options. The reels and capstans are driven directly by four motors, eliminating clutches, belts and flywheels to give maximum reliability and performance. Mean time before failure has been rated at 5000h. The motors have low-mass ironless armatures and are controlled by a servo-system which enables the tape to be accelerated uniformly and accurately. Preferred tape speeds are factory set between 3in/s and 30in/s with variations not exceeding ±2%. Typical acceleration and deceleration times are 20ms at 3in/s and 60ms at 15in/s. Trend Telecommunications Ltd, St. John's Estate, Tylers Green, High Wycome, Buckinghamshire, HP10 8HW.

WW 312 for further details

Microprocessor kit

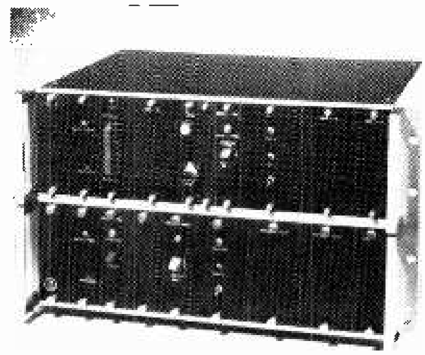
The SC/MP Introkit includes a SC/MP central processing unit — the ISP-8A/500D, a 512 x 8 r.o.m. (MM5214), a 256×8 r.a.m. (MM2112-1), a 1MHz crystal, interface circuits and discrete components. It is claimed that these components can be assembled on to the 100×160mm Introkit printed circuit board in one hour, providing a practical method of familiarising users with microcomputer characteristics. Small programmes can be developed and entered into the r.a.m. using a teletype keyboard or a compatible terminal. These programmes can then be run and their performance monitored by the Kitbug programme which is stored in the r.o.m. Applications for this kit could include automatic control systems, domestic appliance programmes, traffic light sequencing and machine tool control. The kit, which includes a data sheet and technical manuals, was priced at £54.50 at the time of release. DTV Group Ltd, 126 Hamilton Road, London SE27 9SG.

WW 313 for further details

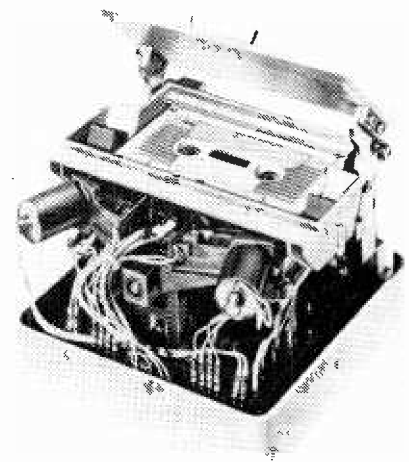
Recorder-calculator

The SX4500 cassette recorder, introduced by Hadley Sales Services, has a built-in calculator. The two-track recorder, which can be operated from either the mains supply or internal batteries, will take C30, C60 and C90 cassettes, has an audio output of 300mW, and uses a built-in condenser microphone. Calculator functions include addition, subtraction, multiplication, division, constant multiplication or division, power calculation, a memory and a percentage calculation. Calculations may be made to seven decimal places. The overall size of the instrument is 4×1¾×8in. Hadley Sales Services, 112 Gilbert Road, Smethwick, Warley, Birmingham B66 4PZ.

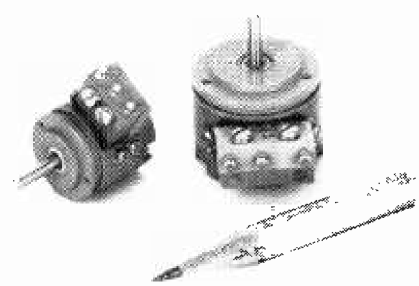
WW 314 for further details



WW 310 for further details



WW 312 for further details



WW 311 for further details

Audio switching system

A system of modules for audio mixing and switching have been introduced by Prowest Electronics Ltd. The system consists of a five channel input buffer, a ten by one switching unit, a twin output amplifier and a d.c. controlled fading amplifier. Four field effect transistors in a series shunt configuration are used as the switching elements and a further series switch on each board reduces system crosstalk to approximately 90dB at 20kHz. Maximum level through the system is +26dBm and distortion is less than 0.03% at all levels up to +20dB. The modules are all based on 7in printed circuit boards, are built into standard Imhoff 19in racks, and use a common ±18V power supply. The switching can be controlled directly or by a binary-coded-decimal address. Prowest Electronics Ltd, Alma Road, Windsor, Berks.

WW 315 for further details

Resistance standards

A range of 4-terminal resistance standards have been manufactured by Croydon Precision Instrument Company for values from 0.0001Ω to 100kΩ. The standards, type RS3, offer accuracies between ±0.005% and ±0.02% depending upon the resistance values. Each standard is designed to have the maximum permanance of calibration combined with a good load coefficient, and is suitable for use in air or in a temperature controlled oil bath. Croydon Precision Instrument Company, Hampton Road, Croydon, CR9 2RU.

WW 316 for further details

Tantalum capacitors

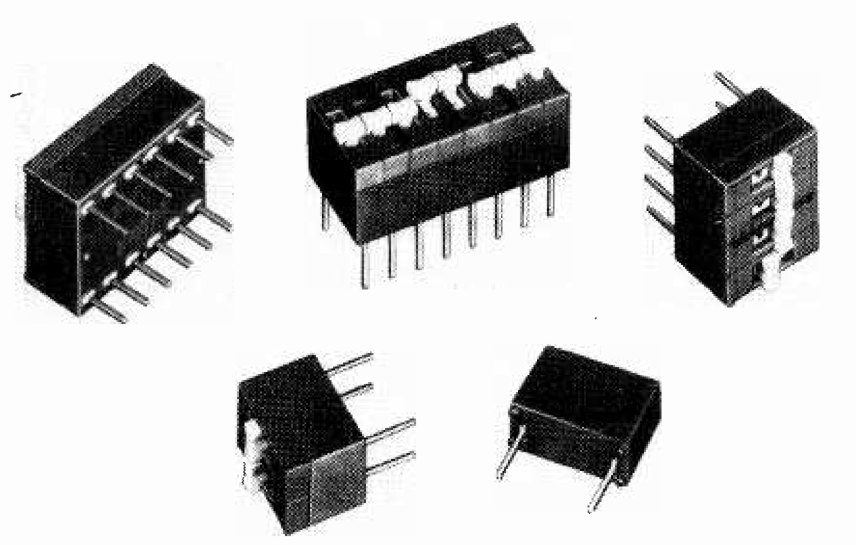
Thomson-CSF have introduced a range of solid-tantalum electrolytic resin-dipped capacitors. The capacitors have values ranging from 0.1μF/35V to 100μF/3V with tolerances of ±20%. Case dimensions vary from 6.5 × 4mm to 10 × 7mm. The leads are 0.6mm diameter and are spaced 5.08mm apart. Thomson-CSF (UK) Ltd, Ringway House, Bell Road, Daneshill, Basingstoke, Hants RG24 0QG.

WW 317 for further details

Dual-in-line switches

A series of subminiature switches for printed circuit applications has been introduced by Secme. Three basic types of switch are available within the range; one to eight single-pole on/off, one to four double-pole on/off, and one to four single-pole change-over. Other functions may be combined in the same body if required. The switches, which are rated for 0.5A at 12V, have a contact resistance of less than 30mΩ, and can be stacked end to end in any number on standard 0.1in pitches. The bases are sealed to prevent the ingress of moisture. Souriau (UK) Ltd, Shirley Avenue-Vale Road, Windsor, Berkshire.

WW 318 for further details



WW 318 for further details

All purpose stroboscope

A compact portable stroboscope has been made available by ESI Nuclear for use in industry, research, education and medicine. The 202, as it is called, has three ranges covering from one to 250 flashes per second with an accuracy of ±2%. A feature of the 202 is its flexibility; two or more units may be coupled to flash simultaneously while controlled by one dial, external sockets may be used to drive an external frequency meter, and there is also a provision for external triggering. At £64, the 202 is claimed to be amongst the most inexpensive instruments of its kind. ESI Nuclear, 6A Holmesdale Road, Reigate, Surrey RH2 0BQ.

WW319 for further details

Line impairment simulator

A new release at the "All Electronics Show" was the model 770 line impairment simulator from Axel. The simulator is claimed to be cheaper and more compact than previous models, and capable of simulating most of the line conditions common in data transmission systems. These conditions include those in voice-transmission-type telephone lines which, when used for data transmission, degrade the digital data – especially at speeds above 2400 bits per second – switch-selection enabling simulation of the worst cases of Bell C1, C2, C4 and 3002 lines. A user may also add to the simulation certain steady-state disturbances such as various random noises, phase jitter, frequency shifts, and harmonic distortion. Transient disturbances such as impulse noise and sudden amplitude changes can also be added. The disturbances may be selected individually or simultaneously, as required. A built-in random noise generator with a calibrated attenuator allows selection of the desired signal-to-noise ratio, having output levels from −16dBm to −88dBm in 1dBm steps. At the time of going to press the model 770, which weighs 16 lb and is suitable for bench or rack applications, could be obtained for £2,650. A portable version, the model 771, is also available. JVN Components, 204-206 High Street, Bromley, Kent BR1 1PW.

WW 320 for further details

High Q bandpass filter

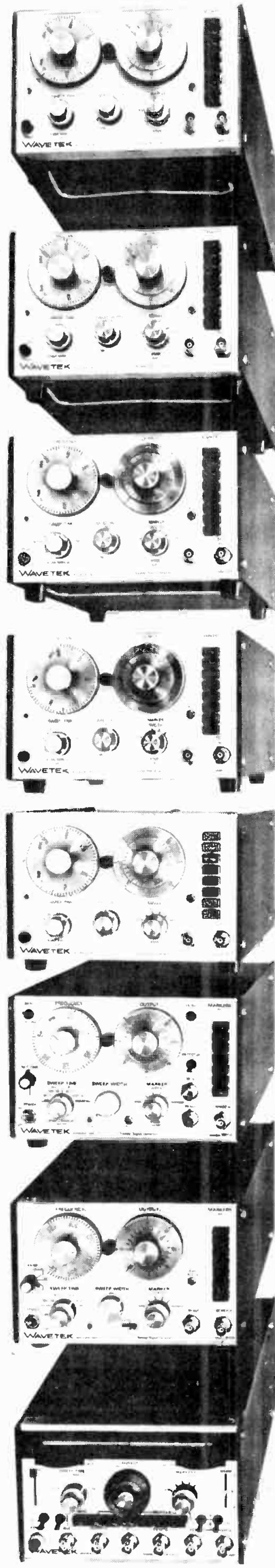
Pulse Engineering has introduced a high Q bandpass filter, PE 86 030, that can be tuned to any frequency from 67Hz to 3kHz. Each tone frequency is actively trimmed to better than ±0.15% and Q factor is typically 150. Deviation from the specified centre frequency over a temperature range 0 to 50°C is less than ±0.25%. These filters can replace tuning forks in paging applications and two-way transceivers for the detection of specific tone frequencies and are claimed to eliminate reliability problems and shock sensitivity. Auriema Ltd, Components Division, 442 Bath Road, Slough, Berks.

WW 321 for further details

Digital thermometer

A pocket-size thermometer, introduced by Kane-May Ltd, is claimed to give a rapid digital reading, to a resolution of 0.1°C, over a temperature range from −30°C to 199.9°C. The device, called the Digitherm "Universal" electronic thermometer, is also available for a wider range from −50°C to 1100°C, to a resolution of 1°C, Built-in circuitry compensates for ambient temperature and also for loss of battery voltage, which can be checked as required, the accuracy being maintained until the battery potential drops away sharply. The thermometer is intended for food processors, plastics manufacturers and in other industries where fast transient temperature changes must be measured. Kane-May Ltd, Burrowfield, Welwyn Garden City, Herts.

WW 322 for further details



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one thousand two...
one thousand four-one...
one thousand four...
one thousand five...
one thousand eight hundred one...
two thousand...
two thousand one...

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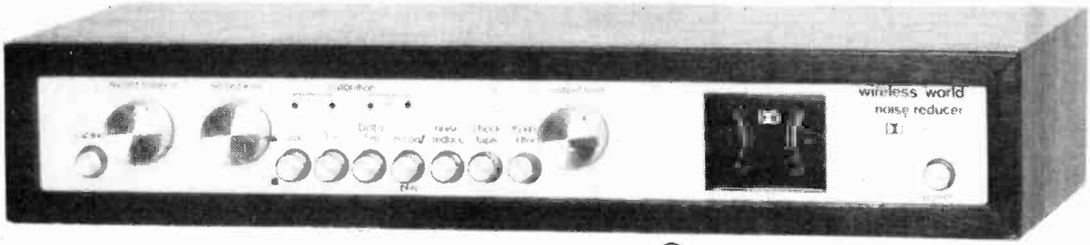

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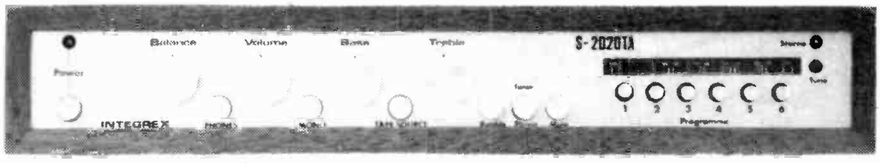

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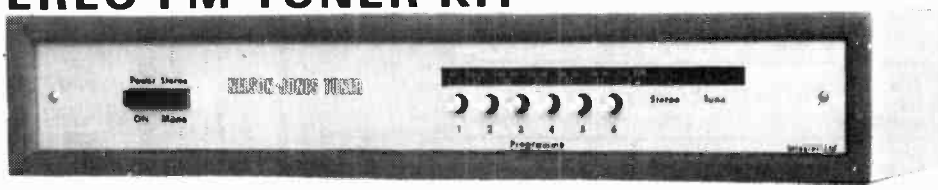
PRICE: £48.95+VAT

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.

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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.
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Sens. 30dB S/N mono @ 1.8µV
THD typically 0.4%
Tuning range 88—104MHz
LED sig. strength and stereo indicator

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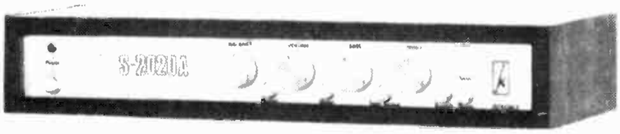

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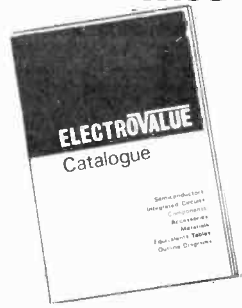

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TELEPHONE 54525

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R216 Receiver MANUAL (photostat copy): £1.50 inc. post

RACAL I.S.B. ADAPTOR RA-95A: £65. Carr. £2.

MUIRHEAD ATTENUATORS: 75 ohms 0-8 Mc/s 3V MAK 3 ranges 0-5, 0-25, 0-50 DB **£3.00** + 75p post.

CREED MODEL 54 TELEPRINTER: £37.50 each. Carr. £4.

CREED MODEL 75 TELEPRINTER: Receiver only **£30.00.** Carr. £3.

EDDYSTONE TELEPRINTER ADAPTOR TYPE 937: £45. Carr. £1.

WILD BARFIELD ELECTRIC FURNACE MODEL CCL22X: With ether indicating temperature controllers Model 990. 0-1400° C. **£250.** Carr. £5.

METROVAC IONIZATION GAUGE MODEL V.C.3: £55. Carr. £3.

AVO VALVE TESTER CT.160: (Portable) similar to Avo Mk. 3 Characteristic meter. Good condition, **£45.00.** Carr. £2.00.

REDIFON TELEPRINTER RELAY UNIT No. 12: ZA-41196 and power supply 200-250V a.c. Polarised relay type 3SEITR. 80-0V 25mA. Two stabilised valves CV 286. Centre Zero Meter 10-0-10. Size 8in. x 8in. x 8in. New condition. **£10.** Carr. 75p.

SOLARTRON PULSE GENERATOR TYPE G1101-2: £75.00 each. Carr. £2.00.

TELEPRINTER TYPE 7B: Pageprinter 24V d.c. power supply, speed 50 bauds per min. second hand cond. (excellent order) no parts broken. **£20** each. Carriage £3.

AUTO TRANSFORMER: 230V 50c/s, 1000 watts. Mounted in strong steel case 5" x 6½" x 7". Bitumen impregnated. **£12.00.** Carr. £1.50.

CRYSTAL TEST SET TYPE 193: used for checking crystals in freq. range 3000-10,000KHz. Mains 230V 50Hz. Measures crystal current under oscillatory conditions and the equivalent resistance. Crystal freq. can be tested in conjunction with a freq. meter. **£25.** Carr. £1.50.

SOLARTRON VARIABLE POWER UNIT S.R.S. 1535: 0-500 volts at 100 mA and 6.3 volts C.T. 3 amps d.c. 110/250 volts a.c. input. **£18.50.** Carr. £1.50.

ADVANCE A.F. SIGNAL GENERATOR H1E: Sinesoidal or square wave output. 15-50kHz. Adjustable level between 200uv and 20v. Overall distortion less than 1%. Output adjustable 1.4mV to 140V. Waveform ratio 50:50 up to 25kHz. Standard A.C. mains input. As new condition **£40.00.** Carr. £2.00.

ADVANCE A.F. SIGNAL GENERATOR H.I.: Same frequency and characteristics as above. Earlier model. Secondhand condition. **£25.00.** Carr. £2.00.

ANTENNA MAST: 40ft. aluminium 1¼" dia. in 5ft. sections complete with guys, etc. **£25.00.** Carr. £3.00.

PULSE GENERATOR PG21: Pulse width variable 15nS to 200msec in 7 ranges. Delay variable 40nS to 200msec with respect to sync pulse output in 7 ranges. Jitter less than .1%. Repetition rate 1Hz to 10MHz in 7 decade ranges. 20MHz available in double pulse mode. Pulse mode: normal, square wave and double pulse. 240v a.c. As new condition. **£125.00.** Carr. £2.00.

CLASS 'D' WAVEMETER NO. 1: Crystal controlled heterodyne frequency meter covering 2-8 MHz. Power supply 6V d.c. Good secondhand condition. **£8.50.** Carr. £1.50.

PRECISION PHASE DETECTOR TYPE 205: Freq. 0.1-15MHz in 5 ranges. Variable time delav microseconds 0-0.1c. 115V input. **£55** each. Carr. £1.

RING TOROIDAL DUST CORES: Size 2½" outside 1¾ inside 5/16" thick. Box of two **£1.00.** Post 30p.

MUIRHEAD PHASEMETER TYPE D729: A.M. **£95.00.** Carr. £3.00.

CT.420 SIGNAL GENERATOR: 200-8000c/s Variable tuning. Two fixed frequencies 9000 and 10,000. Internal calibrator 100 & 500 c/s. **£75** each carr. £2.

NOISE GENERATOR TF-1106: Frequency 1 to 200 Mc/s Direct noise factor calibration. Output impedance 70 ohms **£65** each. Carr. £1.50.

MW-59 UNIVERSAL KLYSTRON POWER SUPPLY: £85. Carr. £3.

TF-1278/I TRAVELLING TUBE WAVE AMPLIFIER: £125. Carr. £2.

BPL A.C. MILLIVOLTMETER TYPE VM.348-D Mk. 3: 2 millivolts-2 volts, 6 ranges. **£30.** Carr. £1.

CAWKELL REMSCOPE TYPE 741 : Memory scope. 'as new' cond. **£150.00.**

MANSON SYNTHESISER Q115-URC: 2-30 mc/s. **£175.00.**

FIREPROOF TELEPHONES: £25.00 each, carr. £1.50.

POWER UNIT: 110/230 volts a.c. input. 28 volts d.c. at 40 amps output. **£30.00** each. carr. £3.00.

SMOOTHING UNIT (for the above): **£10.00** each, carr. £2.00.

X-BAND MODULATOR CALIBRATOR TYPE MC-4420-X: Mnfr. James Scott. **£125** each.Carr. £1.

BACKWARD WAVE OSCILLATOR TYPE SE-125: 6.3 heater, 105V Anode, 7.9mA. Mnfr. Watkins & Johnson. **£85** each. Carr. £1.

TEKTRONIX TIME MARK GENERATOR TYPE 180-S1: 5, 10, 50 MHz. **£65.** Carr. £2.

ROTARY INVERTERS: TYPE PE.218E — input 24-28V d.c., 80 Amps. 4,800 rpm. Output 115V a.c. 13 Amp 400 c/s. 1Ph. P.F.9. **£20.00** each. Carr. £2.50.

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SORENSEN VOLTAGE REGULATOR: Input 190/260 volts a.c. Output 220/240 volts a.c. 1000 watts. **£40.00,** carr. £3.00.

EVERSHED SAFETY OHM. METER: Max 10Ma. Test pressure 30v. Complete in leather case. **£25.00** each, post £1.00.

FYLDE AMPLIFIERS TYPE 154 BDM: Rack mounted 3v d.c. and power supply FE.500.TP. **£65.00,** carr. £2.00.

AUTOMATIC VOLTAGE STABILIZERS: Input 207-242v a.c. Output 230v a.c. at 2.80 amps. **£17.50,** carriage £1.50.

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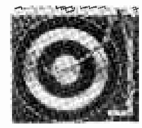
RETURN OF POST MAIL ORDER SERVICE

BSR HI-FI AUTOCHANGER

STEREO AND MONO



Plays 12", 10" or 7" records. Auto or Manual. A high quality unit backed by BSR reliability with 12 months' guarantee. A.C 200/250V. Size 13½-11¼in., 3 speeds. Above motor board 3¼in. Below motor board 2½in with STEREO and MONO CARTRIDGE **£10.25** Post 75p

B S R SINGLE PLAYER P128 Same as MP60 with stereo cartridge cueing device, **£17.50.**

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Modern design. Rexine covered. Vynair front gr·lle. Chrome fittings Size 17 x 15 x 8in. approx Motor board cut for BSR or Garrard deck **£4.50** Post 50p

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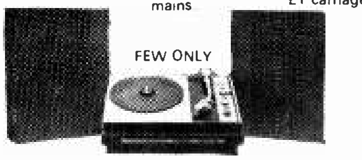
With P V C Cover Cut out for most B S R or Garrard decks Silver grey finish Model "A" Size 12½ x 14¾ x 7½in. **£5.50**

Model 8" Size 16" x 13¾" x 7in **£5.85.** Post 75p

COMPLETE STEREO SYSTEM

Two full size loudspeakers 13¾ x 10 x 3¾in Player unit clips to loudspeakers making it extremely compact, overall size only 13¾ x 10 x 8½in . 3 watts per channel, plays all records 33 r p.m , 45 r p m Separate volume and tone controls Attractive Teak finish 240V a.c mains **£22.50** £1 carriage



SPECIAL OFFER!
SMITH'S CLOCKWORK 15 AMP TIME SWITCH
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Single pole two-way. Surface mounting with fixing screws. Will replace existing wall switch to give light for return home, garage, automatic anti-burglar lights, etc Variable knob. Turn on or off at full or intermediate settings Brand new and fully guaranteed

TEAKWOOD LOUDSPEAKER GRILLES will easily fit to baffle board Size 10½ x 7⅛in—**45p.**

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5kΩ to 2MΩ LOG or LIN. L/S **25p.** D P **40p.** STEREO L/S **55p.** D.P. **75p.** Edge 5K. S.P. Transistor **30p.**

80 Ohm Coax 8p yd.

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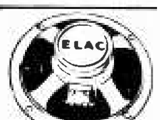
FRINGE LOW LOSS Ideal 625 and colour **15p** yd.

ELAC HI-FI SPEAKER 8in. or 10 x 6in.



Dual cone plasticised roll surround. Large ceramic magnet 50-16,000 c/s. Bass resonance 55 c/s 8 ohm impedance, 10 watts. music power. **£3.95** Post 35p

E.M.I. 13½ x 8in. SPEAKER SALE!

With tweeter and crossover 10 watt State 3 or 8 ohm As illustrated **£5.25** Post 35p

Bass Woofer, 15 watts, 8 or 15 ohm **£6.60** Post 45p

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BLANK ALUMINIUM CHASSIS. 6 x 4—**70p;** 8 x 6—**90p;** 10 x 7—**£1.15;** 12 x 8—**£1.35;** 14 x 9—**£1.50;** 16x6—**£1.45;** 16 x 10—**£1.70.**
ALUMINIUM PANELS. 6 x 4—**17p;** 8 x 6—**24p;** 14 x 3—**25p;** 10 x 7—**35p;** 12 x 8—**43p;** 12 x 5—**30p;** 16 x 6—**43p;** 14 x 9—**52p;** 12 x 12—**68p;** 16 x 10—**75p.**

ELAC 9 x 5in HI-FI SPEAKER TYPE 59RM

This famous unit now available, 10 watts, 8 ohm. **£3.45** Post 35p

RCS LOW VOLTAGE STABILISED POWER PACK KITS

All parts and instructions with Zener diode, printed circuit rectifiers and double wound mains transformer Input 200/240V a c Output voltages available, 6 or 7.5 or 9 or 12V d.c. up to 100mA or less Size 3 x 2½ x 1½ in. Please state voltage required. **£2.95** Post 45p

RCS POWER PACK KIT

12 VOLT, 750mA. Complete with printed circuit board and assembly instructions. **£3.35** Post 30p
12 VOLT 300mA KIT, **£3.15.** 9 VOLT 1 AMP KIT, **£3.35.**

R.C.S. GENERAL PURPOSE TRANSISTOR PRE-AMPLIFIER — BRITISH MADE

Ideal for Mike, Tape, P.U., Guitar, etc Can be used with Battery 9-12V or H.T. line 200-300V d.c. operation. Size 1¾ x 1¼ x ¾in. Response 25 c/s to 25 kc/s. 26 dB gain. For use with valve or transistor equipment. Full instructions supplied. Details S.A.E. **£1.45** Post 30p

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1.5V d.c. operation over 300 hours continuous on SP2 battery, fully adjustable swing and speed. Ideal displays, teaching electro magnetism or for metronome, strobe, etc. **95p** Post 30p

R.C.S. "MINOR" 10 watt AMPLIFIER KIT

This kit is suitable for record players, guitars, tape playback, electronic instruments or small P.A. systems. Two versions available Mono **£11.25;** Stereo, **£18.** Post 45p Specification 10W per channel; input 100mV; size 9½ x 3 x 2in. approx S.A.E. details. Full instructions supplied. AC mains powered.

MAINS TRANSFORMERS

ALL POST 50p

250-0-250V 70mA, 6 5V, 2A **£3.45**
250-0-250 80mA, 6 3V 3 5A, 6 3V 1A or 5V 2A **£4.60**
350-0-350 80mA, 6.3V 3.5A, 6 3V 1A or 5V 2A **£5.80**
300-0-300V 120mA, 6 3V 4A C.T , 6 3V 2A **£7.00**
MIDGET 220V 45mA, 6 3V 2A **£1.40**
HEATED TRANS. 6.3V ½ amp **£1;** 3 amp **£1.40**
GENERAL PURPOSE LOW VOLTAGE Tapped outputs at 2 amp. 3, 4, 5, 6, 8, 9, 10, 12, 15, 18, 25 and 30V **£4.60.** 1 amp 6, 8, 10, 12, 16, 18, 20, 24, 30, 36, 40, 48, 60 **£4.60.** 2 amp. 6, 8, 10, 12, 16, 18, 20, 24, 30, 36, 40, 48, 60 **£7.00.** 3 amp 6, 8, 10, 12, 16, 18, 20, 24, 30, 36, 40, 48, 60 **£8.70.** 5 amp 6, 8, 10, 12, 16, 18, 20, 24, 30, 36, 40, 48, 60 **£11.25.** 6 06V 500mA **£1,** 9V 1 amp. **£1,** 12V 300mA, **£1,** 12V 500mA, **£1,** 12V 750mA, **£1,** 10V, 30V, 40V, 2 amp., **£2.75,** 20V, 3 amp , **£2.45,** 40V, 2 amp . **£2.95,** 22-0-22V, 4 amp. d c., **£3.45,** 16V, ½ amp. **£1,** 16V, 2 amp . **£2.20,** 0, 5, 8, 10, 16V, ½ amp., **£1.95,** 20V ½ amp , **£1.75,** 20V, 1 amp., **£2.20.**
AUTO TRANSFORMERS, 115V to 230V or 230V to 115V 150W **£5;** 250W **£6;** 400W **£7;** 500W **£8.**
FULL WAVE BRIDGE CHARGER RECTIFIERS 6 or 12V outputs, 1½ amp **40p;** 2 amp **55p;** 4 amp **85p.**
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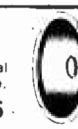
12V. 1½A HALF WAVE Selenium Rectifier, **25p.**

GOODMANS 8-inch HI-FI BASS WOOFER



8 ohm. 10W Large ceramic magnet Special Rubber cone surround Frequency response. 30-8000 c/s Ideal HI-FI Enclosure Systems. **£6.75**

NEW ELECTROLYTIC CONDENSERS

2/350V	20p	250/25V	20p	50+50/300V	50p
4/350V	20p	500/25V	25p	30.000/25V	95p
8/350V	28p	100+100/275V	65p	32+32/250V	20p
16/350V	35p	150+200/275V	70p	32+32/450V	80p
32/500V	60p	8+8/350V	50p	350+50/325V	85p
25/25V	15p	8+16/350V	50p	100+50+50/350V	85p
50/50V	15p	16+16/350V	60p	32+32+32/350V	65p
100/25V	15p	32+32/350V	60p	4700/63V	95p

LOW VOLTAGE ELECTROLYTICS
1, 2, 4, 5 8, 16, 25, 30, 50, 100, 200mF 15V **10p.**
500mF 12V **15p;** 25V **20p;** 50V **30p.**
1000mF 12V **17p;** 25V **35p;** 50V **47p;** 100V **70p.**
2000mF 6V **25p;** 25V **42p;** 50V **57p.**
2500mF 50V **62p;** 3000mF 25V **47p;** 50V **65p.**
5000mF 6V **25p;** 12V **42p;** 25V **75p;** 35V **65p;** 50V **95p.**

SHORT WAVE 100pF air spaced gangable tuner, **95p.**
TRIMMERS 10pF, 30pF, 50pF, **5p.** 100pF, 150pF, **15p.**
CERAMIC, 1pF to 0 01mF, **5p.** Silver Mica 2 to 5000pF, **5p.**
PAPER 350V-0 1 **7p;** 0.5 **13p;** 1mF 150V **15p;** 2mF 150V **15p;** 500V-0 001 to 0.05 **5p;** 0.1 **10p;** 0 25 **13p;** 0.47 **25p.**
MICRO SWITCH SINGLE POLE CHANGEOVER 20p.
SUB-MIN MICRO SWITCH, 25p. Single pole change over
TWIN GANG, "0-0" 208pF + 176pF **£2.00;** 500pF standard **75p;** 365 + 365 + 25 + 25pF, Slow-motion drive **50p.** 120pF **TWIN GANG, 50p;** 365pF **TWIN GANG, 50p.**
NEON PANEL INDICATORS 250V AC/DC. Amber or red, **30p.**
RESISTORS. ¼W, ½W, 1W, 20% **2p;** 2W, **10p;** 10Ω to 10M
HIGH STABILITY. ½W 2% 10 ohms to 6 meg., **12p.**
Ditto 5% Preferred values 10 ohms to 10 meg., **5p.**
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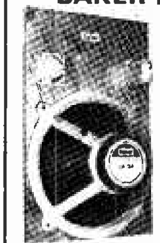
BRIDGE RECTIFIER 200V PIV ½ amp **50p.**
TOGGLE SWITCHES, S P **20p.** D P S T **25p.** D P D T **30p**

BAKER MAJOR 12" £10.35



30-14,500 c/s, 12in. double cone, woofer and tweeter cone together with a BAKER ceramic magnet assembly having a flux density of 14,000 gauss and a total flux of 145,000 Maxwells. Bass resonance 40 c/s. Rated 25W. NOTE: 3 or 8 or 15 ohms must be stated.

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Please state 3 or 8 or 15 ohms.

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12in 30W **£8.95** 3 or 8 or 15 ohm	12in 40W **£10.50** 3 or 8 or 15 ohm	15in. 75W **£19.50** 8 or 15 ohm

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R.C.S. 100 watt VALVE AMPLIFIER CHASSIS

Four inputs Four way mixing, master volume, treble and bass controls. Suits all speakers This professional quality amplifier chassis is suitable for all groups, disco, P A , where high quality power is required. 5 speaker outputs A/C mains operated. Slave output. Produced by demand for a quality **valve** amplifier. Send for leaflet. Price **£85** carr. £2.50

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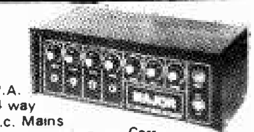
SPECIAL OFFER: 80 ohm. 2¼in., 2¾in., 35 ohm, 2in , 3in , 25 ohm, 2½in. dia , 3in dia , 5x3in , 8 ohm, 2½in., 3in , 3½in , 5in , 15 ohm, 3½in. dia , 6x4in 7x4in 5x3in 3 ohm., 2½in , 2⅝in., 3½in., 5in dia **£1.25 each.**
PHILIPS LOUDSPEAKER, 8in., 4 ohms, 4 watts, ceramic magnet **£1.95**
RICHARD ALLAN TWIN CONE LOUDSPEAKERS 8in. diameter 4W **£2.50.** 10in. diameter 5W **£2.95;** 12in diameter 6W **£3.50.** 3/8/15 ohms, please state
VALVE OUTPUT TRANS. 40p; MIKE TRANS. 50 1, **40p.** Mike trans. mu metal 100 1 **£1.25.**

Loudspeaker Volume Control 15 ohms 10W with one inch long threaded bush for wood panel mounting. ¼in. spindle. **65p**

BAKER 100 WATT ALL PURPOSE AMPLIFIER



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Kit of parts to build a 3 channel sound to light unit. 1,000 watts per channel. **£12.50.** Post 35p. Easy to build. Full instructions supplied, cabinet. **£3.** As featured in December Practical Wireless.

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CP1 150 Capacitors mixed bag of paper silver mica electrolytics etc Approx quantity counted by weight **60p**

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CP14 40 Potentiometers presets wirewounds carbons dual gangs with and without switches etc Mixed values and wattages **£1 20**

CP15 12 Standard crocodile clips screw fixing good quality **60p★**

CP16 5 P C boards each containing a BF180 UHF amplifier transistor A good basis for building a T V aerial pre-amp as various parts inc **60p**

CP17 25 Electrolytic Capacitors various values and voltages many useful types from T V to transistor radio and HI-FI **60p**

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TP12★ 4 BY127 Silicon rectifiers 1000 piv 1 amp Plastic T V rectifier

TP13★ 5 OCP71 Light sensitive transistors

TP14 20 OC71 Germanium PNP audio pre amp transistor black glass type

TP15 20 OC81 Germanium PNP audio output transistor white glass type

TP16 20 OC200/1/2/3 transistors PNP silicon TO 5 unmarked

TP17 20 1 watt zener diodes mixed voltages 6 8 to 43 volts

TP18 20 2N3707/8/9/10 transistors NPN silicon plastic unmarked

TP19 100 Diodes mixture of germanium gold bonded silicon etc a useful selection of many types marked and unmarked

TP20 10 Mullard OC45 transistors I F amp PNP germanium

TP23 20 BFY50/1/2 2N696/7 2N1613 etc NPN silicon TO-5 uncoded COMPLEMENTARY TO PAK TP24

TP24 20 BFY64 2N2904/5 etc PNP silicon TO-5 uncoded COMPLEMENTARY to PAK TP23

TP30 20 NPN silicon planar transistors TO-18 similar to BC108 etc uncoded

TP31 20 PNP silicon planar transistors TO-18 similar to BC178 etc uncoded

TP32 20 2N2926 silicon plastic transistors uncoded and ungraded for colours

● UNTESTED PACKS — 60p each
Specially for keen bargain hunters

UT1 50 PNP germanium transistors. AF and RF Very good yield

UT2 150 Germanium diodes miniature glass type

UT5 40 Zener diodes 250 mW OAZ240 range average 50% good

UT6 25 Zener diodes 1-1½ watt top hat type mixed voltages

UT9 40 NPN silicon planar transistors of the 2N3707 11 range low noise amp

UT10 15 Power transistors PNP germanium and NPN silicon mostly TO-3 but some plastic and some marked

UT13 15 Integrated circuits experimenters pak dual in line, TO-5 TTL DTL marked and unmarked, some definitely good but old types

FOR FULL RANGES — SEE CATALOGUE

POWER TRANSISTORS

	Vce	Watts	1cAmps	Price
40P1	15	20	3	30p★
40N2	40	40	4	30p★
40P2	40	40	4	30p★
90N1	15	45	4	25p★
90P1	15	45	4	25p★
90N2	40	90	8	35p★
90P2	40	90	8	35p★

Many other types available from 3 to 115 watts

INTEGRATED CIRCUITS
MM5314 Dual in line clock chip **£3★**
LMS380/SL60745 Dual in line 2w audio amp with data etc **75p★**
Dual in line I C sockets 8 pin **14p**; 14 pin **15p★**; 16 pin **16p★**.

FETs
2N3919 **18p**
2N4416 **20p**
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3N141/MEM616 **50p**

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2N2160 **65p★**
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P.I.V	50v	100v	400v
1 amp	25p★	35p★	45p★
2 amp	35p★	45p★	55p★
4 amp	45p	50p★	80p★
6 amp	50p★	60p★	90p★

BY164 equiv SKB2/02 400v 1 5 amp **45p★**.

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SIGNAL GENERATOR
For MW and IF Covers 550 KHz to 1 6 MHz for MW and 400 to 550KHz for IF Fully portable Invaluable in AM repair and alignment jobs (p/p 40p) **£4.25★**

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Fountain-pen type Invaluable for fault tracing in radio sets amplifiers TVs tape recorders etc Takes one HP7 battery **£2.00★**

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Not new but in perfect order per pair **50p★**

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MT6	6v 0 6v 100mA	£1.22★
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SST12/1	12v 1amp	£2.05★
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(P/P 50p any one)

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Type	Sizes	Pitch	
SSEC 6-way	1⅛"	156"	32p
SSEC 10	1¼"	156"	50p
SSEC 12	2"	156"	60p
SSEC 16	2½"	156"	75p
SSEC 18	3"	156"	85p
SSEC 22	3½"	156"	1.00

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Improved version of our famous Mk 2 model of which thousands are in regular use Size 150 x 75 x 50mm strong plastic case with handle/stand 4 push button operation 4 patterns Self-contained line and frame generator and synchro pulse Pre-set adjust for R F output and line/frame synch Uses 4 alkaline type 1600 batts Blank raster facility **FOR COLOUR AND MONO** (P/P add 35p)

£27.50 • Built & tested

★ SOME SPECIAL OFFERS

FM STEREO DECODERS
I C unit for negative earth with data **£1.95**
Transistorised version for positive earth **£1.75**

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On P C B s unsorted useful for experimenting etc Various kinds (cannot be exchanged) AM/FM **£1.00**
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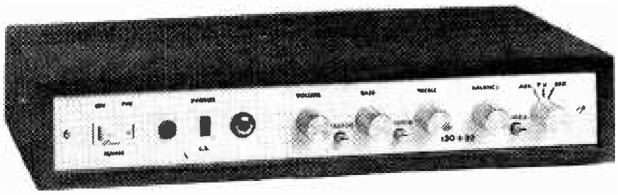


T20+20 and our new T30+30 20W, 30W AMPLIFIERS

Designed by Texas engineers and described in Practical Wireless the Texan was an immediate success Now developed further in our laboratories to include a Toroidal transformer and additional improvements, the slimline T20 + 20 delivers 20W per channel of true Hi-Fi at exceptionally low cost The design is based on a single F/Glass PCB and features all the normal facilities found on quality amplifiers, including scratch and rumble filters, adaptable input selector and head phones socket. In a follow up article in Practical Wireless further modifications were suggested and these have been incorporated into the T30 + 30 These include RF interference filters and a tape monitor facility Power output of this new model is 30W per channel

Pack	T20	T30	Pack	T20	T30
1 Set of low noise resistors	0.95	1.05	8. Toroidal transformer — 240V prim. e.s. screen	4.95	6.80
2. Set of small capacitors	1.50	2.10	9. Fibreglass PCB	2.50	2.90
3. Set of power supply capacitors	1.40	2.05	10. Set of metalwork, fixing parts	4.20	4.80
4. Set of miscellaneous parts	1.90	1.90	11. Set of cables, mains lead	0.40	0.40
5. Set of slide, mains, P.B. switches	1.20	1.20	12. Handbook (free with complete kit)	0.25	0.25
6. Set of pots, selector switch	2.00	2.00	13 Teak cabinet 15.4" x 6.7" x 2.8"	4.50	4.50
7. Set of semiconductors, ICs, skts	7.25	7.75			

FREE TEAK CASE WITH FULL KITS

T20+20 KIT PRICE only **£28.25**

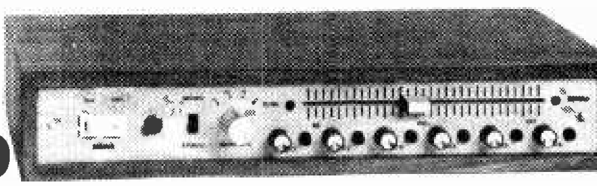
T30+30 KIT PRICE only **£32.95**

2 NEW TUNERS!

WW SFMT II

Following the success of our Wireless World FM Tuner kit we are now pleased to introduce our new cost reduced model, designed to complement the T20 and T30 amplifiers The frequency meter of the more advanced model has been omitted and the mechanics simplified, however the circuitry is identical and this new kit offers most exceptional value for money Facilities included are switchable afc, adjustable, switchable muting, channel selection by slider or readily adjustable pre-set push-button controls and LED tuning indication Individual pack prices in our free list.

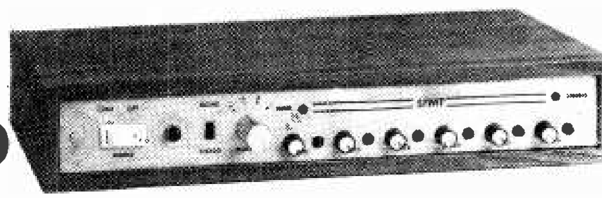
KIT PRICE **£47.40**



POWERTRAN SFMT

This easy to construct tuner using our own circuit design includes a pre-aligned front end module, PLL stereo decoder, adjustable, switchable muting, switchable afc and push-button channel selection As with all our full kits, all components down to the last nut and bolt are supplied together with full constructional details

KIT PRICE **£32.60**



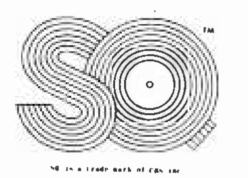
CONVERT NOW TO QUADRAPHONICS!

SQM1 — 30 KIT PRICE **£37.15**

With 100s of titles now available no longer is there any problem over suitable software No problems with hardware either Our new unit the SQM1-30 simply plugs into the tape monitor socket of your existing amplifier and drives two additional speakers at 30W per channel. A full complement of controls including volume, bass, treble and balance are provided as are comprehensive switching facilities enabling the unit to be used for either front or rear channels, by-passing the decoder for stereo-only use and exchanging left and right channels The SQ matrix decoder is based upon a single integrated circuit and was designed by CBS whilst the power and tone control sections are identical to those used in our T30 + 30 amplifier which the SQM1-30 matches perfectly Kit price includes CBS licence fee

Special offer to T20 + 20 and Texan owners!

Owners of T20 + 20 and Texan amplifiers, which have no tape monitor outlet, purchasing an SQM1-30 will be supplied, on request, a free conversion kit to fit a tape monitoring facility to the existing amplifier This makes simple the connection to the highly adaptable SQM1-30 quadraphonic decoder/rear channel amplifier



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2N1613	£0.20	BC182L	£0.10	MPSA66	£0.40
2N1711	£0.25	BC184L	£0.11	MPSU05	£0.60
2N2926G	£0.10	BC212L	£0.12	MPSU55	£0.70
2N3055	£0.45	BC214L	£0.14	SBA750A	£2.50
2N3442	£1.20	BCY72	£0.13	SL301	£1.30
2N3711	£0.09	BD529	£0.85	SL3045	£1.60
2N3904	£0.17	BD530	£0.85	SN72741P	£0.40
2N3906	£0.20	BDY56	£1.60	SN72748P	£0.40
2N4062	£0.11	BF257	£0.40	TIL209	£0.30
2N4302	£0.60	BF259	£0.47	TIP29A	£0.50
2N5087	£0.42	BFR39	£0.25	TIP30A	£0.60
2N5210	£0.54	BFR79	£0.25	TIP29C	£0.71
2N5457	£0.45	BFY51	£0.20	TIP30C	£0.78
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2N5461	£0.50	CA3046	£0.70	TIP42A	£0.90
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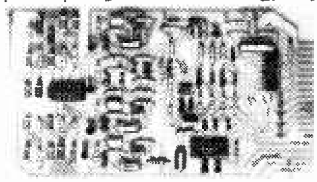
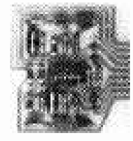
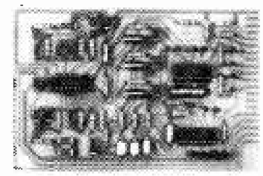
40361	£0.40	MC1310	£2.90	TIP42B	£0.98
40362	£0.45	MC1351	£1.05	1N914	£0.07
BC107	£0.10	MFC4010	£0.95	1N916	£0.07
BC108	£0.10	MJ481	£1.20	1S920	£0.10
BC109	£0.10	MJ491	£1.30	5B05	£1.20
BC109C	£0.12	MJE521	£0.60		
BC125	£0.15	MPSA05	£0.25	**FILTERS**	
BC126	£0.15	MPSA12	£0.55	FM4	£0.80
BC182	£0.10	MPSA14	£0.35	SFG10 7MA	£2.80
BC212	£0.12	MPSA55	£0.25		
BC182K	£0.10				

SQ QUADRAPHONIC DECODERS







Feed 2 channels (200-1000mV as obtainable from most pre-amplifiers or amplifier tape monitor outlets) into any one of our 3 decoders and take 4 channels out with no overall signal level reduction On the logic enhanced decoders Volume, Front-Back LF-RF balance LB-RB balance and Dimension controls can all be implemented by simple single gang potentiometers

These state-of-the-art circuits used under licence from CBS are offered in kits of superior quality with close tolerance capacitors, metal oxide resistors and fibre-glass PCBs designed for edge connector insertion All kit prices include CBS licence fee

M1 Basic matrix decoder with fixed 10-40 blend All components, PCB **£5.90**

L1 Full logic controlled decoder with "wave matching" and "front back logic" for enhanced channel separation All components PCB **£17.20**

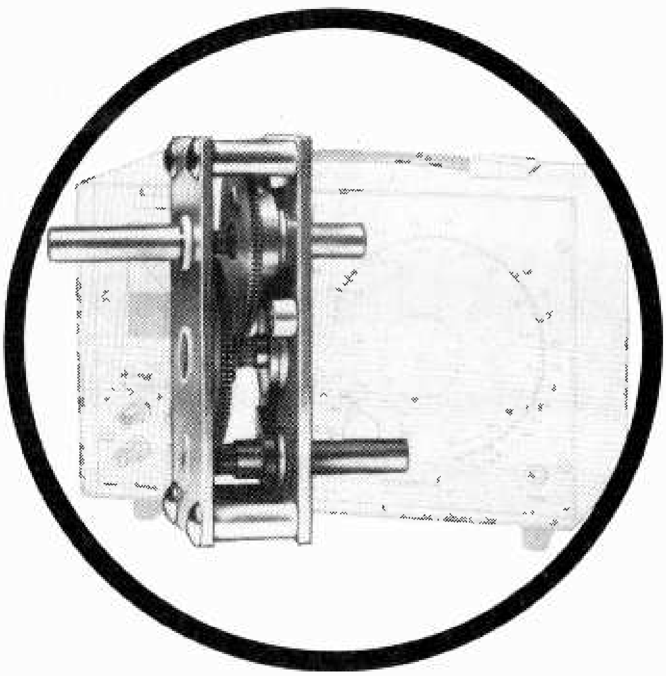
L2A More advanced full logic decoder with variable blend extended frequency response, increased front back separation All components, PCB **£24.60**

EXPORT NO PROBLEM

Our Export Department will be pleased to advise on postal costs to any country in the world. Some of the countries to which we sent kits in 1975 are shown surrounding this advertisement.

Kenya France St. Martin, Java New Zealand Borneo South Africa Denmark Nigeria Anguilla Finland

Ten into one will go.



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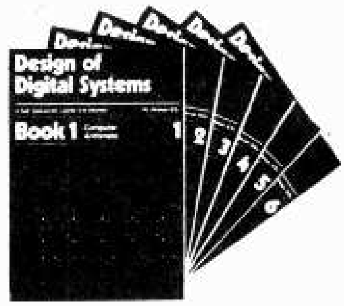

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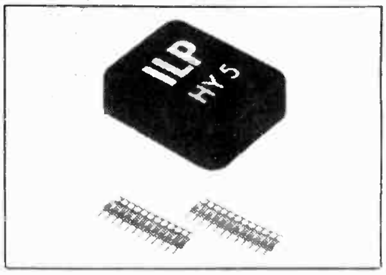
WW7

15—240 Watts!

HY5
Preamplifier



The HY5 is a mono hybrid amplifier ideally suited for all applications. All common input functions (mag Cartridge, tuner, etc) are catered for internally, the desired function is achieved either by a multi-way switch or direct connection to the appropriate pins. The internal volume and tone circuits merely require connecting to external potentiometers (not included). The HY5 is compatible with all I.L.P. power amplifiers and power supplies. To ease construction and mounting a P.C. connector is supplied with each pre-amplifier.
FEATURES: Complete pre-amplifier in single pack — Multi-function equalization — Low noise — Low distortion — High overload — Two simply combined for stereo.
APPLICATIONS: Hi-Fi — Mixers — Disco — Guitar and Organ — Public address.
SPECIFICATIONS:
INPUTS Magnetic Pick-up 3mV Ceramic Pick-up 30mV Tuner 100mV Microphone 10mV Auxiliary 3-100mV input impedance 47kΩ at 1kHz
OUTPUTS Tape 100mV Main output 500mV R.M.S.
ACTIVE TONE CONTROLS Treble ±12dB at 10kHz Bass ± at 100Hz
DISTORTION 0.1% at 1kHz Signal/Noise Ratio 68dB
OVERLOAD 38dB on Magnetic Pick-up SUPPLY VOLTAGE ±16-50V
Price £4.75 + 59p VAT P&P free.

HY30
15 Watts into 8Ω

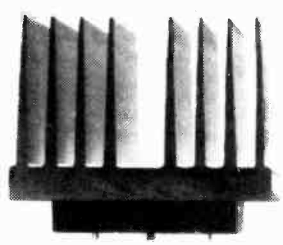
The HY30 is an exciting New kit from I.L.P. it features a virtually indestructible I.C. with short circuit and thermal protection. The kit consists of I.C., heatsink, P.C. board, 4 resistors, 6 capacitors, mounting kit, together with easy to follow construction and operating instructions. This amplifier is ideally suited to the beginner in audio who wishes to use the most up-to-date technology available.
FEATURES: Complete Kit — Low Distortion — Short, Open and Thermal Protection — Easy to Build.
APPLICATIONS: Updating audio equipment — Guitar practice amplifier — Test amplifier — audio oscillator.
SPECIFICATIONS
OUTPUT POWER 15W R.M.S. into 8Ω DISTORTION 0.1% at 15W
INPUT SENSITIVITY 500mV FREQUENCY RESPONSE 10Hz-16kHz -3dB
SUPPLY VOLTAGE ±18V
Price £4.75 + 59p VAT P&P free.

Available June '76

HY50
25 Watts into 8Ω

The HY50 leads I.L.P.'s total integration approach to power amplifier design. The amplifier features an integral heatsink together with the simplicity of no external components. During the past three years the amplifier has been refined to the extent that it must be one of the most reliable and robust High Fidelity modules in the World.
FEATURES: Low Distortion — Integral Heatsink — Only five connections — 7 Amp output transistors — No external components.
APPLICATIONS: Medium Power Hi-Fi systems — Low power disco — Guitar amplifier.
SPECIFICATIONS: INPUT SENSITIVITY 500mV
OUTPUT POWER 25W RMS into 8Ω LOAD IMPEDANCE 4-16Ω DISTORTION 0.04% at 25W at 1kHz
SIGNAL/NOISE RATIO 75dB FREQUENCY RESPONSE 10Hz-45kHz -3dB
SUPPLY VOLTAGE ±25V SIZE 105.50.25mm
Price £6.20 + 77p VAT P&P free.

HY120
60 Watts into 8Ω



The HY120 is the baby of I.L.P.'s new high power range, designed to meet the most exacting requirements including load line and thermal protection this amplifier sets a new standard in modular design.
FEATURES: Very low distortion — Integral heatsink — Load line protection — Thermal protection — Five connections — No external components.
APPLICATIONS: Hi-Fi — High quality disco — Public address — Monitor amplifier — Guitar and organ.
SPECIFICATIONS
INPUT SENSITIVITY 500mV
OUTPUT POWER 60W RMS into 8Ω LOAD IMPEDANCE 4-16Ω DISTORTION 0.04% at 60W at 1kHz
SIGNAL/NOISE RATIO 90dB FREQUENCY RESPONSE 10Hz-45kHz -3dB SUPPLY VOLTAGE ±35V
SIZE 114.50.85mm
Price £14.40 + £1.16 VAT P&P free.

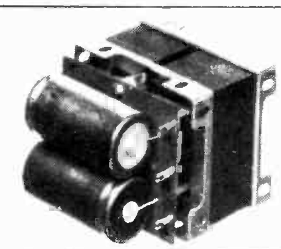
HY200
120 Watts into 8Ω

The HY200 now improved to give an output of 120 Watts has been designed to stand the most rugged conditions such as disco or group while still retaining true Hi-Fi performance.
FEATURES: Thermal shutdown — Very low distortion — Load line protection — Integral heatsink — No external components.
APPLICATIONS: Hi-Fi — Disco — Monitor — Power slave — Industrial — Public Address.
SPECIFICATIONS
INPUT SENSITIVITY 500mV
OUTPUT POWER 120W RMS into 8Ω LOAD IMPEDANCE 4-16Ω DISTORTION 0.05% at 100W at 1kHz
SIGNAL/NOISE RATIO 96 dB FREQUENCY RESPONSE 10Hz-45kHz — 3dB SUPPLY VOLTAGE ±45V
SIZE 114.100.85mm
Price £21.20 + £1.70 VAT P&P free.

HY400
240 Watts into 4Ω

The HY400 is I.L.P.'s "Big Daddy" of the range producing 240W into 4Ω! It has been designed for high power disco or public address applications. If the amplifier is to be used at continuous high power levels a cooling fan is recommended. The amplifier includes all the qualities of the rest of the family to lead the market as a true high power hi-fidelity power module.
FEATURES: Thermal shutdown — Very low distortion — Load line protection — No external components.
APPLICATIONS: Public address — Disco — Power slave — Industrial.
SPECIFICATIONS
OUTPUT POWER 240W RMS into 4Ω LOAD IMPEDANCE 4-16Ω DISTORTION 0.1% at 240W at 1kHz
SIGNAL/NOISE RATIO 94dB FREQUENCY RESPONSE 10Hz-45kHz — 3dB SUPPLY VOLTAGE ±45V
INPUT SENSITIVITY 500mV SIZE 114x100x85mm
Price £29.25 + £2.34 VAT P&P free.

POWER SUPPLIES



PSU36 suitable for two HY30's **£4.75** plus 59p VAT P&P free
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7427	27p*	22½p*	18p*
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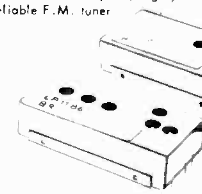

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NOTE: MAN 4000 Series pin outs are 14 pin dil the same as MAN 50; 70 and 80 series.

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Vceo 25v 2N5777

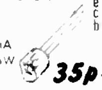
Vcbo 25v

Vebo 8v

I1 250 mA

Pd 200 mW

Hfe 2500



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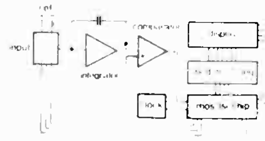

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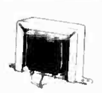

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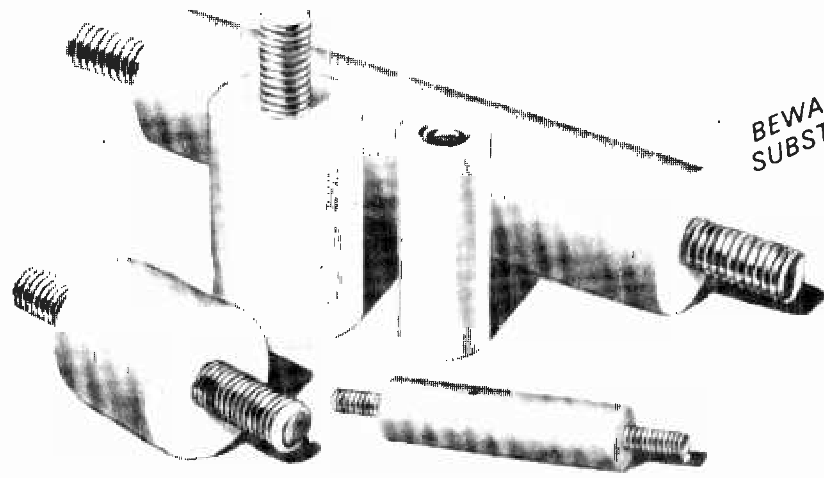

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	4A		6 5A		8 5A		10A		15A	
	(a)	(b)	(a)	(b)	(a)	(b)	(a)	(b)	(a)	(b)
100V	0.60	0.60	0.70	0.70	0.78	0.78	0.83	0.83	1.01	1.01
200V	0.64	0.64	0.75	0.75	0.87	0.87	0.87	0.87	1.17	1.17
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600V	0.96	0.99	0.87	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

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I.C. SOCKETS

14 pin	12p	28 pin	27p
16 pin	15p	40 pin	30p
24 pin	25p		

CAPACITORS

Electrolytic; paper; Non polar Tant
Pack of 25 Mixed our choice 50p

Metal Tant 6v — 1; 3.3; 4 7; 56. 68, 180
10v :— 150,
15v :— 4 7
20v :— 0 1 1 39; 68
35v :— 0 47; 0 56; 0 68; 0 82; 1 2
1 8; 2 7; 3 3; 4 7, 10; 15; 33
50v :— 3 3. 3 9; 10; 15; 22; 27; 50
Plastic Tant 6v :— 47

Tubular 20v .— 15
35v :— 2 2. 3 3; 4 7; 6 8

All values microfarads
Your choice 10p each
Pack of 20 mixed our choice £1.00

Polystyrene — Pack of 25 mixed 50p

RESISTORS

½ Watt Carbon	Mullard CR37	10 for 20p
½ Watt Metal Film	Welwyn MR5	10 for 50p
8 Watt Wirewound	Welwyn W22	37p
12 Watt Wirewound	Welwyn W23	39p
20 Watt Wirewound	Welwyn W24	41p

CR37 and MR5 min. quantity any one value 10 pcs
E12 Series available to 1 MO except W23 and W24 up to 27K only

POTENTIOMETERS

Moulded Track — Panel Mounting
Lin — 1w — 250k 2M
Log — ½w — 10k, 500k
Min. Moulded Track Linear — Panel Mtg
¼w :— 22k, 100k; 220; 2M2
Open Min. Preset ¼w Linear
100R; 220R; 250R; 330R; 470R, 500R; 1k, 10k; 25k. 100k 500k; 500k; 1M
Sealed Min. Preset ¼w Linear
33R, 100R, 220R; 330R; 500R. 4k7. 5k; 8k; 22k. 25k 50k, 100k; 500k
Your Choice 10p each—panel mtg: 5p each — preset
Pack of 10 (inc. 2 panel mtg.) 30p
Wirewound helical pots (10 turn) 100R. 5k, 50p each

Mullard Transistors							
		BD232	£1.10	BRY39	50p	BY128	95p
		BD233	68p	BRY50	52p	BY164	59p
—12½% VAT		BD234	70p	BSW67	96p	BY182	£1.30
AC176/128	61p	BD235	68p	BSX19	32p	BY184	41p
AD161/162	£1.20p	BD237	70p	BSX20	42p	BY206	19p
AC126	32p	BD238	80p	BSY95A	37p	BY207	27p
AC127	28p	BF115	21p	BT102	£1 40p	BYX10	23p
AC128	19p	BF167	27p	BU126	£2.20p	BYX36-150	12p
AC176	25p	BF173	29p	BU205	£2 50p	BYX36-600	17p
AC176/181	25p	BF177	63p	BU206	£3 00p	BYX38-600	41p
AC187/188.01	95p	BF178	47p	BU208	£4.00p	BYX38-600R	59p
AC188	47p	BF179	54p	GET103	6p	BYX49-600R	43p
ACY19	43p	BF180	44p	GET887	6p	OA95	7p
ACY20	23p	BF181	42p	OC28	£1.00p	OA200	13p
ACY22D	11p	BF182	44p	OC70	6p	OA202	9p
AD140	50p	BF183	48p	OC75	6p	OAZ223	69p
AD149	69p	BF184	26p	OC171	6p		
AF114	35p	BF185	26p				
AF115	30p	BF194	9p				
AF116	26p	BF194B	14p	MULLARD			
AF117	25p	BF195	13p				
AF121	13p	BF196	12p	DIODES		ZENERS	
AF125	32p	BF197	13p	— 12½% VAT		— 12½% VAT	
AF126	30p	BF200	30p				
AF139	42p	BF240	20p	AA119	11p	BZV10	59p
AF178	60p	BF241	27p	AA215	13p	BZV15CR12	75p
AF239	90p	BF262	58p	AAZ13	10p	BZX61C27	13p
BAT10	£1 00	BF263	58p	AAZ17	22p	BZX61C72	25p
BAV10	11p	BF336	37p	BA102	23p	BZX70C11	33p
BC107	18p	BF337	42p	BA154	10p	BZX70C30	33p
BC107A	15p	BF338	47p	BA155	11p	BZX79-	
BC107B	15p	BFR90	£3 50	BA156	11p	4.7V-75V	10p
BC108	16p	BFR94	£7 00	BA182	23p	BZY88C6V8	12p
BC108A	17p	BFX84	41p	BAX13	6p	BZY88C13	12p
BC108B	13p	BFX85	40p	BAX17	19p	BZY91C15	£5.20
BC108C	21p	BFY50	48p	BB105B	33p	BZY93C18	74p
BC109B	21p	BFY51	48p	BB105G	29p	BZY93C20	74p
BC109C	28p	BFY52	36p	BR100	33p	BZY93C68	74p
BC147	9p	BFY90	£1.70	BR100-1	39p	BZY95C15	68p
BC148	7p	BR100	33p	BR101	62p	BZY95C18	68p
BC148B	17p	BR100-1	39p	BY126	15p	BZY95C24	68p
BC149	7p	BR101	60p	BY127	13p	BZY95C68	68p
BC158	10p						
BC159	14p						
BC327	27p						
BC328	25p						
BC337	26p						
BCY72	24p						
BD115	31p						
BD124	80p						
BD131	50p						
BD132	72p						
BD133	68p						
BD135	42p						
BD136	44p						
BD138	52p						
BD139	56p						
BD140	68p						
BD144	£1 80						
BD160	£1 00						
BD181	£1 00						
BD182	£1 00						
BD183	£1.00						
BD201	£1 30						
BD203	£1 30						

AUDIO AND RAOIO MODULES

·LP1400 Stereo Decoder Module	£8.02
·LP1162 Audio Amp	£5.46
·LP1173 10W Audio Amp	£7.54
·LP1182/2 Stereo pre-amp	£4.00
·LP1183/2 Stereo pre-amp	£4 92
·LP1184/2 Low distortion stereo pre amp	£8 18
·LP1185 FM IF Amplifier	£6.28
LP1186 FM Tuner Module	£7.78
·LP1194 40 Voltage Multiplier (EHT gen)	£8 10

SPECIAL OFFER

(1) 10 Watt stereo amplifier comprising — 1 x LP1182/2 and 2 x LP1173
Normal price £19 08 ·Offer price £15 00

(2) FM tuner comprising — 1 x LP1185 1 x LP1186 1 x LP1400
Normal price £22 08 ·Offer price £18.00

CS COMPONENTS

Dept. WW, Wellington Road London Colney, St. Albans Herts

All prices exclusive of VAT which must be added
VAT 8% except items ·12½% or specified. Cash with order
Add 30p P&P UK. £1 00 EEC Countries: no other export orders acceptable
Callers by arrangement only

WW — 060 FOR FURTHER DETAILS

BI-PAK

High quality modules for stereo, mono and other audio equipment.

PUSH-BUTTON STEREO FM TUNER

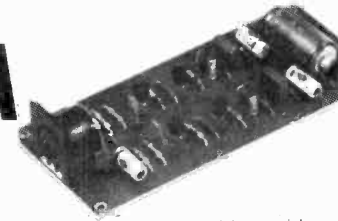
OUR PRICE ONLY **£19.95** **Fitted with Phase Lock-loop Decoder**

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 **T461**.
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. **£2.65**

VAT ADD 12½%

POSTAGE & PACKING
Postage & Packing add 25p unless otherwise shown. Add extra for airmail. Min. £1.00

STEREO PRE-AMPLIFIER PA100

OUR PRICE **£13.50**

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.

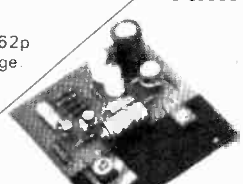
Frequency Response + 1dB 20Hz - 20KHz Sensitivity of inputs
1. Tape Input 100mV into 100K ohms
2. Radio Tuner 100mV into 100K ohms
3. Magnetic P.U. 3mV into 50K ohms

P.U. Input equalises to RIAA 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 £27.55.** plus 62p 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 £9.20** plus 62p postage.

AL10-20-30 AUDIO AMPLIFIER MODULES



The AL10, 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 3 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**

AL10 3w R.M.S. **£2.30** **AL20** 5w R.M.S. **£2.65** **AL30** 10w R.M.S. **£2.95**

STEREO 30

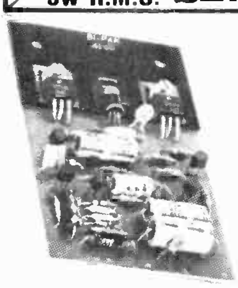
COMPLETE AUDIO CHASSIS
7+7 WATTS R.M.S.

P & P 45p **£15.75**

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 £3.65 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. **£3.95**

NEW PA12

NEW PA12 Stereo Pre-Amplifier completely redesigned for use with AL10/20/30 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.

£6.50

PS12

Power supply for **AL10/20/30, 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 £1.20**

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 **£3.00**

BI-PAK

P.O. BOX 6, WARE, HERTS.

SPECIAL PRICES THIS MONTH

LIST FREE SEND SAE

DRILL CONTROLLER
Electronically changes speed from approximately 10 revs. to maximum Full power at all speeds by finger-tip control Kit includes all parts, case, everything and full instructions **£2.95** including post & VAT Made up model **£1.00** Extra

NUMICATOR TUBES
For digital instruments, counters, timers, clocks, etc Hi-vac XNII Price £1.25 each inc Post and VAT

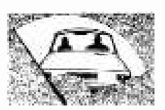
RADIO STETHOSCOPE
Easiest way to fault find, traces-signal from aerial to speaker, when signal stops you've found the fault Use it on Radio, TV, amplifier, anything. Complete kit comprises two special transistors and all parts including probe tube and crystal earpiece. **£2.95** twin stetho-set instead of earpiece inc VAT & Postage

MAINS TRANSISTOR PACK
Designed to operate transistor sets and amplifiers Adjustable output 6v., 9v., 12 volts for up to 500mA (class B working) Takes the place of any of the following batteries PP1, PP3, PP4, PP6, PP7, PP9 and others Kit comprises main transformer rectifier, smoothing and load resistor condensers and instructions. Real snip at only **£1.75** including Post & VAT

MOTORISED DISCO SWITCH
With six 10 amp changeover switches, adjustable over 360° switches are rated at 10 amp each so a total of 2000w's can be controlled and this would provide a magnificent display. The motors are 50v, but are of such a low wattage only 2 watts that they can be driven by a resistor or condenser voltage dropper.
PRICE **£2.25**
DITTO BUT 12 SWITCH **£3.65** POST & VAT PAID.

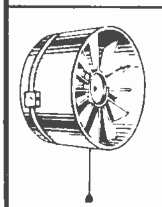
CAR TESTING OSCILLOSCOPE
Enables the electrical performance of the entire ignition circuit to be observed whilst the engine is running It takes into account working conditions including compression and temperature, both of which directly affect the sparking plug firing voltage. Intermittant and/for definate faults are clearly shown by changes in the image display Made by E E. these are self-contained with carrying handle in a crackle finish metal case
PRICE £12.50. Carriage £2 + 8p Complete with operating instructions less leads PLUS 15p POST & VAT

WINDSCREEN WIPER CONTROL



Vary speed of your wiper to suit conditions All parts and instructions to make **£3.25** plus post and VAT.

EXTRACTOR FAN

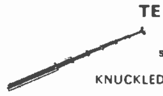


Cleans the air at the rate of 10,000 cubic feet per hour Suitable for kitchens, bathrooms, factories, changing rooms, etc It's so quiet it can hardly be heard Compact, 5½" casing comprises motor, fan blades sheet-steel casing, pull switch, mains connector and fixing brackets **£4.74** including post & VAT
Monthly list available free, send long stamped envelope.

28 R.P.M. GEARED MAINS MOTOR
This is a substantial motor (1" stack induction type) quite powerful, definately large enough to drive a totating display or a tumbler for polishing stones etc Approximate overall size 4" x 3¼" x 2½" these are ex-unused equipment, carrying our normal ex-equipment guarantees
PRICE **£2.95** POST & VAT PAID

GLAMORISE YOUR ROCKS
The way to make rock samples, stamps etc really show themselves off is to light them by means of our miniature UV tube This is only 6w's so the electricity costs are negligible Complete kit comprises UV tube and its 2 mounting holders, control choke and starter
Total price **£3.75** POST & VAT PAID

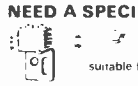
TELESCOPIC AERIALS



for portable, car radio or transmitter Chrome plated—six sections, extends from 7½ to 47in **50p** + 15p Post & VAT
KNUCKLED MODEL FOR F M **80p** + 17p Post & VAT

SPEED CONTROLLED 9 V MOTOR
This is a motor with a governor 9v operation intended for record players and tape recorders These are reversible and electro magnetically and acoustically screened Size approx 1½" diameter by 1" deep with good length spindle. Japanese made, portable replacement in a good many popular cassette and record players
PRICE 95p inc POST & VAT

NEED A SPECIAL SWITCH



Double Leaf Contact Very slight pressure closes both contacts **12p** each Plastic pushrod suitable for operating **10p** each 10 for **68p.**

LIGHT OPERATED SWITCH FOR 12-24V BATTERY OPERATION
This is completely encapsulated and so make weather-proof against all the elements It can, therefore, be put to many useful applications To name a few 1) Automatic switch on for battery mast head light on a boat 2) Automatic switch on for battery operated lights or alarms in remote places 3) Auto parking light for a vehicle, no doubt other applications would be found by our readers and we would be glad to hear about them
Encapsulate unit measures approx 1 6" x 9" x 1 5" deep This can be conveniently mounted through the front panel of a conduit box or similar.
PRICE **£1.95** POST & VAT PAID

MULLARD UNILEX

A mains operated 4 + 4 stereo system Rated one of the finest performers in the stereo field this would make a wonderful gift for almost any one In easy-to-assemble modular form and complete with a pair of Godmans speakers this should sell at about £30 — but due to a special bulk buy and as an incentive for you to buy this month we offer the system complete at only **£14.00** including VAT and postage

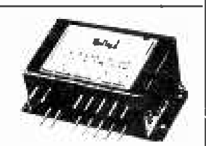
GPO PUSH-BUTTON DIALLING UNIT

Will take the place of the normal rotating dial, has 10 numbered keys, so suitable for other digital systems. A desk mounting unit with rubber feet, this is a very intricate and expensive piece of apparatus New and unused — our price only £9 each including post and VAT

TWIN OUTPUT POWER PACKS

These have two separately R.C smoothed outputs so can operate two battery radios on a stereo amp without cross mudulation (they will of course operate one radio/tape/cassette/calculator, in fact any battery appliance and will save their cost in a few months). Specs. Full wave rectification, double insulated mains transformer — total enclosed in a hard P V C case — three core mains lead-terminal output — when ordering please state output voltage 4½v, 6v, 7½v, 9v, 12v or 24v Price **£3.95.** Post and VAT included

MULLARD THYRISTOR TRIGGER MODULE

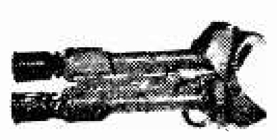


This produces pulses for phase control triggering, it has two isolated outputs, so one thyristor or two thyristor (in separate arms of bridge) may be controlled by one module The timing circuit is synchronised to the mains frequency and control is by an external variable resistor or from a voltage or current source. Provision is made for feed-back where automatic control is required Price **£5.95.**

THIS MONTH'S SNIP

250 watt Transformer is a very versatile transformer which can be used for many purposes Rated at 250 watts it is very well built with frames for upright mounting and is varnish impregnated Its primary is for 230/240 volts 50 cycles, it has four secondaries each 10v very high current windings Just a few of the circuits it can power are 10-0-10v at up to 12 amps, 20-0-20v at up to 6 amps, single 10v at 25 amps, single 20v at 12½ amps, single 30v at 9 amps; single 40v at 6 5 amps The transformer can be used for power circuits (charging, etc) or for amplifiers, there being an earth screen between primary and secondaries. A transformer like this today would cost at least £15 from the makers however, we are making a special offer at **£3.50** + 28p, post £1 + 8p each Grab some while you can, our stock may not last long

INFRA RED BINOCULARS

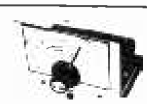


Made for military purposes during and immediately after the last war to enable snipers, vehicle drivers, etc to see in the dark The binoculars have to be fed from a high voltage source (5KV approx) and providing the objects are in the rays of an infra red beam then the binoculars will enable these objects to be seen Each binocular eye tube contains a complete optical lens system as well as the infra red cell, technical data on which is available The binoculars are unused believed to be in good order In fact they were never issued and are still in original cases, but since they were made a long time ago they can hardly be called new Sold without guarantee Price **£16.50** per set.

SMITHS CENTRAL HEATING CONTROLLER
Push-button gives 10 variations as follows (1) continuous hot water and continuous central heating (2) continuous hot water but central off at night (3) continuous hot water but central heating on for 2 periods during the day (4) hot water and central bot on but day time only (5) hot water all day but central heating only for 2 periods during the day (6) hot water and central heating on for 2 periods during the day time only — then for summer time use with central heating off (7) hot water continuous (8) hot water day time only (9) hot water twice daily (10) everything off

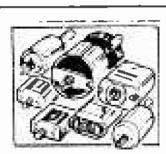
A handsome looking unit with 24-hour movement and the switches and other parts necessary to select the desired programme of heating Supplied complete with wiring diagram Originally sold we believe at over £15 — we offer these, while stocks last at **£6.95** each including VAT & Postage

SHORTWAVE CRYSTAL SET



Although this uses no battery it gives really amazing results You will receive an amazing assortment of stations over the 19, 25, 31 29 metre bands — Kit contains chassis front panel and all the parts. **£1.50** — crystal earphones **55p** including VAT & Postage

ONLY £1.50 FOR SEVEN ELECTRIC MOTORS



7 powerful batt motors as used in racing cars and power models Output and types vary for use in hundreds of projects — Tools, toys, models, etc All brand new reversible and for 1½-12v batts Wiring diag inc VAT & POST PAID

LIGHT PIPE
A mains operated travelling light array 24ft long is uses 130 miniature bulbs which flash in sequence to make bands of light move along the tube — The tube can be draped around a particular item or set and cannot fail to attract attention — complete kit consists of — 24ft of translucent tubing — 140 min lamps — 8 yds multicore cable — motorised switch — taps for quick connections and full wiring instructions
£15.00 FOR COMPLETE KIT POST & VAT PAID

INSTANT START FLUORESCENT LIGHTING BARGAINS
Starterless control gear, complete with tube ends and tube clips for window lighting, signs fascias etc 4ft 40w **£1.90;** 5ft 65w **£2.00;** 5ft 80w **£2.20;** 6ft 80w **£2.45;** and for pairs as follows —twin 2ft 20w **£2.55;** twin 3ft 30w **£3.55;** twin 4ft 40ft **£3.25;** twin 5ft 65w **£3.25;** twin 5ft 80w **£3.95;** twin 8ft 125w, **£5.75.** These are about one half of maker's current prices and can't be repeated once stocks are cleared Please add 30p per peice to cover postage or carriage and 8% VAT

SWITCH TRIGGER MATS

So thin is undetectable under carpet but will switch on with slight pressure. For burglar alarms, shop doors, etc
24in x 18in **£1.90,** post & VAT 30p 13in x 10in **£1.50,** post & VAT 25p

MAINS TRANSFORMERS
All standard 230-250 volt primaries

		£ P
1v	1 amp (special)	**1.78**
2 4v	5 amp	**.85**
6 3v	2 amp	**1.25**
6 3v	3 amp	**1.75**
9v	1 amp	**.95**
9v	3 5 amp	**2.50**
12v	1½ amp	**1.50**
12v	1 amp	**1.00**
6 5v-0 6 5v	1 amp	**1.50**
18v	1 amp	**1.50**
24v	2 amp	**2.25**
24v	3 amp	**3.80**
12 0-12v	50mA	**1.20**
6 0-6v	50mA	**1.20**
8 0-8v	½ amp	**1.50**
250 0-25v	2 amps	**3.50**
25v	1½ amps	**1.95**
50v 2 amp & 6 3v	1 amp	**4.50**
60v 5 amp & 5v	1 amp	**7.50**
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Six speeds are available 500, 850 and 1,100 r p m and 8 000, 12,000 and 15,500 r p m Shaft is ¼in diamtere and approximately 1in long 230/240v Its speed may be further controlled with the use of our Thyristor controller Very powerful and useful motor, size approx 2in dia x 5in long Price **£1.50** including post & VAT
SPEED CONTROL SWITCH **50p** + 4

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SOUND TO LIGHT UNIT

Another new kit this month is single Channel Sound to Light Unit, complete kit including plastic container, main components include 5 amp thyristor, plus transformer, variable pot with on/off switch and theoretical circuit diagram
PRICE £5 95 POST & VAT PAID

SMITHS 24-HR. TIMER HEART
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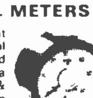
Containing a 15 amp change over switch operated by a diaphragm which in turn is operated by air pressure through a small metal tube The operating pressure is adjustable but is set to operate in approx 10in of water These are quite low pressure devices and can in fact be operated simply by blowing into the inlet tube Original use was for washing machine to turn off water when tube had reached correct level but no doubt has many other applications **£1.95** including post & VAT

DC HIGH CURRENT PANEL METERS



3½" wound wide angle 240° movement meters flush mounting fitted with external shunts made by Crompton Parkinson, brand new, still in maker's cartons These are a real bargain at £5 50 each including post & VAT Reasonable quantities available in the following ranges 0-10 amps, 0-20 amps, 0-30 amps, 0-40 amps 0-50 amps

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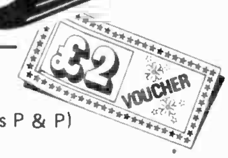

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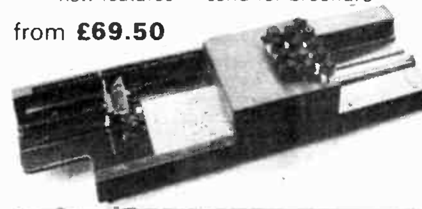

Keyboards

16-Key Japanese Keyboard. BRAND NEW SURPLUS! Magnetically operated reed relay switches mounted on PCB 9 white keys 4 black, 2 yellow, 1 red. Dimensions 3½" × 3" × ½" Price £3 50 (P&P 30p).

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7410	13p	74104	45p
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7412	23p	74110	40p
7413	32p	74118	84p
7414	60p	74121	30p
7416	33p	74122	46p
7417	30p	74123	68p
7420	14p	74126	70p
7421	40p	74132	70p
7422	18p	74136	75p
7423	34p	74141	65p
7425	30p	74145	70p
7427	37p	74148	160p
7428	36p	74150	125p
7430	14p	74151	72p
7432	25p	74153	85p
7437	25p	74154	150p
7438	27p	74155	76p
7440	14p	74156	76p
7441	65p	74160	99p
7442	60p	74161	99p
7443	140p	74162	99p
7444	140p	74163	99p
7445	90p	74164	120p
7446	90p	74166	126p
7447	75p	74174	120p
7448	70p	74175	85p
7450	15p	74176	120p
7451	16p	74177	100p
7453	16p	74180	100p
7454	16p	74181	298p
7460	15p	74182	82p
7470	27p	74185	135p
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CD4020AE	250p
CD4022AE	170p
CD4023AE	19p
CD4024AE	120p
CD4025AE	19p
CD4026AE	196p
CD4027AE	75p
CD4028AE	140p
CD4029AE	175p
CD4030AE	55p
CD4042AE	137p
CD4043AE	202p
CD4046AE	140p
CD4047AE	154p
CD4049AE	63p
CD4050AE	52p
CD4054AE	196p
CD4055AE	196p
CD4056AE	135p
CD4060AE	229p
CD4069AE	37p
CD4071AE	27p
CD4072AE	27p
CD4081AE	19p
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3130	COSMOS/Bi-Polar MosFet	8 pin DIL	100p
3900	Quad. Op. Amp.	14 pin DIL	70p
536T	FET Op. Amp	TO-99	275p
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ICA3046	5 Transistor Array	14 pin DIL	60p
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*CA3090AQ	FM Stereo Multi. Dec.	16 pin DIL	400p
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*LM381	Stereo Preamp	14 pin DIL	160p
*M252	Rhythm Generator	16 pin DIL	800p
*MC1310P	FM Stereo Dec.	14 pin DIL	175p
*MC1351P	Lim/Det. Aud. Preamp	14 pin DIL	97p
MC1495	Multiplier	14 pin DIL	300p
*MC1496L	Bal. Mod/Demod	14 pin DIL	100p
*MFC4000B	1/4W Audio Amp	PCB	70p
MFC6040	Electronic Attenuator	PCB	140p
*NE540L	Audio Pwr driver	TO99	140p
NE555	Timer	8 pin DIL	40p
NE556	Dual 555	14 pin DIL	100p
NE561	PLL with AM Demod	16 pin DIL	325p
NE562	PLL with VCO	16 pin DIL	325p
NE565	PLL	14 pin DIL	200p
NE566	PLL Fun. Gen.	8 pin DIL	150p
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
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*SN76013N	Pwr Aud Amp with int HS		140p
*SN76023N	Pwr Aud Amp with int HS		140p
*SN76033N	Pwr Aud Amp with int HS		245p
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*TBA820	2W Audio Amp	QIL	80p
*TDA2020	20W Audio Amp	QIL	325p
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7A100V	TO5+HS	84p	*2N5060		
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AC127	14p	*MJE340	45p	*2N3704	12p
AC128	12p	MJ2955	100p	*2N3705	12p
AC141	18p	MJE2955	99p	*2N3706	12p
AC142	18p	MJE3055	65p	*2N3707	12p
AC176	11p	*MPS6534	22p	*2N3708	12p
AC187	15p	*MPSA06	30p	*2N3709	12p
AC187K	25p	*MPSA12	50p	2N3773	340p
AC188	14p	*MPSA56	32p	2N3866	90p
AC188K	25p	*MPSU06	62p	*2N3903	18p
AD149	49p	*MPSU56	78p	*2N3904	16p
AD161	36p	OC28	70p	*2N3905	18p
AD162	36p	OC35	70p	*2N3906	16p
AF114	18p	OC36	70p	*2N4058	15p
AF115	18p	*OC71	20p	*2N4059	10p
AF116	18p	*TIP29A	40p	*2N4060	13p
AF117	18p	*TIP29C	55p	*2N4123	22p
AF139	43p	TIP30A	48p	*2N4124	22p
AF239	48p	*TIP30C	60p	*2N4125	22p
BC107	9p	TIP31A	52p	*2N4126	22p
BC108	9p	TIP31C	52p	*2N4289	20p
BC109	10p	TIP32A	58p	2N4347	130p
BC109C	12p	TIP32C	82p	2N4348	160p
*BC117	22p	TIP33A	90p	*2N4401	27p
*BC147	7p	TIP33C	115p	*2N4403	27p
*BC148	7p	TIP34A	115p	*2N5089	27p
*BC149C	8p	TIP34C	160p	2N5296	60p
*BC157	11p	TIP35A	225p	*2N5401	50p
*BC158	10p	TIP35C	290p	2N6107	70p
*BC159	11p	TIP36A	270p	2N6247	190p
*BC169C	12p	TIP36C	340p	(Comp to 2N3055)	
BC177	18p	TIP41A	65p	40360	40p
BC178	17p	TIP41B	70p	40361	43p
BC179	18p	TIP41C	70p	40362	45p
*BC182	10p	TIP42A	70p	40364	120p
*BC183	10p	TIP42B	76p	40409	65p
*BC184	11p	TIP42C	82p	40410	65p
BC187	30p	TIP2955	70p	40411	225p
*BC212	11p	*TI593	30p	40594	81p
*BC213	10p	ZTX108	10p	40595	92p
*BC214	14p	*ZTX300	13p		
BC478	30p	*ZTX500	15p		
BCY70	18p	*ZTX502	18p		
BCY71	22p	2N457A	190p		
BD124	90p	2N697	18p		
BD131	36p	2N698	30p		
BD132	40p	2N706	18p		
*BD135	43p	2N708	18p		
*BD136	43p	2N918	40p		
*BD139	63p	2N930	18p		
*BD140	70p	2N1131	18p		
BF115	22p	2N1132	18p		
BF167	23p	2N1304	36p		
BF170	23p	2N1305	36p		
BF173	25p	2N1306	40p		
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BF178	28p	2N1308	40p		
BF179	33p	2N1309	40p		
BF180	33p	2N1613	25p		
BF184	22p	2N1711	25p		
*BF194	10p	2N1893	30p		
*BF195	9p	2N2219	20p		
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*BF197	15p	2N2369	14p		
BF200	32p	2N2484	30p		
BF257	32p	2N2904	22p		
BF258	36p	2N2905	22p		
*BFR39	30p	2N2906	24p		
*BFR40	30p	*2N2926R	7p		
*BFR79	30p	*2N2926B	7p		
*BFR80	30p	*2N2926O	8p		
*BFR88	30p	*2N2926Y	9p		
BFX30	30p	*2N2926G	9p		
BFX84	30p	2N3053	18p		
BFX85	30p	2N3054	50p		
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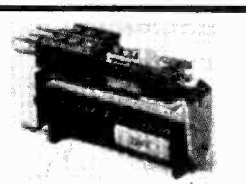

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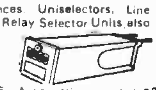

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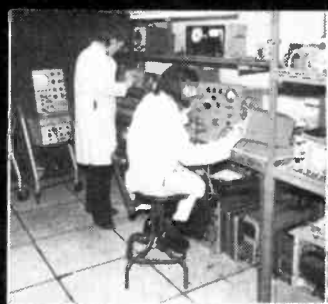

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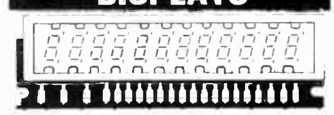

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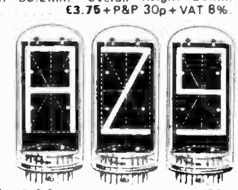

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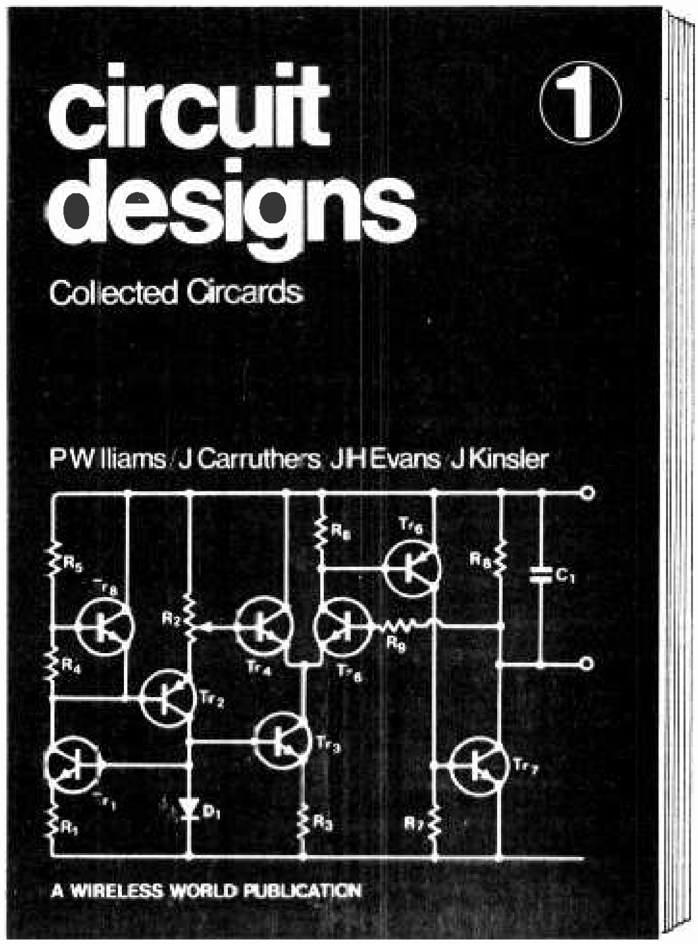

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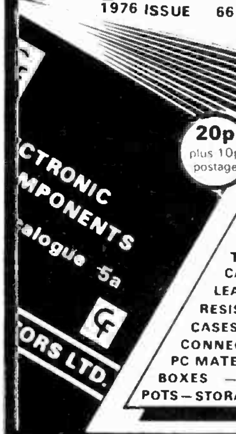

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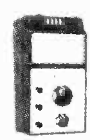
C280 Kit—PC Mounting polyester 250V 5 of each value 0.01. 0.022. 0.047. 0.1. 22μF. 2 of 0.47. 1μF **£1.98** net.
C296 Kit—Tubular polyester 400V 5 of each value 0.01. 0.022. 0.047. 0.1. 0.22μF. 2 of 0.47μF **£2.67** net.
Ceramic Kit—square plaque 50V 5 of each value 22. 33. 47. 100. 220. 330. 470. 1000μF. 2200. 4700μF, 0.01μF **£1.66** net.
250V Paper Kit—Tubular-metal case. 3 of each value 0.05. 0.1. 0.25. 0.5 1μF **£1.41** net.
500V Paper Kit—Tubular metal case. 3 of each value 0.025. 0.05. 0.1. 0.025. 0.5μF **£1.41** net.
1000V Paper Kit—Tubular metal case. 3 of each value 0.01. 0.025. 0.05. 0.1μF **£1.63** net.

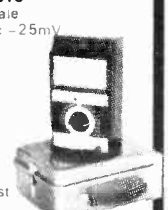
B.H. COMPONENT FACTORS LTD.

MULTIMETER U4341



27 Ranges plus Transistor Tester
16 700Ω/Volt
Vdc—0 3—900V in 8 ranges
Vac—1 5—750V in 6 ranges
Idc—0 06—600mA in 5 ranges
Iac—0 3—300mA in 4 ranges
Resistance—2KΩ—2MΩ in 4 ranges
Accuracy—dc—2½%
ac—4% of F S.D
hfe—10—350 in 2 ranges
Size—115 x 215 x 90mm
Complete with steel carrying case, test leads and battery PRICE **£12.10** net P&P 75p
U4341

MULTIMETER U4313

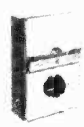


33 ranges Knife edge with mirror scale
20.000Ω/Volt High accuracy mVdc —25mV
Vdc—1 5—600V in 9 ranges
Vac—1 5—600V in 9 ranges
Idc—60—120 microamps in 2
Idc—0 6—1500mA in 6 ranges
Iac—0 6—1500mA in 6 ranges
Resistance—1KΩ—1MΩ in 4 ranges
db scale—10 to + 12db
Accuracy—dc—1½% ac—2½%
Size—115 x 215 x 90mm
Complete with steel carrying case, test leads and battery
PRICE **£16.09** net P&P 75p
U4313

MULTIMETER U4323

22 Ranges plus AF IF Oscillator
20 000Ω/Volt
Vdc—0 5—1000V in 7 ranges
Vac—2.5—1000V in 6 ranges
Idc—0.05—500mA in 5 ranges.
Resistance—5Ω—1M Ω in 4 ranges
Accuracy—5% of F.S.D.
OSCILLATOR—1 KHz and 465 KHz (A M) at approx 1 Volt Size—160 x 97 x 40mm
Supplied complete with carrying case, test leads and battery
PRICE **£9.95** net P&P 75p
U4323

MULTIMETER U4324

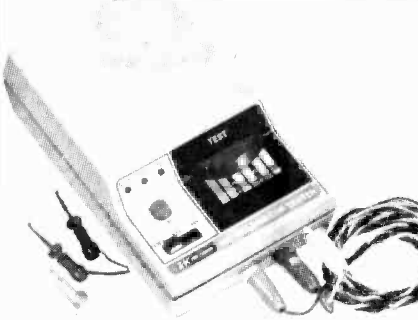


34 Ranges High sensitivity
20 000Ω Volt
Vdc—0 6—1200V in 9 ranges.
Vac—3—900V in 8 ranges
Idc—0 06—3A in 6 ranges.
Iac—0 3—3A in 5 ranges
Resistance—25Ω—5MΩ in 5 ranges
Accuracy—dc and R—2½% of F.S.D
ac and db 4% of F.S.D
Size—167 x 98 x 63mm
Supplied complete with storage case, test leads spare diode and battery
PRICE **£11.72** net P&P 75p
U4324

(WW), LEIGHTON ELECTRONICS CENTRE, 59 NORTH STREET, LEIGHTON BUZZARD, LU7 7EG.
Tel Leighton Buzzard 2316 (Std code 05253)

NEW!

B+K PRECISION Test Instruments



MODEL 510 Exclusive Dynapeak™ With Selectable Hi-Lo Drive For Accurate In-Circuit And Out-of-Circuit Transistor Testing.

- Fast GO/NO-GO in-circuit transistor testing
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- Reliable—fully overload protected
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- Completely portable-use it anywhere!

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- High intensity, high reliability 3½ digit LED display for maximum readability
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For complete specifications and prices write:
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270 Newtown Rd., Plainview, N.Y. 11803
Cable Address: EMPEXINC PLAINVIEW, N.Y. STATE
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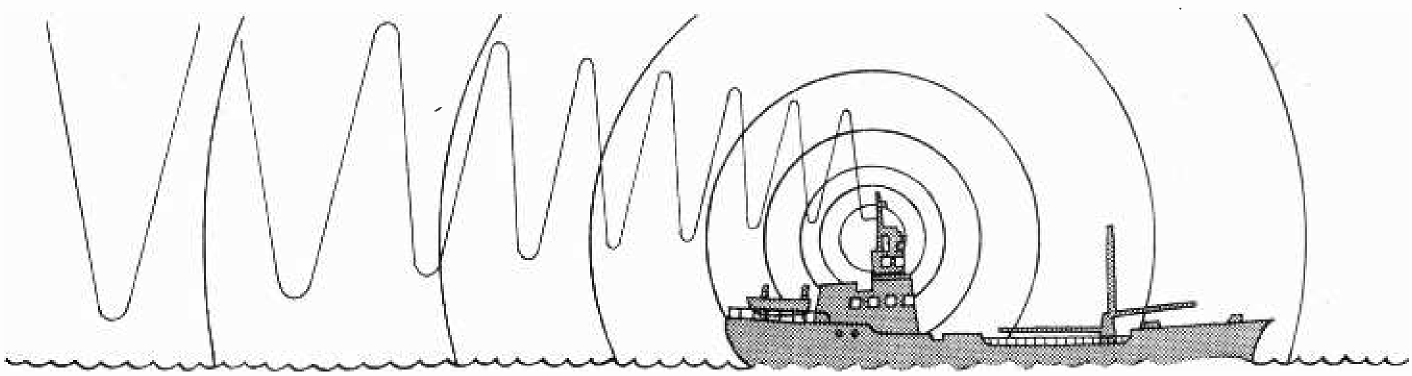
WW—063 FOR FURTHER DETAILS

Appointments

Advertisements accepted up to 12 noon Monday, June 28, for the August issue, subject to space being available.

DISPLAYED APPOINTMENTS VACANT: £6.50 per single col. centimetre (min. 3cm).
LINE advertisements (run on): £1 per line, minimum three lines.
BOX NUMBERS: 45p extra. (Replies should be addressed to the Box Number in the advertisement, c/o Wireless World, Dorset House, Stamford Street, London SE1 9LU.)
PHONE: Owen Bailey on 01-261 8508 or 01-261 8423.
Classified Advertisement Rates are currently zero rated for the purpose of V.A.T.



Radio Officers–now you can enjoy the comforts of home.

Working for the Post Office Maritime Services really makes sense. You still do the work that interests you, but with all the advantages of a shore-based job: more time to enjoy home life, job security and good money. To qualify, you need a United Kingdom Maritime Radiocommunication Operator's General Certificate or First Class Certificate of competence in Radiotelegraphy, or an equivalent certificate issued by a Commonwealth Administration or the Irish Republic.

Starting salaries, at 25 or over, are £2905 rising to £3704 after three years service. Between 19 and 24, the starting salary varies from £2234 to £2627 according to age. You'll also receive an allowance for shift duties which at the maximum of the scale averages £900 a year and there are opportunities to earn overtime. There's a good pension scheme, sick pay benefits and prospects of promotion to senior management.

Right now we have vacancies at some of our coastal radio stations, so if you're 19 or over, write to: ETE Maritime Radio Services Division (L687), ET 17.1.1.2., Room 643, Union House, St. Martins-le-Grand, London EC1A 1AR.

Post Office Telecommunications

93

IMPERIAL COLLEGE OF SCIENCE AND TECHNOLOGY

Department of Electrical Engineering

DEPARTMENTAL SUPERINTENDENT

Applications are invited from candidates with suitable experience for the post of Departmental Superintendent, Electical Engineering Department.

Duties will include supervising the operation of departmental technical services and departmental records/finance office. The superintendent will have regular contact with over 100 departmental academic and technical staff, and with a wide range of college administrative staff. Proven administrative, supervisory and technical ability is essential. Salary in the administrative grade II scale £5214-£6446 per annum plus £450 London allowance.

Further particulars may be obtained from the Head of Department, Electrical Engineering Department, Imperial College SW7 2BT, to whom applications should be sent by 30th June, 1976.

(5884)

audio development engineers

Grampian, a member of the Telephone Rentals group, manufacture a wide range of electronic and electro-acoustic audio and internal telephone equipment. We have vacancies for development engineers to work on all aspects of communications processing and audio distribution systems. We are seeking people with experience of analogue development work, preferably in the audio field, and possessing a high degree of motivation. In return for initiative we offer competitive salaries and generous Pension and Life Assurance schemes.

For application form or further details please contact Mr. G. N. Turner

Grampian

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The Hanworth Trading Estate
Feltham, Middlesex TW13 6EJ
01-894 9141

(5272)

UNIVERSITY OF LIVERPOOL

ELECTRONICS TECHNICIAN/ ENGINEER

Required for the Electronics Workshop of the Department of Electrical Engineering and Electronics. This post would be suitable for a person holding either HNC or C & G Final Certificate for telecommunications technicians, together with practical experience of the lay-out of printed circuit boards and the use of linear and digital integrated circuits. The successful applicant will assist in the development and production of a wide range of instruments used in the teaching and research laboratories.

Initial salary within a range up to £3207 per annum, according to qualifications and experience.

Application forms may be obtained from the Registrar, The University, P.O. Box 147, Liverpool L69 3BX. Quote ref. RV/791/WW.

(5593)

TEST AND LIAISON ENGINEERS

Ferranti in Edinburgh have a number of Ministry of Defence contracts involving the design and development of advanced avionic equipment for military aircraft in an international market.

We have vacancies for test and liaison engineers who will probably be qualified to HND level in electronic engineering with some years' experience in design, test or support of modern avionic equipment. A knowledge of digital and analogue techniques is essential.

Close liaison with design/development teams currently engaged on inertial navigation and display systems will be necessary and the work will entail factory acceptance testing, fault diagnosis and system commissioning on a variety of sophisticated equipment.

There will be opportunities for some of these engineers after a period of in-house training to be selected for technical liaison duties at locations in the U.K., Europe, Middle and Far East.

The Company offers an attractive employment package which includes 22 days holiday and membership of a life assurance and pension scheme. Incoming personnel will qualify for housing under the Scottish Special Housing Association scheme and realistic assistance will be given with relocation expenses where applicable.

Apply in writing giving details of age, experience and qualifications to:
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FERRY ROAD
EDINBURGH EH5 2XS

FERRANTI

Engineer Technicians

EMI have all kinds of future for you at Hayes

With several different EMI industries concentrated at Hayes, Middlesex, the Company offers you work on a wide variety of equipments – plus opportunities to win promotions in one direction or another without ever having to move out of the Hayes area.

And, since the entire EMI Group is constantly expanding – and, indeed, looks likely to continue to expand for years to come – these opportunities may be expected to come up frequently.

Recent practical electronics experience associated with maintenance, commissioning, fault finding, testing or calibration, either in industry or with HM forces is essential.

Ideally, it will have involved work on advanced and complex electronic devices.

Certainly you'll need a good technical background with knowledge equivalent to ONC.

Given these minimum conditions, Engineer Technicians of all levels are required – and you're starting salary will faithfully reflect the experience you have accumulated to date.

Terms and conditions of employment at EMI are everything you would expect of a major international organisation, and assistance towards relocation expenses will be considered where necessary.

To apply, please write to Bill Clark, Personnel Department EMI Limited, 135 Blyth Road, Hayes, Middlesex.
Or telephone him on 01-573 3888 extension 639 or Record-a-call anytime on 01-573 5524.

EMI

The international music, electronics and leisure Group. (5381)

Opportunities in the

ELECTRONICS FIELD

Persons with analogue or digital qualifications/exp. seeking higher paid posts in TEST, SERVICE, DESIGN, SALES, COMMUNICATIONS, phone Gary Bukay or Richard Swain 01-637 0781.

ATA SELECTION (5591)

UNIVERSITY OF STRATHCLYDE

ELECTRONICS TECHNICIAN

(Grade 5)

Applications are invited for the above post in the Department of Psychology. The post involves the use, maintenance and construction of a wide range of electronic equipment for teaching and research. This includes audio and video tape recorders, projectors and other display devices, tape readers and solid state logical circuiting, as well as the usual range of electronic test equipment.

The successful candidate will be expected to be able to take some responsibility for servicing and setting up equipment with minimal supervision, and should hold an O.N.C. or equivalent qualification and have 7-9 years' relevant experience.

Salary Scale £2751-£2307 per annum, with placing dependent on experience and qualifications.

Applications in writing, QUOTING REFERENCE P.33, giving details of age, experience and qualifications, should be made to The Personnel Officer, University of Strathclyde, Royal College Building, 204 George Street, Glasgow G1 1XW.

(5556)

ZAMBIA

A superb location

– particularly for broadening professional and management skills with a 3-year contract. This land-locked central African state, larger than France, Belgium, The Netherlands and Switzerland combined, has a congenial, equable climate and a wealth of fascinating scenery. Although mainly a broad plateau, Zambia also has spectacular mountains, dense forest, penetrating rivers and vast lakes as well as huge wildlife reserves. Large cities and towns containing all the usual modern facilities are linked by excellent road and rail services. Extensive natural resources, copper particularly, have provided the firm economic base for dramatic post-independence progress. Wide-ranging, expanding industries and substantial agriculture, which includes both crops and dairy farming, ensure the long-term continuation of Zambia's prosperity.

Chief Engineer

Qualifications:

A relevant degree or status as a Chartered Engineer. Wide practical experience of sound and television broadcasting systems and knowledge of modern transmitter design and installation.

Duties:

The planning of general broadcasting developments, overall supervision, planning and development of all technical and administrative matters in the Engineering Division. Guiding and training of Zambian Engineers.

Salary Scale:

K7200 x 204 – K7608 p.a. (£5414 – £5720)
Supplement £4128 (Married) £2724 (Single)

Maintenance Engineer

(Radio transmission, Short and Medium wave)

Qualifications:

Final City and Guilds Certificate in Telecommunications or equivalent plus at least 8 years' experience with a Broadcasting Organisation with particular experience in the installation and maintenance of transmitters.

Duties:

The installation of medium and short wave transmitters and antennas ranging in power from 10Kw to 500Kw. He will also be responsible for maintenance of transmitters and will be expected to train local staff.

Salary Scale:

K4416 – K5136 p.a. (£3397 – £3862). Entry point will depend on previous relevant experience.
Supplement £3060 – £3540 (Married) £1710 – £2136 (Single)

Maintenance Engineer

(TV Transmitters)

Qualifications:

As in above post.

Duties:

The operation and maintenance of TV transmitters operating in Band I and Band III. He should have wide experience to be able to train local staff.

Salary Scale:

K4416 – K5136 p.a. (£3397 – £3862). Entry point will depend on previous relevant experience.
Supplement £3060 – £3540 (Married) £1710 – £2136 (Single)

Strong financial attractions

– salaries plus TAX-FREE supplements, TAX-FREE terminal gratuities, low-cost accommodation, low taxation and free passages together add up to exceptional real earnings. Starting salaries relate to qualifications/experience (the maximum of each scale is shown), while gratuities total 25% of basic salary. Salary-related supplements are paid by the British Government to designated British nationals, (annual maximum is shown), while appointment grants, educational allowances, car loans, medical aid assistance and free holiday visits for children educated in Britain are also provided for those receiving supplements. N.B. Sterling equivalents given are approximations only, due to constant exchange rate fluctuations.

For further information please send full personal/professional details (without obligation), to: Recruiting Officer, Zambia High Commission, 7-11 Cavendish Place, London, W.1.

(5574)

Looking for a new job?

Perhaps we can help!

We have regular contact with hundreds of electronics and electrical companies needing qualified electronics engineers and technicians and TV service engineers.
We can, therefore, help you to find an interesting and well paid job. All you need to do is to return the coupon below or give us a ring. Our service is confidential and costs you nothing.

TJB Electrotechnical Personnel Services
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Tunbridge Wells (0892) 39388

TJB Electrotechnical Personnel Services is a division of Technical & Executive Personnel Ltd. and is solely concerned with job placement in the Electronics and Electrical Industries

Please note that this service is available only for engineers who are (or will be) available in the U.K. for interview.

Please send me an "Application for Registration" form
NAME ....
ADDRESS ....
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UNIVERSITY OF READING

Department of Linguistic Science

EXPERIMENTAL OFFICER

required to be responsible for the technical services provided by the Phonetics Laboratory. Equipment in use includes PDP8E computer and a wide range of peripherals for spectrum analysis at audio frequencies. Applicants should be able to design peripheral and suitable interfaces and be familiar with audio recording up to professional standard. Equipment for CCTV, high speed photography and electromyography will be acquired shortly. Maintenance of all equipment is carried out within the laboratory.

Salary within the range £2766-£5418 per annum according to qualifications and experience.

Apply with full particulars and names of two referees, quoting Ref. TWW23A, to Assistant Bursar (Personnel), University of Reading, Whiteknights, Reading, Berks. RG6 2AH.

(5594)

IMPERIAL WAR MUSEUM. Department of Sound Records. Applicants are invited for a post which involves a variety of both technical and library-type duties. The Department of Sound Records has a wide range of professional equipment and facilities and the post would suit a young person interested in working in the audio field. Full training will be provided by an experienced Audio Technician. Candidates must have a strong technical aptitude and be capable of careful and systematic work. The post is graded Library Assistant 2 and the starting salary is from £28.15 at age 16 to £45.21 at age 23 and over rising to £50.91. A Pay Supplement ranging from £4 pw at age 16 to £6 pw at age 18 and over is payable in addition. Leave is 3 weeks 3 days per year, rising to 4 weeks after 7 years' Service. There are prospects of permanent and pensionable employment. Please apply in writing to the Establishment Officer, Imperial War Museum Lambeth Road, London SE1 6HZ. (5576

OK TV

A Great opportunity for

TV Engineers

in South Africa £4800+

With the introduction of Television into South Africa, OK Bazaars are busy capturing the major share of the market. As the largest retail organisation in southern Africa we're building up a comprehensive and professional TV service operation and with our extensive involvement in this exciting new development, we are able to offer outstanding prospects to experienced personnel. Many British Technicians who started with us less than 12 months ago are already in management and senior technical positions and we now need to enlarge our already substantial staff by appointing additional Technicians in various centres throughout the Country.

Initially, the work will entail carrying out repairs in the field and in the workshops, keeping records of time and materials involved and feeding back information to management on recurrent faults and defects in apparatus.

Essential requirements are a recognised apprenticeship or training course on radio and TV servicing and at least three years' experience in colour TV. Applicants should also possess a City & Guilds Final Certificate in radio and TV with RTEB colour endorsement or an equivalent qualification.

Salary will be at least £4800 per annum with an extensive range of fringe benefits including Company assisted pension and medical aid schemes, full air passages, initial hotel accommodation and relocation allowances.

Interviews will be held in the UK, so write now with details of age, qualifications and experience to OK Bazaars, 20, Soho Square, London W1A 1DS, including a telephone number where you can be contacted.

Live and work in the sun

5541

OKOKOKOKOKOKOKOKOKOKOKOKOKOK

TEST ENGINEERS

S. LONDON

UP TO £2,800 p.a.

Dolby Laboratories is a young, go-ahead company with a world-wide reputation for their audio noise reduction system.

Test Engineers with a good understanding of basic circuits are required to test and troubleshoot professional audio P.C.B.s and equipment. This is interesting and well paid work. We give over four weeks' holiday per annum.

Write or phone: Mr. C. Keys
Dolby Laboratories Inc.
346 Clapham Road
London, SW9
Tel. 01-720 1111

(5588)

TEST/SERVICE ENGINEER

Able to work on own initiative with digital circuitry.

Please telephone or write:

MORFAX LIMITED

Willow Lane
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Surrey CR4 4TD
01-648 7040

(5599)

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FIELD SERVICE ENGINEERS (ELECTRONICS)

If you're not earning over **£3,500** p a plus a car — then you had better contact us!

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01-636 9659 (day) or
550 0836 (evening)

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ema

Opportunities in the

ELECTRONICS FIELD

We have selected from many vacancies those which offer exceptional career prospects and job interest. If you have experience in design, test, sales or service and wish to progress your career, please telephone Mike Gernat B Sc who is advising on these opportunities

E.M.A. Management Personnel Ltd.
Burne House, 88/89 High Holborn
London WC1V 6LR
01-242 7773

ENERGETIC YOUNG DOGSBODY

with some electronics training (or better, experience!) required as assistant in maintenance department in enterprising recording studio. An exacting position with good prospects for an intelligent and conscientious person. CONTACT ROB HAGGAS, 01-586 1271.

(5589)

THE OPEN UNIVERSITY

FACULTY OF TECHNOLOGY

Research Post in Telecommunications

The research topic is in the field of telecommunications and the vacancy is for a suitably qualified graduate based at Walton Hall. The successful applicant will be concerned with the development of a low-cost acoustic modem for use with remote teaching terminals that are presently under development at the Open University. It is envisaged that the project will involve considerable use of computing and microprocessor technology. The salary is on the scale £2766-£3990 per annum plus U.S.S. benefits.

Application forms and further particulars are obtainable, by postcard requests only please, stating sender's name and address, from the Personnel Manager (RT3), The Open University, P.O. Box 75, Walton Hall, Milton Keynes MK7 6AL. Telephone Milton Keynes 63868/9. Closing date Monday, 28th June, 1976.

ZAMBIA

A superb location

– particularly for broadening professional and management skills with a 3-year contract. This land-locked central African state, larger than France, Belgium, The Netherlands and Switzerland combined, has a congenial, equable climate and a wealth of fascinating scenery. Although mainly a broad plateau, Zambia also has spectacular mountains, dense forest, penetrating rivers and vast lakes as well as huge wildlife reserves. Large cities and towns containing all the usual modern facilities are linked by excellent road and rail services. Extensive natural resources, copper particularly, have provided the firm economic base for dramatic post-independence progress. Wide-ranging, expanding industries and substantial agriculture, which includes both crops and dairy farming, ensure the long-term continuation of Zambia's prosperity.

Radio Engineer - Aviation

Up to K4416 (c£2870)
Supplement £2898 (married), £1596 (single).

Requirements:

either 5-year apprenticeship, service trade certificate, ICAO certificate or equivalent; knowledge of medium-powered HF transmitters, frequency key shifting, SSB and equipment, medium-frequency non-directional radio beacons plus low and high-powered VHF AM equipment; and knowledge of either (a) VHF, omni-range, automatic VHF, direction finders, distance measuring equipment, (b) instrument landing systems, (c) radar X-band terminal and PPI talkdown equipment, (d) audio and remote control equipment, public address equipment, airport magnetic type equipment, inter-office communications, underground control cables, impulse and DC switching systems or (e) teleprinter telegraphy (torn tape) and associated page printers, tape recorders (auto heads), printing reperforators, semi-automatic message switching systems.

Responsibilities:

installation/maintenance/overhaul of ground terminal radio communication equipment and navigational aids.

Senior Radar Technician

Up to K5136 (c£3862).
Supplement £3156 (married), £1806 (single).

Requirements:

G & GC Level with specialisation in radar or Electronic Engineering Diploma.

Responsibilities:

Controlling a small team operating the Meteorological Department's electronic equipment; training, manual drafting, involvement in obtaining new equipment and establishing an instruments laboratory and workshop.

Strong financial attractions

– salaries plus TAX FREE supplements, TAX FREE terminal gratuities; low-cost accommodation, low taxation and free passages together add up to exceptional real earnings. Starting salaries relate to qualifications/experience (the maximum of each scale is shown), while gratuities total 25% of basic salary. Salary-related supplements are paid by the British Government to designated British nationals, (annual maximum is shown), while appointment grants, educational allowances, car loans, medical aid assistance and free holiday visits for children educated in Britain are also provided for those receiving supplements. N.B. Sterling equivalents given are approximations only, due to constant exchange rate fluctuations.

For further information please send full personal/professional details (without obligation), to: Recruiting Officer, Zambia High Commission, 7-11 Cavendish Place, London, W.1.

ONE ZAMBIA ONE NATION

5573

INTERNATIONAL FIELD SERVICE ENGINEER

Required for our International Mass Spectrometer Service Division based in the U.K. A sound knowledge of modern electronics is essential and a working knowledge of high vacuum systems would be an advantage, although training will be given. Applicants should possess City and Guilds or equivalent qualifications. Due to the extensive travel involved, the position is probably more suitable for a single person aged between 20 and 30 years.

The Company is internationally renowned for the quality of its products and offers excellent working conditions, including company car, pension scheme, superannuation and profit sharing bonus scheme.

Write or telephone for an application form.

Service Manager
G Division
LKB Instruments Limited
232 Addington Road
Selsdon, South Croydon, Surrey CR2 8YD

01-657 8822

(5587)

G.R. International Electronics Ltd
is seeking an

ELECTRONICS ENGINEER

Experienced in the design of consumer audio equipment with particular emphasis on current tape-recording and/or radio receiving techniques.

The position offered is membership of a small but busy design team. The successful applicant will be able to work with a minimum of supervision under the direction of the Chief Engineer. Qualifications are of secondary importance to the ability and willingness to get the job done. The company is situated in a very pleasant part of Central Scotland, with many and varied sporting and social facilities, including an active sports and social club on the company premises.

Removal expenses will be re-imbursed, and where applicable, assistance in re-housing will be given.

Please write in the first instance, giving details of age, experience, marital status, qualification and current salary, to

Mr. J. Bandeen
G.R. INTERNATIONAL ELECTRONICS LTD
Almondbank, Perthshire, Scotland, PH1 3NQ

(5555)

Broadcasting & Television Project Staff

As consulting engineers we are compiling a register of professionally qualified broadcasting and television engineers who would be willing to undertake assignments in the UK and overseas on contract terms for short periods of from 3 to 12 months in connection with preliminary planning, feasibility studies, systems designs, project management, supervision of installation and acceptance testing of broadcasting and television studio and transmitter projects.

Applicants should have experience of the planning and installation of such projects, preferably gained overseas. Experience limited to operations and maintenance will not be acceptable.

Interested applicants should send brief details of relevant technical qualifications and experience to

Crown Agents

Engineering Services Division, 4 Millbank, London SW1P 3JD
quoting reference Q1011/4/2/WF

LEICESTER POLYTECHNIC

School of Chemistry

ELECTRONICS TECHNICIAN

To be responsible for (a) the design, development and construction of prototype electronic equipment for chemical applications; (b) the maintenance of existing equipment.

Successful applicant must have a knowledge of analogue and digital electronics and will probably have at least two years' experience subsequent to taking a Full Technological Certificate, HND, or a degree in Electronics.

Salary: £2,922-£3,702 per annum, plus additions for certain qualifications.

Apply in writing, giving full details, to Staffing Officer, Leicester Polytechnic, P.O. Box 143, Leicester LE1 9BH. (5565)

Kingston Polytechnic CCTV Unit

ASSISTANT ENGINEER/PRODUCER

for the maintenance and operation of TV cameras and recording equipment. The ability is required to help staff and students in preparation and making of short TV programmes. HND electronics or applied physics or equivalent necessary plus keen interest in photographic presentation problems of TV work.

Salary grade AP3/4 £2922-£3702 + £261 London allowance.

Application form from Assistant Registrar, Kingston Polytechnic, Penrhyn Road, Kingston upon Thames KT1 2EE. 01-549 1366. (5580)

AGENTS REQUIRED to sell quality electric soldering instruments and ancillary equipment to Industry. Commission only basis. Suit persons selling allied products who require additional income. Good potential. Box No. WW 5600.

Electronics Development Engineers

Mechanical X-ray power sources for EMI–Scanner systems–

A challenge to your electronic ingenuity.

Pantak (EMI) of Windsor are world-leaders in production of X-ray equipment, and supply the sophisticated high voltage power source units for the internationally acclaimed EMI-Scanner.

Continuous development plans include refinement of the power sources to permit a degree of operational accuracy approaching nil tolerance. To achieve this, the Company's development engineering staff, housed in a new production block, is to be increased by several electronics engineers.

Although this is a highly specialised work it requires broadly based, *non*-specialist experience in electronics development and the ability to fulfil a wide variety of functions, such as production liaison and design and development of own test equipment. Engineers selected will be expected to work on their own initiative with very little supervision.

Senior Engineers should have HNC or degree-level qualification and a minimum of 5 years' *electronics* development experience. Junior Engineers require at least ONC and 2 years' *electronics* development experience.

Salaries will take full account of experience, ability and qualification. Successful candidates will enjoy EMI Group benefits – including future opportunities for advancement, not only with Pantak, but also with other companies in the Group. Relocation expenses will be paid where appropriate.

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Further details from Area Chief Technician Tel (0602) 46161, Ext. 641

Application form from Sector Administrator General Hospital, Park Row, Nottingham (5596)

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(5564)

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Apply in writing, giving full details, to Staffing Officer, Leicester Polytechnic, P.O. Box 143, Leicester, LE1 9BH. (5565)

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4025	15	14
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4040	90	84
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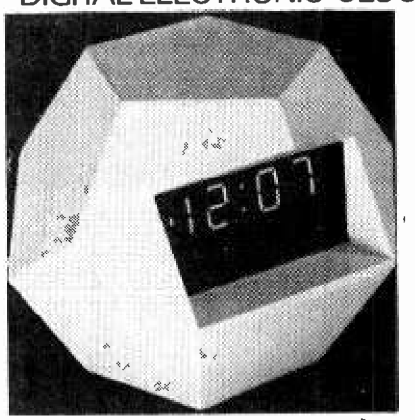

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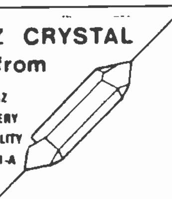

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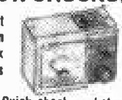

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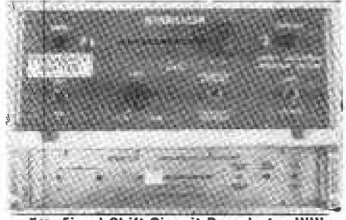

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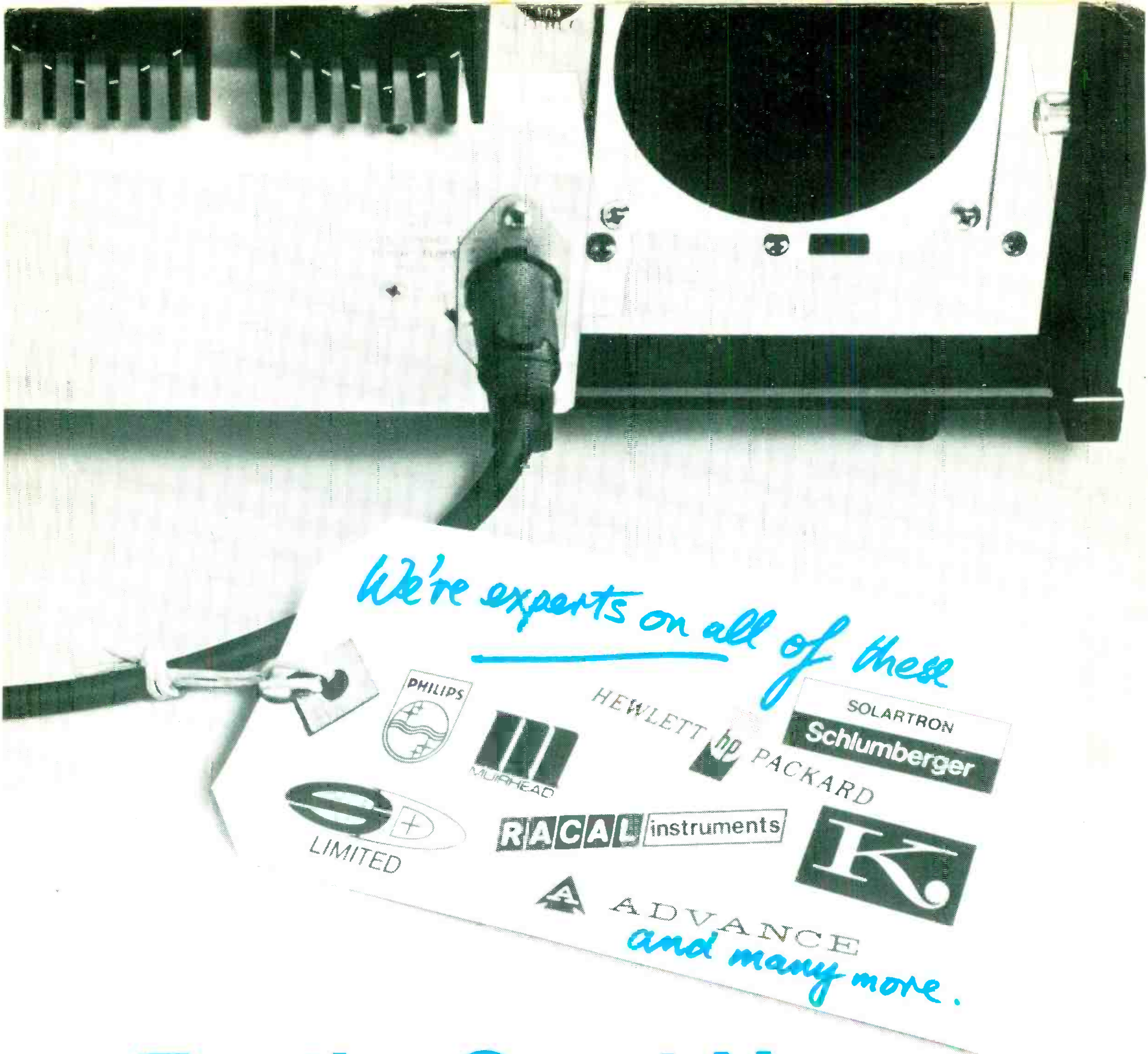

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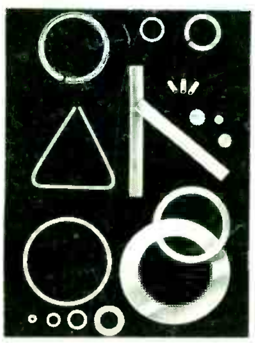

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