

# wireless world

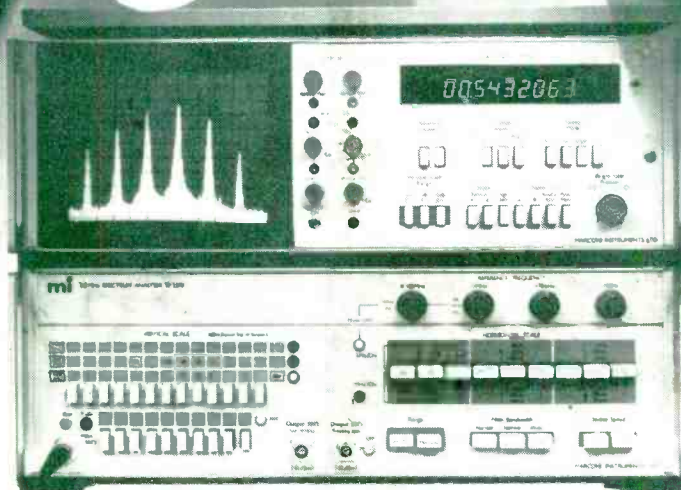
APRIL 1977 35p

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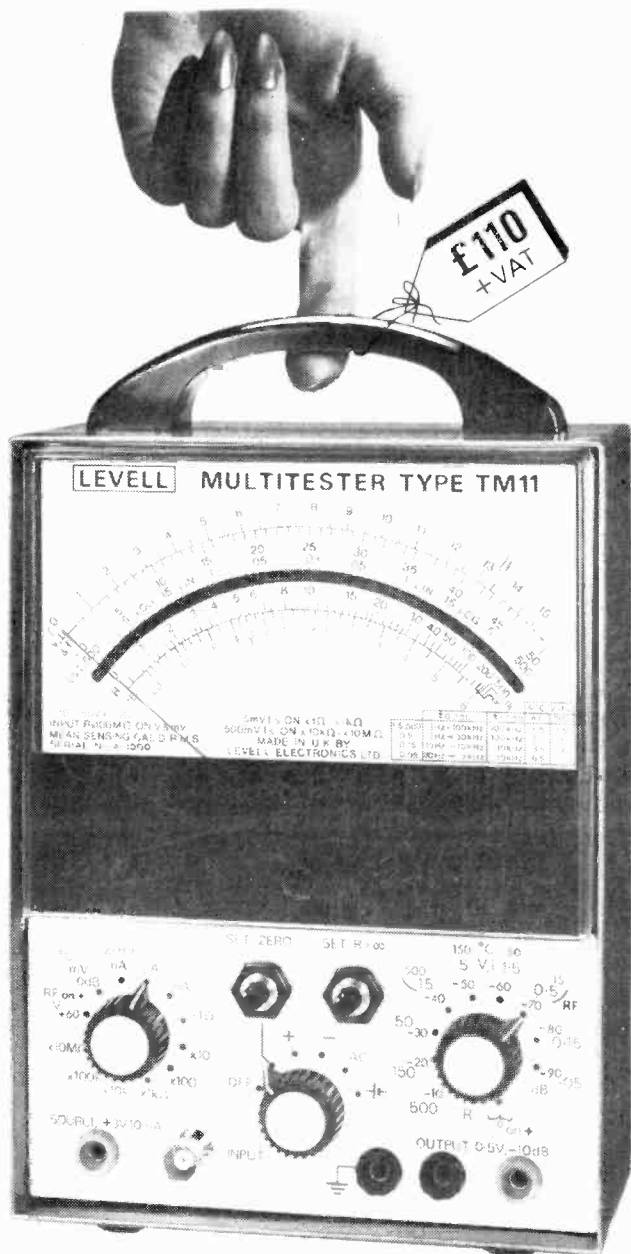
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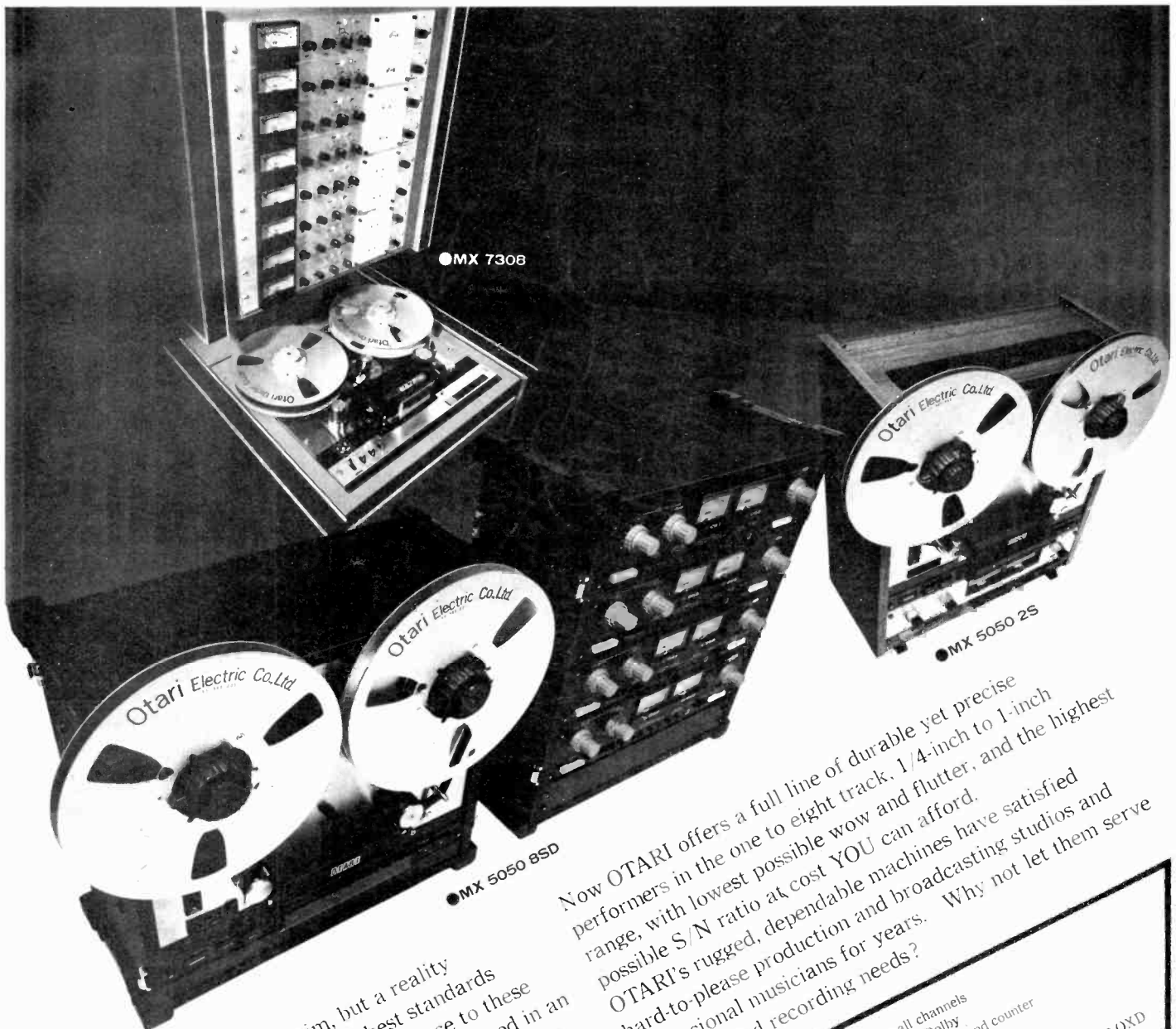
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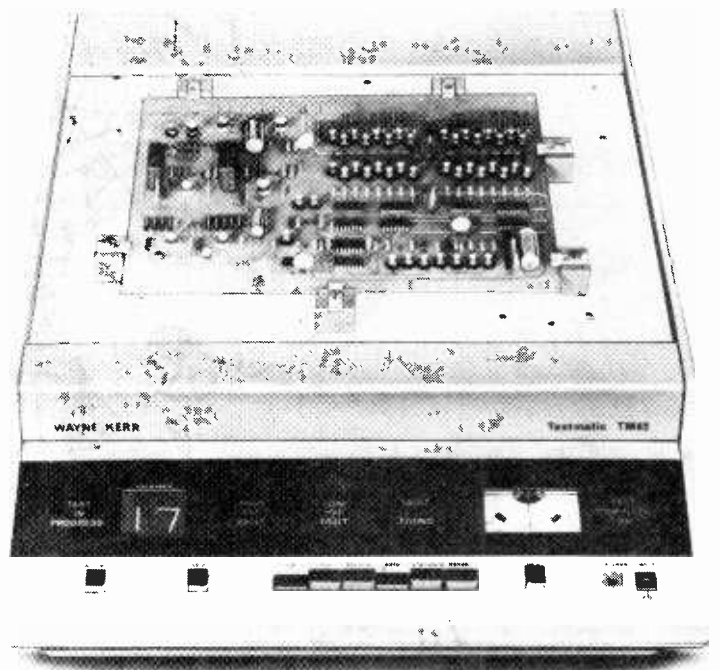
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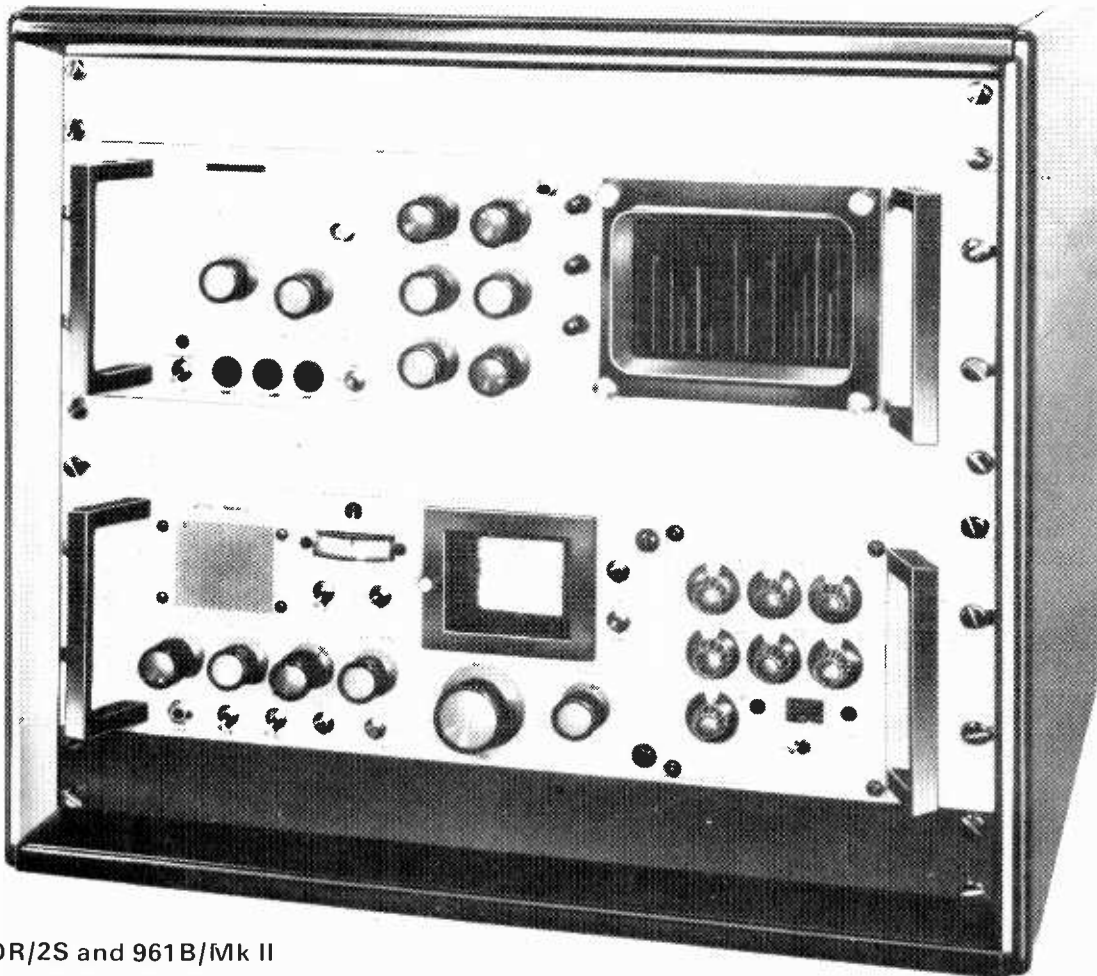
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WWA/77

# Eddystone VHF Monitoring System 1538

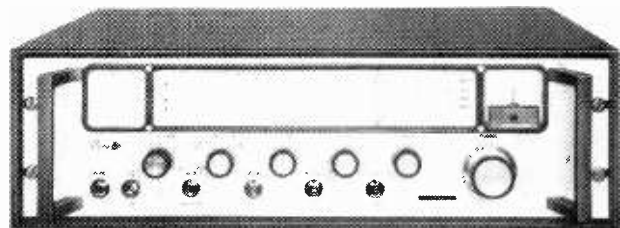


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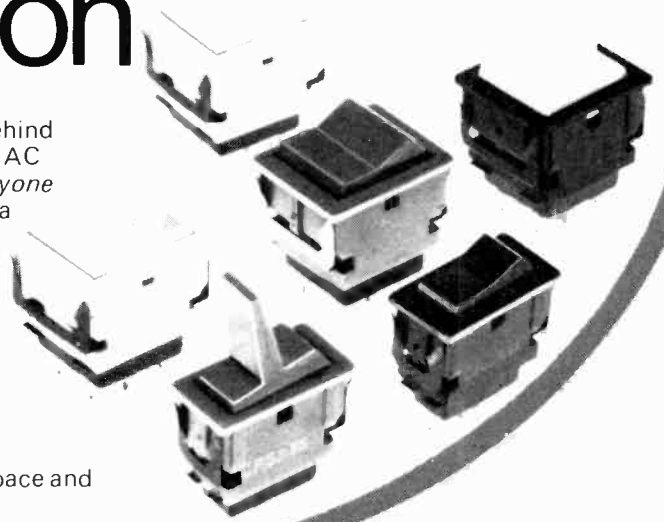
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- ★ UP TO 500 WATTS RMS FROM ONE CHANNEL
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Power Bandwidth	DC 20kHz @ 150 watts + 1db. 0db	Slewing Rate	8 volts per microsecond
Power at clip point (1 chan)	500 watts rms into 2.5 ohms	Load impedance	1 ohm to infinity
Phase Response	+0. -15 DC to 20kHz. 1 watt 8Ω	Input sensitivity	1.75 V for 150 watts into 8Ω
Harmonic Distortion	Below 0.05% DC to 20kHz	Input Impedance	10K ohms to 100K ohms
Intermod. Distortion	Below 0.05% 0.01 watt to 150 watts	Protection	Short mismatch & open cct. protection
Damping Factor	Greater than 200 DC to 1kHz at 8Ω	Power supply	120-256V 50-400Hz
Hum & Noise (20-20kHz)	At least 110db below 150 watts	Dimensions	19" Rackmount, 7" High, 9 3/4" Deep
Other models in the range: D60 — 60 watts per channel		D150A — 150 watts per channel	

Other models available from 100 watts to 3000 watts



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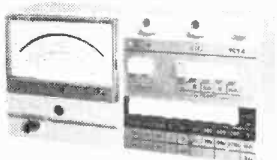
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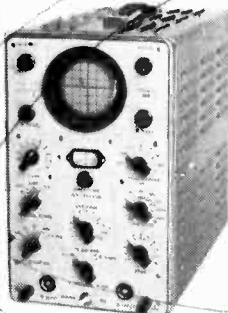
AC/DC current ranges: 60-120-600 μA-3-12-300mA-1-2-6A  
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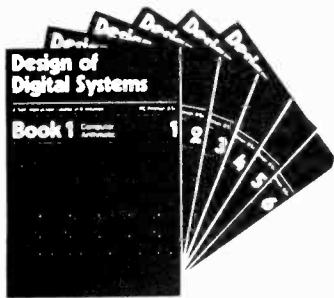


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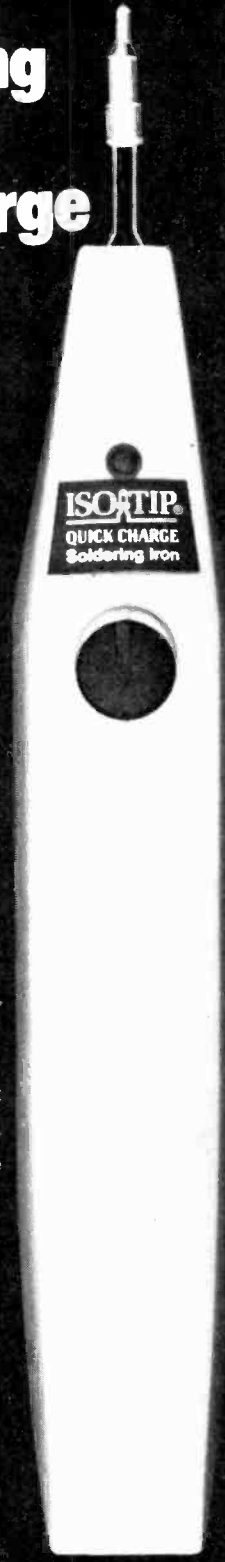
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ww4

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- No need for earthing
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This new rechargeable soldering iron from Greenwood brings added freedom to professional soldering. The Quick Charge recharges so fast that completely dead battery cells can be brought to full charge in about 4 hours — three times faster than before. In its stand the Quick Charge is, of course, being continually charged. A wide range of tips and now also a P.C. Drill attachment make this the most 'versatile' professional soldering iron available.



Illustration actual size.

## Greenwood Electronics

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

WW—025 FOR FURTHER DETAILS

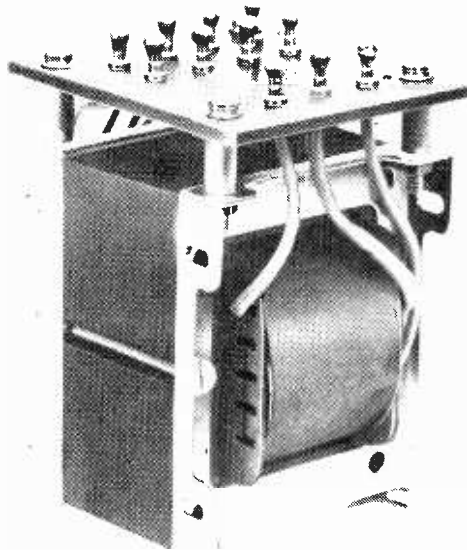
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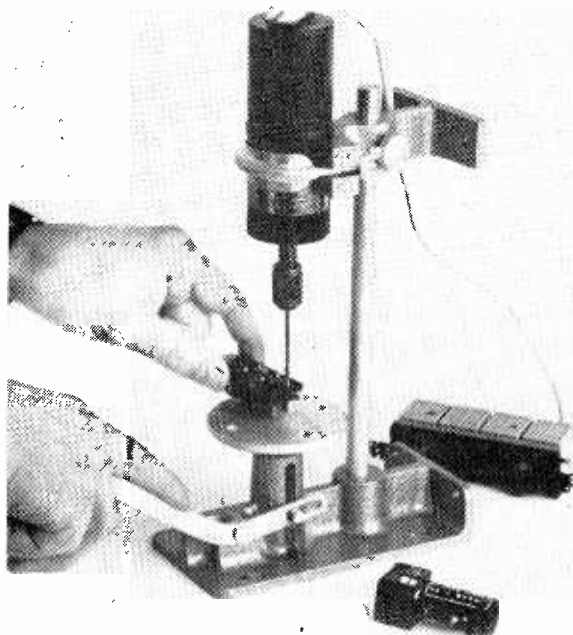
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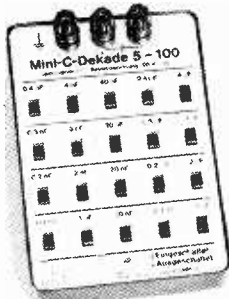
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Stockists Richards Electric, Worcester and Gloucester; Hoopers of Ledbury; Hobbs of Ledbury; D&D Models, Hereford; Bertella, Gloucester

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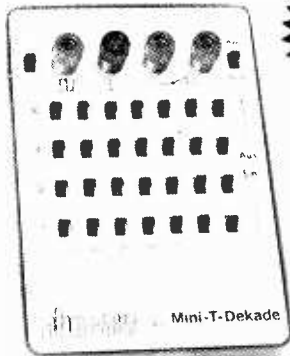
### ESP Mini-C-Dekade



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

**Price £69**  
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### ESP Mini-T-Dekade



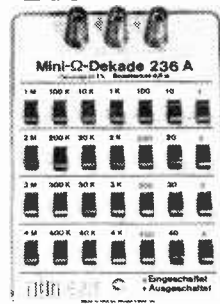
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The Mini-T-Dekade has unique features offering engineers a new fast, accurate means of designing and building electronic circuits  
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Size 10 x 15 x 3 cm  
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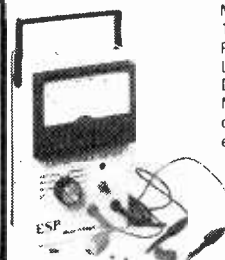
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AUTO RANGING**  
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200 mV  
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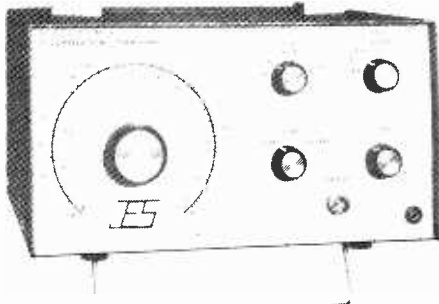


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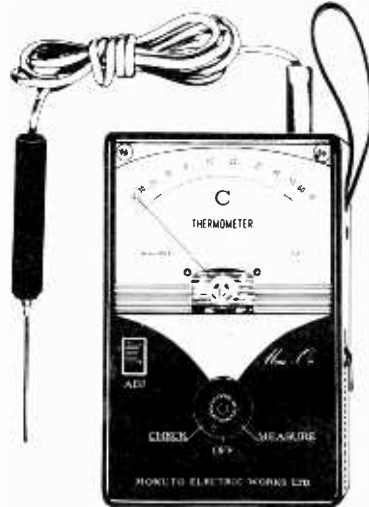
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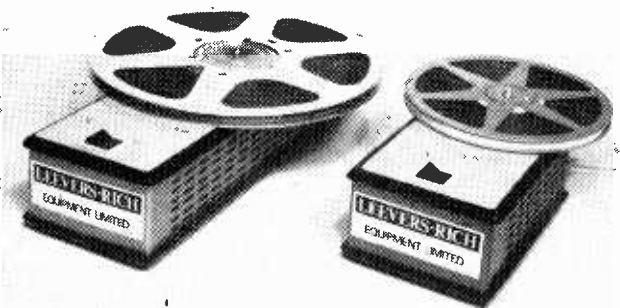
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WW-022 FOR FURTHER DETAILS

## BULK ERASURE PROBLEMS?



**LR71**  
**MAX REEL SIZE 11 1/2"**

**LR70**  
**MAX REEL SIZE 8 1/4"**

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The LR70/71 bulk erasers are currently used in Broadcast Companies, Recording Studios, Government Departments, Educational Establishments and the Computer Industry.

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WW-044 FOR FURTHER DETAILS





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8 channel, 2 group MXT-1000 - each channel fitted with compressor

The new MXT-1000  
A unique system enabling your own requirements to be built from standard equipment

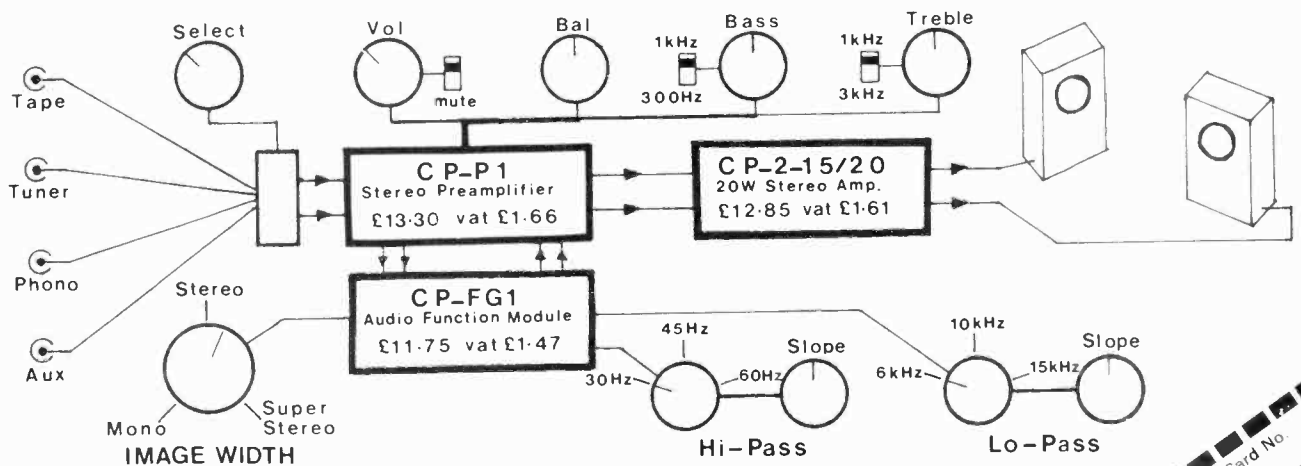
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WW—008 FOR FURTHER DETAILS

### BIMBOARD

Stop Ruining Your I.C.'s And Wasting Time Soldering  
 Plug Into The Revolutionary New

### BIMBOARD

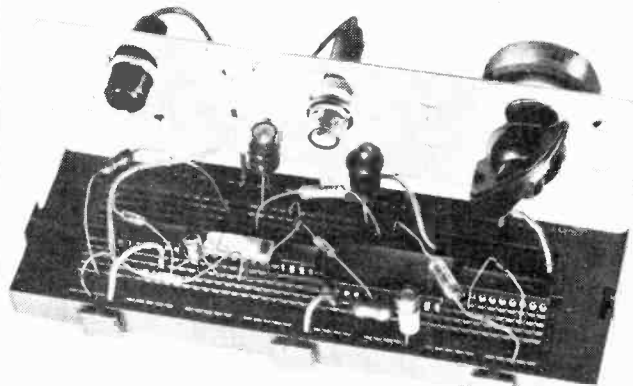
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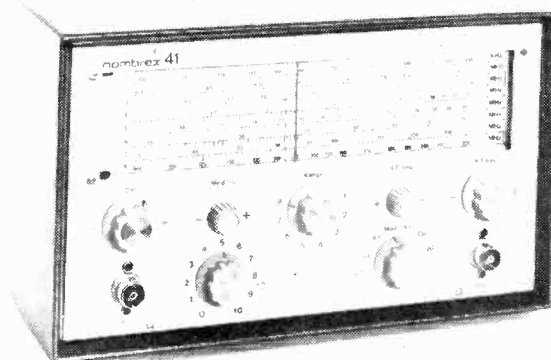


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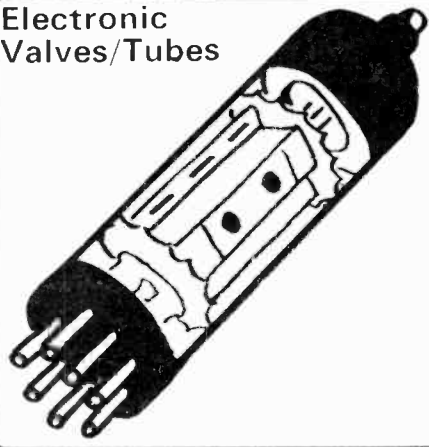
WW—019 FOR FURTHER DETAILS

# Edicron

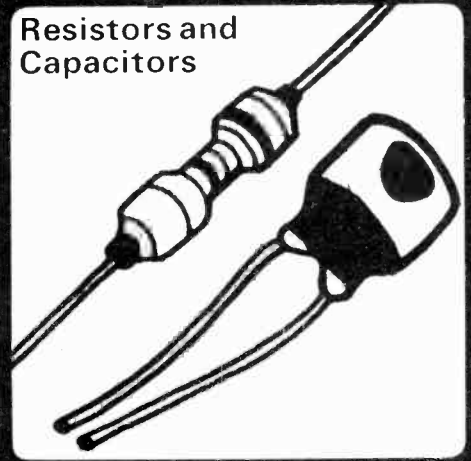
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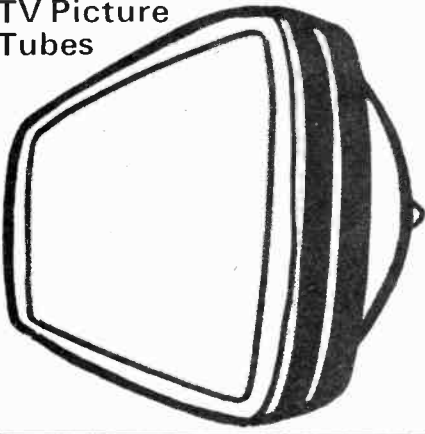
Electronic Valves/Tubes



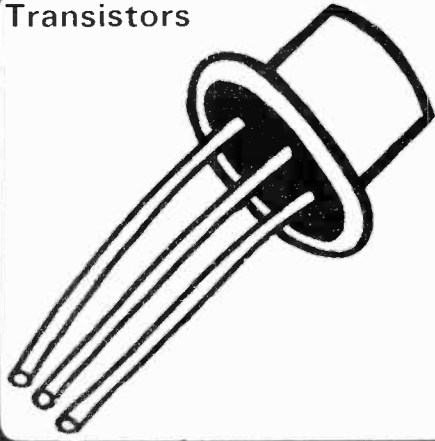
Resistors and Capacitors



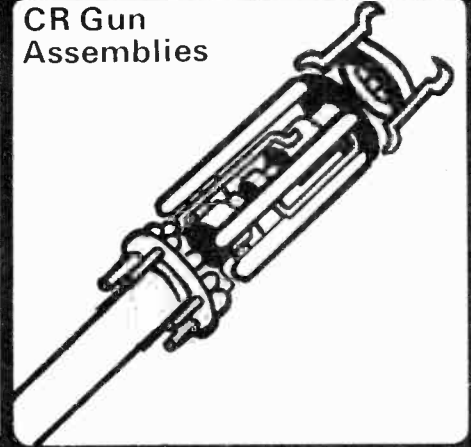
TV Picture Tubes



Transistors



CR Gun Assemblies

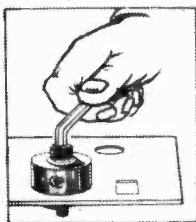


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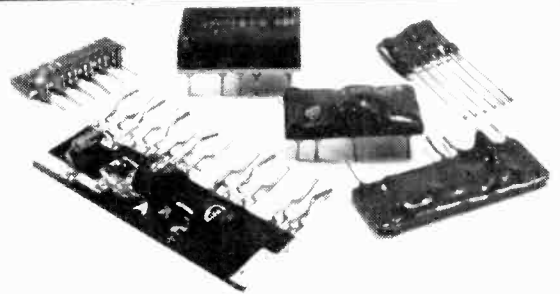
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metric  
and linear  
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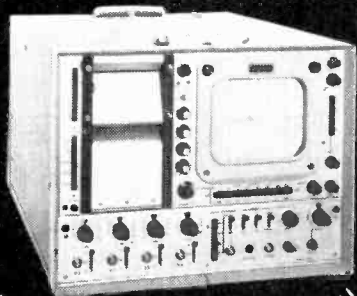
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Components

WW—045 FOR FURTHER DETAILS



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For further information on the new FOR-4-2 or instruments in the range, contact:

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Leaders in  
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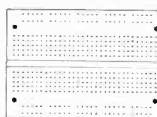
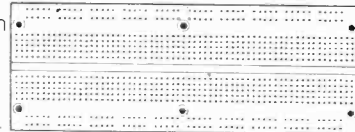
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NO SOLDERING! USE ICs AGAIN & AGAIN!**

**SK10.** Takes up to eight 14 pin DILs. All components insert directly. Insertion life of 10,000 cycles. Contact resistance 5 milliohm average. Housing is acetal copolymer. **£13.38**



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**LABEL THOSE ICs.**

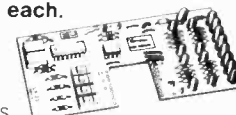
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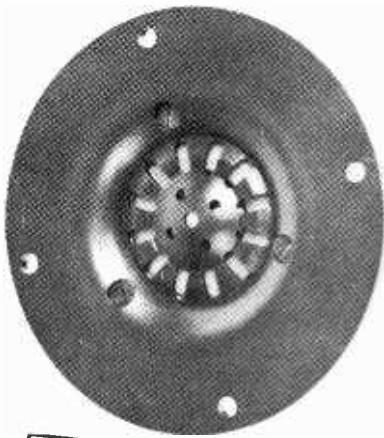
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Telephone: Kidderminster 2212/3

WW—009 FOR FURTHER DETAILS

# NEW 3000 TWEETER



### Technical Data

**Frequency response:**  
2 Kc s to 15 Kc s withn 3db

**Impedance:**  
15 ohms or 8 ohms

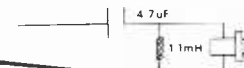
**Flux Density:**  
10 000 gauss

**Dimensions Front Mounting:**

Body 2 1/4" (70.2 mm) dia x 1 1/4" (31 mm) deep  
Flange 3 1/2" (95 mm) x (3 mm) thick  
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**Power Handling:**  
For use on 30 - 50 watt Amplifiers

**Suggested Crossover:**



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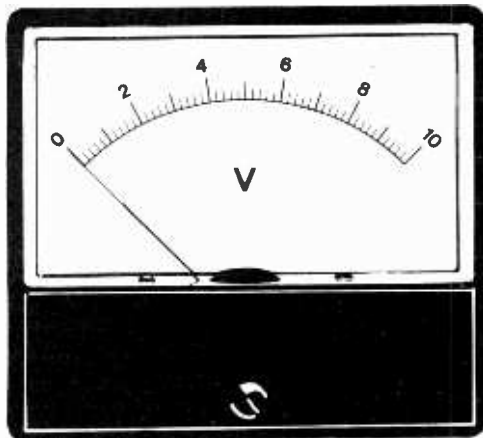


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## METER PROBLEMS?



137 Standard Ranges in a variety of sizes and stylings available for 10-14 days delivery. Other Ranges and special scales can be made to order.

Full Information from:

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WW-053 FOR FURTHER INFORMATION

The world's most famous company in communication, the Nippon Electric Company Ltd., Tokyo, has developed the famous NED CQ radio amateur gears, being with regard to design, quality, reliability and price real pace-setters for today's communicators. First in history of amateur radio, such a big and famous company with more than 80 years of experience in construction of communication facilities, made its experience available to radio amateurs around the world.

The NEC, which has declared microwave space communication to its speciality, knows perfectly which attributes equipments must have for becoming bestsellers.

Today we present:

## NEC CQ 110 E DIGITAL,



allband, HF, 300 watt transceiver, 160 / 80 / 40 / 20 / 15 / 11 / 10A / 10B / 10C / 10D / WWV, modes FSK, USB, LSB, CW, AM, with separate 8 pole X-tal lattice filters for each mode fitted. Further features: Side tone at CW, VOX (automatic transmit-receive by talking into microphone), 11 meter CB band, all channels easily selectable through digital counter, excellent receiver sensitivity at extreme crossmodulation security by application for the 7360 low noise beam, deflection mixer tube.

This feature alone makes of the NEC CQ 110 E a top rider. Fixed channel communication on 22 channels is possible. A 60 page manual and a high quality dynamic microphone are supplied with the transceiver. Speaker, AC 100-235 volts and DC 13.5 volts power supplies are built in of course.

## NEC CQ 301



allband HF, 3KW, linear amplifier, 160/80/40/20/15/11/10 meter, for modern amateur communication. Two EIMAC 3-500 Z triodes, in zero bias grounded grid application guarantee long trouble free communication. The NEC CQ 301 can be driven by our CQ 110E or other excitors capable of about 50-100 watts of drive. AC power supply 100-235 volts is built in of course.

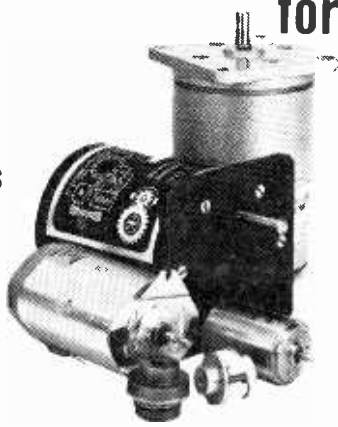
RETAILERS: Do not hesitate to accept our offer. Join us in selling these bestsellers!

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WW030 - FOR FURTHER DETAILS

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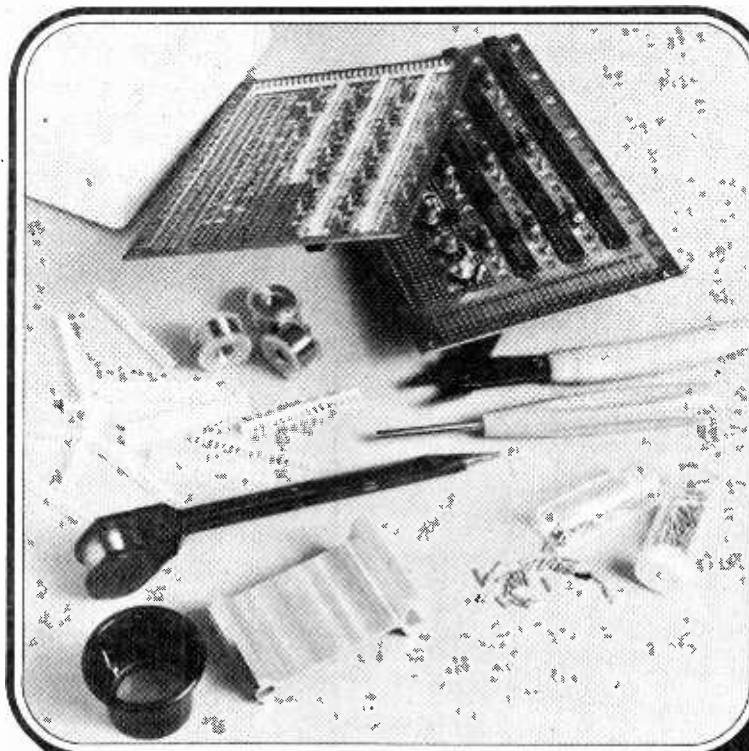
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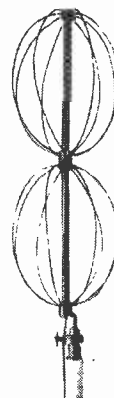
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WW-077 FOR FURTHER DETAILS

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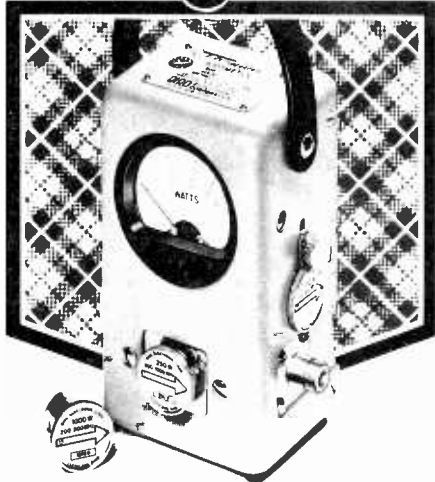
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WW—033 FOR FURTHER DETAILS

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1/8 and 1/4w 70°C 5% tol. E.12

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WW — 059 FOR FURTHER DETAILS

*Crimson Elektrik*

**MINIMUM T.D. POWER AMPLIFIER MODULES**  
WE BELIEVE OUR MODULES ARE UNEQUALLED IN SOUND  
QUALITY, OVERALL PERFORMANCE & VALUE FOR MONEY

★ S/N > 110dB ★ 1.20 x 80 x 25mm ★ Fully prototyped ★ 250 mV/50kΩ ★ 1.2Hz - 35kHz - 3dB ★ 14 Trs 4D  
It has recently been shown that an amplifier with some traditionally desirable features (eg heavy feedback wide bandwidth) can actually sound worse than one with a poorer spec. This has been attributed to distortion caused by transients T.D. Carefully positioned compensation a rise time of 10µs settling time of 10µs ± 2µs and slewing rate of 6V/µs ensure minimum T.D. while T.H.D. is reduced to typically 0.1 - 0.4 max. at 1kHz by ultra-linear output triples, not by excessive feedback. This approach has yielded one of the cleanest sounding amplifiers available, regardless of cost.

- CE 608 180W rms/8v ± 15v £14.55
- CE 1004 100W rms/4v ± 15v £17.55
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H/S kits 50p + 85p H/A kit 100p + 150p

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CE 1008 - Domestic heatsink 150mm

WW—028 FOR FURTHER DETAILS

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The Wireless Specialists for components & modules.

EF5800, 7030 & 91196 - .9µV/30dB S/N., 0.2% THD  
Our top three FM tunermodules. (EF5800 shown with can off).



From left to right, the EF5800 6 circuit varicap FM tunerhead with the 7030 linear phase IF and the 91196 PLL stereo decoder with integral 55kHz 'birdy' filter. The system provides afc muting, meter drives, agc, auto stereo switch, & a specification that exceeds broadcast requirements. Now available with a new EF5801 tunerhead, with FET buffered oscillator output for synthesiser/frequency readout facilities.

EF5801...£17.45; EF5800...£14.00; 7030...£10.95; 91196...£12.99

Complete FM tuner kits/systems (Carriage £3 extra.)

*The Mark 8 Signalmaster - by Larsholt Electronics*

This tuner is based on the popular 7252 tuner set, and provides an incomparable combination of style and performance that can be built by even the relatively inexperienced constructor. Complete kit...£85.00; matching 25+25W amplifier...£79.00.

*International Mark 2 Tuner kits:*

Complete tuner kit, based around the 7253 tuner set, £65.00. Or just the chassis, cabinet, heavy aluminium front panel — for your own choice of modules - see our new info. leaflet on the International Tuner. (SAE please)

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**BIONIC FERRET METAL LOCATOR**

Ambit has designed a new approach to cost effective sensitive metal locators, and now we proudly present the first of the family of 'Bionic Ferrets'. Details OA, but we can say it will detect a 10p piece at 8-10 inches. Coupled with low power consumption and many innovations, this is the first radically advanced detector that can be made from a kit. £37.99

Radio module selection: (Prices for kits in our catalogue & PL)

EF5800	Ambit 6 stage varicap 88-108MHz tunerhead	£14.00
EF5600	TOKO 5 stage varicap	£12.95
EC3302	TOKO 3 stage varicap	£7.50
7020	Dual ceramic filter FM IF system module	£6.95
92310	MPX decoder, with stereo filter and preamp	£6.95
93090	MPX decoder with CA3090AQ + filter stage	£7.35
91197	MW/LW varicap AM tuner module	£11.35
771	New 'Off-Air' UHF varicap TV sound tunermodule with mute, AFC, dual conversion, PSU	£27.00
9014	MW/LW/Stereo FM tuner chassis. Mech. tuned	£26.00

Components: ICs, coils, filters, trimmers, diode law pots etc.

HA1137W/3089E	FM IF	1.94	TOKO AM IFTs:	
TBA120	FM IF and demod	0.75	455/470kHz types	0.30
MC1350	FM IF preamp	0.97	10.7MHz types	0.33
SN76660N	FM IF and det.	0.75	(10mm square, with int. cap.)	
MC1310/4400	PLL MPX	2.20	455kHz Mechanical filters	
CA3090AQ	PLL MPX	3.75	4 or 7 kHz bandwidths	1.95
HA1196	PLL MPX	4.20	455kHz ceramic IF filters	
UA720	AM radio system	1.40	6 or 8 kHz bandwidth CFT 0.55	
TBA651	AM radio system	1.81	SFD455 (Murata)	0.75
HA1197	AM radio system	1.40	455kHz dual ceramic CFX	1.80
LM1496	balanced mixer	1.25	10.7MHz filters for WBFM:	
11C90	600MHz decade ctr	14.00	3132A 6 pole lin phase	2.25
LM380N	2 W Audio	1.00	3125N 4 pole lin phase	1.30
LM381N	audio preamp st.	1.81	CFS ceramic filters	0.50
TDA2020	20W audio amp	2.99	Pilot tone (MPX) filters:	
TCA940	10W audio amp	1.80	BLR3107N stereo	1.90
NE723	voltage reg IC	0.80*	BLR2007N	1.95
TDA1412	12v 600mA reg	0.95*	BLR3152/mono	0.97
78M20	20v 500mA	1.20*	BLR3172N tape bias trap, with TAA550B varicap regulator	0.50*
TAA550B	varicap regulator	0.50*	85 or 100kHz pole	0.97
NE560/1/2B	PLL ICs	3.50*	various chokes etc. see price list	
ICL8038CC	function gen	4.50*		

22turn 100k diode law trimpots, with integral knob 40p  
270° rotary 100k diode law tuning pot 32p  
Also...meters for tuners, AM tuning varicaps, MOSFETs etc....

post/packing 22p per order - except where indicated

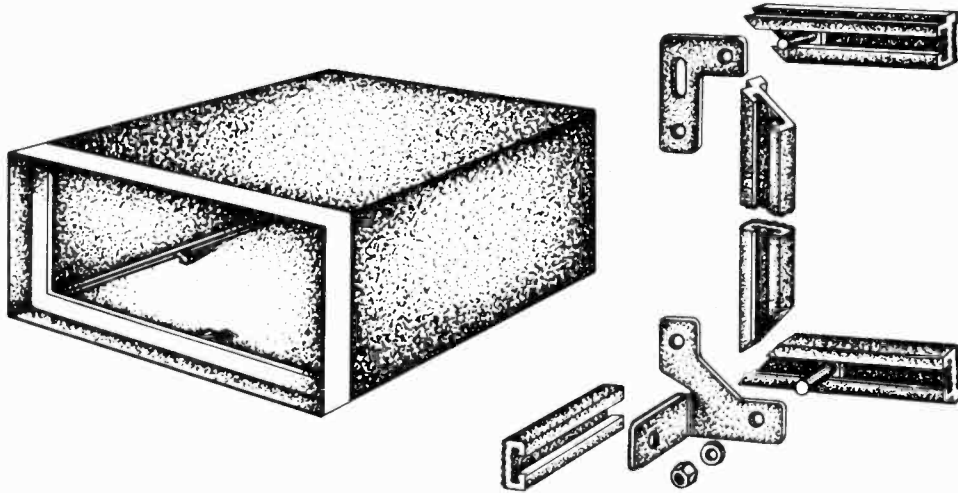
General: All prices shown here exclude VAT, which is generally 12½%. (Except where marked\*). The latest price leaflet is available FOC with an SAE. Please send a (large) SAE with any enquiries. Full catalogue still 40p.

37 High Street, Brentwood, Essex. CM14 4RH.  
TELEPHONE (0277) 216029 - after 3pm if possible please.

WW—032 FOR FURTHER DETAILS

# when is a box not a box?

Instrument boxes are often sold in standard sizes — not always the most practical sizes for your needs. When bought they take up a lot of storage space.



WIDNEY DORLEC Series 3 is a new, simple constructional system for building cases, boxes, chassis, frames, drawers etc. etc. Just 3 basic extrusions and 3 simple brackets — available as components for DIY, kits,

or fully finished products to your design.

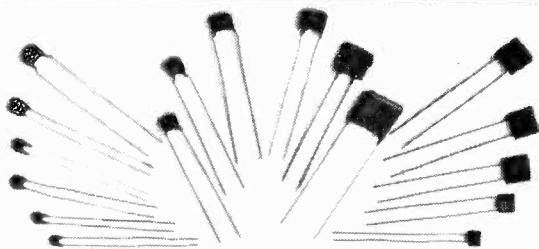
Custom made cases at prices you pay for standards. Ideal for Laboratories, Universities, small workshops. Call Cyril Vaughan on 021-359 3044 for more details.

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WW—098 FOR FURTHER DETAILS



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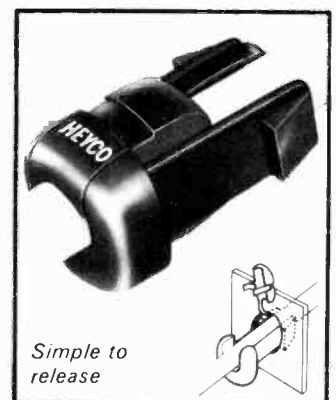
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WW—046 FOR FURTHER DETAILS

# Take the strain off your cable



HEYCO NYLON STRAIN RELIEF BUSHINGS anchor and insulate cables passing through chassis. Lock to withstand 35lb push-back. Effects of 'push', 'pull' and 'twist' are absorbed.

HEYCO NYLON EXTENDED STRAIN RELIEF BUSHINGS do the same job as the standard strain reliefs but remain securely attached to the chassis during cable change.

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WW—072 FOR FURTHER DETAILS

# The greatest public show of home entertainment -at Olympia in September

That's the Audio Fair this year. It's moved with the market – as the emphasis changes, so does the Fair.

More people buy systems. More people look to home electronics for entertainment, as outside attractions become priced out of the market. More people want the package deal. So . . . not only audio and hi-fi, but also the whole spectrum of

**RADIO...TELEVISION...MUSIC...TV GAMES  
...RECORDS...TAPES...HOME RECORDING  
and MUSIC-MAKING**

More young people are among the buyers. More older people are getting into the new scene of sound. That's why the Audio Fair is a big family occasion, with the big family attractions.

Already the exhibitors include Agfa-Gevaert, Amstrad, Hitachi, National Panasonic, Natural Sound Systems, Rank, Sanyo – to name a few that indicate the width of appeal.

***There's a whole world of Home Entertainment  
at the Audio Festival and Fair this year.  
You ought to be there! It's Sound Sense!***

● **LONDON'S OLYMPIA** – the industry's favoured location, where the people and the money are . . . and the only venue with the size, scope and facilities for this great trade and public festival.

● **SEPTEMBER 12 to 18, 1977** – the preferred pre-Christmas selling-time period . . . and opening with a day and a half for the trade only.

● **BACKED** by major IPC specialist, trade and consumer publications, commanding a combined readership of 1,750,000.

● **ORGANISED** by the IPC Business Press specialist exhibition company, with a remarkable record and reputation for handling specialist fairs.

## THE COMPLETE HOME ENTERTAINMENT SHOW



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## GR 1657 Digibridge

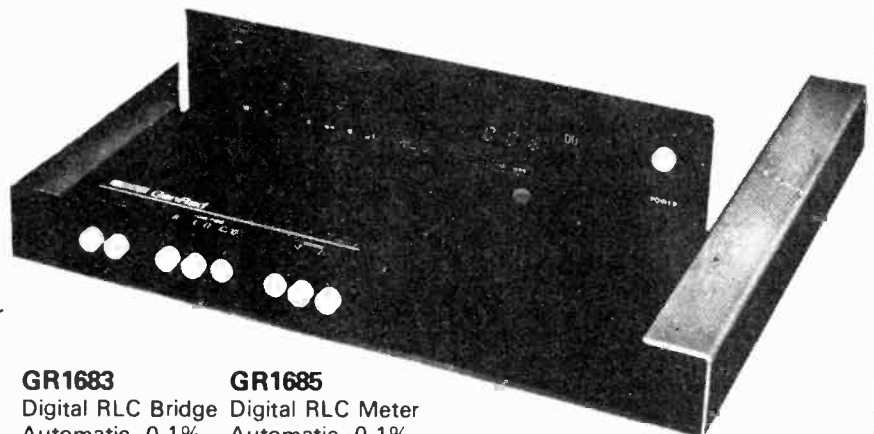
Automatically measures R, L, C, D and Q. Ranging from  $0.001\Omega$  to  $99.999\text{ M}\Omega$ ,  $0.0001\text{ mH}$  to  $9999.9\text{ H}$ ,  $0.0001\text{ nF}$  to  $99999\mu\text{ F}$ . D from  $0001$  to  $9.999$  and Q from  $00.01$  to  $999.9$ . Basic accuracy  $0.2\%$ . Five digit display for R, L and C, four digit display for D and Q.

Microprocessor — directed ranging. Selectable test frequencies of  $1\text{ KHz}$  and  $100\text{ Hz}$  ( $120\text{Hz}$ ).

Series or parallel measurement selection. Built-in Kelvin test fixture tests radial and axial lead components. Other bridges from our range include:

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RLC Bridge	RLC Bridge	RLC Bridge	Digital RLC Bridge	Digital RLC Meter
Precision $1\%$	$0.1\%$	$0.05\%$	Automatic, $0.1\%$	Automatic, $0.1\%$

It is easy to test components with GenRad. Write or call for descriptive literature to GenRad Ltd. Bourne End, Bucks SL8 5AT. (06285) 26611



# GenRad

# 15 — 240 Watts!

## HY5 Pre-amplifier

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.

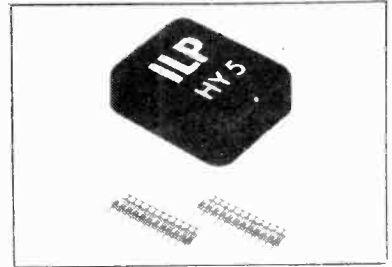
**ACTIVE TONE CONTROLS:** Treble ± 12dB at 10kHz Bass ± at 100Hz

**DISTORTION:** 0.1% at 1kHz Signal/Noise Ratio 68dB

**OVERLOAD:** 38dB on Magnetic Pick-up **SUPPLY VOLTAGE:** ± 16.5V

**Price £5.22 + 65p VAT P&P free**

HY5 mounting board B1 48p + 6p 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 1 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

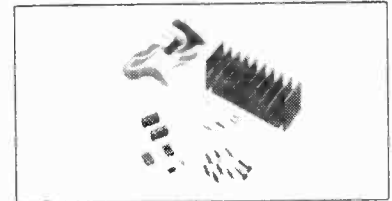
**SPECIFICATIONS:**

**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 £5.22 + 65p VAT P&P free.**



## 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 x 25mm

**Price £6.82 + 85p 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:**

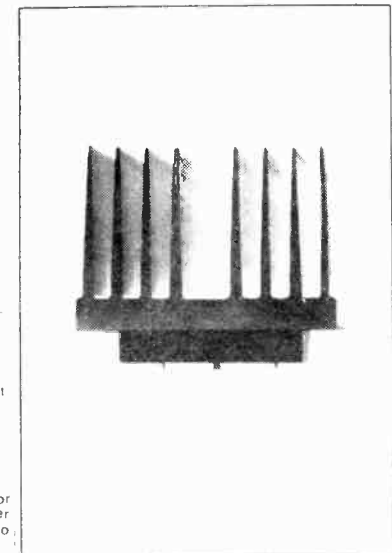
**INPUT SENSITIVITY:** 500mV

**OUTPUT POWER:** 60W RMS into 8Ω **LOAD IMPEDANCE:** 4-16Ω **DISTORTION:** 0.04% at 60W at 1 kHz

**SIGNAL/NOISE RATIO:** 90dB **FREQUENCY RESPONSE:** 10Hz-45kHz — 3dB **SUPPLY VOLTAGE:** ± 35V

**Size:** 114 x 50 x 85mm

**Price £15.84 + £1.27 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:**

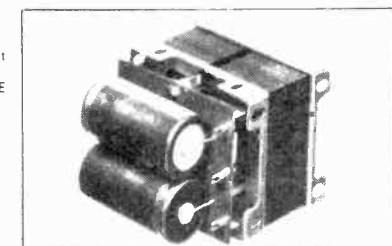
**INPUT SENSITIVITY:** 500mV

**OUTPUT POWER:** 120W RMS into 8Ω **LOAD IMPEDANCE:** 4-16Ω **DISTORTION:** 0.05% at 100W at 1 kHz

**SIGNAL/NOISE RATIO:** 96dB **FREQUENCY RESPONSE:** 10Hz-45kHz — 3dB **SUPPLY VOLTAGE:** ± 45V

**Size:** 114 x 100 x 85mm

**Price £23.32 + £1.87 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 1 kHz

**SIGNAL/NOISE RATIO:** 94dB **FREQUENCY RESPONSE:** 10Hz-45kHz — 3dB **SUPPLY VOLTAGE:** ± 45V

**INPUT SENSITIVITY:** 500mV **SIZE:** 114 x 100 x 85mm

**Price £32.17 + £2.57 VAT P&P free.**

### POWER SUPPLIES

PSU36 suitable for two HY30's **£5.22** plus 65p VAT P.P. free  
 PSU50 suitable for two HY50's **£6.82** plus 85p VAT P.P. free  
 PSU 70 suitable for 2 HY 120's **£13.75** plus £1.10 VAT P.P. free  
 PSU90 suitable for one HY200 **£12.65** plus £1.01 VAT P.P. free  
 PSU180 suitable for two HY200's or one HY400 **£23.10** plus £1.85 VAT P.P. free  
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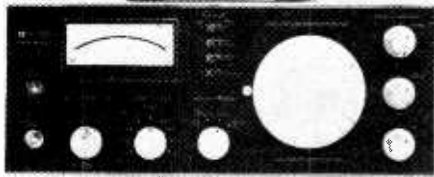
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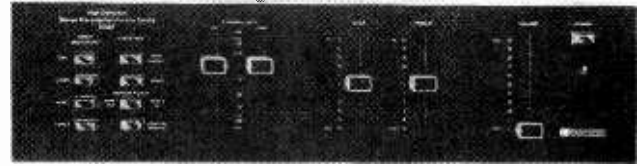
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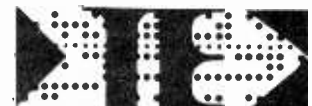
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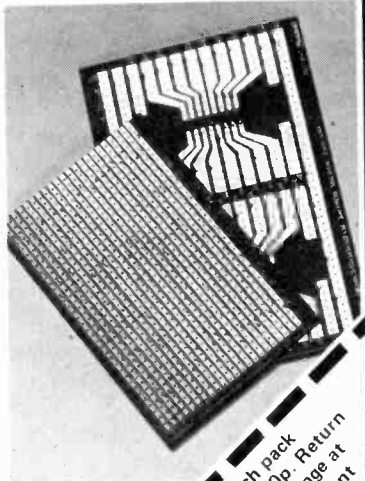
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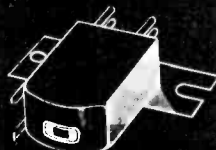


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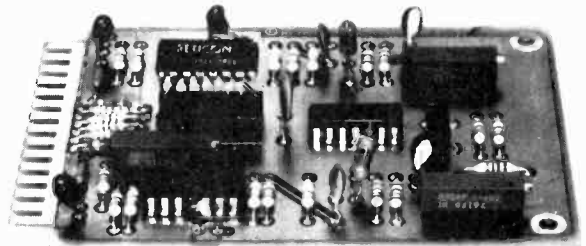
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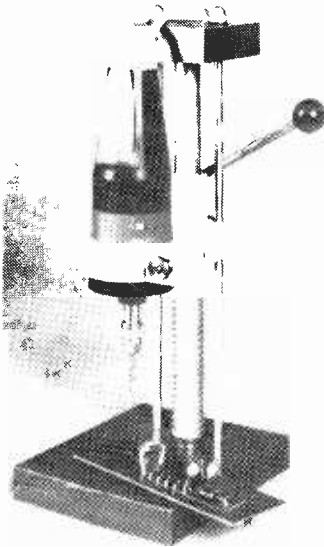
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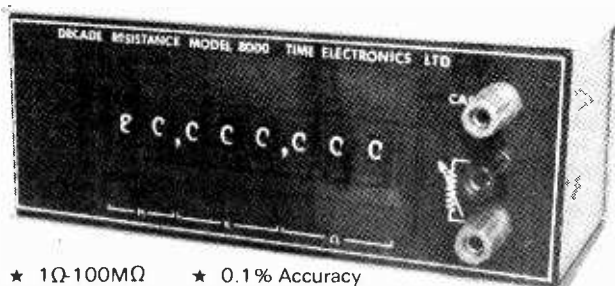
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MWW1

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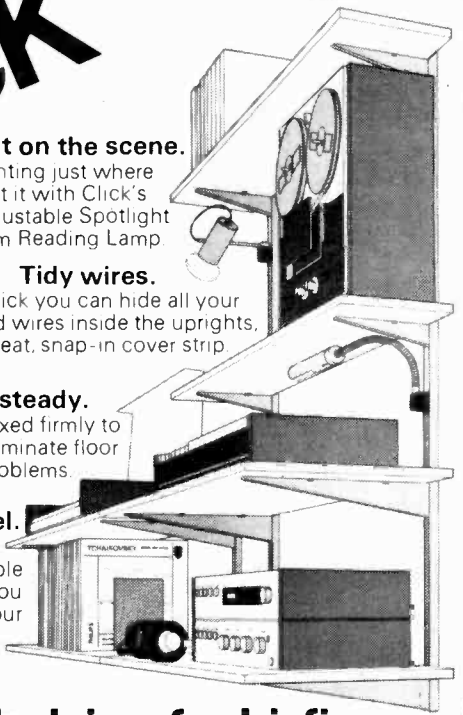
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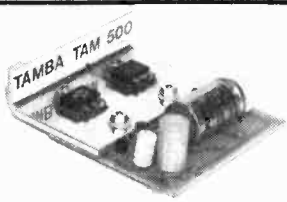
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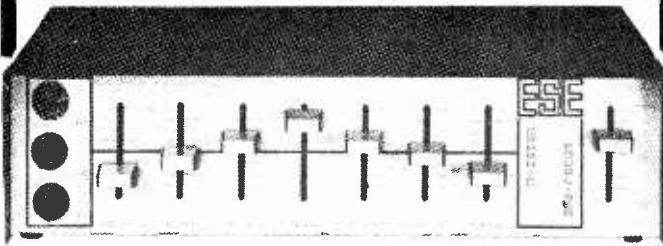
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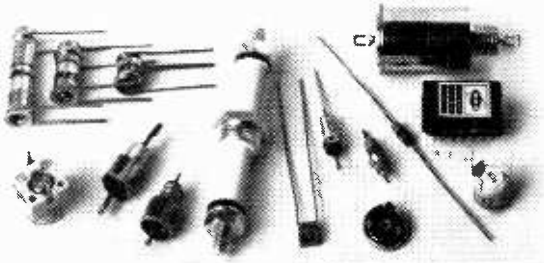
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Part 1 of the Teletext decoder is in our March issue on sale now. It covers fundamentals and power supply details. Part 2 in the April issue begins the logic section.

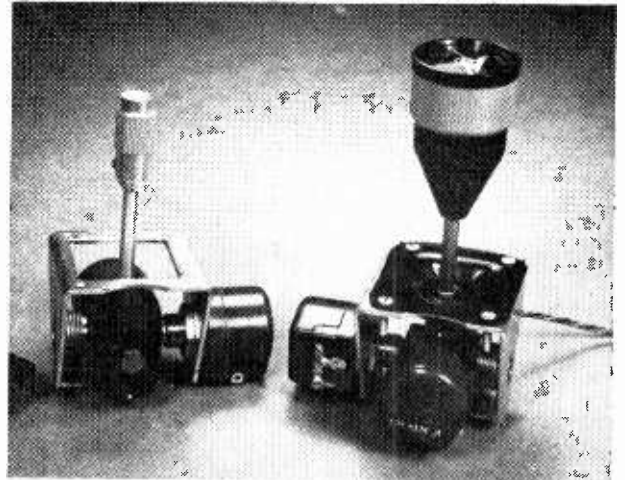
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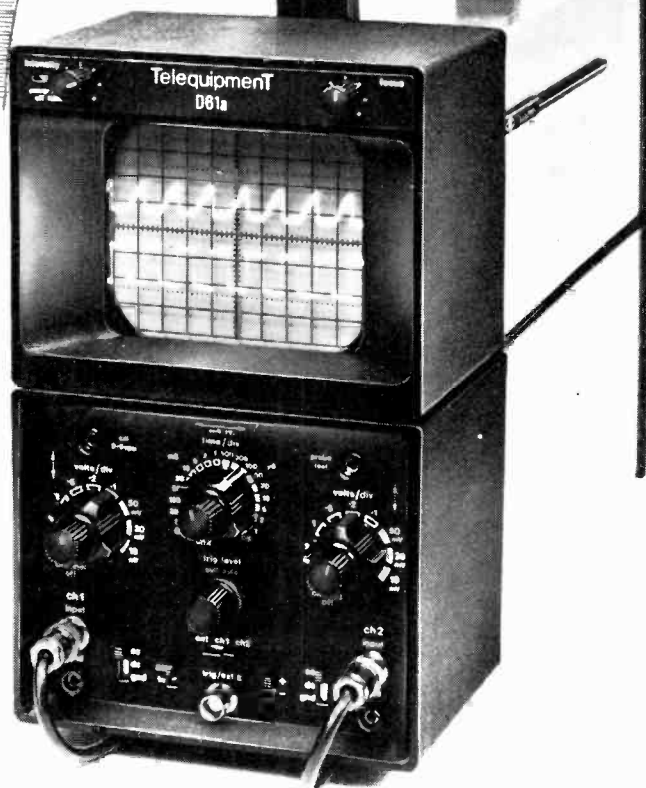
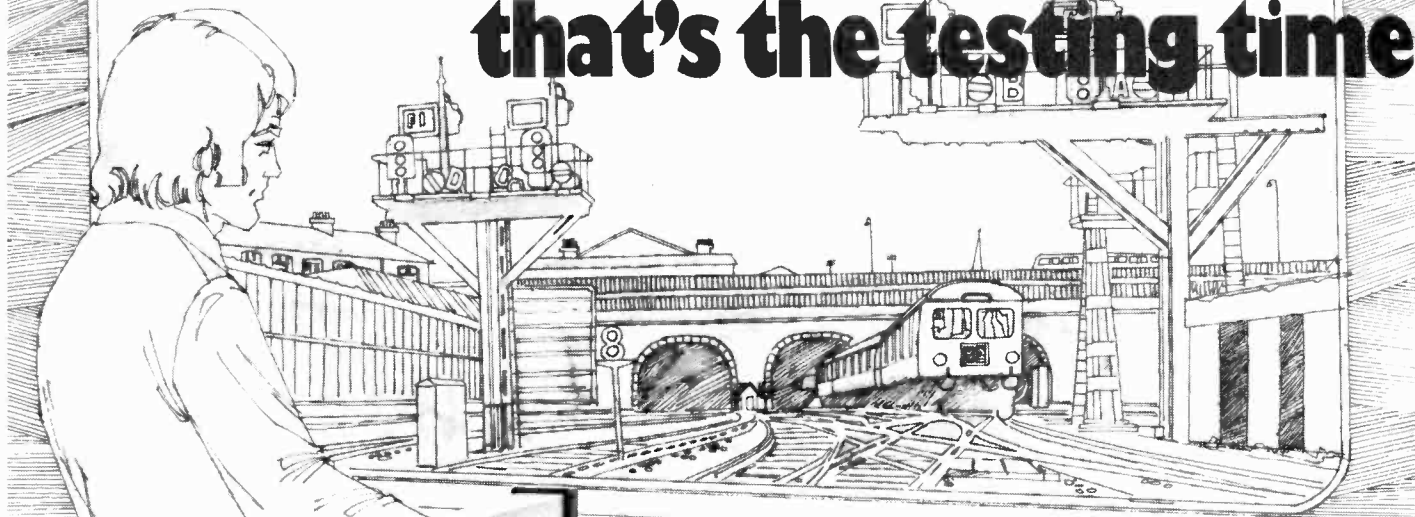
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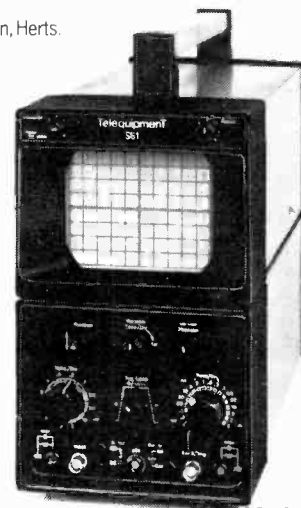
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# wireless world

Electronics, Television, Radio, Audio

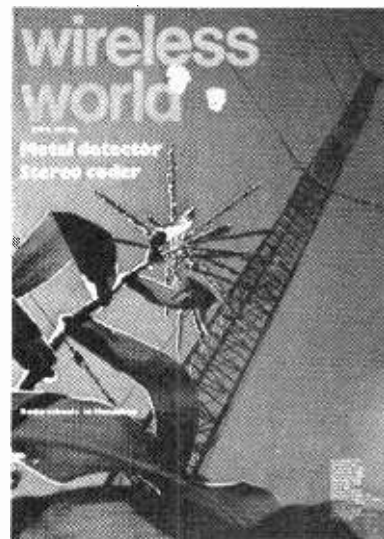
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Photographer Paul Brierley

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### Electrolytic capacitor tester.

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### Two-stage linear amplifier.

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# wireless world

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When this issue of *Wireless World* appears on the news stands the deadline for submissions to the Home Office on British policy on frequency reallocations for the 1979 WARC will be only six weeks away. (See *News of the Month*, March p.37). Yet a few months ago even this much consultation seemed out of reach. The Home Office is to be congratulated on reversing its policy of selective consultation and giving the public a chance to have their say. It could be argued, indeed, that the process might have begun much earlier had the electronics industry and its representatives been less acquiescent in the Home Office's reluctance to encourage public intrusion. Even though the discussions to which the discreet trustees we referred to in December found they had an exclusive entrée were on matters of public concern far beyond their immediate interests, they made, at first, no effort to press for a programme that might dilute their own bargaining strength.

But it is for the electronics industry, singly and collectively, to put its own house in order. The immediate need is to make sure that the 1979 package is a fair reflection of the views of all those with an interest in the allocation of frequencies. The Home Secretary's statement is only a beginning. Indeed it contains a surprising admission of the inadequacy of what he has craftily called "the preliminary phase" of the work for the conference: although, he says, a substantial measure of consultation with users and manufacturers has already taken place, during the next phase "those known to have an interest will be specifically invited to comment." One wonders how "substantial" the measure of consultation during the preliminary phase could have been.

One hopes, too, that equal weight will be given to the public's views as to those "specifically invited." This can only be the case if the public is as well informed as those "known to have an interest," yet we have not received any details of the Home Office proposals for disseminating the contents of the Warden reports and any others relevant to the WARC. If the "wider programme of consultation" is to be anything more than an empty political gesture these reports must be made public.

The ten days following the publication of the next issue of *Wireless World* will not give enough time to read the available material, to consult colleagues, and to draft a considered proposal. The consultation period should be extended, just as the Annan committee extended theirs. An extension to the end of the year would give officials a clear year to collate and prepare the British case. Is that so much to ask?

# NRDC surround-sound system

Michael Gerzon reveals the thinking behind system 45J

by Michael Gerzon, M.A., *Mathematical Institute, Oxford*

**This article gives a feel for how it has proved possible to evaluate the whole range of possible methods of encoding and decoding surround-sound based on fundamental psychoacoustic principles. Although the full development was highly mathematical, the basic principles underlying the Ambisonic or NRDC 45J system\* of surround-sound are described without mathematics, this new system being the best possible according to the methods used.**

Up to now, surround sound system design has to a considerable degree been based on guesswork as to what signals fed to an array of loudspeakers will produce a "desirable" directional affect. As an exhaustive experimental evaluation of the directional effect of arbitrary crosstalk patterns for even just a square speaker array involves consideration of a six-parameter family of crosstalk configurations, and as even small variations of the crosstalk pattern can produce significant alterations of directional effect, it would be necessary to do experiments for about 10<sup>6</sup> different crosstalk patterns before one could say that a system could be optimized purely on the basis of experimental data. This is impracticable.

A very general theoretical framework has been developed<sup>1</sup> to assist in maximizing the information that can be deduced from limited experimental tests on human directional psychoacoustics. Certain aspects only of this psychoacoustic framework are discussed in this article.

At low frequencies, the information reaching the brain consists of the sum of the inputs to the two ears, i.e. an omnidirectional or "pressure" sound pick-up and the difference of the inputs to the two ears, i.e. a sideways-pointing figure-of-eight or "velocity" pick-up, Fig. 1. Most low frequency (<700Hz) theories of hearing assume that only the interaural phase is used to determine direction, which is equivalent to saying that only those components of the sideways figure-of-eight pick-up that

are in-phase or out-of-phase with the pressure signal components are used by the ears. In practice the 90°-phase components of figure-of-eight pick-up do affect localization quality toward the top end of this low frequency range, and produce an effect called "phasiness."

In practice, the head may rotate, so that the forward-pointing figure-of-eight pick-up of sound information is also used to determine sound direction. The relative intensity of in-phase figure-of-eight signals in the forward and sideways direction defines a vector pointing in the apparent sound direction according to Makita's theory and is susceptible to calculation as described in reference 4. The length of this vector

(divided by the pressure amplitude) should be one for real-world sounds, and so decoders should be designed with a pressure-to-velocity ratio assuring this requirement for all reproduced sound directions at low frequencies, in addition to ensuring correct Makita localization. It is an incorrect velocity-vector length that makes the side image reproduction so poor in conventional "discrete" quadraphonics.

If there is too high a phasiness, it is clear that this can be reduced for a given decoder design by subtracting from the figure-of-eight signals a suitable amount of 90° phase-shifted pressure signal. In practice, the amount of unwanted 90°-shifted figure-of-eight information varies with sound direction, so that phasiness compensation to reduce phasiness in one direction will tend to increase it in the opposite direction. Nevertheless, it is possible to use this technique to give a subjectivity optimized phasiness, as shown in Fig. 2.

The block diagram of Fig. 2 is a psychoacoustically optimized decoder consisting of a phase-amplitude matrix producing pressure, forward and sideways velocity and 90° phase-shifted pressure signals from the input channels; the design of the phase-amplitude matrix depends on the encoding system.

Fig 2: Block diagram of decoder satisfying the main psychoacoustic requirements. Shelf filters are all-pass types designed to have identical phase responses, and make the decoding matrix varying frequency according to the frequency-dependent properties of human hearing.

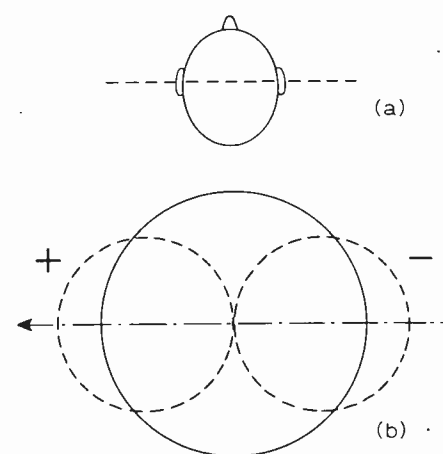
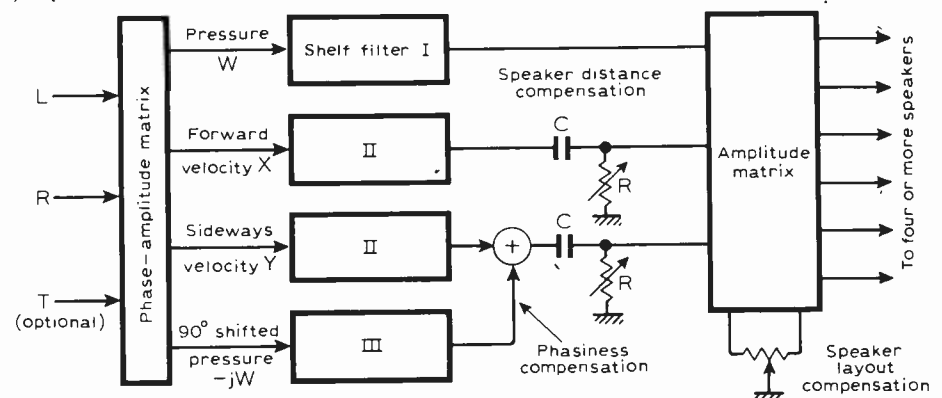


Fig 1: Pressure and velocity (figure-of-eight) pick-up characteristics of the sum and difference of the inputs to the two ears of a listener at low frequencies.



\* System 45J is the subject of a UK-section AES meeting to be held on 12 April at the IEE, Savoy Place, 19.00h. Title is "Hearing and surround-sound," by P. B. Fellgett, M. Gerzon and T. Takagi.

The shelf filters are frequency-dependent gains that permit adjustment of the relative velocity and pressure gains so that at low frequencies the velocity-vector length is correct, and at higher frequencies other psychoacoustic requirements, described later, are satisfied. The "distance compensation" is high-pass RC filtering of velocity, typically  $-3\text{dB}$  at  $20\text{Hz}$ , to compensate the bass boost of the velocity signals produced at the listener by the curved sound field (caused by finite loud-speaker distance). It is mainly the phase response of this filter that is psychoacoustically important. The output amplitude matrix produces speaker feed signals, dependent on the speaker layout used, that create correct pressure and velocity at a central listening position.

At higher frequencies, about  $700$  to  $5\text{kHz}$ , a different class of theories of hearing take over. In these theories localization is via signal energy, and is determined by drawing a vector pointing to each speaker having length equal to the energy of a sound from that speaker. The sum of these vectors is a vector pointing in the intended sound direction, which direction is the "energy vector localization." The length of this vector, divided by total energy (energy vector magnitude) is  $1$  for real-world sounds, and should be as large as possible in decoders for good localization.

There is a transitional frequency band,  $250$  to  $1.5\text{kHz}$  over which both classes of theories may apply, and it is important that decoders should give both correct pressure/velocity and energy localizations as far as possible over this transitional range. This is ensured by designing decoders to give Makita and energy vector localizations that are identical at all frequencies; this may be ensured for many types of speaker layout (rectangle, hexagon, etc.) by a suitable design of output matrix. The shelf filters in Fig. 2 are then chosen to give optimum velocity magnitude at low frequencies and optimum energy vector magnitude at high frequencies. Note that this design procedure involves designing not only optimum low and high frequency decoding matrices, but an optimal variation of the matrix over the transition frequency range.

One result that emerges from this theory is a remarkable mathematical theorem to the effect that the optimal accuracy of reproduction of images in non-speaker directions via a rectangle of speakers can be obtained *only if the four speakers are fed with not more than three information channels*; it may be shown that  $-L_B + L_F - R_F + R_B$  should always be zero for best results. Experiment confirms the theory.

Given that we have a means of designing decoders for optimal psychoacoustic results for any encoding system capable of producing suitable pressure and velocity signals, the aim is

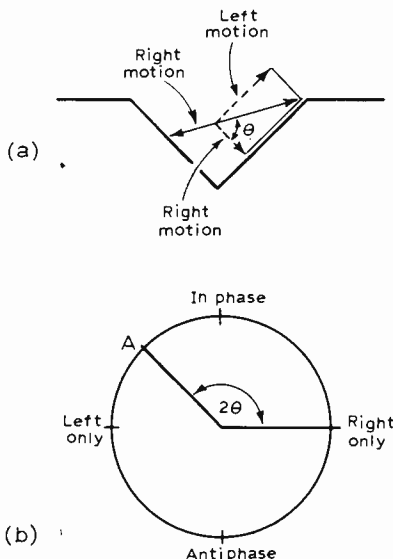


Fig 3: Angle  $\theta$  of stereo stylus motion in record groove corresponds to an angle  $2\theta$  on a circle representing possible stereo positions.

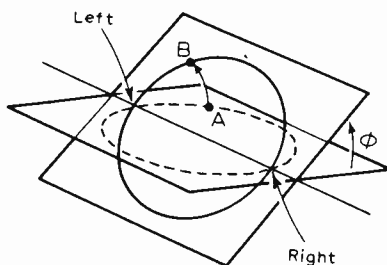


Fig 4: Circle point A goes to point B on sphere by a rotation by angle  $\theta$  equal to the phase lead on the left channel.

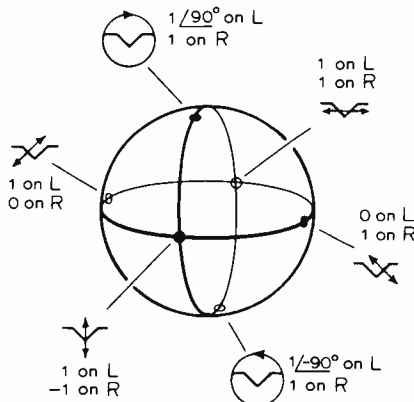


Fig 5: Typical stylus motions (for sine wave signals) and left and right channels gains corresponding to various points on the energy sphere.

then to find the best encoding system, i.e. the one whose optimized decoder gives better results than for all other encoding systems.

It is possible to classify mathematically all systems with not more than three channels that are capable of satisfying the Makita, energy vector and velocity magnitude requirements via suitable decoders. This classification involves about 40 pages of mathematics, but can be solved exactly. The theory involved also gives the detailed

parameters of decoders that optimize the reproduced psychoacoustics of the directional effect for every sound direction.

The requirements on surround-sound performance of such systems include the following.

- The two baseband stereo signals L and R must be decodable for surround directional reproduction in a way satisfying all the basic psychoacoustic criteria discussed earlier.

- It must be possible to supplement the baseband with a third signal capable of being decoded with improved directional effect. A fourth channel is not required as it can only degrade directional reproduction.

- To achieve high quality from carrier discs, which have certain inherent theoretical limitations determinable by standard information theoretic analysis, it is necessary to bandlimit the subcarriers to a few kHz.

- It is required that satisfactory decoders be designable for the case when the third channel is bandlimited, not only in directional effect, but also in flat reproduced frequency response in all encoded directions. The directional effect requirement for such "2½ channel" use means that, as the third channel is attenuated the Makita (and hence energy vector) localization of a three-channel decoder should remain unaltered.

- Within these above constraints, the two channel decoding should be capable simultaneously of low phasiness for front-stage sounds, good localization at the left and right side positions, and with a uniform reproduction of ambience information around the listener on "natural" ambient recordings.

A way of describing the two-channel baseband encoding is the "energy sphere" (ref. 2) which represents the relative phase and amplitude gain of each sound on the two channels as a point on a sphere. A sound recorded on the two groove walls of a stereo disc (Fig. 3), without the use of phase shifters is represented by a point A on the horizontal circle of this sphere, at an angle from the right-most point of the circle twice as big as the angle made by the stylus motion from the right-channel-only direction of stylus motion. In this way all in-phase and out-of-phase lines of stylus motion are mapped to points around a circle. If the left channel is now made to phase-lead one right channel by a phase angle  $\phi$ , then the point B on the sphere representing the method of encoding is also obtained from A by rotating the circle about its left/right axis by an angle  $\phi$  as shown in Fig. 4. Stylus motions and left and right channel phases and gains corresponding to various points on the energy sphere are shown in Fig. 5.

One may describe a method of encoding by the way its energy sphere point varies with encoded direction. The locus traced out on the sphere as the



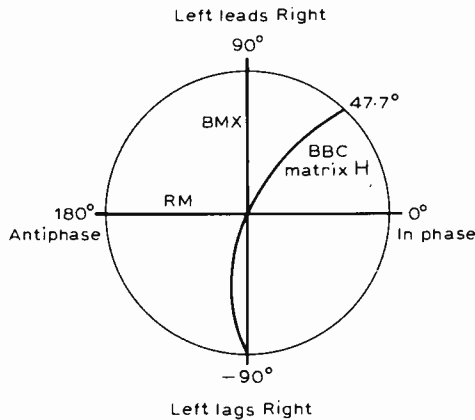


Fig 6: View from right side of energy sphere, showing RM (Regular Matrix) BMX and BBC Matrix H system two-channel encodings. Angles indicated round edge show the phase lead of the left channel.

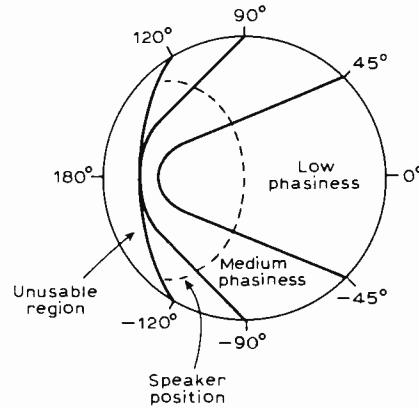


Fig 7: Quality of mono and stereo reproduction shown on energy sphere viewed from right side. "Speaker position" curved indicates appearing to come from one speaker only in stereo.

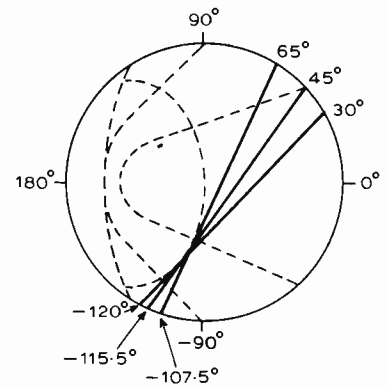


Fig 8: Three possible choices of two-channel encoding system having optimized mono and stereo reproduction.

sound rotates through 360° is shown as the "pan locus" of the encoding system. The best-behaved systems are those in which the left-half and the right-half of the pan locus are mirror images of one another. For such systems, it is convenient to view the locus on the sphere from the right hand side; Fig. 6, shows the side view with various existing system pan loci. The angles round the edge indicate the relative phase lead of the left channel over the right channel, and the centre point represents left-only or right-only.

Fig. 7 gives a rough indication of the acceptability of the mono and stereo quality, as previously discussed. The shaded nearly antiphase region at the back of the sphere must be avoided for direct sounds, both because sound in this region is excessively attenuated in mono, and because the sound is very "phasy" and hard-to-localize in stereo. (It is not always undesirable to have reverberation information in this region, however). Approximate regions of low and medium phasiness effects in stereo are also shown, although the boundaries are not in practice sharply defined. It is possible to have a sensation of unpleasant phasiness for some programme material even when it is all in one low phasiness region, and some material can sound acceptable even in the high phasiness region. In practice, it is found preferable to minimize stereo phasiness for front-sector sounds, even if this means making phasiness marginally worse for rear-sector sounds.

The stereo image must have full stage width. This need not mean the locus passing through the left-only point, but can be achieved as long as the pan locus touches the "speaker position" curve Fig. 7 along which sounds appear to lie in one speaker only in stereo. Thus to get good mono and stereo compatibility, the locus must be moved as far forward as possible, especially for front-encoded sounds, while touching the speaker-position curve.

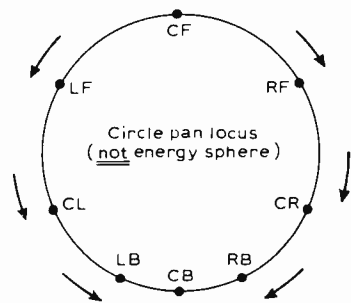


Fig 9: Showing optimized non-symmetric distribution of different encoded directions within the circle "pan locus" of the systems shown edge-on in Fig 8. C<sub>F</sub> stands for "centre-front," R<sub>B</sub> for "right-back," C<sub>L</sub> for "centre-left" and so on. This figure is not a picture of the energy sphere.

Another constraint lies in the requirement for good surround decoding. The effect of using a bent locus, see Fig. 6, rather than a circle locus (whose side view is a straight line!) is that surround decoders give poor side-image localization and it can be proved that this is inevitable for any design made for such systems according to psychoacoustic theory. The asymmetry between side-to-side and front-to-back performance of bent loci means also that ambience reproduction is poor and that 2½-channel decoders cannot give a substantially flat frequency response for all directions of encoding. For these reasons, a circle-locus system must be chosen; otherwise surround reproduction quality inevitably must be degraded.

Pulling a circle locus as far forward as it will go on the sphere while touching the speaker position curve yields possibilities shown in Fig. 8. As the front-centre interchannel phase angle increases from 30° to 65°, the stereo phasiness becomes progressively worse for front-sector sounds, but better for back-sector sounds, and mono compatibility improves. One can argue indefinitely about which compromise of compatibility properties is best, but we have found that the 45°/-115.5° locus

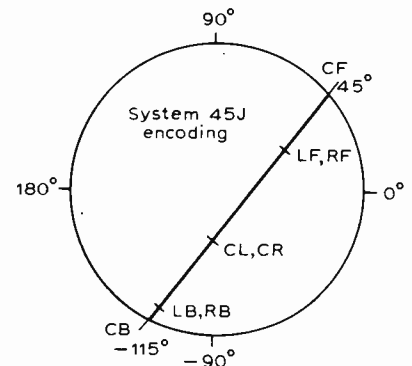


Fig 10: Energy sphere (side view) picture of two-channel version of System 45J encoding.

seems best to satisfy the needs of the widest range of users, including record companies and broadcasters. Moreover, this locus has good performance when used with existing regular matrix (RM) and UMX equipment for decoding. Thus a changeover to this standard should cause minimal disruption, and could simplify the confused market situation by reducing the number of systems on the market.

A further optimization of reproduced surround effect comes from a careful choice of the way different encoded directions are distributed within the circle locus. Low decoded front-stage phasiness in surround may be combined with uniformly reproduced ambience if a sound-azimuth distribution within the circle locus is chosen, as in Fig. 9. This distribution helps widen the stereo presentation for front-stage sounds, thus also giving much better stereo compatibility. The front quadrant of directions alone gives an image filling over 0.8 of the stereo stage in subjective tests. Such "asymmetric circle encoding" requires a careful choice of third-channel encoding to achieve the best 2½-channel decoded results; the mathematics of this is described in reference 4.

The resulting system of encoding, Fig. 10, is called System 45J, and was chosen only after both exhaustive theoretical studies and experimental tests, as well as international discussions within the audio industry. As it is the first system designed based on a complete mathemati-

cal analysis of both system theory and human psychoacoustics, it is possible to say with some confidence that no system appreciably different from it can exceed its performance in optimal surround-sound decoding, so that no further system change is ever likely to be needed for horizontal encoding.

Unlike all previous proposals, System 45J can handle virtually any legitimate requirement in terms of recording philosophy and yet be suitable for listening in mono, stereo, two-channel surround, 2½-channel surround or three-channel surround, giving good results in all modes. There are no sound positions which producers should not use, no incompatibility with types of recording technique such as coincident microphones, and no requirement that variable-matrix decoders be used with their inevitable side-effects.

This choice of encoding system does not prevent equipment manufacturers from using their own decoding philosophy if they desire. For example, both Sansui Variomatrix and the logic decoders can easily be adapted or designed for System 45J. However, if optimum musical results are required, decoders satisfying the maximum number of requirements of human directional psychoacoustics should be used. We have outlined how such decoders may be built\*; and in the near future, a decoder will be publicly demonstrated reproducing sounds via an arbitrary rectangle speaker layout, that can also be hooked up to feed a hexagonal six-speaker layout for an even closer approach to the ideal illusion.

So far, experimental testing has been carried out via about 30 psychoacoustic decoder designs for a wide variety of encoding systems, and a broad spectrum of studio technology developed to get the best possible results. This information will be made available to the industry. The use of System 45J with this technology gives results that are far more convincing and musical, even via two channels, than was the underdeveloped "quadrophonic" approach to surround sound which has now been rendered obsolete by this work. This work was done as a part of the Ambisonic project of the U.K. National Research Development Corporation.

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Following articles will give circuit details of a decoder based on these principles and which will decode system 45J and stereo for square, rectangle and hexagon speaker layouts, with distance and psycho-acoustic compensation. — Tech. ed.

## Post Office "holding back technical improvement"

Sixty-one votes prevented Mr Nicholas Ridley from introducing a bill on February 1 to end the Post Office monopoly of the supply of telephone equipment. Seeking leave to introduce a bill he said: "It may be that there are some subscribers who want telephones of different colours from those provided by the Post Office, and they cannot get them. The Post Office monopoly prevents it.

"A more important example is the pushbutton telephone device. We have these in this House, and I can well understand why they have not been allowed outside. If they were unleashed upon the unsuspecting public, dissatisfaction with the Post Office would increase apace. But there is no reason why a really effective push-button telephone should not be offered to subscribers."

Other examples, he said, included automatic telephone dialling equipment, loudspeaking telephones, and more varied answering equipment. "Telephone engineers believe that eventually it will be possible for the telephone connected to one's house to operate as a minicomputer and to give access to one's bank, department store or supermarket direct, and to allow one's meter to be read direct by the telephone. There are all sorts of imaginative, labour saving and exciting devices all within the realms of possibility. But there is one small difficulty — the Post Office is sitting on them, and its monopoly is preventing the proper development of these technical devices."

This criticism also affected the degree of choice available to those subscribers with their own exchanges. His bill proposed that a committee of independent people should check that any equipment developed for the home was compatible with the Post Office network.

The reply to Mr Ridley, the Conservative member for Tewkesbury, a civil engineer and the opposition spokesman on technology and trade from 1969 to 1970, was given by Mr Ian Wrigglesworth, the Labour and Co-operative member for Thornaby and press spokesman for National Giro. He gave a number of reasons why the bill should not be read. The first was that the Carter committee on the future of the Post Office was still sitting, and would probably consider this very point. The second was that the Annan committee was also sitting; "It will no doubt comment on the future of cablevision and on the whole question of common carrier cables."

A third reason he gave was that the testing of each piece of equipment to be

connected to the system would be "a cumbersome, expensive and ineffective process and the consumer would have to bear the costs." Another was that all Mr Ridley hoped to achieve was the creaming off of profitable parts of the Post Office's operations, of which this was one, leaving the Corporation with unremunerative services like the expensively-maintained 'phone boxes. There was already competition among private firms for making small private branch exchanges, special telephones, data transmission and teleprinter equipment provided by the Post Office, though he agreed the range of the equipment so provided ought to be extended. "The Post Office needs to be much less cautious and more aggressive in its marketing and in the number of pieces of equipment that it provides." Joint efforts with manufacturing industry to provide exportable equipment for sale abroad ought to be done through putting pressure on the Post Office.

In the division 175 members voted for the motion, 236 against.

## New hope for solar power

A student working on a PhD thesis on the properties of films at the department of plasma physics at Sydney University appears to have discovered an important way of tapping solar energy. Until now, solar cells have managed to produce temperatures of a maximum of 150 C, but the reports from Australia indicate that the new method is able to achieve 300 C as well as being cheaper than other methods. Details of the method are not yet available, but it appears to be based simply on a characteristic of one film that was tried, with chromium oxide as a main constituent, in converting much of that part of the sunlight it absorbs into heat. The student is a pupil of Dr Charles Watson Monro, the professor of plasma physics, and Professor H. Messel.

News of the development came about a week before the government published its long awaited paper on solar energy (*Solar Energy: its potential contribution within the United Kingdom-Dept of Energy, Energy paper 16, HMSO £3*) and announced that the Department of Energy would be adding £3.6 million to the £2.4 million already being spent by the Industry and Environment Departments in r & d on solar energy. The main areas of the new study will be in domestic water and space heating. Up to half the cost of suitable projects by commercial firms would be supplied.

A lecture on "An experimental energy-saving house" will be given at the IEE, Savoy Place on April 21 at 5.30.

# Characteristics and load lines

## 5 — Non-linear load lines

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

Part 3 (October 1976) and Part 4 (February) were devoted to linear load lines but in practical circuits load lines can be non-linear for a number of reasons. In this part we shall examine the forms of non-linearity of load lines that can occur and the effect this has on circuit performance.

### A.c. and d.c. load lines

When a load resistor  $R_1$  is capacitance-coupled to a following resistor  $R_2$  there are effectively two load lines, one representing the steady-state or d.c. conditions in the circuit and the other representing the signal-frequency or a.c. conditions: these are sometimes known as the static and dynamic load lines. Because the a.c. resistance in the load circuit is necessarily less than the d.c. resistance, the a.c. load line has a greater slope than the d.c. load line and intersects it at the quiescent point as shown in Fig. 1. As a result the output voltage available from an amplifier is reduced by the connection of  $R_2$ ; in Fig 1 the peak-to-peak value of the voltage is reduced from AB to ab. It is possible that the reduced output may still be adequate for the following stage but the restriction of output voltage is sometimes serious and it is useful to know precisely how great it is. The calculation is easy because the voltage developed across an unshunted load resistor  $R_1$  is  $IR_1$  where  $I$  is the alternating component of the active device output current. For the shunted resistor the output voltage is  $IR_1R_2/(R_1 + R_2)$  in which the reactance of the coupling capacitor is assumed negligible compared with  $R_2$  at the operating frequency. The ratio of the two voltages is  $R_2/(R_1 + R_2)$  which shows that if the shunting resistor is equal to the load resistor the output voltage is halved. To limit the reduction in output voltage to 10 per cent of that developed across  $R_1$  alone,  $R_2$  must not be less than  $9R_1$ . This underlines the requirements, well-known for a voltage amplifier, that the output should be terminated in a high-value resistor.

Fig. 1 also shows the output current waveform as a reminder that there is no corresponding reduction in amplitude as a result of shunting the load. On the contrary the effective reduction in the value of the load resistance increases the current output.

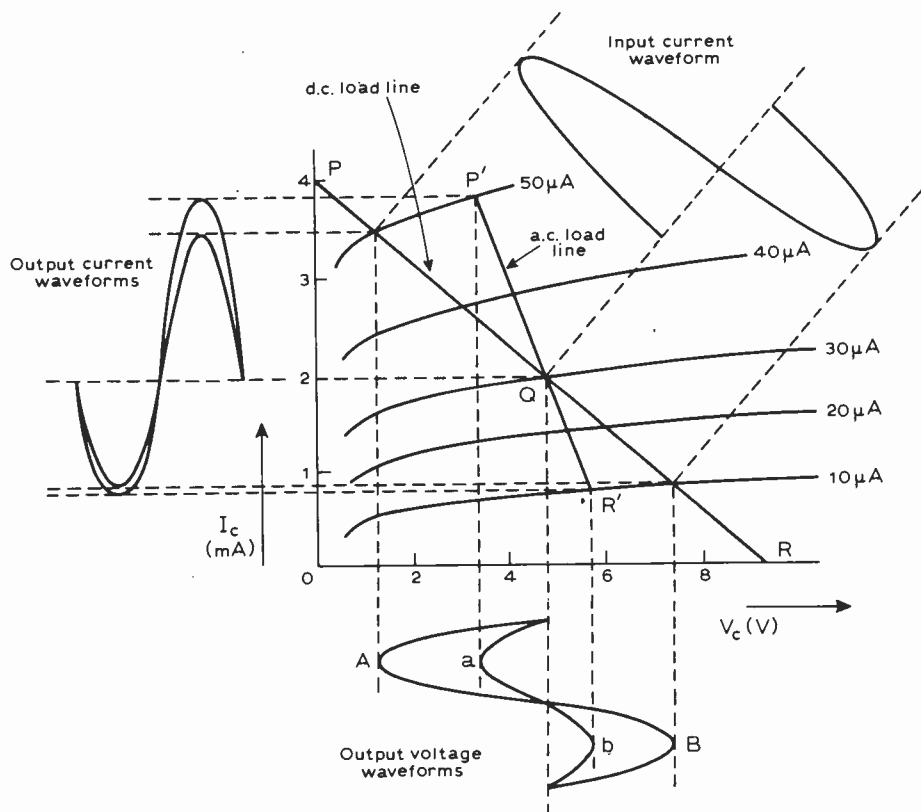


Fig. 1. The reduction in output voltage due to the different slopes of d.c. and a.c. load lines.

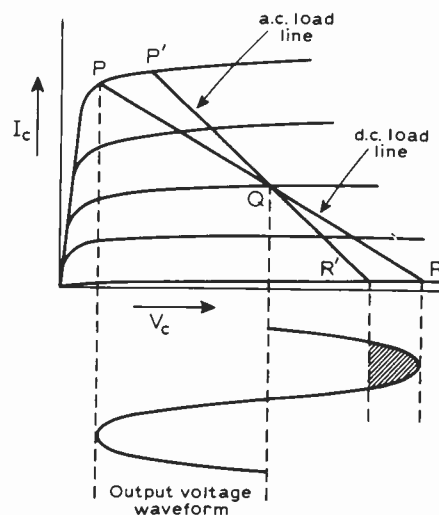


Fig. 2. Clipping of output voltage waveforms as a result of the difference in slope between a.c. and d.c. load lines.

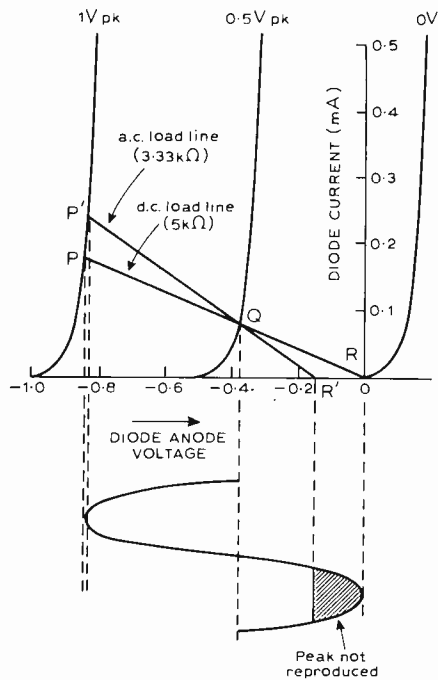


Fig. 3. Clipping of output voltage of a diode detector as a result of the different slopes of the a.c. and d.c. load lines.

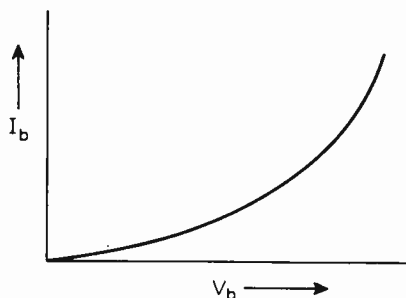


Fig. 4. Relationship between base current and base voltage for a bipolar transistor.

shunt on the diode load. The mechanism of the effect is illustrated in Fig. 3 which shows the anode voltage/anode current characteristics for a diode. These are sometimes known as rectification characteristics and each curve shows the relationship between current and voltage for a particular value of peak input.

It is assumed that the diode feeds a capacitor which charges up to the peak value of the applied signal. Thus for a 1-V peak input signal the diode anode takes up a voltage of -1 V for zero anode current. If current is taken from the diode the anode voltage falls as indicated by the slope of the characteristics. If the signal applied to the diode is amplitude-modulated the peak value varies in accordance with the waveform of the modulating signal and for a 0.5-V peak signal, modulated 100 per cent, the input swings between zero and 1V. The diode load can be represented by a d.c. load line as discussed earlier and PQR shows a load line for 5 kilohms, a value commonly used in transistor a.m. receivers. Q is the quiescent point where

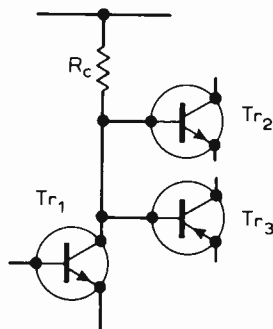


Fig. 5. Skeleton form of a driver feeding a complementary class-B stage.

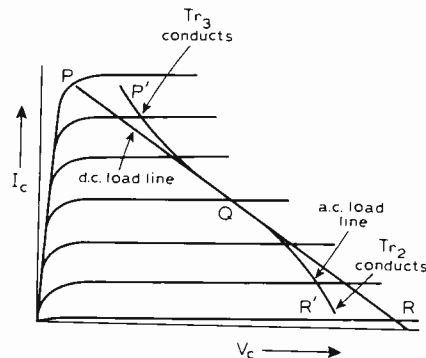


Fig. 6. D.C. and a.c. load lines for the circuit of Fig. 5.

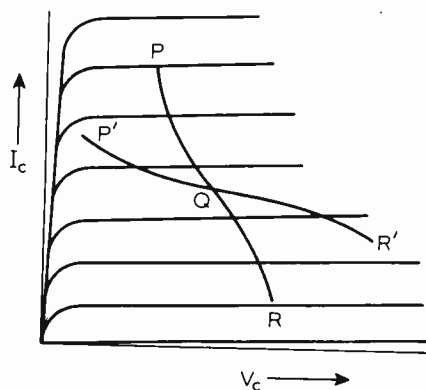


Fig. 7. A.C. load line P'QR' shows the effect of doubling the step-down ratio of the driver transformer feeding a class-B stage.

the characteristic for 0.5-V peak value intersects the load line. In the absence of modulation, therefore, the diode anode has a voltage of -0.38V and the diode current is 0.07mA. When 100 per cent modulation occurs the operating point moves up and down the d.c. load line between the limits of 0.86V (1.7mA) and zero. This represents the performance of the detector if its true load at signal frequencies is 5 kilohms.

In a practical circuit, however, the output of the diode must be applied to the following stage, normally an a.f. amplifier, and this stage has an input resistance which shunts the diode load. Let us assume that this has an input resistance of 10 kilohms. The a.c. load resistance is thus 3.3 kilohms and the a.c. load line therefore has a slope corresponding to this value of resistance and

passes through the quiescent point as shown by P'QR' in Fig. 3. This load line intersects the voltage axis at -0.15V, so clipping one of the peaks of a 100 per cent modulated input to the detector as shown by the shaded area. This represents serious distortion because the upper third of the amplitude range of the signal is not reproduced. The detector can operate reasonably successfully only if the depth of modulation of the input signal is limited to 67 per cent. The tendency in a.m. broadcasting is, in fact, to keep the modulation percentage high so to give a good signal-to-noise ratio. Thus to enable the detector to handle high modulation percentages the shunting effect on the diode load must be minimised and the a.f. amplifier should therefore have an input resistance high compared with the value of the diode load. Perhaps the easiest way of ensuring low distortion would be to interpose an emitter follower between the diode load and the a.f. amplifier.

**Non-linear load resistance**

So far in this series it has been assumed that the loads presented to active devices are purely resistive: the load lines are accordingly linear, showing the direct proportionality between current and voltage for such loads.

If, however, active devices are connected in cascade as in multi-stage equipment the load for one stage is often largely determined by the input resistance of the following stage. For a bipolar transistor the input resistance is not linear but varies with input voltage as indicated by the  $I_b-V_b$  characteristic in Fig. 4. The slope of this curve is low for small values of  $V_b$  showing that the input resistance is high for such values but as  $V_b$  increases the slope increases and the input resistance decreases. For small alternating signals the changes in input resistance may be negligible and it is common in the design of small-signal amplifiers to assume that the input resistance is constant throughout each cycle of input signal. For large signals, however, the variations are significant and must be taken into account in designing circuits. This is particularly true of the input resistance of class-B stages where the transistor is biased near collector-current cut-off and is driven into conduction by the input signal. Because a transistor so biased can amplify only one half cycle of a sinusoidal input, class-B stages in linear equipment are operated in push-pull. This makes the stage symmetrical so that the input resistance for a particular value of positive-going input is the same as for a negative-going input of equal amplitude.

As input increases, however, input resistance decreases. To deduce the effect of such input-resistance variations on the shape of the load line for the driver stage consider the circuit shown



in Fig. 5. The d.c. load line for  $R_c$  is PQR in Fig. 6 and this represents the relationship between  $Tr_1$  collector voltage and collector current in the absence of any shunting effect from the following class-B stage. Q is the quiescent point at which, we shall assume, the two class-B transistors  $Tr_2$  and  $Tr_3$  are almost cut off. The effect of a resistive shunt on  $R_c$  is to introduce an a.c. load line which passes through Q and is rotated clockwise with respect to the d.c. load line to an extent which increases with decrease in the value of the resistive shunt. Thus the rotation is slight for small-amplitude signals (i.e.

for operating points near Q) for which the class-B stage presents a high resistance. The rotation increases however as signal amplitude increases and operating points move away from Q. Thus the a.c. load line has the elongated S shape shown as P'QR' in Fig. 6.

If a sinusoidal signal is assumed applied to  $Tr_1$  base it is possible to deduce from Fig. 6 the waveform of the corresponding collector current and voltage. The curvature of P'QR' is such that it can cause serious distortion of the collector-voltage waveform but this is not generally of importance because it is the shape of the current waveform

which matters and, provided the load line is reasonably steep, there is unlikely to be serious distortion of the current waveform. This is to be expected because a current amplifier should be presented with a low-value load. Such a load ensures that any load-value variations have negligible effect on the output current and that most of the current enters the class-B stage rather than  $R_c$ .

If a transformer is used to couple a class-B stage to the driver stage, the turns ratio can be adjusted to present the driver stage with a desired value of load resistance. As an example consider Fig. 7 which shows at P'QR' the load line representing the input resistance of a class-B stage. If the step-down ratio is doubled, the effective resistance at the primary winding is quadrupled and the driver stage is called upon to deliver twice the voltage swing and one half the current swing. The load line thus rotates anticlockwise about the quiescent point and its new position is at P'QR'.

**Elliptical load lines**

In linear amplification where transformers are used between cascaded stages it is normal practice to make the primary inductance so large that the reactance even at the lowest frequency is large compared with the load resistance. The effective load is then purely resistive and the load line is linear as described earlier.

Suppose, however, that the shunt reactance is not large and absorbs an appreciable fraction of the output current, or that an inductor is connected in series with a load resistor to extend the upper frequency limit as in a video amplifier. How does the reactance so introduced affect the load line?

To determine this consider Fig. 8 which shows the current-voltage relationship for a linear resistor initially free of associated reactance. It is assumed that the resistor is the load of a transistor and the voltage plotted along the horizontal axis is not the voltage drop across the resistor but the voltage at one end of it, e.g. the collector voltage of the transistor feeding the resistor. The other end of the resistor is assumed connected to the positive supply terminal. Thus an increase in the collector voltage means a decrease in the voltage across the resistor and a proportional decrease in the (collector) current through it. If the collector current varies sinusoidally as shown at abcde the corresponding collector voltage ABCDE is inverted with respect to it.

Suppose now that the resistor is shunted by an inductor with a reactance at the frequency in use of twice the ohmic value of the resistor. The sinusoidal current abcde flows in the resistor as before but there is now an additional current (in the inductor) which has half the amplitude of the resistive current and lags it by 90°. This reactive current is shown as a'b'c'd'e' in

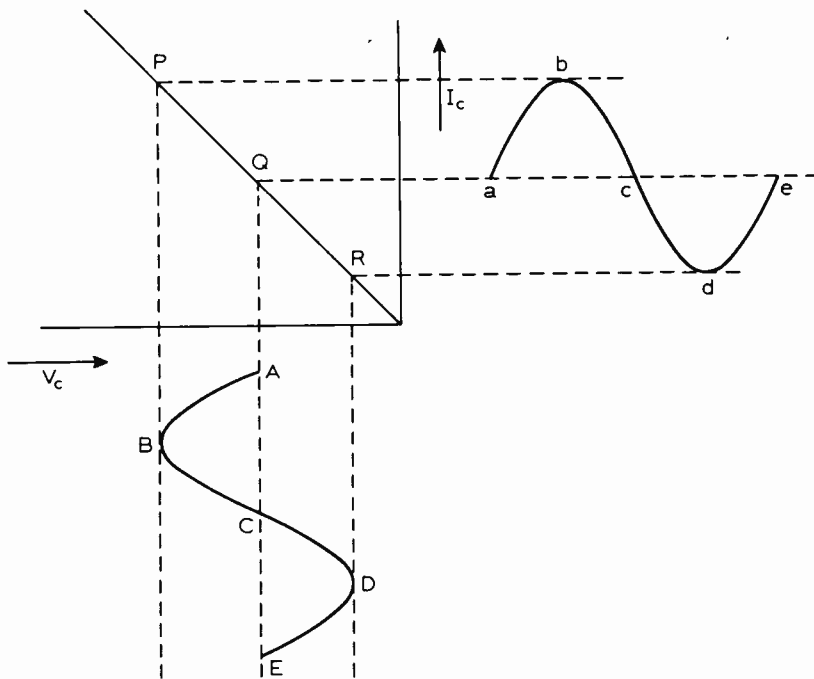


Fig. 8. Current-voltage relationship for a linear resistor.

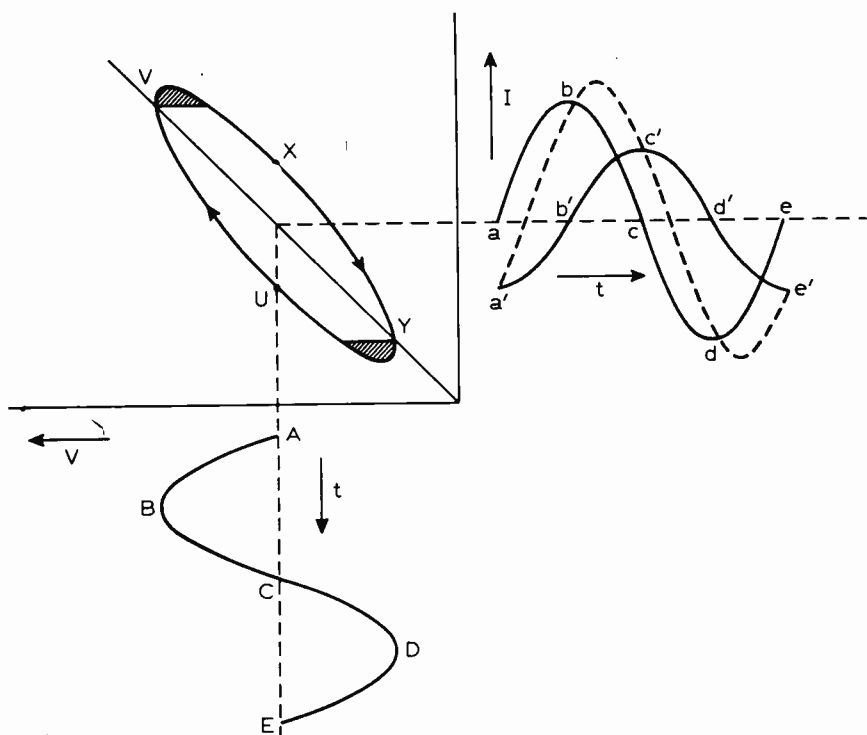


Fig. 9. Derivation of the elliptical load line for a parallel LR combination.

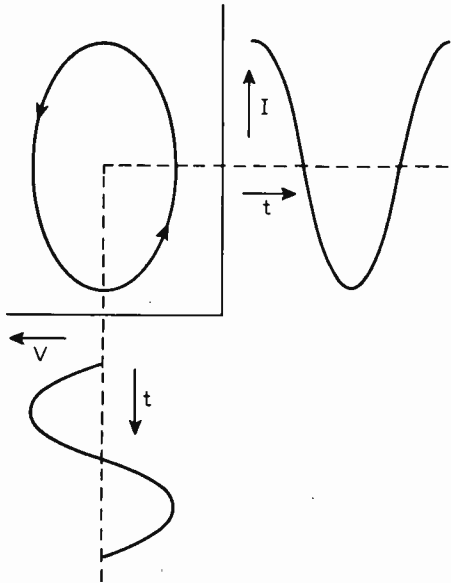


Fig. 10. A purely-reactive load has a load line in the form of a true ellipse. This ellipse and the associated current and voltage waveforms apply to a purely-capacitive load.

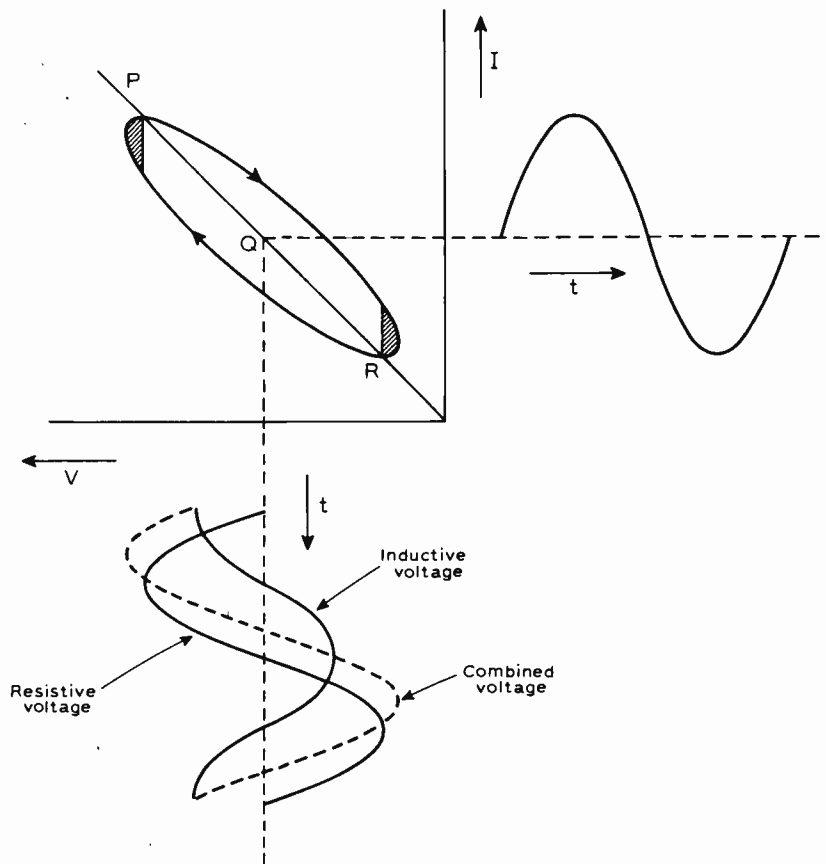


Fig. 11. Elliptical load line for a series LR combination.

Fig. 9. The current in the LR combination, i.e. the output current of the active device, is the sum of  $abcde$  and  $a'b'c'd'e'$ . If we take the datum line  $ace$  as representing zero current, the sum of  $a$  and  $a'$  is at  $a'$ . Similarly the sum of  $b$  and  $b'$  is at  $b$ . By continuing in this way we can deduce the shape of the waveform of the net current. It is shown in dashed lines  $a'bc'd'e'$  in Fig. 9 and is, of course, sinusoidal with a frequency equal to that of the voltage but phase retarded relative to the voltage. The amplitude of this current is in fact approximately 1.12 of that of the resistive current and is  $26.5^\circ$  retarded relative to it. We now know the waveform of the voltage across the LR combination and that of the net current through it. From this information we can deduce the form of the load line in the following manner. The current corresponding to voltage A is at  $a'$ : vertical and horizontal lines from these points meet at U which is therefore a point on the load line. Similarly the current corresponding to voltage B is at  $b$  giving point V on the load line. By continuing in this manner we obtain points X and Y and the next point is back again at U, showing that the load line has the form of an ellipse and that the operating point moves in a clockwise direction around the circumference of the ellipse at the rate of one revolution per cycle of signal.

The elliptical shape results from the interaction of two sinusoidal signals at the same frequency but with a phase displacement between them and can be demonstrated on an oscilloscope by applying the two signals to the X and Y plates: the ellipse is, in fact, one of the Lissajous figures.

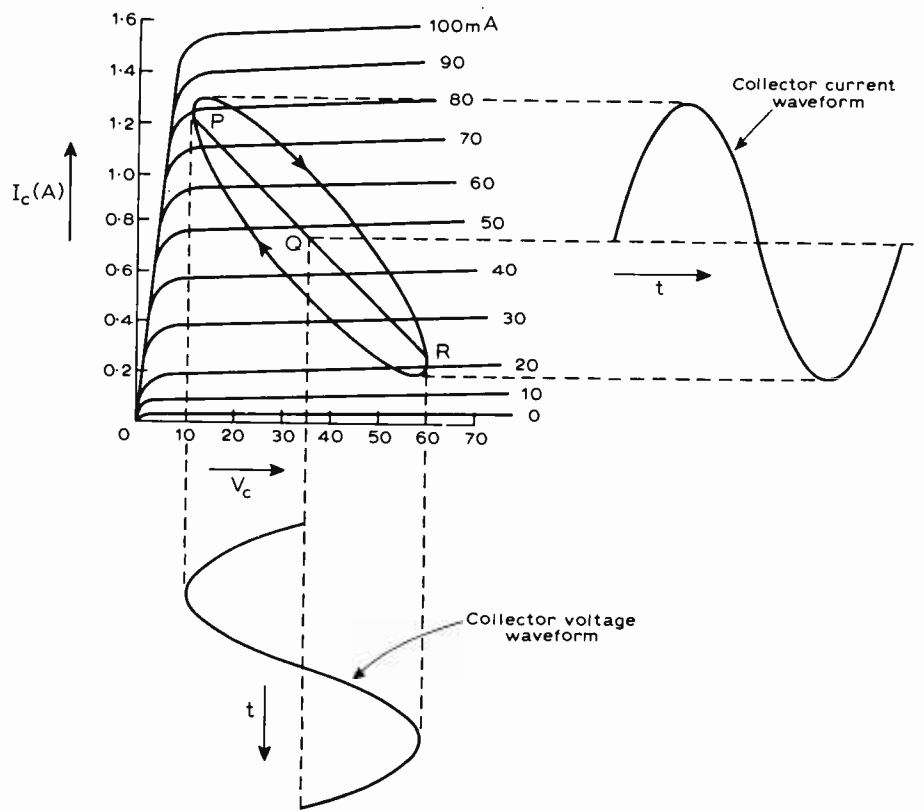


Fig. 12. An elliptical load line superimposed on a set of  $I_c - V_c$  characteristics.

The ellipse shown in Fig. 9 was for a parallel combination of resistance and inductance. For a parallel RC circuit the reactive current is phase advanced on the voltage but a similar elliptical load line results, the operating point this

time moving anticlockwise around the perimeter.

In a series LR combination it is the current which is common to the two components. As shown in Fig. 11 the voltage across the resistor is in phase

with the current; that across the inductor leads the current by  $90^\circ$ . The two voltages are added to obtain the net voltage across the combination and this, together with the current waveform, enables the shape of the load line to be deduced. It is again an ellipse and operating-point rotation is clockwise. A series RC combination gives a similar ellipse but the operating point moves anticlockwise around it.

The "fatness" of the ellipse, i.e. the ratio of the minor to major axis, depends on the phase displacement between the current and voltage in the load. If there is no displacement the ellipse becomes the linear load line VY in Fig. 9. If there is  $90^\circ$  phase displacement, as for a purely inductive or capacitive load, the ellipse has the form shown in Fig. 10. The major and minor axes are now vertical or horizontal and this is a true mathematical ellipse obeying the equation  $x^2/a^2 + y^2/b^2 = 1$ .\*. By suitable choice of scale for the current and voltage axes the major and minor axes can be made equal and the ellipse then becomes a circle. An elliptical load line such as that shown in Fig. 9 is a combination of a true ellipse (representing the reactive component of the load as in Fig. 10) and a linear load line (representing the resistive component of the load). An important point is that the ellipse is not symmetrical about the linear load line but is rotated slightly about the quiescent point in a clockwise direction for a parallel reactance/resistance combination and anti-clockwise for a series combination: thus the resistive load line does not coincide with the major axis of the ellipse.

The shaded areas in Fig. 9 represent the additional current which the active device has to deliver as a result of the reactive component of the load. The voltage swing is unaffected by the addition of the reactive component as would be expected for a parallel combination.

Fig. 11 applies to a series LR combination and the shaded areas here represent the additional voltage which the active device must deliver as a result of the addition of the reactance: the current swing is unaffected.

Curvature of load lines is usually associated with waveform distortion and it might therefore be expected that an elliptical load line (which has pronounced curvature) would also produce distortion. In fact, as shown in Fig. 9, it produces phase shift between the current and the voltage waveforms. This is perhaps clearer in Fig. 12 which shows the same elliptical load line superimposed on a set of  $I_c - V_c$  characteristics. For the particular reactance/resistance ratio chosen (2:1) the collector voltage is phase advanced on

the antiphase condition by  $26\frac{1}{2}^\circ$ . If the load line for a parallel reactance/resistance combination is known only as an ellipse the position of the linear load line representing the resistive component can be found by drawing two vertical tangents to the ellipse at its left-hand and right-hand extremities and by joining their points of contact. (For a series reactance/resistance combination the tangents should be horizontal and touching the upper and lower extremities of the ellipse). The reciprocal of the slope of this line gives the value of the resistance. This construction has been carried out in Fig. 12 and the linear load line PGR corresponds to a resistance of 50 ohms. The shunt reactance is 100 ohms. An input (base)

current swing from 13mA to 83mA gives a collector current swing from 0.15A to 1.25A. The corresponding collector voltage swing is from 60V to 10V. Although the current limits are 0.15A and 1.25A some of this is due to reactance (see Fig. 9) and the useful power output is provided by the swing between 0.2A and 1.2A, the current limits for the linear load line. The single-peak current and voltage values are thus 0.5A and 25V giving the power output as 6.25W.

This has been by no means a complete account of load lines: for example there has been no mention of load lines for push-pull amplifiers. It is hoped, however, that it has proved an interesting introduction to the subject.

## Wireless World amateur radio station

On January 29 *Wireless World's* amateur radio station went on the air. This club station, call sign G8LWW, is licensed to operate in the amateur frequency bands from 144MHz and above (conditionally up to 24GHz). Under the recently-modified licensing conditions this means that *Wireless World* is permitted to operate the modes of fixed, mobile, pedestrian mobile, r.t.t.y. (radio-teletype), television, slow-scan television, facsimile, data and d.s.b.s.c. (double-sideband suppressed carrier). This will also include satellite communications through the amateur satellites Oscar 6 and Oscar 7.

The decision to have a permanent station was made in order that *Wireless World* can participate, in the practical sense, in communications in the same way that it does in the electronics field through constructional projects. This is the first time the journal has had a permanent amateur radio station; the only other time that an amateur station operated from its offices was when *Wireless World* celebrated its 60th anniversary in 1971 with the station GB3WW operating under a special short-term licence (see May 1971 issue).

The station, whose "main address" is at

Dorset House, Stamford Street, London S.E.1, is situated at the top of a nine storey building at about 50m above-sea-level. In due course *Wireless World* intends to design and build its own equipment but until time can be found to carry out this project the station will continue to use tried and proven commercial equipment. Equipment presently in use in the 144 to 146MHz (2 metre) band is the Icom IC201 multi-mode transceiver which provides f.m., u.s.b., l.s.b. and c.w. modes. This 'rig', which uses a v.f.o. to give full 2-metre coverage, also has full facilities for repeater and reverse repeater, an automatic tone burst, break-in on c.w., and v.o.x. (voice-operated switching). The 10W output is fed into a ten-element crossed-yagi aerial mounted twenty feet above the roof of the building on a heavy-duty rotator, and connected for right-hand circular polarization (in preparation for satellite communication). The aerial apparatus and associated equipment was supplied by South Midlands Communications Limited. G8LWW is presently being operated by the licensee, Ray Ashmore, an assistant editor of *Wireless World*, whose own call sign is G8KYY. The station also has available an h.f. (3 to 30MHz) transceiver, the Yaesu Musen FT301, which has been operated from the *Wireless World* station by Ron Leath under his call sign G4ASE. This transceiver, which is capable of delivering the maximum permissible output of 400W, was used with a 40/80m trap-dipole and, after only three QSOs on 80 metres, made contact with SV4KS in Greece.

One disadvantage of the station location is a 31 storey building, part of the IPC complex, directly to the north and only about 100m away from the aerial. Although the effect that this building has on transmission and reception from and to the station has not yet been accurately determined, it represents a line-of-sight restriction of about 12 degrees, which will make contacts to the north of England and Scotland more difficult on 2-metres. However, it is hoped that the favourable "take-off" towards Europe will prove interesting, especially during the summer months when good v.h.f. propagation conditions will be more frequent.



\* This equation applies when the centre of the ellipse is the origin of the rectangular co-ordinate system.

# Metal detector

## B.f.o. circuit using fifth search oscillator harmonic for enhanced sensitivity

by D. E. O'N. Waddington, M.I.E.R.E.

**Metal detectors have fascinated people for a long time and a great many have been designed and built. Some work, but a high proportion have been abandoned as impractical by their disillusioned constructors. This article, in addition to giving the design for a practical metal detector, will explain some of the pitfalls and show how they may be circumvented.**

All the metal detectors known to me use the modification of the magnetic field associated with one or more inductors to locate metal. Three main types are made commercially; b.f.o., induction balance and pulse induction. I will confine my description to the b.f.o., since this is the simplest to implement and, provided that due precautions are observed, it is adequate for most purposes.

Before proceeding any further, however, I think that it is as well to look at some of the legal aspects of metal detectors. Since, under the terms of the Wireless Telegraphy Act 1949 they have been deemed wireless telegraphy apparatus, they come under the jurisdiction of The Home Office who, at present, requires that a licence should be obtained for the use of the detector. Currently, this is £1.20 and permits the use of a "pipe finder" for a period of five years. In addition, the frequency of operation is limited to the range from 16 to 150kHz, with a forbidden band from 90 to 110kHz. In practice, the preferred bands are 85 to 90kHz and 110 to 144kHz. Before a detector may be used it must be "type approved" by the Home Office. Needless to say, the circuit to be described has approval.

With regard to the use of the detector for "treasure hunting" it is as well to observe a few rules:

- Never prospect a known archaeological site. If you do, you will incur the undying wrath of the archaeological fraternity in addition to possibly destroying historical information.
- Report unusual historical finds to your local museum.

- If you find any gold or silver, report the find immediately to the police, who will inform the local coroner. He will hold an inquest to decide to whom the find belongs. (A study of the laws relating to 'treasure trove' will help you to understand your rights.)

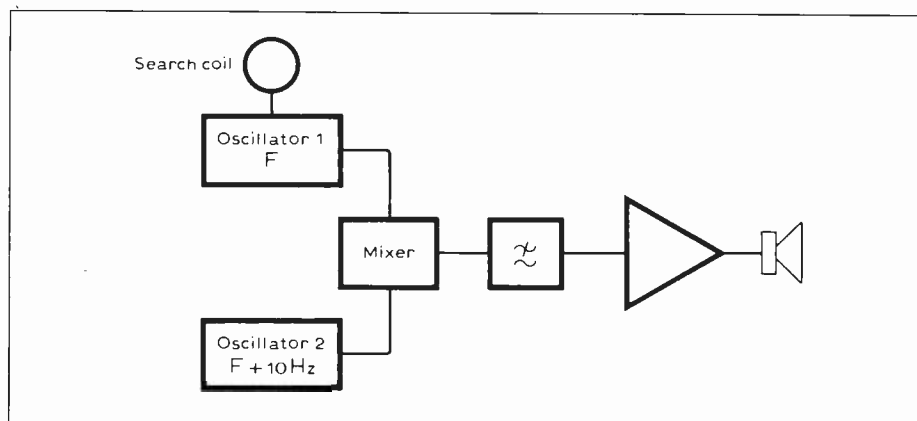
- If you find unexploded ammunition or a bomb, mark the place, leave well alone and inform the police.

- Do not leave a mess after excavating your finds.

- The issue of a licence does not absolve the licensee from obtaining any necessary consent before entering on any private property with any apparatus.

The principle of the b.f.o. detector is illustrated in Fig. 1. The outputs of two oscillators, tuned such that there is a small frequency difference between them, are mixed. The difference frequency is selected by a low-pass filter, amplified and fed to a loudspeaker or headphone. When a metallic object is brought near to the search coil, its inductance changes causing a change in the frequency of oscillator 1 and a corresponding change in the difference frequency. Non-ferrous metals will cause the frequency of the search oscillator to increase and ferrous metals should have the opposite effect. I use the word "should" since, in practice, both the shape of the object and its state of decomposition appear

Fig. 1. Block diagram of a simple b.f.o. metal detector.



to affect the sense of the change. At first sight, it would appear a simple matter to apply this principle to a practical metal detector but there are a number of problems which need to be overcome before a satisfactory design can be achieved. The first of these concerns the search coil.

The frequency of oscillation will change if the reactance of the coil changes at all. Thus it is as susceptible to capacitance as to inductance changes. Indeed the change in coil capacitance caused by moving it relative to the ground may well exceed the inductance change caused by the object being sought. Fortunately, it is quite easy to minimize this effect by fitting a Faraday screen to the coil. This is done by wrapping the coil with a conductive foil, which is connected to the internal "earth" of the oscillator. There should be a break in the foil so that it does not constitute a short-circuited turn. When I first tried this out, I feared that it would reduce the sensitivity of the coil to metallic objects but measurements showed that the sensitivity was unchanged, while capacitive effects were reduced to negligible proportions. Another cause of spurious frequency change is heat: moving the coil from sunlight to shade can cause a large and fairly rapid frequency change. This effect can be reduced by suitable thermal insulation.

In order to select the best size of coil for the detector I made a series of tests plotting the frequency change caused



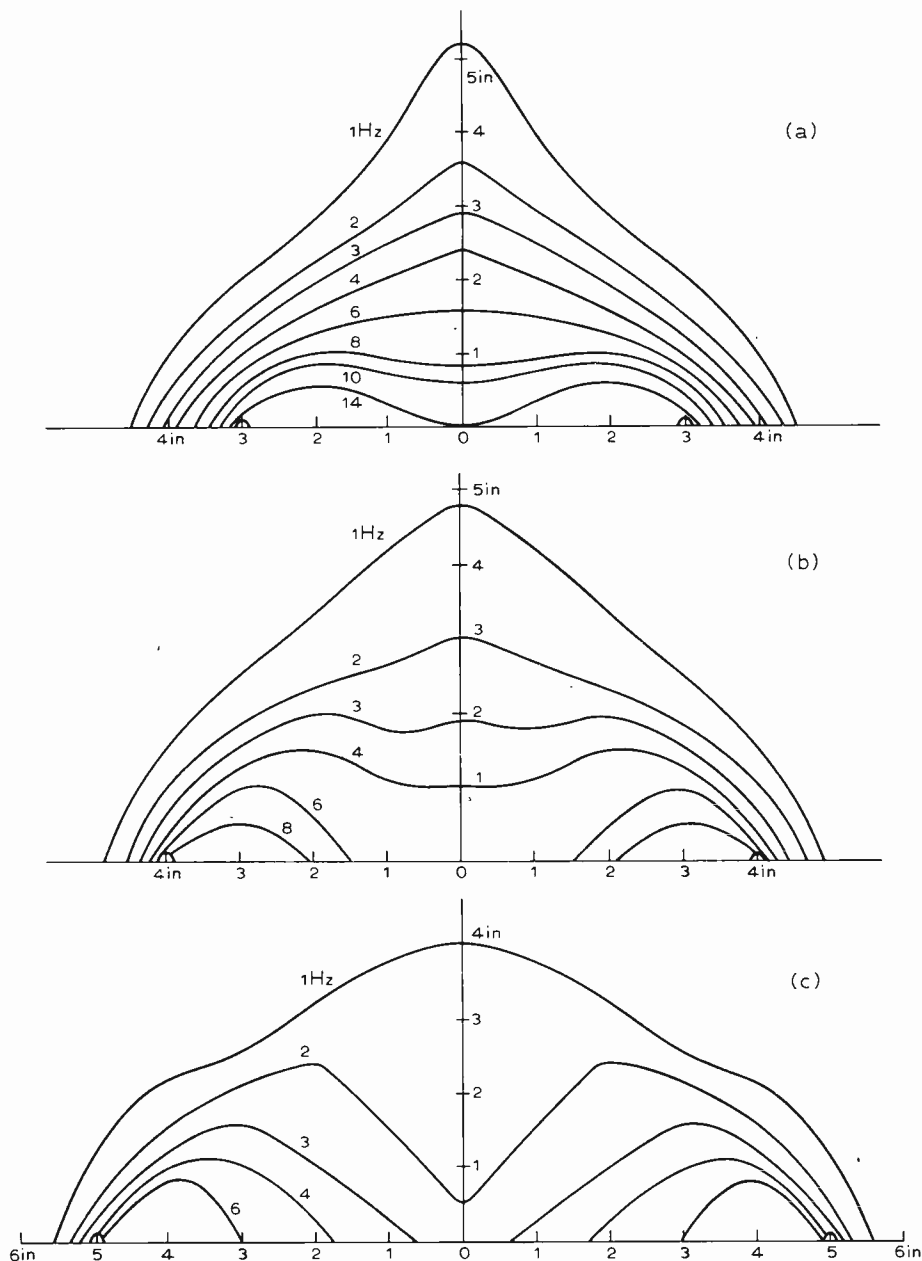


Fig. 2. The lines show the contours of equal frequency change for a 1/2p coin at a frequency of 100kHz with various coil sizes (a) 6" (b) 8" (c) 10"

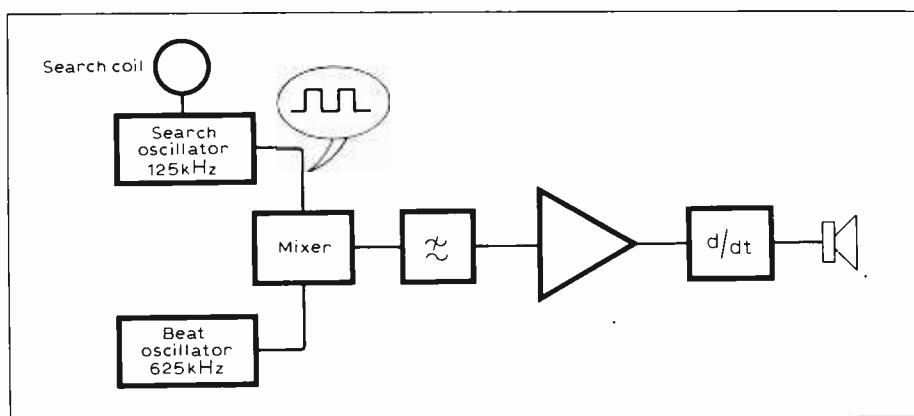
by a 1/2p coin with various coils. The inductance of the coil does not appear to be an important factor, but the diameter is. The results for 6in, 8in and 10in coils are shown in Fig. 2. They may not be strictly accurate, since the measurement is a very tedious one, but they do show what is to be expected. The important points are:

- The frequency change is very small.
- The sensitivity at the centre of the smaller coils is much the same, while the 10in coil is less sensitive.
- The larger the coil, the larger the sensitive area. However, this is not always an advantage, since it is still necessary to pin point the article being sought and the smaller coil gives a much better "focus". For my own design I have chosen the 6in coil.

The magnitude (or should I say smallness), of the frequency change is

one of the main problems in using a b.f.o. metal detector. One very practical solution is to set the oscillator frequencies such that the frequency difference is very small  $< 10\text{Hz}$ . When this is done a change of one or two hertz is readily discernible. If the frequency difference were of the order

Fig. 3. Block diagram of an improved metal detector.



of 250Hz this change could only be heard by a trained listener. Since a normal loudspeaker or headphone does not reproduce low-frequency tones, the low frequency waveform can be converted into a pulse train, which is then easily reproduced.

The sensitivity of the b.f.o. can be increased as shown in Fig. 3. Here the search coil oscillator is operated at a frequency of 125kHz and its output is converted to a square wave, which is rich in harmonics. The beat oscillator runs at a frequency of 625kHz, i.e. five times the search oscillator frequency. Thus, the beat oscillator is mixed with the 5th harmonic of the search oscillator so that any frequency change is multiplied by five. This makes it very much easier to hear a change in frequency, although the susceptibility to drift is much greater. A higher harmonic could be used but it should be remembered that, with a square wave, only odd harmonics are present and the amplitude of the harmonic will be equal to the amplitude of the fundamental divided by the harmonic number. The rather odd choice of frequencies has been dictated by the fact that most constructors will only have a medium-wave radio receiver for setting up purposes and will have no simple means of checking the frequencies. If the beat oscillator is set to 625kHz, the beat note will only be heard strongly if the search oscillator is tuned to an odd sub-harmonic ( $625/5 = 125$  or  $625/7 = 89.286$ ) and the forbidden band from 90-110kHz will be avoided. This precaution is necessary as it is difficult to control all the stray capacities associated with the search coil.

### Design

The circuit of a metal detector based on the above considerations is shown in Fig. 4. I chose the "long-tailed-pair" oscillator for this application because it is easy to design, the tuned circuit needs only two connexions and the output is isolated from the tuned circuit so that the frequency of oscillation is virtually unaffected by loading or signals fed to the output. This last is particularly important for this application, in which it is essential that the oscillators do not lock to each other when the frequency, or in this case, harmonic frequency

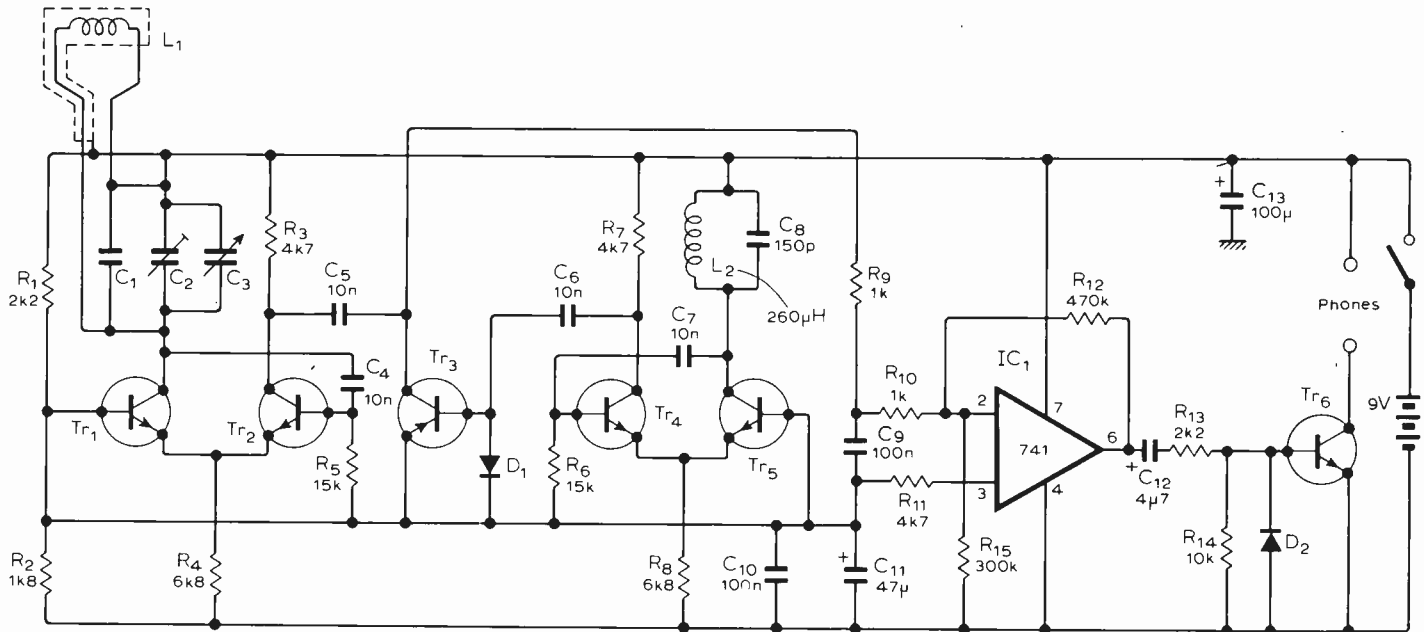


Fig. 4. Circuit diagram for metal detector.

difference is small. The search oscillator uses  $Tr_1$  and  $Tr_2$  with  $L_1$ ,  $C_1$ ,  $C_2$  and  $C_3$  forming the tuned circuit. It will probably be necessary to select  $C_1$  to give the correct frequency, since the Faraday screen and the screened lead add an indeterminate amount of capacitance in parallel with the coil. This capacitance depends upon the physical construction of the coil and the materials used and is rather variable. Coarse tuning is carried out by  $C_2$ , while  $C_3$  is used for fine adjustment. The search oscillator output is taken from the collector of  $Tr_2$  to the mixer  $Tr_3$ . The beat oscillator uses  $Tr_4$  and  $Tr_5$ ;  $L_2$  and  $C_8$  form the tuned circuit, which resonates at 625kHz. The drive to the shunt gate mixer  $Tr_3$  is taken from the collector of  $Tr_4$ . The difference frequency is selected by the low-pass filter, formed by  $R_9$  and  $C_9$  and is amplified by  $IC_1$ , differentiated and then fed to  $Tr_6$ , which drives the phones or loudspeaker. The volume can be controlled by connecting a variable resistor in series with the output.

**Construction**

The layout of the circuit does not appear to be critical - a practical version using matrix board is shown in Fig. 5. Mount the circuit inside a screened box so that hand capacitance does not affect the tuning.

The construction of the search coil is very important. It should be sufficiently robust to withstand rough handling, light, so as to be portable and adequately insulated against temperature change and moisture. I found that the construction shown in Fig. 6 works very well. First cut a ring of about 3/8in plywood as shown. To wind the coil, draw a 6 1/4in diameter circle on a piece of wood. Hammer 3/4in panel pins at about 1in intervals around this circle and then

wind 45 turns of 26 s.w.g. (0.46mm) wire around the pins. Tape the coil in four places to stop it springing undone. Remove the pins. Tape the coil tightly to the underside of the wooden ring, taking care that the ends of the winding come opposite to the tab for the handle. Cover the coil with a second layer of tape. Cut a strip of aluminium cooking foil about 1in wide and tape the coil with it, starting on one side of the tab and finishing at the other. It will probably be necessary to use more than one length of foil, in which case the ends should be overlapped. However take care that the start and finish of the coil do not short to each other. Bind the finish of the coil with 22 s.w.g. tinned copper wire and connect it to one end of the coil and to the screened lead. The other end of the coil is connected to the centre conductor of the screened lead. Cover the coil with a layer of tape. Cut a 1in wide strip of 1/8in thick expanded polystyrene sheet

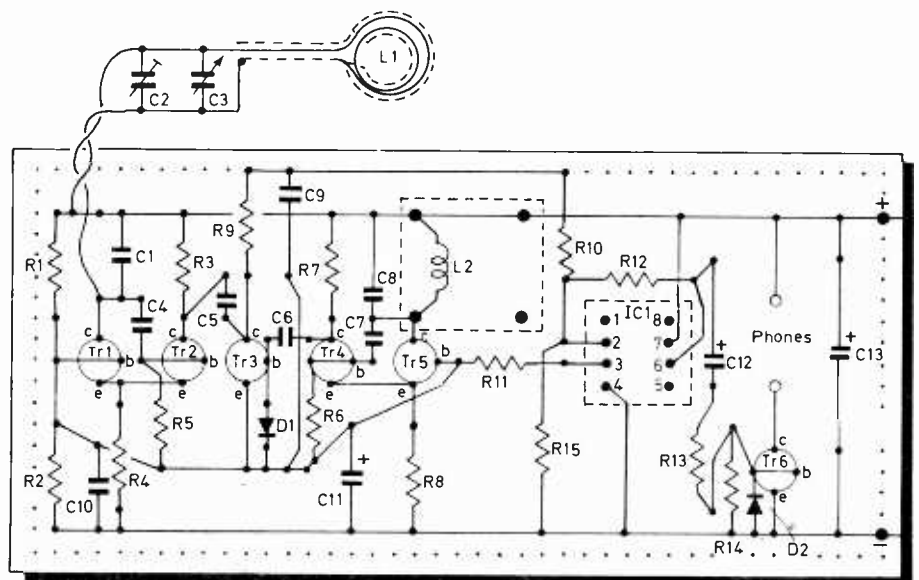
and wind this around the coil. Cover the whole with another layer of tape. Assemble the coil to the handle and paint it with white waterproof paint.

**Setting up**

The first step is to set the beat oscillator to the correct frequency.

- Short the search coil to disable the search oscillator.
- Switch on and adjust the core of  $L_2$  so that the frequency of the beat oscillator is set to 625kHz. If you have no access to a frequency counter, a medium wave radio receiver may be used. Set the dial of the receiver to 625kHz (480m). If the receiver has an aerial connection, place the aerial lead close to the oscillator, but if it only has a ferrite rod aerial it will be necessary to place the receiver close to the oscillator. This setting up must be carried out with the detector circuit mounted in its screened box with the lid off. Tune for maximum signal. Remember that you will be looking for an

Fig. 5. Layout of circuit, using pin board (no copper tracks).



# HF predictions

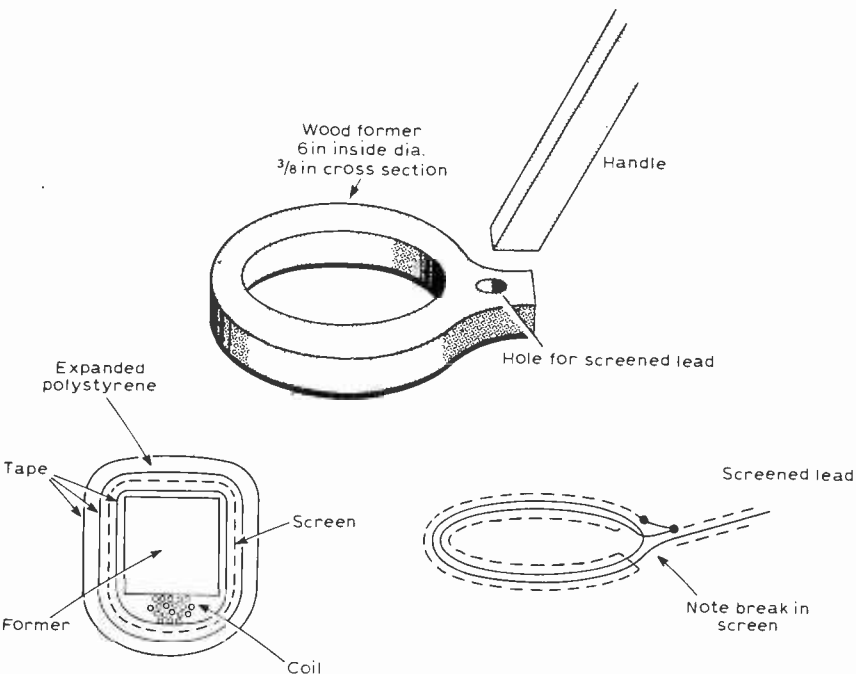


Fig. 6. Coil construction.

unmodulated carrier, so that only hiss will be heard. However, you can check whether you have the correct carrier by shorting the coil. The next step is to set the search oscillator to the correct frequency.

- Remove the short from the search coil.
- Set both the coarse and fine controls to mid-travel.
- Fit a 470pF capacitor for  $C_1$ .
- Adjust  $C_2$  and check that a beat note can be obtained. If necessary increase the value of  $C_2$  by 100pF.
- When a beat note is heard, check the frequency of the search oscillator as follows:

(a) Short the beat oscillator tuning coil.  
 (b) Using the receiver near the search coil, look for the harmonics of the search oscillator which should be as shown in Table 1. It is very probable that you will only be able to identify the odd harmonic frequencies.

(c) If the frequencies are too close together, the search oscillator will probably be running at 89.3kHz. Reduce the value of  $C_1$  and repeat the procedure. If possible it is a good idea to select a value of  $C_1$  which gives the correct frequency with  $C_2$  set to mid travel. This will allow for any drift which may occur during the life of the detector.

Table 1

Harmonic Number	Frequency	Wavelength
5	625 kHz	480 m
6	750 kHz	400 m
7	875 kHz	342.85 m
8	1000 kHz	300 m
9	1125 kHz	266.67 m
10	1250 kHz	240 m
11	1375 kHz	218.18 m
12	1500 kHz	200 m
13	1625 kHz	184.615 m

**PARTS LIST**

**Resistors**

- 1 2k2 All resistors 1/4W ±5%
- 2 1k8
- 3 1k
- 4 6k8
- 5 15k
- 6 15k
- 7 1k
- 8 6k8
- 9 1k
- 10 1k
- 11 4k7
- 12 470k
- 13 2k2
- 14 10k
- 15 300k

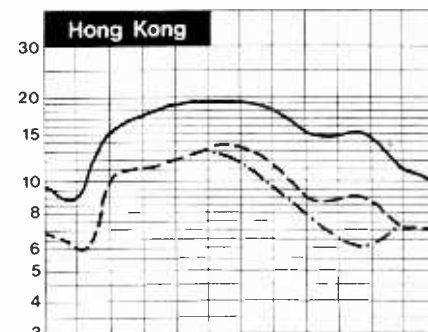
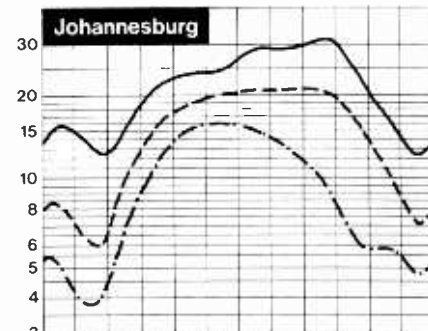
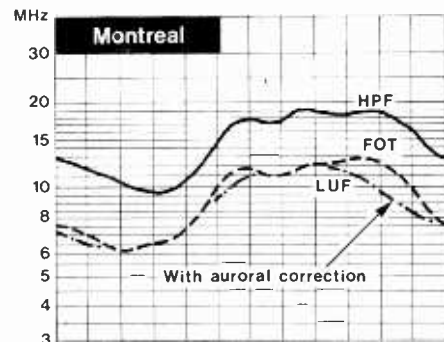
**Capacitors**

- 1 560pF polystyrene (see text)
- 2 150pF variable
- 3 10pF variable
- 4 0.01µF disc ceramic
- 5 0.01µF disc ceramic
- 6 0.01µF disc ceramic
- 7 0.01µF disc ceramic
- 8 150pF polystyrene
- 9 0.1µF 100V P.E.T.
- 10 0.1µF 100V P.E.T.
- 11 47µF 10V electrolytic
- 12 4.7µF 10V electrolytic
- 13 100µF 10V electrolytic

- $Tr_1$  2, 4, 5, 6 BF238, BC108 or equivalent
- $Tr_3$  BC308, BCY72 or equivalent
- $D_{1,2}$  1N4148
- $IC_1$  LA741C
- $L_1$  see text
- $L_2$  49t 0.28mm wire or Mullard Vinkor LA1157 (260-H)

Predicted disturbed days are 1st to 3rd and 17th to 24th of the month.

Seasonable trend and low solar activity combine to produce FOTs and LUFs which give a restricted choice of time and frequency for reliable day to day communication. The charts show that this restriction is particularly severe for circuits having both terminals in the northern hemisphere.









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# News of the Month

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## CEI split again

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The Council of Engineering Institutions has attacked the government's believed intention to hold an enquiry into the engineering profession. Sir Charles Pringle, the chairman, has told the Prime Minister in effect that such an enquiry would cause a further period of uncertainty just as the CEI was sorting itself out after its two years of dissension. But although at least half a dozen of the CEI's 15 members are said to share Sir Charles Pringle's objections to an inquiry, among the larger institutions there is a feeling that Sir Charles has spoken out of turn. All the signs are that yet another big row is brewing.

The CEI reached their attitude after a council meeting on February 10. They say that in opposing the enquiry they were reflecting the IEE and the IMechE though these bodies had also said that if there were an enquiry they would want it to include certain topics. The CEI say their attitude is that an enquiry is unnecessary but that they would cooperate if one were held.

It appears, however, that the two senior institutions take a more positive attitude to the putative inquiry. On 27th January they wrote to Mr Eric Varley saying that they would welcome it, and that it should cover: the education and training of engineers; how that education met the needs of industry; a study of compulsory registration in other countries; a study of how compulsory registration might be applied in the UK, and the allocation of certain jobs in industry to professional engineers.

The CEI say publicly there is merely a difference of emphasis between themselves and the IEE and IMechE, but we are told reliably that the CEI sent a letter to the two institutions, after they sent their letter to Varley, asking for an open apology for putting forward their point of view outside the auspices of the Council. From the other side, the dissenting Institutions have been so angered by the CEI's public pronouncements that they would now like the enquiry to review the CEI itself.

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## Radar simulator for the RAF

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A simulated timebase and echo generator (STEG) is to be added to the airborne early warning mission trainer at RAF Lossiemouth. The STEG will generate fifteen controllable radar targets on the AEW trainer displays as well as "own" aircraft movement, sea clutter, Indicate Friend or Foe, thermal noise and a blind arc. The simulator, which is portable, can also superimpose radar echoes on to a background picture derived from a video recording of an actual mission. Operators learn to spot unidentified radar echoes and to guide interceptor aircraft on to the intruders.

Four hand-held keyboards are connected to the simulator by flexible leads. The keyboards first set the STEG to match the radar parameters and then to set up and control the targets and other effects. Marconi, who make the device, say the system is one of many applications of STEG, which can be coupled to any continuously rotating pulse position indicator radar display via an interface.

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## Components helped again

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Electronic components is one of the five industrial sectors singled out by the Chancellor of the Exchequer, Denis Healey, and the Industry Secretary, Mr Eric Varley, for special help as part of an experiment "to see whether there is scope for the government to act as a catalyst in bringing about, in concert with both sides of the industries concerned, a more rapid improvement in performance. . . ."

Because each industry sector is different the approach will be different in each case, but Healey and Varley say in their memorandum to the National Economic Development Council, responsible for bringing together the necessary elements to the working of the Government's industrial strategy, that "One possible approach would be to begin in the case of each sector with a general wide-ranging meeting with both management and trade unions in that sector together with the members of the Sector Working Party, under the chairmanship of the appropriate minister. This meeting would identify the main issues to be tackled. Thereafter, we envisage that it would be useful to hold discussions with individual firms or, if particular subjects lend themselves to more broadly based consultations, with groups of firms, to pursue these issues." Companies would be asked for their views, particularly on

the sector working party reports but also on the whole range of Government policies.

An element of the Government's as yet vague proposals especially welcome to the components chiefs will be that although in the current economic circumstances resources are limited, "to the extent that public money is needed to solve the problems of the five sectors set out above (or those of other sectors) or, indeed to push forward the work on industrial strategy generally, the resources will within reason be available."

The proposals also follow news of a £20 million aid scheme for the components industry, which *Wireless World* reported last month. Still further help is expected from the European Commission (see WW News, March p48).

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## Students for industry

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Sponsored students may get an extra £500 a year from their employers without a reduction in the local authority grant under a scheme outlined by the Education Secretary, Mrs Shirley Williams, in the Commons on February 3. From September 1977, she said in a written reply, "payments by employers to students whom they wish to sponsor, or by institutions who wish to give scholarships of up to £500 per annum will not be taken into account in the assessment of mandatory awards by local education authorities. This will be in addition to the amount of income disregarded under the present arrangements which is £185 per annum and now under review for the academic year 1977/8."

At present a local authority, in assessing a student's income for making a grant, does not take into account the first £185 per annum of income, any holiday earnings, or various pensions and benefits. Later in the year changes in the rates and conditions applying to mandatory awards, including the £185, will also be announced.

Currently about 7,200 undergraduate students and 2,600 postgraduates are fully supported by employers rather than by a grant. About a third are supported by industrial or commercial concerns and the rest by Government departments. Normally an employer makes a choice between giving a student £185 on top of his grant or paying him a salary greater than the grant would have been. About 400,000 students in Britain receive grants totalling £382 million, according to the Department of Education and Science, though this includes a controversial £107 million supplied by parents or spouses. In 1974-75 a Department survey showed that about half the students on mandatory grants did not get all the parental contribution, or £90 for each student underpaid.

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## Bullock's boardroom and the engineer

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Lord Bullock himself has acknowledged that the proposals the majority of his committee agreed after a year's work may never be carried out. But he is not discouraged. The vigour of the debate since his report was published on January 26 has shown that the call for greater involvement of workers in company policy decisions which affect them has suddenly become a political issue. It is likely to remain so.

Among those who gave evidence were the Association of Professional Scientists and Technologists, the Business Equipment Trade Association, the CEI, the Electrical, Electronic, Telecommunication & Plumbing Union, EMI, GEC, Philips Electronic and Associated Industries, and the United Kingdom Association of Professional Engineers. The EETPU expressed the strongest opposition to the representation of trade unions on the board because they saw a conflict between collective bargaining and such representation: "It is not the responsibility of work people to manage the enterprise . . . It is essential that trade unions retain their independence." The EETPU thought that the job of the trade unions was, through collective bargaining, to "consider, contest and oppose, if necessary, the exercise of managerial prerogatives," but Bullock, unimpressed, says unions and management "have the same objective: to enable employees to participate in decision-making in the enterprise in which they work."

Reading the report makes you no wiser about the future role of the engineer, the scientist or the technician in the proposed new democratic boardroom. It is a fact of modern industrial organisation, however, that their skills and experience are badly needed.

Most of what Bullock says that is relevant to engineers is about middle management.

### Staff associations count

"Some people have suggested to us that managers and other professional groups play a particularly important role in the running of companies and often occupy a unique position between the board and other employees – at one point representing the company in discussions with employees and at another being employees themselves – and they have argued that a special seat on the board should be reserved for these groups. Provided that professional and managerial employees are organised collectively, as increasingly many of them are, we can see no reason why they should not be represented on the board amongst the employee representatives. But we do not think that a special seat should be reserved for them on the board by law." Bullock explains that it would be unfortunate to

give the impression that some employees had a special, and therefore higher, status in the eyes of the law.

Bullock adds that there is no objection to a staff association or professional association or any other employee organisation not affiliated to the TUC from being represented on the board provided it is independent of the company but recognised by it.

### Trade Unions

So if the Bullock proposals are implemented the degree to which technicians and engineers will be able to contribute to the better running of their companies will be largely dependent on the extent to which they are involved in trade unions. The Confederation of British Industry has made clear its bitter opposition to Bullock on just these grounds, saying that trade unions speak for only half the workforce. The true picture is, however, a great deal more complicated than the CBI makes out. Trade union membership is not distributed evenly throughout industry, and the smaller the firm the less likely it is to be unionised.

Of the total workforce, it is true, 50.4% are members of a union. But in manufacturing industry membership is 62%, and if enterprises with less than 200 workers are left out of account the proportion jumps to 89%. In the Post Office and telecommunications the figure is 87.9% and in metals and engineering 69.4%. Bullock's proposals, if adopted, would only affect enterprises employing more than 2,000. In the others, according to Bullock, trade unions represent only 20% of the workforce, and it is because of this that these firms have been excluded from the proposals.

Against that, these smaller companies represent 11 million of the 18 million people employed in the private sector, and two thirds of the total number of enterprises. It seems true that small firms are becoming less important – the 1968 census of production showed that firms with over 2,000 employees then represented only 21% of the enterprises – but it also seems that the Bullock idea is not to extend industrial democracy to workers in the small firms, where the majority of work is done. The CBI has not been heard to complain about that.

### Unionised engineers

On the other hand, trade unionism is still a more potent force among the wearers of blue than white collars. The qualified engineer is generally regarded as a white collar worker and as such if he is a member of a union, he is one of 4.3 million, whereas his manual union colleague is one of 7.5 million. Engineers, therefore, stand less chance than manual workers of getting into the boardroom if Bullock is adopted. But the report also notes the increasing rate at which white collar workers have joined trade unions. Since 1948, union membership among white collar

workers has increased 117%, while manual union membership has increased 0.1%. In the four years to 1974 union membership among manual workers actually fell 1.3% but rose 19% among those off the shop floor.

### The 'Y' element

For the moment, a much more likely opening for engineers lies in the proposal that a third element should balance the shareholder and union representatives. This third element, the Y in the now famous 2X + Y formula, has to be an uneven number greater than one, must be less than a third of the whole board and its membership must be agreed by the other two elements. The system, says the report "will provide an important means by which special experience and expertise can be brought into the boardroom from *inside and outside the company* . . . It may be, for example, that there will be someone in the company itself – among senior or middle management – who both sides agree could be a useful addition to the board."

### The industry view

The electronics industry has identified itself with the CBI's view of Bullock. The Electronic Engineering Association told *Wireless World*: "Our input on that will be done through the CBI." Latest figures are not available but a quick check of 39 of the companies in the EEA shows an average number of employees of around 9,6700. Many of these are companies with a large number of subsidiaries with activities across the whole range of electronics. A council meeting of the British Radio Equipment Manufacturers' Association on February 10 decided that the attitude of many of their members would be decided by parent companies here or abroad, many of them in the EEA.

### Size of firms

According to figures for the third quarter of 1976 at the Business Statistics Office at Newport, 48 enterprises in telegraph and telephone equipment employ 73,100 people; 252 enterprises in radio and electronic components employ 126,700; 37 computer firms employ 44,300; and 132 firms in radio, radar and electronic capital goods employ 90,400. No figures are available for the number of employees in the broadcast receiving and sound reproducing equipment sector.

### Does it matter?

Membership of the EEC, for which the CBI must hold itself largely responsible, commits us to some form of worker participation in the boardroom. However, the National Enterprise Board has, since the report was published, dropped its commitment to putting worker directors on its board, and the Prime Minister agreed with the CBI in February that the Bullock proposals need not be implemented as long as there is greater consultation below board level.



## V.m.o.s. devices "middle of this year"

American Microsystems (AMI) say devices which use their patented v.m.o.s. technique will be available commercially around the middle of 1977. "We are currently in the process of bringing them into production," said AMI's president and chief executive Glenn E. Penisten at a press conference in February.

He described the device as a "short channel n.m.o.s. structure fabricated in v-shaped grooves which entered the silicon surface." Advantages included vertical current paths, higher current density, and higher gain bandwidth than was possible with other devices. It was possible to get 285 dies from each 3in wafer of silicon with a side length of 145 mils each. In line with the general tendency for a reduction in the memory cell area per bit, such devices could be used to store 16kbits of information and this could be increased to 65k "before 1980". Mr Penisten told *Wireless World* that the speed of the devices was "approaching bipolar speeds, the 40ns kind of category." AMI also say the speed is less dependent on temperature change, and could work well at "enhanced ambient temperatures of 70°C." Although others might be producing discrete products using the technique AMI were further ahead, they say, in optimising "the speed/power relationships." It had been thought that v.m.o.s. was a dead-end technology because it could not be scaled (reduced in size to lower silicon consumption), but, said Penisten, that was wrong. "Our product is a product that has been scaled and scaled again." The first commercial product, a 1K static memory would be available "probably by mid-year."

## Goldring falls with the pound

A receiver was appointed on February 3 for Goldring, which in 1973 was trading so strongly that it offered 1.5 million 10p shares at £1.17 each and closed the offer oversubscribed. The day before the receiver, Mr Christopher Morris of Touche Ross, was appointed they were down to 8p.

Goldring was heavily dependent on the home market. About 85% of its business was in the UK, according to the *Financial Times*, and this had a number of effects. The first was that when VAT was increased to 25% they suffered more than firms like Garrard, which now exports something like 70% of its output. At one time Goldring stopped producing almost completely and relied on selling Swiss Lenco turntables, for which they had an agency. Another effect was that when

the pound started to fall this Lenco equipment became uncompetitive in the market they relied on.

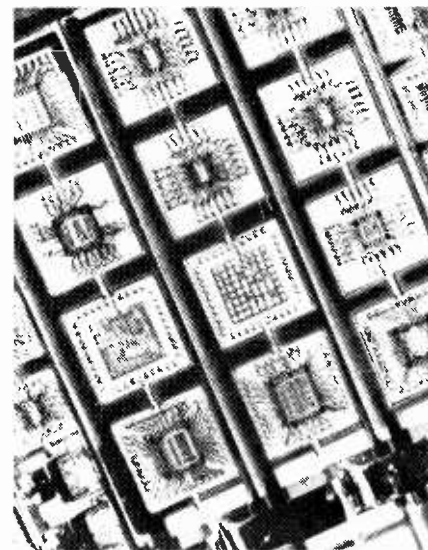
Another blow was that Lasky's stopped selling Goldring equipment when the Japanese put the marketing pressure on direct-drive turntables. While a belt-driven model might have withstood this, Goldring's rim-driven turntables were too far behind the times. They could not rely on the kind of business BSR had so successfully built up, supplying turntables for fitting to other sound systems. BSR turntables can even be found in audio systems imported from Japan, as in the case of Crown, now imported by York Electronics. Goldring also imported Toa public address equipment, which had been affected by import restrictions.

To add to everything else Goldring's premises at Leytonstone were compulsorily purchased by Walthamstow council, and they were faced with the disruption and cost of moving to Bury St Edmunds, still a matter of dispute with Walthamstow council. Cost control was not too strict, and they spent £100,000 there in offices alone, according to one account. Although staff had been reduced from 298 to 179 during 1975, effecting a reduction in the wage bill from £466,772 to £427,622, directors fees went up around £200 to £46,629. In the same year, the Barclay's bank overdraft jumped from £3,650 to £160,746, and the company borrowed a further £200,000 from the family of Mr E. Sharf, the president.

According to an informed source the receiver has now recovered the money owing to Barclay's and it now remains to get back the Sharf money, after which the future of the company seems grim indeed. Most of the money so far obtained has been won by selling off the considerable stock at a low price and keeping staff on while there are enough parts in the store to make more. The main value of the Goldring name will rest on the pickup cartridges and styli, and it has been suggested that Sharf will eventually buy the goodwill of the possibly liquidated firm. Toa have wasted no time in setting up Toa (UK) Ltd, and C. E. Hammond have already taken over the Lenco agency.

## "Britain pioneered the integrated circuit"

Mr G. W. A. Dummer, formerly superintendent of applied physics at the Royal Signals and Radar Establishment, has no doubt that Britain was the pioneer in the invention of the integrated circuit, though not the inventor in the full sense of the word. In a letter to the American journal *IEE Spectrum* (December 1976) he distinguishes between the pioneer "who thinks of it,"



**Liquid-cooled logic.** Current mode logic circuits used in Honeywell's new 66/85 computers. Honeywell say the elimination of transistor storage time makes each chip five to seven times as fast as t.t.l., using half the power: One 3in square micropackage there are up to 110 chips, "almost as much circuitry as a standard 12in square circuit board." At the back of each micropackage a liquid cooled heat exchanger eliminates the need for system air cooling. The exchanger is an oxidised copper diaphragm which, when pressurised by liquid flowing behind it, conforms to the surface of the micropack. Each board has 12 micropacks arranged in four columns of three. The coolant is pumped in parallel through each column. The liquid is cooled in an air-cooled radiator cabinet with an air blower. If the cooling system fails the computer shuts down automatically.

the experimenter "who makes a working model" and the exploiter "who develops and produces it." He writes: "The pioneering stage was certainly that of the Royal Radar Establishment (RRE) in Great Britain. It must be remembered that the "solid circuit" idea was no flash in the pan, but the result of six years' work on miniaturization. The model shown to US military and other visitors at the United Kingdom Symposium in 1957 was intended to indicate my views on the logical future of component miniaturization techniques." The real inventors of the integrated circuit, in Dummer's opinion, were "Noyce and his dedicated team at Fairchild."

As a result of reporting the 1957 UK symposium under the title "Solid Circuits," *Wireless World* (Nov. 1957 issue) subsequently ran into a spot of bother with the lawyers of Texas Instruments because TI, at a date somewhat later than the report, had decided to use "Solid Circuits" as a trade name for their devices (before the term "integrated

*Continued on page 92*

## Binaural broadcast

### First announced BBC programme

From a preliminary analysis of listeners' letters, a large majority of respondents got a sound sensation outside of the head when listening to "Oil Rig" on headphones, says the producer, Richard Imison. The Radio 3 programme was made with "binaural" microphones intended for headphone listening and was the first announced broadcast of its kind in the UK. After reading the first 500 letters, Mr Imison said about a third had experienced good all-round perception, but of the remaining two-thirds, a majority had good sound except within an arc of around  $\pm 45^\circ$  of centre front, and a significant minority found everything in front and nothing behind. The programme, auditioned for the press six days before transmission on 8th February, was a 75-minute distillation of 37 hours of interviews and sound effects from a North Sea oil rig.

An interesting choice of location, this, for while life on an oil rig may possibly make for good journalism, its remoteness from everyday life did perhaps make it a little difficult to relate it to reality, acoustically. But it wasn't difficult to discover the weak point of the technique, that is, in portraying frontal sound images, a widely recognised problem with such binaural techniques.

One found the background sensation to be good and generally located outside the head, though almost always taking place behind. Three kinds of speech were heard. Studio-produced mono narration which, as it was fed to both channels equally, appeared in the head. On location, speech was either in the head or out of the head and elevated but never in front (for those at the audition anyway).

The two sensations were produced

with two different microphone techniques. One used a 10-in diameter perspex disc with two forward-pointing eccentric omnidirectional microphones mounted either side to correspond with ear-to-ear spacing. This was used in the interview of the cook, but gave too much ambient noise on most interviews. The alternative was to mount microphones on the head of the speaker in "stethoscope" fashion — hence an in-head image.

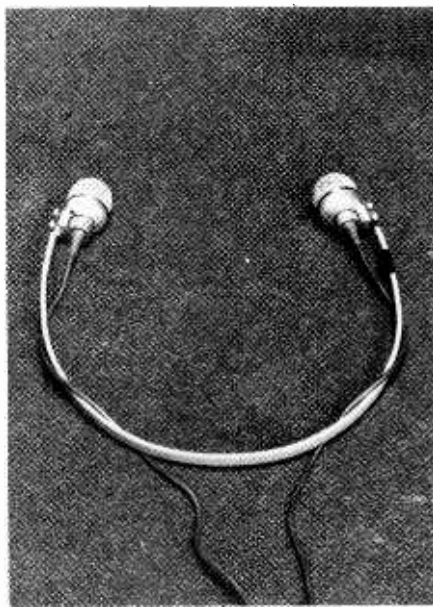
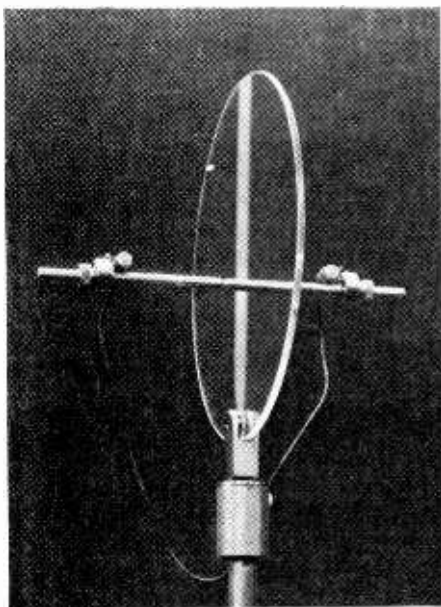
One sometimes found it disconcerting when the out-of-head speech, clearly directed at the listener, didn't come from in front where one would have liked it to come from. This lack of centre front speech is not so upsetting on special demonstrations that are intended to startle, such as on the Sennheiser dummy head recording, but it can spoil the illusion where a speaker is addressing you constantly from behind or the sides — in real life one would quickly turn to face the speaker.

### Why dummy heads weren't used

This disc baffle arrangement came about after three years of experiments by BBC Radio using first the Neumann artificial head and then the Sennheiser (both pictured on page 336 September 1974 issue). They say the heads were subject to countless tests involving hundreds of tapes, starting with a large, dead studio and going on to other studios and the open air, with different kinds of material including test sequences, plays, outside broadcasts, music.

They found that while the Neumann head was "convincing" and impressive on headphones, it had quality shortcomings on loudspeakers, in particular a steep roll off at 5kHz. The Sennheiser head and "stethoscope"-type microphone arrangement brought a

*The baffle and (right) "stethoscope" microphone pairs described in the text.*



response up to 15kHz, but the top was "edgy" and "rather hard" and the quality was not the best. Results with this arrangement on a real head were "a little better with the 'stethoscope' mikes but not good enough," commented Richard Imison. "Not really up to broadcast standards".

This was the point where an alternative had to be found; in fact the project was nearly abandoned, recalls Richard Imison. Derek Taylor of programme operations then found that good results could be obtained using better quality microphones in stethoscope fashion — Sony omnidirectional ECM50's were mounted on a headband with wind-shield and worn at the ears.

Because of the obvious limitations of this technique, checks were then made to see how much an artificial head actually contributed, starting with a head-sized carpet baffle between ear-spaced microphones (with and without plasticine pinnae!). Directional properties of the set up didn't seem any worse. In Derek Taylor's words "As long as the mics were about ear distance apart, with a baffle between to give the correct path length, the directional effects were not significantly different. Model ears or baffles behind the mics did not seem to help in resolving front-to-back confusion." Richard Imison agrees: there is "no significant difference" between the techniques tried as far as front localization is concerned. (They also agree that there isn't much difference in results between closed and open-type headphones either.)

Front-to-back ambiguity, it is argued, occurs with single, transient live sounds anyway. For continuous or longer live sounds one's head has more of a chance at assessing direction, either by unconscious minute head movements or by conscious larger movements, and the poor frontal localization with headphones is thought to be due to loss of such clues.

The BBC have obviously reached a point where they want to experiment with a large audience. But the data from listeners will have to be carefully interpreted as it seems far more likely that those who were impressed with the technique — say on account of well-defined images — would respond more readily than those for whom the technique was disappointing.

The ear-spaced microphone with baffle arrangement was made into more permanent form, as in the photograph, and used for the Oil Rig programme, as well as on other occasions including a proms recording. The prom recording, as with others, was not nearly so effective on loudspeakers though BBC personnel found it as good as the conventional stereo recordings, in some cases better. In simple informal preference tests between conventional and binaural stereo over loudspeakers, the binaural version was the preferred one. — GBS.



# Education by radio in Honduras

A case study in electronics technology in a developing country

by Michael K. Bates\* B.A. (Eng. Tripos, Cambridge)

**Electronics technology is at such a level of sophistication that few countries can sustain their own electronics industry. Nevertheless radio is an effective means of communication the world over and it has had a significant impact on developing countries. In studying a particular application in Honduras, the author draws lessons about the suitability of present technology for use in other developing countries.**

Honduras, Central America, is reputedly the second poorest country in the Western Hemisphere. Although Honduras is less than half the size of the UK, its population density is low since the total population is only three million, of whom nearly all are Spanish-speaking Catholics; over two million eke out a subsistence living in rural areas and are known as *campesinos*, or peasant farmers. Most of the land is mountainous, containing small but fertile valleys. The wide strip of highly productive land on the Caribbean seaboard is mostly owned by foreign banana companies.

Communications systems within the country are on the whole ineffective: not even all the major towns are linked by paved roads, many villages are accessible only on foot or horseback, telephone links are over-subscribed and unreliable, and both the circulation of newspapers and the coverage of television are mostly confined to the cities. But radio has proved to be highly suitable and is the dominant medium for mass entertainment, dissemination of information and passing of messages. The success of radio broadcasting is largely due to an influx of cheap portable transistor radios, ownership of which is often regarded as an indication of social status, and this may account for the range at which the average transistor set is audible. Most broadcasting is on a private commercial basis from nearly one hundred local radio

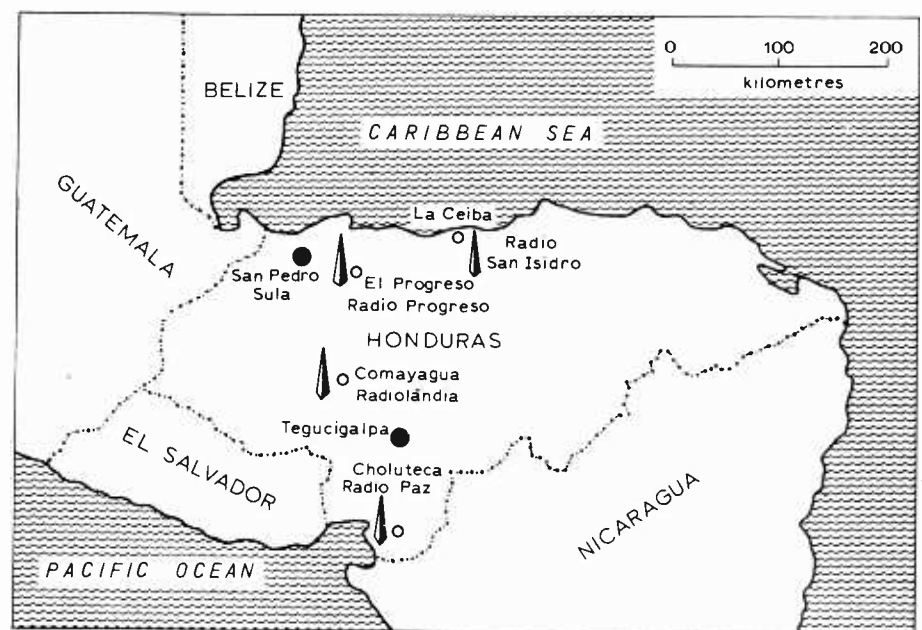


Fig. 1. Map of Honduras showing locations of radio stations mentioned in the text.

stations transmitting in the 540 to 1600kHz band, although use is also made of the 60m short-wave band and the standard v.h.f. f.m. band.

## Radio schools

Although education is free in Honduras and primary school is, in theory, compulsory it is evident that few *campesinos* benefit from it: most have been to school for perhaps only a year or two and over 65% are illiterate. There are obvious difficulties in sparsely populated areas in bringing together enough pupils to make a conventional school viable, especially if the aim is education of working adults. Use of radio can, however, offer a solution to problems like these.

The system of radio schooling prevalent in Latin America originated in Colombia in 1947, when Radio Sutatenza went on the air with a 100W transmitter and just forty-five pupils. The idea proved successful and the organization grew rapidly, until today

the station controls four transmitters with a combined output of over 750kW. Meanwhile radio schools were started in fifteen other Latin American countries, including Honduras.

The radio schools of Honduras have grown up under the auspices of *Acción Cultural Popular Hondureña* (ACPH), a non-government independent development agency which is financed from voluntary sources. There have been considerable problems in achieving autonomy from the influences of commercial enterprise, political forces and more recently a sector of the Catholic Church, partly because ACPH relies on agreements with sympathetic radio stations to buy air-time for transmission of the schools classes: hence, its effectiveness is closely linked to the progress of these stations.

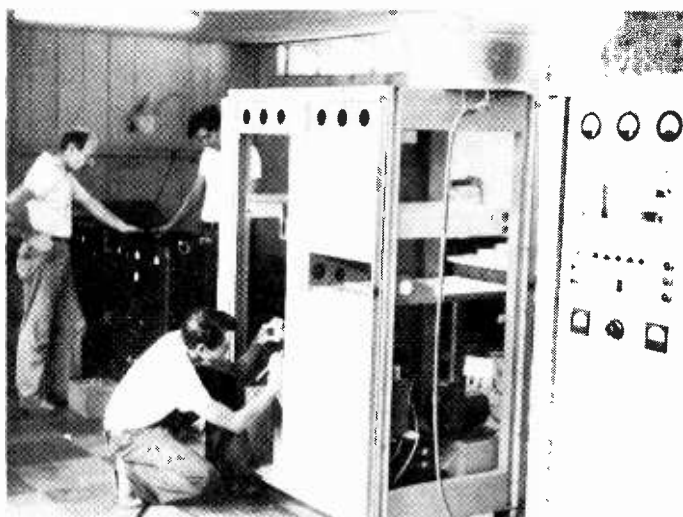
Experimental education of adults by radio began in 1959 with broadcasts from Radio Católica in Tegucigalpa, the capital, and grew successful to encompass 700 school groups by 1964. After several years of organizational problems, the system was re-vitalised in 1969 with the opening by foreign priests of

\*Volunteer radio engineer with the Catholic Institute for International Relations from September 1974 to December 1975 as part of the British volunteer programme.

Radio Paz, in southern Honduras, and the acquisition the following year of Radio Progreso in the north by Jesuits. As well as transmitting schools programmes, then as now recorded in the ACPH offices in Tegucigalpa, both stations followed normal commercial schedules. Plans for more comprehensive coverage of the country developed, and in 1974 surplus equipment was bought in the USA and shipped to Honduras for in-country construction of transmitters and studio facilities with local help. However this scheme has not reached fruition due to diverging aims of ACPH and the Catholic Church, a situation which has also caused Radio Católica to cease passing schools classes. Some expansion of the network was nevertheless achieved in 1975 with a low power short-wave installation at Radio San Isidro, La Ceiba, and complete new studios and transmitters for medium and short wavebands at Radiolândia, Comayagua. But these gains were offset by the closure of Radio Paz in June 1975 by the military government, following struggles over land tenancy in the east of the country, and attempts to regain the broadcast licence have so far only brought prevaricative responses.

The current disposition of facilities illustrates the wide spread of techniques which occurs in any technology in Honduras, ranging from the relatively sophisticated to the unbelievably crude. At the more impressive end of the spectrum, Radio Progreso broadcasts via a new Gates/Harris 5kW pulse-width modulated transmitter on

Fig. 2. Transmitter construction in workshops at Radio Paz, Cháuteca. On the right is the completed transmitter for Radiolândia; in the centre is a copy of it under construction; on the left is a BC610 US surplus being converted for short wave broadcasting. Note the tin bath, used to supply cooling water for a dummy load during necessarily brief transmitter tests at full power.



1110kHz, with a modified 10kW Collins on 4920kHz; on both frequencies there are back-up transmitters, a rare achievement for a Honduran station. Radio Paz transmitted on 990kHz using a modified Contel unit with 4-1000 tetrodes in the modulator and 3-1000 triodes in the final, and the locally constructed transmitter for Radiolândia draws from the same series of valves but with a single anode-modulated zero grid bias 4-1000 on the r.f. side to deliver 1.5kW on 1460kHz. For short-wave broadcasting at both Radiolândia and Radio San Isidro BC610 transmitters are in use, boosted to 500W with a final 833, a good robust valve which has been known to withstand accidental use as a light bulb. Even surplus equipment like this looks elegant alongside some home-made transmitters, which have been seen to use wood blocks to support and isolate transformers and domestic light switches on the control panel. It will be noticed that transmitter powers are all fairly low: 10kW is the legal upper limit and Honduran stations are at the moment spared the spiral of ever-rising powers. Despite the higher radio noise levels under tropical conditions, most areas are served well by their local transmitters and there is little adjacent or co-channel interference even at night.

On the studio side, there is such a range of equipment in use as to prohibit more than a mention here. The radio schools central recording studio is well equipped with a double turntable sound mixing desk, two Magnecord professional recorders, three Ampex series 600 machines and two high-speed tape duplicators. So too Radio Progreso has an impressive line up of Ampex 351 recorders in two fully interchangeable control rooms serving three studios. However, at the other end of the scale, the type of station with "mic and two decks" (one of them probably non-operational) is common.

#### Broadcasting policy

Radio Schools classes are broadcast from 4 p.m. to 6 p.m. Monday to Friday

with supplementary material on Saturday including news and current affairs for *campesinos*. These programmes are followed by some 1200 community school groups involving about 22,000 students which means that, with their families included, the broadcasts affect some 100,000 people, around 5% of the rural population. Each group is guided by a *monitor* who will be a local *campesino* with approximately one month's training at one of a number of regional centres. The *monitor* also plays an important part in a feedback path of opinion via a regional co-ordinator to the production team in the capital. Instruction is given in reading, writing and basic arithmetic, progressing to geographical and cultural knowledge, but at all stages there is practical advice on agriculture, health and home management. However it is the teaching method which is significant. Education follows the idea, originated in Latin America, of "conscientization", a very pragmatic philosophy intended to create a critical awareness of one's environment and capabilities within it, with emphasis on democratic and co-operative processes as means of achieving communal aims. Hence it is not so much a "handing downwards" of information but rather a combined search by students and teachers in the context of a localized community to find solutions to very real practical problems.

The importance of employing local radio stations is noteworthy. Firstly the schedules of classes need to differ in various parts of the country to accommodate variations in the tending of crops. Secondly there is a chance for the local radio station to become the focal point in a community and give a sense of identification to those living around it, through their knowing personally the announcers, being able to participate in discussion programmes, or merely by hearing their own record dedications.

Fig. 3. A typical radio schools class, making use of a primary school out of normal school hours.





Fig. 4. An exercise in Handwriting for a Honduran campesino.

### Operational problems

Operation of a radio network in a developing tropical country brings its own special difficulties not normally encountered here. There are frequent troubles with the *campesino* transistor radios which are often subjected to extreme conditions of heat or mechanical abuse, such as use as a temporary seat in a bus with doubtful suspension driven along a rocky dirt road. Sometimes a little "home servicing" is attempted too, with the aid of the first implement which comes to hand, normally a machete, and often the back of the set is lost and the loudspeaker cone is eaten by cockroaches.

Broadcasting stations also suffer from the climatic conditions. Ventilation can be a major difficulty: at the Radio Paz transmitter in Choluteca, admittedly one of the warmest parts of the country, shade temperatures in March and April regularly exceed 40°C, and even after increasing the size of blowers it was necessary to run the transmitter without sides and play a domestic fan on the modulator chassis. Concurrent with temperature problems are often those of high humidity: a particularly bad case is in La Ceiba, where the damp salt-air has affected even the BC610, designed for military and tropical use. During the wet season, lightning strikes cause frequent disruption of service and damage to transmitters and for this reason a folded unipole (caged) aerial configuration, in which the base of the tower is earthed, has been adopted for m.w. radiation at both Radio Progreso and Radiolândia.

The studio equipment is not normally subjected to such extreme conditions, but in studios without air conditioning there are problems of overheating in turntable and tape-recorder motors, and much valve equipment such as line amplifiers and compressors has to be blown. Fluctuations in mains voltage

can also be troublesome; for example the Radiolândia transmitter shows a tendency to trip out on the surge caused by a local factory shutting down at the end of the day.

Many stations have no technical staff and hence no regular maintenance, repairs being effected only when breakdown occurs. In a country dependent on agriculture rather than industry and technology, the whole environment is non-scientific and there are few technicians and engineers of any description. There appear to be several reasons for this. The social circumstances of most families tend to inhibit rather than encourage a child's natural curiosity; the education system, for those who benefit from it at all, is biased towards learning by rote rather than from exploratory and logical deduction processes, and Honduran technicians experience particular difficulty in fault diagnosis. For those few privileged enough to go on to higher education, most seeking technical studies would travel to the U.S.A. or Mexico, and perhaps not return. Latin American technicians encounter additional problems with language, as a large proportion of service manuals and specification sheets are in English only. Nevertheless, the enthusiasm and capacity for hard work of those trying to better themselves is an inspiration. Moreover most Hondurans are capable with their hands and adept at improvisation with what materials and knowledge they possess.

### Electronics technology for developing countries

One of the dilemmas which developing countries face is whether to accept certain totally imported technologies,

such as electronics, or to manage without them. The extent of radio ownership leaves no doubt that radio broadcasting is both desirable and successful in Honduras, yet even an organization like the radio schools, trying to go its own way to suit the needs of its own people, has to accept the technology of the industrialized countries and the way in which it is administered.

Furthermore, there is no half-way stage in radio, no "intermediate" technology. Other branches of engineering, for example transport, can be upgraded by better techniques while remaining within the framework of traditional styles: the wooden wheels and axles of an ox-cart can be replaced by pneumatic tyres and a suspension system without a complete changeover to use of a tractor and trailer. But there is no parallel process in radio, which is not a development of a traditional method of communication but a totally new science. It is hard to simplify a transmitter beyond a basic valve-driven anode-modulated circuit, yet at present this remains as incomprehensible to most Hondurans as ampliphase, Doherty or pulse amplitude systems: it is just another proverbial "black box".

So how suitable is present day electronics technology for developing countries such as Honduras? Despite the extent and importance of radio systems in such countries, little equipment is manufactured specifically for their needs and often standard equipment is unsuitable without modifications such as tropicalized components or additional cooling. At times equipment cannot be set up correctly or maintained through lack of test gear and spares: an example is an ampliphase transmitter imported into Honduras which has never given optimum performance. On the other hand, confusion is caused when a range of test equipment is specified which is not normally used

Fig. 5. Radio schools classes are often held in ordinary campesino houses such as this one near Choluteca.



outside a laboratory; the list of "required equipment" for tape-head alignment on one model of recorder included a valve voltmeter, a low-distortion oscillator and a spectrum analyser. The station concerned did not possess even a multimeter.

Nevertheless, the Latin American broadcast equipment market is booming; a periodical is produced, in English and Spanish, for free distribution to any radio personnel requesting it, and many of the larger electronics companies now have agencies in Central and South America.

Bearing in mind the possible size of the market for electronic and radio goods in developing countries, it seems appropriate to consider some of their basic requirements. It would indeed be a noteworthy advance if there were available a cheap, simple, foolproof transistor radio, in a tough impact-resistant case with firmly secured back and control knobs, with reliable battery contacts and protection against incorrect battery insertion. Suitable circuitry might include integrated circuit i.f. and a.f. stages and ceramic filters, with servicing simplified to the level of quick circuit-block replacement or perhaps even a complete change of encapsulated, throwaway electronics. The criteria of low cost, robustness under exacting conditions and misuse, reliability and ease of servicing by non-expert personnel also apply to broadcasting equipment, appearing more important than high performance and sophistication of design. Such ideas as solid-state relays, ball-race bearings lubricated for life, modular construction but with far more attention given to connectors, and generously rated components immediately suggest themselves. A plea might well be added for VU meters with flexible pointers and unbreakable end-stops.

Current technology can adequately satisfy these requirements if suitable production and marketing policies are adopted. Future demands from developing countries are likely to be for television as well as radio equipment in ever-increasing quantities, but understanding and ability to use the technology can only come slowly. In the meantime, these countries require the sort of equipment which can be used successfully in the present environment. The Honduran *campesino* needs his indestructible transistor radio for entertainment and for education, and must hope that progress in electronics technology will move towards providing it. And there might even be something in it for us.

#### Acknowledgements

Thanks are due for the considerable assistance provided by R. J. Levey, engineer for ACPH; P. G. Nairne, now with the British Council; and the Catholic Institute for International Relations.

# One hundred years ago

No, *Wireless World* was yet a thing of the future in 1877, but the groundwork for the development of the electronic twentieth century was being laid and already, a hundred years ago, an impressive list of theoretical and practical invention was in existence. Computers, relays, transformers, diaphragm microphones, motors, fuel cells had all been made and the theory of wave propagation was well advanced.

In April 1877, Thomas Alva Edison filed a U.S. patent application for the design of the carbon microphone, which immediately took precedence over the efforts of Reis (diaphragm type — 1860) and Bell (magnetic — 1875). The "other end" of a speech communication system was attacked by E. W. Siemens, who applied for a German patent on the moving-coil loudspeaker in December, 1877. The device used the now-familiar motor with a circular coil moving in a radial field.

A rather more publicized centenary this year is the invention by Edison of the phonograph (or gramophone) using tin foil wrapped round a hand-cranked cylinder. This patent was applied for in December, 1877.

Moving on to fifty years ago, 1927 was an important date in the history of the cinema

when the first really effective "talkie" film, "The Jazz Singer", with Al Jolson, was a tremendous success. The Western Electric sound system — the Vitaphone — used 16in disc turntables driven at 33½ r.p.m. from the same constant speed motor system as the film projectors. But this method of synchronism was soon to be supplanted by the "sound track" (sound-on-film system) introduced in the same year by Fox Movietone News. On a quieter and somewhat less distorted note, but highly significant to audio engineering, was the invention in 1927 of the negative feedback amplifier by H. S. Black of Bell Laboratories.

These are just a few of the significant inventions described in a new book "Electronic Inventions 1745-1976" by G. W. A. Dummer just published by Pergamon Press at £4.00. This contains mainly brief accounts of important inventions in electronics but also has some interesting graphs showing historical trends. For example, it shows that in the 200 years from 1745 to 1945 some 106 electronic inventions originated in Europe against 66 in the same period in the USA; but in the mere 31 years from 1945 to 1976 the situation was reversed with 32 inventions for Europe and 85 for the USA.

## Literature Received

Power supply price list is now available from Weir, including bench types, a unit for use with microprocessors and a range of card supplies. Weir Instrumentation Ltd, Durban Road, Bognor Regis, Sussex ..... WW401

Video cassette recorder control unit is made by Crow of Reading for use with the Ampex ACR-25. A leaflet describes the function of the unit, which is designed for remote control of the programmed recorder. Crow of Reading Ltd, PO Box 36, Reading, RG1 2NB ..... WW402

Demonstration panels for teaching electronics are produced by Taran International. The panels take the form of large mimic diagrams with the circuit printed on the front, the components being plugged in. A leaflet can be obtained from Raynham Road, Bishop's Stortford, Herts CM23 5PG ..... WW403

Component lead forming machinery from Eraser International is described in a "Wyber" catalogue. Hand-operated and automatic forming and cropping tools are illustrated and several implements for cleaning printed boards are described. Eraser International Ltd, 2/3 Hampton Court Parade, East Molesey, Surrey KT8 9HB ..... WW404

Prices of measuring instruments in the Electroplan catalogue are brought up to date in their February 77 list, which briefly describes additions to the range from Advance, Solartron, Weston, Bryans, Telequipment and Systron-Donner. Electroplan Ltd, PO Box 19, Orchard Road, Royston, Herts SG8 5HH ..... WW405

Printed-circuit manufacture by the Nevin group is the subject of a new brochure, which includes a wall-chart of board design information, protective finishes and metric conversions. Nevin Electric (Holdings) Ltd, Arkwright Road, Poyle Trading Estate, Colnbrook, Bucks SL3 0HJ ..... WW406

Connectors in the Amphenol range include the r.f. types to DEF standards — the 27GB Subminax, the 31GB series quick disconnecting connectors and the 82GB 'C' weatherproof type. A set of data sheets covering all these is now obtainable from Amphenol Ltd, Thanet Way, Whitstable, Kent CT5 3JF ..... WW407

Distance measurement techniques over a period of 5000 years are illustrated on a new wall-chart from Tellurometer, which has been involved in only the later, microwave methods of measurement. Tellurometer, Oakcroft Road, Chessington, Surrey KT9 1RQ ..... WW408

Capacitors and semiconductor devices by RIFA are fully described in a catalogue, now available. A very full range of capacitors is offered and the semiconductors are rectifiers, timers and driver/interface circuits. Rifa, Fac. S-161 11 Bromma, Sweden ..... WW409

Power supplies by Gardners are detailed in a series of recently published leaflets. Chargers for nickel-cadmium cells, 50Hz d.c.-to-a.c. inverters, regulators and d.c.-to-d.c. converters are all described and the leaflets can be obtained from Gardners Transformers Ltd, Christchurch, Dorset, BH23 3PN ..... WW410

Speaker drive units, crossovers, materials and accessories for loudspeaker construction are listed in a new catalogue, obtainable from Badger Sound Services Ltd, 38(a) St Andrews Road South, St Annes, Lytham St Annes, Lancs FY8 1PS at 10p per copy.

Pressure transducers of various types are made by Bell & Howell who describe them in four bulletins. Types covered are: thin-film types, high-output versions with amplifiers, marine and industrial transducers with electronics in a bulkhead-mounting case and flameproof transducers. Bell & Howell Ltd, Electronics and Instruments Division, Lennox Road, Basingstoke, Hants RG22 4AW ..... WW411

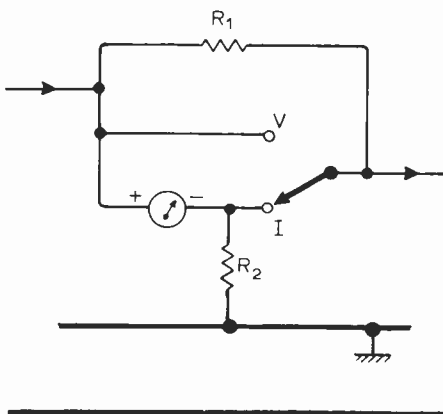
General electronic components, instruments, kits and books are all listed in the Maplin 1977 catalogue, available at 50p from Maplin Electronic Supplies, PO Box 3, Rayleigh, Essex SS6 8LR.

# Circuit Ideas

## Voltage/current meter switch

The circuit arrangement shown enables a single pole two way switch to be used in place of the two pole, two way type which is usually required when one meter indicates both current and voltage. Resistors  $R_1$  and  $R_2$  are the meter shunt and series resistances respectively. The change of output voltage due to  $R_1$  being switched in and out will usually be negligible if the circuit is included in the feedback loop of a stabilised power supply.

S. V. Essex,  
London W.14.

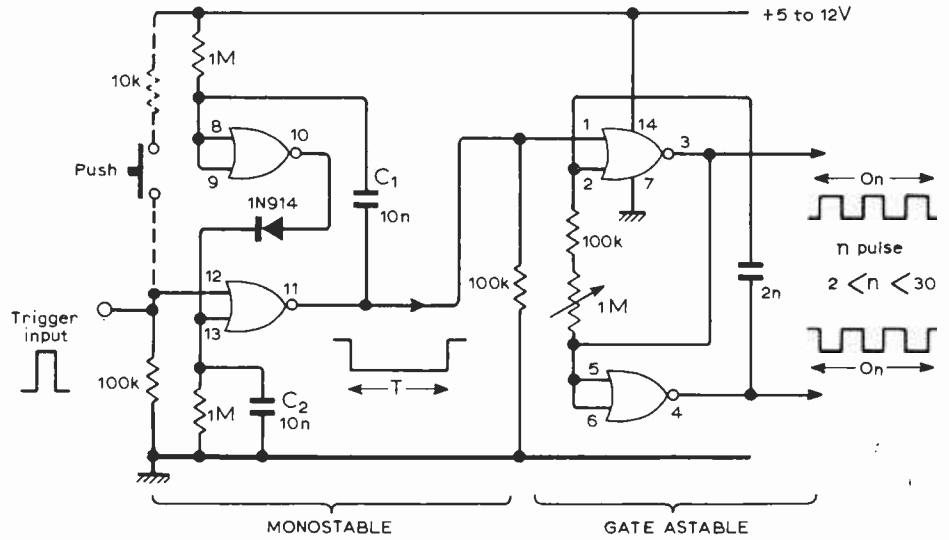


## N-stable multivibrator

This circuit produces a fixed number of pulses when triggered. Applications include number indicators, frequency multiplication, and number loaders. A monostable feeds a gated astable and, by adjusting the frequency control of

the last mentioned, between two and thirty pulses can be obtained. This has been realised using a single CD4001 i.c. A pushbutton can be used instead of a trigger pulse for manual circuits.

Dr K. Padmanabhan,  
University of Madras,  
India.



## Variable band-pass filter

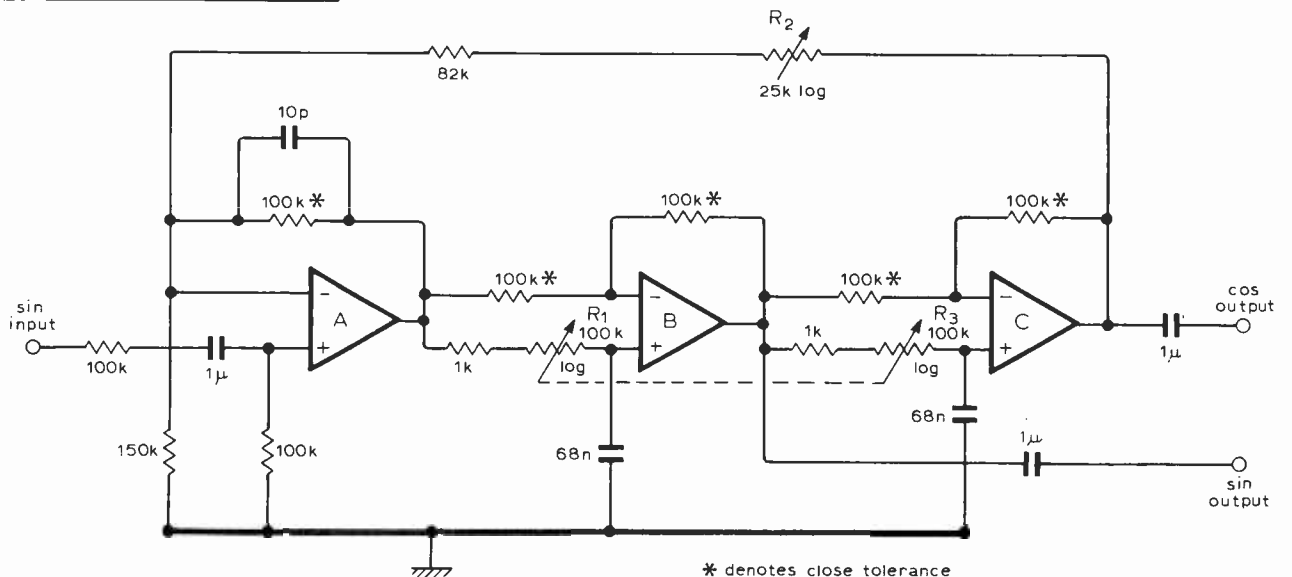
Sometimes it is required to have a high-Q, bandpass filter which is adjustable over a wide frequency range without an appreciable change in Q, or more particularly, without the loop-gain becoming greater than unity which causes oscillation. With this circuit the centre frequency can be adjusted over a 100:1 range whilst maintaining  $Q > 100$ , and over smaller frequency ranges, a Q of up to  $10^4$ . In addition, a two-phase output is also available.

Two cascaded all-pass networks, B and C, each have a  $0^\circ$  to  $180^\circ$  phase variation, and unity gain at all frequencies. This cascade is driven from a third operational amplifier whose feedback signal is the sum of the input

and output of the all-pass network. The sum becomes zero when there is exactly  $180^\circ$  phase shift over the cascade, and thus the overall gain approaches half the open-loop gain of amplifier A. At other frequencies the gain tends towards unity.

Because the frequency determining components only affect the overall phase-shift and not the gain, there is a no danger of having a loop-gain greater than unity. If the two-phase output or large frequency range is not required one R can be fixed. The Q is adjusted by  $R_2$ , and with the values shown gives the circuit a 20Hz to 2kHz range.

J. M. Worley,  
Colchester,  
Essex.



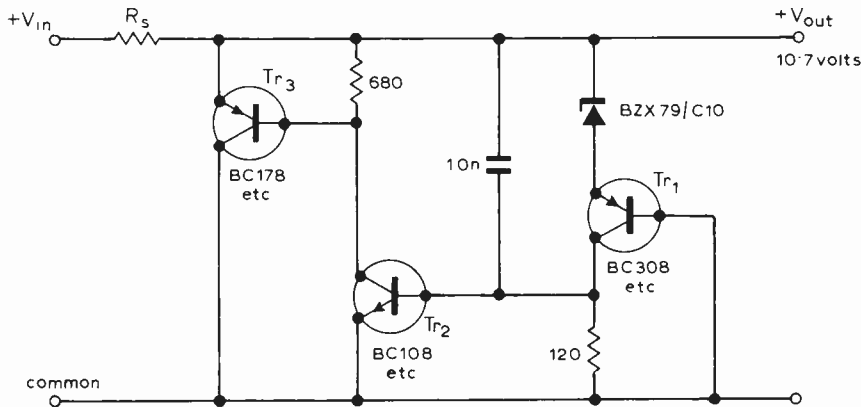


## Ripple eliminator

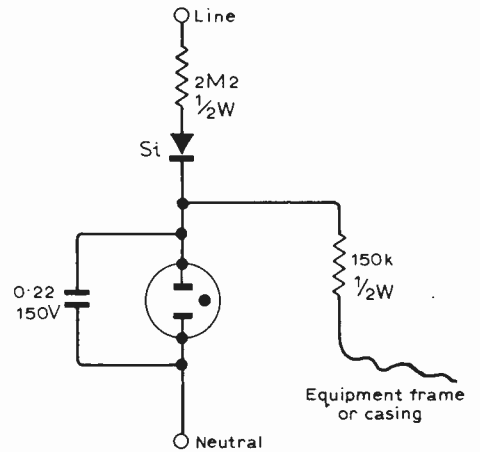
This shunt regulator circuit virtually removes all mains ripple without using a large capacitor, and is inherently short-circuit proof. The regulator is ideal as a stabilized supply line for audio preamplifiers and other applications where a precise voltage level is not important but freedom from ripple is. The circuit's simplicity is due to silicon transistors which can operate at very

low levels of collector-emitter voltage. The zener diode should be operated with enough current to make its dynamic resistance significantly less than  $R_1$ . Transistor  $Tr_3$  may be a power type or a Darlington. The Miller capacitor should be large enough to stop high frequency oscillations.

P. S. Bright,  
Christchurch, New Zealand.



## Earth warning indicator



This simple circuit gives a warning if the earth wire is disconnected from the chassis of an instrument. It is particularly useful for oscilloscopes which may be left in a hazardous state when the earth wire is purposely disconnected to avoid hum loops etc.

The neon is normally extinguished, and flashes if the earth is not connected.  
R. H. Troughton,  
Gatwick Airport, Surrey.

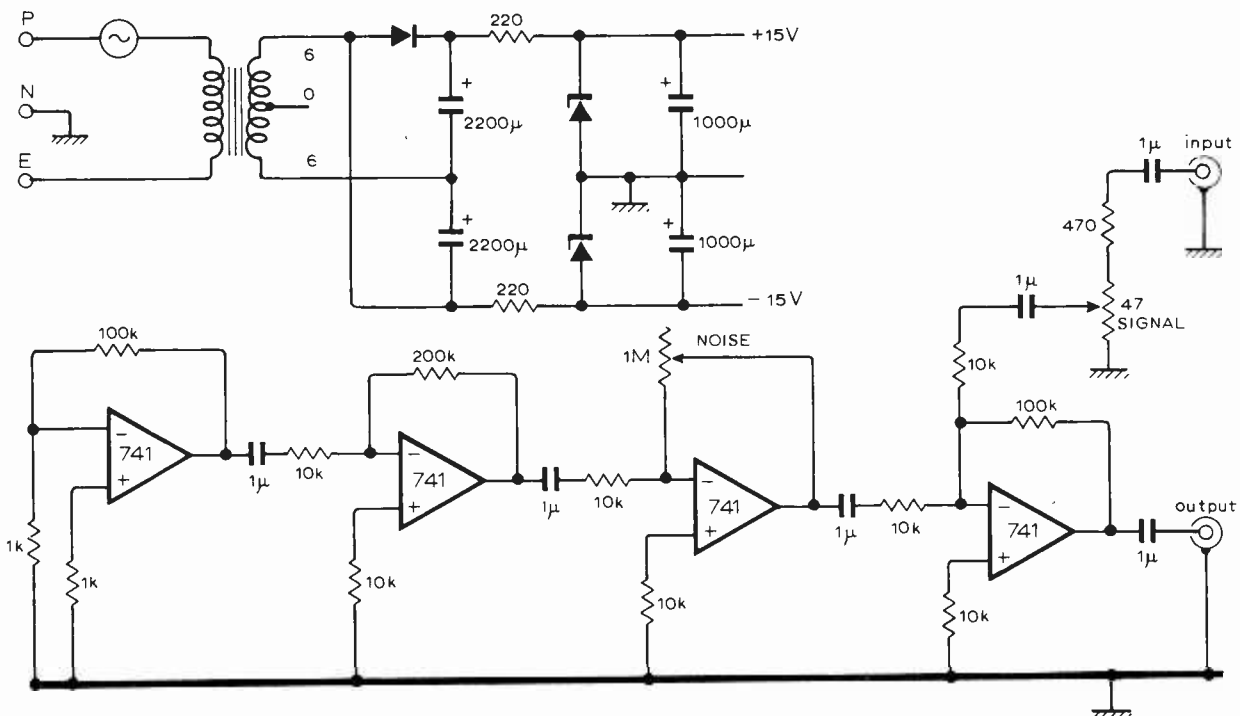
## Simple noise generator

Phase-lock loop techniques, for the recovery of low level information from noisy signals, have become increasingly important. This note describes a simple noise generator in which both signal and noise levels are continuously and independently variable from zero to maximum. The only point requiring care is the positioning of the transformer to avoid 50Hz hum. The voltage doubler supply may be replaced by any convenient configuration. The input

impedance is approximately 500Ω. Four stages of gain have been used to minimize instabilities and provide the maximum noise amplitude without reaching the limits of output excursion. The a.c. coupling between stages eliminates offset compensation and provides low frequency roll-off. High frequency roll-off is determined by the gain of each stage and varies slightly with the noise level control. Output noise is essentially "white" from below 50Hz to above 5kHz. This range was selected as appropriate to demonstrate

the recovery of a 500Hz signal from noise of similar frequencies. The circuit will operate at maximum noise output into a load of 1.5kΩ. For smaller load impedances, the noise level must be reduced or the 1000μF power supply capacitors increased to prevent oscillation.

The author wishes to acknowledge the contributions of Dr T. G. L. Shirtcliffe, Mr J. E. Nixon and Mr P. D. Turner to the project.  
J. E. Morris,  
University of Wellington,  
New Zealand.



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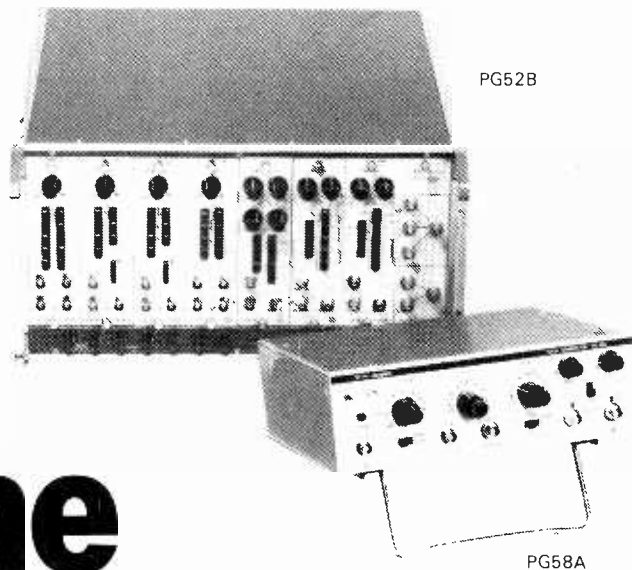
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# VIEWDATA

## 3 — Operation of the system: terminals and codes

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

**Part 1 of this series, in the February issue, gave an introduction to Viewdata, with mentions of earlier systems. Part 2, in the March issue, dealt mainly with applications. This article now describes the overall arrangement of the system, the codes used and the Viewdata terminal.**

Fig. 1 gives an overall view of a Viewdata connection. The home terminal, shown at the bottom left hand side, comprises a domestic television set, a telephone instrument, a Viewdata adaptor and a keypad. The actual assembly is shown in Fig. 2. Two types of keypads proposed are shown in Figs. 3 and 4. The basic keypad is Fig. 3; this provides the ten numerals, \* and  $\#$  symbols and keys for automatic dialling, if installed. Fig. 4 is an alphanumeric keypad. This contains in addition to the above, the complete upper case alphabet, punctuation marks and symbols like £, %, /, arithmetic and algebraic symbols and cursor control characters. A typical Viewdata terminal for the office, the Viewdataphone, is shown schematically at the bottom right hand side of Fig. 1. This consists of a Viewdata terminal and a self-contained telephone instrument. A typical Viewdataphone was shown in the March issue. The Viewdata computer is shown at the top of Fig. 1, notionally connected to a variety of data banks, either direct or through the switched telephone network.

As mentioned in the February issue communication between the terminal and the Viewdata computer is at a rate of 1200 bits/s from computer to terminal and 75 bits/s in the opposite direction. More details of this arrangement will be given later.

In order to establish a connection to the Viewdata computer the user dials the telephone number of the computer as for a normal telephone call. When the connection is established the computer generates a high pitched tone (frequency 1300Hz) which is heard in the telephone receiver. The user then presses a button marked "data" on the telephone set, which switches the telephone line from the telephone set to a modem (modulator-demodulator). The telephone receiver is then set by the

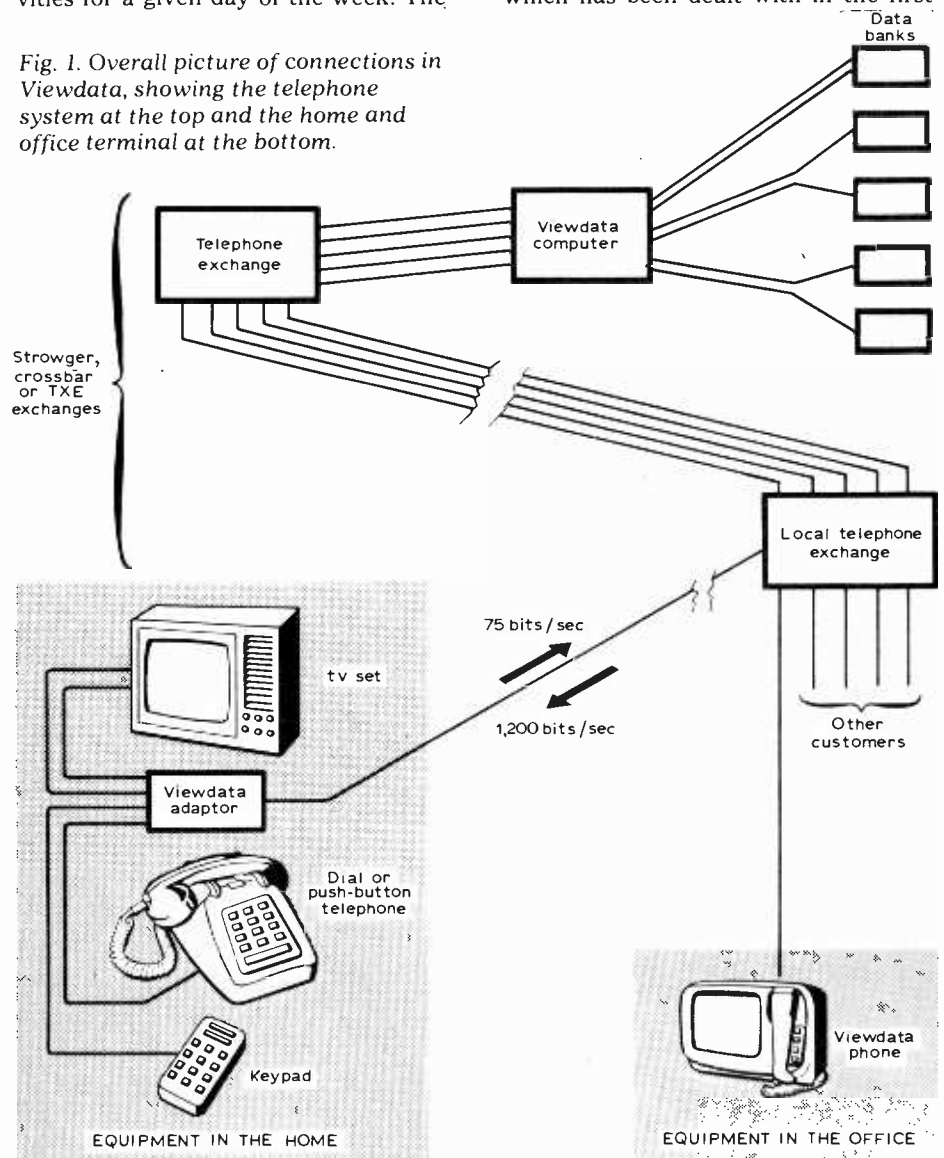
side of the cradle. Once contact is established, the computer transmits a first frame, which requires the user to enter a user number. When this has been done Viewdata offers the first index (shown in the February issue, p. 32).

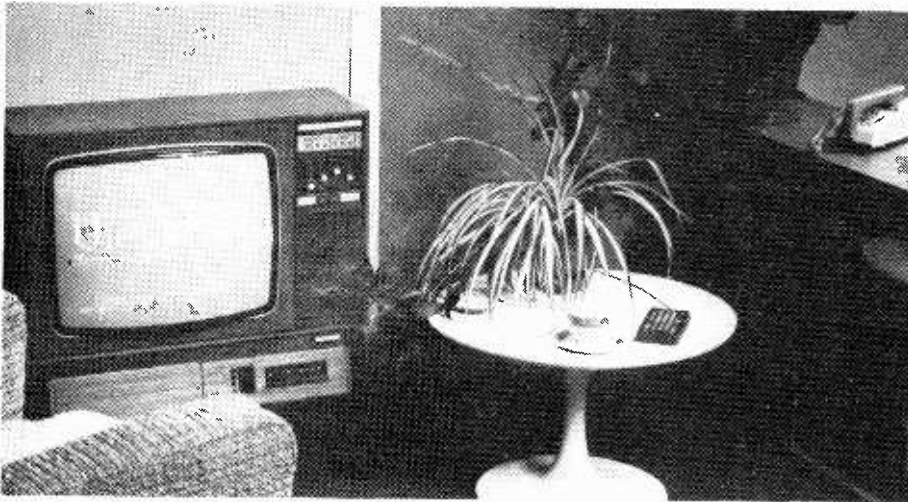
The action is now transferred to the keypad. On this the user keys-in his user number and any further responses. Suppose the user wishes to obtain information about entertainment activities for a given day of the week. The

user may enter the entertainment page direct by keying \*3230 $\#$ . An example of one of the pages in the entertainment sequence was Fig. 6 in the February issue. In later models of the terminal, use is made of the calling key on the keypad. This calls the Viewdata computer automatically and switches over to the modem without the user's intervention. The keypad may then be used as previously.

The design philosophy of Viewdata which has been dealt with in the first

Fig. 1. Overall picture of connections in Viewdata, showing the telephone system at the top and the home and office terminal at the bottom.





▲ Fig. 2. Home terminal for Viewdata, with television set, telephone (right) and keypad on the table.

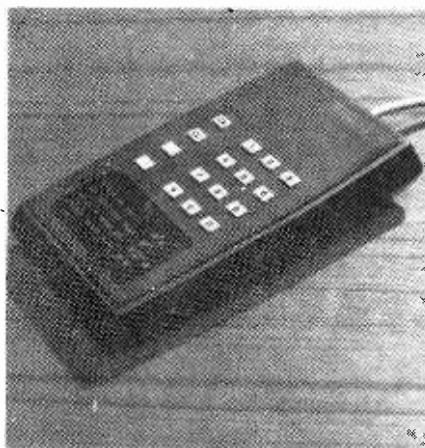
two parts of this article referred to the need to keep the cost of Viewdata down to very low levels, both on the terminal side and on the computer usage side. Indeed, unless the cost of using the computer facility is kept substantially below that of using current computer time-sharing systems, the whole project may not become viable. This therefore postulates the use of a distributed computer system, so arranged that the majority of users may have access to a nearby computer centre, at the cost of a local telephone call for the connection plus a correspondingly modest charge for the use of the computer and the information provided.

The resulting network is typically as shown in Fig. 5. Users are within a local call distance of their computer centres, shown as rectangles. A cluster of local computer centres is grouped under the control of a regional centre for the purpose of data gathering and distribution. A national data centre controls the operation of the whole system and distributes to each regional centre new information, news and data updates. Regional centres also accept information of regional or local interest and distribute this to the local centres.

**The Viewdata terminal**

**Display format.** The display format of Viewdata is identical with that of teletext, i.e. a page consists of 24 rows of 40 characters each, each character being generated by a 5 × 7 matrix with upper and lower case, character rounding, graphics symbols and colour. Thus a great deal of the electronics in a terminal may be common to Viewdata and teletext, the differences being primarily concerned with the additional functions needed in Viewdata, the different modes of transmission applicable to these two systems and the different constraints appertaining to the different communications media involved.

In the case of Viewdata the data enters the terminal via the telephone line at relatively low speed, and, as the probability of data corruption is quite low, little is needed for the purpose of error detection and correction. Indeed, extensive Viewdata tests have been



▲ Fig. 3. Basic keypad used in a Viewdata terminal, providing ten numerals and a few other keys.

carried out over the past two years from a large number of centres in the UK and on the Continent. In all these tests the public switched telephone network was used to connect up to the experimental Viewdata system based at Martlesham, near Ipswich, and transmission difficulties have been very rare.

The character codes used for Viewdata and teletext are also identical,

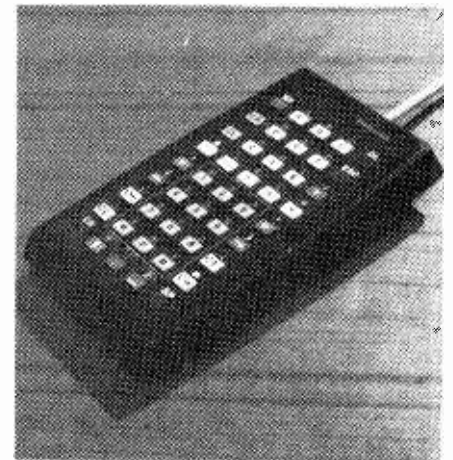
except for the actual codes transmitted over the line, where a slight change is made to comply with International Standards Organization recommendations.

The table of codes used for Viewdata is shown in Figs. 6, 7 and 8. Fig. 6 shows the joint Viewdata and teletext codes for alphanumeric characters only. This differs from earlier versions in the following characters:

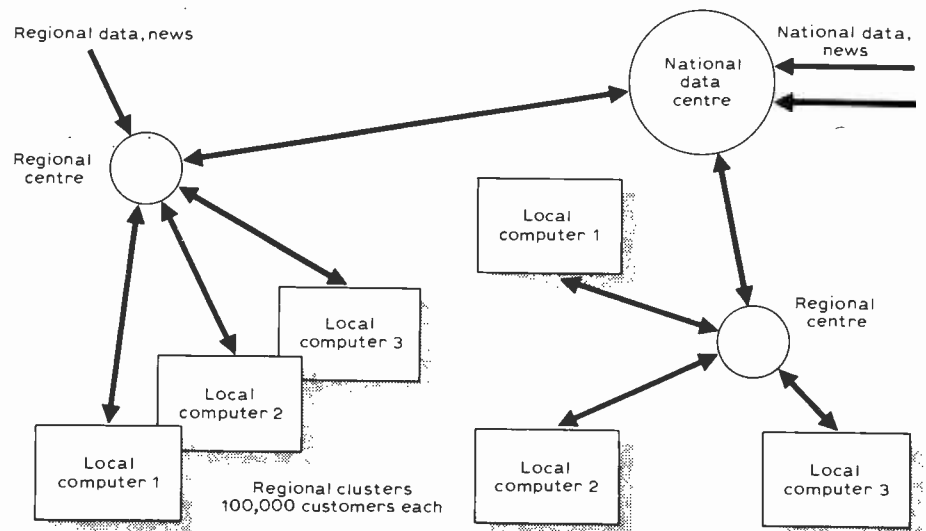
Column	Row	Was	Is now
5	11	[	←
5	12	\	½
5	13	]	→
5	15	-	≠
6	0	-	-
7	11	:	¼
7	12	i	
7	13	:	¾
7	14	-	÷

Note: The top, left-pointing, arrow is used as an assignment statement; the lower, right-pointing, arrow means "go to"; and the sign ≠ is used as a terminator and for special functions. Note also that the arithmetic operator × (multiply) used in Viewdata is shown as x (lower case x), while the minus sign (-) is code 2/13 and the exponentiation sign is code 5/14 shown as ↑.

▼ Fig. 4. More elaborate, alphanumeric, keypad with a variety of other symbols.



▼ Fig. 5. A distributed Viewdata network, showing local computers, regional centres and national data centre.





Bits	b <sub>7</sub>	b <sub>6</sub>	b <sub>5</sub>	b <sub>4</sub>	b <sub>3</sub>	b <sub>2</sub>	b <sub>1</sub>	Col	Row
	0	0	0	0	1	1	1	0	0
	0	0	1	1	0	0	1	1	1
	0	1	0	1	0	1	0	1	2
	0	0	0	0	0	0	0	0	3
	0	1	0	0	0	0	0	1	4
	0	1	0	1	0	0	0	1	5
	0	1	1	0	0	0	0	1	6
	0	1	1	1	0	0	0	1	7
	1	0	0	0	0	0	0	0	8
	1	0	0	1	0	0	0	0	9
	1	0	1	0	0	0	0	0	10
	1	0	1	1	0	0	0	0	11
	1	1	0	0	0	0	0	0	12
	1	1	0	1	0	0	0	0	13
	1	1	1	0	0	0	0	0	14
	1	1	1	1	0	0	0	0	15

▲ Fig. 6. Codes for alphanumeric characters only, as used in both Viewdata and teletext.

Fig. 7 shows the graphics and control characters use in teletext, as at September 1976\*, the conventions being as before, that is:

1. All character rows start in the "steady", "alphanumeric white" and "unboxed" condition without control characters.
2. Control characters shown are displayed as spaces, but control whether alphanumeric or graphic characters are displayed and what colour is used.
3. Alphanumeric characters in columns 4 and 5, i.e. all of the upper case letters and a few others, may be displayed next to graphic symbols without an intervening space.

While the intervening space convention following a control character is essential in teletext, it has been accepted in Viewdata for the sake of uniformity, although it is not really essential and imposes undesirable constraints on the page format.

Additional control characters have recently been added to teletext to provide enhanced display facilities. The "intervening space" convention is somewhat modified and made less onerous, although not all its undesirable effects are eliminated.

The new control characters, which may be applied equally in Viewdata are in four groups:

**Contiguous/separate graphics.** Codes 1/9 and 1/10 in teletext, 5a/9 and 5a/10 in Viewdata. This provides the choice of graphics symbols filling the whole of a character rectangle, or only six discrete and separate dots.

**Normal height/double height.** Codes 0/12 and 0/13 in teletext, 4a/12 and 4a/13 in Viewdata. This provides for the optional display of alphanumeric characters in the standard size, i.e. within the normal char-

\*Broadcast Teletext Specification. Published jointly by the Broadcasting Corporation, Independent Broadcasting Authority and British Radio Equipment Manufacturers Association.

Bits	b <sub>7</sub>	b <sub>6</sub>	b <sub>5</sub>	b <sub>4</sub>	b <sub>3</sub>	b <sub>2</sub>	b <sub>1</sub>	Col	Row	0a	1a	2a	3a	6a	7a
	0	0	0	0	1	0	1	0	0	(NUL)	(DLE)				
	0	0	0	1	0	0	1	1	1	alpha <sup>n</sup> red	graphics red				
	0	0	1	0	0	0	0	0	2	alpha <sup>n</sup> green	graphics green				
	0	0	1	0	0	0	1	0	3	alpha <sup>n</sup> yellow	graphics yellow				
	0	1	0	0	0	0	0	0	4	alpha <sup>n</sup> blue	graphics blue				
	0	1	0	1	0	0	0	0	5	alpha <sup>n</sup> magenta	graphics magenta				
	0	1	1	0	0	0	0	0	6	alpha <sup>n</sup> cyan	graphics cyan				
	0	1	1	1	0	0	0	0	7	alpha <sup>n</sup> white	graphics white				
	1	0	0	0	0	0	0	0	8	flash	conceal display				
	1	0	0	1	0	0	0	0	9	steady	contiguous graphics				
	1	0	1	0	0	0	0	0	10	end box	separated graphics				
	1	0	1	1	0	0	0	0	11	start box	(ESC)				
	1	1	0	0	0	0	0	0	12	normal height	black background				
	1	1	0	1	0	0	0	0	13	double height	new background				
	1	1	1	0	0	0	0	0	14	(S0)	hold graphics				
	1	1	1	1	0	0	0	0	15	(S1)	release graphics				

Fig. 7. Codes for graphics used in teletext.

Bits	b <sub>7</sub>	b <sub>6</sub>	b <sub>5</sub>	b <sub>4</sub>	b <sub>3</sub>	b <sub>2</sub>	b <sub>1</sub>	Col	Row	0	1	2a	3a	4a	5a	6a	7a
	0	0	0	0	1	0	1	0	0	NUL							
	0	0	0	1	0	0	1	1	1	DC1			alpha <sup>n</sup> red	graphics red			
	0	0	1	0	0	0	0	0	2	DC2			alpha <sup>n</sup> green	graphics green			
	0	0	1	0	0	0	1	0	3	DC3			alpha <sup>n</sup> yellow	graphics yellow			
	0	1	0	0	0	0	0	0	4	DC4			alpha <sup>n</sup> blue	graphics blue			
	0	1	0	1	0	0	0	0	5	ENQ			alpha <sup>n</sup> magenta	graphics magenta			
	0	1	1	0	0	0	0	0	6				alpha <sup>n</sup> cyan	graphics cyan			
	0	1	1	1	0	0	0	0	7				alpha <sup>n</sup> white	graphics white			
	1	0	0	0	0	0	0	0	8	BS	CAN		flash	conceal display			
	1	0	0	1	0	0	0	0	9	HT			steady	contiguous graphics			
	1	0	1	0	0	0	0	0	10	LF			end box	separated graphics			
	1	0	1	1	0	0	0	0	11	VT	ESC		start box				
	1	1	0	0	0	0	0	0	12	FF			normal height	black background			
	1	1	0	1	0	0	0	0	13	CR			double height	new background			
	1	1	1	0	0	0	0	0	14		cursor home IS <sub>2</sub>			hold graphics			
	1	1	1	1	0	0	0	0	15					release graphics			

Fig. 8. Control and graphics codes used in Viewdata.

acter rectangle or stretched vertically to double height, the width of each character and the intervening spaces between characters remaining the same.

**Black background/new background.** The background colour of the character rectangle is normally black. Whenever the new background control character 1/13 in teletext or 5a/13 in Viewdata occurs, the display colour then obtaining is adopted as the new background colour.

**Hold graphics/Release graphics.** Codes 1/14

and 1/15 in teletext, 5a/14 and 5a/15 in Viewdata. This allows a limited range of abrupt display colour changes in a row whereas normally there is at least one space between rectangles with different display colours in the same row.

The graphics and control characters in Viewdata are show in Fig 8, but before these are looked at in detail, the use of a cursor in Viewdata should first be explained.

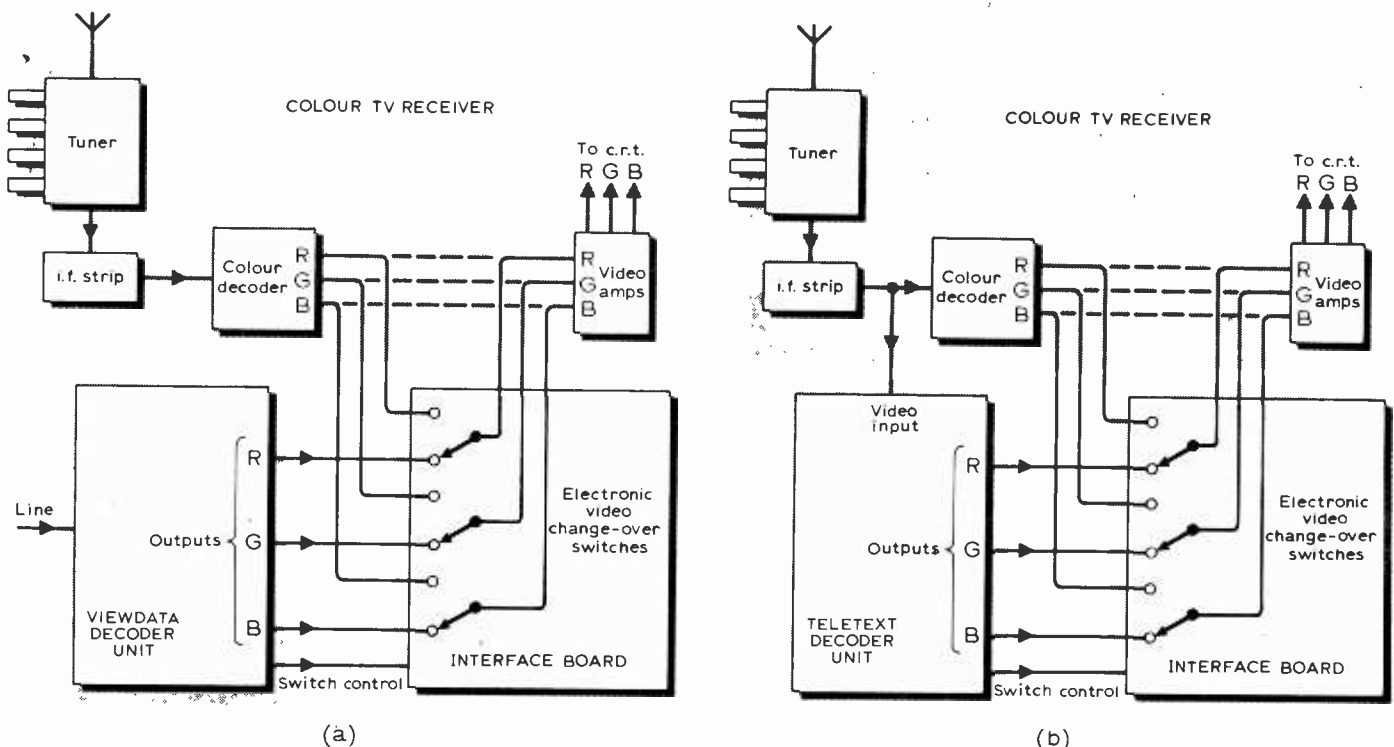
**Cursor.** The cursor in Viewdata is a symbol which shows up on the display as a bright rectangle, filling the space of an upper case alphabetic character. It may be switched on and off, as required, by a switch on the terminal or on the keypad, or by remote control from the computer. It may also be moved anywhere over the display either manually by using special keys on the keypad or by remote control from the computer.

The cursor has many functions.

Bits	b <sub>7</sub> b <sub>6</sub> b <sub>5</sub> b <sub>4</sub> b <sub>3</sub> b <sub>2</sub> b <sub>1</sub>	Col Row	0	1	2	2a	3	3a	4	4a	5	5a	6	6a	7	7a
			0	1	2	2a	3	3a	4	4a	5	5a	6	6a	7	7a
	0 0 0 0	0	NUL		SP		0		@		P		-		p	
	0 0 0 1	1	DC <sub>1</sub>	!		1		A	alpha <sup>n</sup> red		Q	graphics red	a		q	
	0 0 1 0	2	DC <sub>2</sub>	"		2		B	alpha <sup>n</sup> green		R	graphics green	b		r	
	0 0 1 1	3	DC <sub>3</sub>	£		3		C	alpha <sup>n</sup> yellow		S	graphics yellow	c		s	
	0 1 0 0	4	DC <sub>4</sub>	\$		4		D	alpha <sup>n</sup> blue		T	graphics blue	d		t	
	0 1 0 1	5	ENQ	%		5		E	alpha <sup>n</sup> magenta		U	graphics magenta	e		u	
	0 1 1 0	6		&		6		F	alpha <sup>n</sup> cyan		V	graphics cyan	f		v	
	0 1 1 1	7		,		7		G	alpha <sup>n</sup> white		W	graphics white	g		w	
	1 0 0 0	8	BS	CAN	(	8		H	flash		X	conceal display	h		x	
	1 0 0 1	9	HT	)		9		I	steady		Y	contiguous graphics	i		y	
	1 0 1 0	10	LF	*	:			J	end box		Z	separated graphics	j		z	
	1 0 1 1	11	VT	ESC	+	;		K	start box	←			k		¼	
	1 1 0 0	12	FF	,	<			L	normal height	½		black background	l		½	
	1 1 0 1	13	CR	-	=			M	double height	→		new background	m		¾	
	1 1 1 0	14		.	>			N		↑		hold graphics	n		÷	
	1 1 1 1	15		/	?			O		⌘		release graphics	o			

◀ Fig. 9. Complete set of Viewdata codes. columns 2a, 3a, 6a and 7a for graphics and columns 4a and 5a for the controls.

▼ Fig. 10. Block diagrams of (a) a Viewdata terminal and (b) a teletext terminal, showing video connections to the television set.



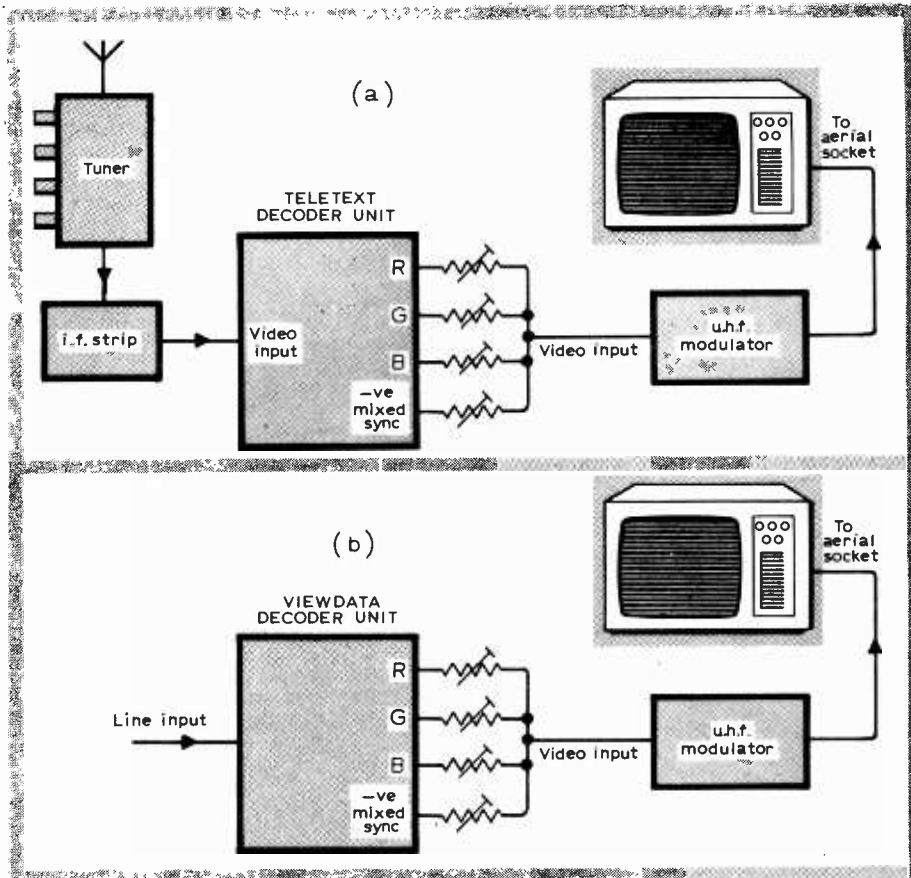


Fig. 11. Block diagrams of (a) a teletext terminal and (b) a Viewdata terminal, showing r.f. (u.h.f.) connections to the television set.

Basically it gives a visual indication of the position on the screen at which the next character sent by the computer will be displayed. When the computer sends a new page of information to the terminal, it first sends a code which returns the cursor, whether visible or not on the display, to the "home" position which is at the top left-hand side of the display. Thereafter, as each character is entered, the cursor is moved one character position to the right. The position of the cursor, whether this is switched on or off, is recorded by two counters, a character counter and a row counter, which maintain at all times a knowledge of the position at which the next character is to be displayed (and entered on memory). Thus we talk of the cursor as if it were a real entity, whether or not it is displayed.

By moving the cursor by means of the controls available (see below), the computer may position it to where the next character is to be entered. Thus it is not necessary to send a series of spaces where one or more blank lines are required, or where a row of characters is shorter than the full length of the line. The cursor also enables the computer to overwrite a portion of a display without having to first erase and retransmit the whole page.

The cursor may also be used at the terminal for editing purposes, e.g. when composing messages or doing calculations, or to point at a feature of the display it is desired to manipulate. In this context the cursor is a powerful communication channel between com-

puter and user which resembles a pointer (but more about this later).

Control characters in columns 0 and 1 must comply with ISO7 for line transmission and so far 15 have been allocated. Additional characters in the same columns may be allocated in future as more facilities are included.

The control characters which have so far been allocated in the experimental system undergoing pilot trials are:

Col/row	Name	Function
0/1	NUL	None-used for timing purposes
0/5	ENQ	Code sent by computer to terminal to initiate automatic terminal identification
0/8	BS	Back-space. Moves cursor one character position to left
0/9	HT	Horizontal tab. Moves cursor one character position to right
0/10	LF	Line feed. Moves cursor one line position down
0/11	VT	Vertical tab. Moves cursor one line position up
0/12	FF	Form feed. Erases screen and moves cursor to top left hand side of screen (position 1)
0/13	CR	Carriage return. Moves cursor to first position on same line
1/1	DC1	Device control 1
1/2	DC2	Device control 2
13	DC3	Device control 3

Combinations of these characters will be used to switch on tape recorders and hard copy devices remotely

- 1/4 DC4 Device control 4. Used to switch off both tape recorder and hard copy unit
- 1/8 CAN Cancel. Used to delete line of character. This code is used only from terminal to computer
- 1/9 ESC Escape. Used to indicate to terminal that the character following is from another set of control codes (in this case the control code set 2a to 7a of colours or graphics)
- 1/10 IS2 Home. Returns cursor to character position 1 on screen (top left hand side)

**Graphics characters.** The graphics and colour control characters for Viewdata are shown in Fig. 8 columns 2a, 3a, 6a, 7a for graphics and 4a and 5a for the controls. For line transmission the control characters of 4a and 5a are always preceded with ESC (code 1/11). On receipt of this code the terminal reverses the polarity of bit 7 from 1 to 0, thus restoring compatibility with teletext and places the characters in store.

The graphics characters in columns 2a, 3a, 6a and 7a are fully compatible with teletext and are treated in the same way when displayed. The complete set of Viewdata codes is shown in Fig. 9.

**Block diagram of terminal.** A block diagram of a Viewdata terminal is shown in Fig 10 (b). This shows the interconnection between the Viewdata decoder and the video amplifier of the colour tv receiver. An interface board contains the electronic switch which provides the changeover from tv reception to Viewdata. The input to the Viewdata decoder unit is, of course, the telephone line. By contrast Fig 10 (a) shows the teletext decoder connections (*Wireless World*, December 1975, pp. 563-566). The input to the teletext decoder is obtained from the i.f. input.

Fig 11 shows a similar set of connections where the entry to the television set for display purposes is the aerial socket of the tv receiver. In Viewdata only (b) a u.h.f. modulator has to be added, whereas for teletext (a) an additional tuner and i.f. strip must be provided. Hence the considerably greater attraction of a built-in decoder in the case of teletext.

(To be continued)

**The journal you like**

*Wireless World's* average circulation last year was up 4,604 copies to 69,220 per month, according to the Audit Bureau of Circulations. Overseas readers, in countries from the USSR and USA to the Falklands and Seychelles, bought 21,000 of these. On average, for the past eight years 200 more readers have joined our circulation each month.

# World of Amateur Radio

## Space and propagation

Martin Sweeting, G3YJO, of the University of Surrey's Oscar telecommand station reports that early this year one of the NiCad cells in the upper half of the Oscar 6 spacecraft (launched in 1972) "took a turn for the worse" and may fail completely; if this happens it is likely that the battery will be irretrievably damaged. He appeals for strict adherence by all amateurs to the operating schedules if Oscar 6 is to survive the year. Additional telemetry information received from the satellite would be welcome and should be sent to: UOS-AMSAT, Department of Electronic Engineering, University of Surrey, Guildford, Surrey. Incidentally, the UK FM Group (London) state that many amateurs in the Thames Valley area have been puzzled by the 144.8MHz wideband transmissions from the UOS-AMSAT telecommand station, G4DVT, at Guildford. This station operates daily for up to 25 minutes at a time, repeating every 100 minutes between 0530 and 2300 GMT.

GB3LBH, the 10GHz beacon station at Romford, Essex recently increased power and now uses a 200mW Gunn oscillator on 10.1GHz; it is regularly received at distances up to 25km including some obstructed paths; this beacon may be used for studies being carried out, by students at Imperial College. A 144MHz beacon (possibly 9H3ML) may be set up in Malta. The 1.3GHz beacon at Andover (GB3AND) with a power of 5 watts e.r.p. has been heard in Devon.

28MHz c.w. and s.s.b. activity periods are now being run by the RSGB on the first Sunday of each month (1200-1800 GMT, 28.0 to 28.1 and 28.5 to 28.6MHz). A new 28MHz beacon is expected to be set up at Lannion in Brittany, France, with the callsign F3THF on 28.227MHz; it also hoped that 50MHz beacons may be established at Lannion and also at Gibraltar as part of a new series of 50MHz transatlantic tests.

It is now thought likely that the

minimum of Sunspot Cycle 20 was reached during July 1976 with a maximum for Cycle 21 predicted around 1981.

## Licence totals

The Radio Regulatory Department of the Home Office are currently distributing (as renewals fall due) the new form of amateur licence (see February issue). Two reasons are given for the changes: "(1) To give you greater flexibility to pursue each aspect of amateur radio without having to apply to us each time for authority to do so; (2) we, in turn, expect to be able to keep within the Government's staff ceiling over the next few years while maintaining the issue of amateur licences without undue delays."

On January 1, 1977 the number of new-style Class A and B licences were: Class A 15,956; Class B 6202; total 22,158.

How the number of old-style licences built up to over 29,000 during the past few years is shown below:

	end- 1968	end- 1971	end- 1974	end- 1976
Class A	13,082	14,082	15,304	15,956
Class B	1,352	3,012	4,966	6,142
Class A/M	2,589	2,666	3,424	4,173
Class B/M	132	545	1,549	2,463
Class F/M	-	-	-	23
Television	186	214	277	318
<b>Totals</b>	<b>17,341</b>	<b>20,502</b>	<b>25,520</b>	<b>29,075</b>

## Amateur TV News

Mr R. C. Hills, G3HRH, Chief Engineer (Transmitters) of the IBA, is the new President of the British Amateur Television Club. He succeeds Mr R. S. Roberts, G6NR, who recently completed his four-year term of office. BATC has recently published a new 110-page book "A guide to amateur television" (non-members £1.75 post paid from BATC, 64 Showell Lane, Penn, Wolverhampton, Staffordshire).

P. Blakeborough, G3PYB, is constructing a vision transmitter for 1296MHz in addition to his 100-watt 625-line transmissions in the 432MHz band. Alan Morris, G4ENS, of Luton is trying to raise interest in proposals for an amateur tv beacon on 432MHz and later a 1296MHz repeater capable of handling tv signals.

## U.H.F. aerial gain

Des Clift, VK2AHC (formerly G3BAK) who has operated on every available band from 1.8MHz to 10GHz has commented in *Electronics Australia* on the problems of reproducing aerial designs from constructional articles, noting that the element dimensions given by different constructors for the same bands often show surprising differences. For 1296MHz he has attempted with only moderate success to build 8-over-8 skeleton slot array; 34-element long Yagi; four square helix; conical reflector with dipole feed, etc.

Arrays for 5.8 and 10GHz which can more readily be based on dishes have proved more successful.

The problem of obtaining gains (reference dipole) of above about 14dB on 432MHz is underlined in the results of the 10th national antenna-gain measuring contest held in the United States last year. The leading designs were: eight times 16-element Yagi (K2CBA) 16.1dB; four times 13-element wooden-boom Yagi (K2UYH) 16dB; G3JBL-type 28-element long quad-loop Yagi (K1LOG) 15dB; 15-element W0EYE-type Yagi (K1LOG) 11.8dB. On 1296MHz a 7ft dish aerial (WA2FGK) registered a gain of 24.3dB; a G3JBL-type 28-element long quad-loop Yagi (K2UYH) 17.1dB.

Such events indicate that many amateurs have an inflated idea of the forward gain of their aerials, possibly due to high front/back ratios.

## In Brief

The death has occurred of Austin Forsyth, OBE, G6FO, for many years editor of *Short Wave Magazine*. Before the war he operated from Newport, Monmouth and for a time from North Devon; more recently from Mads Morton, Buckinghamshire. . . . A working party is being set up by the RSGB "to study the whole Society in depth with a particular relation to the organisation of the Society's headquarters, the organisation of Council and its committees and the inter-relation between HQ, Council and Committees". . . . Seychelles now use the prefix S7, and the prefix S8 has been allotted to Transkei. . . . A mountain top in the Antarctic has been named "Cima Radioamatori" by a recent Italian expedition that kept in daily touch with northern Italy with the help of a number of Italian amateurs. . . . Endorsements for five-band operation are now made by the RSGB for the British Commonwealth Radio Transmission Award, the British Commonwealth Radio Reception Award and the DX Listeners' Century Award. . . . The ARRL National Convention for 1977 is being held (June 3-5) in Canada at the Sheraton Centre Hotel, Toronto; special get-togethers are planned for visiting British and "ex-G" amateurs. . . . Attention was drawn last September to the attractions offered by crystal ladder filters for the home construction of s.s.b. filters. Now, after extensive investigation of this type of filter, J. A. Hardcastle, G3JIR, has reported: "If a single outstanding factor were to be chosen from all the measurements which have been made, it would be that it is almost impossible not to produce a filter of some sort, if guidelines are followed. This should be sufficient to encourage even the most hesitant to try to construct their own crystal filters."

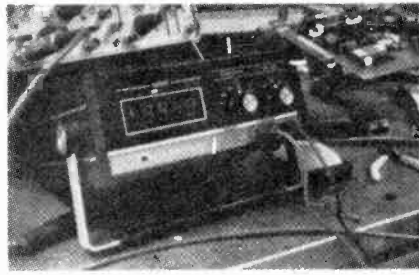
PAT HAWKER, G3VA

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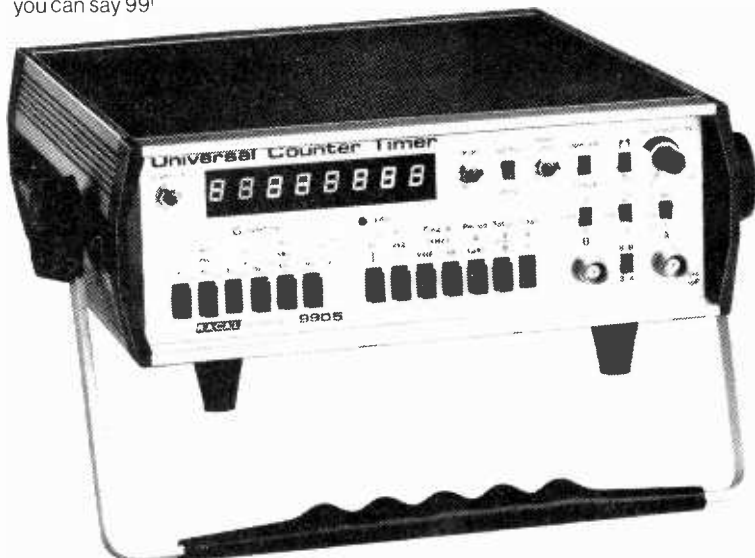
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# Electronic rhythm unit

## Interfacing the M252 and M253 circuits, described in the March issue

by A. Battaiotto and G. Ronzi, *SGS-Ates Application Laboratory, Agrate, Italy*

So that the rhythm section may be inserted into an electronic organ, a signal must be available which indicates whether one or more keys on the organ key board have been played. This signal, which we call the key played, starts the rhythm section. When a key is played the rhythm section can be arranged to start at the beginning of the bar (touch or key operation), i.e. the playing of a key removes the reset from the clock and from the M 252 or M 253.

Alternatively it can be arranged to start at any point in the bar (continuous or silent operation) i.e. the rhythm generator runs continuously, but its output is enabled by the "key played" signal. In continuous operation, therefore, the down-beat indicator is indispensable as it allows the first key to be played when the bar begins.

A third method (continuous free running) allows the unit to operate without playing any of the keys. This is done simply by selecting a rhythm on the push button array of the rhythm section. Neither the touch key nor the continuous silent key must be on when this method is used.

Fig. 11 illustrates the insertion of the electronic rhythm section into an organ. The two parts within dashed lines are details of the rhythm section, of interest for the connections to the keyboard of the organ.

### Rhythm section with 15 rhythms and 9 instruments

This rhythm section, realized with the M 252AA, is programmed with 15 different rhythms in such a way that each rhythm can use up to a maximum of eight of the nine instruments available, Fig. 12. The 15 rhythms programmed are the waltz, jazz, waltz, tango, march, swing, foxtrot, slow rock, pop rock, shuffle, mambo, beguine, cha cha, bajon, samba and bossa nova, and can be brought in one at a time by means of the key board. The instruments available are the bassdrum, snare drum, claves, high bongo, low bongo, conga drum, long cymbals, short cymbals and maracas.

The three controls are volume, tone and tempo. In addition, a switch allows the rhythm to be started at the begin-

ning of the bar or stops the rhythm. The assembly is carried out on two printed circuits, one contains the sound generators and preamplifier, and the other contains the supply, the M 252AA, the variable clock generator and the monostable circuit for driving the down-beat lamp.

The circuit can be divided into four parts, the sound generators, the variable clock generator, the down-beat monostable and the encoder. Operation of the M 252AA has already been described in the first part, but some further details will be given toward the end of this description.

### Sound generators

The generators are designed to reproduce as faithfully as possible the sounds made by percussion instruments. They

can be divided into two broad groups, namely, sounds consisting of damped, sinusoidal waves, like drums, and those consisting of damped white noise, like cymbals.

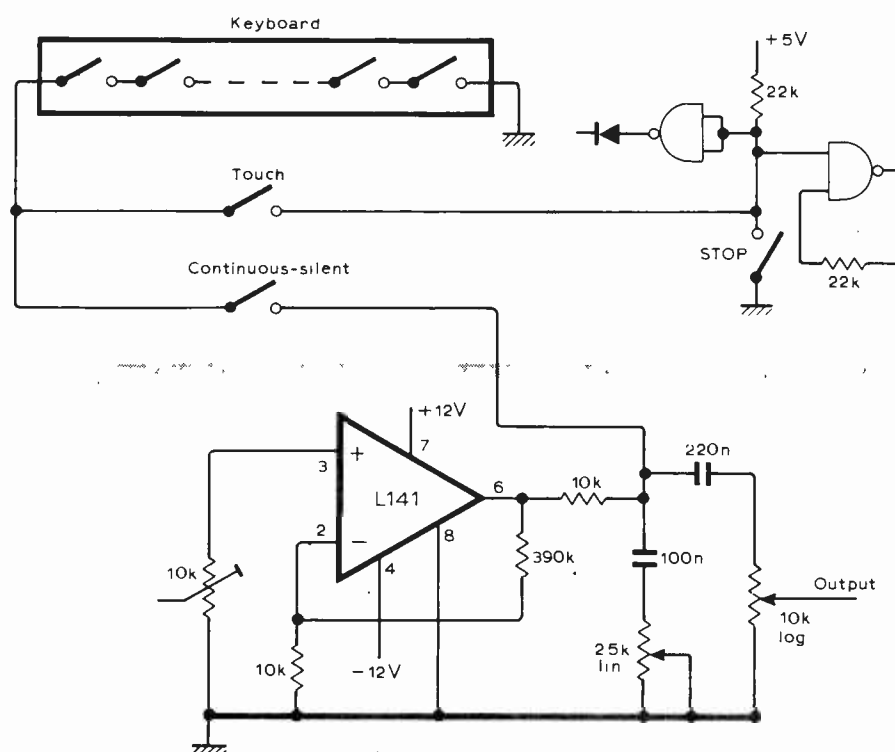
In the first category we can include the bass drum, high bongo, low bongo, conga drum and the claves, for which the basic circuit is shown around the twin-T parts of Fig. 13.

This circuit is a simple twin-T oscillator with active c.m.o.s.\* element kept slightly below the point of oscillation by the pre-set resistor. To obtain the effect of different frequency instruments you only have to select the right values for the capacitors. The potentiometer also regulates the length of the damping, so that longer or shorter sounds can be obtained.

The command from the M252AA is applied at points BD, HB, etc. As the M252 produces a square wave, the RC

\* A discrete-component oscillator circuit is available on request.

Fig. 11. Connections for incorporating into electronic organ. Rhythm unit parts are within shaded enclosures.



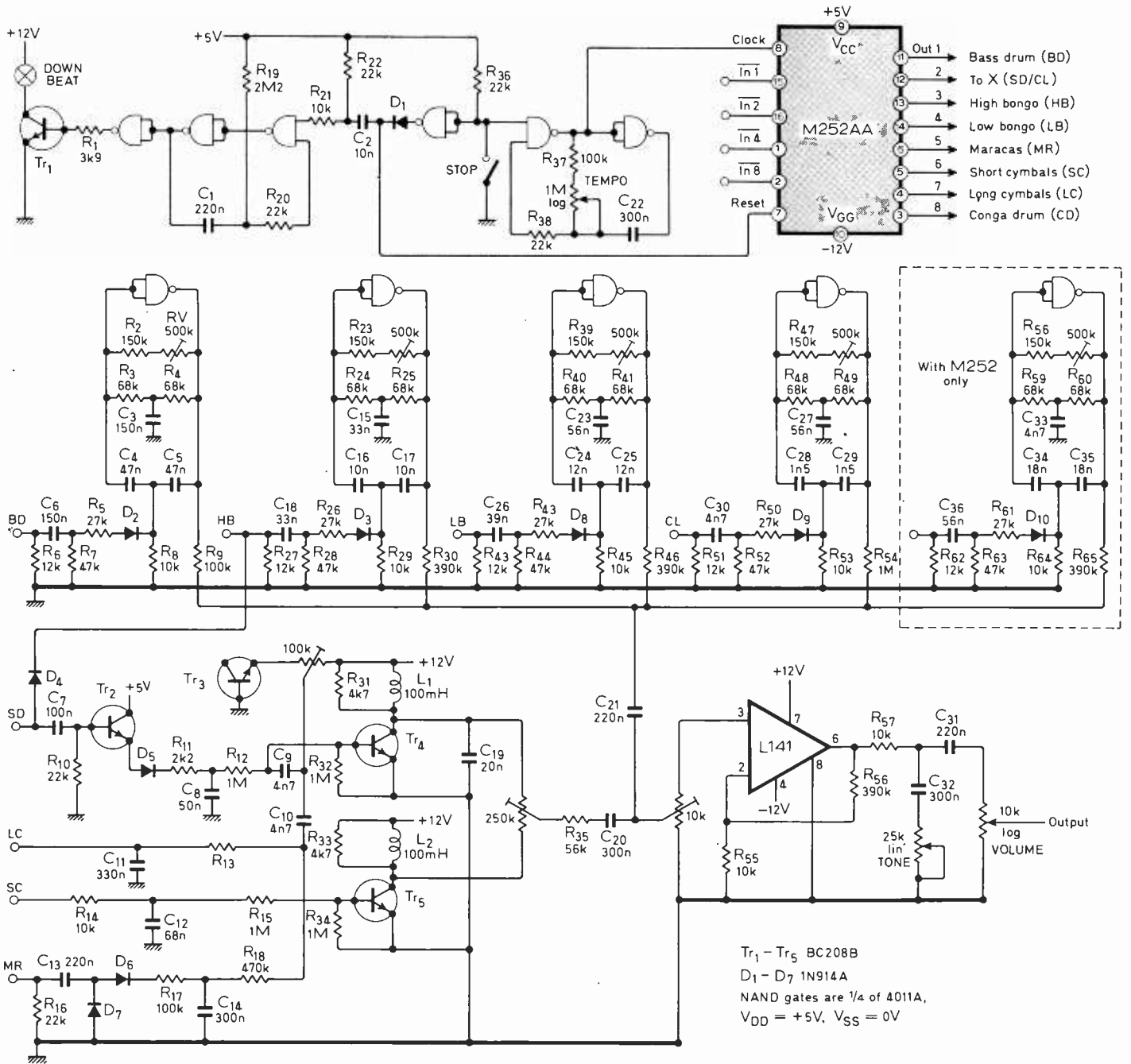
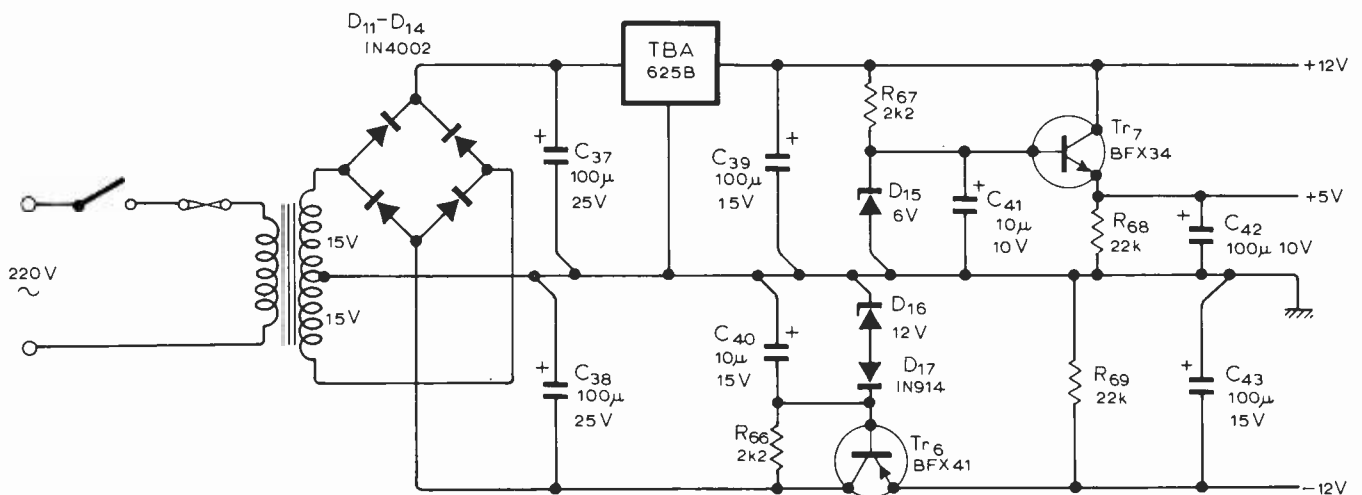


Fig. 12. Use encoder circuit of Fig. 13 with this M252 15-rhythm unit. (Rhythm selection details for M253 circuit will appear in part 3.) Circuit includes twin-T oscillators.

Below is show a conventional three-rail power supply circuit for rhythm generator.



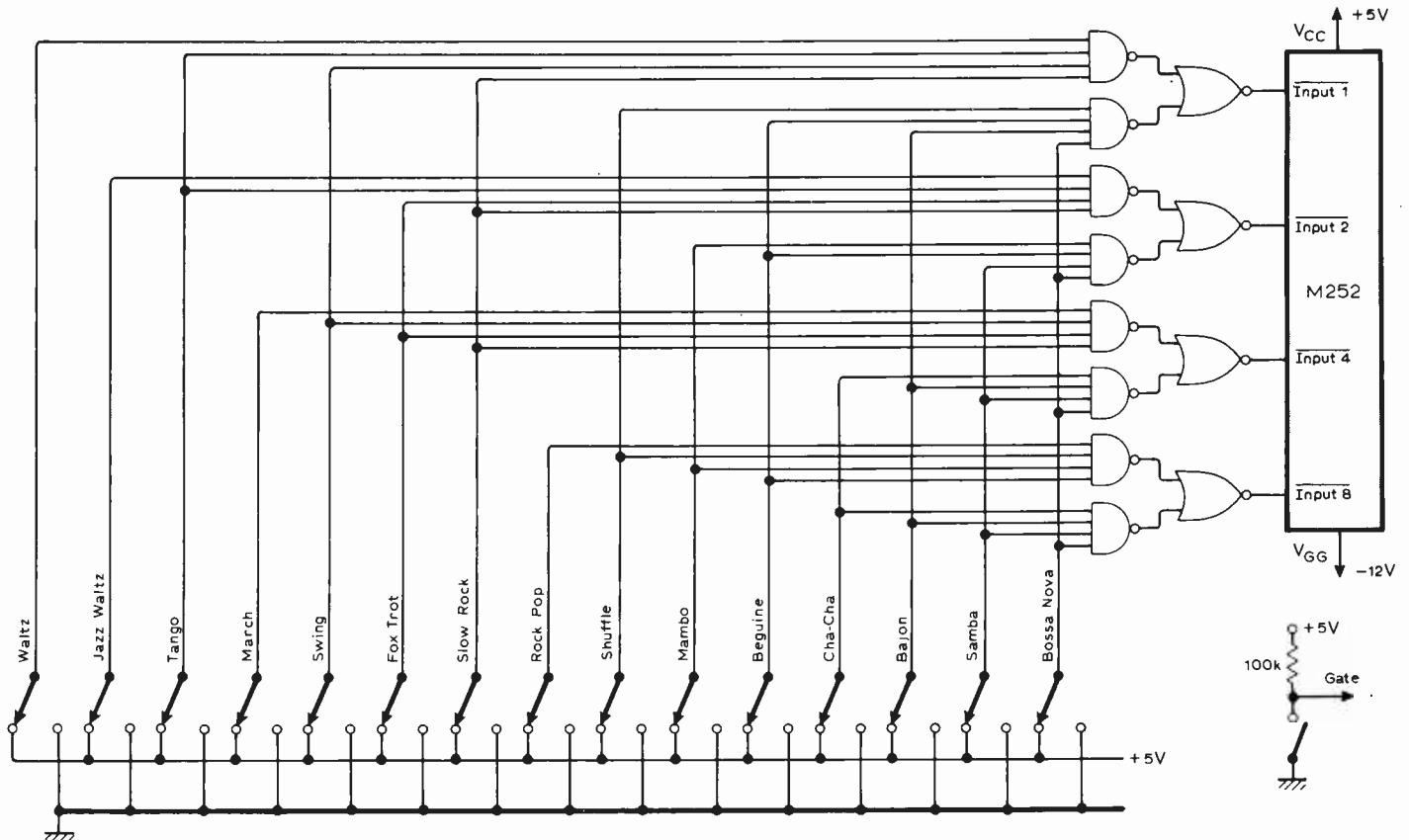


Fig. 13. In c.m.o.s. encoder for use with M252 rhythm unit single-pole switches can be used with resistors if desired. (See part 3 for M253 rhythm selection.)

differentiator (e.g.  $C_6$ ,  $R_7$ ) must be introduced so that a fairly short pulse arrives at the oscillator, which should not interfere with the damping of the oscillation but should be sufficient to activate the oscillator itself. Resistors  $R_{27}$ , etc, keeps the input at earth in the absence of a command, otherwise it would remain floating since the outputs of the M252AA are open-drain types.

In the second category are the long cymbals, short cymbals and maracas, for which the basic circuit is shown bottom left in Fig. 13. Transistor  $Tr_2$  charges the capacitor  $C_8$  during the short command pulse. This capacitor then discharges through  $R_{12}$  and the base of  $Tr_4$ .

The white noise produced by the zener effect of the base-emitter junction of a transistor is applied at the base of  $Tr_4$ . during the discharge of  $C_8$ , therefore, transistor  $Tr_4$  can amplify this noise. The level of amplification, however, will follow the discharge curve of  $C_8$  and therefore a damping effect of variable length will be obtained according to the values of  $C_8$  and  $R_{12}$ .

The inductor and the capacitor at the collector of  $Tr_4$  allow partially selective amplification to be obtained so that some harmonics can be boosted and an effect more similar to the instrument being simulated can be obtained.

Almost all the instruments used in this rhythm section start immediately with maximum amplitude and decrease exponentially. The only exception is the maracas simulator, whose signal increa-

ses progressively and then decreases like the others. This effect was achieved by means of the integrator-differentiator circuit which allows controlled amplification of the white noise. The snare drum is obtained by adding a signal of the second type, i.e. a metallic sound, to a drum sound. Each sound starts on the positive edge of the control pulse.

**Variable clock generator\***

The clock generator is realized with two c.m.o.s. gates and the tempo regulated by means of a potentiometer. When closed, the switch sets the generator in such a way that the output remains at 1 and at the same time the M252AA is reset. By opening this switch the bar begins i.e. the output immediately goes to 0 so generating the negative edge necessary to cause the first command pulse or pulses to be produced by the M252AA, according to the rhythm selected.

**Down-beat\***

This too is made with two c.m.o.s. gates. The down-beat pulse supplied by the M252AA is too short to light a lamp. Also it occurs at the end of the bar whereas the lamp should be lit at the beginning. This monostable, Fig. 12 top, which starts on the negative edge i.e. at the beginning of the bar, operates with an auxiliary transistor in such a way that the lamp lights for a sufficient period of time to indicate the beginning of each bar.

\* Alternative clock generator and downbeat circuits have been designed using t.t.l., h.l.l. and discrete components. Copies are available from editorial office.

**Encoder†**

Circuit, Fig. 13, uses HBF4012A four-input NAND gates, and HBF 4001A two-input NOR gates. If simple single-pole switches are to be used rather than an array of two-way switches, 15 resistors of 100kΩ must be inserted as indicated.

**Rhythm section with 12 rhythms and 8 instruments**

An alternative rhythm section was realized with the M253AA in which 12 different rhythms are programmed, each rhythm being able to drive simultaneously a maximum of seven out of the eight instruments available.

The 12 rhythms programmed are the tango, waltz, shuffle, march, slow rock, swing, pop rock, rumba, beguine, cha cha, samba and bossa nova. These rhythms can also be combined; two more can be selected simultaneously.

The instruments are the same as for the preceding unit with the exception of the conga. The adjustments too are equivalent, and the assembly is simply carried out on two printed circuit boards (£6 inclusive from M. R. Sagin, 23 Keyes Road, London NW2).

The sound generators, variable clock generator and monostable for the down-beat, are the same as for the M252 rhythm section.

The keyboard has the function of connecting the snare drum or the claves to the third output of the M253AA, according to the rhythm selected.

† Alternative encoder circuits are possible using mechanical switching, a diode matrix or t.t.l. gates. Copies of circuits may be obtained from the editorial office.

To be concluded

# Letters to the Editor

## THE WARDEN REPORT

Having read your leading article "WARC talk" (December 1976) and the follow-up article "Who is warden over the Wardens" (January issue), we feel it might be informative to your readers to learn of the mobile radio industry's reaction to these two articles.

We should confirm that the EEA were given an opportunity to examine carefully the Warden report, an industry working party was set up and its view of the report was placed before the Home Office Mobile Radio Committee.

The industry was critical of many sections of the report but all companies supported, *inter alia*, that part of the Warden report which called for additional spectrum for land mobile services.

It should be emphasised that this report was probably the first of its kind with anything like its depth, and was a major contribution to the understanding of the many factors which affect the use of the spectrum by all mobile radio users.

Subsequently, one of our member companies has produced a report (the Pannell report) which presents a view supported in large measure by the industry and demonstrates that something like 100MHz, is required between now and 1999. [See leader in February issue — Editor.]

It is quite understandable for a regulating department to take a rather conservative attitude but, as they are aware of the views of the users and the industry, we have confidence that the Home Office strategy at WARC will result in these views carrying considerable weight.

In conclusion, we ought to point out that your "Warden" article is misleading in three matters. Mr Warden has not, as far as we are aware, (a) completed a report on broadcasting; (b) reached the conclusion that there was "no further need for any allocation to mobile radio above what it had already got"; (c) said that "any further channels which did become available should go to the Post Office" — indeed, we understand that the Post Office were asked to go to 12.5kHz channel spacing and to prove further need for more spectrum.

We trust this will be helpful in explaining the EEA view on this very important matter. J. W. Carlton, Chairman, Mobile Radio Committee, Electronic Engineering Association, London WC2.

## CURRENT DUMPING AMPLIFIER

The recent controversy on the current dumping amplifier (December 1975 issue and subsequent letters) has not come up with any consensus as to whether it is just an elegant method of applying feedback or whether there is an element of feedforward in it. It can be shown quite easily that with an amplifier of finite open loop gain (and consequently finite feedback), the current dump trick achieves much more than feedback alone possibly could. An expression is derived below for the current dump configuration given by Mr Walker and Mr Albinson in *Wireless World* (Dec. 1975), but the amplifier considered has a finite open loop gain and a finite input impedance. With these constraints, and assuming an arbitrary non-linear transfer function for the current dump block, an expression can be derived wherein it can be shown that the error in the current through  $Z_4$  is exactly compensated for by the current through  $Z_1$  provided the conditions given in equation 4 are satisfied.

$$V_{o1} = A(V_{in} - V_i) \tag{1}$$

$$V_i = (Z_1 || Z_3 || Z_{in}) \left( \frac{V_{o1}}{Z_3} + \frac{V_{in}}{Z_{in}} + \frac{N(V_{o1})}{Z_2} \right) \tag{2}$$

$$V_L = (Z_L || Z_4) \left( \frac{V_{o1}}{Z_1} + \frac{N(V_{o1})}{Z_4} \right) \tag{3}$$

Simplification yields the combination required to make  $V_L$  independent of  $N(V_{o1})$

$$\text{i.e. } \frac{Z_1 Z_2}{Z_3 Z_4} = \frac{1}{1 + \frac{1}{A} \frac{Z_3 || Z_4}{Z_1 || Z_2 || Z_3 || Z_4}} \tag{4}$$

For an infinite gain op-amp, equation 4 reduces to Walker's original form. To confirm this result an amplifier was made with a variable open loop gain (A). This variation in open loop gain was obtained in an elegant manner by connecting a potentiometer across the compensating terminals of the operational amplifier used. The circuit was designed to have minimum distortion for an open loop gain of approximately 52dB, corresponding to 20dB of feedback. Fig. 2 shows the results which confirm that increasing feedback beyond a particular value makes the distortion figure worse. In fact with all the current dump elements removed and the same amount of feedback (20dB), the distortion measured 3.1% against the null reading of 0.4%. This should remove any doubt about the effectiveness of the method, and Mr Walker and Mr Albinson of the Acoustical Manufacturing Company should be congratulated on innovating a most elegant method for removing distortion and for eliminating thermal problems associated with the output stages of high power audio amplifiers.

D. M. Divan and V. V. Ghatge, Philips India Ltd.

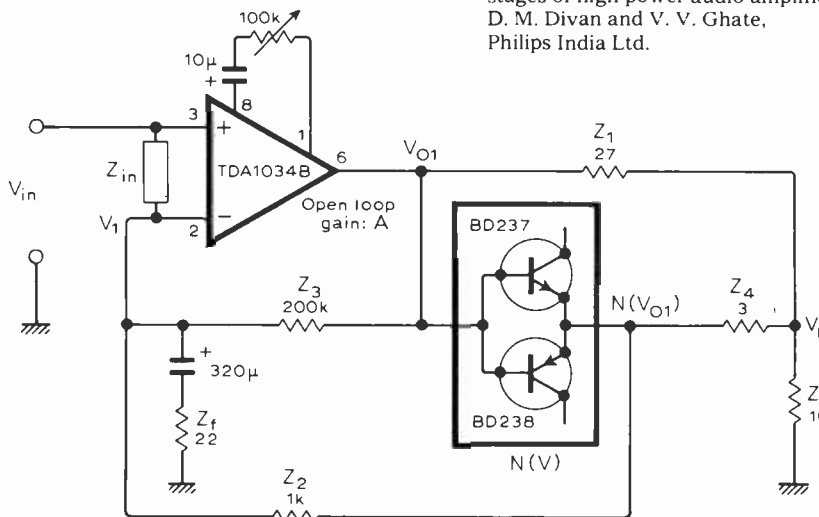


Fig. 1

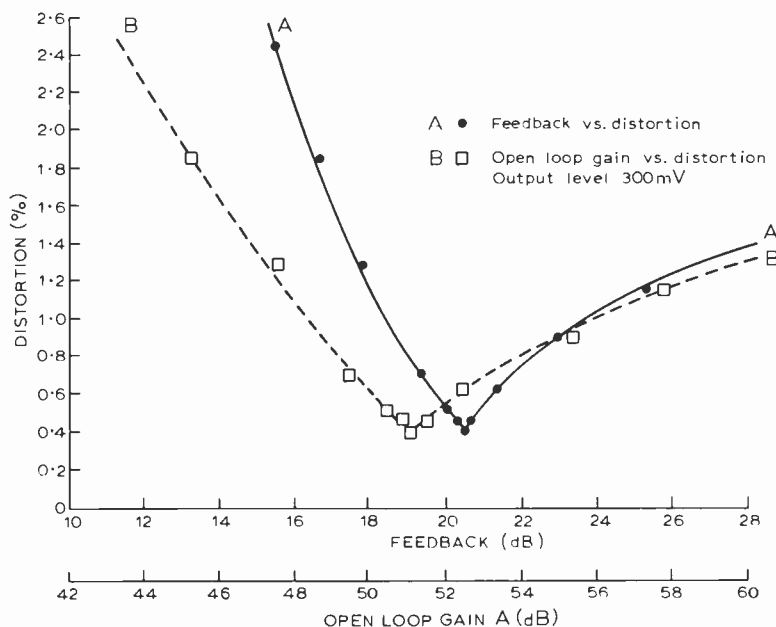


Fig. 2



## ADVANCED PREAMPLIFIER DESIGN

The letter from Mr Watts in your February issue and the answer from Mr Self is notable for two factors — the abrasive language of the former's criticism and the surprisingly temperate reply from the latter. Frankly, I, too, could find much to fault in the design but, of course, there are ways of expressing it, aren't there?

My main criticism of Mr Self's design is that it is over-engineered, conceived by a hi-fi enthusiast who apparently has not been too involved in the costing process when putting together the elements of a circuit. The principle of Occam's Razor is also the essence of good design technique. He has also overlooked the simple facts of life — that despite the extremes to which one may go in designing equipment of this type, the aberrations that are inherent in all programme sources available to the domestic user are likely to be far greater than those introduced by even the most modestly designed reproducing equipment.

But Mr Watts is guilty of worse errors, in dealing with pure theory, opinion, and dressing it up as fact. Let me take one example — and since he seems to invite challenges, here's another from me. If he is able to produce for me a *high grade pickup cartridge* capable of the sort of amplitude linearity input when correctly loaded that he insists should be observed in the equalised input stage and will deliver consistently peaks in excess of 200mV, then there is £5 ready in my hand for any charity he cares to name.

Reg Williamson,  
Norwich.

## AURAL SENSITIVITY TO PHASE

As comment on the two letters in the February issue may I summarise some comment that I have made many times on the subject of the effects of phase shift in a monaural channel?

If a wideband speech or music signal is fed into a transmission system the system design must ensure that the low frequency components and the high frequency components arrive at the output end at about the same time. Clearly there will be some loss in sound quality if the low frequency components arrive today and the high frequency components arrive tomorrow. Thus there must be a limit to the differences in the transmission time that can be allowed. The CCIR standards define the permissible differential time delays for high quality systems, typically the 5kHz components may be delayed by around 5 milliseconds with respect to the 1kHz reference signal before a quality change is noticeable.

If we (mistakenly) choose to express this permissible time delay as a phase shift, it is some 9000 degrees, that is, the start of the 5kHz component can be delayed by about *twenty five cycles* before the shift is aurally noticeable. The wave shape at the system output then bears no relation to the waveshape at the system input.

If anybody has any evidence that time delays inside the CCIR values can result in

obvious differences in sound quality then the data should be produced as a contribution to the art. Our own work appears to show that if a skilled listener has the opportunity to listen repeatedly to a signal while the time delay is switched in and out of circuit, he will eventually come to detect a shift of about 3 milliseconds (rather than 5 milliseconds quoted above) but these observations only serve to confirm that the delay limit specified by CCIR is a reasonable choice for the ordinary situation where repeated comparison is not possible.

James Moir,  
James Moir & Associates,  
Chipperfield,  
Herts.

## DISTORTION AND THE EAR

After reading D. Self's article, "Advanced preamplifier design" in your November issue, I feel obliged to comment on the general attitude to audio amplifier design taken by the majority of WW contributors. At the core of this approach is the assumption that any loss of realism, originating from amplification within the reproducing train, is a direct function of t.h.d. Consequently with each new design appears detailed analysis of t.h.d. performance but, from the user's point of view, the lack of any comparative listening test is painfully obvious.

A striking example of the ear's dissimilarity to a t.h.d. meter would be the attempted measurement of distortion from an audibly inferior preamplifier of a sinewave signal recorded on disc. Wow and tracing distortion combine to swamp the amplifier's contribution by orders of magnitude, but the amplifier's imperfections are all too obvious through the reproduction of voice or music from the same source.

If an accurate model of the human audio processing path existed, it would be possible to design with confidence circuits that introduced the theoretical minimum of audible colouration. Unfortunately, this model does not exist and any major advancement in amplifier quality can only be achieved through extensive, practical listening comparisons of all types of active devices and circuit configurations.

After experimenting for several years in this direction and through the careful analysis of designs proved to be audibly superior, the one common factor to emerge is an appreciation of the ear's uncanny ability

to detect high order distortion products under heavy masking by low order products and noise. In essence, the ear will react favourably to 1st order distortion products in the order of one per cent, provided all higher order products are virtually non-existent. Although it has been long accepted that the ear does favour colouration derived from low order products, the relative weighting ratio (for a given degree of colouration) has never been established and I believe has been consistently under-estimated.

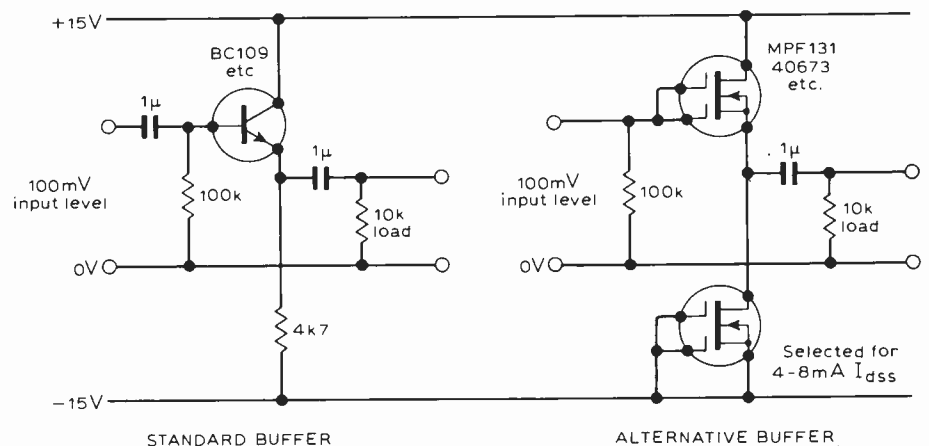
If one applies this theory to high quality amplifiers, the design rules are radically altered. Bipolar transistors become virtually useless in low level stages because of the complex exponential transfer characteristic. Negative feedback (even locally applied) tends to be a disadvantage because innocuous low order distortion products are converted to lower level, but audibly more apparent, higher order ones (Ref. Scroggie) and the output impedance of devices becomes a significant source of distortion. Space allows no further elaboration but a simple example of this alternative approach is given in the form of a unity gain buffer stage. Anyone interested in conducting a comparative listening test (on a high quality stereo system) between this circuit and the standard emitter-follower may find the lack of correlation between measured t.h.d. and audible colouration interesting.

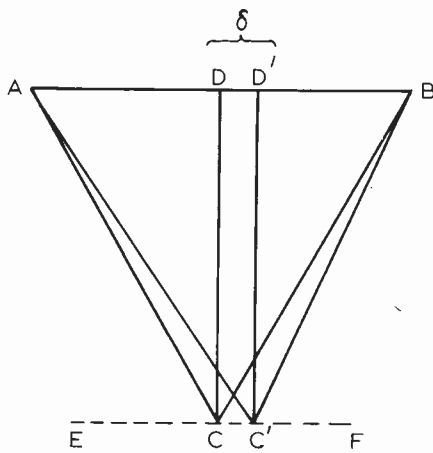
A. King,  
Glenroy,  
Victoria, Australia.

## LINEAR PHASE LOUDSPEAKERS

As Mr Gorman pointed out in his letter in the February 1977 issue, the arguments arising from the advocacy of linear phase loudspeakers have generated much interest, heat and correspondence. May I be allowed to add to the last by enquiring of your other correspondents what importance should be attached to the position of the listener who has set up his linear phase loudspeakers in the normal stereophonic configuration?

In the diagram (overleaf) I shall assume that two linear phase loudspeakers (which I assume may be regarded as point or at most line sources) have been situated at points A and B of an equilateral triangle ABC of side, say, 2 metres. The listener being conscientious (and also being a point receiver) situates himself at C. Unfortunately before he can begin to appreciate the benefits of a linear





phase configuration, a malevolent deity displaces him a small distance  $\delta$  metres along the line EF to C'. Trivial geometry shows that in these circumstances there is a difference in path lengths  $AC' - BC'$  equal to

$$\sqrt{3+(1+\delta)^2} - \sqrt{3+(1-\delta)^2} \approx \delta \text{ metres.}$$

Thus, assuming a speed of sound of, say, 330m/s, a displacement of 10cm will produce approximate cancellation of a steady signal of wavelength 20cm, i.e. a frequency of 1.65kHz, and will do funny things to the phase of signals near that frequency.

Of course the listener should not have allowed himself to be displaced from point C, but the malevolent deity who is also cunning provided him with two ears placed about 20cm apart. Thus the poor listener (who, being conscientious has avoided the trap of inducing phase distortion by, say, wagging his head from side to side) is left in the position that the only way he can effectively enjoy the linear phase of the stereophonic set-up is to block-up one of his ears and locate the other at C.

N. G. Shipley,  
London, EC4.

## AMPLIFIER DESIGN

There is clearly an interesting disputation in the making regarding pre-amplifiers between Messrs Watts and Self (February letters). I particularly note that both seek upwards of 40dB overload margin. Why? There is no point in it unless the main amplifier and the loudspeakers could also handle 40dB overload. But in a real world what would happen? If such a sound level could be produced it is more than likely to permanently damage the ears, a fearful consequence of some such little *faux pas* as dropping the pickup.

Reality calls for a limitation of peak power and that limitation is best achieved by a means which minimises the resulting and inevitable distortion. More by accident than design valve amplifiers working in Class A had that useful property.

Mr Sundqvist (February issue) is now spelling out for us the details of i.m. distortion and it is becoming more generally apparent that transistor design needs far greater thought and attention to detail if i.m. and other distortion is to be kept at innocuous levels. In particular he is making us aware of the danger of feedback over several stages of undefined bandwidth in that a transitory condition will arise of a maximum signal at some point where feed

back has failed, for an instant, to reduce the signal to its normal working level. Several cures were suggested including a generous overload margin.

May the current vogue and justifications for large overload margins arise from a possible subconscious reaction to hearing i.m. distortion which is then irrationally justified in terms of some supposed large transient output from the pickup? How in a practical world would this transient find its way on to the record, and if it could be present will not the normal mechanical constraints ensure it is never produced? Why in fact does virtually all discussion of high fidelity reproduction assume no significant defects in the recording amplifiers etc? Were this really true there are, and have long been, practical designs for near perfect reproduction amplifiers.

Be that as it may; the recordist does not, indeed he dare not, shrink back from some means of volume compression even if it be no more than simple manual control. That is his tool for avoiding the overload situation and if he has done his job properly may I ask what distressing signal, capable of upsetting a pre-amp, can come off a record via a pickup?

The truth of the situation is more likely that pre-amps are generally badly designed and, transistors being deceiving little beasts, they react in ways that are not expected. Mr Self would not have it that the first part of his pre-amp was, as Mr Watts claimed, a phase shift oscillator, but I can safely say from recent practical experience that similar arrangements are quite capable of oscillating at h.f. or l.f. and showing h.f. oscillation on part of an l.f. cycle when fed with a normal sine wave. They have in fact mutual conductances far beyond those of valves, and these increase more or less directly with current flow and have no clear inbuilt limiting mechanism as has a valve, which limits in most circuits just as soon as the grid becomes positive. Without limiting, a transistor may well start an h.f. oscillation; the circuit comprising *inter alia* stray reactances, in which its own widely variable capacitances will figure. This of course may establish a form of blocking oscillator. If the crucial reactances are within the transistor chip the designer has a fearsome problem on his hands.

Here Mr Watts chooses a policy of avoidance by using an i.c. in the no doubt well founded belief that these have been the subject of such exhaustive designing processes, so that they may be marketed as being vice free, that he needs fear no unwanted side effects. Mr Self attacks on the grounds that i.c.s have greater noise, which seems to be yet another airing of the irrational oversight of the way in which noise in later stages is lost in the amplified noise from earlier stages.

However, the most intriguing feature of Mr Self's design and defence concerns the 1 n 5 capacitor from base to emitter of the input transistor. Why not to earth, if as claimed, it is an r.f. bypass? May the truth be that by some chance it is solving some instability problem? Certainly by trying out a number of preamp designs I have learnt to realise RIAA stages are exceedingly prone to strange problems. But then a warning was issued by J. Linsley Hood in the September 1971 issue of *Wireless World* concerning two, let alone three, transistor high gain circuits. Perhaps we do not learn and continue to fall into the same traps.

C. Streatfield,  
Poole,  
Dorset.

## NORTH SEA COMMUNICATIONS

I have read with interest your report in the December 1976 issue (p.44) of Mr L. Buttriss's talk to the World Offshore Oil Conference.

How easy it is to knock those who are pace setting and breaking new ground and who occasionally fall short of the standards which Mr Buttriss sets. Considering that Mr Buttriss's organisation is only following along behind others who are in the front line, as it were, I suppose he is in a very good position to develop hindsight, which as we all know is a splendid quality.

If Mr Buttriss was a little nearer the front line action he might recognise the difficulties with which the British Post Office have had to cope, not to mention systems designers like my organisation whose clients found themselves at the mercy of a takeover exercise near to Mr Buttriss.

It is always easy to generalise on the failings of others, unspecified of course, but not always the wisest policy if your livelihood depends to a large extent on the said others.

W. T. Brown,  
Macclesfield,  
Cheshire.

## TALKING BOOKS APPEAL

A few years ago you were good enough to publish an appeal for servicing volunteers for the British Talking Book Service for the Blind. As a result many new volunteers were enrolled.

As the service has expanded so has the need for servicing volunteers and I would ask anyone who can repair a simple tape recorder, and can spare a little time, to contact the address given below for further details.

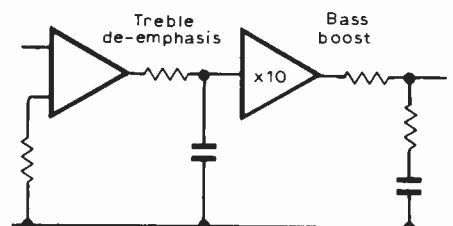
These Talking Books mean a lot to the blind people who use them and their gratitude for the help given by servicing volunteers amply compensates for the loss of a few hours spare time.

The address to contact is: British Talking Book Service for the Blind, Nuffield Library, Mount Pleasant, Wembley, Middx. HAA 1RR. Telephone: 01-903-6666  
A. J. Smale,  
London N21.

## Corrections

The diagram below was inadvertently omitted from Mr Graham Nalty's letter in the February issue on the Advanced Pre-amplifier Design.

Also, the heading "Re-invention" was omitted from Mr K. H. Green's letter (top of page 60). Apologies to Mr Nalty, Mr Green and our readers.



# Stereo coder

## 1 —Choice of method/oscillator stability

by Trevor Brook

**A practical design for a high quality coder suitable as a test instrument is described. Apart from the audio filtering, inductors have been avoided and a compact board layout produced. A v.h.f. unit for servicing checks on receiver performance could also be used by demonstration showrooms to feed programmes of their own choice to stereo tuners.**

**Part 1 examines the stereo multiplex system and establishes tolerance limits for signal components. Channel separation is considered as this would assume increased importance if a matrix system of surround sound broadcasting were adopted. Part 2 gives construction and alignment details for the coder and Part 3 gives modifications to the Portus and Haywood decoder to provide a low distortion reference decoder.**

Work on this coder started originally out of curiosity as to whether an inductorless design would be possible. Early experiments were promising and the design has been pursued to give performance of broadcast quality.

The specifications of stereo coders now in use at both national and independent local radio transmitters are given in Table 1 and most existing coders have similar figures. Particular objects of this design are to improve crosstalk at the higher audio frequencies and achieve mid-frequency distortion better than 0.05%.

### Stereo signal specification

The modulating signal in the Zenith-GE pilot tone system is defined as

$$0.9 \left( \frac{A+B}{2} + \frac{A-B}{2} \sin 2\pi f_c t + 0.1 \sin \pi f_c t \right)$$

where A is pre-emphasized left channel, B is the pre-emphasized right channel, and  $f_c$  is 38kHz.  $\frac{1}{2}(A+B)$  is called the sum or M signal, and  $\frac{1}{2}(A-B)\sin 2\pi f_c t$  is called the stereo difference or S signal, and is a double sideband suppressed-carrier signal.  $0.1\sin \pi f_c t$  is the pilot signal at 19kHz.

Substituting the maximum values  $A=+1$  and  $B=+1$  or  $-1$  gives the maximum amplitude of 90% for the M

and S signals respectively. Monophonic receivers continue to produce only the M signal as audible output thus giving the system its compatibility.

### Decoding

To retrieve the stereo information involves a decoder which can take the form in Fig. 1. The reduction in channel separation if a decoder adjusted to

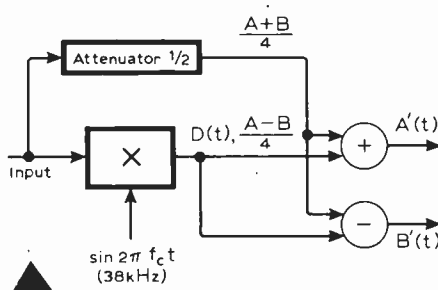
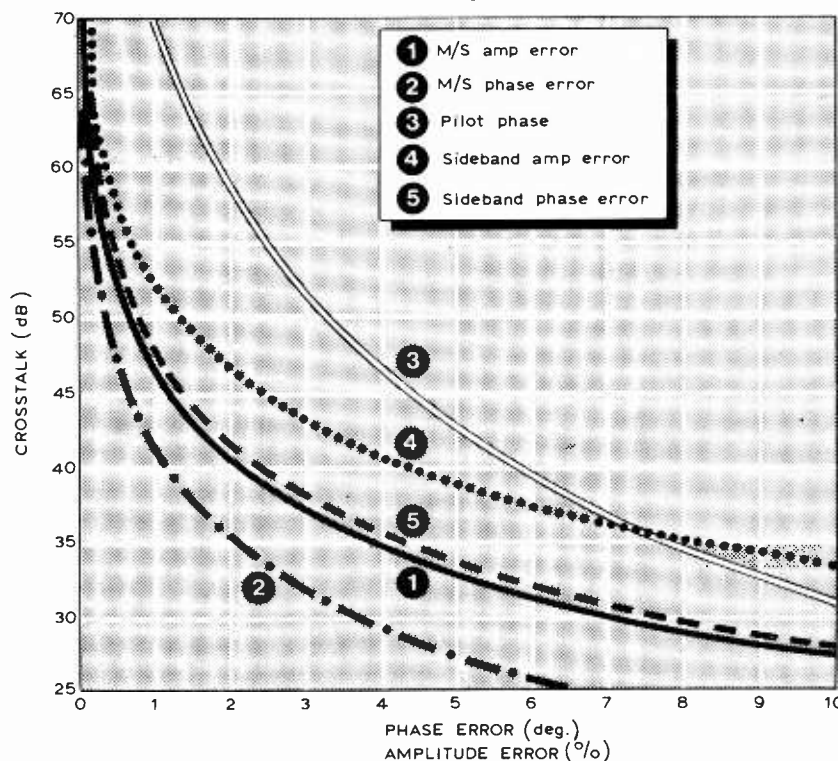


Fig. 1. How the stereo multiplex signal can be decoded. After de-emphasis the A' and B' outputs become left and right channels.

decode a perfect multiplex signal is presented with signals having the five following departures from ideal is shown in Fig 2:

- amplitude error between the M and S signals
- phase error between the M and S signals
- phase error in the pilot relative to the 38kHz suppressed carrier. The requirement for pilot phase accuracy is substantially less than for M/S phase accuracy
- amplitude error of one sideband only of the S signal, typical of the h.f. loss

Fig. 2. Inherent crosstalk of the multiplex signal plotted against  
 1) Amplitude error between the M and S signals  
 2) Phase error between the M and S signals  
 3) Error in pilot phase  
 4) Amplitude imbalance between the sidebands of the S signal  
 5) Phase shift in a sideband of the S signal



**Table 1. Some parameters of the broadcast coders in use today.**

	BBC	IBA
Amplitude response $\pm 0.5\text{dB}$ $\pm 1\text{dB}$	60Hz — 10kHz 40Hz — 15kHz	50Hz — 15kHz —
Channel separation	100Hz — 10kHz $\geq 40\text{dB}$ 10kHz — 15kHz $\geq 36\text{dB}$	400Hz — 5kHz $\geq 48\text{dB}$ 30Hz — 15kHz $\geq 42\text{dB}$
Harmonic distortion (1kHz)	0.3% at 2dB above peak level	0.5% at peak level
38kHz leakage	$< 40\text{dB}$	$\leq 40\text{dB}$

encountered in receivers

— phase error of one sideband only of the S signal.

For reasonably high channel separation, say better than 45dB, the above effects may be considered as algebraically additive. It is evident that extremely stringent amplitude and phase performance requirements are set for a coder intended to give high channel separation.

Another problem in the multiplex system is distortion. Apart from the usual harmonic and intermodulation distortions, spurious beat tones can be produced in the decoded outputs. This is the result of intermodulation between the various components of the stereo signal and, though predominantly a receiver problem, could also be caused in the signal generation method or in a coder's output amplifier. Beat tone distortion is worst at the higher audio frequencies and subjectively produces an unpleasant 'splashing' sound on sibilants. Most stereo receivers will give clearly audible low- or mid-frequency beats on the 10 and 14kHz bursts during the BBC stereo test zone transmissions even though these tones are not at full level. On mono reception of a stereo signal the effect is not noticeable except on very poor receivers. Fig 3 shows the beat tone possibilities in both mono and stereo reception.

**Generating multiplex signals**

There are two principal ways of producing the coded stereo signal. The first and almost universal are switching methods, while the second is the matrix method where the individual signal components are generated separately and then added together.

Conceptually the simplest and also a common way of switch encoding is to switch between the A and B signals with a diode ring or similar device driven by 38kHz, Fig 4. For a square wave switching signal the following output is produced

$$\frac{A+B}{2} + \frac{A-B}{2} \cdot \frac{4}{\pi} \left| \sin 2\pi f_c t \right. \\ \left. + \frac{1}{3} \sin 6\pi f_c t + \frac{1}{5} \sin 10\pi f_c t + \dots \right|$$

The snag is that sidebands around odd harmonics of the switching frequency are present in the output and, more difficult, the required difference signal

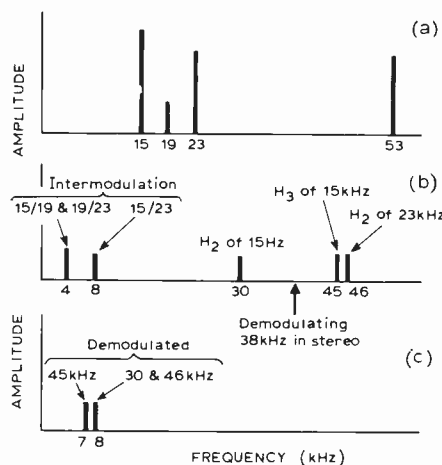


Fig. 3. Principal possibilities for production of beat tone distortion in any receiver (b) whenever a composite stereo signal (a) undergoes intermodulation distortion. Additional tones are produced in a stereo receiver (c).

has too high an amplitude. To remove the components above 53kHz as well as reduce the S amplitude by  $\pi/4$  requires a filter with the amplitude characteristic shown in Fig 5, and a linear phase response at frequencies below 53kHz! Broadcast quality coders typically use ten or so inductors in such a filter. Other switching arrangements can avoid the necessity for S amplitude correction and in other respects switching coder performance is largely determined by switching time and 1:1 accuracy of the 38kHz square wave. Whatever low-pass filter is required practical realisations need careful alignment involving several interdependent adjustments and

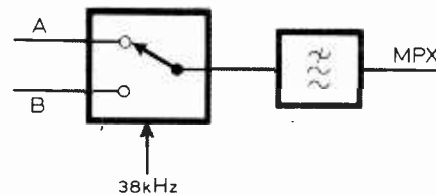


Fig. 4. Basic arrangement for the switch encoding method. Switch would typically be a ring of diodes or f.e.t. switch driven by the 38kHz square wave.

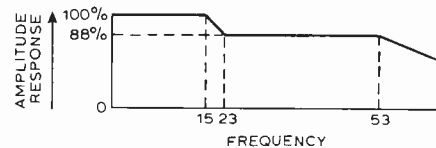


Fig. 5. Desired characteristic for the filter in the simple switch coder, Fig. 5. A linear phase response is required up to 53kHz.

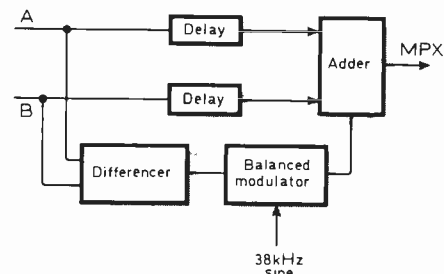
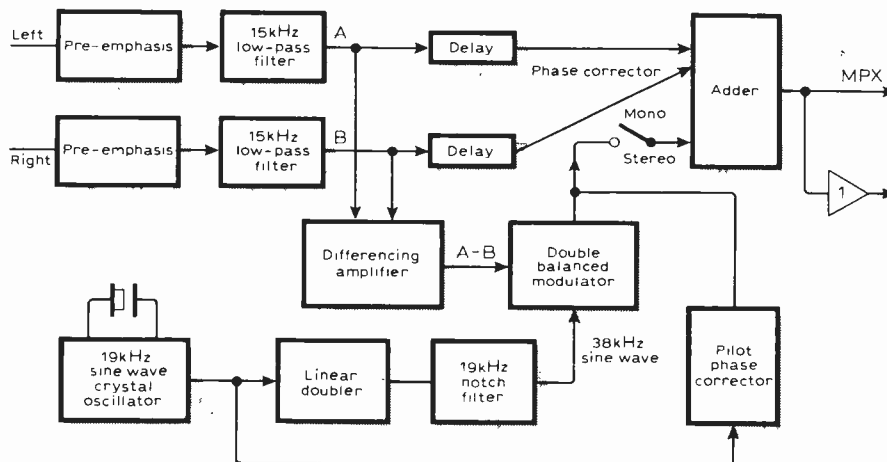


Fig. 6. Block diagram for the matrix coding method.

deficiencies in the filter make such coders susceptible to all the forms of signal degradation listed earlier. A complete switching coder design has been published by Mack<sup>1</sup> and the virtues of diode cross modulator circuits for applications including coding stereo extolled by the same author<sup>2</sup>.

The matrix form of coding is shown in Fig 6. A point to note is that the 38kHz fed to the multiplier in this case is a sine wave. Another alternative would be to use a conventional switching multiplier

Fig. 7. Complete block diagram of the coder described.



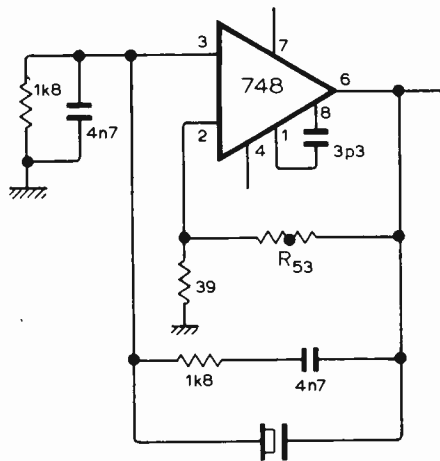


Fig. 8. Thermistor-controlled oscillator with the R53 bead running at 205°C, and a resistance of 82 ohms.

fed by a square wave, filter out the difference signal from the odd harmonic components, and then feed it to the adder. With the matrix arrangement in the diagram the last three degradations can be made negligible so crosstalk performance mainly rests on achieving good gain stability and phase matching between the sum and difference signal paths.

However, some new problems arise with this form of coder. The linearity of the multiplier to audio frequencies will have an effect on beat tone distortion performance and in a practical design there is the danger of impurities on the 38kHz producing further beat tone outputs. Common to all forms of coder is the need for a low distortion 19kHz pilot of correct phase and good stability, and audio pre-emphasis and filtering to limit the bandwidth of A and B signals to 15kHz.

**Choice of matrix method**

With an instinctive loathing of inductors and poor prospects at the time of realising a sensible active filter meeting the stringent phase and amplitude requirements while introducing negligible noise and distortion, the matrix approach looked more promising. Using the matrix principle only the first two signal degradations should be apparent and to meet a target channel separation of 55dB implies an M/S amplitude error of less than 0.18% and an M/S phase error better than 0.1°.

The block diagram of the coder is shown in Fig 7. Both 19 and 38kHz sine waves are required in this coder and starting with a 19kHz sine wave which is then doubled using a linear multiplier to square its input (a sine-wave squared equals a single wave of double frequency plus a d.c. term) and produce 38kHz of correct phase involves less filtering than starting with a square wave at a higher frequency (38, 76 or 152kHz) and dividing down.

If the coder is to be fed from any practical signal source other than a distortionless audio signal generator then the 15kHz filters are essential to

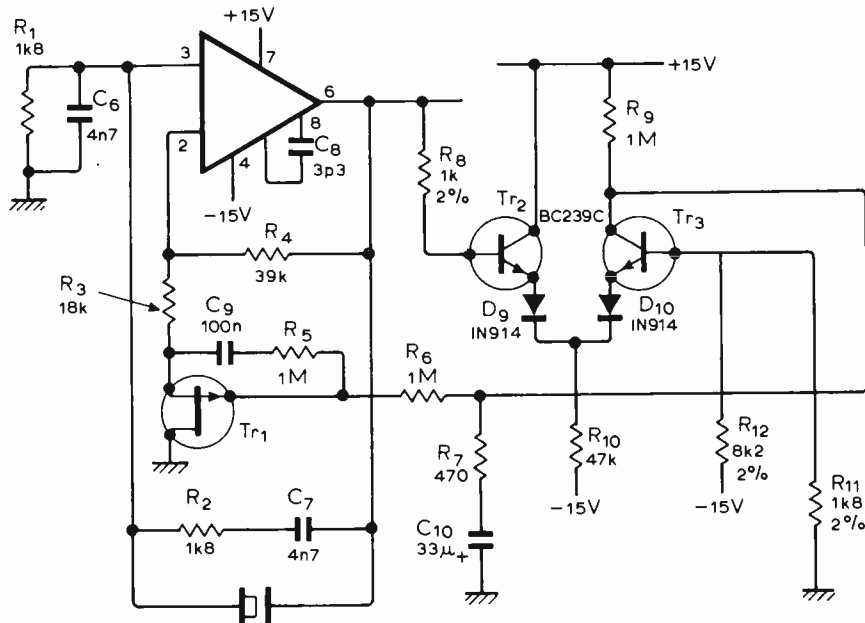


Fig. 9. Oscillator with improved amplitude/temperature drift. Tr<sub>2</sub> and Tr<sub>3</sub> form a long-tailed pair comparator and R<sub>5</sub>, R<sub>6</sub> equalize the signal voltages across the f.e.t. to linearize it and reduce distortion of the sine wave output.

prevent gross beat tone effects due to ultrasonic components on the audio inputs. It is desirable that rejection of frequencies of 19kHz and above be at least 45dB so this means that when pre-emphasis is in use, giving around 20dB boost at 19kHz, a filter attenuation of 65dB is required by 19kHz. If a passband ripple of only 1dB is allowed this implies the enormous attenuation rate of 200dB/octave between 15 and 19kHz.

Fortunately two cascaded Toko filter blocks can exceed the requirements in a very small space and at reasonable cost. The drawback of a filter with such violent attenuation so close to the passband is that there is little hope of achieving a linear phase characteristic and this is a deficiency common to all stereo coders. Part 2 includes a spectrum analyser photograph of the present filter response and a graph of measured phase shift.

The audio difference is derived and fed via the balanced modulator to the output adder while the sum signal is produced by feeding equal amounts of A and B directly to the output adder. The longer route of the difference signal means that it is slightly delayed at the adder compared to the A and B components and at the higher audio frequencies this would amount to a significant phase shift between the M and S components, hence the phase correctors inserted in the A and B lines to the adder.

Because the linear doubler used to produce 38kHz is not a perfect device some leakthrough of 19kHz may occur, particularly at extremes of the temperature range, so a 19kHz rejector

is placed before the multiplier's carrier input. The pilot must also arrive at the output adder at the correct amplitude and phase and a small phase shift is required to equal the time delay through the doubler, amplifier, notch filter and balanced modulator. To provide balanced outputs a straightforward unity gain inverter is fed from the adder output.

Power supplies are entirely conventional, producing plus and minus 15 volts at around 100mA. Power take off points are provided for running the clipping amplifier and v.h.f. oscillator described later.

**19kHz oscillator**

The accepted frequency tolerance for the pilot tone is ±2Hz so crystal control, if not essential, is certainly desirable. As a sine wave is required anyway it seems sensible to start with a sine wave crystal oscillator. This is something which often gives circuit designers a problem but a reliable inductorless circuit is easily formed at low frequencies by building a Wien bridge oscillator around the correct frequency and then putting the crystal across the series element of the bridge. Easy starting with reliable crystal lock is the result.

The standard thermistor amplitude control method, Fig 8, proved adequate for an early prototype, but even running the bead as hot as permissible, 200 deg C, still means that its operating point is determined roughly 9 parts in 10 by the oscillation voltage and 1 part in 10 by the ambient temperature. With this circuit I measured an amplitude drift of -0.02dB/deg C over the range +10 to +40 deg C and distortion was below 0.05%. Evidently some form of amplified control was needed to improve this drift figure tenfold and allow maintenance of good channel separation over a wide temperature range.

The circuit evolved is in Fig. 9 where an f.e.t. replaces the thermistor as the

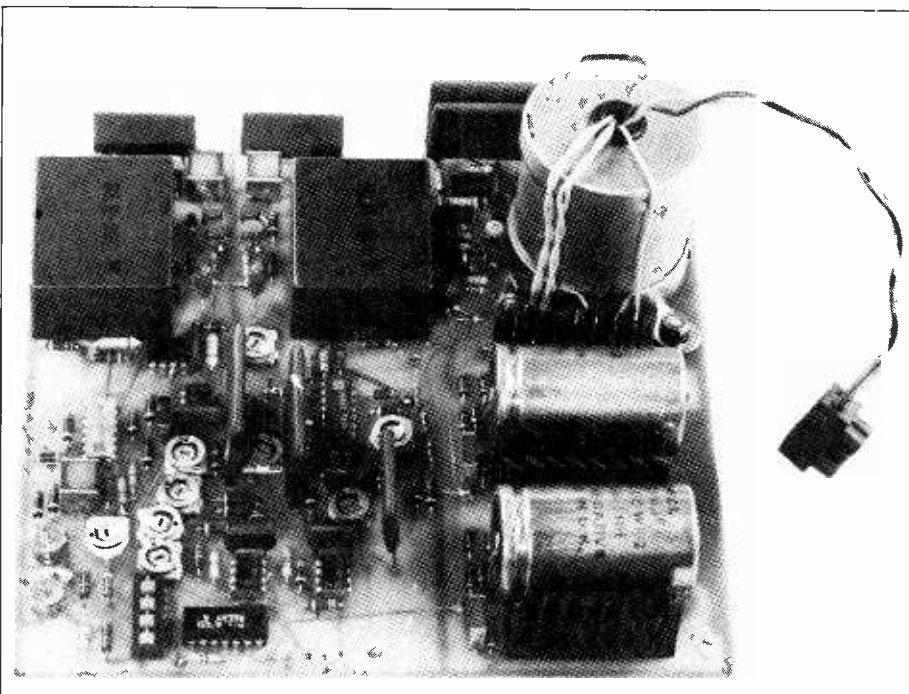


gain control element but with linearizing components to maintain the distortion performance. Linearizing is achieved by equalizing the gate/drain and gate/source signal voltages and is done by  $R_5$  and  $R_6$ . The f.e.t. is also only allowed to contribute a small amount of the total resistance between pin 2 of the i.c. and common, and this fraction is determined by  $R_3$  in the source lead. Linearizing produces distortion better than 0.05% compared with around 0.4% without.

Transistors  $Tr_2$  and  $Tr_3$  form a long tailed pair which compares the oscillator amplitude with a direct reference voltage. Resistor 8 prevents loading of the oscillator output by changes in  $Tr_2$  input impedance over each cycle. The direct error voltage feeds the f.e.t. gate after filtering ( $R_7, C_{10}$ ) to remove oscillator components. The two transistors are identical types and mounted together so that their two base-emitter junctions provide temperature compensation; the use of a matched pair in a single can does not seem to be justified. Stability of the d.c. reference is assured by using low temperature coefficient resistors for  $R_{11}$  and  $R_{12}$  as well as a stabilized negative line.

Though a square wave oscillator followed by a filter could have produced similar amplitude stability simply by defining the voltage excursion of the square wave generator there is a unique advantage in the method described. Namely, the long-tailed pair comparator need not look at the oscillator output directly; it could look at the level of 38kHz which feeds into the multiplier and thus act as a servo, taking up gain drift in the doubler, amplifier and notch filter.

Printed boards (a total of three) are available for this encoder for £7.50 inclusive from M. R. Sagin, 23 Keyes Road, London NW2.



**Appendix**

**Inherent crosstalk arising from deficiencies in the coded signal.**

Crosstalk is expressed relative to the full level on the decoded channels when  $A = B = 1$  as this is the most convenient reference when making measurements.

*Amplitude error between the M and S signals.*

Ignoring the pilot signal and considering an error  $\delta$  so that the composite signal becomes

$$\frac{A+B}{2} + \frac{A-B}{2+\delta} \sin 2f_c t$$

i.e. S is low in level if  $\delta$  is positive. After multiplication in the decoder, considering only the 38kHz component of the reinserted carrier waveform

$$D(t) = \left[ \frac{A+B}{2} + \frac{A-B}{2+\delta} \sin 2\pi f_c t \right] \sin 2\pi f_c t$$

Adding  $\frac{1}{4}(A+B)$  to give the decoded A signal, and considering only baseband components gives

$$\frac{A+B}{4} + \frac{A-B}{2(2+\delta)}$$

Related to peak level,  $\frac{1}{2}B$ , fractional crosstalk is  $\frac{\delta}{2(2+\delta)}$ .

*Phase error between M and S signals.*

Suppose  $A = 0, B = 1$  and  $B(t) = \sin 2\pi f_B t$ . If a delay of  $\delta t$  exists on the S signal, the composite signal is

$$\frac{\sin 2\pi f_B t}{2} - \left( \frac{\sin 2\pi f_B (t + \delta t)}{2} \right) \sin 2\pi f_c t.$$

After decoding, adding  $\frac{1}{4}(A+B)$ , i.e.  $\frac{1}{4}\sin 2\pi f_B t$ , and neglecting non-baseband components, the decoded A signal

$$\frac{1}{4} \sqrt{(1 - \cos 2\pi f_B \delta t)^2 + \sin^2 2\pi f_B \delta t}$$

$= \frac{1}{2} \sin \pi f_B \delta t$ , so that fractional crosstalk is  $\sin \pi f_B \delta t$ .

*Error in pilot phase.*

Suppose pilot is 0.1  $\sin f_c (t + \delta t)$ , so in the decoder the regenerated 38kHz is  $\sin 2\pi f_c (t + \delta t)$ .  $D(t) =$

$$\frac{1}{2} \frac{A+B}{2} + \frac{A-B}{2} \sin 2\pi f_c t \sin 2\pi f_c (t + \delta t).$$

Add  $\frac{1}{4}(A+B)$  and neglecting non-baseband terms the decoded A signal is

$$\frac{A}{4} (1 + \cos 2\pi f_c \delta t) + \frac{B}{4} (1 - \cos 2\pi f_c \delta t).$$

and fractional crosstalk is  $\sin^2 \pi f_c \delta t$ .

*Amplitude imbalance between the sidebands of the S signal.*

If  $A = 0, B = 1$  and  $B(t) = \sin 2\pi f_B t$  and a sideband imbalance exists then the composite signal is

$$\frac{\sin 2\pi f_B t}{2} - \frac{\cos 2\pi (f_c - f_B) t}{4} + \frac{\cos 2\pi (f_c + f_B) t}{4 + \delta} \quad A1$$

Considering only baseband terms

$$D(t) = -\sin 2\pi f_B t \left[ \frac{8 + \delta}{8(4 + \delta)} \right].$$

Adding  $\frac{1}{4}(A+B)$  the decoded A signal is

$$\sin 2\pi f_B t \left[ \frac{\delta}{8(4 + \delta)} \right].$$

and fractional crosstalk is therefore

$$\frac{\delta}{4(4 + \delta)}$$

*Phase shift in the upper sideband of the S signal.*

Taking equation A1 but for a phase error in the  $(f_c + f_B)$  component, signal is

$$\frac{\sin 2\pi f_B t}{2} - \frac{\cos 2\pi (f_c - f_B) t}{4} + \frac{\cos 2\pi (f_c + f_B) (t + \delta t)}{4}$$

$$D(t) = \frac{1}{8} \left[ \sin 2\pi f_B t \cdot \cos 2\pi (f_c + f_B) \delta t + \cos 2\pi f_B t \cdot \sin 2\pi (f_c + f_B) \delta t \right] - \frac{\sin 2\pi f_B t}{8}$$

and the decoded A signal is  $\frac{1}{4}\sin(f_c + f_B)\delta t$ , giving a fractional crosstalk of  $\frac{1}{2}\sin(f_c + f_B)\delta t$ .

**References**

1. Z. Mack, Stereo service generator (in German). Circuit of a switching type coder is given. *Funk-Technik* 1968 p.532.
2. Z. Mack, Comparison of transformerless ring-modulators and cross modulators. *Radio and Electronic Engineer* vol. 44 1974 p.407.

# Power semiconductors— 2

## A survey of devices, technologies and applications

by Mike Sagin, Assistant editor *Wireless World*

Over recent years much development has taken place in the power semiconductor field. Conventional devices are getting larger, quicker and more efficient, and several new devices have been introduced to the design engineer. These semiconductors allow far more freedom in the design of a power control system provided that they are used correctly. This article covers the various types of device currently available and outlines applications, together with future developments.

### Thyristors

Thyristor is the generic name for a semiconductor bistable switch which has at least four semiconductor layers. The most common type, the silicon controlled rectifier, was first introduced

in the 1950s and was used to replace thyratrons and mercury-arc rectifiers. Since then it has undergone much development to produce devices which can switch 1000A or 1000V in one microsecond, withstand voltages up to 4kV, handle r.m.s. currents up to 2.5kA, and operate at frequencies up to 5kHz. Several types of construction are now used, all of which have very definite advantages and corresponding disadvantages. Because designers have to "rob Peter to pay Paul" s.c.r.s are designed for specific applications.

The basic s.c.r. as shown in Fig. 1(a) is a half way device whose bistable state depends on a positive feedback loop. When the s.c.r. is forward biased it can be switched from a high to low impedance state by making the gate positive with respect to the cathode. This action is analogous to a complementary pair of

internally connected transistors as shown in Fig. 1(b). A regenerative situation exists when the positive feedback gain exceeds unity. Under reverse bias, the s.c.r. behaves like a p-n junction rectifier. The switching characteristics of a typical reverse blocking s.c.r. are shown in Fig. 2 and the important ratings and characteristics are shown in table 1.

In general, for high operating voltages, the p-n-p-n structure must be thicker and possess a higher resistivity. Unfortunately, this increases the voltage drop, which reduces the current rating. High frequency performance is also degraded because the rate of rise in current ( $di/dt$ ) rating is reduced and the turn-off time increased, due to a larger stored charge in the structure. Another important factor which determines the voltage rating is the surface condition

Table 1  
Important ratings and characteristics

<b>Off-state</b>	
$V_{DRM}, V_{DSM}$	Peak repetitive and non-repetitive voltages (V)
$I_{DRM}$	Peak current (mA)
<b>On-state</b>	
$V_{IM}$	On-state voltage (V)
$I_{IAV}$	Mean on-state current (A)
$I_{IRM}, I_{ISM}$	Repetitive and non-repetitive currents (A)
$I_H$	Holding current (mA)
<b>Trigger</b>	
$V_{GT}, I_{GT}$	Gate trigger voltage (V) and current (mA)
<b>Reverse bias</b>	
$V_{RRM}, V_{RSM}$	Peak repetitive and non-repetitive voltages (V)
$I_{HRM}$	Peak current (mA)
<b>Thermal</b>	
$R_{th}$	Thermal resistance (deg C/W)
$T_j$	Junction temperature (deg C)
<b>Turn-on</b>	
$t_{gt}$	Turn-on time
$dI/dt$ on	Rate of rise of current (A/s)
<b>Turn-off</b>	
$t_g$	Turn-off time (s)
$dI/dt$ off;	Rate of fall of current and
$dV/dt$ off	rise of reverse voltage in turn-off (A/s, V/s)
$dV/dt$	Rate of re-application of forward blocking voltage (V/s)

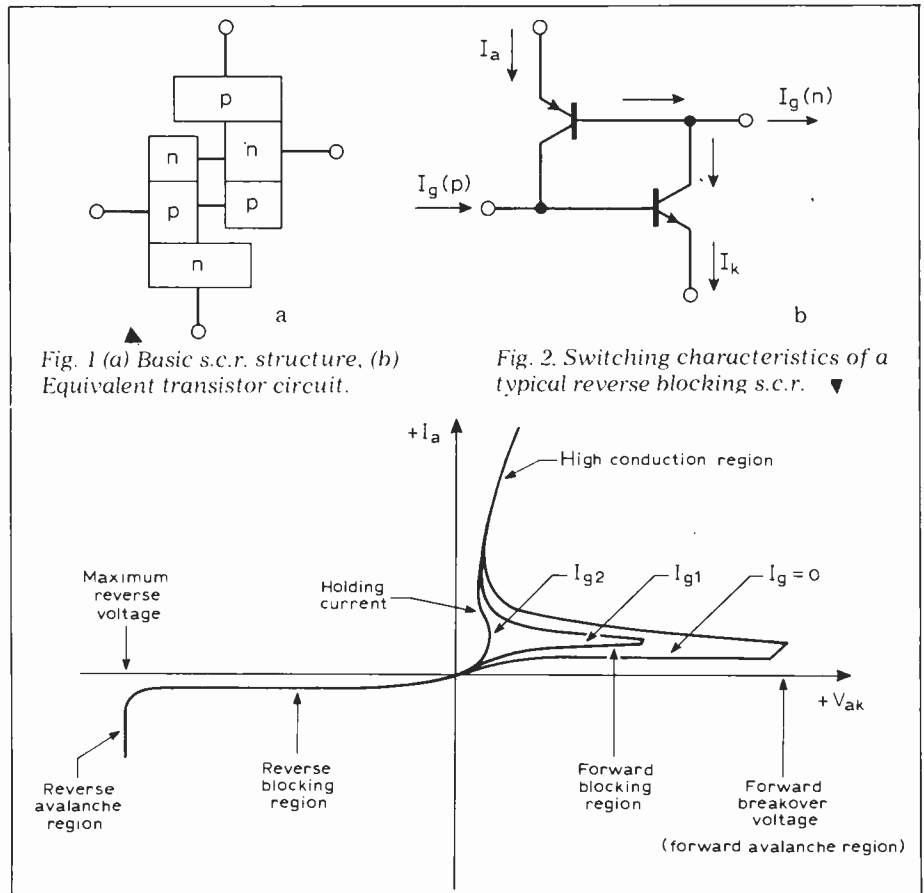


Fig. 1 (a) Basic s.c.r. structure, (b) Equivalent transistor circuit.

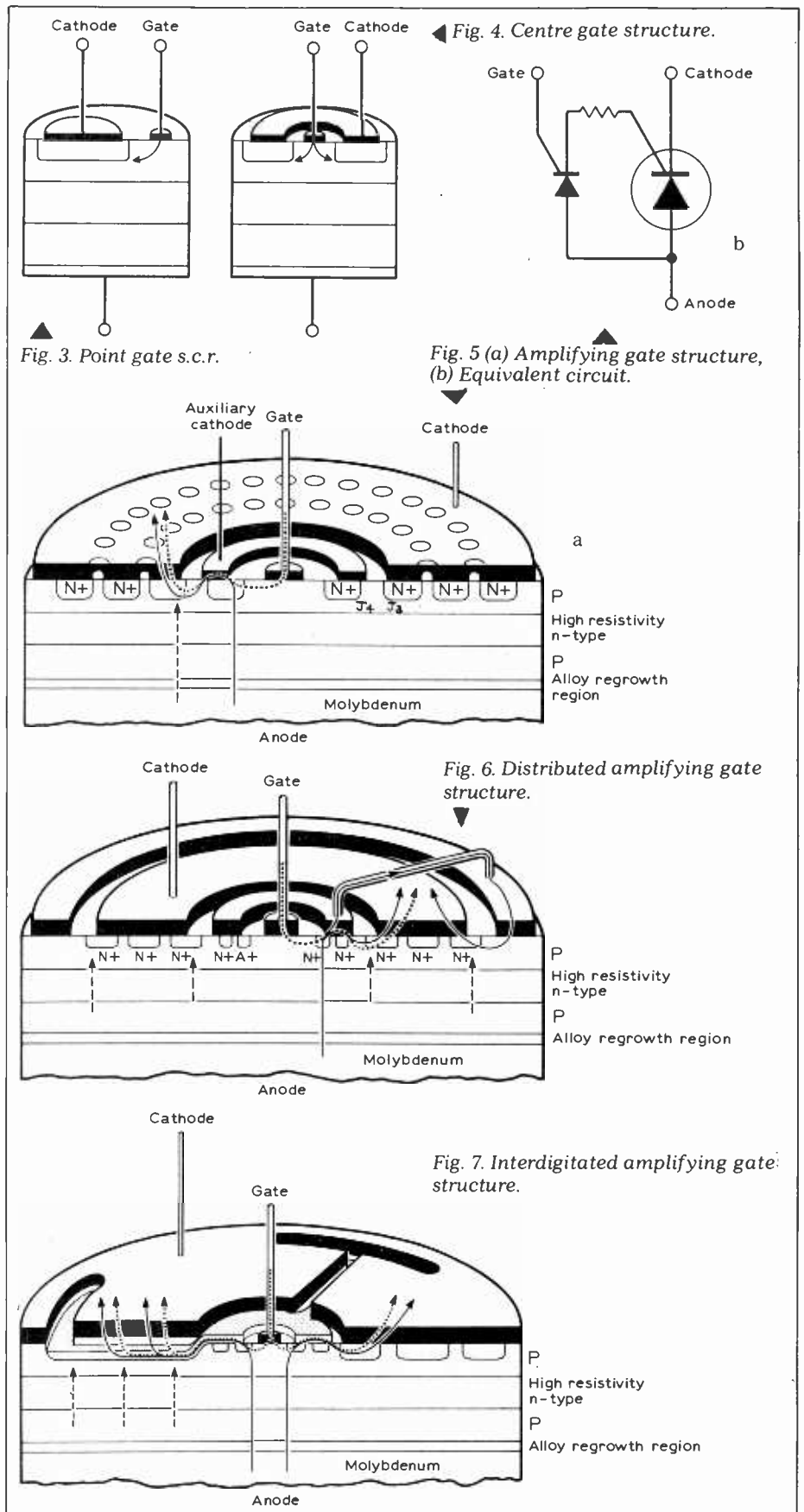
Fig. 2. Switching characteristics of a typical reverse blocking s.c.r.

where the p-n junction meets the silicon surface. Surface contouring or bevelling allows higher voltage operation by reducing the electric field in the depletion layer at the surface of the silicon pellet.

The allowable current through a device depends mainly on the conducting area. Silicon slices of 50mm diameter are now used in high power s.c.r.s and larger devices are being produced in the laboratory.

**Switching performance** has received much attention because of the  $di/dt$  problems which have been encountered. The turn-on process of a s.c.r. is two dimensional because the structure has an electrical resistance across the silicon wafer. Switching is initiated near to the gate electrode and the conducting area spreads outwards until a uniform current density is established. If the build-up of load current is too fast, localized "hot-spots" are created which can damage the device. This problem is most acute in the early point-gate structure, shown in Fig. 3. The area initially turned on is very small and is dependent upon the amplitude of the gate signal. An obvious progression was the centre gate, shown in Fig. 4. This type of construction is widely used in consumer and light industrial s.c.r.s and allows  $di/dt$  ratings up to  $100A/\mu s$  when using gate pulses of 1-2A. The next development to improve the switching performance was the amplifying gate s.c.r. — see Fig 5. This type of structure may be considered as two radial s.c.r.s with a common anode connection. When a positive gate signal is applied, current flows into the p region beneath the gate contact and across the p-n junction at the nearest point to the gate. This forward biases junction J4 and current flows into a metallized region which overlays the outside edge of this junction. The gate-pulse current then re-enters the p region and crosses the p-n junction J3 at the nearest point. Because the length of the auxiliary s.c.r. inner cathode edge is shorter than the main s.c.r. inner edge, the current density at J4 is higher than J3. This ensures that the auxiliary s.c.r. switches before the main section. When the auxiliary s.c.r. has switched, most of the anode current flows in the lowest impedance circuit to the cathode lead which includes the inside edge of the main s.c.r. The equivalent circuit is shown in Fig. 5(b).

Although this structure greatly improves the  $di/dt$  ratings, further developments have produced the distributed amplifying gate s.c.r. shown in Fig. 6, and the interdigitated amplifying gate s.c.r. — Fig. 7. These are extensions of the basic amplifying gate device in which the length of the main s.c.r. cathode switching edge has been increased to reduce the spreading distance. Although this appears to be the answer to all power switching




problems, "Peter" is effectively robbed again because as the surface area of the distributed gate increases, so the main cathode area, and hence, anode current carrying area decreases.

A second rating which effects the switching performance is the  $dv/dt$ . Rapidly rising voltage waveforms and high junction temperature can cause

spurious triggering of an s.c.r., due to the capacitance of the p-n junction and the leakage current from the gate junction. The effect is one of increased gate sensitivity. This brought about the shorted-emitter structure which uses partial shorting links between the gate and cathode junction, to produce the same effect as placing a resistor

Continued on page 87



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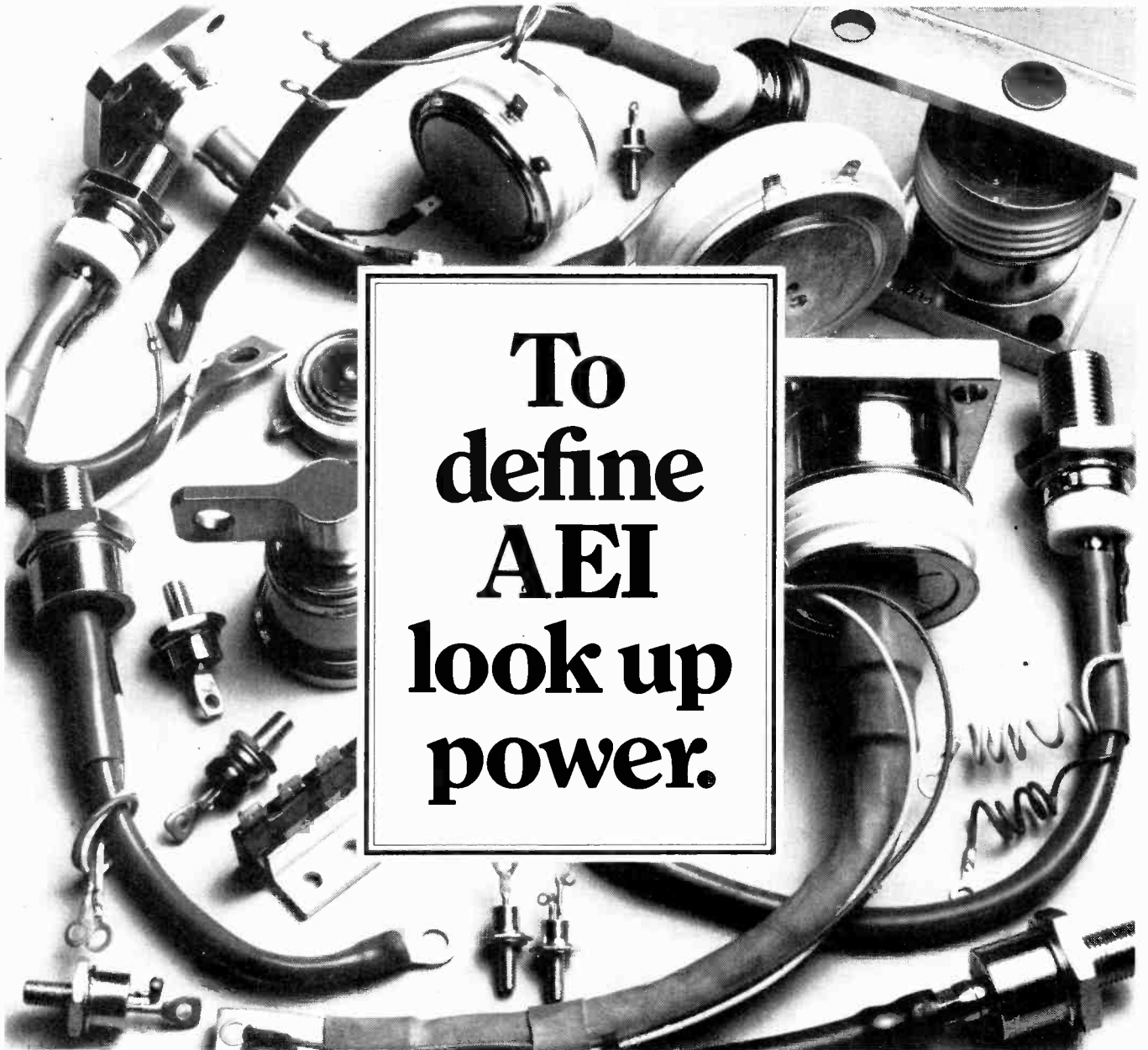
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between the gate and cathode. The only disadvantage of this type of construction is the slightly increased firing requirements.

The turn-off time for a s.c.r. will determine the maximum operating frequency of the device. During the turn-off period the excess minority charge must either be swept out by an electric field or must decay by recombination within the silicon before the s.c.r. will block a forward voltage. For rapid decay more recombination centres must be introduced. One method of achieving this is gold diffusion during fabrication. The introduction of gold impurities does, however, reduce the voltage and current ratings, and gate sensitivity.

**Construction.** The heart of a thyristor is its multi-layered pellet of alternate p and n-type semiconductor material. The pellet structure may be fabricated in several ways, depending on the characteristics and complexity of the device. The most popular fabrication methods are alloy diffusion, full diffusion and planar diffusion. The first two methods use large-area p-n-p wafers which are formed by gaseously diffusing p type impurities simultaneously into both faces of a thin n type wafer. Where specific device characteristics are required, a second diffusion step is used to complete the all-diffused p-n-p-n structure. To do this, each p-n-p wafer is selectively marked on one side and diffusion takes place through the windows in the mask. The finished wafers are then diced into individual pellets. In the manufacture of some higher power s.c.r.s where only one pellet is available from the wafer, the original p-n-p wafer is converted into a pellet structure before the final n region is added. In this construction the alloying technique is used to fuse a gold-antimony layer into each p-n-p pellet — see Fig. 8.

Planar structure describes a type of device where all of the p-n junctions are on a single surface of the pellet. In this construction a thin layer of silicon dioxide is grown over the wafer before diffusion starts. This prevents contamination of the silicon surfaces. Because the planar construction requires more silicon per amp, the process is normally used for low current devices where many pellets can be cut from a single wafer.

Encapsulation of the s.c.r. pellet has played an essential role in the progressive increase of power ratings. All s.c.r. characteristics are temperature sensitive and provision must be made to conduct away heat generated in the silicon. The older, more traditional method is to hard solder the pellet between a pair of thermally matched plates, one of which is then soldered to a copper stud. The stud serves as one terminal and the thermal conducting path. A newer method of encapsulation for devices rated at above about 150A is the pressure contact system. This

replaces the solder joints between the silica pellet and the plates and, in turn, relieves much of the thermally induced stress on the pellet. This system is the only practical method for encapsulating pellets of more than 1 inch in diameter. An even more recent development in pellet encapsulation is glass passivation. A thin coating of low temperature glass is fused on to the silicon chip and performs the same function as the silicon dioxide layer used in the planar diffusion process. Glass passivation is a post-diffusion process and is superior to  $\text{SiO}_2$  because it can be applied in thicker coatings, which also allow higher voltage ratings. Another advantage of glass passivation is the hermetic seal it produces which allows simple plastic packages to be used instead of the hermetic metal containers.

Future devices will no doubt have improved voltage and current ratings especially with the development of more uniformly doped silicon. As mentioned earlier, 50mm diameter silicon is now commonly used in high current s.c.r.s. Larger diameter slices are already well advanced and will shortly be used in commercial devices.

**Triacs**

A bidirectional triode thyristor, commonly called the triac, is basically two

s.c.r.s connected back to back. These devices are mainly used for a.c. power control and are generally restricted to lower power applications. The structure of a typical glass passivated triac is shown in Fig. 9. Seven steps are necessary in the construction of such a device and the process begins with an n type high resistivity silicon wafer which has p layers deeply diffused into both sides. Silicon-dioxide diffusion masks are grown, and p<sup>+</sup> regions are defined and diffused into the wafer. A second diffusion mask is grown, and n<sup>+</sup> regions are defined and diffused into the wafer. A silicon-dioxide etch mask is grown and defined. Grids and gate moats are etched into the wafer and the glass passivated layer is then applied in these grids and moats. Finally, contact areas are opened on the wafer and nickel-lead-tin solder metallization is applied. The wafer is then separated into pellets.

The triac can be triggered by either a positive or negative gate signal regardless of the voltage polarity across the main terminals of the device. The triggering mechanism and current flow within the triac is shown in Fig. 10. Gate trigger polarity is always referred to terminal 1, and the potential difference between the two terminals is such that gate current flows in the direction indicated by the dotted arrows. Because

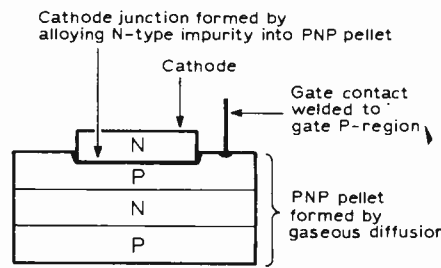


Fig. 8. Alloy-diffused pellet formation.

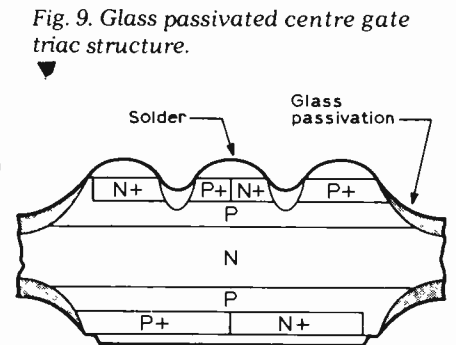
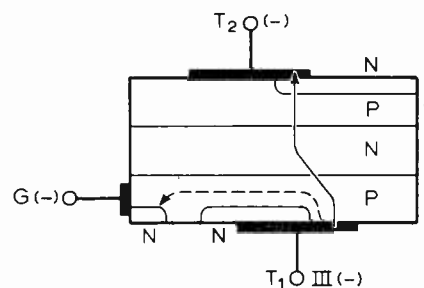
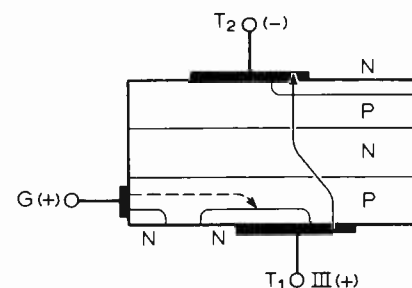
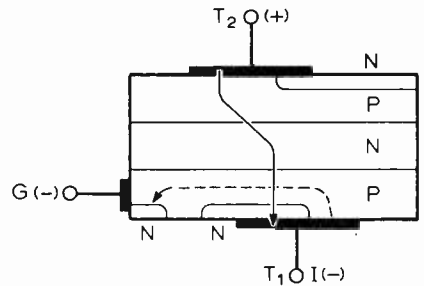
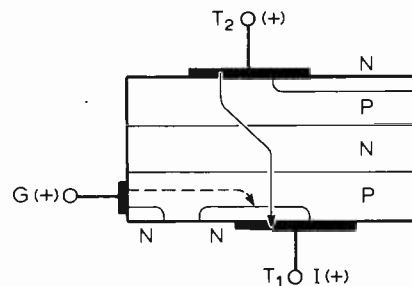


Fig. 9. Glass passivated centre gate triac structure.

Fig. 10. Current flow in a triac. Dotted lines show the direction of gate current.



the direction of current flow influences the gate trigger current, the gate requirements differ for each of the four modes. The operating modes in which the main current is in the same direction as the gate current require less trigger current than those in which the main current opposes the gate current.

Unlike s.c.r.s, turn-off times are not associated with triacs because of the physical structure of the device. The ability of a triac to commute a fixed value of current is an important characteristic, which is known as the commutating  $dv/dt$  capability of the device. In a.c. applications a triac must

switch from the conducting state to the blocking state at each zero-current point. This action is called commutation. If the triac fails to block the circuit voltage, control of the load power is lost. Commutation for resistive loads presents no special problems because the voltage and current are in phase. For inductive loads, however, the current lag causes an applied voltage, opposite to the current and equal to the peak of the a.c. line voltage, across the triac after the zero current point. The maximum rate of rise of this voltage which can be blocked without the triac reverting to the on state is the

commutating  $dv/dt$  capability of the device, and is specified in volts per microsecond for the following conditions. The maximum rated on-state current  $I_{T(RMS)}$ , the maximum case temperature for the rated value of on-state current, the maximum rated off-state voltage ( $V_{DROM}$ ) and the maximum commutating  $di/dt$ .

The addition of a series capacitor and resistor "snubber" network across the triac reduces the commutating  $dv/dt$  of a circuit and is often used for inductive loads. The sizes of these components vary with the load but typical values are 100 ohms and 0.1 $\mu$ F. Table 2 shows

*Continued on page 91*

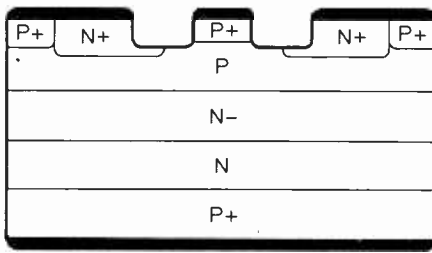
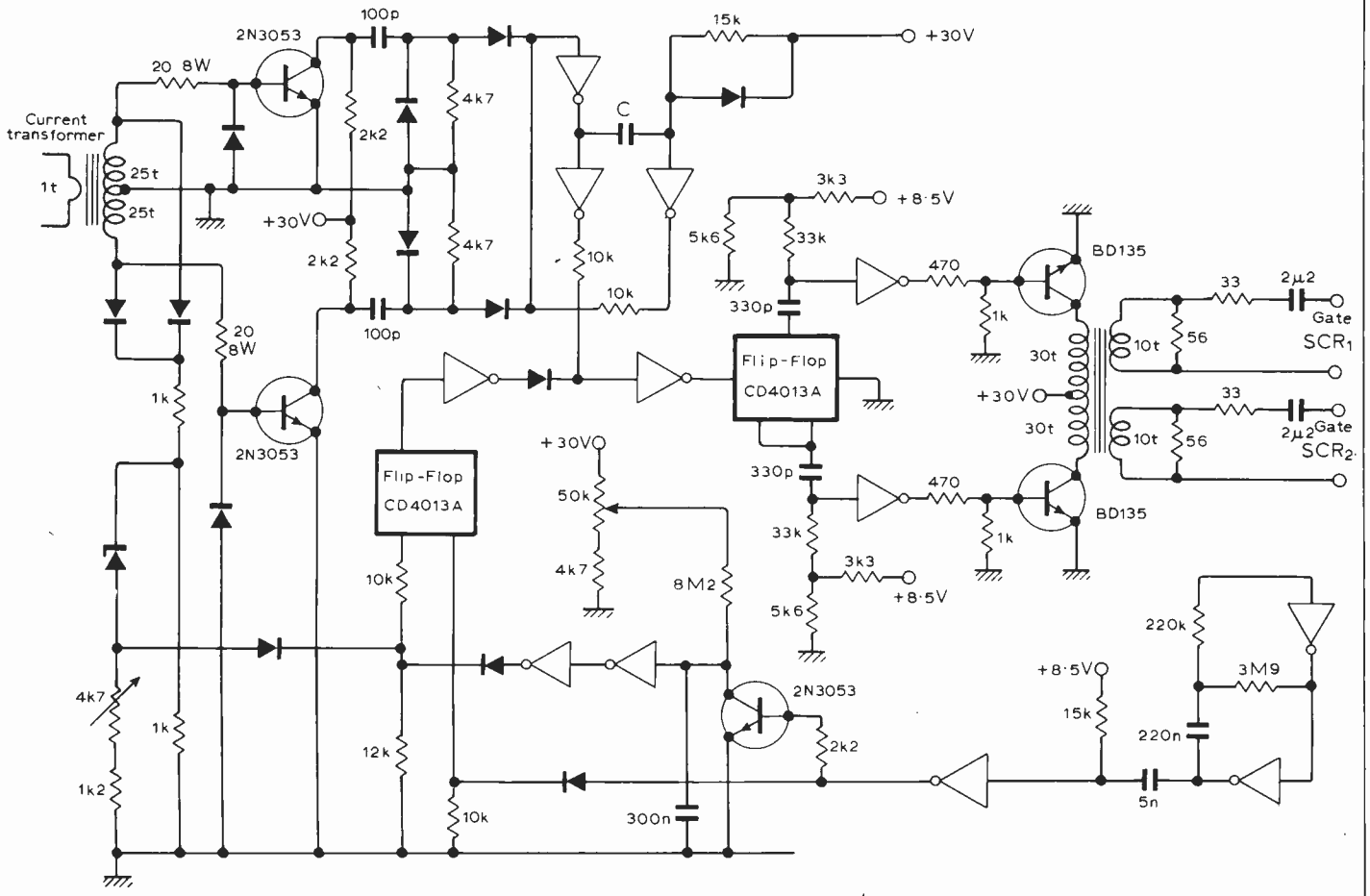
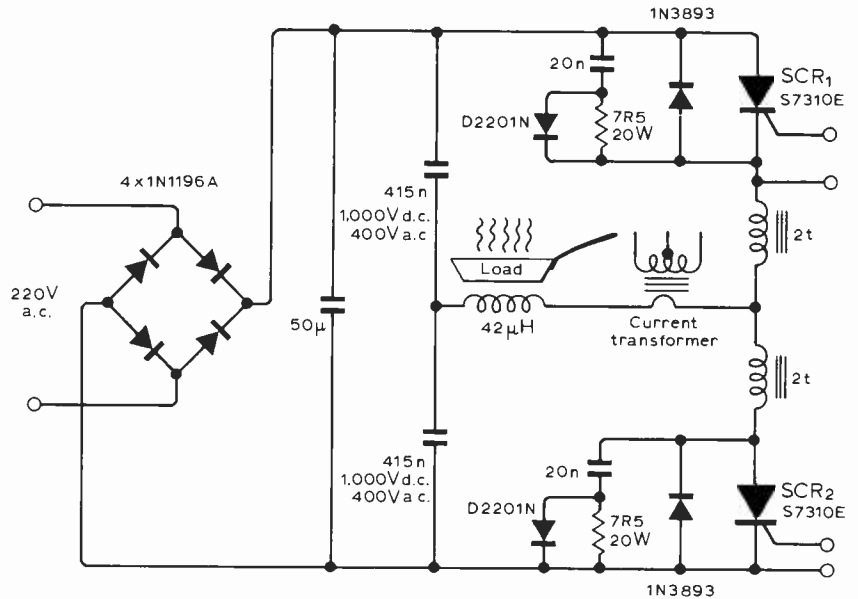


Fig. 11. Asymmetrical s.c.r. junction structure.

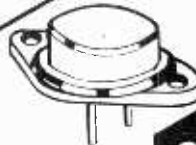
Fig. 12. Practical circuit for an induction cooker hob. For further details see RCA application note number AN-6456.



# Six power levels in high speed switching



**400W**  
ESM 1000  
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TO-83



**250W**  
BUX 20 to 25  
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BUX 59 to 65  
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**40W**  
BUX 49 to 55  
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WW-068 FOR FURTHER DETAILS

Table 2

**Commutating di/dt for various currents and frequencies.**

Commutating di/dt A/-s	Sine wave Amperes r.m.s.	Operating Frequency Hz
141	40	400
88	25	400
21.1	40	60
13.2	25	60
17.6	40	50
11.0	25	50

commutating di/dt for various currents and frequencies.

**Asymmetrical silicon controlled rectifier**

A recently introduced device from RCA, known as an a.s.c.r., has been specially designed to achieve high dv/dt and di/dt capabilities. A gold dopant is diffused into the a.s.c.r. pellet to achieve fast turn-off capability but, as discussed earlier, gold doping tends to increase turn-on time and decrease di/dt capability. Special techniques are used to overcome this problem. The structure of an a.s.c.r. is shown in Fig. 11. It differs from a conventional s.c.r. in that an additional n-type layer is inserted between the p<sup>+</sup> and n<sup>-</sup> regions. This new layer is doped so that it increases the forward blocking voltage of the device. The reverse blocking voltage, which is a function of the n<sup>-</sup>/p<sup>+</sup> junction, is much lower than in conventional s.c.r.s and is about 15V. The dv/dt capability of the a.s.c.r. is also increased with the introduction of a p<sup>+</sup> ring at the edge of the pellet.

Asymmetrical s.c.r.s can be used in fast switching applications at frequencies up to 35kHz. A recently developed circuit uses these devices in an induction cooker hob. A high-frequency generator is used to supply an alternating current to a flat coil under a working surface. When an iron or steel utensil is placed above the induction coil, high-frequency currents are induced into the pan which generates heat. A functional circuit for such a unit is shown in Fig. 12. This design offers an output of 1275W, and a typical efficiency of 80%.

**Gate turn-off s.c.r.**

Gate turn-off devices (g.t.o.) are also four-layer, three-junction structures as shown in Fig. 13 but, unlike the s.c.r., they can be turned off by the application of a negative gate pulse. The g.t.o. can be turned on in a similar way to the conventional s.c.r. by making the gate positive with respect to the cathode. As positive current is applied to the gate, the voltage/current relationship resembles that of a forward-biased p-n junction until the point is reached where regeneration takes over to switch the structure on. The g.t.o. incorporates the regenerative properties of the two-transistor model of a

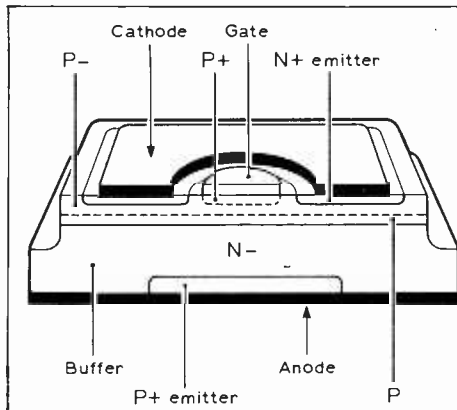


Fig. 13. Gate turn off s.c.r. structure showing centre gate and double p base layer.

Fig. 14. Anode current rise time versus gate drive current.

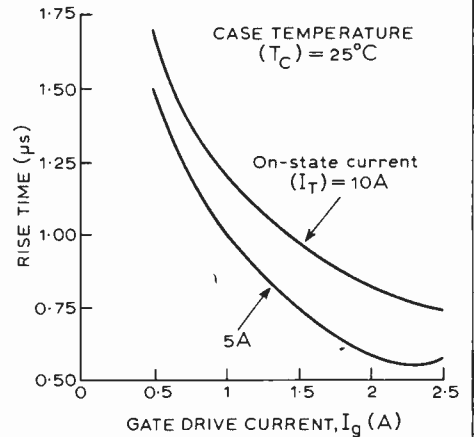
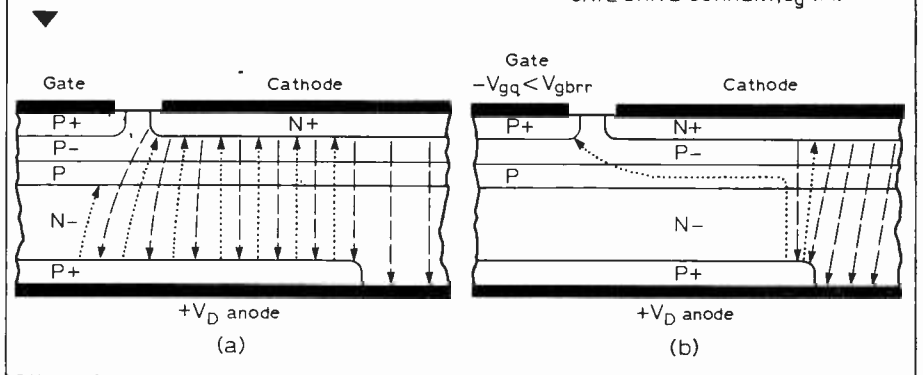


Fig. 15 (a) Gate turn off s.c.r. in the on-state and, (b) during turn off. The high density filament forms a non-regenerative region.



s.c.r., but the loop gain is reduced to allow turn-off control at the gate. In effect, turn-on in a g.t.o. is similar to that of a desensitized s.c.r. and, if sufficient gate drive is applied during turn-on, satisfactory performance can be achieved. The effect of increased values of gate-current on anode-current rise time for two values of on-state anode current, is shown in Fig. 14. The on-state voltage of the g.t.o. is a function of the regenerative properties of the device, so the transient on-state voltage drop can be reduced by the use of an increased gate drive.

During the turn-off process, the conducting electron/hole plasma is deflected from an area close to the gate, which has the highest negative potential, to the most remote area beneath the cathode, which has the least negative potential, see Fig. 15. In the on-state the device conducts uniformly over the entire cathode area. Upon application of a negative bias to the gate, the plasma is squeezed into a high-density filament. This filament is deflected into a non-regenerative three-layer section and cannot sustain itself.

The structure has a centre-gate geometry and a double-layer p base

which allows a low lateral resistance. This low resistance causes a very small voltage drop from the negative gate current. The g.t.o. is surrounded by a non-regenerative section in which the final phase of the turn-off cycle takes place. Device dimensions are about 3 × 3mm and this size allows a continuous current operation up to 15A and a forward blocking voltage of above 600V.

**Gate-drive techniques.** For the best switch-on rise times a positive gate current of between 0.5 and 1A with at least a two microsecond pulse width is recommended by the manufacturers. Also, a pulse of -70V between the gate and cathode for the duration of the turn-off interval is advised. Fig. 16 shows gate drive systems that may be used when a negative voltage source of 70V is not available. In circuit (a) the resistor causes unnecessary dissipation during switching and in circuit (b) an inductor is substituted to reduce the dissipation. The configuration shown in (c) is the best method of switching the g.t.o. The peak value of the reverse gate current carried by the switch in Fig. 16 is approximately half the maximum



Continued from page 55

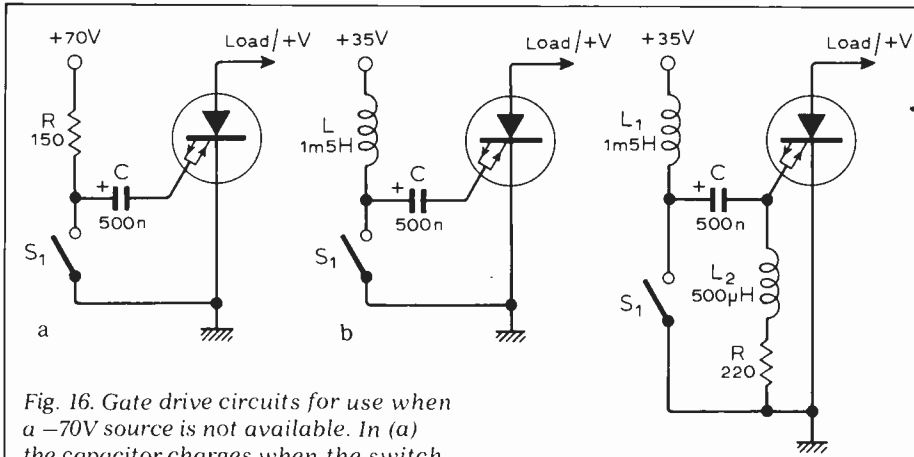


Fig. 16. Gate drive circuits for use when a -70V source is not available. In (a) the capacitor charges when the switch is opened and gate current turns the g.t.o. on. When the switch is closed the charged capacitor acts as a source of negative potential. In (b) when the switch is closed the g.t.o. is turned off by the capacitor and the extra energy stored in the inductor. In (c) when the

switch is opened the g.t.o. is turned on because of stored energy from  $L_1$  and the increased drive provided by the stored energy in  $L_2$ . When the switch is closed the g.t.o. turns off because of the negative voltage from the capacitor.

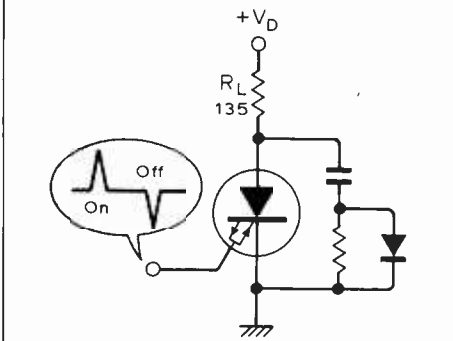


Fig. 17. Typical d.c. switch. The capacitor and resistor form a "snubber" network.

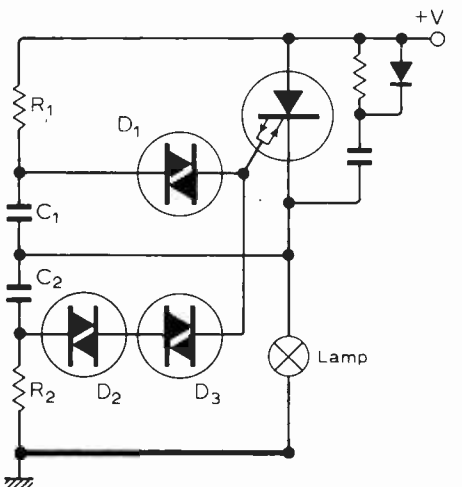
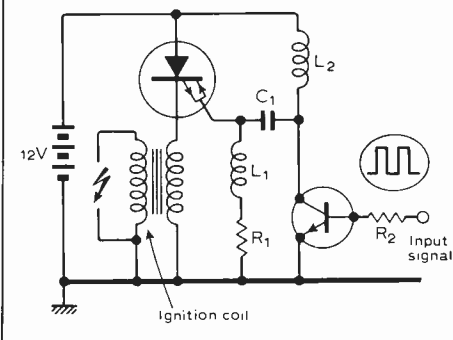


Fig. 18. Lamp flasher circuit. The on and off times can be adjusted by the time-constant networks  $R_1C_1$  and  $R_2C_2$  respectively.

Fig. 19. Car ignition circuit.

anode current of the g.t.o. prior to turn off. This current lasts for about 400ns and then decreases to a value less than 0.7A for the rest of the turn-off interval. The switch may be an n-p-n transistor or low voltage s.c.r.

Applications of the g.t.o. are mainly in d.c. circuits, and use in cars will be popular. Particular devices can operate at frequencies up to 30kHz and Fig. 17 shows a circuit suitable for use as a d.c. switch. Fig. 18 shows a circuit breaker or lamp flasher. Diacs  $D_2$  and  $D_3$  are connected in series to provide a maximum peak negative gate voltage of -70V during the turn off period. The RC "snubber" network in parallel with the g.t.o., protects the device against high

dv/dt. The circuit in Fig. 19 illustrates a typical use in a car ignition unit. The input signal can be obtained from the mechanical distributor or from an electronic generator.

In the near future it is expected that new devices will have much lower gate turn-off voltages of around -20V, higher current capabilities, and increased gate sensitivities. Because the g.t.o. can switch higher voltages at greater currents with a semiconductor pellet the same size as a conventional bi-polar transistor, these devices are likely to replace high power transistors in many d.c. switching applications.

To be continued.

circuits" had gained currency). Texas were anxious to establish that what we saw at the symposium was not in fact a working device but a model, and our reporter agreed to sign an affidavit to this effect. This incident demonstrates the Americans' awareness of the possibility of British priority in integrated circuits.

Mr Dummer is author of a new book "Electronic Inventions 1745-1976" just published by Pergamon Press at £4.00. This contains mainly brief descriptions of important inventions in electronics but also has some interesting graphs showing historical trends. For example, it shows that in the 200 years from 1745 to 1945 some 106 electronic inventions originated in Europe against 66 in the same period in the USA; but in the mere 31 years from 1945 to 1976 the situation was reversed, with 32 inventions in Europe and 85 in the USA.

## Time by satellite

A digital clock controlled by a time code transmitted from a satellite has been developed by the US National Bureau of Standards (NBS). Once set by the time code the clock, which uses a simple and cheap microprocessor, continues to keep time in the presence or absence of the satellite signal. The clock was designed to use transmissions from the National Oceanic and Atmospheric Administration's meteorological satellites, which relay information from buoys, automatic weather stations, ships, aircraft and balloons. The time code used dates the information or organises its transmission into sequence.

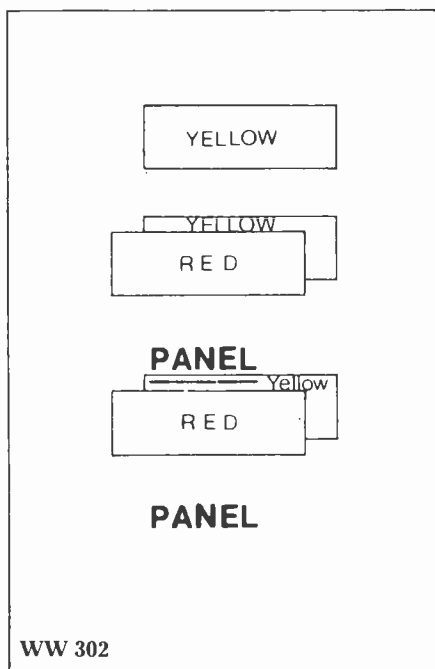
The clock receives a 100Hz pulse stream and time code information in 30s data frames. "Since each time code frame differs from the previous one by only 30s there is a high degree of redundancy in this data which can be used to improve the signal to noise ratio. The microprocessor stores the received time in random access memory and continually updates it by counting the 100Hz pulse stream." During every time code frame the r.a.m. time is compared with the new time message for errors. The r.a.m. time is assumed to be correct in the case of error in three consecutive comparisons. On the fourth the r.a.m. is assumed wrong and is reset in the next frame.

To counteract noise in the pulse stream the microprocessor crystal oscillator is divided down to 100Hz from 4.096MHz and phase locked to the received pulse stream. The adjustment of the crystal frequency is accomplished with varactor diodes.

# New Products

## Graphic transfers

P.c.b. and rub-down acid-resist graphic transfers, manufactured by E. R. Nicholls, includes space bars which enable users to lay transfers level and with the correct letter, word and line spacings. A yellow strip is first placed on to the artwork below the desired position of the wording, and a red straight edge is positioned over it. The space bar of the first character is then lined up on the visible yellow strip so that when rubbed down the character transfers to the artwork and the space bar transfers to the yellow strip. By lining up the space bars of adjacent characters, correct spacings will result. White line spacers are used in a similar way to give correct line spacings. Another important feature is that the transfers contain adhesive only on the character area and not on the surrounding area. Transfers include capitals and lower case letters and numerals in 1/8, 1/4 and 1/2 inch sizes. Prices for complete kits are from £1.00, for the 1/8in set. E. R. Nicholls, 46 Lowfield Road, Stockport, Cheshire, **WW 302**



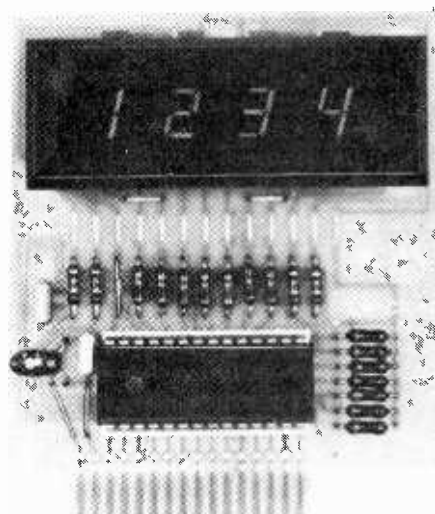
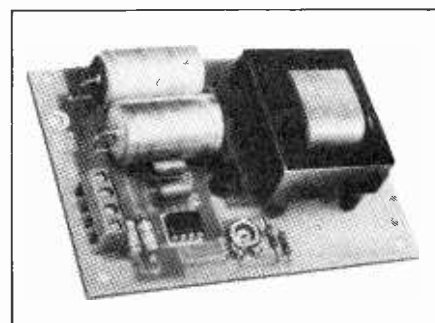
## Circuit module "time-savers" for development engineers

A range of circuit modules, called Cirblocs, includes power supplies, amplifiers, timers, comparators, count displays, waveform generators, relay drivers and switching and phase control units. All of the units are either ready to use or, by simple wire links and component programming, can be set up to provide desired operating characteristics. The manufacturers, Lascars Electronics Ltd, are a new organisation formed specifically to manufacture and market modules covering the most widely used electronic circuits so that engineers can produce many different electronic systems in the shortest possible time. The managing director of Lascars pointed out that all over the world engineers are spending time hard wiring the same basic types of circuits, during the development stage of their particular system. This range, he claims, offers these engineers a means of saving time by supplying basic, ready to use, circuits, leaving the engineer to devote more time to the development work. Also, he says, fault diagnosis and repair is simplified and complex systems may be constructed without specialised electronic knowledge.

Two of the modules, a power supply and a count-display unit, are illustrated below.

The  $\pm 15V$ , 100mA power supply is suitable for operational amplifiers, and has current, thermal shut-down and output short-circuit protection. Other features include a load regulation of 0.6%, line regulation of 0.13% and an output noise voltage of 0.06V; all of these parameters being typical and measured at 25°C. Five-, 12- and 24-V power supplies are also available.

The count-display module is a four-digit unit based on the Ferranti ZN1040E i.c. It has a 0.3in red (or green) i.e.d. display and may be supplied with a mounting bezel and filter. If the module is to be fitted in a low-profile instrument it may be divided in two and reconnected with ribbon cable. This unit, which has a t.t.l.-compatible input and requires a 5V supply, features up/down



counting up to 5MHz, a reset zero, a display latch, and "unwanted zero" suppression. An add-on module is also available to convert this count-display into a digital frequency meter with ranges 0 to 9.999kHz and 0 to 99.99kHz.

Full details of the complete Cirbloc range, together with connection instructions and a selection of hand tools, are given in a catalogue which may be obtained from Lascars. All of these products are offered on a same-day basis, if orders are received before 4 p.m. and include no minimum order charges. Lascars Electronics Limited, P.O. Box 12, Second Avenue, Billericay, Essex CM12 9QA. **WW 301**

## Duplex muting unit

Full duplex operation requires the simultaneous operation of both a transmitter and receiver. In order to avoid breakthrough from the transmitter to the receiver the antennae are often geographically spaced, typically 30 miles apart in land-based installations. This is obviously impossible with ship-board installations. The Duplex Muting Unit, which is placed between the receiver and the antennae, eliminates breakthrough by monitoring the nature and level of the r.f. and introducing attenuation for the duration of the

potential breakthrough — imitating the ear by automatically reducing sensitivity when the owner is talking. The unit requires no modifications to existing equipment, is compatible with all receivers without affecting the "type approval" and can represent, it is claimed, a saving of up to 90% against the costs of fitting feeders.

The frequency range of the unit is 0.1 to 30MHz and the insertion loss is typically 1dB. Callbuoy Marine Electronics Limited, 6 Somerset Road, Cwmbran, Gwent NP4 1QX. **WW 303**

## Polypropylene capacitors

Capacitors in the KP72 range have polypropylene dielectrics, instead of polystyrene, and use aluminium foil as electrodes. It is claimed that these capacitors offer a considerable improvement in heat resistance compared to polystyrene capacitors. Nickel silver terminals, welded to the foil electrodes, make the capacitors suitable for r.f. applications. Capacitances range from 100 to 33,000pF in tolerances of  $\pm 10\%$ ,  $\pm 5\%$  and  $\pm 2.5\%$  and are available with working voltages of 63, 160 and 630V. AEG-Telefunken UK Limited, Bath Road, Slough, Berks SL1 4AW.

WW 304

## Miniature variable capacitors

Miniature trimmer capacitors in the Voltronics CP range, from ITT Components, are suitable for tuning circuits up to 5GHz. Two basic capacitance types 2.5 and 9pF, are available and these are tuned by sliding a shuttle from one end of the component to the other. They may be used to facilitate rough tuning of several stages before final tuning. The devices have contact resistances of  $0.005\Omega$ , voltage ratings of 15V d.c. (300V d.c. max. surge) and temperature coefficients of  $\pm 100$  p.p.m./ $^{\circ}\text{C}$ . Minimum life is quoted as 1000 cycles. ITT Components Group Europe, Capacitor Division, Brixham Road, Paignton, Devon TQ4 7BE.

WW 305



WW 305

## Stereo equalizer

The EQ2 stereo equalizer has eleven bands per channel and provides full equalization from 20Hz to 20kHz with a cut or boost of  $\pm 15\text{dB}$  on each band. Each filter has a control which allows an  $\pm \frac{1}{2}$  octave variation of the centre frequency, and tone controls are also provided allowing very low phase distortion equalisations. Balanced inputs provide either unity gain or switched 10dB gain. L.e.d.s are provided to monitor and indicate overload. Frequency response is  $\pm 0.1\text{dB}$  from 20Hz to 20kHz and i.m. distortion is below 0.01% at the rated output of 2.5V r.m.s. Macinnes Laboratories Limited, Macinnes House, Carlton Park Industrial Estate, Saxmundham, Suffolk.

WW 306

## Drive/stepping motors

A series of drive and stepping motors specifically designed for floppy disc drive applications has been introduced by Eastern Air Devices. The standard 1/100 h.p. a.c. drive motor has a high inertia ratio and output speeds of 1500rev/min at 50Hz or 1800 rev/min at 60Hz. This unit is a permanent-split-capacitor synchronous motor with an automatic-reset thermal overload protector.

The stepping motors, sizes 18 and 20, have single or multiple-start lead screws and are available with  $15^{\circ}$  step angles for 3 or 4 phase supplies. These variable

reluctance motors are totally-enclosed bi-directional devices with permanently lubricated ball bearings. Computer Controls Limited, 19 Buckingham Street, London WC2N 6EQ.

WW 307

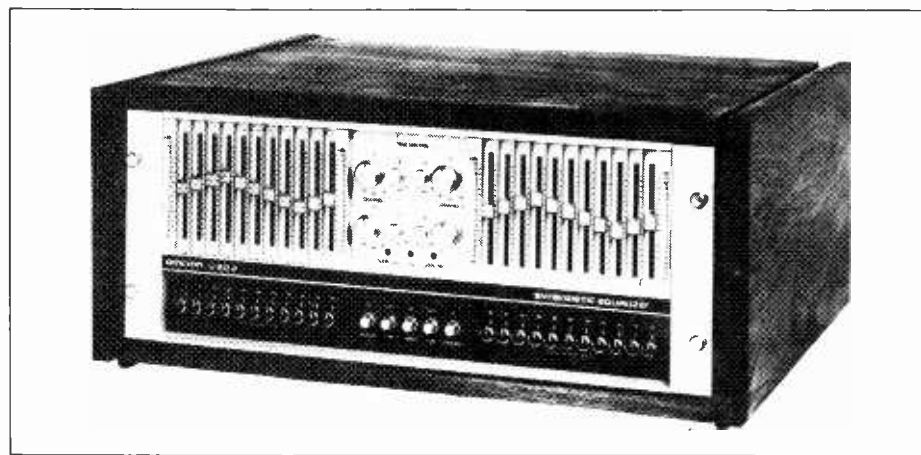
## Rotary switch

A multi-wafer rotary switch, designated as Type 30, has ground, silicone treated h.f. ceramic wafers for high insulation resistance. The switch, which has a roller-type index mechanism allowing central bush or two-hole mounting, is available with up to 26 shorting and 13 non-shorting positions, with or without stops. Contacts are gold flash on silver plate as standard or hard gold plating as an option, and are protected from dust and solder vapour by transparent plastic covers. Operational life is quoted as 25,000 rotations and the temperature range is  $-40$  to  $+85^{\circ}\text{C}$ . Radiatron Components Limited, 76 Crown Road, Twickenham, Middlesex.

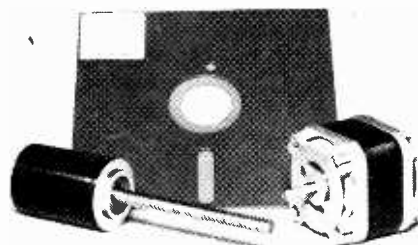
WW 308

## Precision resistors

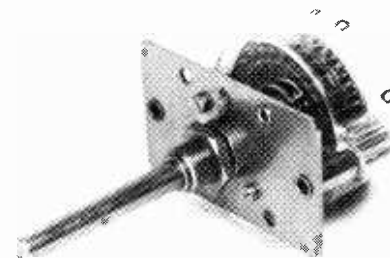
Wirewound resistors, available from G.E. Electronics Ltd, have standard tolerances of 0.1% and are rated at 0.3W ( $70^{\circ}\text{C}$ ). These resistors, in values from  $10\Omega$  to  $1\text{M}\Omega$ , have temperature coefficients of  $\pm 3$  p.p.m. over the range 0 to  $85^{\circ}\text{C}$  and  $\pm 5$  p.p.m. over the range  $-55$  to  $145^{\circ}\text{C}$ . The components are also available in 0.025 and 0.01% tolerances



WW 306



WW 307



WW 308

and are manufactured and tested to MIL-R93, MIL-Std-202 and DIN40040. G.E. Electronics Limited, 182-184 Campden Hill Road, Kensington, London W8 7AS.

**WW 309**

## Low-cost 5MHz oscilloscope

The S61 oscilloscope is a single trace 5MHz instrument featuring calibrated deflection factors from 5mV/div to 20V/div and sweep rates from 1 s/div to 500ms/div. Simple trigger controls provide a clear, jitter-free trace at all settings and levels over the entire bandwidth it is claimed. A trigger source may be switch selected from either an internal, external, or line frequency. An external X facility is provided for the X-Y display of Lissajous figures and other interactive signals, particularly useful in educational applications. The S61 has an 8 × 10cm screen and is priced at £125 + V.A.T. Electroplan Ltd, P.O. Box 19, Orchard Road, Royston, Herts.

**WW 310**

## General purpose multimeter

The UM11 multimeter, from Poland, has 38 ranges and offers high sensitivities coupled with high input impedances. It has nine direct voltage ranges having input impedance of 100kΩ/V and



**WW 310**

covering full scale values from 150mV to 1500V. Eight alternating voltage ranges, with sensitivities of 31.6kΩ/V, cover the range 1.5 to 1500V. Other ranges cover direct and alternating current, resistance and dBm. The meter is supplied with a leather carrying case and is priced at £39.50. Electronic Brokers Limited, 49-53 Pancras Road, London NW1 2QB.

**WW 311**

## Wheatstone bridge

A Wheatstone bridge, designated as type 2272, enables measurement of resistances from 0.001Ω to 1,000MΩ with an accuracy of ±0.002% between 22 and 24°C or ±0.005% between 18 and 28°C. The load on the unknown resistor is less than 50mW. The bridge, which is equipped with leakage current protection for improved accuracy, is supplied by a built-in power supply and has a zero-indicator having a sensitivity of 150nV/mm. Tettex AG Instruments, P.O. Box, CH 8042 Zurich, Switzerland.

**WW 312**

## U.h.f. attenuators

Variable attenuators in the 67DR range, from AEG-Telefunken, are constant impedance units suitable for use in broadband amplifiers — for example in distribution systems having frequencies 40 to 860MHz. The attenuators are available in three versions: 50, 60 and 75Ω with attenuations from 0 to 20dB.

**WW 311.**



Four mechanical versions, with vertical or horizontal mountings, are also produced for p.c. or conventional wiring boards. AEG-Telefunken UK Limited, Bath Road, Slough, Berks SL1 4AW.

**WW 313**

## V.h.f./u.h.f. amplifiers

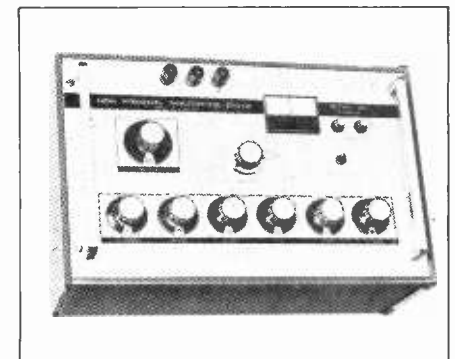
A series of high dynamic range, wide-band linear-amplifiers, from the Microwave Semiconductor Corporation, operate over the range 20 to 1000MHz. The amplifiers have outputs of about 25 to 29dBm at the 1dB compression point, with typical gains of 30dB at 1GHz. Typical noise figures are 7.5dB and operating temperatures range from -20 to +70°C. Tranchant Electronics UK Limited, 100a High Street, Hampton, Middlesex TW9w wST.

**WW 314**

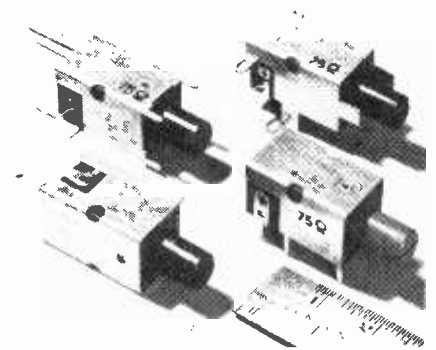
## Silent timers

A silent operating elapsed-time control, the Type ET from NSF Controls, is variable from 4 to 30 minutes and has a switch rating of 16A at 240V a.c. The unit has an eddy current brake mechanism and may be produced to customers' specifications for time cycles, mounting, shaft details and other characteristics. Switches are either s.p.s.t. or d.p.s.t. NSF Controls Ltd, Fence Houses, Houghton-le-Spring, Tyne & Wear DH4 5RG.

**WW 315**



**WW312**



**WW 313**

# Just for the record

## Memories of the early years of recording

by Alan D. Foster

We have already been reminded that the year 1977 marks the centenary of the invention of sound recording. To me, this prompts the very sobering thought that I can clearly remember further than half way back over this period of time.

My earliest recollection of the wonders of recorded sound was at about the age of eight. An uncle of mine had an Edison phonograph and a large number of cylinder records. There may in fact have been less than 30 of them in all, but to me at the time it was a very impressive collection. The model of phonograph he had was a fine machine, all nickel plate and shining black, lavishly decorated in gold. It had two soundboxes, one for making and another for playing records, and must have cost about £10, with records in those days running at around one shilling.

Phonographs were made in a variety of models, the cheaper ones being very simple machines, driven by a key-wound clockwork motor with a fan governor rather like a musical box. These models had the unfortunate habit of slowing down during the run of the record. "Melody in 'F'" could well finish up "Melody in 'E,'" and if the machine were not placed on a perfectly level table, the stylus was prone to jump a groove now and then.

I remember my uncle's bitter complaint that blank cylinders for making one's own records cost more than professionally-made ones but, of course, they could be used over and over again. The record was simply placed on the machine, and a special cutting tool would shave off a thin layer of wax, removing the previous recording. After the application of wax polish and a finish-off with a soft duster, the cylinder would gleam like new all ready to be re-used. About 20 or more recordings could be made before the record became too thin and had to be discarded. Cylinder records were fragile things, sold in flock-lined boxes to protect the relatively soft wax surface. Apart from being dropped on to the floor an untimely end could result simply by forgetfully leaving a record on the machine overnight. In the morning, there could be a gaping crack running right across the face of the record! With the usual overnight fall in room temperature the record would shrink on to the machine cylinder so tightly that it would simply burst.

Although he may have known a good deal about music, my uncle knew a good

deal less about technical matters. I remember him one day standing by the window, closely inspecting a record through a pocket magnifier. "I just can't understand," he said, with a very puzzled expression, "how it is possible to record so many different notes all at the same time." "After all," he reasoned, "There is only one track of vibrations on the record and only one stylus to follow them so how on earth does it work!"

The disc record with which we are familiar today dates from the beginning of this century, yet so well established was the phonograph that both cylinder and disc records co-existed for many years. Edison and other manufacturers were producing cylinder records up to the 1920s until the demand fell off completely in favour of the disc record. The big breakthrough came after 1924, with what nowadays we call electronics. This had a dramatic effect on the recording industry. Technical know-how flourished at a healthy pace and, combined with a widening knowledge of acoustics, records were produced of such quality that some still bear comparison with today's high standard.

### The heavy gang

In the late 20s, The H.M.V. Gramophone Company, as it was then, presented a demonstration of electrical recording at the premises of Rushworth & Dreaper, a leading, long established family music house in Liverpool. The demonstration was arranged in the large, ground floor showrooms, the handsome display of grand pianos and cases of musical instruments being put aside to make room for all the paraphernalia necessary to make a record. This consisted of an amplifier rack, control panel, two recording lathes and a large supply of thick, yellow, wax recording blanks. They even brought along their own power supply in the form of dozens of large lead acid accumulators. I was surprised to see that the record cutting lathes were powered not by an electric motor or even clockwork but by a huge iron block suspended like a clock weight under the cutting lathe. This, I suppose provided the smoothest possible source of power but, amongst the other sophisticated hardware, did look a bit primitive.

The advent of electrical recording gave voice to the silent films of the day. Sound accompanying some early films was recorded on 16in discs, running on a turntable directly coupled to the film

projector. Projectionists of the day found this period in the development of the talkies to be a very tedious one indeed. In order to maintain synchronization between sound and picture, both the film in the projector and the disc on the turntable had to be set at precise starting points. Of course, the inevitable mistake had to happen. Everything was set, the projector and turntable started together. The sub-titles came on the screen, "World Boy Scout Jamboree" followed by the usual credit titles. Meanwhile background music came from the record on the turntable. Everything seemed OK. The projectionist was himself interested in the subject to settle down to watch the film. The music slowly faded as, on the screen, Lord Baden-Powell mounted the rostrum to make the opening speech — and then it happened.

As the chief scout's lips moved there came out, not inspiring words appropriate to the occasion, but the loud sound of a dog barking! Obviously something was radically wrong, but momentarily the projectionist was transfixed by the near perfect synchronization between the movement of Baden Powell's lips and the barking of the dog — "it was uncanny," he said. The record he had put on the turntable was intended to accompany a film of the "Down on the Farm" type. In haste, he had mis-read the film code mark S.O.F. (sound-on-film) for S.O.D. (sound-on-disc). The experience, he said, haunted him for weeks although he did admit to the satisfaction of having caused as big a laugh as Laurel and Hardy. Only the cinema manager wasn't amused.

This state of affairs was fortunately short-lived and ended with the exclusive use of the "Photophone" system. Thereafter, the sound to accompany a film was recorded photographically along the film itself.

As a result of well directed propaganda, I became the proud owner of my uncle's phonograph and what remained of his record collection. Inspired by the demonstration I had seen at Rushworth & Dreaper, I made an electrical recording head from an S. G. Brown Type A earphone. The old machine was given a new lease of life. Gone was the large horn and in its place was a hefty coil speaker, mounted on a large baffle board, driven by a push-pull amplifier. There was no end to my recordings, music and variety from the radio, piano duets with a friend and even the interval signals between programmes (who, I wonder, can remember those?). One day I found my father, glass in eye, closely studying the works of his watch. Its normally good timekeeping had gone completely crazy, he said. I remembered then I had made a record of the chimes of Big Ben which was wont to come booming out of my den at any time of day. Could the "old man" have been setting his watch to the recorded chimes? I often wondered but never asked.



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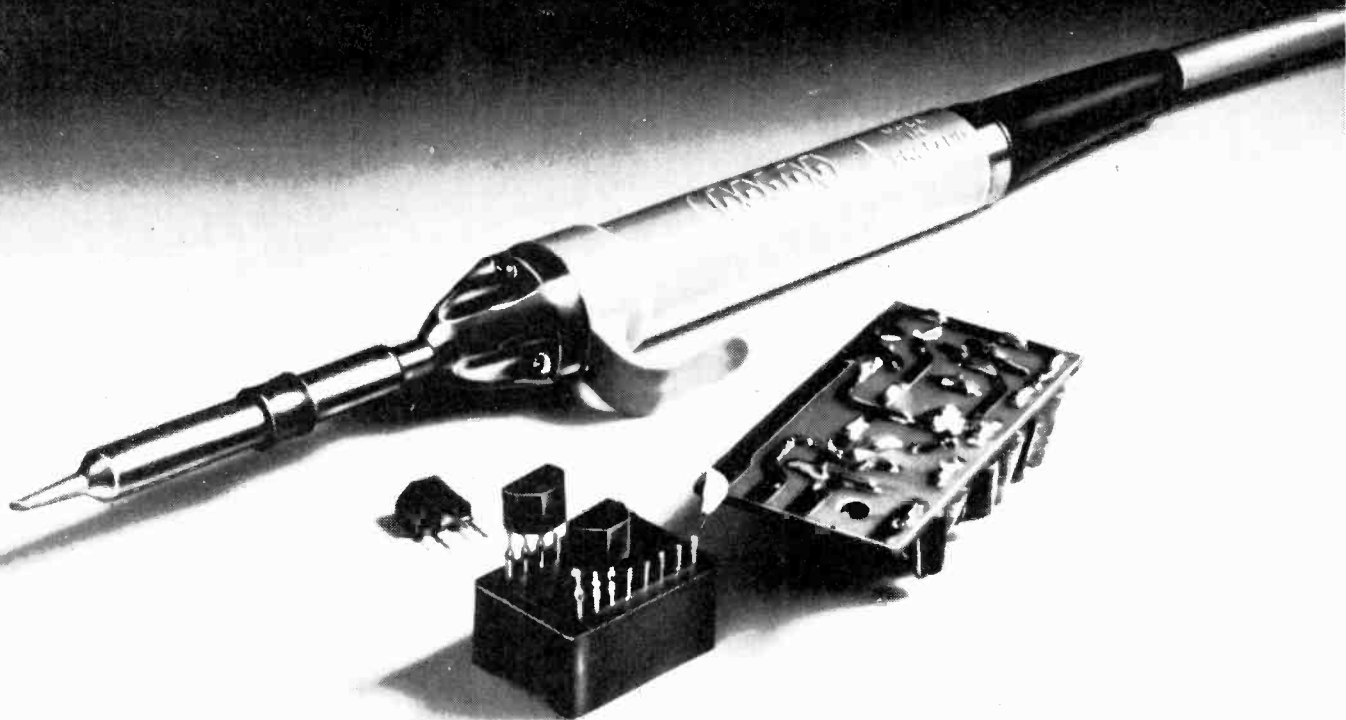


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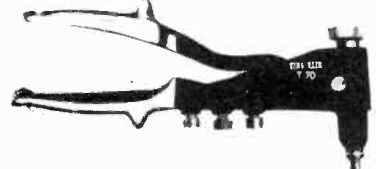
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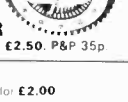
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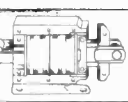
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### \* HY-LIGHT STROBE Mk. IV \*

\* Latest type Xenon white light tube. Solid state timing and triggering circuit. 230/240 volt A.C. operation. Speed adjustable 1/2 to 1 p.s. Designed for large rooms, halls, etc. Light output greater than many so called 4 Joule strobes. Price **£18.00.** Post 75p. Specially designed case and reflector for Hy-Light **£8.25.** Post 11 00

### \* XENON FLASH GUN TUBES \*

Range of Xenon tubes available from stock. S.A.E. for full details



### \* ULTRA VIOLET BLACK LIGHT FLUORESCENT TUBES \*

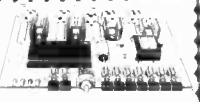
\* 4ft. 40 watt £7.00 (halogens only). 2ft. 20 watt **£4.60.** Post 60p (for use in stan. bipin fittings). MINI 12in. 8 watt **£1.75.** Post 25p 9in. 6 watt **£1.40.** 6in. 4 watt **£1.40.** Post 25p Complete ballast unit. Either 6" 9" or 12" tube 230V A.C. op. **£3.50** plus p&p 40p. Also available for 12V D.C. op. **£3.50** plus p&p 40p

### \* BIG BLACK LIGHT \*

\* 400W Mercury Vapour Ultra Violet Lamp. Powerful source of UV P.F. ballast unit is essential with this lamp. Price of bulb and matched ballast unit. **£28.** Post £2 Spare bulb only **£10.** Post 80p

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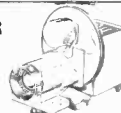
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Wide range of AC and DC relays available from stock. Phone or write in your enquiries

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200/240v a.c. 50Hz 150W lamp complete with oil filled colour wheel and motor plate. Takes intachange accessories and full range of lenses **£32.00.** Post £1 00



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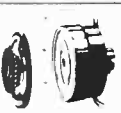
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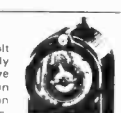
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Superb example of electro-mechanics. Main body in two sections. Coil section is fixed and has 3/8" sleeve. The drive section rotating on the outer perimeter. When engaged the transmission is extremely powerful. Diameter 1 1/2". Total width 1 3/4". 24V D.C. op. Price **£3.50** plus p&p 45p



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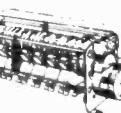
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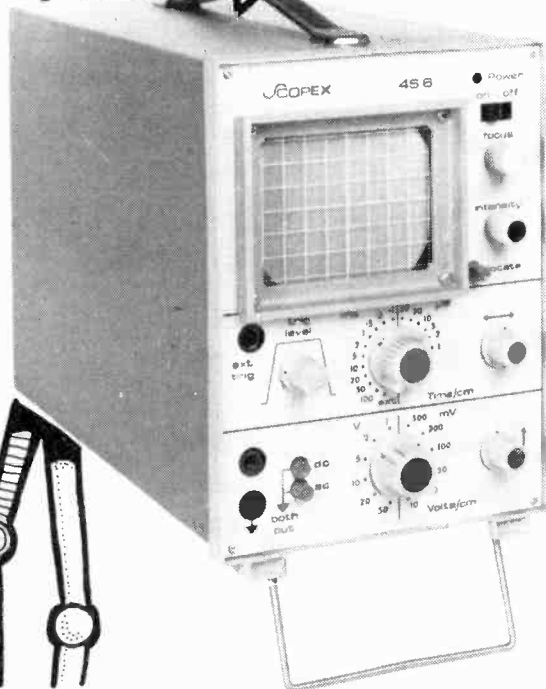
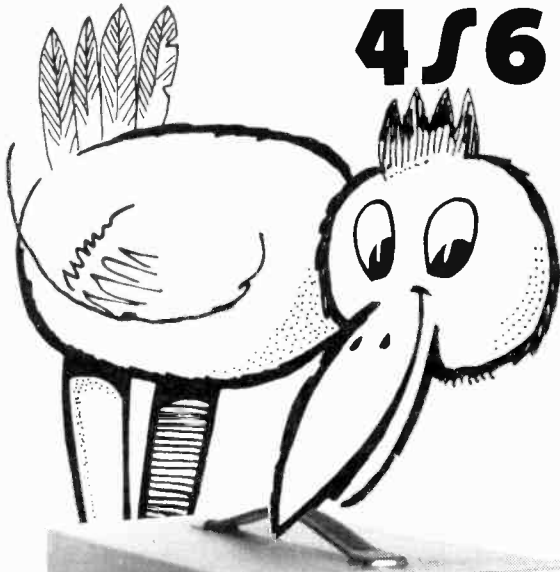
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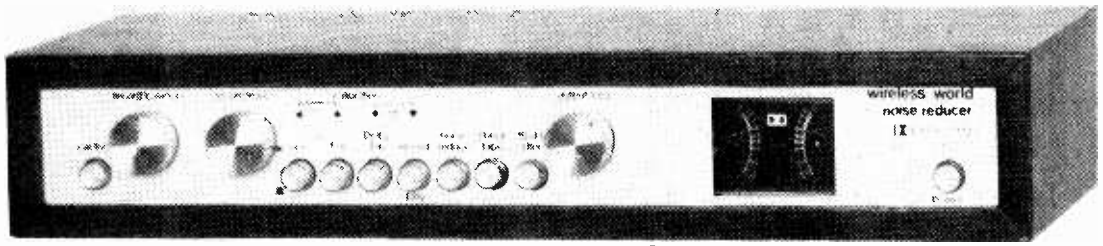
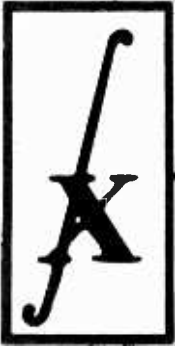
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# Wireless World Dolby<sup>TM</sup> noise reducer

Trademark of Dolby Laboratories Inc.

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

### Featuring

- switching for both encoding (low-level h.f. compression) and decoding
- a switchable f.m. stereo multiplex and bias filter
- provision for decoding Dolby f.m. radio transmissions (as in USA)
- no equipment needed for alignment
- suitability for both open-reel and cassette tape machines
- check tape switch for encoded monitoring in three-head machines

### The kit includes

- complete set of components for stereo processor
- regulated power supply components
- board-mounted DIN sockets and push-button switches
- fibreglass board designed for minimum wiring
- solid mahogany cabinet, chassis, twin meters, front panel, knobs, mounting screws and nuts

**Typical performance**

Noise reduction better than 9dB weighted

Clipping level 16.5dB above Dolby level (measured at 1% third harmonic content)

Harmonic distortion 0.1% at Dolby level typically 0.05% over most of band, rising to a maximum of 0.12%

Signal-to-noise ratio: 75dB (20Hz to 20kHz, signal at Dolby level) at Monitor output

Dynamic Range >90dB  
30mV sensitivity.

**PRICE: £37.90 + VAT**

Also available ready built and tested ..... **Price £52.00 + VAT**

Calibration tapes are available for open-reel use and for cassette (specify which) ..... **Price £2.00 + VAT \***

Single channel plug-in Dolby<sup>TM</sup> PROCESSOR BOARDS (92 x 87mm) with gold plated contacts are available with all components ..... **Price £7.20 + VAT**

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Selected FETs **60p** each + VAT, **100p** + VAT for two, **£1.90** + VAT for four

Please add VAT 12½% unless marked thus\*, then 8% applies  
We guarantee full after-sales technical and servicing facilities on all our kits, have you checked that these services are available from other suppliers?



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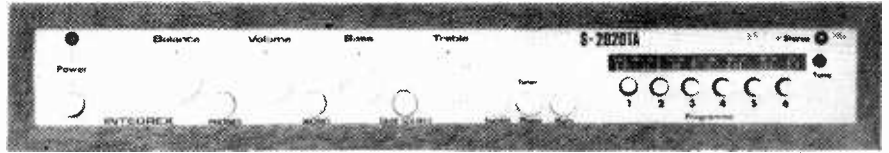
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# INTEGREX

## S-2020TA STEREO TUNER/AMPLIFIER KIT

**SOLID MAHOGANY CABINET**

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

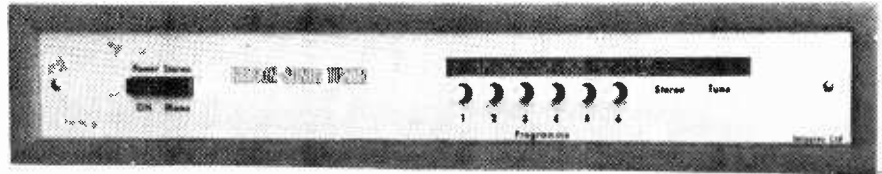


**Brief Spec.** Amplifier Low field Toroidal transformer, Mag. input, Tape In/Out facility (for noise reduction unit, etc.), THD less than 0.1% at 20W into 8 ohms. Power on/off FET transient protection. All sockets, fuses, etc., are PC mounted for ease of assembly. Tuner section uses 3302 FET module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

**PRICE: £53.95 + VAT**

## NELSON-JONES STEREO FM TUNER KIT

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



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

*Compare this spec. with tuners costing twice the price.*

**Mono £29.15 + VAT**

**With ICPL Decoder £33.42 + VAT**

**With Portus-Haywood Decoder  
£35.95 + VAT**

## STEREO MODULE TUNER KIT

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

**PRICE: Mono £26.85 + VAT**

**Stereo £29.95 + VAT**

## S-2020A AMPLIFIER KIT

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

*Power 'on/off' FET transient protection.*



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

**PRICE: £31.95 + VAT**

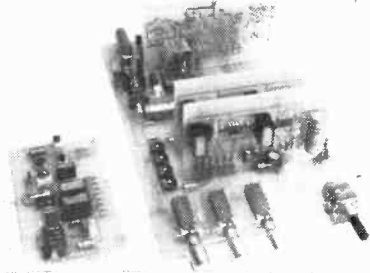
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<b>BASIC MODULE TUNER KIT (stereo)</b>	<b>£16.75 + VAT</b>	<b>PUSH-BUTTON UNIT</b>	<b>£4.50 + VAT</b>
<b>PORTUS-HAYWOOD PHASE-LOCKED STEREO DECODER KIT</b>			<b>£8.00 + VAT</b>

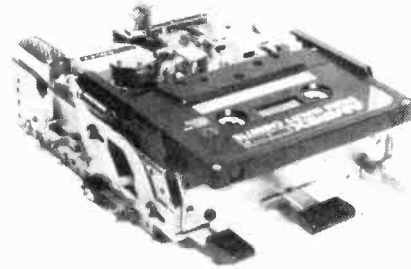
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Master Board with one Replay Amp removed



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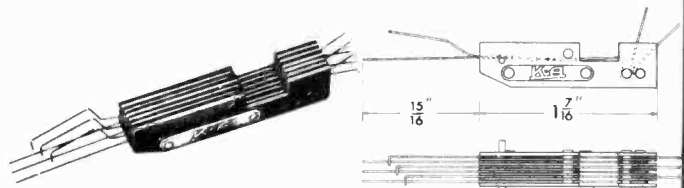
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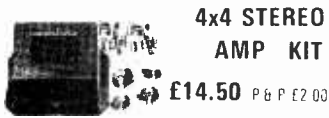


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A build-it-yourself stereo power amplifier with latest integrated circuitry, 10W RMS per channel output, full short-circuit and overheat protection. Complete with PZ20 Power Supply

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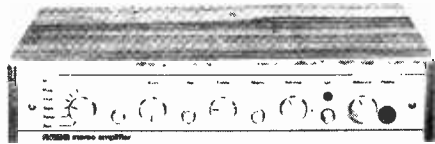
**BSR TURNTABLES**

BSR MP60 TYPE  
Single play record player (Chassis form) less cartridge  
Cartridges to suit above  
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CERAMIC STEREO  
BSR automatic record player deck (Chassis form) with cueing device and stereo ceramic head



P & P £2.00

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

**HOW YOU CAN SAVE**

**SYSTEM 1B** For only £80, you get the 20+20 watt Viscount IV amplifier, a pair of our 12-watt-rms Duo Type 11b matched speakers; a BSR MP 60 type deck complete with magnetic cartridge, de luxe plinth and cover.

£80.00  
- p & p £8.00

Carnage surcharge to Scotland System 1B : 2.50 System 2 : 5.00

**SYSTEM 2** Comprising our 20+20 watt Viscount IV amplifier; a pair of our large Duo Type 11b matching speakers which handle 20 watts rms each, and a BSR MP 60 type deck with magnetic cartridge, de luxe plinth and cover.

£92.00  
- p & p £10.00

**SPEAKERS** Two models - Duo 11b, teak veneer, 12 watts rms, 24 watts peak, 18 1/2" x 13 1/2" x 7 1/4" approx.

£34 PER PAIR  
- p & p £6.50

Duo 111, 20 watts rms, 40 watts peak, 27" x 13" x 11 1/2" approx

£52 PER PAIR  
- p & p £7.50

**TURNTABLE** Popular BSR MP 60 type, complete with magnetic cartridge, diamond stylus, and de luxe plinth and cover.

£29.00  
- p & p £4.50



**30 x 30 WATT AMPLIFIER KIT**

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

£29.00  
+ p & p £2.10

**BSR T145 8-TRACK CARTRIDGE PLAYER MECHANISM**

Requires some attention. Complete with built in pre-amp, A.C. 240V

**SPECIAL OFFER**

£6.95  
- p & p £1.50

**TOURIST IV PUSH BUTTON CAR RADIO KIT**

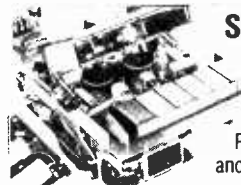


**MOTOR TOP 10 AWARD**

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

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

£10.50  
- p & p £1.50



**STEREO CASSETTE DECK KIT**

Again, this kit is specially designed for the experienced constructor - for mounting into his own cabinet. Features include solenoid-assisted AUTO-STGP, 3-digit counter, record/replay PC board, mains transformer and input and output controls. AC BIAS AND ERASE.

£32.50  
+ p & p £1.50

**DELUXE ACCESSORY KIT** Comprises of a matched pair of dynamic mics. and two replacement slider level controls. This item post **POST FREE** when purchased with Cassette Deck kit

£3.95  
- p & p £1.00

**35-WATT DISCO AMP**

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

£27.50  
- p & p £1.50



**PORTABLE DISCO CONSOLE with built-in pre-amplifiers**

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

£64.00  
+ p & p £6.50



**70 & 100 WATT DISCO AMPS**

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

**70 WATT**  
£49.00  
- p & p £3.00

**100 WATT**  
£65.00  
- p & p £4

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VALVES		INDUSTRIAL VALVES		TRANSISTORS & ICs		TUBES	
EAH81	0.35	EY86	0.50	OC71	0.25	2N1304	0.45
EAH83	0.50	EZ40	0.60	OC72	0.45	2N1305	0.45
EAH84	0.50	EZ41	0.75	OC73	0.50	2N1306	0.50
AZ31	1.00	EZ42	0.50	OC74	0.75	2N1307	0.50
CLB1	0.70	EZ43	0.50	OC75	0.75	2N1308	0.50
CLB2	1.40	EZ44	0.50	OC76	0.75	2N1309	0.50
CLB3	1.50	EZ45	0.50	OC77	0.75	2N1310	0.50
CL33	1.50	EZ46	0.50	OC78	0.75	2N1311	0.50
CY31	1.00	EZ47	0.50	OC79	0.75	2N1312	0.50
DAF31	0.40	EZ48	0.50	OC80	0.75	2N1313	0.50
DAF36	0.60	EZ49	0.50	OC81	0.75	2N1314	0.50
DCC90	1.35	EZ50	0.50	OC82	0.75	2N1315	0.50
DF91	0.40	EZ51	0.50	OC83	0.75	2N1316	0.50
DF96	0.60	EZ52	0.50	OC84	0.75	2N1317	0.50
DK91	0.50	EZ53	0.50	OC85	0.75	2N1318	0.50
DK92	1.00	EZ54	0.50	OC86	0.75	2N1319	0.50
DL92	0.50	EZ55	0.50	OC87	0.75	2N1320	0.50
DL94	0.65	EZ56	0.50	OC88	0.75	2N1321	0.50
DL96	0.55	EZ57	0.50	OC89	0.75	2N1322	0.50
DM70	0.70	EZ58	0.50	OC90	0.75	2N1323	0.50
DY96/7	0.45	EZ59	0.50	OC91	0.75	2N1324	0.50
DY902	0.47	EZ60	0.50	OC92	0.75	2N1325	0.50
EABC90	0.38	EZ61	0.50	OC93	0.75	2N1326	0.50
EAF42	0.70	EZ62	0.50	OC94	0.75	2N1327	0.50
EAF801	0.75	EZ63	0.50	OC95	0.75	2N1328	0.50
EBC33	1.00	EZ64	0.50	OC96	0.75	2N1329	0.50
EBC41	0.75	EZ65	0.50	OC97	0.75	2N1330	0.50
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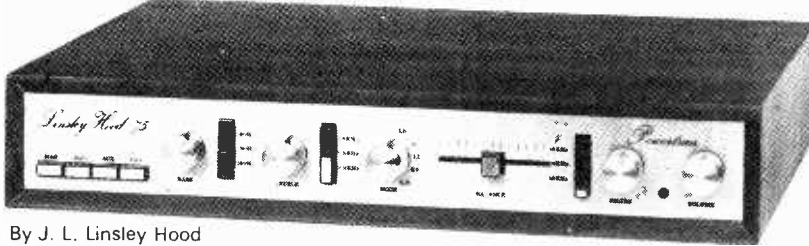
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## HI-FI NEWS 75W/CHANNEL AMPLIFIER



By J. L. Linsley Hood

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

- | Pack                                                                                                                 | Price  |
|----------------------------------------------------------------------------------------------------------------------|--------|
| 1. Fibreglass printed-circuit board for power amp                                                                    | £1.15  |
| 2. Set of resistors, capacitors, pre-sets for power amp                                                              | £2.15  |
| 3. Set of semiconductor for power amp                                                                                | £6.50  |
| 4. Pair of 2 drilled, finned heat sinks                                                                              | £1.10  |
| 5. Fibreglass printed-circuit board for pre-amp                                                                      | £1.75  |
| 6. Set of low noise resistors, capacitors, pre-sets for pre-amp                                                      | £3.40  |
| 7. Set of low noise, high gain semiconductors for pre-amp                                                            | £2.40  |
| 8. Set of potentiometers (including mains switch)                                                                    | £3.15  |
| 9. Set of 4 push-button switches, rotary mode switch                                                                 | £4.50  |
| 10. Toroidal transformer complete with magnetic screen/housing primary: 0-117V-234V; secondaries: 33-0-33V, 25-0-25V | £10.95 |

- | Pack                                                                                                                   | Price |
|------------------------------------------------------------------------------------------------------------------------|-------|
| 11. Fibreglass printed-circuit board for power supply                                                                  | £0.85 |
| 12. Set of resistors, capacitors, secondary fuses, semi-conductors for power supply                                    | £4.60 |
| 13. Set of miscellaneous parts including DIN skts, mains input skt, fuse holder, inter-connecting cable, control knobs | £5.35 |
| 14. Set of metalwork parts including silk screen printed fascia panel and all brackets, fixing parts, etc.             | £7.30 |
| 15. Handbook                                                                                                           | £0.30 |
| 16. Teak cabinet 18.3" x 12.7" x 3.1"                                                                                  | £9.85 |
- 2 each of packs 1-7 inclusive are required for complete stereo system. Total cost of individually purchased packs ..... £83.75

Designed in response to demand for a tuner to complement the world-wide acclaimed Linsley Hood 75W Amplifier, this kit provides the perfect match. The Wireless World (Skingley and Thompson - April, May 1974) published original circuit has been developed further for inclusion into this outstanding slimline unit and features a pre-aligned front end module, excellent a.m. rejection and temperature compensated varicap tuning, which may be controlled either continuously or by push button pre-selection. Frequencies are indicated by a frequency meter and sliding LED indicators, attached to each channel selector pre-set. The PLL stereo decoder incorporates active filters for "birdy" suppression and power is supplied via a toroidal transformer and integrated regulator. For long term stability metal oxide resistors are used throughout

- | Pack                                                                                                                                                        | Price |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------|-------|
| 1. Fibreglass printed board for front end IF strip, demodulator, AFC and mute circuits                                                                      | £2.15 |
| 2. Set of metal oxide resistors, thermistor, capacitors, ceramic preset for mounting on pack 1                                                              | £4.50 |
| 3. Set of transistors, diodes, LED, integrated circuits for mounting on pack 1                                                                              | £5.25 |
| 4. Pre-aligned front end module, coil assembly, three section ceramic filter                                                                                | £8.50 |
| 5. Fibreglass printed circuit board for stereo decoder                                                                                                      | £1.10 |
| 6. Set of metal oxide resistors, capacitors, ceramic preset for decoder                                                                                     | £2.60 |
| 7. Set of transistors LED, integrated circuit for decoder                                                                                                   | £2.90 |
| 8. Set of components for channel selector switch module including fibreglass printed circuit board, push-button switches, knobs, LEDs, preset adjuster etc. | £8.80 |
| 9. Function switch, 10 turn tuning potentiometer, knobs                                                                                                     | £5.30 |
| 10. Frequency meter, meter drive components, fibreglass printed circuit board                                                                               | £9.45 |

- | Pack                                                                                                                                                                   | Price |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------|
| 11. Toroidal transformer with electrostatic screen, Primary: 0-117V-234V                                                                                               | £4.45 |
| 12. Set of capacitors, rectifiers, voltage regulator for power supply                                                                                                  | £2.95 |
| 13. Set of miscellaneous parts, including sockets, fuse holder, fuses, inter-connecting wire, etc.                                                                     | £1.50 |
| 14. Set of metal work parts including silk screen printed fascia panel, acrylic silk screen printed tuning indicator panel insert, internal screen, fixing parts, etc. | £7.50 |
| 15. Construction notes (free with complete kit)                                                                                                                        | £0.25 |
| 16. Teak cabinet 18.3" x 12.7" x 3.1"                                                                                                                                  | £9.85 |
- One each of packs 1-16 inclusive are required for complete stereo FM tuner. Total cost of individually purchased packs ..... £76.85

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

### PRICE STABILITY

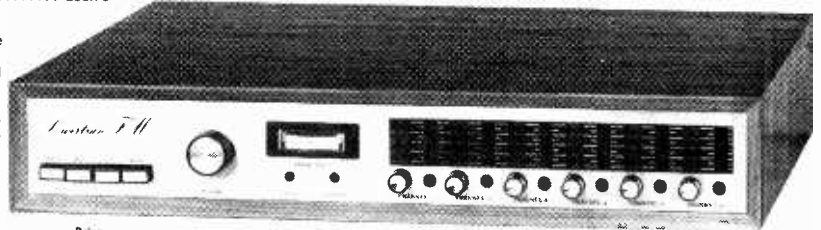
Order with confidence! Irrespective of any price changes we will honour all prices in this advertisement for two months from issue date provided that this advertisement is quoted with your order. E&OE VAT rate changes excluded. All components are brand new first grade full specification devices. All resistors (except where stated) are low noise carbon film types. All printed circuit boards are fibre-glass, drilled, roller tinned and supplied with circuit diagrams and construction layouts.

FREE CATALOGUE U.K. customers just send name and address - Overseas customers, please send 5 International Reply Coupons and you will receive your catalogue by return AIRMAIL

EXPORT ORDERS No VAT charged. Postage charged at actual cost plus 50p documentation and handling. Please make payment by Bank Draft, Postal Order, International Money Order in sterling. SECURICOR DELIVERY For this optional service (U.K. Mainland only) add £2.50 (VAT INC.) per kit. U.K. ORDERS: Subject to 12 1/2 % \* surcharge for VAT. Carriage free. MAIL ORDER ONLY (\*or at current rate if changed)

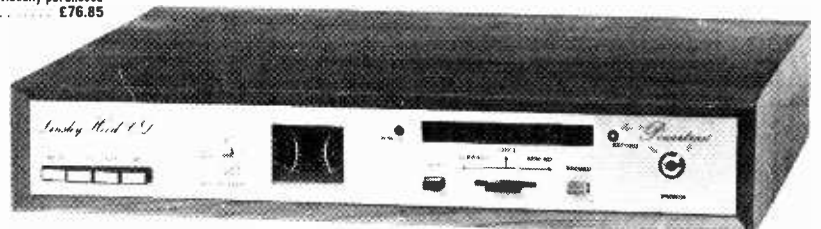
**FREE** TEAK CASE WITH FULL KITS  
KIT PRICE ONLY **£73.90**

## WIRELESS WORLD FM TUNER



**FREE** TEAK CASE WITH FULL KITS  
KIT PRICE ONLY **£66.75**

## NEW KIT! LINSLEY-HOOD CASSETTE DECK



- | Pack                                                                                       | Price  |
|--------------------------------------------------------------------------------------------|--------|
| 1. Stereo PCB (accommodates 2 rep. amps, 2 rec. amps, 2 motor amps, bias/erase osc. relay) | £3.35  |
| 2. Stereo set of capacitors, M.D. resistors, potentiometers for above                      | £9.80  |
| 3. Stereo set of semiconductors for above                                                  | £8.90  |
| 4. Miniature relay with socket                                                             | £2.45  |
| 5. PCB, all components for solenoid, speed control circuits                                | £3.20  |
| 6. Goldring Lenco mechanism as specified                                                   | £21.95 |
| 7. Function switch, knobs                                                                  | £1.60  |
| 8. Dual VU meter with illuminating lamp                                                    | £7.20  |
| 9. Toroidal transformer with E.S. screen prim, 0-117V, 234V, Sec. 15V                      | £4.45  |

- | Pack                                                                                              | Price |
|---------------------------------------------------------------------------------------------------|-------|
| 10. Set of capacitors, rectifiers, i.c. voltage regulator for power supply (Powertran design)     | £2.80 |
| 11. Set of miscellaneous parts, including sockets, fuse holder, fuses, interconnecting wire, etc. | £2.50 |
| 12. Set of metalwork including silk screened fascia panel, internal screen, fixing parts, etc.    | £7.10 |
| 13. Construction notes                                                                            | £0.25 |
| 14. Teak cabinet 18.3" x 12.7" x 3.1"                                                             | £9.85 |
- One each of packs 1-14 inclusive are required for complete stereo cassette deck. Total cost of individually purchased packs ..... £85.40

**SPECIAL PRICE FOR COMPLETE KITS £81.35**

Further details of above given in our FREE CATALOGUE

PLEASE NOTE ALL PRICES VAT EXCLUSIVE - DEPT. WW4

# POWERTRAN ELECTRONICS

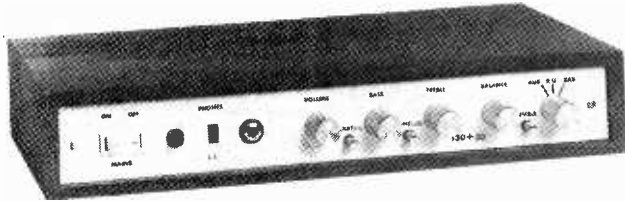
PORTWAY INDUSTRIAL ESTATE  
ANDOVER, HANTS SP10 3NN

Indonesia Brazil Switzerland Canada Saudi Arabia New Zealand Norway Iceland Sweden



Guernsey Cyprus Belgium Uganda Brunei Trinidad South West Africa Italy Java Grenada

# AUDIO KIT SUPPLIERS TO THE WORLD



## 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 hi-fi 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	1.40	1.50	8. Toroidal transformer - 240V prim.		
2. Set of small capacitors	2.20	2.80	9. s.s. screen	4.95	6.80
3. Set of power supply capacitors	1.90	2.30	10. Fibreglass PCB	3.20	3.60
4. Set of miscellaneous parts	3.20	3.20	11. Set of metalwork, fixing parts	4.20	4.80
5. Set of slide, main, P.B. switches	1.20	1.20	12. Set of cables, mains lead	0.40	0.40
6. Set of pots, selector switch	2.80	2.80	13. Handbook [free with complete kit]	0.25	0.25
7. Set of semiconductors, ICs, scts.	7.25	7.75	14. Teak cabinet 15.4" x 6.7" x 2.8"	4.50	4.50

## SPECIAL PRICES

FOR COMPLETE KITS!

T20+20  
KIT PRICE only **£31.10**

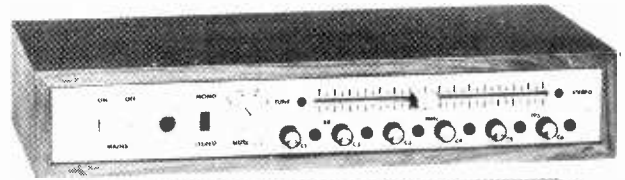
T30+30  
KIT PRICE only **£35.90**

## 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.

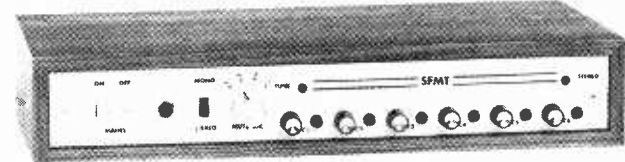
KIT PRICE  
**£45.50**



### 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 kits, all components down to the last nut and bolt are supplied together with full constructional details.

KIT PRICE  
**£32.60**

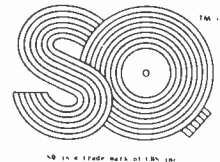


## CONVERT NOW TO QUADRAPHONICS!



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.

**Wireless World Amplifier Designs.** Full kits are not available for these projects but component packs and PCBs are stocked for the highly regarded Bailey and 20W class AB Lindsey Hood designs, together with an efficient regulated power supply of our own design. Suitable for driving these amplifiers is the Bailey Burrows pre-amplifier and our circuit board, for the stereo version of it features 6 inputs, scratch and rumble filters and wide range tone controls which may be either rotary or slider operating. For those intending to get the best out of their speakers we also offer an active filter system described by D.C. Read which splits the output of each channel from the pre-amplifier into three channels each of which is fed to the appropriate speaker by its own power amplifier. The Read/Texas 20W, or any of our other kits are suitable for these. For tape systems a set of three PCBs have been prepared for the integrated circuit based high performance stereo Stuart design. Details of component packs are in our free list.

30W Bailey Amplifier	
BAIL Pk 1 F/Glass PCB	£1.00
BAIL Pk 2 Resistors, Capacitors, Potentiometer set	£2.35
BAIL Pk 3 Semiconductor set	£4.70
20W Lindsey Hood Class AB	
LHAB Pk 1 F/Glass PCB	£1.05
LHAB Pk 2 Resistor, Capacitor, Potentiometer set	£3.20
LHAB Pk 3 Semiconductor set	£3.35
Regulator Power Supply	
60VS Pk 1 F/Glass PCB	£0.85
60VS Pk 2 Resistor, Capacitor set	£2.20
60VS Pk 3 Semiconductor set	£3.10
60VS Pk 6A Toroidal transformer (for use with Bailey)	£8.80
60VS Pk 6B Toroidal transformer (for use with 20W LH)	£7.25
Bailey Burrows Stereo Pre-Amp	
BBPA Pk 1 F/Glass PCB	£2.80
BBPA Pk 2 Resistor, capacitor semiconductor set	£6.70
BBPA Pk 3R Rotary Potentiometer set	£2.85
BBPA Pk 3S Slider Potentiometer set with knobs	£3.10
*Active Filter	
FILT Pk 1 F/Glass PCB	£1.40
FILT Pk 2 Resistor, Capacitor set (metal oxide 2%, polystyrene 2 1/2%)	£4.20
FILT Pk 3 Semiconductor set	£2.25
2 off Pks 1, 2, 3 reqd for stereo active filter system	
Read/Texas 20W Amp	
READ Pk 1 F/Glass PCB	£1.00
READ Pk 2 Resistor, Capacitor set	£1.20
READ Pk 3 Semiconductor set	£2.30
6 off pks 1, 2, 3 required for stereo active filter system	£2.30
Stuart Tape Recorder	
TRRP Pk 1 Replay Amp F/Glass PCB	£1.30
TRRC Pk 2 Record Amp F/Glass PCB	£1.70
TROS Pk 1 Bias/Erase/Stabilizer F/Glass PCB	£1.20

Further details of above and additional packs given in our FREE LIST

## 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-HB 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" for increased front back separation	All components, PCB	£22.60
L3A Decoder similar to L2A but with discreet component front end with high precision 6-pole phase shift networks for increased frequency response	All components (carbon film resistors), PCB	£25.90
Also available with M.O. resistors, cermet pre-set - add		£4.20

## SEMICONDUCTORS as used in our range of quality audio equipment.

2N699	£0.20	40361	£0.40	BD530	£0.55	MJE521	£0.60	TIP29C	£0.55
2N1613	£0.20	40362	£0.45	BDY56	£1.60	MPSA8	£0.25	TIP30C	£0.60
2N2926G	£0.10	BC107	£0.10	BF257	£0.40	MPSA12	£0.35	TIP41A	£0.70
2N3055	£0.45	BC108	£0.10	BF259	£0.47	MPSA14	£0.30	TIP42A	£0.80
2N3442	£1.20	BC109	£0.10	BFR39	£0.30	MPSA55	£0.25	TIP41B	£0.75
2N3711	£0.09	BC109C	£0.12	BFR79	£0.30	MPSA65	£0.35	TIP42B	£0.90
2N3904	£0.17	BC125	£0.15	BFY51	£0.20	MPSA66	£0.40	1N914	£0.07
2N3906	£0.20	BC126	£0.15	BFY52	£0.20	MPSU05	£0.50	1N916	£0.07
2N4062	£0.11	BC182	£0.10	CA3046	£0.70	SBA750A	£1.90	1S920	£0.10
2N4302	£0.60	BC212	£0.12	LP1186	£6.50	SL301	£1.30		
2N5087	£0.25	BC182L	£0.10	MC1310	£2.20	SL3045	£1.20	FILTERS	
2N5210	£0.25	BC184L	£0.11	MC1351	£1.05	SN72741P	£0.40	FM4	£1.00
2N5457	£0.45	BC212L	£0.12	MC1741CG	£0.65	SN72748P	£0.40	SF110 /MA	£1.50
2N5459	£0.45	BC214L	£0.14	MFC111U	£0.95	TIL209	£0.20		
2N5461	£0.50	BCY72	£0.13	MJ381	£1.20	TIP29A	£0.40		
2N5830	£0.35	BD529	£0.55	MJ491	£1.45	TIP30A	£0.45		

## EXPORT NO PROBLEM

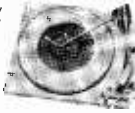
Our Export Department will be pleased to advise on postal costs to any country in the world. Some of the countries to which we sent kits in 1976 are shown surrounding this advertisement.

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



RETURN OF POST MAIL ORDER SERVICE


**BSR HI-FI AUTOCHANGER**  
**STEREO AND MONO £11.95** Post 75p  
 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 13 1/2 x 11 1/4 x 13 speeds. Above motor board 3 3/4 in. Below motor board 2 1/2 in. with STEREO and MONO CARTRIDGE B.S.R. SINGLE PLAYER similar to above with stereo cartridge and cueing device. Large turntable £13.50 B.S.R. P128 with magnetic cartridge. Balanced arm cueing device £23.50



**PORTABLE PLAYER CABINET**  
 Modern design. Remixe covered. Vynair front grille. Chrome fittings. Size 17 x 15 x 8 in. approx. £4.50 Post 75p  
 \*Motor board cut for BSR or Garrard deck

**HEAVY METAL PLINTHS** £6.50 Post £1 50  
 With P.V.C. Cover. Cut out for most BSR or Garrard decks. Silver grey finish. Model "A" Size 12 1/2 x 14 3/4 x 7 1/2 in. Model "B" Size 16 x 13 3/4 x 7 in. £7.50. Extra large plinth & cover. Teak wood base. Size 20" x 17 1/2" x 9" £19.50. Callers only.

**COMPLETE STEREO SYSTEM**  
 Two full size loudspeakers 13 3/4 x 10 x 3 3/4 in. Player unit clips to loudspeakers making it extremely compact. Overall size only 13 3/4 x 10 x 8 1/2 in. 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  
 FEW ONLY £1 carriage



**SPECIAL OFFER!**  
**SMITH'S CLOCKWORK 15 AMP TIME SWITCH** £2.95 Post 35p  
 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. 0-6 hour version—£3.30



**TEAKWOOD LOUDSPEAKER GRILLES** will easily fit to baffle board. Size 10 1/2 x 7 1/2 in—£4.5p.

**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 9 1/2 x 3 x 2 in. approx S.A.E. details. Full instructions supplied. AC mains powered

**VOLUME CONTROLS**  
 5KΩ to 2MΩ. LOG or LIN. L/S 35p. D.P. 60p. STEREO L/S 85p. D.P. £1. Edge 5K. S.P. Transistor 30p.

**80 Ohm Coax 8p yd.**  
 STANDARD TYPE VHF. FRINGE LOW LOSS 15p yd. Ideal 625 and colour PLUGS 10p. SOCKETS 10p. LINE SOCKETS 18p. OUTLET BOXES 50p.

**ELAC HI-FI SPEAKER**  
**8in. TWIN CONE**  
 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. 13 1/2 x 8in. SPEAKER SALE!**  
 With tweeter and crossover. 10 watt. State 3 or 8 ohm. As illustrated. £5.95 Post 45p

Ditto 15 watts. 8 or 15 ohm. £8.50 Post 65p

With tweeter and cross-over. 20 watt. Bass res. 25 c.p.s. Flux=11,000 gauss. 8 or 15 ohm. 20 to 20,000 c.p.s. £9.50 Post 75p

**Bookshelf Cabinet** £7.50 Post £1 00  
 Teak finish. For EMI 13 x 8 speakers

**THE "INSTANT" BULK TAPSE ERASER AND HEAD DEMAGNETISER.** Suitable for cassettes, and all sizes of tape reels. A.C. mains 200/250V. Leaflet S.A.E. Will also demagnetise small tools. £4.50 Post 50p



**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; 16 x 6—£1.45; 16 x 10—£1.70. ANGLE ALI. 6 x 3/4 x 3/4 in—15p.

**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.

**MANY ALI BOXES IN STOCK. MANY SIZES**

**ELAC 9 x 5in HI-FI SPEAKER** £3.45 Post 35p  
 TYPE 59RM  
 This famous unit now available. 10 watts. 8 ohm

**R.C.S. LOW VOLTAGE STABILISED POWER PACK KITS** £2.95 Post 45p  
 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 2 1/2 x 1 1/2 in. Please state voltage required.

**R.C.S. POWER PACK KIT** £3.35 Post 30p  
 12 VOLT. 750mA. Complete with printed circuit board and assembly instructions

**R.C.S. GENERAL PURPOSE TRANSISTOR PRE-AMPLIFIER — BRITISH MADE** £1.45 Post 30p  
 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 1 3/4 x 1 1/4 x 3/4 in. 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.

**ELECTRO MAGNETIC PENDULUM MECHANISM** 95p Post 30p  
 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.

**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	£1.75
HEATED TRANS. 6.3V 1/2 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 £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, 30V 5A and 34V 2ACT £3.45, 16V, 2 amp. £2.20, 0, 5, 8, 10, 16V. 1/2 amp. £1.95, 20V 1/2 amp. £1.75, 20V, 1 amp. £2.20, 20V 3 amp. £2.50, 20-0-20V 1 amp. £2.95, 30V 1/2 amp. £2.75; 20V, 40V, 60V or 20-0-20V, 1 amp. £3.50.	
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. 1 1/2 amp 40p; 2 amp 55p; 4 amp 85p.	
CHARGER TRANSFORMERS 1 1/2 amp £2.75; 4 amp £4.60. 12V. 1 1/2A HALF WAVE Selenium Rectifier. 25p.	

**R.C.S. BOOKSHELF SPEAKERS**  
 Size 14 1/2 in. x 9 1/4 in. x 6 in. 50 to 14,000 cps. 8 watts rms. 8 or 4 ohms



**£16 pair** Post £1.30  
**KUBA-KOPENHAGEN STEREO**

**TUNER-AMPLIFIER CHASSIS AM-FM 5+5 WATT**  
 This Continental 4-band radiogram chassis uses first class quality components throughout. Features. Large fascia panel with 7 push buttons for medium, long, short, VHF-FM, AFC, phono. mains on-off, 4-rotary controls, tuning, volume, tone, balance. Fascia size 17 x 4 1/2 inches. Chassis size 17 x 4 1/2 x 5 1/2 inches. DIN-connector sockets for tape record/playback, loudspeakers, phono pick-up, external FM-AM aerials. Automatic stereo beacon light. Built-in ferrite rod aerial for medium/longwave A.C. 240V mains. Circuit supplied Above speakers are suitable £33.50 Post £1 50

**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.  
 3900mF 100V £1.60.  
 4700mF 63V £1.20.  
 5000mF 6V 25p; 12V 42p; 25V 75p; 35V 85p.

**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 17p; 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 CHANGEVER** 20p.  
**SW-MIN MICRO SWITCH**, 25p. Single pole change over  
**TWIN GANG**, 385 + 385pF 50p; 500pF standard 75p; 365 + 365 + 25 + 25pF. Slow motion drive 65p.  
**120PF TWIN GANG**, 50p; 365pF TWIN GANG, 50p.  
**NEON PANEL INDICATORS** 250V, Amber or red 30p.  
**RESISTORS** 1/4W, 1/2W 1W 20% 2p; 2W, 10p; 10 to 10M.  
**HIGH STABILITY** 1/4W, 1/2W 2% 10 ohms to 6 meg. 12p.  
 Ditto 5% Preferred values 10 ohms to 10 meg. 5p  
**WIRE-WOUND RESISTORS** 5 watt, 10 watt, 15 watt, 10 ohms to 100K 12p each

**TAG STRIP** 28-way 12p.  
**TAPE OSCILLATOR COIL**. Valve type. 35p.  
**BRIDGE RECTIFIER** 200V PIV 1/2 amp 50p.  
**TOGGLE SWITCHES** S.P. 20p. D.P.S.T 25p. D.P.D.T 30p.  
**MANY OTHER TOGGLES IN STOCK**  
**PICK-UP CARTRIDGES** ACOS GP91 £1.50. GP93 £2.50.  
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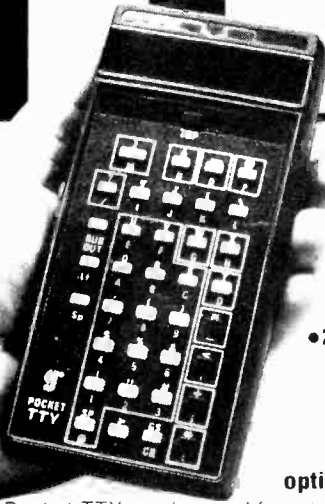
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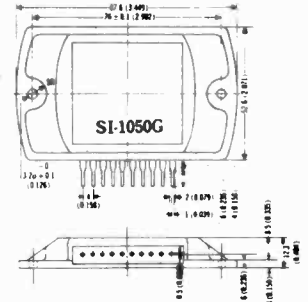


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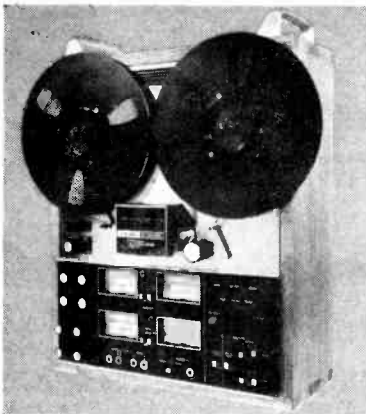
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**Instrument cases**

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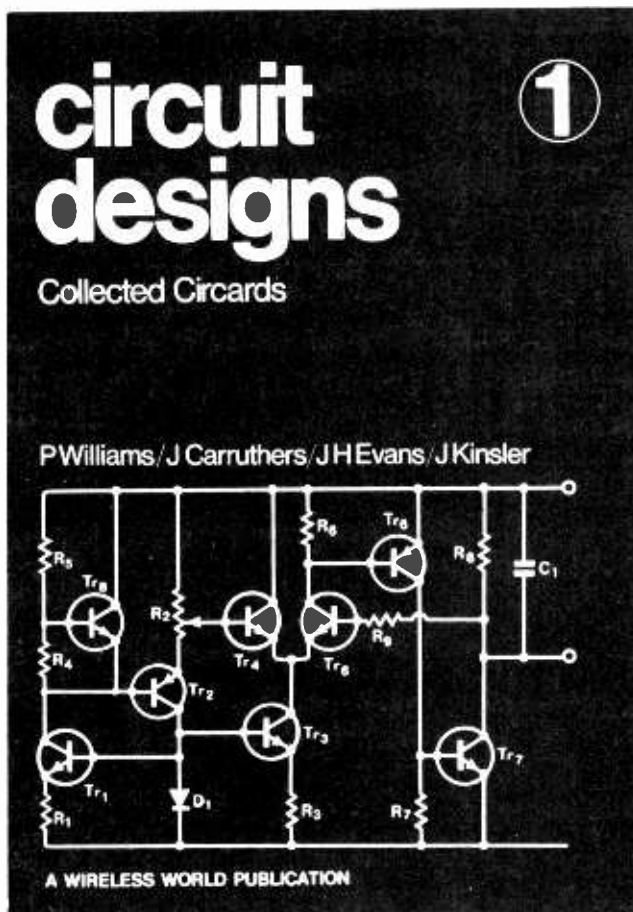
**CASE SPECIALISTS**

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# Two books from Wireless World

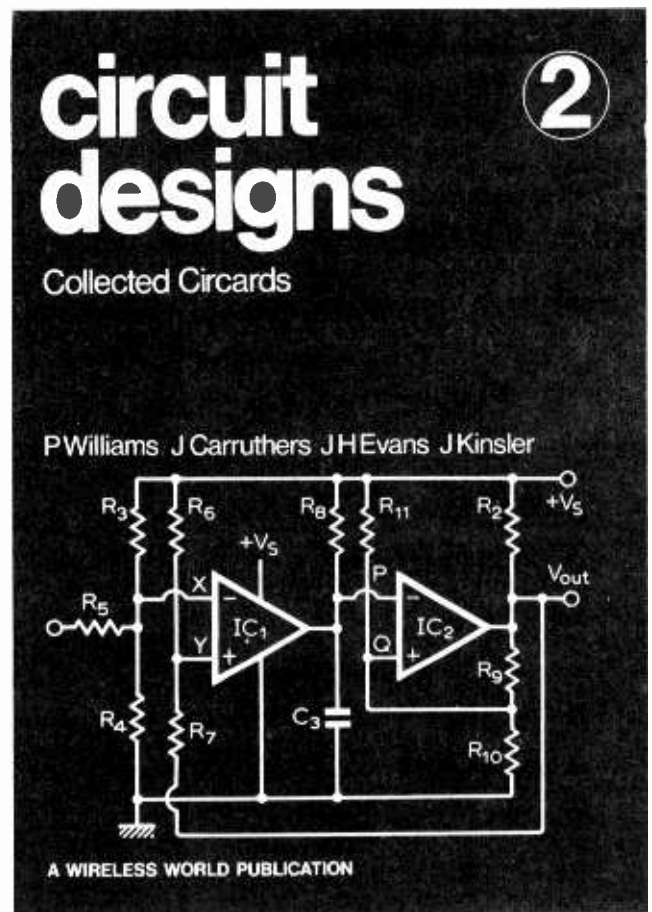
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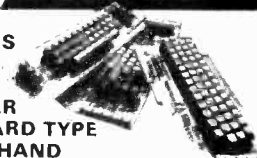
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AC127	0.16	BC168	0.09	BD132	0.40	BFX29	0.26	OC84	0.40	2N3706	0.10*
AC128	0.16	BC169	0.12	BD133	0.36*	BFX30	0.30	OC139	0.30	2N3707	0.10*
AC128K	0.25	BC169C	0.14*	BD136	0.39*	BFX84	0.23	OC140	1.30	2N3708	0.09*
AC141	0.22	BC170B	0.12*	BD137	0.40*	BFX85	0.25	OC170	0.23	2N3709	0.09*
AC141K	0.34	BC171	0.12*	BD138	0.48*	BFX86	0.25	1P29A	0.44*	2N3710	0.10*
AC142	0.18	BC172B	0.12*	BD139	0.58*	BFX87	0.20	1P30A	0.52*	2N3711	0.10*
AC142K	0.32	BC182	0.11*	BD144	2.20	BFX88	0.20	1P31A	0.54	2N3715	1.80
AC176	0.16	BC182L	0.12*	BD157	0.60	BFX89	0.90	1P32A	0.64	2N3716	1.80
AC176K	0.32	BC183	0.10*	BD181	0.86	BFY11	1.10	1P41A	0.68	2N4123	1.14*
AC187	0.18	BC183L	0.10*	BD182	0.92	BFY18	0.50	1P42A	0.72	2N3772	1.90
AC187K	0.36	BC184	0.11*	BD183	0.97	BFY40	0.50	2N404	0.40	2N3773	2.10
AC188	0.18	BC184L	0.12*	BD184	1.20	BFY41	0.60	2N696	0.20	2N3819	0.28*
AC188K	0.32	BC187	0.24*	BD232	0.60	BFY50	0.20	2N697	0.20	2N3904	0.16*
AD149	0.09	BC207	0.12*	BD233	0.48	BFY51	0.18	2N706	0.15	2N4347	1.10
AD161	0.35	BC207B	0.12*	BD237	0.55	BFY52	0.19	2N718	0.18	2N4306	0.11*
AO162	0.35	BC212	0.11*	BD238	0.60	BFY53	0.25	2N929	0.22	2N4124	0.14*
AF114	0.20	BC212L	0.12*	BD410	0.60	BFY64	0.35	2N1131	0.15	2N4290	0.14*
AF115	0.20	BC213	0.12*	BDX32	2.30	BFY90	0.90	2N1132	0.16	2N4291	0.14*
AF116	0.20	BC213L	0.14*	BDY11	2.00	BSX19	0.16	2N1302	0.40	2N4292	0.14*
AF117	0.20	BC214	0.14*	BDY11	2.00	BSX19	0.16	2N1303	0.40	2N4347	1.10
AF118	0.50	BC214L	0.15*	BDY20	0.80	BSX20	0.18	2N1304	0.45	2N4348	1.20
AF124	0.25	BC237	0.16*	BDY38	0.60	BSX21	0.20	2N1305	0.45	2N4870	0.35*
AF125	0.25	BC238	0.16*	BDY60	1.70	BSX76	0.30	2N1306	0.50	2N4871	0.35*
AF126	0.25	BC300	0.34*	BDY61	1.65	BSX77	0.30	2N1307	0.50	2N4918	0.60*
AF139	0.35	BC301	0.32	BDY62	1.15	BSX78	0.35	2N1308	0.60	2N4919	0.70*
AF239	0.37	BC302	0.40	BDY95	2.15	BSY52	0.28	2N1309	0.60	2N4920	0.60*
AL102	1.45	BC303	0.46	BDY96	2.46	BSY53	0.39	2N1711	0.24	2N4922	0.58*
AL103	1.30	BC307	0.15*	BDY97	4.95	BSY54	0.33	2N2102	0.44	2N4923	0.46*
AL107	3.30*	BC308	0.16*	BF127	0.50	BSY55	0.74	2N2217	0.10		
AL110	1.75*	BC309	0.18*	BF157	0.50	BSY65	0.30	2N2369	0.30		
AL113	1.60*	BC310	0.17*	BF177	0.25	BSY76	1.75	2N2483	0.60		
BC107	0.09	BC317	0.12*	BF178	0.28	BSY78	0.20	2N2369A	0.14		
BC107B	0.09	BC319	0.13*	BF179	0.28	BSY95A	0.16	2N2484	0.16		
BC108	0.09	BC320	0.18*	BF180	0.30	BU105	1.80*	2N2646	0.50		
BC108B	0.09	BC321	0.18*	BF181	0.30	BU105.02	1.90*	2N2711	0.20		
BC109	0.09	BC323	1.60*	BF182	0.30	BU108	3.00*	2N2712	0.15		
BC109B	0.09	BC327	0.83*	BF183	0.30	BU109	2.50*	2N2904A	0.20		
BC109C	0.12	BC328	0.18*	BF184	0.20	BU126	1.60*	2N2905	0.18		
BC117	0.19*	BC337	0.17*	BF185	0.20	BU133	1.60*	2N2905A	0.22		
BC119	0.25	BC338	0.17*	BF194	0.10*	BU204	1.60*	2N2906	0.18		
BC125	0.18*	BC407	0.22*	BF196	0.12*	BU205	1.90*	2N2925	0.14*		
BC126	0.20*	BC408	0.22*	BF197	0.12*	BU206	2.40*	2N2926	0.09*		
BC140	0.32	BCY30	0.55	BF200	0.40	BU208	2.60*	2N2926B	0.10*		
BC141	0.28	BCY31	0.55	BF218	0.30	MJ480	0.80*	2N2926C	0.09*		
BC142	0.23	BCY32	0.60	BF219	0.30	MJ481	1.05	2N2926G	0.10*		
BC143	0.23	BCY33	0.55	BF220	0.28	MJ490	0.90	2N3053	0.20		
BC144	0.30	BCY34	0.55	BF224J	0.18*	MJ491	1.15	2N3055	0.50		
BC147	0.08*	BCY38	0.18*	BF244	0.17*	MJ520	0.40*	2N3133	0.30		
BC148	0.09*	BCY39	1.15	BF257	0.35	MJ521	0.45	2N3134	0.30		
BC149	0.09*	BCY40	0.75	BF258	0.35	MJ521	0.55	2N3137	1.10		
BC152	0.25*	BCY42	0.30	BF259	0.48	OC43	0.95	2N3440	0.56		
BC153	0.18*	BCY44	1.60	BF336	0.35*	OC44	0.32	2N3442	1.20		
BC157	0.09*	BCY70	0.12	BF337	0.32*	OC45	0.32	2N3570	3.60		
BC158	0.09*	BCY71	0.12	BF338	0.45*	OC46	0.20	2N3702	0.10*		
BC159	0.09*	BCY72	0.12	BFW30	1.75	OC70	0.30	2N3703	0.10*		
BC160	0.32	BD115	0.15	BFW59	0.50	OC71	0.35	2N3704	0.10*		

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7425	0.30	74122	0.47
7427	0.48	74123	0.47
7430	0.16	74141	0.78
7432	0.37	74145	0.68
7437	0.35	74154	1.62
7441AN	0.76	74164	0.93
7442	0.65	74165	0.93
7445	1.50	74174	1.00
7447AN	0.81	74175	0.94
7448	0.81	74180	1.06
7470	0.32	74181	3.20
7472	0.26	74191	1.32
7473	0.30	74192	1.35
7474	0.32	74193	1.35
7475	0.47	74194	1.20
7476	0.36	74196	1.6*

THYRISTORS											
PV	1A	3A	4A	4A	5A	8A	10A	15A	10A	15A	10A
	[05]	[Stud]	[C106]	[T0220]	[T0220]	[T0220]	[T0220]	[T0220]	[T0220]	[T0220]	[T048]
200	0.35	0.50	0.45	0.40	0.58	0.60	0.68	1.14			
400	0.64	0.60	0.50	0.45	0.88	0.88	0.98	1.40			
600	0.65	0.85	0.70	-	1.09	1.19	1.26	1.80			
BT106	BT107	BT108	BT109	BT116	BT116	BT3525					
£1.00	£1.60	£1.60	£1.00	£1.00	£1.00	£0.50					

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400V	0.77	0.78	0.80	0.83	0.97
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### Diodes

Type	Price (p)	Type	Price (p)
BA115	10	OA90	7
BA145	18	OA95	6
BA148	18	OA202	11
BA154	12	IN60/OA91	7
BA155	15	IN914	6
BAX13	6	IN4001	6½
BAX16	10	IN4002	7
BY126	10½	IN4003	8
BY127	12	IN4004	8
BY133	17½	IN4005	9
BY199	25	IN4006	9½
BY206	17	IN4007	10
BYX10	16	IN4148	4½
QA47	8		

### Semi Conductors

Type	Price (p)	Type	Price (p)
AC107	25	AF115	27
AC126	20	AF116	27
AC127	20	AF117	27
AC128	15	AF118	65
AC128K	30	AF124	40
AC141	24	AF125	32
AC141K	34	AF126	38
AC142	20	AF127	42
AC142K	36	AF139	45
AC151	28	AF178	69
AC154	18	AF180	69
AC155	18	AF181	69
AC156	28	AF239	45
AC176	22	AF240	20
AC176K	34	AL102	£1.40
AC187	20	AL103	£1.30
AC187K	36	AU107	£1.50
AC188	25	AU110	£1.30
AC188K	38	AU113	£1.30
AC193K	36	BC107	14
AC194K	35	BC107B	16
AD140	69	BC108	14
AD142	75	BC109	14
AD143	65	BC109C	14
AD149	70	BC113	15
AD161	50	BC114	15
AD161/2	£1.00	BC115	17½
AD162	50	BC116	17½
AF114	27	BC116A	30

### Semi Conductors

Type	Price (p)	Type	Price (p)
BC117	14	BC237	12
BC118	15	BC238	12
BC119	27	BC301	30
BC125	17½	BC303	30
BC125B	18	BC327	13
BC126	16	BC328	13
BC132	15	BC337	12
BC135	20	BC338	12
BC136	16	BC546	13
BC137	25	BC547	12
BC138	33	BC548	12
BC139	28	BC549	13
BC140	32	BC550	14
BC141	28	BC557	13
BC142	25	BC558	12
BC143	28	BCY72	16
BC147	10	BD115	39
BC147A	11	BD116	65
BC147B	11	BD124	75
BC148	10	BD131/	
BC149	10	BD233	43
BC153	20	BD132	45
BC154	20	BD133	45
BC157	11	BD135	29
BC158	10	BD136	30
BC159	11	BD137	30
BC160	30	BD138	33
BC161	33	BD139	37
BC171	10	BD140	39
BC172	10	BD144	£1.99
BC173	15	BD160	£1.65
BC178	18	BD181	90
BC178B	20	BD182	90
BC179	24	BD183	80
BC182	11	BD184	£1.10
BC182L	12	BD222	50
BC183L	12	BD225	47
BC184	13	BD232	50
BC186	25	BD233	43
BC187	25	BD234	49
BC204	14	BD235	49
BC212	11	BD236	53
BC212L	12	BD237	49
BC213	12	BD238	55
BC213L	11	BDX32	£2.75
BC214	13	BDY20	80
BC214L	15		

### Semi Conductors

Type	Price (p)	Type	Price (p)
BF115	38	BFX88	25
BF123/		BFY50	20
T092	25	BFY51	30
BF152	20	BFY52	20
BF158	20	BFY90	£1.10
BF160	35	BR100	32
BF167	28	BR101	38
BF173	32	BRC4443	80
BF178	33	BRY39	38
BF179	38	BSY52	30
BF180	36	BT106	£1.20
BF181	36	BT108	£1.50
BF182	30	BT116	£1.25
BF183	30	BU105/02	£1.90
BF184	30	BU108	£2.10
BF185	30	BU126	£1.49
BF186	32	BU204	£1.80
BF194	10	BU205	£1.67
BF195	10	BU206	£2.10
BF196	10	BU208/02	£2.75
BF197	11	BUY69B	£2.50
BF197A/		BUY69A	£2.65
BF597A	17½	E1222	38
BF198	30	MJE340/	
BF199	25	BF459	48
BF200	30	MJE520	44
BF218	56	2N696	30
BF224	20	2N706	15
BF240	18	2N3053	20
BF241	18	2N3054	65
BF257	28	2N3055	60
BF258	30	2N3702	12
BF259	30	2N3703	12
BF336	37	2N3704	10
BF337	35	2N3705	10
BF338	34	2N3706	10
BF355	50	2N3819	38
BF457	37	2N5293	52
BF458	37	2N5294	52
BF459	48	2N5295	52
BFT42	36	2N5296	46½
BFT43	35	2N5297	52
BFX29	29	2N5298/	
BFX84	29	TIP31A	52
BFX85	30	2N5496	53
BFX86	28	OC71	29

### Semi Conductors

Type	Price (p)	Type	Price (p)
OC72	38	TIP32A	62
R2008B	£2.10	TIP41A	70
R2010B	£2.10	TIP42A	75
RCA16334	80	TIS91	27
RCA16335	80	2SC1172A	£2.73
S.2802	2.99	2SC643A	£1.48
S.6080A	£4.90	4.43MHZ	
TIP31A/		Crystal	£1.10
2N5298	52		

### Integrated Circuits

MC1349	£1.02	SN76660N	66
ML231B	£4.20	SN76666N	£1.10
ML232B	£4.20	TAA550	39
SL414A	£1.68	TAA570	£1.30
SL415A	£2.20	TAA661B	81
SL1310	£1.54	TAA700	£2.56
SL1327	97	TBA120AS	69
SL3046	73	TBA120SQ	£1.14
SL76544	£1.50	TBA440	£3.00
SN76003N	£2.45	TBA480Q	£1.40
SN76013N	£1.65	TBA520Q	£2.06
SN76013ND	£1.40	TBA530Q	£1.30
SN76023N	£1.65	TBA540Q	£2.00
SN76023ND	£1.40	TBA550Q	£2.56
SN76033N	£2.45	TBA560Q	£2.56
SN76110N	£1.75	TBA750Q	£1.43
SN76228N	£2.20	TBA800	£1.10
SN76227N	£1.65	TBA920Q	£2.64
SN76532N	£1.60	TBA990Q	£2.56
SN76533N	£1.60	TCA270Q	£2.64
SN76544N	£1.80	TCA800	£4.60
SN76650N	£1.50	TDA440	£3.00

### Toshiba

Type	Equivalent	Price
TA7050P	CA3044 RCA	£1.13
TA7051P	CA3042 RCA	£1.45
TA7072P	MC1351 Motorola	£1.53
TA7074P	MC1352 Motorola	£1.34
TA7141AP	MC1327 Motorola	£1.40
TA7171P	SAS560S Siemens	£1.65
TA7172P	SAS570S Siemens	£1.65
TA7173P	TCA270 Philips	£2.20
TA7176P	CA3065 RCA	£1.30



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# SEMICONDUCTORS - COMPONENTS

## TRIACS

2 Amp			TO5 Case			10 Amp			TO48 Case		
Volts	No.	Price	Volts	No.	Price	Volts	No.	Price	Volts	No.	Price
100	TR12A 100	£0.31	100	TR110A 100	£0.77	200	TR12A 200	£0.51	200	TR110A 200	£0.92
200	TR12A 200	£0.51	400	TR110A 400	£1.12	400	TR12A 400	£0.71			

6 Amp			TO66 Case			10 Amp			TO220 Case		
Volts	No.	Price	Volts	No.	Price	Volts	No.	Price	Volts	No.	Price
100	TR16A 100	£0.51	200	TR16A 200	£0.61	400	TR16A 400	£0.77			

## DIACS

BR100 £0.23 D32 £0.23

## SUPER UNTESTED PAKS

PAK No.	Description	Order No.	Price
U50	100 Germ. Gold bonded OA47 diode	16130	£0.60
U51	150 Germ. OA70 B1 diode	16131	£0.60
U52	100 Silicon Diodes 200mA OA200	16132	£0.60
U53	150 diodes 75mA 1N4148	16133	£0.60
U54	50 Sil Rect. Top Hat 750mA	16134	£0.60
U55	20 Sil Rect. Stud type 3 Amp	16135	£0.60
U56	50 400mW Zeners D07 Case	16136	£0.60
U57	30 NPN Trans BC107 B Plastic	16137	£0.60
U58	30 PNP Trans BC177 178 Plastic	16138	£0.60
U59	25 NPN TO39 2N697 2N1711 sil	16139	£0.60
U60	25 PNP TO59 2N2905 silicon	16140	£0.60
U61	30 NPN TO18 2N706 silicon	16141	£0.60
U62	25 NPN BY50 51	16142	£0.60
U63	30 NPN Plastic 2N3906 silicon	16143	£0.60
U64	30 PNP Plastic 2N3905 silicon	16144	£0.60
U65	30 Germ. 0071 PNP	16145	£0.60
U66	15 Plastic Power 2N3055 NPN	16146	£1.20
U67	10 TO3 Metal 2N3055 NPN	16147	£1.20
U68	20 Unijunction trans IS43	16148	£0.60
U69	10 1 amp SCR TO39	16149	£1.20
U70	8 3 amp SCR TO66 case	16150	£1.20

Code No's mentioned above are given as a guide to the type of device in the pak. The devices themselves are normally unmarked.

## COMPONENT PAKS

Pack No.	Qty.	Description	Order No.	Price
C1	200	Resistor mixed value approx (Count by weight)	16164	£0.60
C2	150	Capacitors mixed value approx (Count by weight)	16165	£0.60
C3	50	Precision resistors Mixed values	16166	£0.60
C4	80	1/8 W Resistors mixed preferred values	16167	£0.60
C5	5	Pieces assorted ferrite rods	16168	£0.60
C6	2	Tuning ganged MW 1W VHF	16169	£0.60
C7	1	Pack wire 50 metres assorted colours single strand	16170	£0.60
C8	10	Reed switches	16171	£0.60
C9	3	Micro switches	16172	£0.60
C10	15	Assorted pots	16173	£0.60
C11	5	Metal jack sockets 3 x 3.5mm 2 x standard switch types	16174	£0.60
C12	30	Paper condensers preferred types mixed values	16175	£0.60
C13	20	Electrolytics trans types	16176	£0.60
C14	1	Pack assorted hardware - Nuts bolts grommets etc	16177	£0.60
C15	5	Mainis slide switches ass	16178	£0.60
C16	20	Assorted tag strips and panels	16179	£0.60
C17	15	Assorted control knobs	16180	£0.60
C18	4	Rotary wave change switches	16181	£0.60
C19	2	Relays 6 - 24V operating	16182	£0.60
C20	1	Pak copper laminate approx 200 sq ins	16183	£0.60
C21	15	Assorted fuses 100mA-5 amp	16184	£0.60
C22	50	Metres PVC sleeving assorted size and colour	16185	£0.60
C23	60	1/2 watt resistors mixed preferred values	16186	£0.60
C24	25	Presets assorted type and value	16187	£0.60
C25	30	Metres stranded wire assorted colours	16188	£0.60

## SLIDER PAKS

Pack No.	Qty.	Description	Order No.	Price
S1	6	Slider potentiometers mixed values - 470pf 560pf 680pf 820pf	16190	£0.60
S2	6	Slider potentiometers all 470 ohms	16191	£0.60
S3	6	Slider potentiometers all 10k lin	16192	£0.60
S4	6	Slider potentiometers all 22k lin	16193	£0.60
S5	6	Slider potentiometers all 47k lin	16194	£0.60
S6	6	Slider potentiometers all 47k log	16195	£0.60

## CERAMIC PAKS

Containing a range of first quality miniature ceramic capacitors Unrepeatable value

Order No.	Price		
MC1	24 miniature ceramic capacitors 3 of each value - 22pf 27pf 33pf 39pf 47pf 68pf 82pf	16160	£0.60
MC2	24 miniature ceramic capacitors 3 of each value - 100pf 120pf 150pf 180pf 220pf 330pf & 390pf 270pf	16161	£0.60
MC3	24 miniature ceramic capacitors 3 of each value - 470pf 560pf 680pf 820pf 1000pf 1500pf 2200pf & 3300pf	16162	£0.60
MC4	24 miniature ceramic capacitors 3 of each value - 470pf 560pf 680pf 820pf 1000pf 1500pf 2200pf & 3300pf	16163	£0.60

## ORDERING

Please word your orders exactly as printed not forgetting to include our part number.

## V.A.T.

Add 12 1/2% to prices marked \*. Add 8 1/2% to others excepting those marked † these are Zero

## CARBON POTENTIOMETERS

SINGLE GANG with wire end terminations 6mm x 50mm plastic shaft 10mm bushes supplied with shake proof washer and nut. Tolerance ±20% of resistance.

### LINEAR TRACK

Value	No.	Price
1K	1831	£0.22
2K2	1832	£0.22
4K7	1833	£0.22
10K	1834	£0.22
22K	1835	£0.22
47K	1836	£0.22
100K	1837	£0.22
220K	1838	£0.22
470K	1839	£0.22
1M	1840	£0.22
2M2	1841	£0.22

### LOG TRACK

Value	No.	Price
4K7	1842	£0.22
10K	1843	£0.22
22K	1844	£0.22
47K	1845	£0.22
100K	1846	£0.22
220K	1847	£0.22
470K	1848	£0.22
1M	1849	£0.22
2M2	1850	£0.22

DUAL GANG These high quality pots are fitted with wire end terminations 6mm x 50mm plastic shaft 10mm bushes supplied with shakeproof washer and nut. Track tolerance ±20% but matched to within ±0.8 of each other.

### LINEAR TRACK

Value	No.	Price
4K7	1851	£0.68
10K	1852	£0.68
22K	1853	£0.68
47K	1854	£0.68
100K	1855	£0.68
220K	1856	£0.68
470K	1857	£0.68
1M	1858	£0.68
2M2	1859	£0.68

### LOG TRACK

Value	No.	Price
4K7	1860	£0.68
10K	1861	£0.68
22K	1862	£0.68
47K	1863	£0.68
100K	1864	£0.68
220K	1865	£0.68
470K	1866	£0.68
1M	1867	£0.68
2M2	1868	£0.68

SINGLE GANG SWITCHED. Fitted with double pole on/off switches. The switch action is incorporated within the rotary action of the pot. Switch rating 1.5 amps at 250V AC.

### LINEAR TRACK

Value	No.	Price
4K7	1870	£0.48
10K	1871	£0.48
22K	1872	£0.48
47K	1873	£0.48
100K	1874	£0.48
220K	1875	£0.48
470K	1876	£0.48
1M	1877	£0.48
2M2	1878	£0.48

### LOG TRACK

Value	No.	Price
4K7	1879	£0.48
10K	1880	£0.48
22K	1881	£0.48
47K	1882	£0.48
100K	1883	£0.48
220K	1884	£0.48
470K	1885	£0.48
1M	1886	£0.48
2M2	1887	£0.48

## VEROBOARDS

### DRILLED COPPER P.C.B.

.1 Pitch			.15 Pitch			
Size	No.	Price	Size	No.	Price	
2.5 x 5	2201	£0.46	2.5 x 17	2209	£1.13	
2.5 x 3.75	2202	£0.39	2.5 x 5	2210	£0.42	
2.5 x 17	2203	£1.42	2.5 x 3.75	2211	£0.31	
3.75 x 5	2204	£0.52	3.75 x 17	2212	£1.51	
3.75 x 3.75	2205	£0.45	3.75 x 5	2213	£0.57	
3.75 x 17	2206	£1.82	3.75 x 3.75	2214	£0.42	
4.75 x 17.9	2207	£2.34	2.5 x 1	(pack of five)	2216	£0.52
2.5 x 1	(pack of five)	2208	£0.57			

### DRILLED PLAIN P.C.B.

.1 Pitch			.15 Pitch		
Size	No.	Price	Size	No.	Price
3.75 x 17	2217	£1.18	2.5 x 17	2221	£0.78
3.75 x 2.5	2218	£0.26	3.75 x 17	2222	£1.00
5 x 3.75	2219	£0.42	2.5 x 5	2223	£0.26
			2.5 x 3.75	2224	£0.21
			5 x 3.75	2225	£0.36

### VERO SPOT-FACE CUTTER

Order No. 2231 Price £0.68

## PLUGS AND SOCKETS

### PLUGS

P1	Description	No.	Price
P1	DIN 3 pin 2 pin speaker	1689	£0.08
P2	DIN 3 pin	1690	£0.12
P3	DIN 4 pin	1691	£0.16
P4	DIN 5 pin 180	1692	£0.14
P5	DIN 5 pin 240	1693	£0.15
P6	DIN 6 pin	1694	£0.20
P7	DIN 7 pin	1695	£0.20
P8	Jack 2 5mm screened	1696	£0.12
P9	Jack Plug 4.5mm plastic	1697	£0.10
P10	Jack Plug 3.5mm screened	1698	£0.15
P11	Jack Plug mono plastic	1699	£0.14
P12	Jack Plug mono screened	16100	£0.28
P13	Jack Plug stereo screened	16101	£0.32
P14	Phono	16102	£0.10
P15	Car aerial	16103	£0.16
P16	Coax free TV	16104	£0.16
P17	Right angle jack	16105	£0.12
P18	Jack 2 5mm plastic	16106	£0.12
P19	Jack stereo plastic	16107	£0.20
P20	Phono free screened	16108	£0.14
P21	D.C. 2 pin plug	16109	£0.12
P22	D.C. 2 5mm plug	16110	£0.12
P23	2 pin AC plug U.S. type	16111	£0.18
P24	AM aerial	16112	£0.13
P25	Cassette mains plug	16113	£0.15
P26	FM 300 ohms plug	16114	£0.13

### CHASSIS SOCKETS

CS1	Description	No.	Price
CS1	DIN 3 pin loudspeaker	1652	£0.08
CS2	DIN 3 pin	1653	£0.10
CS3	DIN 4 pin	1654	£0.10
CS4	DIN 5 pin 180	1655	£0.12
CS5	Jack 6mm	1656	£0.06
CS6	Jack 4.5mm	1657	£0.06
CS7	Jack Mono-switched	1658	£0.15
CS8	Jack Stereo-switched	1659	£0.18
CS9	Phono single	1660	£0.08
CS10	Phono couple	1661	£0.10
CS11	Coax surface	1662	£0.21
CS12	Coax plug	1663	£0.25
CS13	Jack switched Mono	1664	£0.20
CS14	Jack socket DPDT switch	1665	£0.32
CS15	Car aerial	1666	£0.10
CS16	AC mains US type	1667	£0.16
CS17	Phono 4 way	1668	£0.16
CS18	D.C. power	1669	£0.18
CS19	AC switched	1670	£0.32
CS20	Phono 8 way	1671	£0.32

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5 I.C.s 75110 Ekv to MC1310P-MA767 Data supplied with pak  
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74F 50 Flip Flops assorted  
7470 72 73 74 76-104-109 Etc  
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74M 30 MSI Assorted Types 7441-47-90-154 Etc  
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## VEROBOARD PAKS

V81 Approx 30 sq ins various sizes all 1 matrix  
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High quality modules for stereo, mono and other audio equipment.

**NEW**



**PUSH-BUTTON STEREO FM TUNER**

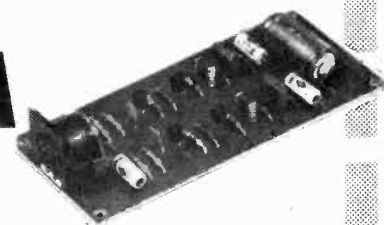
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Fitted with Phase Lock-loop Decoder

- ★ FET Input Stage
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- ★ Multi turn pre-sets
- ★ LED Stereo Indicator

The 450 Tuner provides instant program selection at the touch of a button ensuring accurate tuning of 4 pre-selected stations, any of which may be altered as often as you choose, by simply changing the settings of the pre-set controls. Used with your existing audio equipment or with the BI-KITS STEREO 30 or the MK60 Kit etc. Alternatively the PS12 can be used if no suitable supply is available, together with the Transformer T538. The S450 is supplied fully built, tested and aligned. The unit is easily installed using the simple instructions supplied.

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



**MPA 30**

Enjoy the quality of a magnetic cartridge with your existing ceramic equipment using the new M.P.A. 30, a high quality pre-amplifier enabling magnetic cartridges to be used where facilities exist for the use of ceramic cartridges only. It is provided with a standard DIN input socket for ease of connection. Full instructions supplied.

**£2.85**

**STEREO PRE-AMPLIFIER**



**PA 100**

**OUR PRICE £13.75**

Frequency Response + 1dB 20Hz 20KHz. Sensitivity of inputs  
1 Tape Input 100mV into 100K ohms  
2 Radio Tuner 100mV into 100K ohms  
3 Magnetic P.U. 3mV into 50K ohms  
P.U. Input equalises to R1AA curve with 1dB from 20Hz to 20KHz  
Supply — 20-35V at 20mA

Dimensions 299mm x 89mm x 35mm.

**AL-20-30 AUDIO AMPLIFIER MODULES**

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

**SPÉCIFICATION:**

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

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

**VAT ADD 12 1/2%**

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

**STEREO 30 COMPLETE AUDIO**



**7 + 7 WATTS R.M.S.**

**£16.25**

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

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

**AL 60 25 Watts (RMS)**



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

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

**£4.35**

**NEW PA12**

NEW PA12 Stereo Pre-Amplifier completely redesigned for use with AL 20/30 Amplifier Modules. Features include on/off volume, Balance, Bass and Treble controls. Complete with tape output.

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

**£6.70**

**Stabilised Power Supply Type SPM80**

SPM80 is especially designed to power 2 of the AL60 Amplifiers, up to 15 watts (R.M.S.) per channel simultaneously. With the addition of the Mains Transformer BMT80, the unit will provide outputs of up to 1.5A at 35V. Size: 63mm. 105mm. 30mm. Incorporating short circuit protection.

**Transformer BMT80 £2.60 + 62p postage**

**£3.75**

**PS12** Power supply for AL20/30, PA12, SA450 etc.

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

**OUR PRICE £1.30**

Transformer T538 £2.30

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TF987/1.**

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PUMP**

Twin Cylinder opposed with Integral 1/2 H.P.  
50HZ Single Phase Motor Tested & Checked.  
110 Volts models only **£15 ea.**  
1/2 H.P. Motor 110V **£10 ea.**

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RANGE PULSE GENERATOR**

+/- variable outputs up to 50V. Optional  
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TAPE  
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Complete with 3BI Time Base &  
3AI Dual Trace Amplifier  
**£375 each**

**THE HONEYWELL KEYSPE UNIT**

is a multi-channel Keyboard to Magnetic Tape System recording Keyboard entered data on 1/2" tape in 80 or 120 character records in a form easily usable as a computer input/output and verifier. 240 Volt operation.

From the simple to understand electro mechanical / vacuum system to the +15 -15 +5 Power Supply and hinged wire wrapped card frame. The flexibility and reliability are outstanding. This coupled with the ease of interfacing to a VDU, Mini/Micro computer, etc. make all the Honeywell Keytapes on offer very fine value.

Honeywell Keypate Unit, checked, tested with Manual **£215 ea.**

As above but less data boards. Tested forward / backward tape movement and control, etc. Data entry / exit via read / write boards. **£105 ea.**

Exactly as above but less keyboard and table **£80 ea.**

All units carriage paid.

KEYBOARDS also available at **£20 each**. Carr. **£2.50**

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Complete with 3BI Time Base &  
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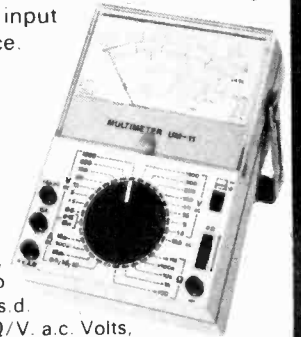
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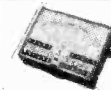
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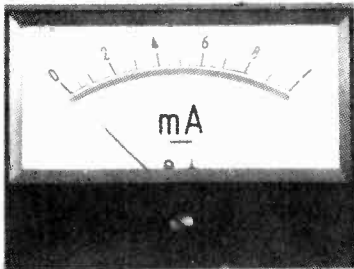
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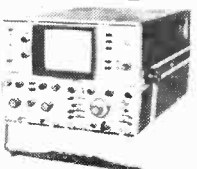
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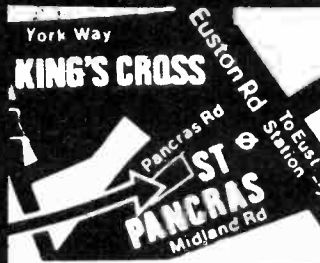
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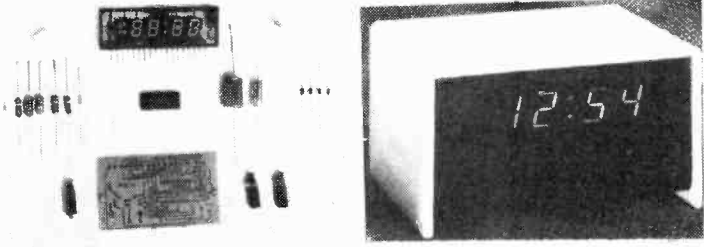
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AC153K 37	BC126 20	BC179C 19	BC213K 12	BC308K 15	BCY83 14	BF274 34	BU219 2.45	TIP34C 129
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AF118 70	BC147A 11	BC182J 18	BC213Y 12	BC308Y 15	BCY97 14	BF274 34	BU233 2.45	TIP37E 60
AF124 30	BC147B 11	BC182K 18	BC213Z 12	BC308Z 15	BCY98 14	BF274 34	BU234 2.45	TIP37F 60
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AF126 28	BC148A 09	BC182M 18	BC213AB 12	BC308AB 15	BCY100 14	BF274 34	BU236 2.45	TIP37H 60
AF127 28	BC148B 09	BC182N 18	BC213AC 12	BC308AC 15	BCY101 14	BF274 34	BU237 2.45	TIP37I 60
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AF179 120	BC149B 12	BC182Q 18	BC213AF 12	BC308AF 15	BCY104 14	BF274 34	BU240 2.45	TIP37L 60
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1A3	0.60	68E6	0.40	6L18	0.80	12AV6	0.60	30PL15	1.00	CL33	1.75	EC54	1.00	EM8003	3.20	PCC85	0.75	PY500A	1.20	U25	0.71	Z719	0.29	AF115	0.30	FSY41A	0.26	OC45	0.13		
1A5GT	0.55	68G6G	1.00	6L19	2.00	12AX7	0.34	35A3	0.75	CV6	0.60	EC86	0.84	EY1	0.50	PCC80	0.40	U26	0.60	Z729	0.45	AF117	0.23	GD4	0.38	OC46	0.18	OC65	0.13		
1A7GT	0.80	68H6	0.70	6LD12	0.40	12AY7	1.00	35C5	0.80	CV63	1.00	EC88	0.84	EY81	0.45	PCF80	0.40	U31	0.50	Z749	0.65	AF121	0.35	GD5	0.32	OC65	1.31	OC70	0.14		
1B3GT	0.55	68J6	0.85	6LD20	0.80	12BA6	0.50	35D5	0.90	CV988	0.25	EC92	0.55	EY83	0.60	PCF82	0.45	U33	1.75	Z759	5.85	AF124	0.36	GD6	0.32	OC70	0.14	OC71	0.13		
1C2	1.00	68K7A	0.65	6N7GT	0.70	12BE6	0.55	35L6GT	0.80	CY1C	1.00	EC32	1.00	EY84	1.20	PCF84	0.70	U35	0.50	Z839	1.15	AF125	0.50	GD8	0.23	OC72	0.13	OC78D	0.18		
1D5	0.75	68Q5	0.54	6PL12	0.40	12B8A	0.55	35W4	0.55	CY31	0.70	EC33	2.00	EY86/7	0.37	PCF87	0.77	U36	0.50	Z844	0.21	AF128	0.38	GET113	0.23	OC79	0.13	OC81D	0.13		
1G6	1.00	68Q7A	0.60	6P15	0.34	12BY7	0.70	35Z3	0.80	D1	0.50	EC35	2.00	EY91	0.50	PCF200	1.20	U37	2.00	QV03/10	U37	2.00	Transistors	AF139	GD9	0.23	OC79	0.13	OC81D	0.13	
1H5GT	0.80	68R7	1.00	6Q7G	0.50	12E1	3.50	724GT	0.70	D63	0.30	EC40	0.90	EY95	0.50	PCF201	1.00	U38	1.00	U45	1.20	U46	1.20	AF139	GD9	0.23	OC79	0.13	OC81D	0.13	
1L4	0.25	68R8	1.25	6Q7GT	0.50	12J5GT	0.50	725GT	0.80	DAC32	0.80	EC41	0.34	EZ31	0.50	PCF800	0.77	U39	1.00	U45	1.20	U46	1.20	AF139	GD9	0.23	OC79	0.13	OC81D	0.13	
1LD5	0.70	68S7	1.70	6Q7M	0.70	12K7G	0.70	72	1.50	DAF91	0.35	EC82	0.34	EZ40	0.52	PCF800	0.77	U40	1.00	U45	1.20	U46	1.20	AF139	GD9	0.23	OC79	0.13	OC81D	0.13	
1LN5	0.70	68W6	1.70	6R7G	0.70	12K7G	0.70	72	1.50	DAF96	0.60	EC83	0.34	EZ41	0.52	PCF800	0.77	U41	1.00	U45	1.20	U46	1.20	AF139	GD9	0.23	OC79	0.13	OC81D	0.13	
1N5GT	0.70	68W7	0.65	6R7(M)	1.00	12K7GT	0.50	50C5	0.70	DC90	0.70	EC84	0.35	EZ40	0.32	PCF802	0.54	U42	1.00	U45	1.20	U46	1.20	AF139	GD9	0.23	OC79	0.13	OC81D	0.13	
1R4	0.50	68X6	0.29	6SA7	0.55	12K8	0.75	50CDBG	1.20	DA	0.80	EC85	0.30	EZ31	0.40	PCF806	0.53	U43	1.00	U45	1.20	U46	1.20	AF139	GD9	0.23	OC79	0.13	OC81D	0.13	
1S5	0.40	68Y7	0.38	6SC7GT	0.75	12Q7GT	0.50	50EH5	0.85	DF33	0.75	EC88	1.25	EZ90	0.45	PCH200	1.00	U44	1.00	U45	1.20	U46	1.20	AF139	GD9	0.23	OC79	0.13	OC81D	0.13	
1S5	0.35	68Z6	0.60	6S7G	0.50	12SA4GT	0.75	50L6GT	1.00	DF91	0.30	EC88	0.51	FC4	1.00	PCL82	0.40	U45	1.20	U46	1.20	U47	1.20	AF139	GD9	0.23	OC79	0.13	OC81D	0.13	
1T4	0.30	6C4	0.40	65H7	0.55	12S4GT	0.75	66K6U	0.52	DF96	0.60	EC91	0.35	FW4/500	1.00	PCL83	0.40	U46	1.20	U47	1.20	U48	1.20	AF139	GD9	0.23	OC79	0.13	OC81D	0.13	
1U4	0.70	6C5G	0.60	6S7G	0.60	12S7G	0.55	72	0.70	DH63	0.50	EC189	0.80	FW4/500	1.00	PCL84	0.46	U47	1.20	U48	1.20	U49	1.20	AF139	GD9	0.23	OC79	0.13	OC81D	0.13	
1U5	0.35	6C6	0.45	6SK7GT	0.55	12SH7	0.50	77	0.45	DH76	0.50	EC80A	0.79	G230	0.40	PCF806	0.53	U48	1.20	U49	1.20	U50	1.20	AF139	GD9	0.23	OC79	0.13	OC81D	0.13	
2D21	0.55	6C9	2.80	6SQT	0.60	12SK8	0.75	85A2	0.75	DH81	0.80	ECF80	0.50	EZ32	0.40	PCL805/85	0.80	U49	1.20	U50	1.20	U51	1.20	AF139	GD9	0.23	OC79	0.13	OC81D	0.13	
2K5	0.70	6C10	0.71	6U4GT	0.80	12SK7	0.60	85A3	0.75	DH81	0.80	ECF80	0.50	EZ32	0.40	PCL805/85	0.80	U50	1.20	U51	1.20	U52	1.20	AF139	GD9	0.23	OC79	0.13	OC81D	0.13	
2X2	0.70	6C8A	0.50	6L7E	0.55	12SN7GT	0.75	90CV2	2.80	DK40	0.70	ECF86	0.80	G234	0.75	PEN4DD	0.60	U51	1.20	U52	1.20	U53	1.20	AF139	GD9	0.23	OC79	0.13	OC81D	0.13	
3A4	0.55	6C12	0.4	6D8	0.50	12SQ7	0.80	108C1	0.40	DK40	0.70	ECF86	0.80	G234	0.75	PEN4DD	0.60	U52	1.20	U53	1.20	U54	1.20	AF139	GD9	0.23	OC79	0.13	OC81D	0.13	
3B7	0.55	6CD8G	1.10	6V8G	0.30	12T07GT	0.80	108B2	1.00	DK91	0.50	EC81	2.00	G232	1.00	PEN4DD	0.60	U53	1.20	U54	1.20	U55	1.20	AF139	GD9	0.23	OC79	0.13	OC81D	0.13	
3D6	0.40	6CG8A	0.50	6V8GT	0.80	12SR7	0.75	150C2	0.85	DK92	1.00	EC85	1.00	HABC80	0.80	PEN25	1.00	U54	1.20	U55	1.20	U56	1.20	AF139	GD9	0.23	OC79	0.13	OC81D	0.13	
3Q4	0.70	6C6	0.75	6K4	0.40	12SR7	0.75	215G2	0.60	DK96	0.70	EC84	0.71	HL13C	0.60	PEN4DD	0.60	U55	1.20	U56	1.20	U57	1.20	AF139	GD9	0.23	OC79	0.13	OC81D	0.13	
3Q5GT	0.80	6CL8A	0.55	6K5GT	0.45	14S7	1.00	302	1.20	DL63	0.70	EC81	0.40	HL23	0.70	PEN4DD	0.60	U56	1.20	U57	1.20	U58	1.20	AF139	GD9	0.23	OC79	0.13	OC81D	0.13	
3V4	0.45	6CM7	1.00	6Y6G	0.95	18	1.25	303	1.20	DL82	0.80	EC83	0.50	HL23D	0.68	PEN4DD	0.60	U57	1.20	U58	1.20	U59	1.20	AF139	GD9	0.23	OC79	0.13	OC81D	0.13	
3V4	0.80	6C56	0.45	6Y7G	1.25	19A05	0.85	305	1.20	DL92	0.45	EC84	0.50	HL41	1.00	PEN4DD	0.60	U58	1.20	U59	1.20	U60	1.20	AF139	GD9	0.23	OC79	0.13	OC81D	0.13	
4CB6	0.75	6C55	0.90	7A7	1.00	19B6G6	1.00	807	1.10	DL94	0.80	EC80	0.45	HL41DD	1.00	PEN4DD	0.60	U59	1.20	U60	1.20	U61	1.20	AF139	GD9	0.23	OC79	0.13	OC81D	0.13	
5C6G	0.75	6D3	0.75	7B6	0.80	19G6	6.50	956	0.50	DL96	0.60	EC82	0.50	HL42DD	1.00	PEN4DD	0.60	U60	1.20	U61	1.20	U62	1.20	AF139	GD9	0.23	OC79	0.13	OC81D	0.13	
5R4GY	1.00	6E27	0.80	7B7	0.80	19H1	1.00	1625	2.50	DM70	0.80	ECL82	0.74	HN309	1.70	PEN4DD	0.60	U61	1.20	U62	1.20	U63	1.20	AF139	GD9	0.23	OC79	0.13	OC81D	0.13	
5T4	1.00	6D15A	0.85	7D6	2.00	19Y3	0.40	1821	1.00	DM71	1.00	ECL84	0.65	HL23	0.70	PEN4DD	0.60	U62	1.20	U63	1.20	U64	1.20	AF139	GD9	0.23	OC79	0.13	OC81D	0.13	
5A4G	0.60	6EW6	0.85	7F8	2.00	20D1	0.70	5702	1.20	DW4/350	1.15	ECL85	0.70	HYR2A	1.00	PFL200	0.70	U63	1.20	U64	1.20	U65	1.20	AF139	GD9	0.23	OC79	0.13	OC81D	0.13	
5V4G	0.60	6E5	1.00	7H7	0.80	20D4	2.50	5763	1.65	DY87	0.65	EC86	0.64	KT2	0.90	PL33	1.00	U64	1.20	U65	1.20	U66	1.20	AF139	GD9	0.23	OC79	0.13	OC81D	0.13	
5Y3GT	0.55	6F1	0.80	7R7	2.00	20F2	0.85	6057	1.00	DY802	0.45	EF22	1.00	KT8	3.00	PL36	0.60	U65	1.20	U66	1.20	U67	1.20	AF139	GD9	0.23	OC79	0.13	OC81D	0.13	
5Z3	1.00	6F6G	0.60	7V7	2.00	20L1	1.20	6060	1.00	E80CC	2.50	EF40	0.78	KT41	1.00	PL81	0.49	U66	1.20	U67	1.20	U68	1.20	AF139	GD9	0.23	OC79	0.13	OC81D	0.13	
5Z4G	0.48	6F12	0.50	7Y4	0.50	20P1	1.00	6067	1.00	E80CF	5.00	EF41	0.75	KT44	1.00	PL81A	0.53	U67	1.20	U68	1.20	U69	1.20	AF139	GD9	0.23	OC79	0.13	OC81D	0.13	
5Z4GT	0.55	6F13	0.80	7Z4	0.80	20P3	1.00	6068	3.50	E80F	2.20	EF42	0.90	KT63	0.80	PL82	0.50	U68	1.20	U69	1.20	U70	1.20	AF139	GD9	0.23	OC79	0.13	OC81D	0.13	
6/30L2	0.70	6F14	0.80	8D2	0.50	20P7	0.84	6068	2.90	E83F	1.60	EF73	1.75	KT66	3.00	PL83	0.45	U69	1.20	U70	1.20	U71	1.20	AF139	GD9	0.23	OC79	0.13	OC81D	0.13	
6A8L2	1.40	6F15	0.85	8D8	0.45	20P5	1.50	7025	1.50	E88CC	1.20	EF80	0.20	KT71	1.00	PL84	0.50	U70	1.20	U71	1.20	U72	1.20	AF139	GD9	0.23	OC79	0.13	OC81D	0.13	
6AC7	0.55	6F16	0.75	9B76	0.90	25A6G	0.70	7193	0.80	E92CC	0.70	EF83	1.25	KT81	2.00	PL302	0.90	U71	1.20	U72	1.20	U73	1.20	AF139	GD9	0.23	OC79	0.13	OC81D	0.13	
6AG5	0.35	6F18	0.60	9D7	0.70	25L6G	0.70	7475	1.20	E18																					

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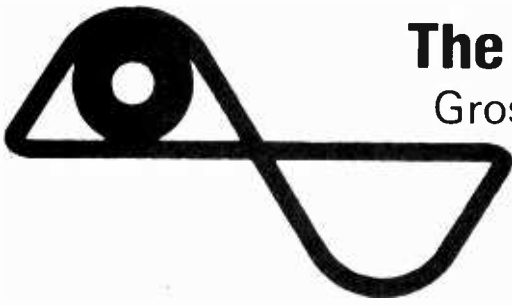
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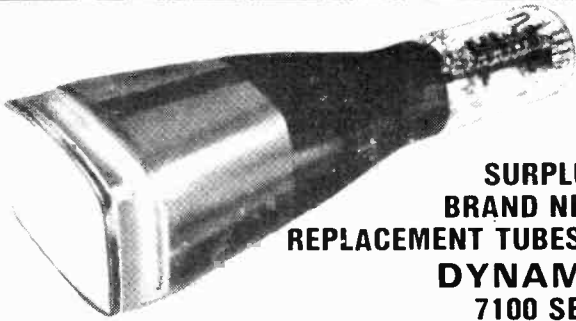
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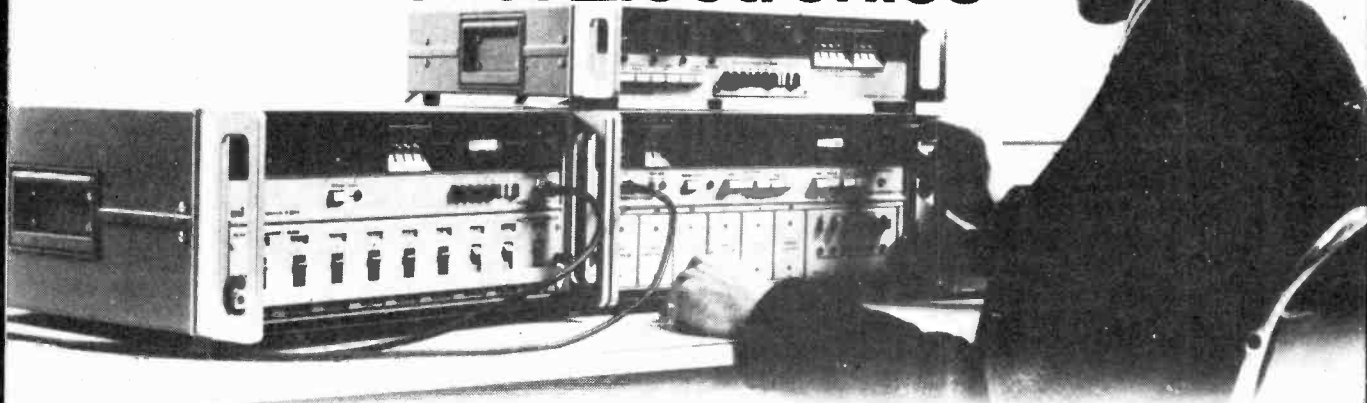
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Advertisements accepted up to 12 noon Monday, April 4, for the May issue, subject to space being available.

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Candidates should be conversant with ½", ¾" and 1" black and white and colour equipment and be capable of electronic maintenance. Experience in professional broadcasting would be an advantage, as well as an interest in experimental video work. The successful applicant will be expected to assist in running studio productions, and video tape editing. Salary scale £3190-£4702 inclusive (ST1/2).

Application forms, returnable within 14 days, obtainable from the Senior Administrative Officer at the college.

(7050)

## ITN

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(7088)

Re-advertisement

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School of Physical and  
Molecular Sciences

## ELECTRONICS TECHNICIAN GRADE 5

Applications are invited for the post of Electronics Technician Grade 5 in the above mentioned School.

The successful applicant would be concerned with the development, construction and maintenance of specialised electronic equipment for a wide range of research work and teaching in the School.

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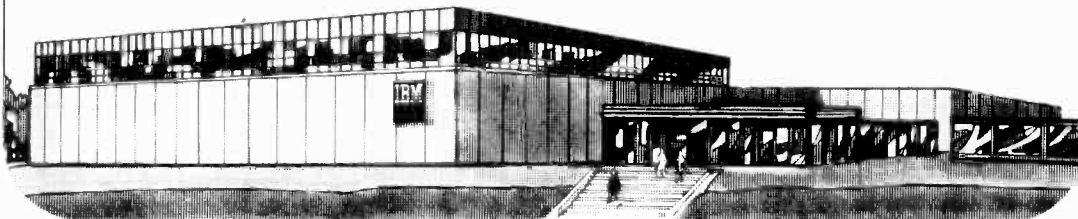
Here at Havant where we currently manufacture large systems we're looking for Technicians, male or female, with experience of sophisticated electronics, and the ability to diagnose and rectify malfunctions on a complex computer system.

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School of Materials Science and Physics

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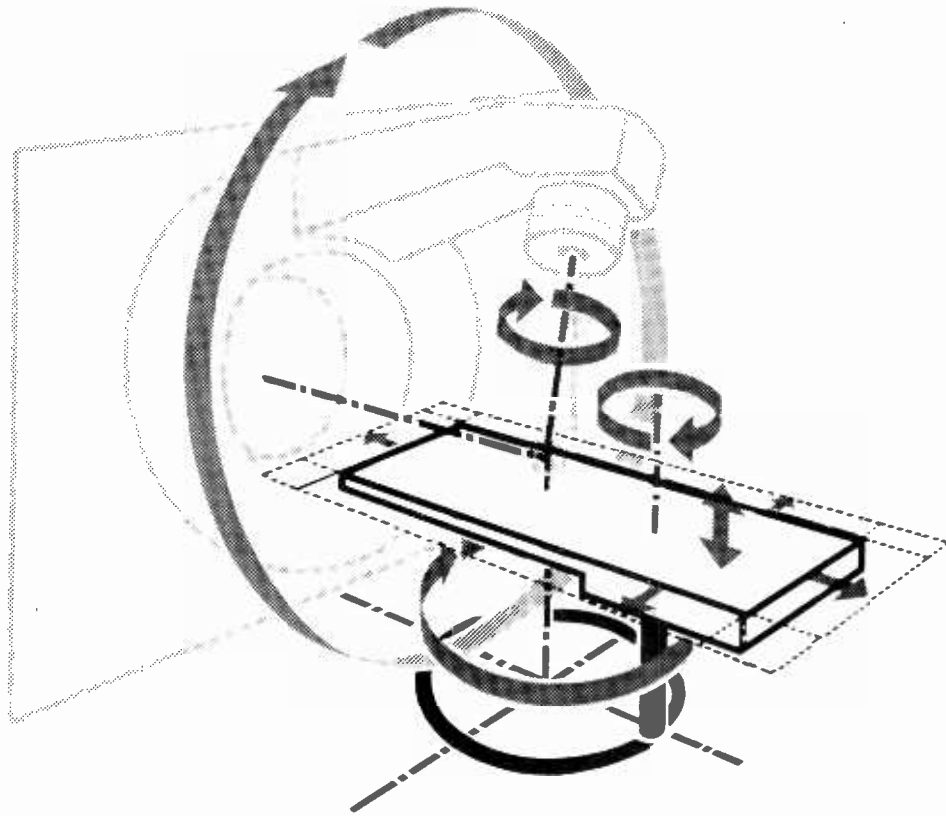
Accepting that good Development Engineers are in universal demand, we nevertheless believe that our vacancies here at Hastings, open to both men and women, offer attractions second to none. Such as . . .

- \* Technically challenging, professionally rewarding, personally satisfying work on: Advanced colour television and audio-product design, incorporating the latest concepts in digital and integrated circuitry, microprocessors, and L.S.I. Then there's the development of Teletext, Viewdata — the list is almost endless.
- \* Opportunity to become involved with a successful company, which intends to accelerate its growth and build on its already high reputation for quality and innovation.
- \* The probability of overseas travel. The certainty of a good salary, generous holidays, "big company" fringe benefits, Pension and Life Assurance schemes, subsidised sporting and social facilities.
- \* Assistance, where appropriate, in moving to this pleasant, socially attractive, healthy coastal area, where housing is available and more reasonably priced, yet the amenities of the "big city" are within easy reach.

Sounds good? Then, if you have a degree or HNC, plus experience in a relevant speciality, write giving brief personal and career details (or phone for Application Form) to: —George Greaves, Personnel Officer, ITT Consumer Products (UK) Ltd., Theaklen Drive, Hastings, E. Sussex. Tel: Hastings (0424) 437061.

7080

TV • Radio • Stereo **ITT**



## INDEPENDENCE & WORLD TRAVEL IN A CHALLENGING FIELD FOR EXPERIENCED **Service & Installation Engineers**

The MEL Equipment Company Limited, the professional electronic division of the International Philips Group produce the advanced linear accelerators used in many of the major hospitals throughout the world for the treatment of cancer.

The equipment is highly sophisticated and offers those involved with installation and field support the opportunity to develop skills in this innovative area.



At present we are looking for self reliant, adaptable engineers who would appreciate the challenge and rewards of working on advanced medical equipment. Spending periods of up to 4 months duration overseas they would work in important medical centres installing and servicing the equipment.

Applicants will need professional qualifications of at least HNC level and a good knowledge of semi-conductor circuitry and ideally have experience of equipment such as high power radar systems. They will also need personal qualities which will enable them to deal with various senior members of organisations and act as "ambassadors" for our company.

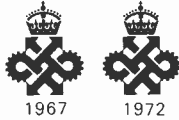
We offer excellent progressive salaries with full expenses and allowances, an annual bonus, Pension and Life Assurance schemes and at least 4 weeks and 3 days annual holiday entitlement. Where candidates do not live in the Crawley area relocation will be necessary. Assistance will be given, including nomination for rented

accommodation from Crawley New Town Commission. Crawley is an established New Town situated on the Surrey/Sussex borders offering excellent educational and recreational facilities, including a local sports centre and swimming pool.



If you would like to take this opportunity to work on vital, highly sophisticated equipment please write or telephone for an application form to Barbara Newman, Personnel Officer, M.E.L. Equipment Company Limited, Manor Royal, Crawley, Sussex. Tel: 0293 28787.





## OXFORD INSTRUMENTS DEVELOPMENT ENGINEER

Applicants should be practical, innovatory electronics engineers with experience in r.f., and precision analogue circuit design. A knowledge of digital techniques, would be useful, but is not a prime requirement.

The successful applicant will be a key member of a small new group with multidisciplinary interests. He or she will primarily supply the electronics expertise required for the development of sophisticated new instruments, but will also be expected to become involved in other aspects of innovation. The ability to work with minimal supervision and to be self-motivated is essential.

Salary negotiable according to age and experience.

Contact Dr. Peter Hanley, telephone Oxford 41456 or write to The Oxford Instrument Co., Osney Mead, Oxford OX2 0DX, to arrange an interview.

(7064)

**CABLESYSTEMS  
CANADIAN LIMITED**

## SYSTEMS ENGINEER

**CANADA**

We have an opening in our London, Ontario, Engineering Office, for a shirt sleeves professional engineer who has a strong background in Video Engineering. A working knowledge of R.F. Transmission, preferred in C.A.T.V. would be an asset. You would be a highly results orientated individual who will enjoy the challenge of making your place in a small team of engineers. Canadian Cablesystems is a company with ten C.A.T.V. Systems in Ontario with over 400,000 Subscribers. Salary will be in the range of \$20,000 per annum. If you wish to pursue this position within our organisation please send your résumé in confidence to

**G. F. Stone**

9 Great Lawn, Ongar, Essex

Interviews will be held in London, England.

(7113)

## Electronic Research & Design

W. London To £4,600

Our client is the Development Division of a major and highly successful international company. To ensure continued leadership in the field of Special Application Control Systems, 5 additional engineers are needed to strengthen small teams developing new and advanced products.

Applicants (male or female), aged 21+, should have a Degree or HNC and experience of Analogue/Digital Circuit Design. A knowledge of Micro-processors, Hydraulic Systems or Scientific Programming would be an advantage.

The posts carry a good basic salary and other "big company" benefits. In addition, there are excellent opportunities for promotion on merit within an expanding organisation.

For further information, please contact Mike Gernat.



**Technomark**  
Engineering and Technical Recruitment

5-11 Westbourne Grove, London W2.  
Telephone 01-229 9239

7070

## ELECTRONIC DESIGN ENGINEERS

**DO YOU** want to earn a better than average salary?

**DO YOU** want to join a go-ahead company?

**DO YOU** have experience in the design of audio to UHF circuitry or Assembly level programming of mini or micro processors?

**DO YOU** like working with the minimum of supervision?

**YOU DO?** Then apply to:



**The Technical Director  
Burndept Electronics (ER) Ltd  
St. Fidelis Road  
Erith, Kent  
Erith 39121**

(7062)



**LONDON BOROUGH  
OF  
LEWISHAM**

**TOWN CLERK & CHIEF EXECUTIVES  
DEPARTMENT**

## Administrative Officer (Telecommunications)

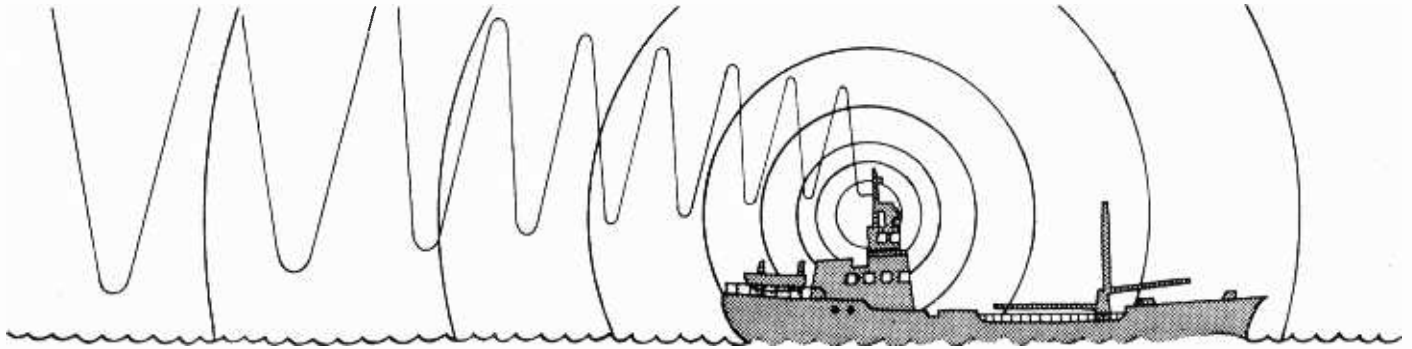
**£4836-£5142**

To provide and maintain an effective integrated telecommunications service for all Council establishments and to ensure that the service fully meets the Council's current and anticipated requirements.

Applicants must have a wide knowledge of Post Office and commercial communication installations.

**Application form, returnable by 1st April, and detailed job description from Chief Personnel Officer, Town Hall, Catford, London SE6 4RU, or telephone 01-690 7666 (24-hour Ansafone service) quoting reference CE 78 and job title.**

(7052)



## Radio Officers—now you can enjoy the comforts of home.

Working for the Post Office Maritime Services really makes sense. You still do the work that interests you, but with all the advantages of a shore-based job: more time to enjoy home life, job security and good money. To qualify, you need a United Kingdom Maritime Radiocommunication Operator's General Certificate or First Class Certificate of competence in Radiotelegraphy, or an equivalent certificate issued by a Commonwealth Administration or the Irish Republic.

Starting salaries, at 25 or over, are £2905 rising to £3704 after three years service. Between 19 and 24, the starting salary varies from £2234 to £2627 according to age. In addition, a supplement of £312

p.a. is payable. You'll also receive an allowance for shift duties which at the maximum of the scale averages £900 a year and there are opportunities to earn overtime. There's a good pension scheme, sick pay benefits and prospects of promotion to senior management.

Right now we have a few vacancies at some of our coastal radio stations, so if you're 19 or over, preferably with sea-going experience, write to: ETE Maritime Radio Services Division (L690), ET 17.1.1.2., Room 643, Union House, St. Martins-le-Grand, London EC1A 1AR.

Post Office Telecommunications

### SOUTH COAST

Several of our clients require the following personnel urgently, offering excellent salaries and relocation expenses where necessary.

**PROJECT ENGINEERS  
ELECTRONIC ENGINEERS  
TEST ENGINEERS AND  
TECHNICIANS  
QUALITY ASSURANCE ENGINEERS  
TECHNICAL AUTHORS  
SYSTEMS PROGRAMMERS  
DRAUGHTSMEN/WOMEN. Electro-Mechanical and BUYERS**

Please write or ring - **CBS APPOINTMENTS**  
224 Old Christchurch Rd., Bournemouth, Bournemouth  
292155 or Wimborne 4891 after 7 p.m. (7084)

### PIPCO (S & W SERVICES)

For Electronic Engineers, Technicians & TV Service Engineers.

26a High Street  
Hounslow, Middx.  
Tel: 01-572 7363  
Telex PIPCO Hounslow 935413  
(6552)

### CA CAPITAL APPOINTMENTS LTD.

**FREE JOBS LIST**  
for  
**FIELD SERVICE ENGINEERS**  
BASIC SALARIES TO  
£5,000 + CAR (7083)

34 Percy Street, London, W.1  
01-636 9659 (day) or  
550 0836 (evening)

**ELECTRONICS ENGINEER** wanted. With experience in modern amplification and electronic keyboards. Hiring Department, Maurice Patquet. Tel. 01-749 3232. (7107)

## Applications and Production Engineers

Dolby Laboratories manufacture and market professional audio noise reduction equipment which is widely used by major recording companies, recording studios and broadcasting authorities throughout the world. Established in London, the Company has enjoyed successful growth since incorporation in 1968.

### Applications Engineer c.£5,000

Reporting to and working closely with the International Marketing Manager the person appointed will be involved in all aspects of sales, eg providing technical information to distributors and customers, giving demonstrations and training courses, and visiting recording studios and broadcasting organisations in the UK and abroad.

The successful applicant will be an electronics engineer who enjoys dealing with people and problems. Aged between 25 and 35 he, or she, will probably have a degree and may well have experience of recording studio or broadcasting practice. European languages would be a distinct advantage.

### Production Engineer c.£4,000

The person appointed will join a small team which provides the technical support to the production department. Working under the Production Technical Manager this section is responsible for establishing assembly and testing procedures, quality control and interfacing with sales and design engineers on product improvements and new product introductions.

The successful applicant will be an electro-mechanical engineer who enjoys using his specialist knowledge to resolve day-to-day problems as much as the more theoretical aspect of the job. He, or she, will probably have a degree and experience in electronic equipment manufacturing.

Write or telephone:

Gary Holt, General Manager  
Dolby Laboratories Inc  
346 Clapham Road, London SW9  
Telephone 01-720 1111 (7094)

  
Dolby Laboratories

### THE OPEN UNIVERSITY Faculty of Technology ELECTRONIC TECHNICIAN



An Electronic Technician (Calibration) is required to join the general electronic facilities of the Open University.

Main duties of the post are to provide a 95% in-house calibration and maintenance service for all measuring equipment using mainly electronic techniques

To assist all O U staff (academic, research, technicians and maintenance) with electronic problems and the use of their equipment

To set up and maintain the necessary record system to operate such a service.

**Experience:** Ten years in electronics, five years of which should be relevant to the above duties

**Qualifications:** HNC or C and G in an appropriate subject

**Salary:** Technician Grade 5 £2889-£3367 per annum

**Holidays:** 20 working days, plus 6 university closed days plus 7 national days. The post is within the New City of Milton Keynes

There is a university office to assist with housing. The applicant may be eligible for development housing and part removal expenses from the Open University

Application forms and further particulars are available, by postcard request please, from the Personnel Manager (ET2) The Open University, P O Box 75, Walton Hall, Milton Keynes, MK7 6AL Telephone Milton Keynes 63868

Closing date for applications 31st March 1977

(7065)

### TRAINEE ELECTRONICS EXPORT SALESMAN

Good basic knowledge and German Language required by active Company. Interesting position with variety

**EMPEXION LTD.**

233/243 Wimbledon Park Road

S.W.18

Tel: Abott 01-874 4362

7111



## Transmitter Engineering

# SENIOR DEVELOPMENT ENGINEER

# DEVELOPMENT ENGINEER

Pye TVT Limited are among the world's leaders in the field of professional broadcast equipment. Expanding activities in our transmitter engineering department now create the need for more personnel to join a team working on the design and development of TV and broadcast transmitters. The more senior position involves greater responsibility and some supervision activities. The successful candidates are likely to have a degree or equivalent, but more importantly should have had several years of development experience on transmitting equipment – broadcast or radar. Relocation expenses to this pleasant part of East Anglia will be given in approved cases. Other benefits



include a pleasant working environment, a good salary (with recently implemented supplement), restaurant and cafeteria service, staff shop and an active sports and social club. Please telephone or write to: Mr. D. Barnicoat, Personnel Officer, Pye TVT Limited, P.O. Box 41, Coldhams Lane, Cambridge CB1 3JU. Tel: Cambridge 45115. 7074



**Pye TVT Limited**  
The Broadcast Company of Philips

A member of the Pye of Cambridge Group

### SALOP AREA HEALTH AUTHORITY

Electronic and Bio-medical Engineering Department

## TECHNICIAN IV

required for the Area Works Department based initially at Copthorne Hospital South

Qualifications: O N C / H N C Electronics

Responsible to: Area Engineer

Salary scale: £2 346-£3 267 p.a. + £312 p.a. supplement

A technician is required for the above department to be responsible for the maintenance of medical (mechanical) and electronic apparatus used in the Area

The Technician will join a team who carry out a continuous servicing and overhauling programme to ensure that the equipment in their charge will run at the peak of its available efficiency at all times

Application form and job description to be obtained from the Area Engineer, Shrewsbury Hospital, Copthorne South, Mytton Oak Road, Shrewsbury, Salop. Tel Shrewsbury 52244 Ext 3273. Completed application forms to be returned by 14 days after insertion date.

711

# X-Ray Service Engineer

(\*4190 Saudi Riyals per month)

for the  
**King Faisal Specialist Hospital and Research Centre,  
Riyadh, Saudi Arabia.**

If you are an experienced Service Engineer, fully conversant with the most modern therapeutic and diagnostic radiology equipment, here is a unique opportunity to make a break for two years and practise your skills in one of the most modern hospital and research complexes in the world.

We urgently need an experienced Service Engineer, who will be responsible to the Chief Bio-Medical Engineer, to service and maintain a range of predominantly Philips' radiology equipment.

Newly-built, air-conditioned accommodation is provided, together with wide facilities for sport and recreation.

Two year contracts will be offered to suitably qualified applicants. Passages and accommodation will be provided for up to three dependants and there are generous leave periods.

At this time no income tax is payable in Saudi Arabia.

\*Sterling exchange rate at the time of going to press 5:97 riyals to the £.

Please apply in writing or telephone:

**Peter Coles,**  
Director of Human Resource Management (UK)  
**HOSPITAL CORPORATION  
INTERNATIONAL LTD.,**  
33 Cavendish Square,  
London W1M 0AA.  
Tel: (01)-491 3211

7079



**CAPITAL APPTS.**

**FREE LISTS**  
101 Design/Development and Test Jobs  
Permanent and Contract  
**To £6,000** (7093)

36, Percy St. London, W.1.  
637 5557 day, 550 0836 eve.

**ELECTRONICS TECHNICIAN** (Grade 6) required by Physiology Dept. for the design and construction of biophysical instrumentation to be used in muscle research. Experience in analog, digital and computer interfacing circuitry desirable. This is a three-year grant supported post. Salary in range £3,802-£4,435 inc. of London Weighting. Application form from Personnel Officer (Technical Staff FF5) University College London Gower Street London WC1E 6BT (7106)

### COURSES

**RADIO and Radar M.P.T. and C.G.L.I. Courses.** Write: Principal, Nautical College, Fleetwood, FY7 5JZ. (25)

### BOOKS

**"VINTAGE CRYSTAL SETS, 1922-1927"**. Just published by Wireless World, contains 128 pages. Chapters on the first days of broadcasting. The Crystal Set Vintage Wireless Trademarks. Also catalogue sections listing and describing crystal sets together with their original prices in £:s:d. A book for the collector or those interested in nostalgia. Available from main bookshops or direct from us. Please send £2.50 inclusive to IPC Business Press Ltd., Room 11 Dorset House, Stamford Street, London, SE1 9LU. (6125)

**LINK****BROADCAST TELEVISION**

We have several vacancies for top electronic engineers to be involved in various aspects of our organisation, which covers the design and manufacture of a full range of studio television equipment, including colour cameras and complete studio/O. B. systems. We are a young successful company supplying sophisticated equipment world wide to major broadcasting organisations.

All positions require engineers with at least two or three years' experience in an industrial/broadcasting environment and offer the chance to make your individual ability felt within an expanding company.

**Systems Engineer**

To be involved in all stages of project management on the design and the building of studio and mobile TV systems. Occasional world wide travel. The appointment requires someone with a knowledge of the operational side of television engineering and the ability to take charge of people and deal with problems in the field.

**Development Engineer**

For this position we need someone with a thorough knowledge of the latest circuit techniques plus the ability to put theory into practice in the design of sophisticated professional electronic equipment. You should be of HND/Degree level although relevant experience could outweigh formal qualifications.

**Test Engineers**

This position again requires somebody with a good knowledge of current analogue and digital circuit techniques plus recent experience with broadcast television or similar equipment sufficient to enable you to integrate quickly into the team engaged in the testing of colour and monochrome cameras.

Experience solely of domestic television is insufficient and we regret that at the moment we are unable to consider further applications from newly qualified engineers.

We can offer satisfying work in a congenial environment. Our modern factory is in a pleasant part of rural Hampshire with easy access to London and major towns. There is a good choice of housing and special arrangements exist for those moving from the G. L. C. area.

Salary offered depends on age and experience but will be above average for the right people. Fringe benefits include a pension scheme, free life and health insurance, generous holidays, staff restaurant and assistance with relocation.

Please phone for an application form or write with sufficient detail of your qualifications and experience to make this unnecessary.

Contact: **Mic Comber — Personnel Manager — Andover (0264) 61345**

**LINK**  
ELECTRONICS

Walworth Industrial Estate,  
Andover, Hampshire, England Telephone: Andover (0264) 61345

(7078)

**There's only  
one person  
who can get  
you a good  
job...  
...and that's  
you.**

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**All you have to do is to complete our special — highly confidential — application form.**

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**And they'll approach you direct.**

**We guarantee to safeguard all your correspondence and never to get in touch with any company you specify — from among our list of clients.**

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**Phone us today for an application form or, clip the coupon for our comprehensive and confidential information pack.**

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WW15/3

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(7099)

## Interested in computers?

### Lecture on Computer Servicing

## International Computers

think computers—think ICL

(7001)



We are looking for Lecturers to teach the practicalities of computer servicing

You will be based at our Engineering Training Centre in Letchworth, Herts – the largest of its kind in Europe. Here you will be given a comprehensive grounding in computer technology in general and ICL equipment in particular.

You will be thoroughly prepared to train engineers to the point where they will be capable of maintaining computers at the optimum operational specification.

Ideally, you will have an HNC or Forces' training in a technical subject. Any experience of digital electronics, computers or instructing on these subjects, while not essential, will be useful. Fluency in written and spoken French or German would be a distinct advantage but is not essential.

We'll start you as an Assistant Lecturer on a salary of not less than £3800 a year. You'll be encouraged and expected to progress to the position of Senior Lecturer which carries a salary in excess of £5000.

Relocation expenses will be considered where appropriate

For an application form, phone David Reeves on 01-788 7272 extension 4150, or write to him at ICL, 85/91 Upper Richmond Road, Putney, London SW15 2TE. Please quote reference WW 1134

#### UNIVERSITY OF SURREY

#### DEPARTMENT OF ELECTRONIC AND ELECTRICAL ENGINEERING AN ELECTRONICS ENGINEER/TECHNICIAN

is required to join the Industrial Electronics Group working on a wide range of advanced electronic design and construction projects. The post entails working with the minimum of supervision on the construction and testing of high quality prototypes and presents an opportunity for career development in instrumentation, computers and communications.

A second post exists in the Department's Electronics Workshop where an ELECTRONICS ENGINEER is required to join a team designing, building and servicing a wide range of specialised electronic equipment. The successful candidate will be expected to work with a minimum of supervision and be capable of taking projects from outline design to final product

The successful candidates will be appointed in one of the Technician Grades 2 to 5, depending on qualifications and experience. For the higher grades a minimum of 3 years' relevant experience and qualifications equivalent to ONC are expected. Opportunities are provided for further study leading to higher professional qualifications. There are promotion prospects to higher grades.

Salaries Technician Grade

2A	£2152 — £2452	4	£2689 — £3087
3	£2455 — £2788	5	£2889 — £3367
		6	£3314 — £3950

Application forms may be obtained from the Staff Officer, University of Surrey, Guildford, Surrey GU2 5XH, or Tel. Guildford 71281, Ext. 452, and should be returned as soon as possible.

(7056)

## SERVICE ENGINEER

L.K.B. Instruments require an additional engineer to service their range of clinical and nuclear products installed in customers' premises throughout the West Country and South Wales. The applicant should live or be prepared to move to this area.

Experience with nuclear counting equipment would be an advantage but a good general knowledge of digital electronics and a mechanical aptitude is considered essential.

The company offers a salary commensurate with experience, bonus scheme, company car, and assisted B.U.P.A. membership.

Please contact for application form —

**The Service Manager**  
**L.K.B. Instruments Limited**  
**232 Addington Road**  
**South Croydon, Surrey**  
**Tel: 01-657 8822**

(7059)

#### UNIVERSITY OF MANCHESTER

Hester Adrian Research Centre  
Anson House Pre-School Project for  
Mentally Handicapped Children

#### A vacancy exists immediately for a TECHNICIAN

(Grade 3)

in the above project. The successful applicant will work in the pre-school facility which is one mile from the University but will have access to electronic and mechanical workshops in the University itself. A major requirement will be that the technician will be responsible for the operation of an extensive CCTV system and will undertake the editing of tapes. Experience with CCTV is therefore important. Subsidiary functions will involve some electronic and mechanical work. ONC is essential and HNC (Electronics or Physics) (or equivalent qualification) is desirable. Salary Scale £2325-£2655 p.a. plus earnings supplement of £130 p.a. Applications with full details of age, qualifications and previous experience should be addressed to Dr J. Hogg, Hester Adrian Research Centre, The University, Manchester M13 9PL (7015)

## VIDEO & ELECTRONICS ENGINEER

required with experience of servicing and installation of Video and HiFi equipment for a responsible position in a new organisation in the centre of Bath. This is a challenging job for the right man, with excellent salary and promotion prospects.

**Apply in writing to: Video South, 101 Eden Vale Road, Westbury, Wilts, or telephone Westbury (Wilts) 823140.**

(7038)

## Aural and Visual Aids Technician

£3963-£4299 per annum

An experienced technician is required by the Croydon Education Service to maintain and repair a range of Audio and Video equipment including T.V. Receivers in schools.

Commencing salary in the scale will be according to qualification and experience.

In an appropriate case consideration will be given towards assistance with removal and lodging expenses.

## CROYDON

Apply in writing giving details of age, qualifications, present post and relevant work experience to **The Superintendent, Education Service Centre, Princess Road, Croydon CR0 2QZ** or telephone the **Superintendent, Mr. A. Bevan (tel: 01-684 9093)** for further details.

(7037)

**APPOINTMENTS**



**HF RADIO SYSTEMS ENGINEER**

£5,000 to £6,000 per annum

The Cable and Wireless Group, a leader in global telecommunications, has an interesting career opening at its Central London Head Office for a design engineer (male/female) of radio systems operating below 30 MHz.

Duties will include responsibility for provision of HF prediction services, propagation studies, advice on technical characteristics of antennae and modulation methods.

Applicants should preferably have an acquaintance with working systems, knowledge of the ionosphere and some computer programming experience. A suitable degree in electrical engineering, professional engineering qualification or HNC would be an advantage.

Excellent conditions of service are offered with commencing salary of between initially £5,000 and £6,000 per annum, depending on experience and qualifications, on progressive career scales rising to over £7,000 per annum. Generous leave and pension arrangements, Sports and Social Club, and other benefits.

Application forms may be obtained from:—  
**Recruitment Manager,**  
**Cable and Wireless Limited, Dept. A.443a/643**  
**Theobalds Road, London WC1X 8RX.**  
**(01-242 4433 ext. 211)**

(7066)

**Cable & Wireless**

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**WORLD-WIDE RANGE NEVER BEFORE OFFERED**

**PHILCO HC-150 POINT-TO-POINT STRIP RADIO HF RECEIVERS** 2.30 m.c.s. Ten fully tuneable channels (to 0.5 Mcs with synthesizers) Single and diversity reception on ISB, DSB, SSB with 4 sub-bands to each channel. Full details and prices on application.

**HIGHEST QUALITY 19" RACK MOUNTING CABINETS & RACKS**

**ENQUIRIES INVITED FOR NEW STOCKS NOW AVAILABLE**

**AUDIO AND INSTRUMENTATION-TAPE RECORDER-REPRODUCERS**

- \* Plessey 1D33 Digital Units, 7 track 1/2"
- \* Plessey M5500 Digital Unit, 7 tracks 1/2"
- \* Ampex FR-1100, 6 speeds, stereo 1/4"
- \* Ampex FR900, 4 speeds, 7 tracks 1/2"
- \* D.R.I. RMI, 4 speeds, 4 tracks 1/4"
- \* EMI TR90 2 speeds, 1 track 1/2"
- \* EMI BTR1, 1 speed, 1 track 1/4"
- \* EMI R301G, 2 speeds, 2 tracks 1/4"
- \* EMI RE321 1/4", 7 1/2" 1 track
- \* Licord IA, 1/4", 1/4", 7 1/2" 1 track
- \* Minicom CMP 100, 6 speeds, 7 tracks 1/4", 1/2"
- \* Leavers Rich DA 2P, 2 speeds, 2 tracks 1/4"
- \* Leavers Rich Console 2 track 1/4", 2 speeds

Prices of above £70 to £500

Also Transport Decks only available

We have a large quantity of "bits and pieces" we cannot list — please send us your requirements, we can probably help — all enquiries answered.

All our aerial equipment is professional MOD quality

- \* Oscilloscopes Gen. purpose 3" £35.00
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- \* Airmec 702 Sig Gen 30/300KCS £85.00
- \* 10T Lightweight Mast sections, 6 sides £14.00
- \* Oscilloscope Trolleys from £12.00
- \* I.B.M. Video Display Units 4 col. £48.00
- \* Vener 5336 Counters £40.00
- \* Autopion VHF Receivers 20/120mcs £140.00
- \* Solartron CD 524 Oscilloscopes £90.00
- \* 100 amp Beiling Lee Interference Filters £75.00
- \* Marcom TF231 Distortion Meters £160.00
- \* AVO VI Voltmeters CT-471A £75.00
- \* Solartron Digital Voltmeters LM 1420/2 £120.00
- \* Racal MA197 Pre-Selectors £85.00
- \* Marcom TF-888 Receiver Testers £60.00
- \* Collins 500 watt 2/18 mcs. Transmitters £1000.00
- \* Collins KW16 SSB 500w Transceivers £1250.00
- \* Collins KW16 200 m. w AM Transceivers £750.00
- \* STC RX5 2/25 mcs Receivers Diversity £140.00
- \* Rack Mounting Operator Tables £18.00
- \* Gaumo Kalec 584 Jitter Meters £75.00
- \* Hewlett Packard 618B Sig. Gen. 3.8-7.2 GHz £120.00
- \* Rohn 95ft masts lattice 12 sides P.U.R.
- \* 30ft Lattice Masts, 14 sides £55.00
- \* 15ft Lattice Mast sections, 12 sides £35.00
- \* 12ft Lattice Masts, 15 sides P.U.R.
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- \* Heavy Aerial Rotators P.U.R.
- \* Racal SA 504 Voltage converters £25.00
- \* Elliot Recording M.A. Meters £75.00
- \* 75ft Aluminium Lattice Masts, 20ft sides £400.00
- \* Plessey peak distortion meters £35.00
- \* Polarad Microwave power meters £55.00
- \* Rhode & Schwarz SSB sig gen. 1.6/2.4 gmc £70.00
- \* S.E. 4000 System Units P.U.R.
- \* Large Aerial Turning Units P.U.R.
- \* 45 feet Uniradio 4 Co-ax 50 ohms £2.00
- \* Baluns Professional Exterior 600/75 ohms £6.00
- \* 25ft Telescopic Aerial Masts £24.00
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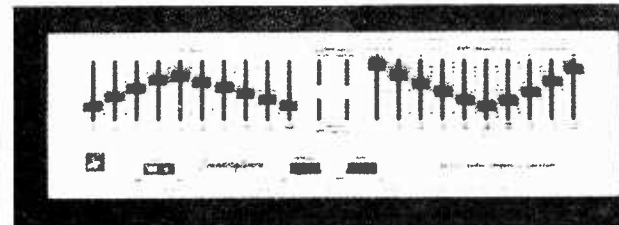


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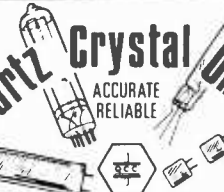
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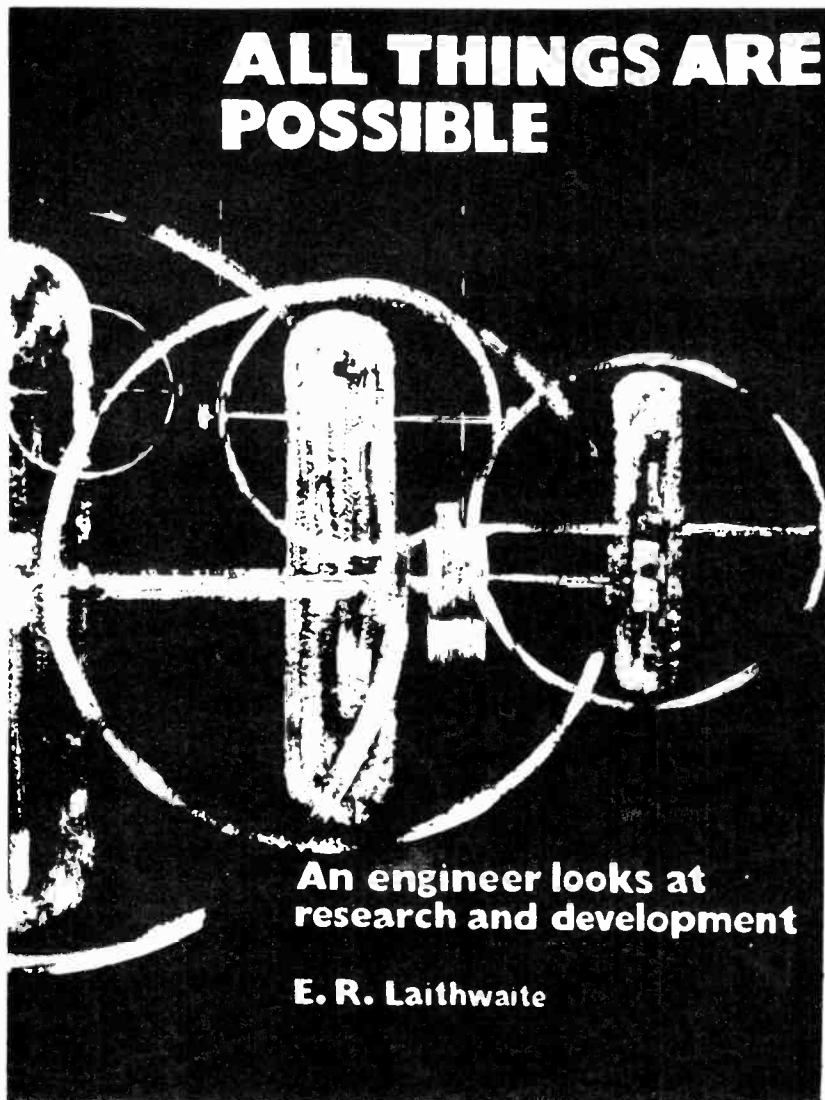
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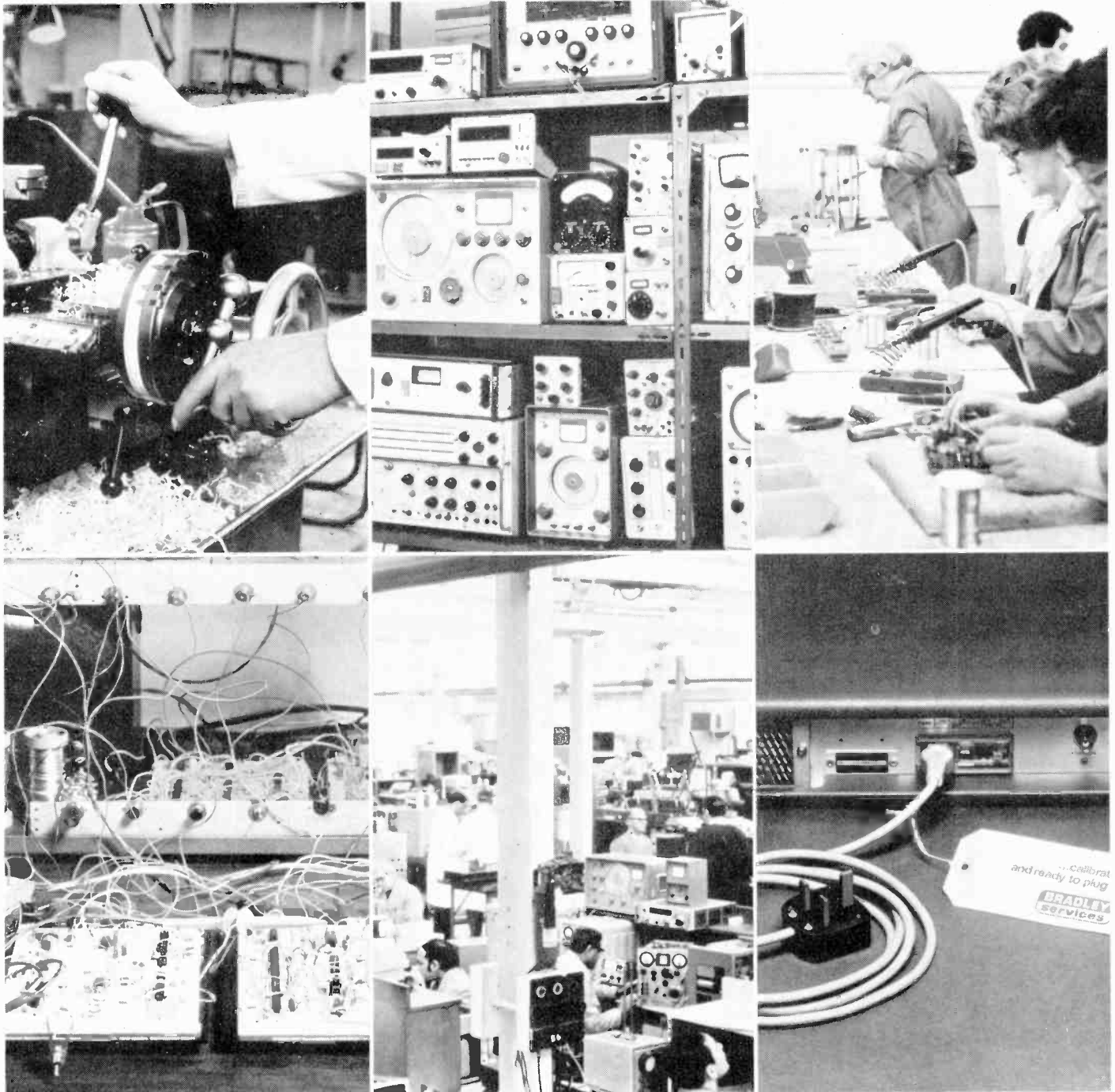
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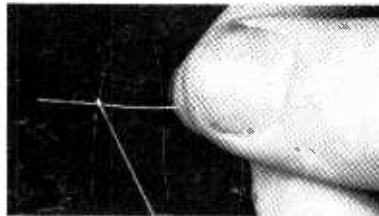
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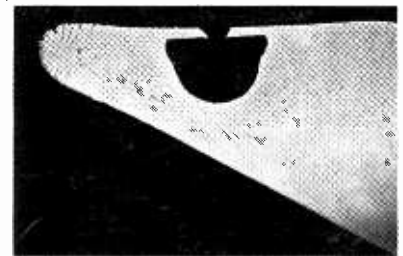
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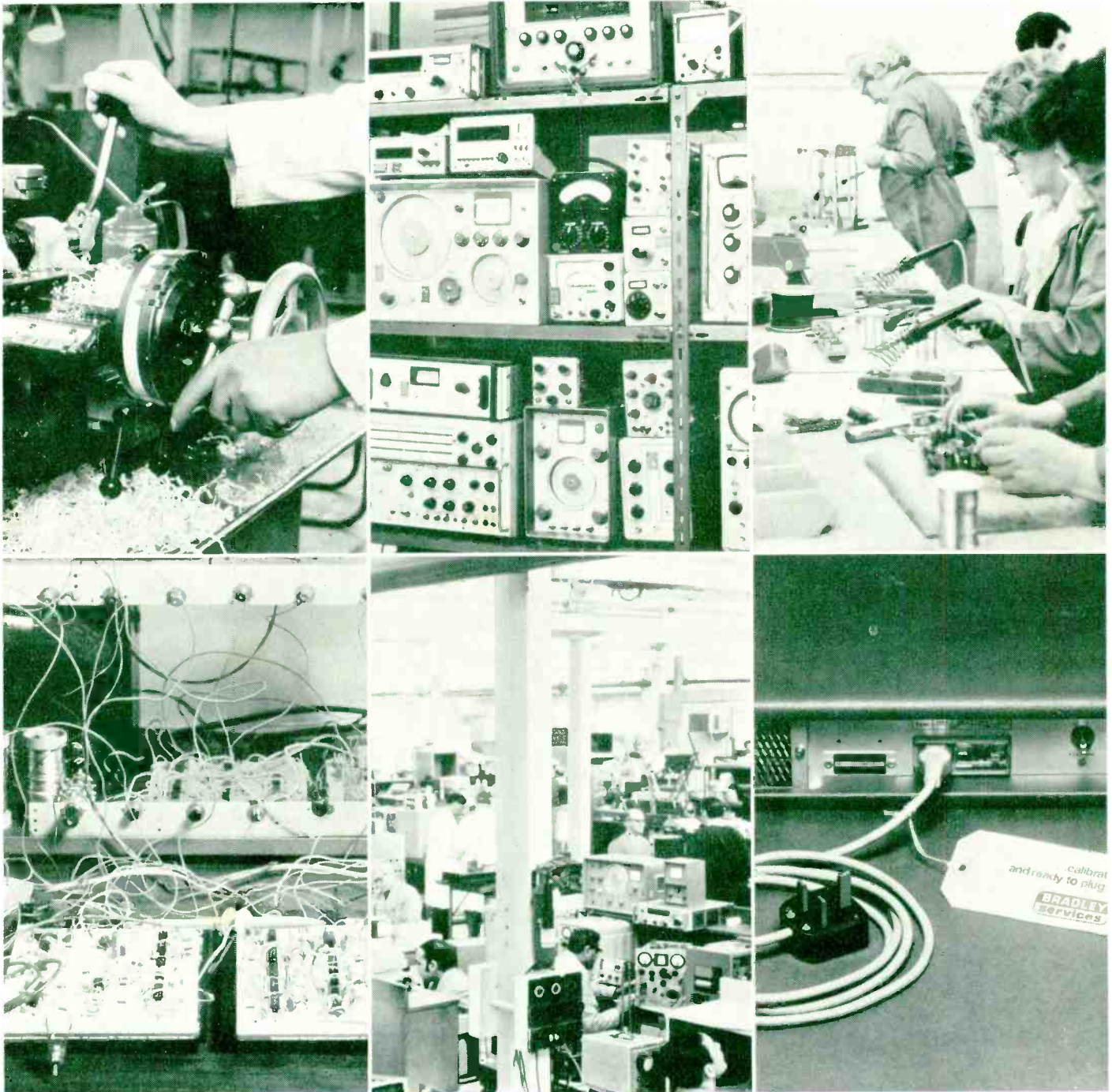
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# Ersin Multicore- the international solder

## Ersin Multicore 5-Core Solder

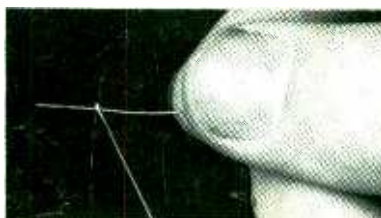
The proved superiority of ERSIN Multicore Solder for over thirty years is due to many factors. We have specialised throughout this period in the manufacture of cored solders. Consequently our research and manufacturing staff have been able to devote all their energies to the development of Multicore Solders. All alloys are of highest purity, carefully formulated and checked.

Our unsurpassed ERSIN flux is rigorously tested before and after it is incorporated in the solder wire. Our five separate cores of flux ensure flux continuity, leave only an ultra-thin layer of solder separating flux from work for instant wetting and provide a more accurate ratio of flux to solder. It is therefore possible to

use less solder and obtain greater reliability.

Our Quality Control at all stages of manufacture is guaranteed and recorded by the batch number on every reel.

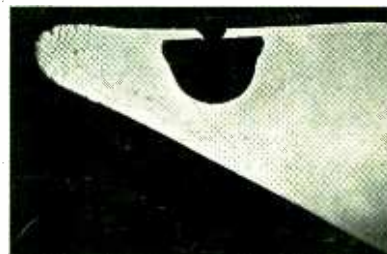
## Needle fine gauges



In addition to our standard range of wire diameters (10-22 swg: 3.2-0.7 mm) supplied on 2½ kg and ½ kg reels we also mass-produce needle-fine gauges (24-34 swg: 0.56-0.23 mm) on 250 g reels for microminiature soldering applications—still with 5 Cores of flux.

## Savbit Solder

One of our most popular special ERSIN Multicore Solder alloys is SAVBIT alloy. Compared with ordinary tin/lead solders it dramatically reduces the erosion of soldering iron bits, copper wires and printed circuit conductors. It also saves costs and increases reliability. SAVBIT alloy containing 5-Cores ERSIN 362 flux has received special Ministry approval—under DTD. 900/4535 for Military applications.



Sectioned iron-plated bit, after 40,000 simulated operations using 60/40 Solder.



Sectioned iron-plated bit, after 40,000 simulated operations using SAVBIT Solder.

Composition (nominal major elements)	Grade	Melting Temperature		Specification
		Solidus °C	Liquidus °C	
50/33/17 Sn/Pb/Cd	TLC	145	145	DIN 1707
62/36/2 Sn/Pb/Ag	LMP	179	179	DIN 1707
62/35.7/2/0.3 Sn/Pb/Ag/Sb	Sn62	179	179	QQ-S-57 1E
63/38.7/0.3 Sn/Pb/Sb	Sn63	183	183	QQ-S-57 1E
60/40 Sn/Pb	K	183	188	B.S. 219
60/39.7/0.3 Sn/Pb/Sb	Sn60	183	188	QQ-S-57 1E
50/50 Sn/Pb	F	183	212	B.S.219
50/49.7/0.3 Sn/Pb/Sb	Sn50	183	212	QQ-S-57 1E
50/48.5/1.5 Sn/Pb/Cu	Savbit 1	183	215	DTD 900/4535 DIN 1707
45/55 Sn/Pb	R	183	224	B.S.219
40/60 Sn/Pb	G	183	234	B.S.219
40/59.7/0.3 Sn/Pb/Sb	Sn40	183	234	QQ-S-57 1E
30/70 Sn/Pb	J	183	255	B.S.219
20/80 Sn/Pb	V	183	275	B.S.219
15/85 Sn/Pb	—	225	290	—
Pure Tin	P.T.	232	232	B.S.3252
95/5 Sn/Sb	95A	236	243	B.S.219
5/93.5/1.5 Sn/Pb/Ag	H.M.P.	296	301	B.S.219



For full information on these and a Selector Guide to other MULTICORE products please write on your Company's letterhead direct to:

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