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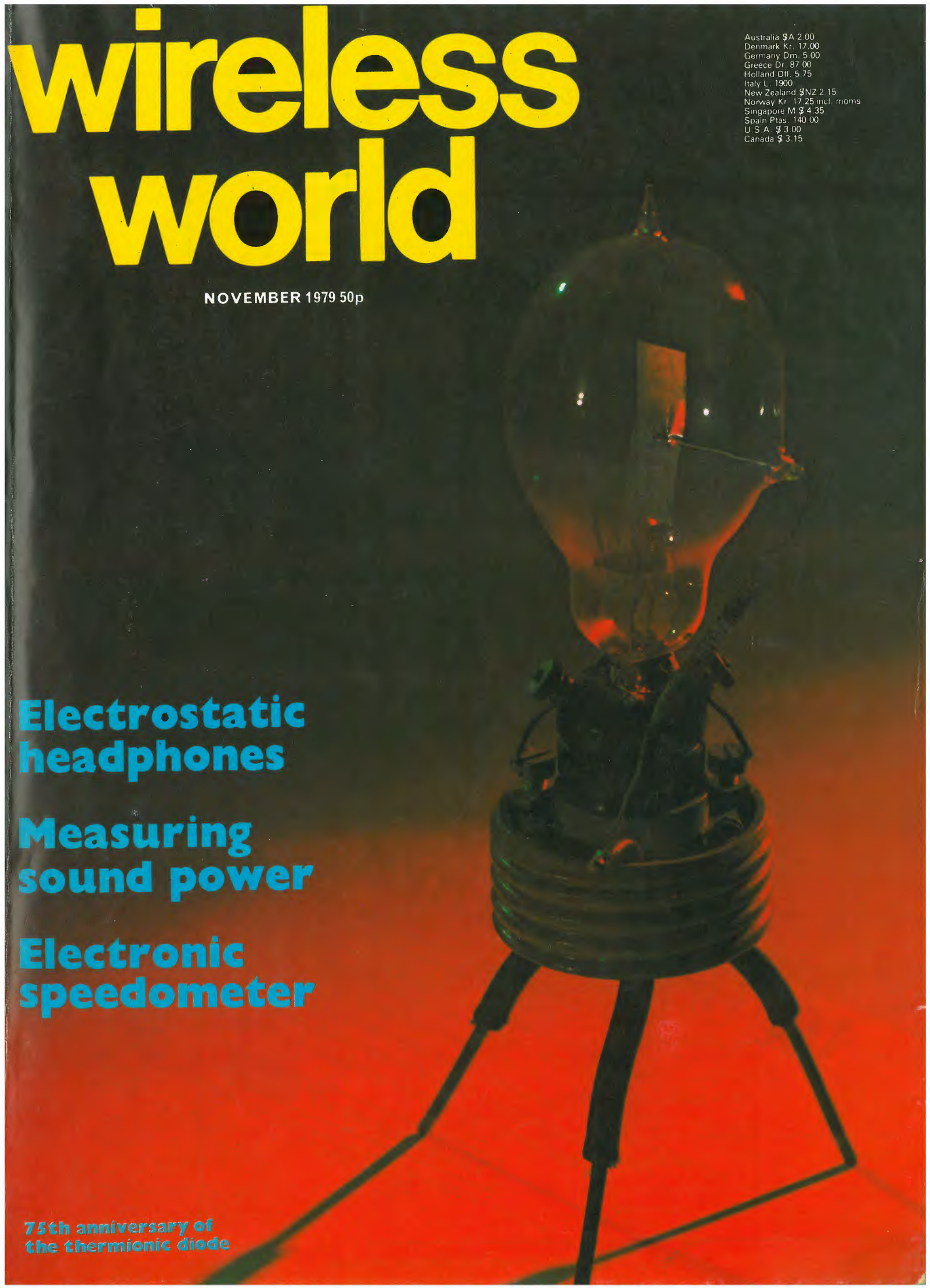

Electrostatic headphones

Measuring sound power

Electronic speedometer

75th anniversary of the thermionic diode

WIRELESS WORLD NOVEMBER 1979 VOL 85 NO 1527

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Electrostatic headphones

Measuring sound power

Electronic speedometer

75th anniversary of the thermionic diode

Front cover shows Fleming's first diode, patented November 1904 (see article in this issue). Photo: courtesy of The Marconi Company.

IN OUR NEXT ISSUE

Parallel-tracking pickup arm. **Constructional design using optical servo is much cheaper than commercial models.**

Control via the mains. **Using house wiring to send digital signals for remote control of domestic appliances.**

Why your speaker is full of foam. **Explaining the acoustics of domestic loudspeaker systems.**

Current issue price 50p, back issue (if available) £1.00, at Retail and Trade Counter, Paris Garden, London SE1. Available on microfilm: please contact editor.
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NOVEMBER 1979 Vol 85 No 1527

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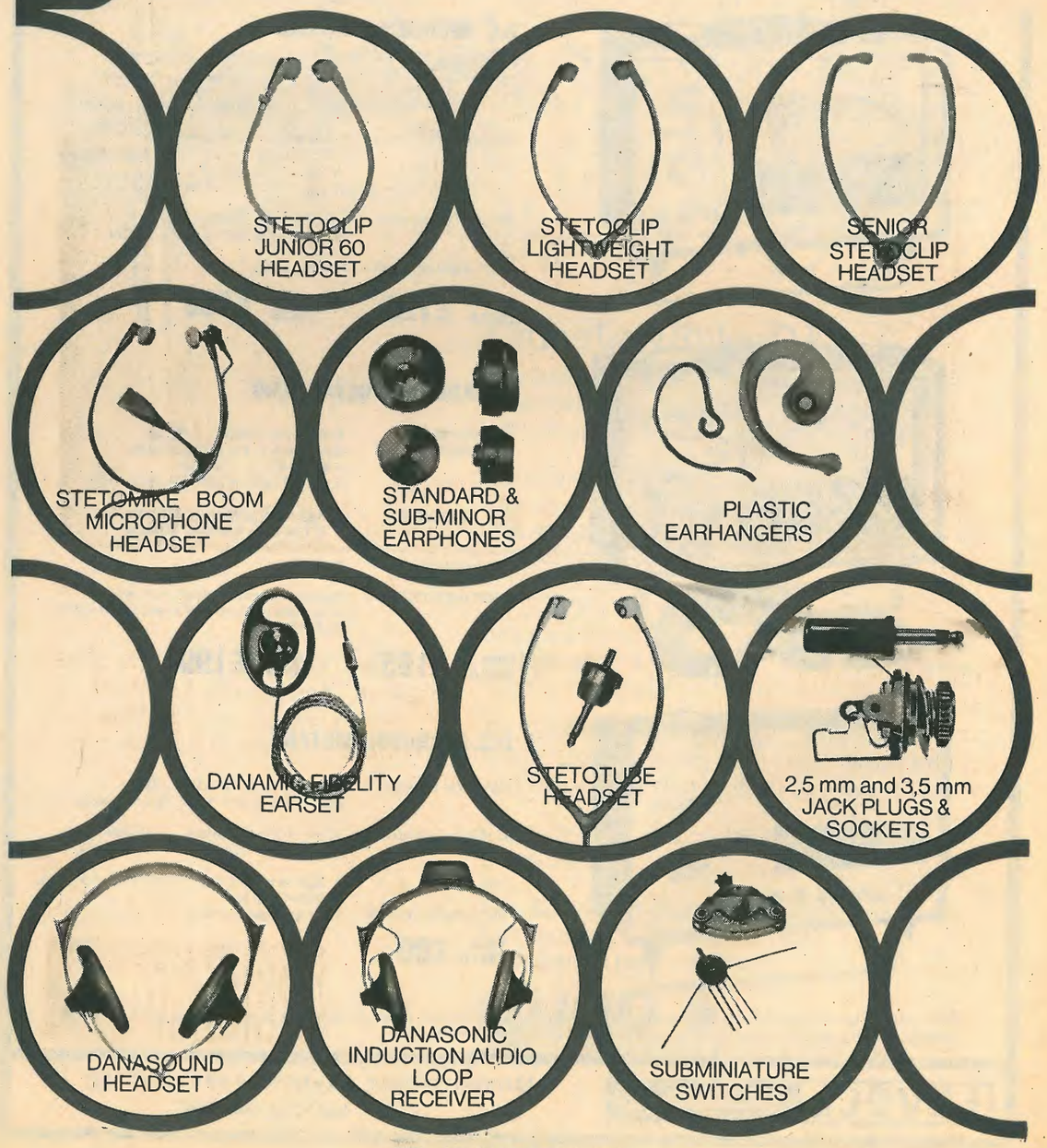

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Our main competitor!

The stiffest opposition we find against making a sale for a bench power supply is your old friend alongside. There are thousands of them still working perfectly after more than 10 years in service.

Around 40,000 L series bench power supplies have been sold and the latest units are still uncompromising in performance and reliability. They provide constant voltage or constant current, feature large recessed meters, overload and short-circuit protection, coarse and fine adjustment controls, a separate output switch and LED indicators for mains on and current limit.

Models available

L50-05	**0-50V, 0.5A**	**L12-10C***	**0 – 12V, 10A**
L30-1	**0-30V, 1A**	**LT50-05** twin output unit	**2 x 0 – 50V, 0.5A**
L10-3C*	**0-10V, 3A**	**LT30-1** twin output unit	**2 x 0 – 30V, 1A**
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Digital Multimeter Model 2010A Kit

Only £49.95 + VAT

+ £3.50 P&P

BRIEF SPECIFICATIONS:
3½ Digit Lab standard. Basic accuracy 0.1% ± 1 Digit.
6 functions with 31 ranges.
Autozero, autopolarity, overrange indication.
Laser trimmed resistor network.
Built in calibration procedure.
DC Volts: 100μV to 1 kV in 5 ranges
AC Volts: 100μV to 1 kV in 5 ranges
DC Current: 0.1μA to 10 A in 6 ranges
AC Current: 0.1μA to 10 A in 6 ranges
Resistance: 0.1Ω to 20 MΩ in 6 ranges
ACV frequency response: 40 Hz to 40 KHz
Diode Test current: 0.,1μA, 10 μA, 1mA
Input Impedance: 10 MΩ on ACV and DCV
Overload protection: 1200 VDC or RMS on all voltage ranges except 250 VDC or RMS on 200 mV and 2V AC ranges.
Fuse protected on Ohms and mA ranges.
Power requirements 4.5 to 6.5 VDC (4 "C" cells)
Optional: NiCd batteries or AC adaptor/charger
Display: 0.36" (9 mm) Digits reading to ±1999

Digital Frequency Counter Model 7600 Kit

TCXO Time Base

Only £69.95 + VAT

+ £3.50 P&P

BRIEF SPECIFICATIONS:
• Frequency Range: Switch selectable, 10 Hz to 60 MHz, 10MHz to 600MHz guaranteed (10MHz to 700 MHz typical).
• Sensitivity: < 10mV to 60MHz, 25mV to 150MHz (50mV to 450MHz typical) • Impedance: 1MΩ/20pF (60MHz), 50Ω (600MHz)
• Accuracy: ±1Hz + time-base accuracy • Ageing: < 2 ppm/yr
• Temperature Stability: 0.08 ppm/°C (< ±1 ppm, 20°C to 40°C typical) • Resolution: 1Hz*, 10Hz, 100Hz • Gate Time: Switch Selectable, 100 msec, 1 sec • Display: 7-digit LED • Input overload protection, automatic decimal point placement • Power Requirement; 7.5 - 15 VAC/VDC @ < 250mA.
(* 1Hz Resolution with switch is an optional accessory.)

Digital Capacitance Meter Model DCM 1000 Kit

Only £69.95. + VAT

+ £3.50 P&P

4 Digits. 1pF- 9999 μF
Quartz crystal time base for exact capacitance measurements.
4 ranges: 1/pF 0000-9999pF
2/μF .0000-.9999μF
3/μF 00.00-99.99μF
4/μF 0000.-9999.μF
Accuracy: 1pF,2pF ±1% of reading ±1 count
3/μF ±1.5% of reading ±1 count
4/μF ±2% of reading ±1 count
Time base: 5,579MHz ±0.05% accuracy
Operating temp. range +5°C to +45°C
LED display (13mm)
Power requirements; 6 to 12VDC,250mA

Digital Clock-Thermometer Model DTU 101 Fully Assembled & Tested

Only £29.95 + VAT

+ £2.00 P&P

For internal and external temperature measurements and normal time clock, with alarm capabiity.
Digital thermometer: °C or °F (–40° to +90°C.)
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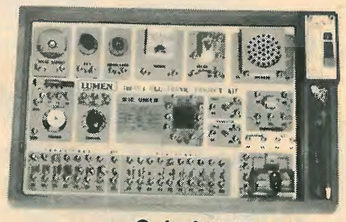
Alarm clock: 24 hour time readout.
Stop watch function up to 59 min.
Adjustable display illumination.
Complete with case all parts and instruction manual (Optional: Automatic alternating parts for alternating readout of time and temperature £5.95.)

100 in 1 Universal Experimenters Kit.



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Send payment with your order

As individual oscilloscope and digital multimeter, SuperScope and The Ultimate Multi-mate are market sensations in their own right. As a matched pair, they complement each other to perfection.

Supermate

SuperScope (PM 3207)
* Philips quality and advanced technology in design and construction
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* Auto triggering from either channel with adjustable level between peaks. TV triggering, too
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* Autoranging with manual override
* Comprehensive overload protection
* Current measurements to 10A
* Accessories include temperature and data hold probes

PHILIPS **Test & Measuring Instruments**

Further information about both instruments is available from the Philips Electronic Instruments Department at Pye Unicam (see below for address).

The instruments may be purchased from the department or from the following distributors: British Tungsram. West Road, Tottenham, N17 0RN; Philips Service (call at your local Philips Service Shop — there are 25 throughout the country. Telephone 01-686-0505 for the address of your nearest branch); Wessex Electronics Ltd, 114-116 North Street, Downend, Bristol BS16 5SE.

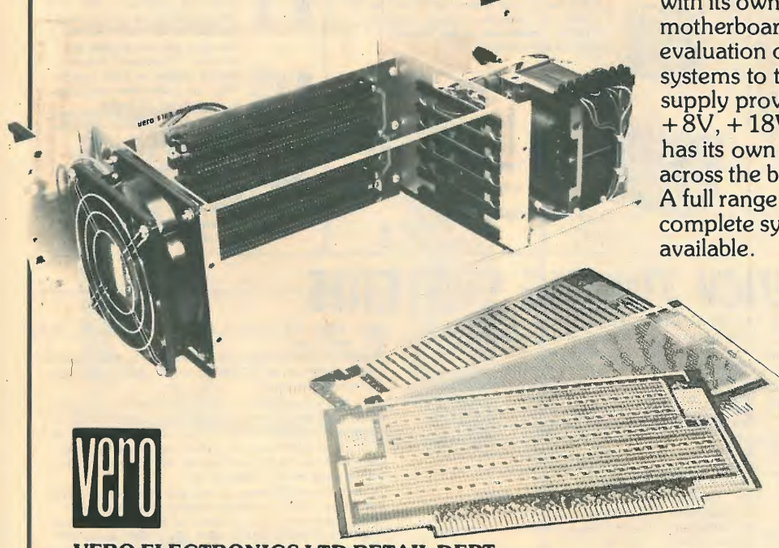
In addition, The Ultimate Multi-mate only is also available from ITT Instrument Services, Edinburgh Way, Harlow, Essex CM20 2DF and Rank Radio International, Watton Road, Ware, Herts.

Pye Unicam Ltd
Philips Electronic Instruments Dept.,
York Street, Cambridge, England CB1 2PX.
Tel: Cambridge (0223) 358866 Telex 817331

PHILIPS

WW — 056 FOR FURTHER DETAILS

S100-the British way



The Vero S100 Sub Rack is a 19" rack mountable development kit, complete with its own power supply and backplane motherboard, for the construction and evaluation of microprocessor based systems to the S100 format. The power supply provides three voltage levels — +8V, + 18V and -18V. The Sub Rack has its own cooling fan providing airflow across the boards and the power supply. A full range of allied items to enable a complete system to be constructed are available.

ORDER CODE	ITEM DESCRIPTION
188-2341H	S100 Sub Rack
06-0095L	S100 Dip Board
06-2337L	S100 High Density Board
06-2338F	S100 Square Pad Board
15-1630K	Compatible Connector (Solderlug)
15-1632L	Compatible Connector (Miniwrap)
09-2340H	S100 Extender Board
48-8345K	Mk. II D Series Case
75-2867G	Keyboard Console
79-1729L	Verowire Wiring Kit

vero

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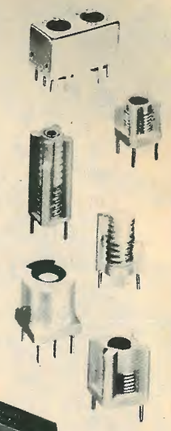
TOKO MAKE THE WORLD'S BEST RANGES OF COILS.



It seems a long time since TOKO first revolutionized the coil manufacturing business with their unique ranges of miniature RF and IF coils. Many imitators have come - and gone - in the meantime, but none have managed to equal TOKO's consistent quality, and skill in innovative coil design.
However, perhaps TOKO's supremacy in designing and supplying these types of wound component has tended to overshadow the other product areas of TOKO's manufacturing capability.
So the rest of this advertisement is devoted to semiconductors, ceramic and mechanical filters, and their new low cost ceramic resonator to replace the costly quartz crystal in many MPU and ultrasonic systems. And don't forget - not only do we offer you some exciting and innovative products in print - the supply is carefully maintained at all times through the only stockist/distributor of signal frequency processing coils in the UK.

SEMICONDUCTORS

Wide capacity range tuning diodes: KV1210 and KV1220 series

A unique range of matched dual and triple diodes, possessing tuning capacity ranges in excess of 15:1 (1 - 9 v, or 1-25v series.) The diodes are supplied in either a single package, or in a snap-apart package, where each anode and cathode is separately available, and circuit layout flexibility is unrestricted.
The two basic series are for either 9v or 25v maximum bias, with a maximum matching deviation of only 2% over the entire bias range.

SIL package

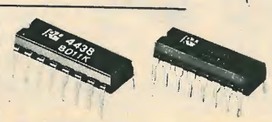
Snap-apart package(s)

Electrical characteristics		Each diode - 9v series (25 volt series)				
Item	Symbol	min	typ	max	units	conditions
Reverse voltage	V_{BR}	20 (30)			V dc	I_R = 10uA
Leakage	I_R			100	nA	V_R 15v (25v)
Capacitance	C_{1v}	440 (510)	500	560 (620)	pF pF	V_R = 1v, f = 1MHz
Capacity ratio	$C_{1v\text{-}9v}$ / $C_{1v\text{-}25v}$	15 (20)	17 (22)			f= 1MHz
Q (both series)		200				V_R 1v, f= 1MHz
Temp. Coeff.	TC_Q		500 (130)		ppm/°C	V_R 5v, f= 1MHz V_R 13v, f= 1MHz

Ordering information:

Stucture	9v	25v
3 SIL	1210	1220
2 SIL	1211	1221
3 s/a	1215	1225
2 s/a	1216	1226

SIL : Single in line
s/a : Snap apart
Prefix all types "KV"



The TOKO range of ICs is based largely on custom applications in radio/audio, calculator, printer and allied applications. Custom designs in all major technologies are available, and the standard list includes :
AM/FM complete radio and IF amplifier devices KB4402 (CA3089E), KB4420 (HA1137), KB4400 (MC1310), KB4419(AM/FM portable radio IC), KB4420 (HiFi AM tuner IC), KB4436 (FM noise blanker IC), KB4423 (Noise blanker IC), KB4437 (Pilot cancel stereo decoder IC), KB4438 (Muting HiFi audio preamp - two channel)
Clock LSI : The MK50366/50372 direct drive multifunction clock/timer ICs for LED or Fluorescent displays.
Driver arrays for gas discharge/fluorescent displays, gas ignition drivers etc.

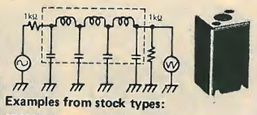
FILTERS

TOKO's new CFSH series of FM IF filters have been designed for excellent thermal and long term stability in applications such as communications and car radio. Three basic bandwidths are available to suit various standards. Spurious responses in the 8-12MHz region are typically below 50dB down.
1off : 60p 100 off: 36p each

CFM2-455

TOKO's CFM2 series of AM mechanical filters are available in the range 200-600kHz. The mechanical design ensures low spurious response, and excellent stability when compared to cheap ceramic filter alternatives. With the appropriate input/output matching transformers, a shape factor of better than 3:1 is possible. Stock types are centered on 455kHz versions.
1off : 65p 100off: 45p

Coil block filters:
TOKO expertise in coil design is refected in the wide range of very high specification, low cost filter blocks for radio and audio.
Several standard ranges have evolved for use in 19/38kHz stereo pilot tone notching, and other custom requirements may be readily met from the standard range of tuneable inductances in the 1-50mH range held by AMBIT.



Examples from stock types:
19/38kHz mono filter 1 off £1.00
100 off £0.65
6 pole FM linear phase filter
1 off £2.45
100 off £1.36

CHOKES

TOKO's range of fixed inductors is based on three main styles (as illustrated). Between them, a range covering 1uH to 120mH in E24 series is available, with other values available to special order. (Subject to min. order quantity.)
The rigid pins are suitable for all types of automatic insertion, and are spaced on 5mm centres.
Prices are unbeatable compared to other types of choke:

Type	1-49	50-99	100-499
7BA	16p	9.5p	7.2p
8RB	19p	16p	12p
10RB	33p	27p	21p

7BA covers 1uH to 1mH
8RB covers 100uH to 36mH
10RB covers 1mH to 120mH
(Tuneable signal chokes are also available in this range)

DIGITAL FREQUENCY TUNING SYSTEMS

In keeping with TOKO's policy of being prepared for all the latest advances in radio technology - Ambit have been carrying out extensive work on evaluating the new digital frequency synthesiser systems from the major manufacturers. Harware for evaluation is available now.
Mullard's uniquely versatile LN123/4 system for professional communications of all types, the low cost 'RTS' serial data controlled system for up to around 200MHz in consumer and amateur radio applications.
National Semiconductor's DS8906 AM/FM synthesiser using a single IC for prescaler/serial programmable counter/phase detector.
Hitachi's dedicated AM/FM/SW car radio MPU controlled system.
OKI electric's solution with on board RAM station recall.
Fairchild's versatile FEX2500 system for radio/TV.
Plessey's various offerings for professional, commercial and industrial applications.
Plus any others that are made available to us for general release in the meantime.

And as well as the synthesiser hardware, there are various radio systems to use as building blocks. And as you might have come to expect from Ambit, the radios are just as technology concious as the rest of the system. Not simply an afterthought in the shape of MPU specialists idea of a wireless to hang on the end of 'his baby'.
The synthesiser driven units include both bandswitched versions of fully DC operated LW/MW/FM receivers, FM only, AM only - and a new continuously tuned 5kHz to 30MHz system with switched bandwidth IFs and most of the features you would expect to find on systems costing ten or twenty times more.
Plus, of course, VHF tuners ranging from 30MHz to 220MHz in our standard PIN agc 4 and 6 circuit variants.
In other words, a total package approach to radio in the eighties - from one source.
As well as the synthesiser systems, Digital Frequency Readouts are already available with either Fluorescent, LED or LCD.
All the standard IF offsets for AM/FM, plus the new DFM4 with the addition of 10.7MHz and 2MHz offsets in the SW range. 100Hz AM resolution, 4mA consumption at 5v, 10kHz VHF resolution.
In other words, something that covers nearly all applications and requirements up to 200MHz (or 399.99MHz with the appropriate prescaler).
Next time you are thinking about any form of radio system, either consumer, communications or any associated aspect - remember that TOKO coils are available ex-stock from Ambit, or to custom specifications. A full range of chokes from one microhenry to 120 millihenries, with tuneable versions with as much as 40% tuning range.
To complement this range, Ambit also offer various crystal and ceramic filters to communications standards, a wide range of semiconductors, including JFET, MOSFET signal amplifiers. (40673/3SK51 - 100+ 33p). 100W power MOS devices, varicaps of all sorts, plus most other semiconductor requirements for your system. (Plessey 1600 series now in stock.)

TOKO UK Ltd., Ward Royal Parade, Alma Road, Windsor, Berkshire TLX.848095 TOKO G
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AMBIT INTERNATIONAL, 2 Gresham Road, Brentwood, Essex. tel (0277) 227050/216029

WW — 076 FOR FURTHER DETAILS

WATTS & RMS

Some instruments claim true RMS but are AC coupled, so that a composite input cannot be measured without calculation -

not so the WM80!

For true RMS or Power with 'difficult' waveforms the WM80 AC/DC Test Set is a new instrument giving direct readings. Measurements of true RMS, true Average and Peak values are given for:—

Voltages in the range 30mV to 500V
Current in the range 1mA to 15A

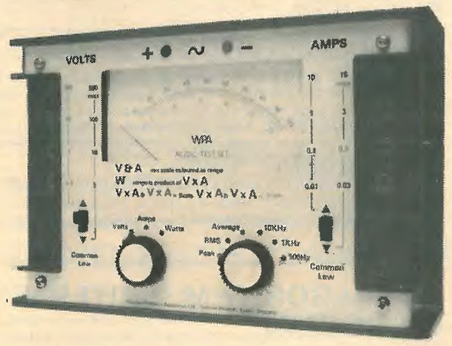
Other direct readings are obtained for:—

Power in the range 3mW to 7.5KW
Frequency in the range 10Hz to 10KHz.

Indirect determinations can be made of

Power factors
Form factors
Crest factors

The WM80, at a price of less than £200, is the latest product from WPA Ltd., a company well known in the Science Education field where they have been serving the needs of schools and universities for over a decade.



WPA WALDEN PRECISION APPARATUS LTD.
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ESSEX CB11 3BD (Tel: 0799 23018)

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Constant current and voltage modes over three voltage ranges from 0-60V - ideal for a wide variety of laboratory applications.
Continuously variable but highly stable outputs combine with proven reliable circuit design to provide trouble-free operation into any type of load. Outputs are fully floating. Either terminal may be grounded.
Series or parallel operation - the units may be series connected in the voltage mode or parallel connected in the constant current mode - is an important feature. Both single and twin units are compact in design, occupying minimum valuable bench space.
Voltage and current, set by multi-turn or concentric potentiometers, can be monitored on separate or dual scale moving coil meters.

Available ex-stock.
Send for price breaks and full specifications.

coutant power

England Coutant Electronics Limited, Trafford Road, Reading RG1 8JR. Tel. Reading 55391. Telex 847519.

France Coutant S.A., 14-16 rue Gabriel, Peri-92120 Montrouge. Tel. (010331) 656-05-15. Telex 204813F.

Coutant also operate in all other European countries.

WW.— 088 FOR FURTHER DETAILS

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specialists in second user test and measuring instruments

AS NEW

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DC-100MHz Dual Trace 5mV-5V/Div Delayed T/B XY DC 4MHz
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£1200

TEKTRONIX 475A
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0.01μs-0.5s/Div Delayed T/B XY DC 3MHz
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RACAL
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LDO2 10Hz-100KHz Oscillator 160
Modulation Meters
MARCONI
TF2300A AM/FM 1000MHz 495
Oscilloscopes
DYNAMCO
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PHILIPS
PM3210 DC-25MHz Dual Trace 325
TEKTRONIX
547/1A1 DC-50MHz Dual Trace DTB 525
547/1A4 DC-50MHz Four Trace DTB 625
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1A2 Dual Trace Plug-In DC-50MHz 180
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Z Differential Plug-In 140
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RACAL
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9059 DC-560 MHz with battery pack 300
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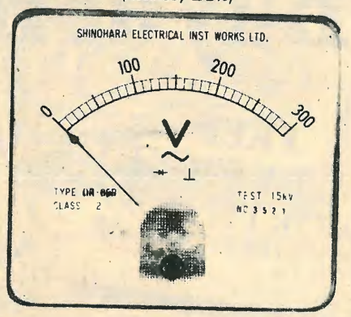

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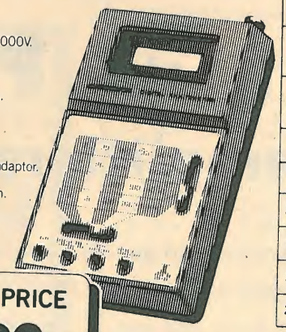

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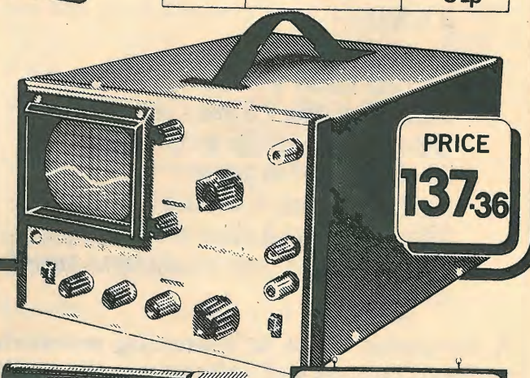

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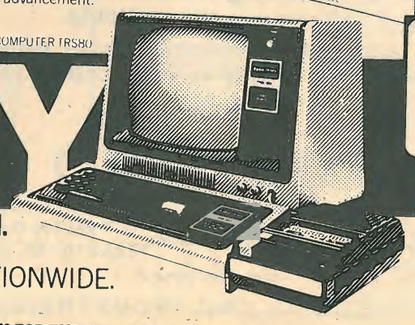

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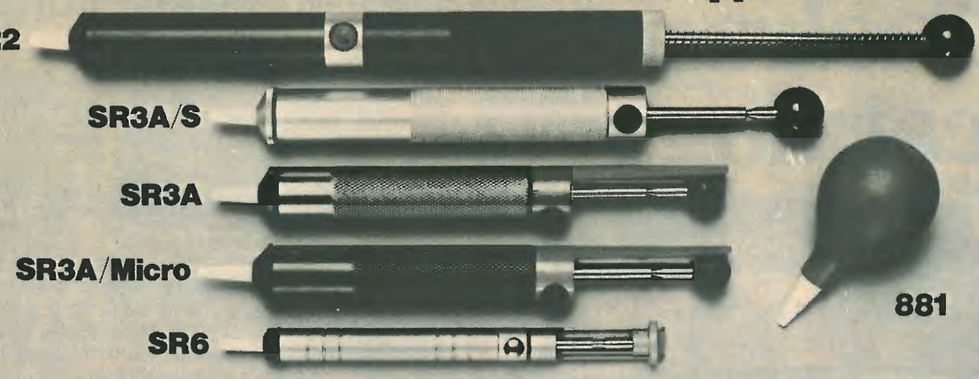

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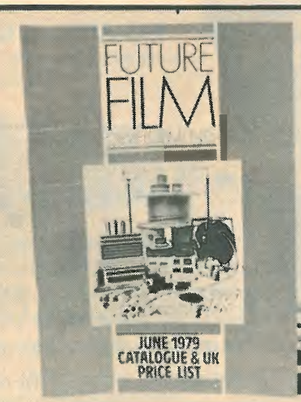

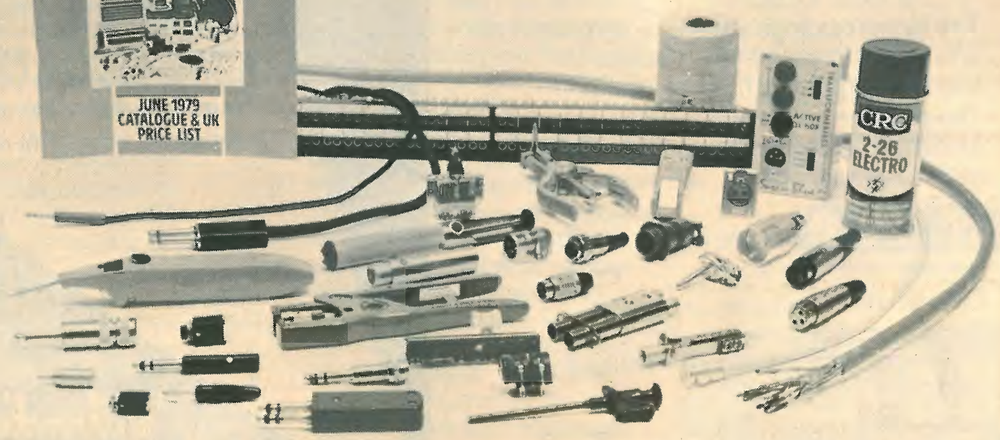

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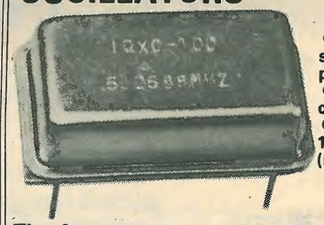

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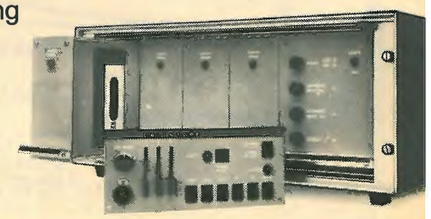

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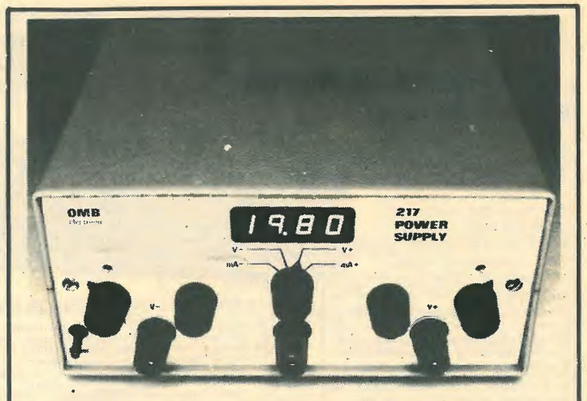

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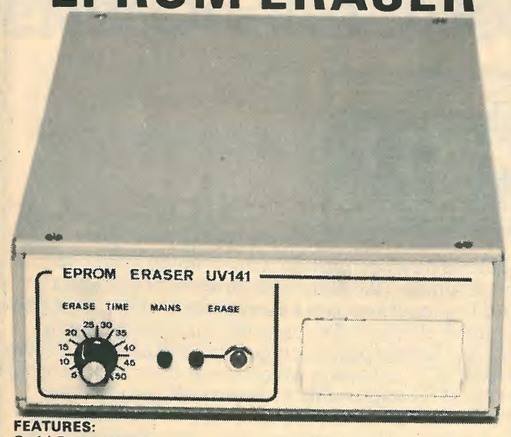

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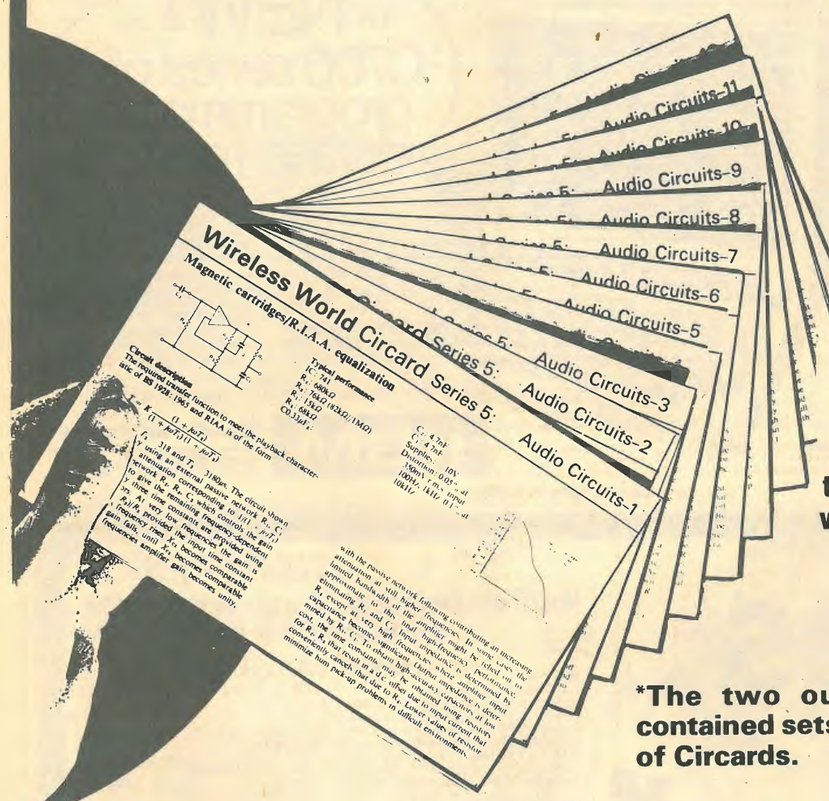

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Trickle, trickle little chip

Place a microprocessor in the soil-begrimed hand of an Indian peasant and tell him that this is the latest thing for increasing material wealth, and he will stare at you in utter disbelief. What possible connection could there be between this enigmatic device and the simple tools by which he scrapes a meagre existence from the dusty plains around him? The very height of his aspiration in technological development is that one day he might be able to replace the animal drawing his plough with a tractor. And yet, ironically, the price of microprocessors is now so low that he could probably buy one in a few weeks or months, if there were any point in doing so.

While Britain and other industrialized countries debate the impact of new technologies such as microelectronics and squabble over how the economic benefits should be shared out, there stands in the background, casting a great shadow over all of us, the poverty and deprivation of the majority of mankind. Today, when there are no longer any technical reasons for failing to supply all the world's inhabitants with adequate food, clothing, shelter and health and education services, it is a crime against humanity that in Europe, America and Japan we have huge productive resources locked up in catering for the buying power of an already affluent minority which has been made avid for luxury goods such as (in our field) television games, hi-fi equipment, home computers and microprocessor-driven door chimes.

Conservative minded politicians, industrialists and their tame economists argue that it will all come right in the end, by a process of what they call "trickle down." The present stark inequalities between peoples will eventually be smoothed out by improvements in capital investment and productivity in the poor countries. Meanwhile they shed crocodile tears and continue to give economic "aid" which in practice merely increases the dependence of these countries on the technology of the rich and powerful ones, and on the multi-national corporations, and is used cynically as a weapon in the world power struggle.

One possible solution to the problems of the poor countries is "alternative technology," as it is popularly known. In most cases this means the use of labour intensive manufacturing techniques instead of the capital intensive, labour saving ones that the industrialized countries have developed so thoroughly. This may prove helpful as an intermediate measure, but in the long term the poor countries are not likely to want to shut their doors permanently against high technology. In a recent paper presented to UNCSTED (United Nations Conference on Science and Technology for Development) at Vienna, the Research Policy Institute at the University of Lund, Sweden, points out that labour intensive manufacturing could become a dead end, because there are fundamental limitations to human powers compared with the increasing speed, accuracy, reliability and low cost production of modern electronically controlled machines. Consequently the goods made by "alternative technology" methods could become relatively lower in quality, less attractive and therefore less competitive on world markets. The Institute thinks that the developing countries should harness high technologies such as microelectronics to increase the productivity of their industries as a means of accelerating capital accumulation. "This capital is essential for rural and urban development and for providing manufactured inputs for agriculture as well as for meeting the essential material needs of the entire population at the lowest possible cost."

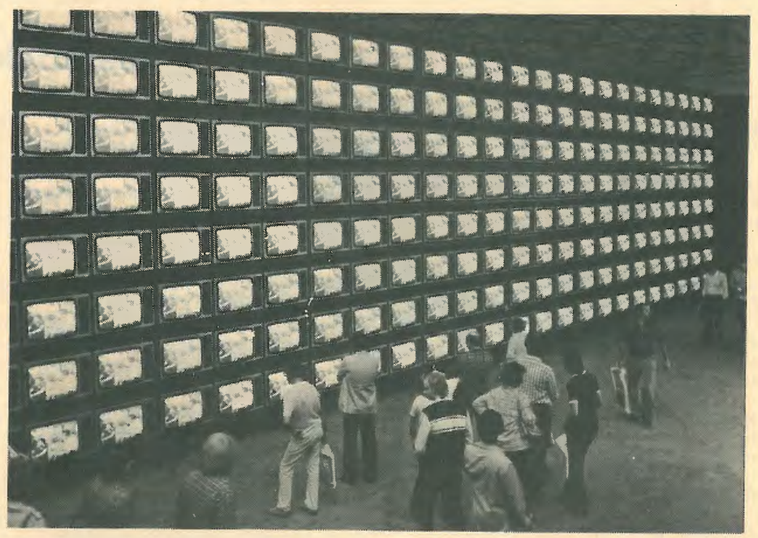
The Institute's call for microelectronics technology to be diffused as rapidly and openly as possible to the whole world, instead of just being left to "trickle down," is heartening and optimistic for engineers and technicians who work in this field and perhaps see it at present as a narrow specialization.

Europe responds to Japanese video

Internationale Funkausstellung, Berlin 24.8-2.9

by Geoffrey Shorter

Highlight of the 1979 International Radio TV Exhibition was undoubtedly the consolidation of a European video effort, spearheaded by the public launch of the Video 2000 system. Just how successful the Grundig-Philips joint effort would be was more the talking point than the media-political questions and micro/p.c.m./TV projection gadgetry.



Sheer size is the most apparent feature of the German Radio and TV Exhibition, attracting 628,000 visitors and 525 exhibitors (383 from abroad) within its 90,000 square metres.

TWO REASONS WHY TV companies are looking toward a video boom to help them out: First there is a gradual levelling off in demand for colour television in Europe, especially Germany, as the number of households with colour sets increases, tending to make sales progressively more difficult. And second, manufacturers must be expecting increased competition as the ageing PAL patents, which have hitherto protected the European large-screen tv market, run out. So the declining market share of Europe's two video cassette recorder manufacturers — Philips & Grundig — in the now fast-growing market of video cassette recorders is doubly bad news for them. "This is probably the most important area in terms of prospects and growth. It must not be lost to firms overseas" says Roland Klink, Grundig video product manager. "This is not a question of prestige" added Klink, "but primarily one of maintaining jobs", as he introduced the long-awaited response to the VHS and Betamax systems. The Video 2000 system, developed jointly by Grundig & Philips to keep the technology of video recording in Europe, aims to "put European video recorder engineering in a leading position in the world". And to consolidate their joint stand with Grundig, Philips are expecting to take a 24.5% stake in Grundig* — the maximum allowed by the German cartel office.

Main design aim of the Video 2000 system was to reduce tape usage below that of Betamax but without making any sacrifice in quality. At the same time the system was to allow rapid location of programmes and anticipate all forseeable future developments. For example, stereo sound can be catered for by using a 650μm-wide audio track. Near the tape centre room has been left for a control track, not used on the present models, which could be used for time codes or other marker signals. An automatic track following technique makes it easier to introduce new features, and a keyed cassette will cater for new tape types, e.g. iron particle tape.

The most obvious way to reduce tape consumption is to narrow the video track width. Now that would normally result in a tape speed below the 1.87cm/s of Betamax, and sound quality would then noticeably deteriorate — and it sounds muffled at that already low tape speed. Philips and Grundig solved this problem by using only half of the ½-in tape width, which means that the tape can run at double its lowest theoretical speed (2×1.22cm/s) for the same tape area, thus easing the sound quality problem. (Conscious of the poor sound quality at these speeds Philips have added a dynamic noise suppressor to improve signal-to-noise ratio by 8dB to a weighted figure of 52dB; at 10kHz h.f. resonse is down 6dB on Grundig's Video 2x4 model and actually 8dB on the Philips VR2020). The track width chosen is a third less than that of Betamax (see table), and it is "dynamic track following" that has enabled the quality of their N1700 series to be maintained especially, they say, for still, slow-motion and speed-up playback, while reducing track width by a factor of four.

- Sales of video recorders in Federal Germany were 95,000 last year; 150,000 expected this year.
- UK imports were 29,000 for the first seven months of 1978; figure for same period 1979 is 100,000.
- In 1978 over half the value of imports to the UK were from Japan: in first six months of this year two thirds were. In terms of quantity the number of units from Japan is now three quarters.
- Exports to Europe from Japan amounted to about 55,000 units in 1978 first half; for the same period 1979 number is 206,722.
- Since 1976 Japanese production of video tape recorders increases at the rate of 600,000 a year.

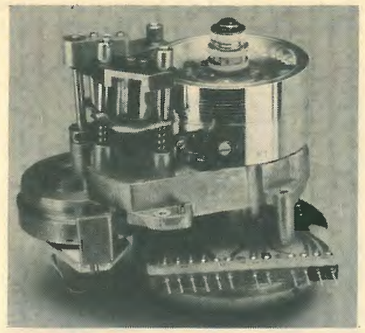
*Grundig have since announced signing of contracts on 5 September. Philips will hold 32.03% of Grundig EMV & Co KG, 67.97% of the capital remaining with the Max Grundig Trust. Cartel regulations restrict voting proportion to Grundig 75.5%, Philips 24.5%. Philips receive a loan from the Trust of 400 million guilder, convertible into 10 million Philips shares of 10 guilders each.

In this technique the positions of the two video heads on the head wheel are adjusted by piezoelectric actuators. And because of the absence of guard bands, the inherent by hysteresis in the actuator material and other tolerances, the two heads must be precisely aligned during recording. This is achieved by recording with one actuator in a nominal position and the other in a control loop. A signal, situated below the colour information in the spectrum at 223kHz, is recorded in the vertical blanking interval at the beginning of each track. Its amplitude value, lasting for 1½ lines, is stored and the heads switched to play so that crosstalk from the preceeding track containing a similarly recorded signal can be read, at a level that depends on its distance from the head.

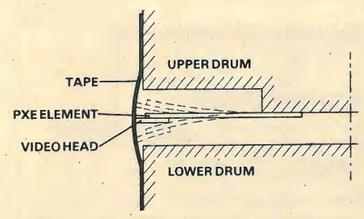
As displacement of the two tracks is less 1½ lines, each burst in a subsequent track finishes at the beginning of the burst of the one previously recorded. The difference is used to feed the head actuator so that a predetermined crosstalk figure is achieved.

The track following mechanism is al so operative on playback. To allow the side of the track and head to be identified four supplementary track-following signals have to be recorded on each of four consecutive tracks, and at four different frequencies that do not interfere with the picture signals (102, 117, 149 and 164kHz are chosen). Three frequencies are picked up and fed to a mixer, one from the track being followed and one crosstalk signal from each adjacent track, together with a reference signal of a frequency equal to that on the wanted track. The output contains sum and difference frequencies; filtering eliminates the sum signals leaving two difference signals that are rectified, compared and the resultant control signal used to actuate the corresponding head position and tape servo. This is the feature that enables the manual track control, needed in all previous systems, to be dispensed with. The sync track featured in other systems isn't needed either. (There are two, so far unused, control signal tracks in the V2000 format, which may be used for coded programme identification.)

The sequence of 'tones' is: head one records 102kHz, head two 117kHz, head one 164kHz and head two 149kHz. As a particular arbitrary example consider head one playing 102kHz with crosstalk frequencies of 117 and 149kHz appears, and if it deviates upward a 15kHz signal is produced. (For head two, playing 149kHz, a downward deviation provides 164—149=15kHz, whereas an upward deviation gives a high difference 49—102=47kHz.) Through a comparator and corresponding actuator these difference signal levels keep the heads in the correct position. If the two video heads move in the same direction, the control voltage is fed to the tape servo to move the tape and achieve correct alignment.



Tape consumption of the Philips/Grundig compact video cassette recorder works out to be 0.56 m² per hour – 35% lower than Betamax and nearly 50% lower than VHS – about 10 guilders per hour, say Philips. Kernel scanning assembly shown will be bought by Körting, Loewe, Metz, ITT.



Piezoelectric actuators allow video head movement to be controlled automatically both on record and playback with the aid of recorded guidance signals.

Relative head-tape speed is the other factor effecting tape consumption, being determined by the shortest recordable wavelength of about 1μm. The 5.08m/s speed derives from a tape speed of 2.44 cm/s — phase controlled by a 116.4 rev/min directly-driven tacho-capstan and reference oscillator (on record) of 419.376Hz — and a 65mm dia. head drum rotating at 1500 rev/min in the same direction as the tape. A photograph shows the head drum assembly with recessed guide groove, protruding spindle and slip rings, audio and erase heads and tape guides. The lower, fixed tape drum contains the motor for the upper head disc. Coupled to a 125-pole tacho generator, the disc triggers one pulse per revolution, which rate is compared with a 25Hz reference, obtained by dividing the vertical frequency during record and by a quartz oscillator during play. The whole scanning unit is factory-adjusted and can be readily exchanged during servicing. Philips say they will supply the assembly to "reputable" manufacturers.

As with earlier Philips and Grundig VCR machines angled heads at ±15° reduce crosstalk in the luminance region. And a comb filter and adder circuit is designed to eliminate crosstalk from the chroma signal, which is translated down to a 625kHz sub-carrier.

Microprocessor sequence control, search tuning and programmability are features of the first machines. The Philips model VR2020 stores 26 programme tunings (19 in the UK) and memorizes five recording times, with start and stop times, day and channel number for up to 16 days in advance. The Grundig Video 2×4 model however has an eight-station memory and allows programming of four times over a period of ten days, individually alterable. The two companies are of course quite free to produce completely different machines; the essential provision is that of complete interchangeability of cassettes, a feature guaranteed by the automatic track following technique. Price of the VR2020 model will be 20-30% higher than that of the N1702 recorder. Philips, Eindhoven say that both the N1500 and N1700 series will remain "as long as there is demand for them" but a later statement from the UK end that "the series will continue into 1980" is less open.

★ ★ ★

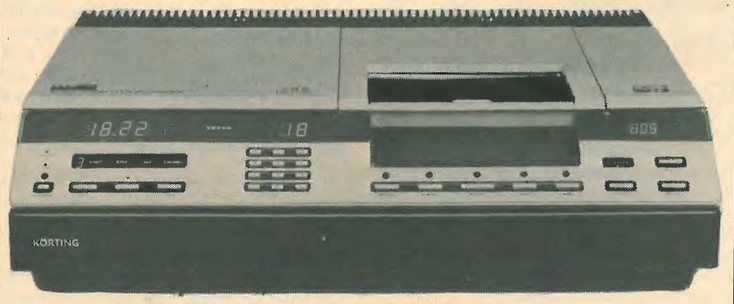
Back in 1974, the only video cassettes (Sony and VCR) lasted an hour at most and consumed tape at the rate of 6.6m² per hour or more. The announcement by BASF of a two-hour longitudinally-recorded cassette with a tape consumption of 2.3m² per hour looked good, especially as the 28 tracks on the 6.25mm tape could be copied simultaneously. Three years later, at the 1977 Berlin show BASF gave a progress report which showed it could get 48 tracks onto 8mm of tape; with a tape speed of 4 m/s and using 6μm-thick tape they could get up to two hours playing time. Since then, things have changed dramatically of course. LVR can no longer compete on the ground of tape consumption, nor on the basis of playing time, though BASF can now put 72 tracks on the tape and get a playing time of three hours. Claims laid to lightweight operation are being eaten away too — Hitachi announced an NTSC portable VHS recorder weighing 5.7kg, very close to BASFs 5kg — though it's pretty obvious LVR has potential for further miniaturization. Playing for three hours then, the BASF video cassette (cartridge?) measures 114×106×17mm and making it the world's smallest. Actually BASF wouldn't have been able to claim this distinction if they hadn't obtained an injunction preventing Blaupunkt from showing a miniaturized version. The two firms announced a licensing contract for the development of longitudinal video recording two years ago using the Newell tape transport

approach. Shortly after Blaupunkt were sponsored by the Federal ministry for research and technology to investigate the possibilities of an ultra-small drive unit that would play for 30 minutes and fit inside a video camera. On development of their Mini-Maz 1, as Blaupunkt called it, it seemed clear to BASF that some of their ideas had been used, at least from the account of it published in *Funkschau* (August 17 issue); hence its non-appearance at the exhibition.

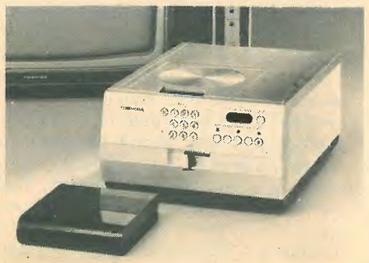
In the BASF recorder, shown for the first time in pre-production form at Berlin, the transport mechanism feeds tape longitudinally past the head. A central motor and capstan are in close contact with each of two tape reels. The combined magnetic head can be placed in any of 72 different positions on the 8mm tape and a display shows track position from 1 to 72. One pass through of the tape takes 2½ minutes, after which the head is stepped to the next track and the running direction reversed. Total running time is therefore 7×2.5 minutes, or 3 hours. Reversing is done in a period that is a multiple of the field time – in this case 100ms. Reversal starts at the beginning of a field and ends synchronously at the end of the fifth field and results in an almost unnoticeable interruption, comparable with a scene change. A timebase corrector reduces error on the combined video and sound signal to 60ns.

Characteristics of recent domestic video systems shows trend to narrower track width and lower tape consumption in helical scan systems

	VCR	VCR-LP	SVR	VHS (PAL)	Beta (PAL)	2000	BASF (Longitudinal)	Toshiba (Longitudinal)
Max. time (h)	1	2+	4	3+	3	8	3	1
Track width (μm)	130	85	51	49	33	22.5	100	50%
Tape speed (cm/s)	14.3	6.56	3.95	2.4	1.87	2.44	400	600
Tape width (mm)	12.5	12.5	12.5	12.5	12.5	12.5	8	12.5
Tape usage (m^2/h)	6.6	3	1.83	1.07	0.86	0.56	1.6	1.25
Write speed (m/s)	8.1	8.1	8.2	4.85	5.83	5.08	4	6
Drum diameter (mm)	105	105	105	62	74.5	65	—	—
Head angle (deg)	±15	±15	±15	±6	±7	±15	—	—



New front loading Video 2000 format is adopted by Philips, who will also make recorders for Körting (shown above), Loewe-Opta and Metz, and by Grundig who will also manufacture for ITT.



BASF say they will sell 5kg longitudinal video recorder next year (right-hand part of picture above) while Toshiba NTSC model (left) is still in the laboratory.

The recorded signal uses the "colour under" approach with two frequency modulated sound carriers of about 100 and 200kHz. BASF say the recorder could be used for high quality or studio sound application, in place of digital recording equipment, but their suggestion that "expensive digital recording techniques may become obsolete for consumers" is a little over-enthusiastic. Present audio capability of the video system is an improvement for video cassette recorders, with a response to 12.5kHz, a signal-to-noise ratio of 56dB, and a wow and flutter of 0.01%, thanks to the timebase corrector. An attractive feature – besides the potential for compactness that the transport gives – is that all 72 tracks can be duplicated in minutes in one pass. Marketing is planned mid-1980.

An engaging comparison of video recorders on the BASF stand showed a surprisingly similar performance on programme – at a somewhat superficial level between all the current formats, but the comparison didn't include the Toshiba longitudinal recorder, first shown at this year's Consumer Electronics Show, Chicago. This endless tape system uses a special lubricant layer backing on the tape and eliminates the signal breaks of the BASF LVR. Playing time is 17 seconds×220 tracks. The unit measures 250×140×330mm and the cassette 135×35×140mm. The NTSC prototype unit demonstrated gave rather poor colour and sound performance, but a good noise reduction system could easily improve the 40dB sound signal-to-noise ratio. Incidentally, Dolby Laboratories announced that the VHS group of manufacturers, Matsushita, Mitsubishi, Akai, Hitachi and Sharp, have all agreed to add Dolby B noise reduction (much needed) to the new two-channel VHS recorders as a standard feature.

★ ★ ★

Like the Dolby B system, Telefunken's High Com is a simplified form of a studio compander. Telefunken's approach back in 1970 was to look for a technique that would

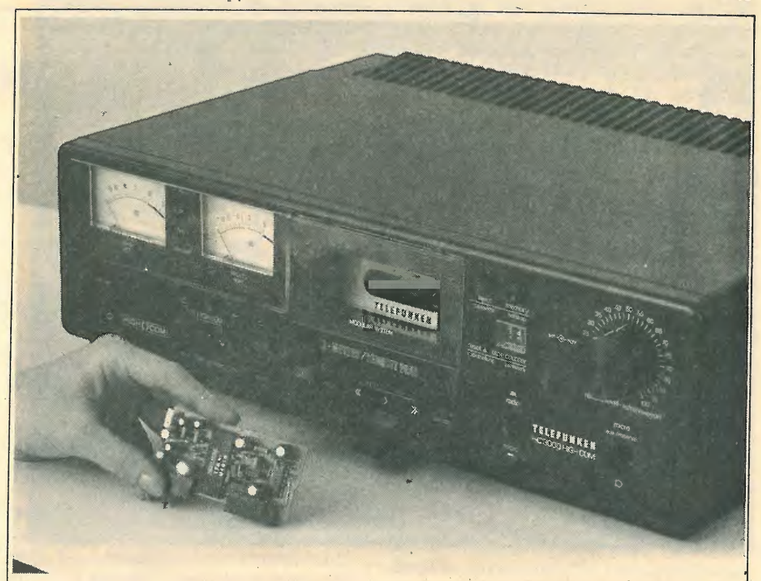
—provide adequate compression and expansion
—be complementary in behaviour, even with errors in the transmission channel
—not change spectral balance in the case of transmission errors
—reduce audibility of noise to at least that obtaining between signals, and
—not cause audible noise modulation.

The result, "telcom C4", appeared in 1974/75 featuring four independent bands so that attack and decay times could be optimized and masking made more effective. Attack time was chosen so that for transients gain adjustment is completed in a quarter-cycle of the uppermost frequency of the band; decay time is adjusted so that non-linearity distortion didn't exceed 0.1%.

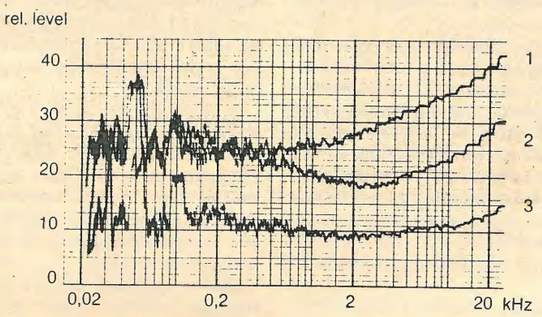
However the consumer type is a wideband compander, with fixed h.f. pre-emphasis during compression and de-emphasis on expansion acting to reduce audibility of noise when masking fails. Turnover frequencies are 1.2 and 8.6kHz. Noise suppression amounts to ZOdBA weighted (see Fig,); in "silent" passages, High Com gives 11dB less noise than Dolby B. Another difference of course is that this suppression is effective over the whole of audio band, including hum frequencies. And according to developer Gerhard Dickopp transmission errors of up to ±6dB in level —3dB at 10kHz do not result in any impairment in (static) amplitude response. Harmonic distortion arising from negative-going transients is given as 1% at 30Hz, reducing to 0.2% at 1kHz in less than 200ms. (Fig. shows response time to a positive-going transient.)

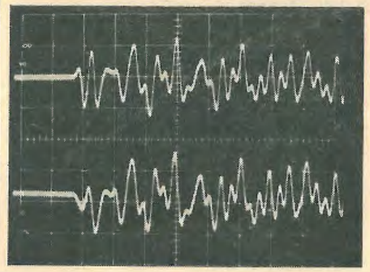
The Telefunken people didn't think the recent addition to the Dolby B system would alter things as far as High Com is concerned. By using the control signal of B-type circuitry, the HX or headroom extension technique adjusts recording bias and equalization automatically to allow recording up to 10dB higher in level at 10kHz (3dB at low and mid-frequencies). But a sentiment voiced more than once was that the improvement was too little, too late to present any real resistance to High Com.

Telefunken say they had made contact with 60 firms so far and had 30 "interested". Hans-Joachim Thuy, licensing manager for High Com, told us this had culminated in seven firm licensees in Japan and the USA. And they were expecting German cassette recorder makers to adopt it shortly, more or less *en masse*. Telefunken are initially supplying assembled compander boards to set makers for around DM20; and will hope to have a second source for the U401B i.c. used in the compander. Fifteen exhibitors displayed prototype High Com cassette recorders, though not all are licensees yet, including Aiwa, BASF, Blaupunkt, Eumig, Europhone, Grundig, Körting, Nakamichi (with a two-band version), Saba, Schneider, Uher, as well as Telefunken of course. Though Telefunken stopped making open-reel recorders almost two years ago, a separate noise reduction unit is planned for 1980 so that open-reel fans can benefit too.



First cassette deck using Telefunken High Com system for noise suppression offers 76dB signal-to-noise ratio.





Noise spectra of FeCr tape cassette without compander (1), with compander of Dolby B kind (2) and High Com (3).

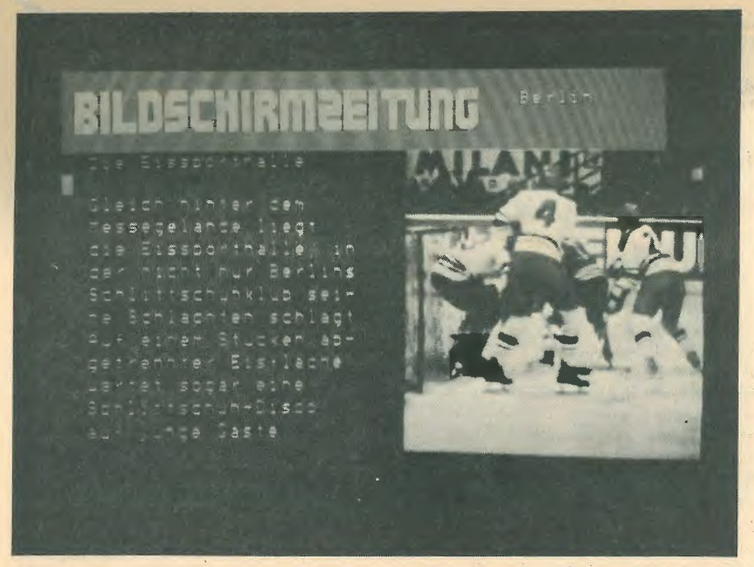
Waveforms from a struck triangle shows how quickly High Com compander responds to transient information (bottom trace is with compander; horizontal axis 200ns/div.)

1980 viewdata trial

Reported by D. Fishman

Viewdata, or to give it its German name Bildschirmtext, is big news in the Federal Republic of Germany at present. Introduced to the public for the first time in 1977 (see Berlin report, Nov. 1977, pp.46-9) it has made significant progress since then. At this year's Funkausstellung, Bildschirmtext was one of the major attractions and talking points, and emerged as a focal point of general and professional interest. To a casual observer, it looks remarkably like our own Prestel system. Small wonder, in view of the sale to the German PTT (Deutsche Bundespost) successfully concluded in 1977 by the GPO. This gave the DBP the right to use the software developed for Prestel, as well as the ability to draw on UK expertise and to benefit from the experience gained on the British system.

During the period 1977 to 1979 a "non-public" pilot trial has been started, based on a GEC-manufactured databank located in Darmstadt, near Frankfurt. This allowed the PTT, as well as potential information providers, to



Combination picture of text and tone made possible in BDZV two-way cable tv demonstration.

gain practical experience and to evaluate the potential of a future public service.

The Funkausstellung marked the beginning of the next phase, which consists of a large-scale field trial over a 12-month period starting in January 1980, and taking place simultaneously in Berlin and in the Düsseldorf area. It will involve some 6,000 users and the results will be evaluated by an independent research institution. In consequence, exhibits reflected the specific involvement of the different interested groups.

Manufacturers, notably Philips, ITT, Telefunken and Siemens, showed their latest models of colour tv sets with built-in decoders and remote-control units. The latter were mainly of the numeric variety, but some compact remote-control units with alpha-numeric keyboards, suitable for domestic users, were also on show.

German viewdata tv sets do not contain a built-in modem. Differing in this respect from the UK system, the modems are an external component which will be supplied and installed by the post office. During the current pilot trials, normal dial-up data modems (D1200S) were used. A new modem has now become available which is quite small and contains an autodialling facility. In future, an even smaller, miniaturised version will be manufactured and introduced into service.

Some of the manufacturers demonstrated auxiliary devices for attachment to their sets. In particular, printers were considered a useful option, enabling a permanent record of the screen display to be obtained. In several cases, use was made of the Olympia thermal printer, but the tendency seems to be to develop in-house manufactured printers. Optimism was shown regarding a low price to the consumer, once mass-production got under way. It was considered that the price wojld have to be under 500 Deutschmarks (about £120), and that this was an achievable target figure.

A prototype of a colour-printer was shown on the Siemens stand. The reproduction quality was very good, although the cost of this printer may well be above the level the average user would consider worthwhile, the business user may quite likely find this a very useful adjunct.

Other optional extras concerned storage facilities. These were either r.a.m. modules incorporated in the tv set itself and capable of holding a number of frames (as opposed to the standard single-frame storage), or external magnetic cassette attachments with, of course, unlimited storage capacity.

For information providers, manufacturers showed full editing keyboards, both as prototype and production versions, some with built-in storage capabilities to allow off-line editing. It was indicated that special editing systems were under development, as well as equipment containing floppy-disc drives with large capacity.

The Bundespost (PTT) was represented at a large stand which in fact was a complete section of one of the halls, where demonstrations and live entertainment shows took place, and do-it-yourself or rather test-it-yourself facilities were available to the general public. A directory was provided, listing the page numbers of the information suppliers which had provided information stored in the system. There were about 150 of these, including newspaper, journal and book publishers mail order houses, travel organisations, insurance companies, public organisations such as the German Automobile Club (ADAC) the meteorological office and others. The information could be called up from tv sets in the PTT display area, as well as from the many sets scattered around the whole exhibition.

Another group of exhibitors were the newspaper publishers who apart from supplying information stored in the system as mentioned earlier, also had stands of their own showing and explaining their involvement in the new medium. In cooperation with the well-known research establishment, the Heinrich Hertz Institute in Berlin, a group of newspapers, BDZV, showed a more advanced concept of home terminal, based on a two-way cable-tv communication system as a means of linking the terminals with the data banks. □

LITERATURE RECEIVED

Application notes from Tau-Tron describe properties of pseudo-random binary sequences **(p.r.bs)** and uses. Tau-Tron Inc., 27 Industrial Avenue, Chelmsford, MA, U.S.A. WW 401

Neosid **coil assemblies** and components are now available to the amateur in small quantities. A catalogue can be obtained from Small Order Division, Neosid Ltd, Eduard House, Brownfields, Welwyn Garden City, Herts AL7 1AN. WW 402

Microcomputer components, kits and service detailed in a catalogue from Transam, makers of the Triton computer. Triton kits and extensions, i.c.s, tools and hardware, with prices, Transam Components Ltd, 12 Chapel Street, London NW1 5DH. WW 403

Booklet explaining use of **selective paging** as a public service produced by European Selective Paging Manufacturers' Association, Gerretsonlaan 2, Eindhoven, Netherlands. WW 404

"A Low Cost Log IF" is an applications booklet on the Plessey SL1613C i.c., which has a bandwidth of 15MHz at a centre frequency of 30-60MHz. Booklet describes design of log. i.f. strip, with p.c.b. pattern, using nine i.cs. Semiconductor Specialists, Premier House, Fairfield Road, West Drayton, Middx UB7 8EX. WW 405

Leaflet on Shure SC39 series of **pickup cartridges** for professional use obtainable from Shure Electronics Ltd, Eccleston Road, Maidstone ME15 6AU. WW 406

Survey of market prospects for **television and radio** manufacturers, published by Keynote Publications Ltd, 22 Danbury Street, London N1 8JU. This nine-page, typed document costs £12.25.

Electrostatic headphones

Constructional design with improved acoustic output

by N. Pollock M.E., M.I.E. Aust.

The electrostatic headphone designs previously published in *Wireless World,* while giving good results, cannot produce high sound pressure levels. They can also be difficult to construct due to the small diaphragm-to-plate clearances required. The headphone and matching driver amplifier presented here attempt to alleviate these problems.

THE SOUND PRESSURE output of a push-pull electrostatic transducer is directly proportional to the differential plate drive voltage, the diaphragm polarizing potential and the reciprocal of the square of the plate spacing. Unfortunately, the polarising potential is dependent on the plate spacing and a high acoustic output can only be obtained by using a high plate drive voltage.

As far as I am aware all commercial electrostatic headphones use wide range step-up transformers to produce the necessary plate voltage when driven by a low voltage power amplifier. Unfortunately the design and construction of a suitable transformer is very difficult due to the high inductance, low capacitance and good insulation requirements. Because of these difficulties, most constructional designs are driven directly by high voltage amplifiers. Valve [1,2] and transistor [2,3] amplifiers have been used but in all cases the h.t. supply has been less than 400V. For convenience the amplifier h.t. supply is normally used to provide the diaphragm polarizing potential. With a 400V potential the minimum spacer thickness (plate spacing/2) is about 0.5mm which places stringent requirements on plate flatness and diaphragm tension.

Headphone units with the above specifications are limited to a maximum free field r.m.s. sound pressure (rel. 0.00002 Pa) of about 93dB. For orchestra music at realistic volume levels a sound pressure capability of around 100dB is necessary and for rock music even higher levels are desirable.

Amplifier design

Most transistors currently available have a maximum V_{CE} of less than 400V. However, there are a number of special devices designed for tv horizontal deflection circuits which have peak V_{CE} values of about 1.5kV and power ratings of 10W or more. The present design is based on the Matsushita 2SD 200 but other types such as the BU206, BU209A, MJ105, PTC 146-RT or SK 3115-RT can be directly substituted.

The circuit in Fig. 1 is a development of an amplifier described in reference 3. Two high voltage class A amplifiers are used, one of which is driven by a unity gain inverting buffer. Operation of the amplifier is quite straightforward but it must be remembered that the LM3900 is a current input device[4] with both inputs clamped near earth. All of the amplifiers are biased from the high and low vol-

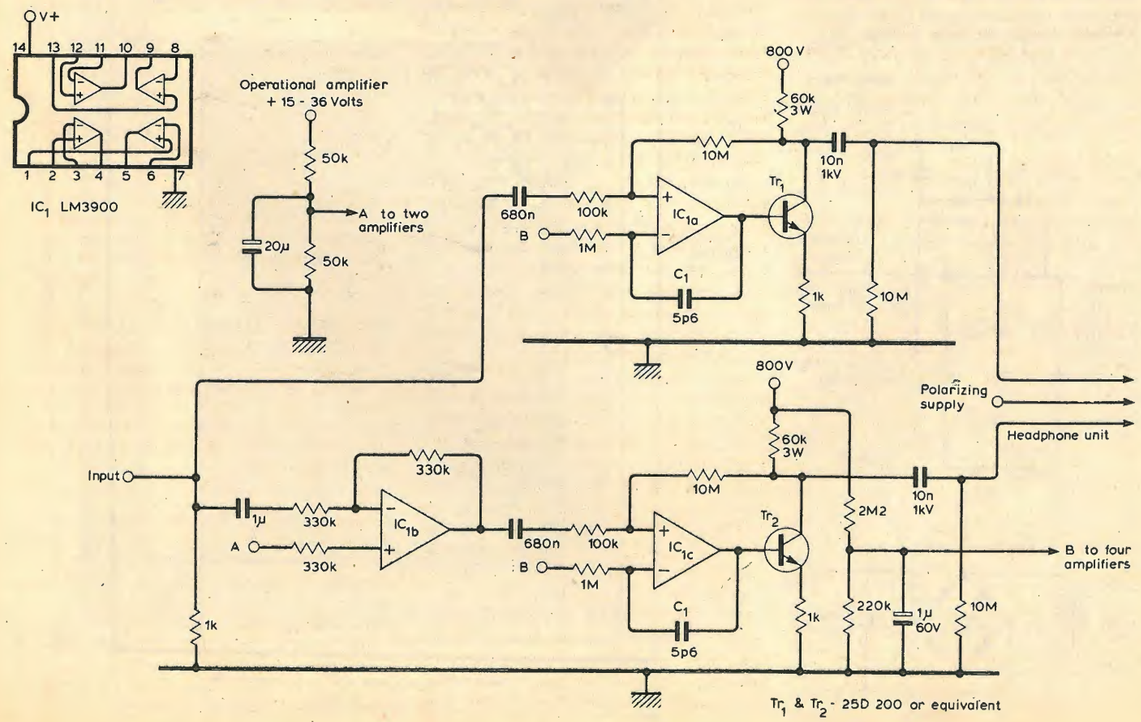


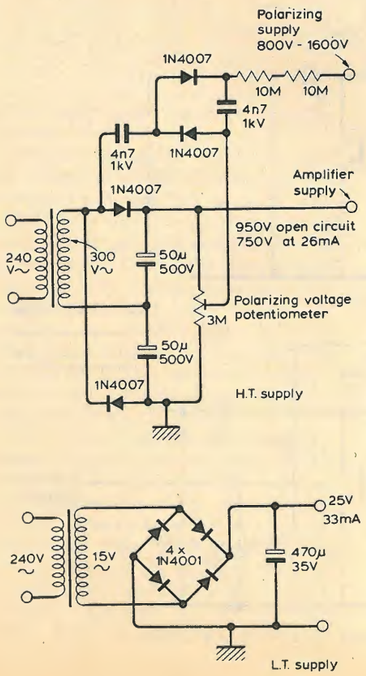
Fig. 1. *Amplifier for one channel. Note that the bias sources A and B supply both channels.*

tage supplies so no circuit changes or adjustments are required if the supply voltages are altered. The suggested h.t. of 800V allows the transistors to operate well within their safe operating area. The prototype functioned satisfactorily with a 900V supply, but above this the transistors may suffer from secondary breakdown.

A headphone amplifier sensitivity of 2.8V r.m.s. for maximum output was selected so that it could be driven from the headphone output provided on most amplifiers. A 1kΩ resistor from the input to ground prevents amplifier oscillation when the input is not connected. The prototype was built on two pieces of Veroboard to keep the high and low voltage circuits separate. This arrangement limits the possibility of damage due to construction errors and helps amplifier stability. If instability occurs, the value of C_1 can be slightly increased. The transistors are mounted on small separate heat sinks to avoid the insulation problems of a common heat sink.

The power supply design depends on the transformers available. The prototype used a valve power transformer with a 300V winding to drive a full-wave voltage doubler for the amplifier h.t. supply as shown in Fig. 2. The polarizing supply was produced by a half-wave voltage doubler connected to a potentiometer across the amplifier h.t. supply. Because the headphone diaphragms have a long charging time constant, filtering of the polarizing supply was not considered necessary. A separate

Fig. 2. *Power supplies. The l.t. supply should be decoupled with 0.1μF disc ceramic capacitors near to each i.c.*



15V transformer was used to provide the amplifier l.t. supply, but if the high voltage transformer also has a 6.3V filament winding, this can be used with voltage doubling.

It is important that the amplifier and power supply are housed in a metal case which is ventilated and connected to mains earth. To avoid ground loops the headphone amplifier signal earth should be derived from the amplifier

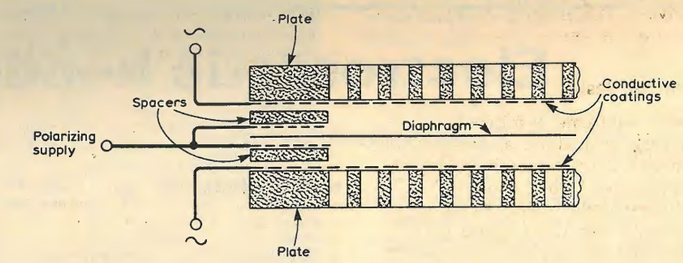
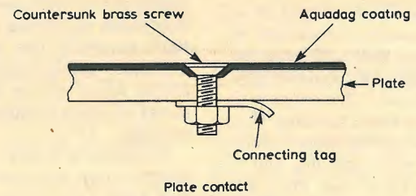
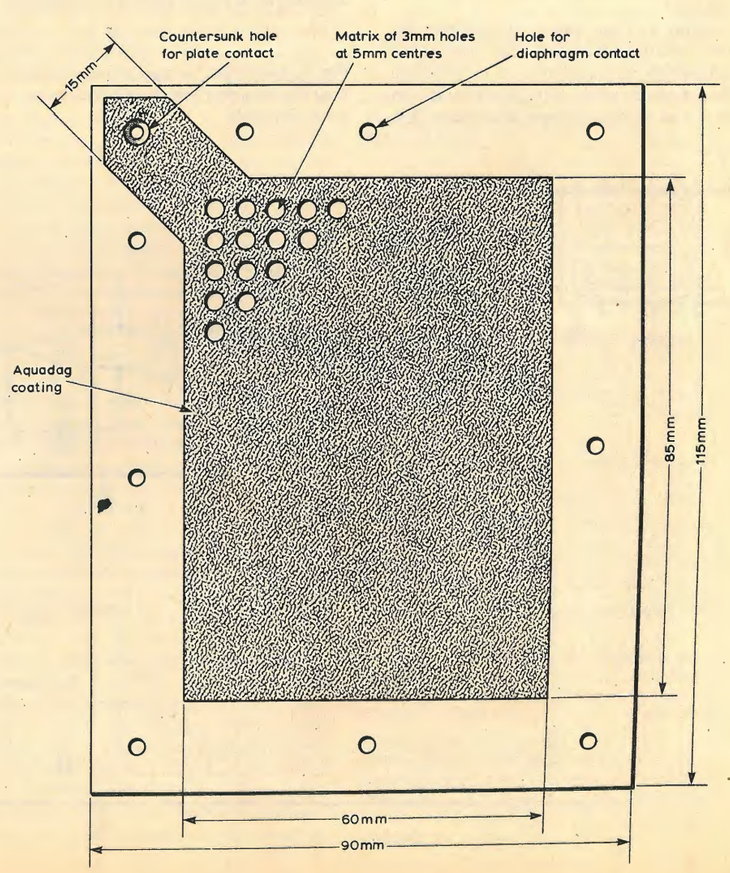


Fig. 3. *Cross-section of a headphone assembly.*

Fig. 4. *Fixed plate construction. Two symmetrical plates are required for each transducer. The matrix of 3mm holes should cover the rectangular conductive area. Aquadag is available from BDH Chemicals, Broom Road, Poole, Dorset.*





that drives it. Performance details of the amplifier are shown in Table 1.

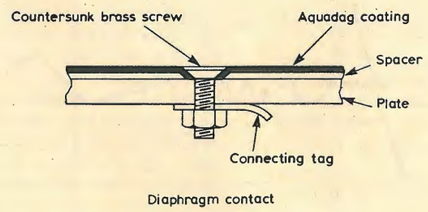
Headphone design

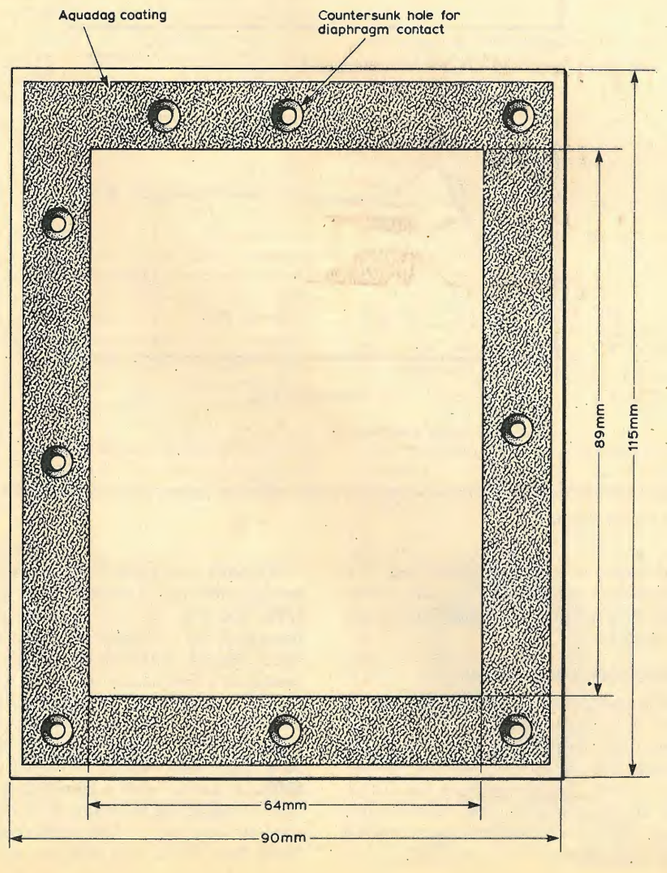
The basic requirements for electrostatic headphone transducers, covered in references 1, 2 and 6 and the appendix, are summarized below. The area of the transducer should be large enough to completely cover the ear and give an acceptably low diaphragm resonant frequency without accurate control of the diaphragm tension. The area of the transducer should not be larger than necessary because the interplate capacitance and the problem of drive amplifier design increases with area. For maximum acoustic output the spacer thickness should be as small as possible consistent with unrestricted low-frequency diaphragm movement. The plates must be rigid, at least 20% open and have a perforation spacing much smaller than the shortest wavelength to be reproduced. The surface resistance of the diaphragm must be sufficiently high to prevent charge migration at the lowest frequency to be reproduced. Sufficient acoustic damping must be provided to damp the diaphragm resonance and to prevent ringing on transients. The rear of the diaphragm should radiate freely to the air.

Table 1. Amplifier performance. All measurements were made with the headphone transducers connected which provided a plate-to-plate capacitance including leads of about 100pF.

Small signal frequency response	3Hz to 25kHz
Maximum differential push-pull output	1400V pk-to-pk at 5kHz
Differential slew rate limit	25V/μs
Signal-to-noise ratio relative to 1400V	better than 83dB
Maximum distortion before clipping or slew rate limiting	0.1% 20Hz to 20kHz 0.01% below 5kHz

Fig. 5. *Spacer construction. This "gasket" is 0.8mm thick and can be constructed from any flexible insulating material.*





Construction

Following the guidelines mentioned above, the headphone design has been optimized for use with the amplifier in Fig. 1. A cross section of the headphone transducer is shown in Fig. 3.

Cut four plates from a sheet of 3mm acrylic, such as Perspex, to the size shown in Fig 4. Drill a matrix of 3mm holes in all four plates which should be clamped together so that they can be drilled simultaneously. A piece of Veroboard clamped on top of the plates makes a useful drilling guide. Drill a countersunk hole in one corner of each plate so that the head of a M2.5 or M2 brass screw will lie slightly below the surface. Roughen the surface of the plates and remove the sharp corner of the countersunk hole with fine wet and dry paper. After masking the plate as shown in Fig. 4, paint the surfaces and the countersunk holes with a smooth generous coat of Aquadag. After fitting screws into the countersunk holes with tags under the nuts, the resistance between the tag and any point on the plate should be less than 10kΩ. If the resistance is greater add another coat of Aquadag. To prevent localised breakdown of the airgap in high humidity conditions, the Aquadag is painted with a coat of clear polyurethane varnish. When the varnish is dry, rub the surface lightly with fine wet and dry paper to remove the gloss which tends to stick to the diaphragm.

Cut four spacers, 0.8mm thick, to the size shown in Fig. 5. The spacers can be constructed from any good insulating material, I prefer plastic drafting film laminated to produce the required thickness using rubber contact adhesive. This material is easy to cut and flexible enough to clamp the diaphragm around its entire circumference when the transducer is assembled. After sticking the spacers to the coated faces of the plates, drill suitable countersunk holes for the diaphragm contacts. Place the two pairs of plates and spacers face to face and drill for the assembly screws. To provide connections to the diaphragm, the four spacers are painted with generous Aquadag coatings as shown in Fig. 5. These coatings must extend to the inner edge of the spacer and into the countersunk hole, but must be kept clear of the mounting screw holes. After fitting the diaphragm contact screws check that there is a resistance from the connection tags to all points on the Aquadag contacts.

The diaphragm material that I used was a 0.0127mm soft plastic foodstuff wrapping film. From its behaviour it appears to be identical to Vitafilm [1,2]. After extensive experimentation with high resistance coatings I found that the uncoated film, with its very high surface resistance, gave excellent results provided that the diaphragm contacts were arranged as described. This method removed one of the most difficult steps in headphone construction.

To assemble the diaphragm cut a hole somewhat larger than the plates in a rigid sheet of cardboard, stretch a piece of diaphragm material across the hole and attach it to the cardboard with adhesive tape. When the film has been made wrinkle free, place a plate and spacer assembly on each side of the film, hold them firmly together and bolt the complete unit via the pre-drilled holes and diaphragm. Finally, cut the protruding diaphragm film around the outside of the assembly with a razor blade.

To test the headphone units, connect the drive amplifier with the polarizing potential set to its minimum value of 800V and check that the diaphragm remains central. If the diaphragm attaches itself to one plate or oscillates at a low frequency it must be tensioned. This can be done by heating the headphone assembly with a radiator or light bulb until the diaphragm wrinkles at which point it is left to cool.

After testing both units connect the leads to the headphones and insulate all exposed contacts with silicone rubber. The drive units should then be enclosed in acoustic dampers constructed from envelopes of 6mm foam plastic. These envelopes may be sewn around the edges of glued with rubber contact adhesive. The drive unit mounting arrangement will depend on the preference of the constructor. The prototype used an acrylic bridge between two of the assembly screws which protruded through the foam plastic dampers. This bridge was then attached to the headband from an old pair of headphones as shown in Fig. 6. The connecting wires between the headphones and amplifier should be less than 1.5m long and loosely bundled rather than twisted to minimize their capacitance.

With both transducers connected to the amplifier, increase the polarizing potential to just below the value which causes diaphragm collapse or airgap breakdown. For the prototype a maximum potential of 1.3kV was set by the onset of low frequency clicking sounds.

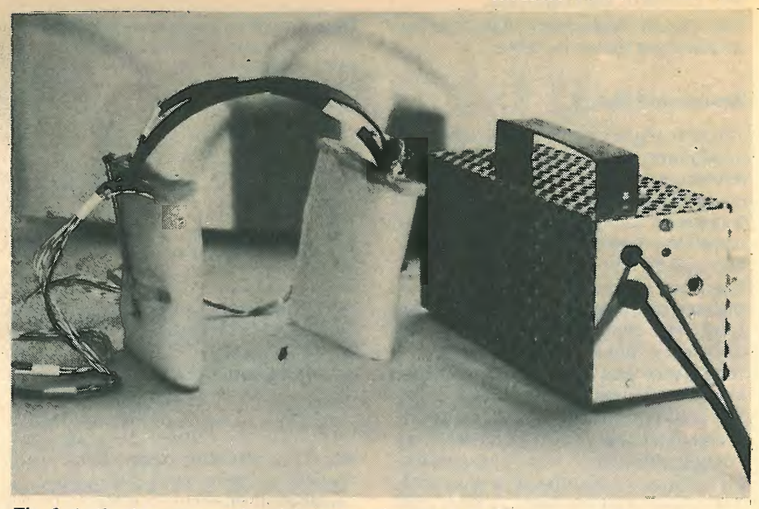


Fig. 6. *Author's prototype headphones and power supply.*

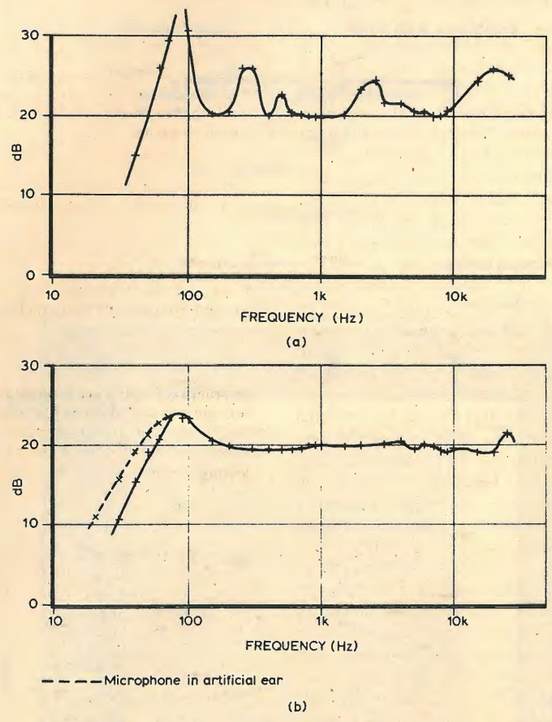


Fig. 7. *(a) Headphone frequency response without foam plastic dampers and (b) with dampers.*

Safety

Although the high impedance of the polarizing supply ensures that it is not lethal, an uncomfortable shock can be received from the plates at high output. The foam plastic envelopes and the insulation on the connecting leads must be inspected at regular intervals. Provided that these precautions are taken and common sense is exercised, the headphones are completely safe. However, they are not recommended for use by children.

Headphone performance

Performance measurements were made with a 12.5mm diameter B & K condenser microphone in contact with the centre of the damper or the centre of the plate when the damper was not fitted. For absolute sound pressure measurements the system was calibrated with a B & K pistonphone.

Without the plastic dampers the headphones had a resonance at about 85Hz, see Fig. 7a, and a pronounced overshoot on the recovery from transients, Fig. 8a. Addition of the dampers produced a frequency response within ±5dB between 40Hz and 30kHz with no overshoot on transients as shown in Figs. 7b and 8b. Placing the microphone in a crude artificial ear, comprising a 6000mm³ cavity with a 20mm diameter orifice contacting the damper, extended the low frequency —5dB point down to 20Hz. Brief tests with the microphone moved away from the centre of the headphone unit indicated that the average response over the whole diaphragm area was much flatter than shown in Fig 7b. The r.m.s. sound pressure produced by a 1400V peak-to-peak differential plate voltage at 100Hz to 5kHz was 102dB (rel. 0.00002 Pa).

During extensive tests no difficulties were experienced with the uncoated diaphragms. When the polarizing potential is applied, the charge spreads over the diaphragm and the headphone output rises to its full value within a few seconds. Under extremely dry conditions it is conceivable that the surface resistance may become sufficiently high to prevent charge spreading. If this occurs, gentle breathing on the diaphragm through the dampers should provide a cure. It should be noted, however, that even a fine piece of fluff bridging the diaphragm-to-plate gap will bleed away the diaphragm charge and reduce the headphone output.

Listening tests have been made with a wide range of music. The audible performance is marked by great clarity and I have detected no faults. The acoustic output levels are more than adequate for most listeners but some rock music enthusiasts might prefer another 10dB. The quality of the recordings and reproduction equipment is very important because all defects are heard much more clearly than with loudspeakers or inferior headphones. This problem with programme source quality was also noted in ref. 1. However, with the best available recordings and good quality equipment, very impressive results are obtained.

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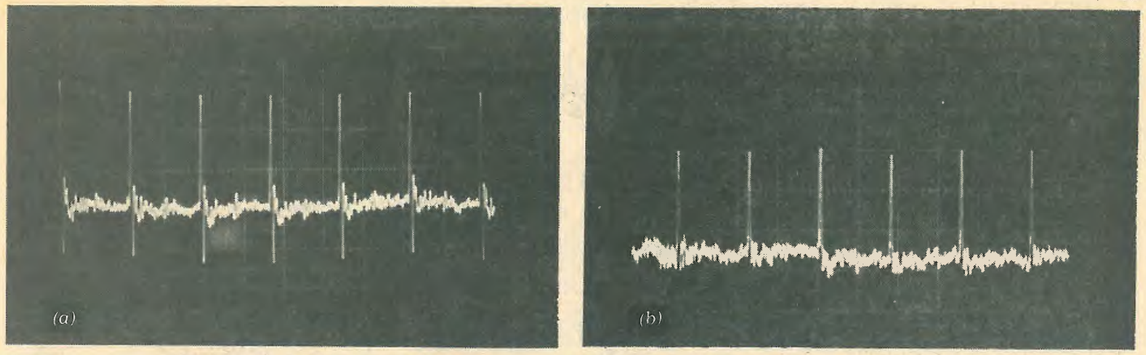


Fig. 8. *Headphone response to 20μs pulses at 1kHz (a) without dampers and (b) with dampers.*

Appendix

Factors affecting acoustic output

For a push-pull electrostatic transducer with a diaphragm centrally mounted between two plates

$$F=\frac{eQ}{zd} \quad (1)$$

where F is the force acting on the diaphragm, e is the differential plate voltage, Q is the total charge on the diaphragm and d is the spacer thickness. Also,

$$Q=EC \quad (2)$$

where E is the polarizing potential, C is the total diaphragm-to-plate capacitance. And,

$$C\propto\frac{A}{d} \quad (3)$$

where A is the diaphragm area. By combining the above equations we can show that

$$F\propto\frac{eEA}{d^2} \quad (4)$$

In practice E and d are interrelated by airgap breakdown and diaphragm stability. Hunt[6] has shown that for diaphragm stability, the maximum value of E is limited in the following manner

$$E_{max}\propto\left(\frac{Td^3}{A}\right) \quad (5)$$

where T is the diaphragm tension.
From the last two equations the maximum diaphragm force, and hence the maximum acoustic output, is given by

$$F_{max}\propto e\left(\frac{AT}{d}\right)^{½} \quad (6)$$

If the transducer completely covers the ear, the force per unit area is a more relevant parameter and the above expression can be re-written to give

$$\left(\frac{F}{A}\right)_{max}\propto e\left(\frac{T}{Ad}\right)^{½} \quad (7)$$

or

$$\left(\frac{F}{A}\right)_{max}\propto e\left(\frac{T^2}{A^2E}\right)^{½} \quad (8)$$

The maximum polarizing potential that can be used before the diaphragm-to-plate airgap arcs is given by

$$E_{max}\propto d \quad (9)$$

therefore

$$\left(\frac{F}{A}\right)_{max}\propto\frac{e}{d} \quad (10)$$

or

$$\left(\frac{F}{A}\right)_{max}\propto\frac{e}{E} \quad (11)$$

For the diaphragm tension and dimensions of a typical headphone transducer, diaphragm instability usually occurs before airgap breakdown so equations 7 and 8 should be used. For high frequency transducers using high tension diaphragms, equations 10 and 11 would probably be appropriate.

From equations 7 and 8 the design requirements for a high output transducer are; a high diaphragm tension and small diaphragm area to give the highest acceptable diaphragm resonant frequency. The smallest plate spacing consistent with low frequency diaphragm movement and manufacturing difficulty.

It is important to note that a reduction in output caused by increasing d cannot be offset simply by increasing E.

The author

Neil Pollock studied mechanical engineering at Melbourne University and, after graduating, spent three years working with aircraft flight test instrumentation. Neil then gained a masters degree for work on the design of aerofoil sections for transonic speeds. He also has an interest in electronic and optical instrumentation for wind tunnels. Neil says his main hobby is designing unconventional mechanical and electronic devices which avoid the normal textbook method. He also admits that, although interesting, his approach is not always as good as the standard method.

Transatlantic meteor scatter?

Over three decades, amateurs have been striving to achieve two-way contact across the Atlantic on 144MHz by a variety of propagation modes: tropospheric ducting; double-hop Sporadic E; auroral reflections, etc. So far only "moonbounce" and the amateur satellites have yielded results. But a recent determined attempt to get across by means of scattering from meteor trails came very near to success.

In a six-hour test at the peak of the Perseid meteor shower members of the "Lizard Expedition Group" (G3SEK, G4ANB, G4ASR, G4DEZ, G4DGU, G8HDR, G8KQB and G80AC) operating G4DGU/P from Predannack Head on the Cornish coast endeavoured to contact the Canadian station VE1ASJ operated by Andy McLellan in St John, New Brunswick, a distance of 4470km.

Signals were received in both directions, although no positive identification proved possible. The signals recorded in the UK exhibited noticeable decorrelation: spectral spread and Doppler shift were both present. A maximum burst length of about 750 milliseconds was observed, with typical signal strengths of the order of 0dB s/n in a bandwidth of 2.5kHz. More detailed analysis of the tape recordings may reveal further information.

"TEST" not CQ

The death of Wing-Cmdr John Scott-Taggart, OBE, MC (News, October issue) has diminished still further the small number of people who can claim to have held one of the old "three-letter" experimental (amateur) call-signs issued before the outbreak of World War 1. His call was then LUX and in 1920-21 he became the first owner of the call 2LR. In 1924, as publisher of *Wireless Weekly*, he joined forces with *Wireless World* when both journals offered to put the sum of £500 each to support the RSGB in fighting a test case if the Post Office enforced a new licence condition which stated: "Messages shall be transmitted only to stations in Great Britain and Northern Ireland which are actually co-operating in the licensees experiments and shall relate solely to such experiments" — in other words a complete ban on random contacts or indeed *any* overseas contacts. The spirited opposition to this harsh edict led to a face-saving compromise by the authorities: overseas contacts and general working were permitted provided that the British stations were carrying out "tests": what this soon came to mean in practice was simply that British amateurs called "TEST" and never "CQ," and this remained a feature of British amateur operation right up to the ban on all amateur operation imposed 40 years ago just before the outbreak of World War II.

WORLD OF AMATEUR RADIO

The death of Capt. S. R. Mullard (News, this issue) also marks a break with the first valves used by British amateurs just after World War I.

Amateur satellite progress

The British UOSAT project (WoAR, April 1979) is making steady progress in spite of difficulties that have been experienced at the University of Surrey in finding a second full-time engineer with the necessary practical experience to work on the project. Small teams at Sheffield and Leeds universities, Marconi Instruments and Marconi Space and Defence Systems (Stanmore) have been making design studies for the proposed microwave beacons, though these depend on the outcome of WARC79. Evaluation of solar cells indicates that five panel strings may be needed to supply the 14V nicad battery.

It is anticipated that effective radiated powers (power in the antenna multiplied by antenna gain) of about 1kW in the 432MHz band will be needed to access the Phase 3-A high altitude, long-lifetime AMSAT satellite expected to be launched next Spring. This should have a period of about 660 minutes with a apogee of 35,000km and perigee of some 1500km and should be accessible from virtually any part of the world for at least some period each day. Down signals will be in the 144MHz band.

Scanning the news

The RSGB Sunday-morning news bulletins ("GB2RS") are being extended by the addition of a 7047.5kHz a.m. transmission at 1100 hours local time, usually from the station of Gordon Adams, G3LEQ at Knutsford, Cheshire. Coverage is likely to be highly dependent upon "skip distance" although at present there is often virtually no dead zone. The transmission can be received by short-wave listeners having only conventional "all-band" receivers. There are now seven GB2RS transmissions on 3650kHz on s.s.b. or a.m. from different sites, eight s.s.b. transmissions on 144.250MHz and some 19 n.b.f.m. transmissions on 145.525MHz.

FM News reports that the Home Office has agreed in principle to a detailed plan for additional 144MHz n.b.f.m. repeaters in the London area including GB3SL at Crystal Palace, GB3WL at Hillingdon, GB3EL at Havering Atte Bower, GB3NL at Enfield. However, it is clear that groups are not being encouraged to apply for permission to operate linear or cross-band repeaters.

A Dutch beacon station, PAoJTA on 148.82MHz, is being operated as an auroral and Sporadic E aid, being switched on only during periods when such propagation conditions have been observed.

Amateur radio made news when during the aftermath of hurricane "David" when a battery-operated amateur station was for a time the only link out of Dominia, and was used also by Government ministers to speak to the stricken islanders. Amateur radio also provided emergency communications following the bad floods in India.

One hears increasingly complaints about the now excessive number of "contests" that seem to take over the bands — particularly on h.f. — almost every weekend. There is strong feeling among those who do not want just to swap numbers that enough is as good as a feast. One wonders which national society will be considerate enough to announce their intention of holding fewer rather than more contests?

In brief

The Luxembourg amateur LX1DB, well known for moonbounce operation on 432MHz, is now active also on this mode on 1.3GHz including contacts with California .... There is now appreciable activity by Russian amateurs on the 1.8MHz band and signals from the Baltic countries, White Russia, the Ukraine and the Moscow area can be heard most evenings . . . New callsign prefixes (Y21 to Y29) are due to be introduced soon in East Germany to replace the familiar "DM" — a pity since DM comes easier off the key than Y29 .... Richard Thurlow, G3WW has now worked over 1250 different slow-scan tv stations in 99 countries .... Despite the introduction of multiple-choice questions in the May Radio Amateurs' Examination most candidates had to wait until early September to learn whether they had passed . . . Angus Taylor, G8PG received strong support for his plea for the introduction of a novice licence in the UK (letters, June, p82) with more than 250 people indicating their support for the proposal. . . .The Science Museum GB2SM station now includes a special collection of miniature h.f. equipment originally designed for "clandestine and infiltration" purposes from about 1940 up to about 1960.

PAT HAWKER, G3VA

NEWS OF THE MONTH

WARC 79 starts in dissension

Influence of the non-aligned nations

The opening of the World Administrative Radio Conference at Geneva was delayed for three days because the delegations from the 148 nations represented were unable to agree who should be chairman of the ten-week event. This delay and dissension was "unprecedented" according to one official of the International Telecommunication Union, which has organized the conference (see October issue, pp. 51-53 for background). The disagreement seemed to be not so much an East-West matter but a result of the fundamental differences between the interests of the rich industrialized nations of the northern hemisphere and those of the developing countries of the southern hemisphere — the so-called North-South struggle. The poorer part of the world was represented largely by the group of politically non-aligned nations which had met earlier this year at a political summit at Havana. This group held a meeting of its own at Geneva, and at one point it was thought these nations would force in their own candidate as chairman because their number would ensure a majority in a vote.

The question of who is chosen as chairman at this conference is a highly sensitive matter, first because WARC 79 itself will set the pattern of radio use — notably in frequency allocations — for the next twenty years, and secondly because the way the chairman controls the discussions leading to decisions is obviously influenced by his background, predilections and any political pressures to which he is subject.

Early candidates proposed were Derek Rose of New Zealand, T.V. Srirangan of India and Henry Kieffer of Switzerland, but none of these proved to be acceptable to everyone. Eventually, at an afternoon meeting on September 27, the heads of the delegations agreed on R.J.P. Severini of Argentina, and the plenary assembly of the conference was able to start on the same day with Mr Severini in the chair.

Member countries of the ITU had submitted some 14,000 proposals for revisions to the existing Radio Regulations (the UK proposals are summarized in the July 1978 issue, p.47, and June 1978 issue, p.57). Preparatory documentation for the conference amounted to some 7000 pages, and 2500 copies of these were printed in three languages. In addition to the 148 national delegations taking part, 38 international organizations (such as the EBU and the OIRT) sent along their observers. The UK delegation consisted of 33 people, headed by D.E. Baptiste of the Radio Regulatory Department of the Home Office.

British c.b. "could not be on 27MHz"

As this issue is published Parliament is returning from its summer recess and the all-party committee of MPs which is pressing for a citizens' band in the UK almost certainly will be meeting the Home Office for further discussions. Meanwhile, a report on c.b. prepared by the Home Office's Radio Regulatory Department has been sent to the Home Secretary, Mr William Whitelaw, for consideration and, according to the Citizens' Band Association, some "important admissions" have been made by the Home Office. These are, first, that no change in the law is necessary for them to authorize c.b. in the UK; second, the current WARC 79 in Geneva is irrelevant to whether or not the British Government legalizes c.b. purely within the UK; and third, it is really up to the Government to show why c.b. should *not* be introduced rather than up to the pressure groups to show why it should be.

An important point to come out of a meeting earlier in the year between the committee of MPs and the Home Office was, according to the CBA, that both sides were unanimous in agreeing that any c.b. in Britain could not be on 27MHz. The Home Office "took the view that the rapid growth of illegal 27MHz use had no bearing on the case for legalization of another frequency since 27MHz users were criminals and should be treated as such. The Committee did not press the point at the meeting but both they and the CBA believe that if illegal 27MHz use is simply ignored it will not go away but may cause a delayed decision to be in favour of 27MHz – against the wishes of almost all parties – simply because too many people will be using it."

● Pye Telecommunications, whose associated company Philips-TMC make u.h.f./f.m. citizens' band equipment in Australia, have issued a public statement recommending the u.h.f. band for any c.b. system in Britain. Their reasons are: u.h.f. is more suitable for the high population density in the UK; narrow deviation f.m. at u.h.f. allows more users in a given spectrum space because of increased re-use of channels by the suppression of weaker signals — the "capture effect"; avoidance of interference with domestic radio, television and other equipment; avoidance of poor grade service experienced on 27MHz due to congestion resulting from long-range propagation — skip effect; avoidance of harmonic interference with other radio communication users — police, fire, ambulances, etc; avoidance of the problem of re-allocation of existing users, which would make 27MHz c.b. slow and costly to implement; and u.h.f. has high quality transmission and reception as well as predictable range and channel re-usability.

ERA NAME CHANGE

On September 1, the Electrical Research Association Ltd changed its name to ERA Technology Ltd in order to reflect adequately the extensive services which they now provide for clients throughout the world.

ERA was incorporated in 1920 to undertake co-operative research in the electrical industry and was in fact one of the first UK industrial research associations to be formed. In 1969 it became the first such body to become established commercially and in 1973 it relinquished all its remaining government grant aid. This year the company celebrated its first decade as an independent contract research organisation with the announcement of record results – an income totalling £2,957,230. Today ERA employs 300 staff of which 160 are technically qualified.

Prestel to test international market

Britain is to begin experiments with an international viewdata service later this year. Mr Peter Benton, managing director of PO Telecommunications, said when he announced the trial, "We are not yet certain that a full Prestel international service would be a viable proposition, but there has been sufficient interest in the prospect to justify launching a market trial which, as well as giving us evidence of demand, will give us practical experience in resolving the many technical, social and legal problems associated with moving Prestel from the national to the international arena."

It is hoped that the trial will identify the kind of information which today's businessman, or government official, needs to know, but cannot obtain quickly, so that the new service could then provide this information almost instantly. The trial will be open to selected users in up to seven countries – the UK, Australia, the German Federal Republic, the Netherlands, Sweden, Switzerland and the United States. Information offered will include stock markets, currency exchange rates, airline schedules, shipping news, commodity prices, economic analyses and company news, drawn from many parts of the world. Logica Ltd, who carried out an evaluation of the potential market for the Post Office, will be assisting in implementing the trial which is expected to last about one year. Discussions are now taking place with the countries' telecommunications authorities, information providers, and the tv set manufacturers who will be needed to supply a few hundred terminals required for the trial.

Post Office comes under the knife

Sir Keith Joseph, Secretary of State for Industry, announced at a press conference in London on September 12 that the government intended to separate the Post Office into two Corporations, one for posts and giro, and the other for telecommunications. In addition, he added that they would also begin consultations "with a view to early relaxation of the operation of the Post Office's telecommunications monopoly." This follows discussions (see p.73 September 1979 issue) in the House of Commons and the House of Lords on points relating to the monopoly, raised in the Carter Report (see p.51, September 1977 issue).

"It is now two years," Sir Keith said, "since the Carter Committee recommended that the Post Office should be divided into two independent Corporations, one for posts and giro and the second for telecommunications. I have now been able to consult the Chairman of the Post Office, the Post Office Users' National Council and other interested parties, including the Trade Unions." He continued, saying that there was a broad measure of support for the proposed division, even though half of the Trade Unions immediately concerned preferred a single Corporation to be retained. The government had come to the conclusion that the balance of advantage was strongly in favour of implementing the Carter Committee's recommendation. The two main businesses were entirely different and each needed its own independent board. The government, he said, agreed with the Carter Committee's view that separation was an essential step towards improving the effectiveness of both businesses.

Legislation would be required to create the new telecommunications corporation, but it was unlikely that this would come before the end of next year, Sir Keith said. However, he hoped that the Post Office would start to effect as many changes as possible before the legislation. The preparatory moves, according to Sir Keith's time scale, would begin in the next few months, but the whole process would take two to five years. He was shortly to begin consultations with the Post Office, the unions, the manufacturing industry and the Post Office Users' National Council on the subject of the PO's exclusive rights to the supply of apparatus for connection to the main telecommunications network, and hoped to have detailed proposals by early next year. Abolishing the PO's monopoly on telecommunications would allow private manufacturers, both British and foreign, to supply equipment for connection to the main network. This would obviously include equipment such as telephones, telex machines and computer terminals, but it could also provide freedom for individuals to use telephone answering devices, radio telephone systems, slow-scan tv transceivers and other video units, of any manufacture, with the network.

The Post Office chairman, Sir William Barlow, who has been tipped as the eventual head of the telecommunications corporation, welcomed the decision to split the Post Office because he thought that the organisation would be more manageable as two separate units, but he had reservations about the monopoly relaxation.

The unions' views

Sir Keith's announcements brought mixed reactions from the unions. Mr Tom Jackson, the general secretary of the Union of Post Office Workers, said that he was saddened to see the "destruction of a great national institution", and claimed that it would lead to wasteful competition. He disagreed with Sir Keith that the separation would not raise prices, and said that it could lead to the import of "junk from abroad". Mr Brian Stanley, general secretary of the Post Office Engineering Union said that the POEU believed that the separation would benefit staff and customers but it did not think it a good idea to open up the telecommunications business to private competition. The Society of Civil Servants promised to vigorously resist moves to split the two services and the TUC is also promising all-out opposition to the proposals. The chairman of the Post Office Users National Council, Mr John Morgan, said however that the move to separate the services was overdue.

Decca i.l.s. for the R.A.F.

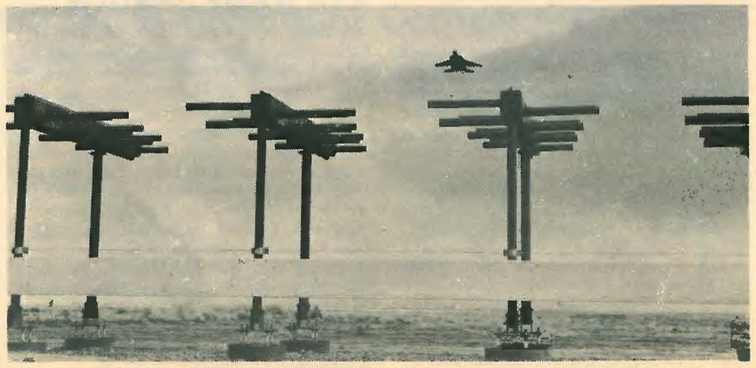
Obsolescent instrument landing systems at 31 R.A.F. airfields are to be replaced by Decca 81100 equipment – the company's first venture in the landing system market. The 81100 is a version of the American Wilcox i.l.s., a system which has proved reliable in its two years of service at U.S. airfields. Decca has unrestricted export rights for the equipment outside North America.

I.l.s. has been the standard radio aid for many years, having been used in one form or another since World War II. It has been improved over the years in accuracy and, in its most exotic forms, is good enough for completely 'blind' landings. Readers will recall that, last year, the International Civil Aviation Organization reached a decision on the microwave landing system (m.l.s.) to be used in the future. This will go into service during the next few years, but ICAO have insisted that the older, v.h.f. and u.h.f., i.l.s. will still be used until at least 1995, alongside m.l.s. at some locations. The equipment used in an i.l.s. consists of the localizer, which defines the horizontal approach path, a glide-path transmitter and marker beacons, which inform the pilot when he is four nautical miles and 3,500ft from the runway threshold. Monitors assess the radiated signals from each element of the arrays and in the far field, switching off or to standby in the event of failure.

One problem of i.l.s. localizers which is reduced in effect by the new equipment is the size of the v.h.f. aerial array which is located beyond the stop end of the runway. Narrow beams need large arrays and the dipoles-plus-parabola type of antenna previously used occupied a good deal of space vertically, as well as horizontally. Large objects in an aircraft's take-off or overshoot path are not considered a good idea, as a general rule, and the array of log. periodic elements in the new design do something to reduce the height of the obstacle.

A further benefit of the design, which is modular in concept, is that installation time is reduced from an average of around fifteen weeks to about nine. Maintenance time is also reduced.

Log. periodic elements in the localizer array of the Wilcox i.l.s. The Decca 81100 system uses a similar array.



New Braille processor developed

A new type of word processor has been developed by Micronex Ltd for the Royal National Institute for the Blind (RNIB). The processor, called the BDET-2940AN Braille Display and Editing Terminal, is a small self-contained system that is capable of scanning braille pages produced on normal braille writers, so converting the text into machine readable form for editing and reproduction. Once captured by the scanning process, the 29-line by 40-character text page is presented as a 20in (50cm) raster-scan graphics display for editing and/or reformatting utilizing the braille equivalent of word processing. Processed text can then be output to a braille line printer or recorded on a special cassette tape. The BDET also includes a braille keyboard which may be used for keying transcribed braille into the diplay without using a writer.

An optional floppy-disc unit permits several volumes of braille to be stored and can enable weekly publications, such as the braille Radio Times, which demand a fast turn-around time, to be prepared rapidly.

British Standard revisions

The British Standards Institution has revised the standard BS3192 covering **safety requirements for radio and television transmitting equipment.** BS3192 was first published in 1968, but with the new revisions, which relate only to transmitters and auxiliary apparatus operated under the direction of skilled personnel, it is now identical to the International Electrotechnical Commission Standard, IEC publication 215. This standard deals with precautions against electric shock, skin burns, high temperatures and fire, explosion and implosion, harmful radiation and other miscellaneous hazards. It gives design and construction requirements to ensure the safety of personnel both under normal and some abnormal operating conditions, and when carrying out routine adjustments, fault-finding and repairs.

A new standard, BS CECC 30600 — **harmonized system of quality assessment for electrical components under the sectional specification, fixed ceramic capacitors, type 1** — has just been published. It specifies the preferred values for characteristics and ratings and also the inspection requirements for fixed ceramic dielectric capacitors with a defined temperature coefficient (dielectric type), intended for use in electronic equipment. This includes leadless capacitors but excludes those capable of carrying high r.f. currents and multi-layer ceramic chip capacitors.

Successive editions of the **BSI specification for safety requirements of household equipment** have added to the scope of the standard, which was originally only for domestic radios. Now it is entitled BS415 — safety requirements for mains-operated electronic and related apparatus for household and similar general use — and includes monochrome and colour tv receivers, radio receivers, clock radios, stereo amplifiers, record players, music centres, tape recorders, video cassette recorders and electronic musical instruments. Auxiliary equipment provided for use with this apparatus is also covered, e.g. microphones, loudspeakers, cable-connected remote control devices and battery eliminators. Requirements are arranged to ensure that the apparatus is designed and constructed so as to present no danger either in normal use or in a faulty condition. In particular it provides for personal protection against electric shock, excessive temperature, ionizing radiation, implosion, mechanical instability, moving parts and fire. The standard may also be applied to professional electronic apparatus likely to be used by laypersons where there is no other appropriate standard. An appendix gives supplementary requirements for splash-proof electronic apparatus. The new revision brings the British Standard more closely in line with the corresponding International Standard, IEC publication 65.

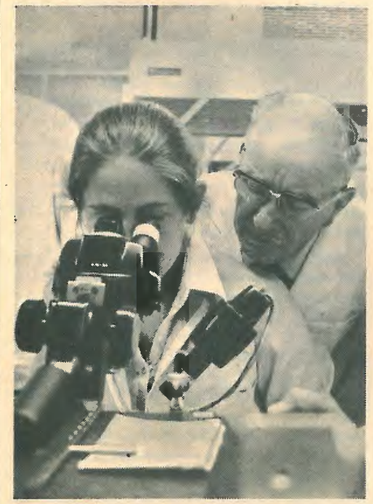
Sinclair Radionics changes

Clive Sinclair has left the company he founded, Sinclair Radionics, well known to readers of this journal for its kits, calculators and Microvision miniature television set. He has resigned all his executive responsibilities with the firm but still remains a minority shareholder. The majority of the shares, 73%, is owned by the National Enterprise Board, which invested £4.5 million in the company. However, the NEB has sold the Microvision and calculator parts of the organization to Binatone International for £1 million and it plans further sales in the future. New chairman and managing director of Sinclair Radionics is Dennis Taylor, former managing director of Hewlett Packard in the UK, who has been on the board of the Sinclair company for about a year.

But the indefatigable Sinclair is by no means bowing out from the electronics scene. He has formed a new company, Sinclair Research Ltd, at Cambridge, which will develop new products, either on behalf of outside companies to which they will be licensed, or, in cases where no suitable licensee exists because the product is too advanced, on behalf of Science of Cambridge Ltd. This last-mentioned company is also owned by Clive Sinclair, and, as *Wireless World* readers will be aware, produces small computers for the hobbyist market.

One of the most interesting developments being undertaken by the new company is a flat television tube, for which a patent has been taken out. This is being developed under contract for the NEB and is funded, at £400,000 per year, partly by the NRDC and partly by Sinclair Radionics Ltd. The contract will run for six months while negotiations are being made with a television tube manufacturer. There is also a computer project; a new pocket tv set using a conventional miniature tube prior to any flat tube becoming available; a novel form of electronic motor aimed at the potential electrical vehicle market; and a new instrument.

Sinclair Research intends to work with various manufacturing firms, acting as their research departments. It has already made exclusive arrangements with companies in the field of instruments and computers, and "negotiations are in progress in other fields."



Lord Scanlon, formerly president of the Amalgamated Union of Engineering Workers, in his role as chairman of the Engineering Industries Training Board, took a close look at the silicon chip during a recent tour of the Siliconix manufacturing plant at Swansea. Afterwards he said that he could not help being impressed by the technology and, on the question of whether or not microprocessor technology will cause unemployment, he "wondered whether industry as a whole was expanding quickly enough to take advantage of the many benefits and employment opportunities which silicon chip technology was creating."
Siliconix are having an extension built to more than double their manufacturing area.

Tektronix reports good year

Tekronix Inc. reported a 36% increase in earnings for its 1979 fiscal year — which ended in May 1979 — with $77,151,000 (about £38,575,500) compared with $56,846,000 (about £28,423,000) last year. Sales were $786,936,000, up 31% from $598,886,000 a year ago, with 62% of the total being in the US.

Radio Luxembourg by satellite?

Radio and television programmes may be broadcast from a European satellite for which Radio Luxembourg has commissioned a design study from British Aerospace Dynamics Group. The satellite would incorporate experienced gained in the design and development of the European Communications Satellite (ECS), and could utilize the same basic satellite platform as ECS but with a different electronics payload. British Aerospace say that this "could be the first direct-broadcast satellite to enter service in the world," although of course there are, and have been, a number of experimental broadcasting satellites in operation already.

● Meanwhile, a further three ECSs for communications have been ordered by the European Space Agency from British Aerospace Dynamics Group. Worth £37 million, the order brings to five the total number of ECSs to be built, and is the largest satellite procurement ever made in Europe. The five satellites will provide Europe with an indigenous communications system for relaying telephone, telex and television traffic. (For details see December 1978 issue, p.63.) The communication coverage will extend from the southern and eastern shores of the Mediterranean, including the Atlantic Islands, and to Iceland and Scandinavia in the north.

All five satellites are to be launched by the Ariane launcher (soon to have its maiden flight) from the equatorial site at Kourou, French Guiana. The first is scheduled to be placed in orbit in 1981, followed by the second in 1982. These two will provide the initial service. The later satellites will provide continuity of service into the 1990s. Each satellite is expected to have a minimum operational life of seven years.

Marconi doppler velocity sensor for Boeing 737

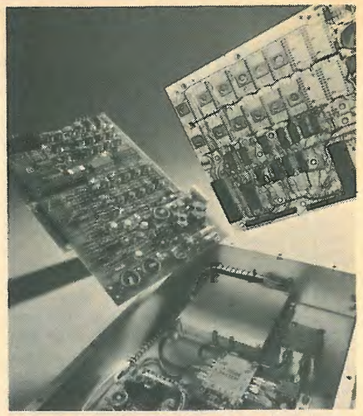
Doppler velocity sensors, made by Marconi Avionics of Basildon, have been ordered by Boeing for installation in Lufthansa's 737s.

The AD660 DVS is the newest in a succession of doppler ground-speed sensing equipments, which started with the AD2000 "Green Satin" used in the old V bombers shortly after the war. Ground (as opposed to air) speed measurement was originally intended to do just that, but the potential was such that the data from the equipment was used in navigation systems, in conjunction with highly-accurate compasses and inertial sensor references. With the introduction of the AD660, the cost of using the equipment purely as a ground-speed sensor is low enough to be practicable, although it will inevitably be employed in a wider role.

The new design is in a single unit, which is composed of antenna, semiconductor Tx/Rx, and computer, the whole being about the size of an attaché case. Since the antenna is a microstrip type, it is flat and can be adapted to the shape of the aircraft skin. The small size of the antenna also means that it can be installed without carving great holes in the aircraft.

Four time-multiplexed beams are radiated fore-and-aft and laterally, angled towards the ground. Since only three beams are needed for sensing ground speed, the fourth is redundant when the aircraft is flying level, serving only to provide a consensus with the other three. With alterations in aircraft attitude in pitch or roll, it is possible that one of the beams would be directed away from the ground, whereupon the three remaining beams would continue to provide the necessary information.

DVS, being usable down to 10 knots, can be used to measure taxy speed, and the equipment will be used in the 737 to provide information for a fuel economy system. Wind shear, which is effectively a rapid change in wind speed, often causes pilots to respond incorrectly to changes in the rate of descent near the ground: this condition can be detected by the AD660, enabling pilots to adjust the engine controls in the correct sense.



Marconi's AS660 ground speed doppler. The two boards are mounted in the case, directly on the printed-circuit antenna. Antenna switching unit is in centre of case.

HP's long-awaited multi-station processor development system

Hewlett Packard recently announced their 64000 system which is reckoned to be the most advanced logic development package currently available. The system comprises up to six desk top "workstations" which share a 20 to 120 Mbyte hard disc store and a printer.

Each workstation incorporates a 16-bit n.m.o.s. host processor, 64 Kbytes of r.a.m., 16 Kbytes of r.o.m., I/O control and display facilities. Software options include a choice of assemblers and compilers, and ten card slots accommodate hardware options such as real-time emulators, a p.r.o.m. programmer and a PASCAL compiler. The system allows up to six operators to each use a workstation simultaneously and independently without changing discs. As well as developing and debugging hard and software, the operator can write code, emulate hardware and carry out logic analysis.

A very useful feature on the workstation is a row of uncommitted or "soft" keys whose function during development is labelled on the v.d.u. This approach, combined with directed syntax, greatly reduces errors.

The cost of the system depends on the number of stations and options, but £17,000 to £50,000 is a general guide.

Shortly after Hewlett Packard's launch, Livingston Hire demonstrated their faith in the system by announcing themselves to be the first purchasers in the world of the equipment. The 64000 will support Livingston's microsystems rental service which has been in operation for about a year. This facility enables prospective purchasers to evaluate the system thoroughly and gain practical experience before parting with the purchase price.

Power f.e.ts aid radio navigation

Adney Automation Ltd, a Sussex-based company, claims to have made a major breakthrough by incorporating Siliconix v.m.o.s. power f.e.ts in the output stages of maritime radio transmitter beacons. The beacons, known as Orb, are intended to give positive radio navigation guidance at harbour entrances. They are entirely off-shore based and rely upon solar cells or wind-driven generators, or a combination of both, to provide the transmission power. The use of high current v.m.o.s. f.e.ts, type VN64GA, in the output stages, allows the beacon to operate more efficiently and reduces the overall size and power consumption of the unit. This improvement enables maritime radio beacons in the 285 to 315kHz band to operate remotely and dependably for long periods while giving an acceptable power output over a wider area for positive identification and navigational guidance. So far, Poole and Chichester are the only harbours to benefit, but already the Poole harbour master has reported beacon reception at distances of 20 to 24km.

Death of Stanley Mullard

Stanley Robert Mullard M.B.E. (MIL), one of the pioneers of the UK radio industry, died on September 1 at the age of 95.

Stanley Mullard was born in 1883 and after leaving school and attending a Sussex polytechnic, joined a firm of electric lamp manufacturers. He continued his studies at the Northampton Institute (now the City University) and became a director of the company when he was only 24. Later he joined the Ediswan Company and in 1915, while working in the lamp research laboratory, he developed the "Pointolite" arc lamp which was used in projection appratus for over 40 years.

At the start of the first world war Stanley Mullard enlisted in the Engineers' Battalion of the Royal Naval Reserve, but continued his work at Ediswan at the Admiralty's request. His interests by then extended to radio valves and his wide knowledge of glass technology and vacuum techniques enabled him to make valuable contributions to the fast growing use of valves in military radio equipment.

In 1916, as a lieutenant in the RN Volunteer Reserve, he was posted to the RN Air Service and put in charge of a special valve laboratory at Imperial College, London. It was largely due to his participation that the manufacture of silica-type power transmitting valves became practicable by the end of 1919. By September 1920, an order for 250 valves raised the capital required for him to form the Mullard Radio Valve Company. Demand for small receiving valves quickly exceeded output time and again, in particular with the introduction of the BBC's London transmitter, 2LO, until by 1924 production had reached 2½ million a year. By demonstrating that reliable valves could be made cheaply Stanley Mullard helped materially to lay the foundations of the British radio industry.

Further increases in production and the establishment of the Mullard Wireless Co., to handle marketing and distribution, were followed by the need to move to a larger factory at Mitcham in Surrey. Eventually the call for research facilities beyond the scope of such a young company led to the establishment in 1924 of close links with N.V. Philips in Holland and over the next few years Philips acquired all the shares in the company.

In 1929 Stanley Mullard resigned as managing director of the company, but continued as a director actively interesting himself in the company's affairs until its golden jubilee celebrations in 1970. He lived to see the small venture he founded grow to an organisation employing more than 11,000 people and occupying a leading place in the world's electronic industry.

Slow counters

Slow-acting counter circuits for greater signal purity

by A. D. Ryder, M.A., Ph.D., F.I.E.E.

The production of clean logic signals using an input channel barrier for use with open contacts may require an opto-isolator to avoid earth loops, a low-pass filter to remove noise and contact bounce transients and a trigger circuit to clean up the resulting slow edges. A response time of 5 to 10ms exceeds the bounce time of most contacts and removes virtually all unwanted noise. Often the power supply is filtered and suppressed but the cost of such precautions can be significant. The author of this article outlines an approach which exploits the fact that the switching speed required in a given control application is often considerably less than that already available and maintains that such methods can be cost-effective in small systems.

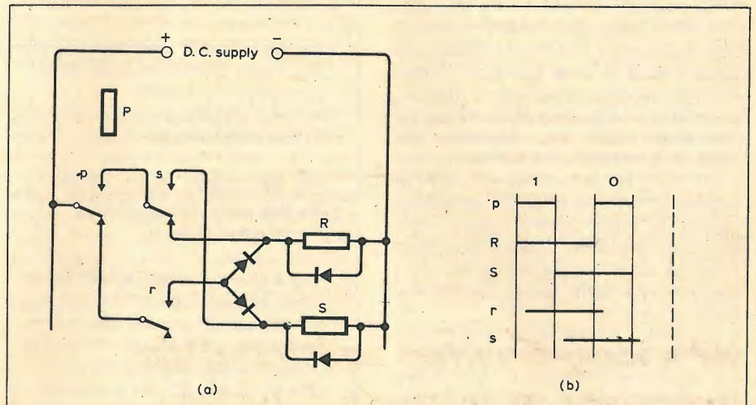


Fig. 1 (a). *Divide-by-two cell using relays. The events counted are the operations of P. Changeover contact r is on relay R and so on. The basic logic is* $R = p.s + p.r$, $S = p.r + p.s$.

Fig. 1(b). *Sequence diagram for Fig. 1(a). The duration of each mark or space of p must exceed the response time of relay R or S, indicated by the horizontal displacement of signals r and s from signals R and S, representing relay coil voltages*

LOGIC INPUT SIGNALS sometimes come from open contacts or their equivalent and can be severely contaminated by the effects of contact bounce and noise, to which circuits with feedback using latches, flip-flops and counters are particularly vulnerable. Designers accustomed to relatively slow relay systems sometimes failed to appreciate this problem, which led to many malfunctions in the early days of development and gave solid-state controls a reputation for unreliability.

To a lesser extent, signal races within the logic itself contributed to anomalies which were difficult to diagnose although this is now a problem which concerns mainly the i.c. designer, appearing to the user principally as an upper limit on input rise time.

Fig. 1 shows a basic counter cell using relays with changeover contacts. This type of circuit will work with almost any general-purpose relay and depends upon the fact that the momentary interruptions when a changeover contact operates are too short to be 'seen' by the magnetic circuit of the relay switched. Such interruptions, or situations when for example neither p nor $\bar{p}$ is true, are typical of the race hazards which are so important in the design of fast logic. In the Fig. 1 circuit they can be disregarded, for the same reason that interference and bounce can be disregarded, namely the slow response of the active devices.

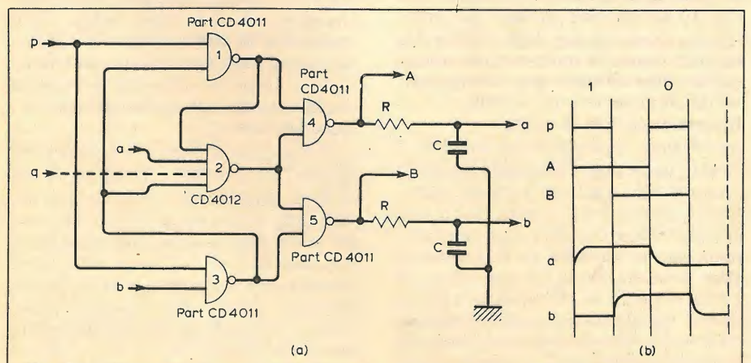


Fig. 2(a). *Counter cell using NAND gates. Points marked "a" are joined together as are those marked "b" and the basic logic is* $A = p.b + p.q.a$, $B = p.q.a + p.b$. *Input q is used for cascading only. i.e.* $q = 1$ *in the basic form – see text.*

Fig. 2(b). *Sequence diagram for Fig. 2a when* $q = 1$.

A slow-counter cell

Fig. 2 shows an electronic analogue of the Fig. 1 relay cell; the inversions of p and b are achieved by using the outputs of gates 1 and 3. If the components R and C are omitted, the circuit is similar to a 6-gate circuit given by Zissos[1], who uses it as an example for hazard analysis, building up to a 14-gate circuit with a very low probability of malfunction. Lewin[2], treating a similar circuit, arrives at a total of 10 gates after considering hazard corrections.

If the Fig. 2 circuit is assembled without the R and C components it is unworkable. Several hazards or races can be deduced and observed, especially if the signal applied at p has slow edges. The RC delay required for correct operation depends mainly on the spread of gate switching levels and the slope of

the p signal edges. For example if A changes from 0 to 1 on a transition of p, point 'a' will some time later rise to a voltage high enough to switch gate 2 (assuming its other inputs are high) and this delay must exceed the time taken for the undelayed switching actions caused by the p transition to be effectively completed.

The circuit is conveniently implemented using c.m.o.s. gates because of their high input resistance and symmetrical transitions, though it will work with t.t.l. if extra transistors are used to match signals a and b into gates 2 and 3.

Assume that, for c.m.o.s. on 12 volts, gate switching takes place between input levels of 4V and 8V. The time that signal p takes to cross this gap is virtually the maximum period of danger, since other transitions are shortened by gate amplification and the minimum value of RC is that sufficient to prevent a or b rising by 4V (or falling to 8V) in this time. With fast edges at p, the circuit is thus usable up to the frequency where the undelayed switching times are no longer negligible, say 1 MHz, but the main interest is for low speed applications.

The input p must of course remain above 8V (or below 4V) long enough for the signal a or b to reach 8V (or 4V). Thus a particular choice of RC fixes both the maximum rise-time and the minimum half-period of the counted signal. It is possible to achieve reliable operation over a limited frequency range with a sine-wave at p of 12V pk-to-pk (centred on 6V) and this could perhaps be useful for timing from noisy 50 Hz mains, but in most l.f. applications the provision of adequately fast p edges presents no difficulty.

The sequence diagram, Fig. 2(b), shows two points of interest. First, when the frequency is low enough for gate switching times to be negligible, the signals A and B are synchronous with p, despite the delays of a and b. Second, the transitions of a occur only when p=1, i.e. when gate 2 is off. Similarly the transitions of b occur when 1 and 3 are off, thus these slow edges do not create slow gate output transitions, which could cause excessive dissipation.

Apart from making the circuit work, i.e. circumventing the hazards, the RC delays can give it the same kind of immunity to contact bounce and interference as the relay circuit of Fig. 1. Although a short pulse on signal line p, for instance, will appear at either A or B, it will be filtered from a or b, and so prevented from corrupting the latches, i.e. altering the stored count. A test made using RC=10 ms and a 40 Hz square wave input to p showed that reliable division was obtained even in the presence of full-amplitude square interference pulses, of either sense, in excess of 2 ms duration.

It is not essential to use the particular gates shown in Fig. 2, many different arrangements are possible and the number of gates in each path is not critical. Unfortunately there is no standard package ideally suitable, but Fig. 10 shows one of four possible circuits based on the 4539 (Motorola) which is usable in most configurations and provides a reset input. Component values are shown for RC=4.7 ms.

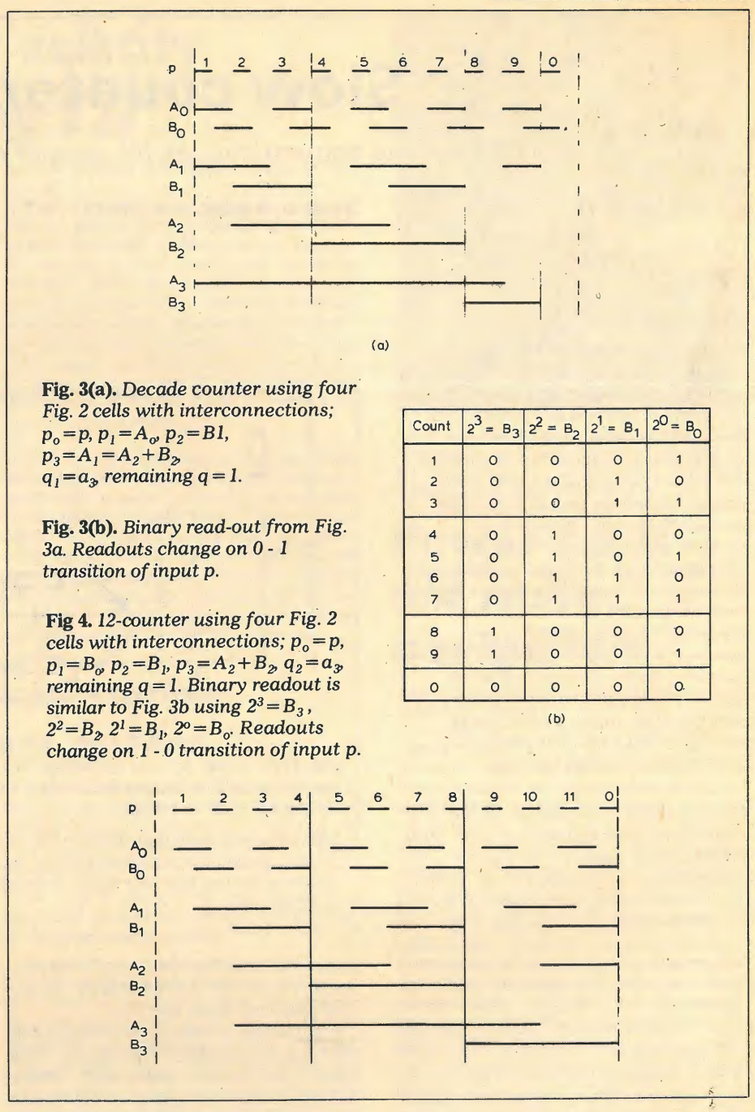


Fig. 3(a). *Decade counter using four Fig. 2 cells with interconnections; $p_o=p$, $p_1=A_o$, $p_2=B1$, $p_3=A_1=A_2+B_2$, $q_1=a_3$, remaining $q=1$.*

Fig. 3(b). *Binary read-out from Fig. 3a. Readouts change on 0 - 1 transition of input p.*

Count	$2^3=B_3$	$2^2=B_2$	$2^1=B_1$	$2^0=B_0$
1	0	0	0	1
2	0	0	1	0
3	0	0	1	1
4	0	1	0	0
5	0	1	0	1
6	0	1	1	0
7	0	1	1	1
8	1	0	0	0
9	1	0	0	1
0	0	0	0	0

(b)

Fig 4. *12-counter using four Fig. 2 cells with interconnections; $p_o=p$, $p_1=B_o$, $p_2=B_1$, $p_3=A_2+B_2$, $q_2=a_3$, remaining $q=1$. Binary readout is similar to Fig. 3b using $2^3=B_3$, $2^2=B_2$, $2^1=B_1$, $2^0=B_o$. Readouts change on 1 - 0 transition of input p.*

Interconnection of cells.

An obvious application for the Fig. 2 circuit is to provide a reliable push on-push off function from an open-contact push button, connecting it to p directly*. More complex counting functions can be provided by interconnecting several cells. If Fig. 2(a) is compared with a JK flip-flop used to divide its clock frequency (setting J=K=1), it will be seen that the signal B corresponds to what is normally called the Q output changing on the back edge of the clock, whereas A corresponds to an output of the 'slave' bistable, not usually brought out, which changes on the front edge. The availability of the A output simplifies cascading and for certain divisions, such as 10 or 12, allows binary-coded outputs to be generated directly as described later.

If Fig. 2(a) circuits are cascaded directly, using the A or B output of each as the p signal for the next, counts are restricted to powers of two and to permit other divisions the additional input q is used at gate 2. Clearly when q=0 signal B never appears and A simply follows p. Using c.m.o.s. gates in particular, a simple diode OR permits a connection such as:

$$p_3=B_1+A_2$$

that is, the p signal into the third stage can have the combined duration of B from stage 1 and A from stage 2.

The combinations of possible forward

*See "An electronic organ tone system, part 5", *Wireless World* March '79. This also shows pre-setting.

cascading connections and feedback connections from later stages to earlier q inputs are numerous and can be interesting to work out. Before dealing with specific examples, some general points may be noted.

(a) There are several ways of achieving a desired division ratio. For even numbers, it is usually possible to find a cascading/feedback set which will generate binary-coded outputs directly. For odd divisions some external decoding is usually needed.

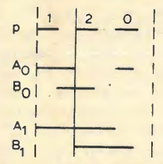


Fig. 5. *3-counter using two cells; $p_o=p$, $p_1=A_o$, $q_o=a_1$, $q_1=1$, $2^1=A_1.B_1$, $2^0=A_1.A_o$. Change on 0-1 transitions. B_1 excursions are each 1½ periods of p.*

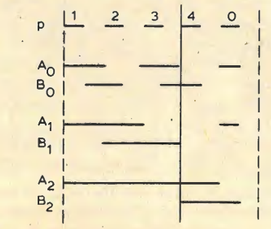


Fig. 6. *5-counter using three cells; $p_o=p$, $p_1=A_o$, $p_2=A_1+B_1$, $q_o=a_2$, $q_1=a_2$, $q_2=1$; $2^2=A_2.B_2$, $2^1=B_1$, $2^0=A_o.A_2$, change on 0 -1 transitions.*

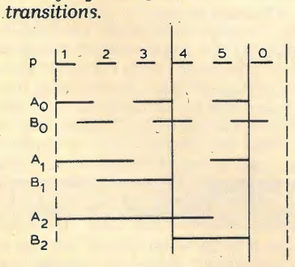


Fig. 7. *6-counter using three cells. Change on 0-1 transitions.*

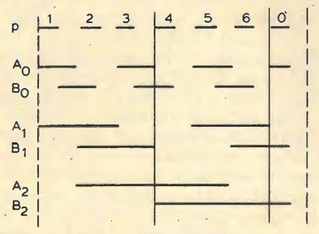


Fig 8. *7-counter using three cells; $p_o=p$, $p_1=A_o$, $p_2=B_1$, $q_o=a_1+a_2$, $q_1=1$, $q_2=1$, $2^2=B_2(A_1+A_2)$, $2^1=B_1(A_1+A_2)$, $2^0=A_o(A_1+A_2)$. Change on 0-1 transitions. B_2 excursions are each 3½ periods of p.*

(b) Because both A and B outputs are available it is (apparently) always possible, with odd as well as even divisions, to arrange that one of the last stage outputs is a square wave (assuming that the input is a square wave). For example, for division by 7, an output signal of which each excursion lasts for 3½ input periods can be obtained.

(c) The transitions of outputs can be made to occur at either the 0-1 or the 1-0 transitions of the input signal.

(d) The switch-on state (with input absent) can be predetermined by returning the various capacitors appropriately to the high or low supply rails. The ground connection as shown in Fig. 2(a), is the normal one, and results in a 'reset' state at switch-on.

(e) Reset from any stage can be achieved by setting the input and any q signals at zero, or otherwise forcing all 1, 2, and 3 gate outputs high.

(f) Presetting (programming) is possible, for example by directly charging appropriate capacitors via diodes. Fig. 3 shows the sequence diagram and connection-set for a decade counter with binary-coded outputs (b.c.d.) changing on the 0-1 input transitions and using four cells numbered from 0 (l.s.d.) to 3 (m.s.d.). The action can be followed bearing in mind that the A or B transitions of each stage occur at those of its own p signal. For example, it is the transitions of B_1 which control A_2, B_2, and this ensures that B_2 has the correct duration to provide the 2^2 output digit. The feedback connection $q_1=a_3$ suppresses a third appearance of the signal B_1 because a_3 becomes zero following the start of input pulse 9. For the proper action of A_1, B_1 on earlier pulses, it is necessary to establish q_1 (i.e. a_3) at the same time as a_1 and this is achieved by the component A_1 in the signal p_3. Finally, the inclusion of both A_2 and B_2 in the p_3 signal ensures that the signal B_3 does not appear until the start of pulse 8, allowing it to be used directly as the 2^3 output digit.

It is clearly necessary that when an 'a' signal is used for feedback to an earlier stage, it must be established at the same time as that stage's own 'a' signal. In the 12-counter of Fig. 4, the feedback is from stage 3 to stage 2 and this allows a_3 to appear later (though there would be no objection to its being established with a_1 as in Fig. 3). The use of B_0 rather than A_0 as the p_1 signal results in the readouts changing at the back edge of each input pulse, as with a JK counter, rather than at the front edge as for Fig. 3. For this reason B_0 is also used as the 2^0 digit output; otherwise the readouts are as Fig. 3, the two extra counts being covered by the third appearance of B_1 and the longer duration of B_3. The configuration of Fig. 4 has been used to count at the rate of one 2-minute input pulse per hour and has operated without trouble for more than a year in a situation where difficulty was ex-

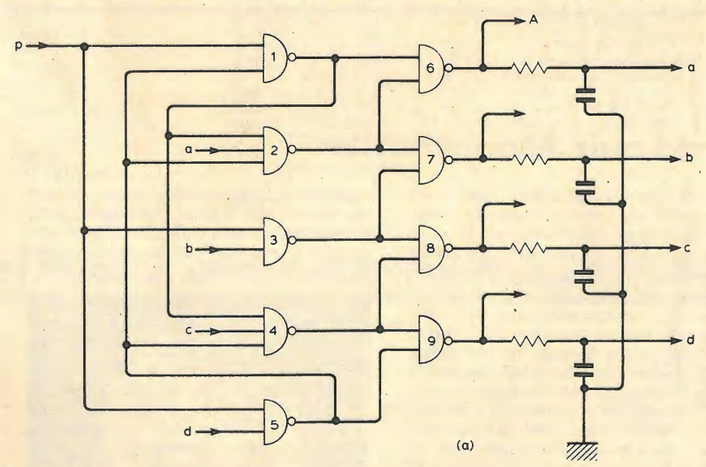
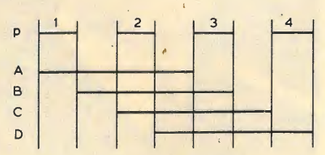


Fig 9(a) *Johnson code 4-counter. Points a,a, etc. are joined and the basic logic is $A=p.d+p.a$, $B=p.a+p.b$, $C=p.b+p.c$, $D=p.c+p.d$.*



Time slot	Decode
1	A. $\overline{C}$
2	C. A
3	$\overline{A}$. C
4	$\overline{C}$. $\overline{A}$

Fig. 9(b) *Sequence diagram and decoding key for Fig. 9a.*

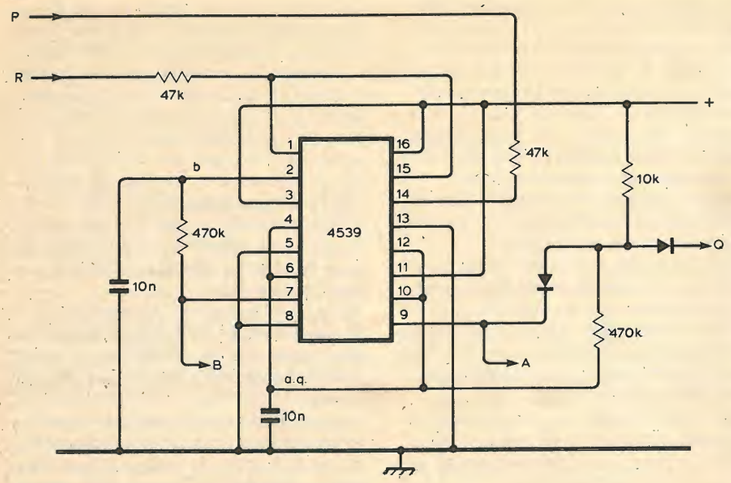


Fig. 10 *One-package cell using a 4539 dual multiplexer. The diode AND requires connection $Q_n = A_m$ rather than $q_n = a_m$ in Figs 3-7. It is omitted for $q = 1$. $R = 1$ to reset.*

perienced with a fast m.s.i. counter.

Figs. 5 to 8 show some of the arrangements possible for different divisions, with their interconnection expressions. Other configurations can provide different facilities, for example an output which goes high for one or more out of every n input periods and so on. A variation on the Fig. 2 cell is the Johnson code counter shown in Fig. 9. This circuit can be extended to any even division.

In general the counters, and any subsequent decode logic, are transparent to input disturbances which exceed the switching levels, but this does not result in malfunction if the eventual output device is slow, for example a relay or contactor.

References:

1. Zissos and Copperwhite, "Logical Design Manual", Pitman.
2. Lewin, "Logical Design of Switching Circuits", Nelson. □

Lord Louis Mountbatten

It was an ironic twist of fate that Lord Mountbatten, who did so much for radio, should have been killed by means of radio remote control. The bomb that ended his life was detonated via a medium of communication and control that he had fostered enthusiastically throughout his long career. His contribution was not merely the patronage he was able to give through his aristocratic birth and connection with the Royal Family (he was born Prince Louis of Battenberg in 1900) — though in a country like Britain, where everyone loves a Lord, this certainly had its value for promotional purposes. He had a real knowledge of and interest in the technology, which arose from the early part of his career as a naval officer, and later a genuine concern about the effects of electronics on people's lives, which continued right up to his death in August this year. He inspired some people in the electronics industry but got from others, perhaps without knowing it, only sycophancy or grudging admiration.

Mountbatten's interest in radio started in 1924 when, already in the Royal Navy for eleven years, he began to specialise in naval communications. He went to the Royal Naval Signal School, Portsmouth, and qualified as a communications specialist in 1925, incidentally winning the Jackson-Everett prize as the most outstanding student in wireless engineering. He then took a higher course at the Royal Naval College, Greenwich, which qualified him in 1926 to become a member of the IEE. In the same year he was appointed

Earl Mountbatten of Burma

Reserve Fleet Wireless and Signal Officer and continued in this operational work until 1929 when he became a senior instructor in wireless telegraphy at the Royal Naval Signal School. It was during this period at Portsmouth that he was responsible for producing the famous Admiralty Handbook of Wireless Telegraphy, 1931, from which many students, not only naval people, learned the fundamentals of radio. (The Ministry of Defence tell us that he "wrote two handbooks" on the subject.) From 1931 to 1933 Mountbatten was appointed Fleet Wireless Officer to the Mediterranean Fleet, in which post he was responsible for the radio efficiency of some seventy ships.

His period of specialization in radio ended in 1934 when he was put in command of HMS *Daring*, but there was a continuing link with the technology in that he had qualified for membership of the Brit. IRE (now IERE) in 1932 and was elected a member in 1935. Then in 1938, just before he became so deeply engaged in the 1939-45 war, he was elected vice-president of the Institution. There is no need to repeat here the well-known facts of Mountbatten's career as Chief of Combined Operations and later as Viceroy of India in which he skilfully carried out the difficult task of dismantling the British raj. After the war, in 1946, he was elected President of the Brit. IRE and gave a forward-looking presidential address on computers and the retrieval of information which showed his awareness of the latest applications of electronics. This interest in electronic computers continued and in 1966 he was invited to become president of the British Computer Society.

For the last 30 years, his life could be seen as an accumulation of official appointments, honours, memberships, patronages, mostly to do with science and technology and ranging from an exalted Fellowship of the Royal Society to the relatively obscure vice-presidency of the British Wireless Dinner Club. He became president of the IERE again in 1961 when the Institution received its Royal Charter – and the two events were not entirely unconnected. But in the last 15 years he was associated more prominently than anyone else with the activities of the National Electronics Research Council, later to become the National Electronics Council. Indeed it was very much his idea — the IERE did all the donkey work of carrying out his commands – and as chairman he was such a dominating influence that those who didn't think much of the Council's contribution to British electronics tended to dismiss it as "Mountbatten's hobby".

One function of the present NEC is to consider the effects of electronics on society and this was very much the theme of the first of the annual lectures it instituted in 1978 under the name The Mountbatten Lectures. Lord Louis himself gave this first lecture ("Electronics – the Lifeline") in that highly personal style which came naturally from his aristocratic upbringing and military training – abrupt, self-confident and conveying a strong sense of duty. Having pointed out that all technical innovations were "capable of selfish and sometimes dangerous exploitation" he characteristically wasted no time in exploring the wider implications of this fact but put his remedy in terms of personal obligation, quoting from *Paradise Lost* the words of another man with a clear and strong if simple vision of life.

"Accuse not Nature, she hath
done her part;
Do thee but thine."

Two-metre s.s.b. and f.m. transceiver — 2

Signal-frequency circuits and phase-lock unit

by G. R. B. Thornley, G2DAF

THE THREE UNITS described so far accept and emit signals at 10.7MHz. Figure 1 in the first part of the article shows a further five units, concerned with transmission and reception at carrier frequency.

Phase-lock unit

Figure 5 shows the block diagram of the voltage-controlled oscillator phase-lock unit. To allow flexibility in the design and the development work, the unit was constructed in three sections, with the p.c.bs mounted on stand-off pillars in an aluminium box, with a tight-fitting lid 7½in by 5½in by 1½in deep. Any digital device produces a rich spectrum of harmonics and the screening is essential to protect the very sensitive 144-146MHz receiver input circuits.

The MC4044P phase detector produces a voltage proportional to the phase difference between the two input signals, and this voltage is used to control a v.c.o. (voltage-controlled oscillator). The v.c.o. output frequency is proportional to the control voltage so that any change in potential from the phase detector control line will frequency-modulate the oscillator.

Second harmonic output from a crystal-controlled oscillator and the output of the v.c.o. are fed into a m.o.s.f.e.t. mixer. The resultant i.f., in the range 8.3 to 9.3MHz, is amplified and fed to an emitter follower. The v.f.o. (variable-frequency oscillator) output of 8.3 to 9.3MHz, and the i.f., are squared and fed to the phase detector as logic levels. After filtering, the loop output is used to control the v.c.o.

When the frequencies from the i.f. amplifier and the v.f.o. are not the same, the loop voltage from the phase detector will change and alter the v.c.o. output frequency which, in turn, will alter the i.f. output until the frequencies and phases of the two signals are the same. At this moment the loop will lock, and in the locked condition tuning the v.f.o. from 8.3 to 9.3MHz will cause the v.c.o. output frequency to change from 133.3 to 134.3MHz. Full 2MHz coverage of the 2m band is obtained by switching to a second crystal in the crystal oscillator and i.f. amplifier unit. The frequency translations used are shown in the block diagram of Fig. 5.

The complete phase-lock unit is shown in Fig. 6. The f.e.t. Tr_{30} v.c.o. is tuned over the required frequency range of 133.3 to 135.3MHz by the variable-capacitance diode D_{24}. Transistor Tr_{31} is a source-follower buffer stage whose output is split into two branches. One branch is amplified by the m.o.s.f.e.t. Tr_{32} with the drain circuit L_{23} C_{161} being connected to an output terminal. This output, after further amplification in an external two-stage unit, drives the transmit and receive converter units. The second branch is amplified by the m.o.s.f.e.t. Tr_{33} whose output circuit L_{24} C_{166} is taken to gate 1 of the mixer Tr_{36}.

Crystals XL_5 (62.5MHz) and XL_6 (63.0MHz) are selected by the "Band" switch S_2 and switched by the diodes D_{26} and D_{27} to control the oscillator Tr_{34}. The oscillator output drives the class C frequency doubler Tr_{35}, to provide either 125.0MHz or 126.0MHz input to gate 2 of the mixer Tr_{36}. Unwanted multiplication products are greatly suppressed by the resonant circuit L_{26} C_{179}.

The mixer output in the range 8.3 to 9.3MHz is further amplified by the i.f. stage Tr_{37}. Coils L_{28} L_{29}, together with the resonating capacitors C_{188} C_{189} and damping resistors R_{165} R_{166}, form a low-Q bandpass circuit at the required i.f. range. Transistor Tr_{38} is an emitter follower, giving low-impedance output to drive the phase detector section.

Class B amplifiers Tr_{39} and Tr_{40} convert the two sine wave inputs to half wave pulses. Each input drives two NAND gates in IC_2 and the square wave outputs from pins 6 and 8 are connected to the inputs of the phase detector IC_3. The phase detector is locked in when the reference inputs at pins 1 and 3 are equal in frequency and phase. If the variable input is lower in frequency or lags in phase, the output at pin 13 goes low. Conversely, if the variable input is higher or leads in phase, the output at pin 2 goes low. The charge pump (pins 4 and 11) converts the phase detector output to fixed-amplitude, positive and negative pulses appearing at pins 5 and 10. These pulses are applied to a lag-lead active filter Tr_{41}, C_{199}, R_{169} and an internal amplifier between pins 9 and 8, which provides a direct voltage proportional to the phase error. Logic levels from the phase detector are applied to two NAND gates in IC_4, whose output pin 6 drives Tr_{42} so that the l.e.d. il-

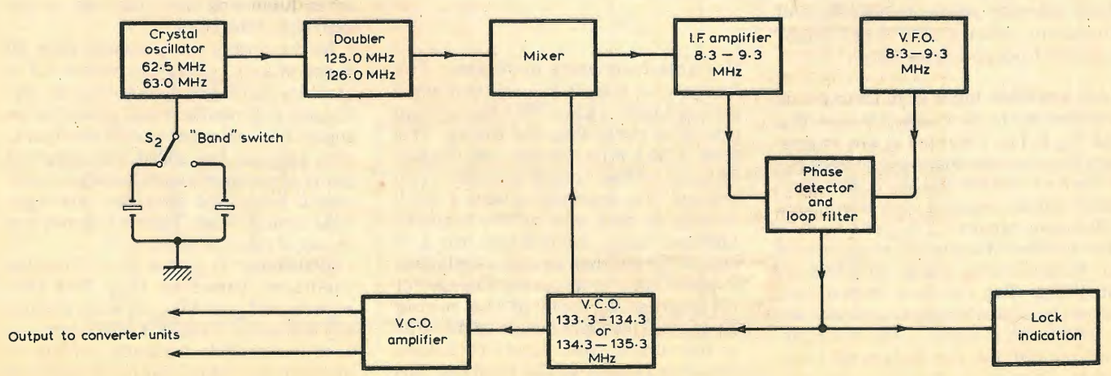
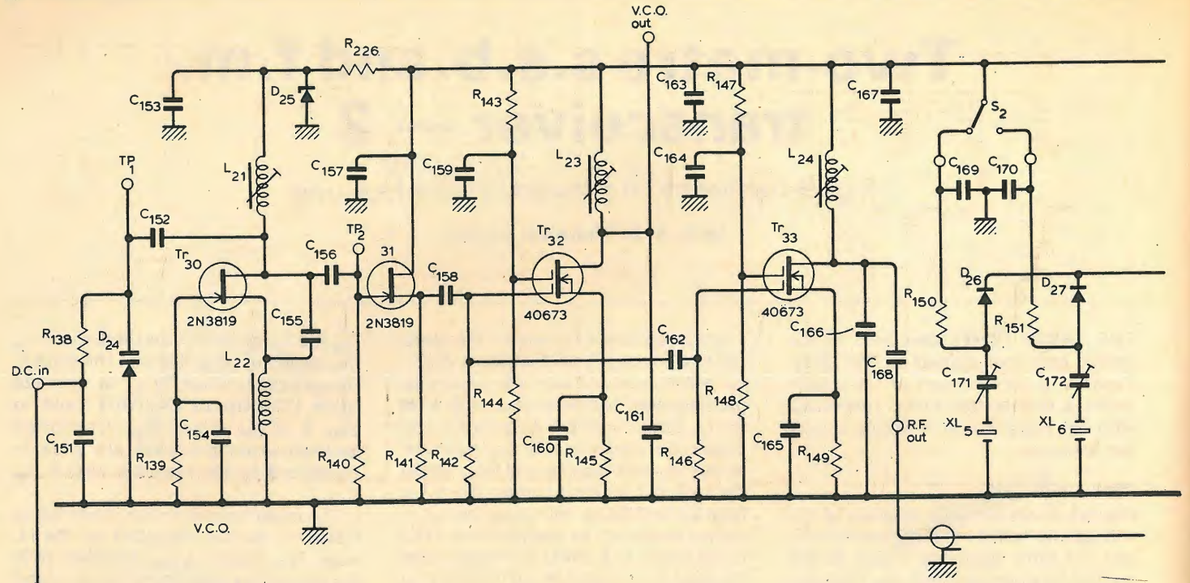
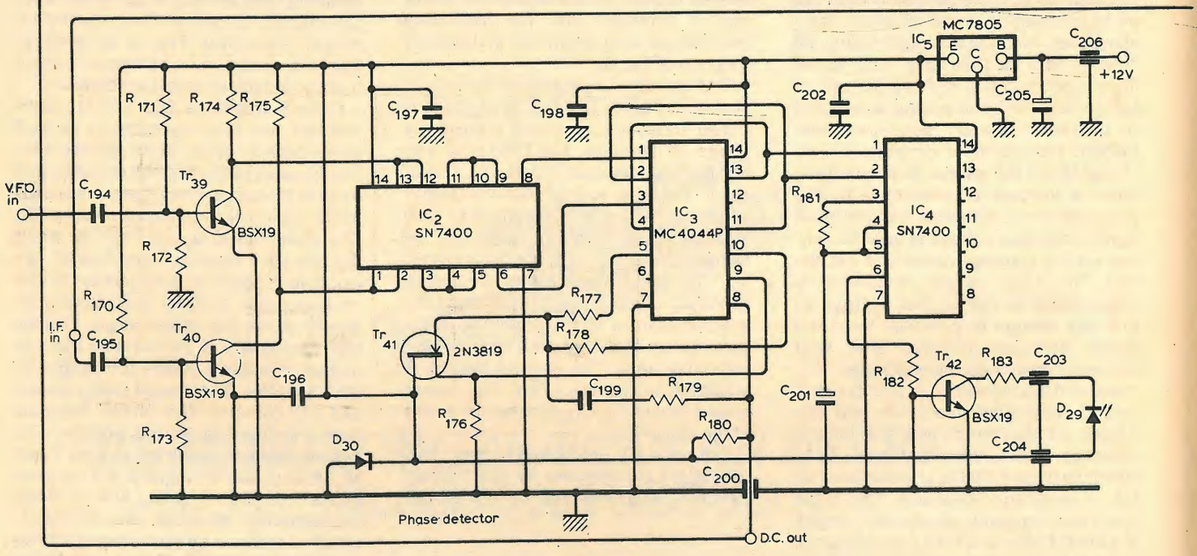


Fig. 5. *Block diagram of the v.c.o. phase-lock unit. V.f.o. and v.c.o. amplifier are built as separate units.*





luminates when the loop is locked. Diode D_{30} is for protection only.

The MC4044P integrated circuit phase detector produces reliable and consistent results, and locks automatically from switch on.

V.c.o. amplifier. Input from the v.c.o. is amplified by the two class A stages Tr_{43} and Tr_{44} in Fig. 7 and fed at low impedance from the secondary windings of L_{31} to the f.e.t. mixers of the receive converter and the transmit converter units.

Resonant circuits L_{30} C_{210} and L_{31} C_{213} have sufficient bandwidth to cover the full heterodyning range of 133.3 to 135.3MHz. The two low-impedance outputs each provide approximately 500 to 700mV r.m.s. which is the optimum requirement for the balanced f.e.t. mixers.

Fig. 6. *Phase-locked voltage-controlled oscillator provides frequency of 133.3 to 134.3MHz.*

Variable-frequency oscillator. The master v.f.o. is built as a self-contained screened unit, with a 100:1 ratio worm gear drive controlling the tuning. This gives a 50:1 ratio for the 180 degrees rotation of the tuning capacitor. In practice, it is desirable to have a small overlap at each end of the required 1,000kHz range. Accordingly, the L/C ratio of the resonant circuit is optimized to give 1,000kHz frequency change for 144 degrees rotation of the tuning capacitor. This corresponds to 40 turns of the tuning dial, equal to 25kHz frequency change per dial rotation. This is very convenient in practice, slow enough to enable precise setting for reception of s.s.b., and not too tedious when traversing from the low to the high end of the band.

In the author's experience over 20 years of s.s.b. operation where v.f.o. stability is of great importance, the Colpitts L/C oscillator has proved to be superior to any other circuit configuration, and has the added advantage of purity of waveform and almost constant output amplitude over the relatively wide tuning range. Figure 8 shows the circuit of the v.f.o. unit.

Transistor Tr_{45} is a f.e.t. Colpitts oscillator, tuned by C_{222}. The two capacitors C_{224} and C_{225} in series swamp any change in transistor input capacitance and provide feedback voltage to maintain oscillation. Output is taken at

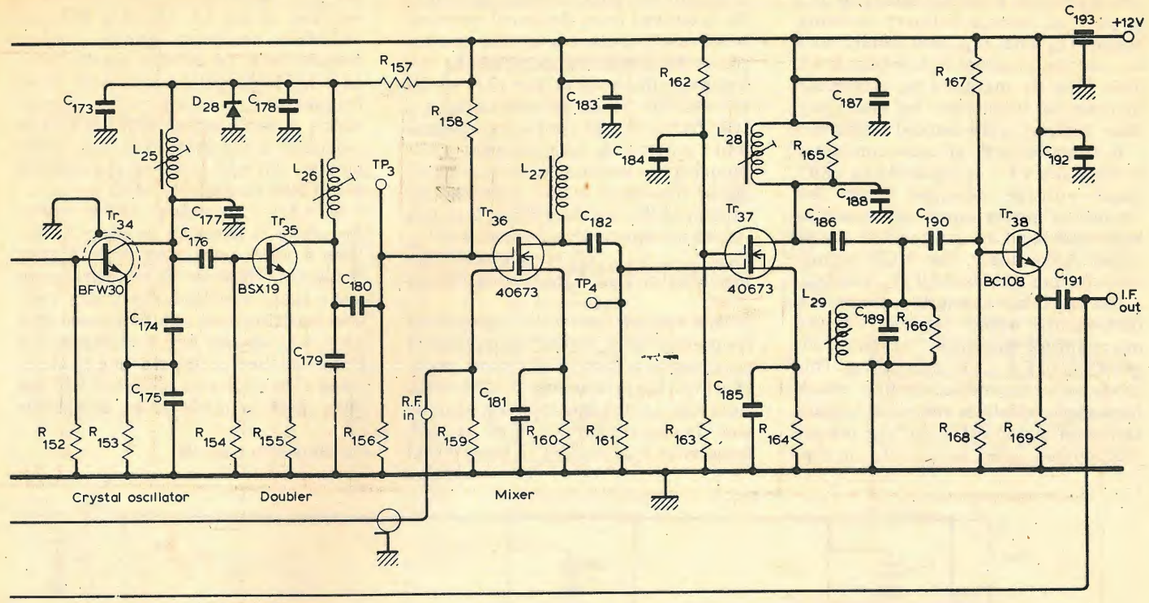


Fig. 7. *V.c.o. amplifier drives transmitter and receiver converters.* ▶

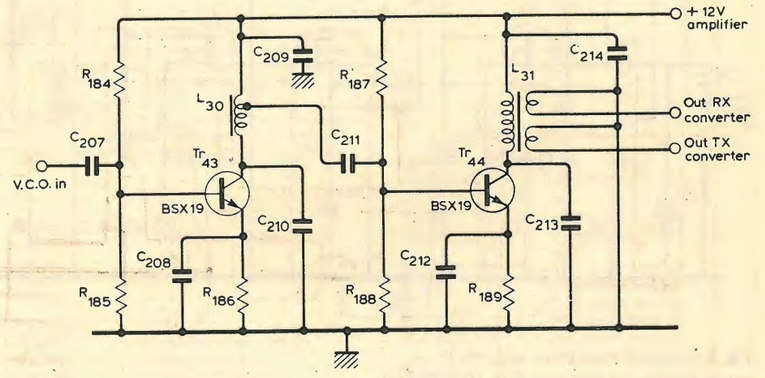
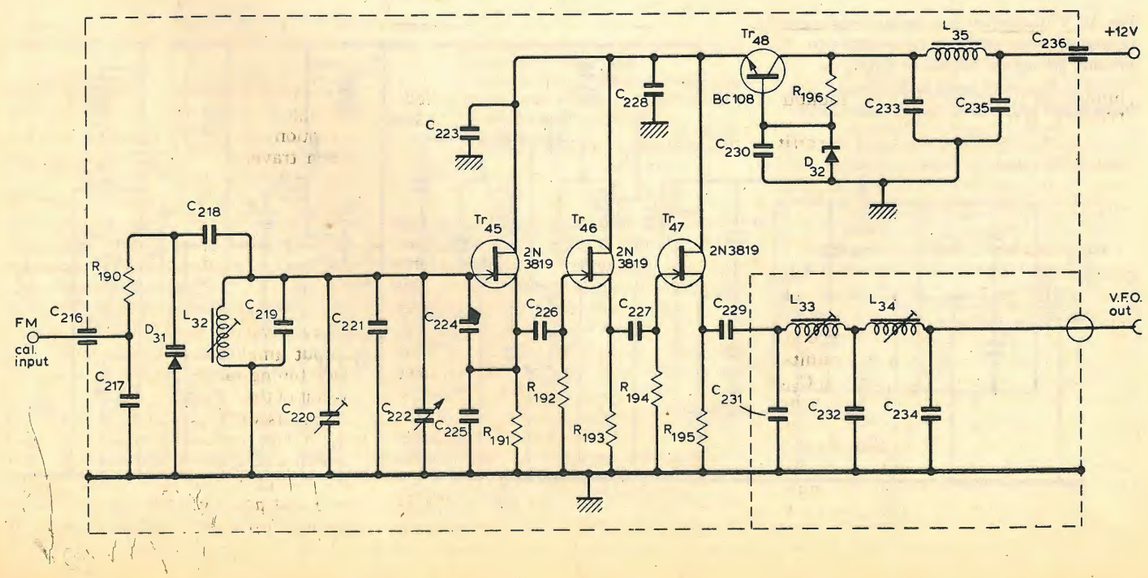


Fig. 8. *Variable-frequency oscillator covering 8.3 to 9.3MHz.* ▼



low impedance from the source of Tr_{45} to two f.e.t. source-follower isolating stages Tr_{46} and Tr_{47}, and finally to a two-section, constant-K, low-pass filter. This filter is included to attenuate higher-order harmonics that could produce "birdies" in the wanted 2m band.

In common with all semi-conductor devices, the v.f.o. is sensitive to quite small voltage changes from the "stabilized" power supply and would be hum modulated by any residual mains ripple. Accordingly, the +12V supply rail is further stabilised by Tr_{48} and D_{32}.

The variable capacitor diode D_{31} receives the audio output from the microphone amplifier of the f.m. generator of Fig. 3, via resistor R_{190}. This produces a capacitance change, which frequency modulates the v.f.o. output. Deviation is controlled by the pre-set "microphone gain" resistor R_{117} in Fig. 3. Initially the direct voltage applied to D_{31} is derived from the panel operated "calibrate" control and this facility allows precise setting of the tuning dial frequency divisions at any part of the 144-146MHz band, by reference to a 100/25kHz crystal controlled calibration oscillator or alternatively while sampling the transmitter output with a digital frequency meter. With the exception of the low-pass filter, C_{216}, C_{236} (which are separately screened) and L_{32}, C_{219}, C_{220}, C_{222}, all components are assembled on a p.c.b. measuring 2½in by 2½in.

The choice of v.f.o. operating frequency is of importance, and is governed by a number of factors, some of which are conflicting. Additionally, since the s.s.b. generator can equally well become the heart of an h.f. transceiver it is prudent to ensure that the v.f.o. fundamental and harmonics are clear of the 3.5, 7.0, 14.0, 21.0 and 28.0MHz amateur bands. Other frequencies to be avoided are 10.7MHz and 5.35MHz (filter and half filter frequencies), and any v.f.o. output which, in conjunction with the crystal oscillator, could produce a third-order product ($2f_1 \pm f_2$) crossing the wanted 144 to 146MHz amateur band.

A v.f.o. operating on a lower frequency is likely to be more stable than a v.f.o. operating on a higher frequency. However it is desirable to use a small, mechanically-stable variable capacitor that can be housed in a very rigid die-cast box, and in practice this limits the maximum swing to about 100pF. The choice of 8.3 to 9.3MHz has been carefully made as an acceptable

Continued on page 96

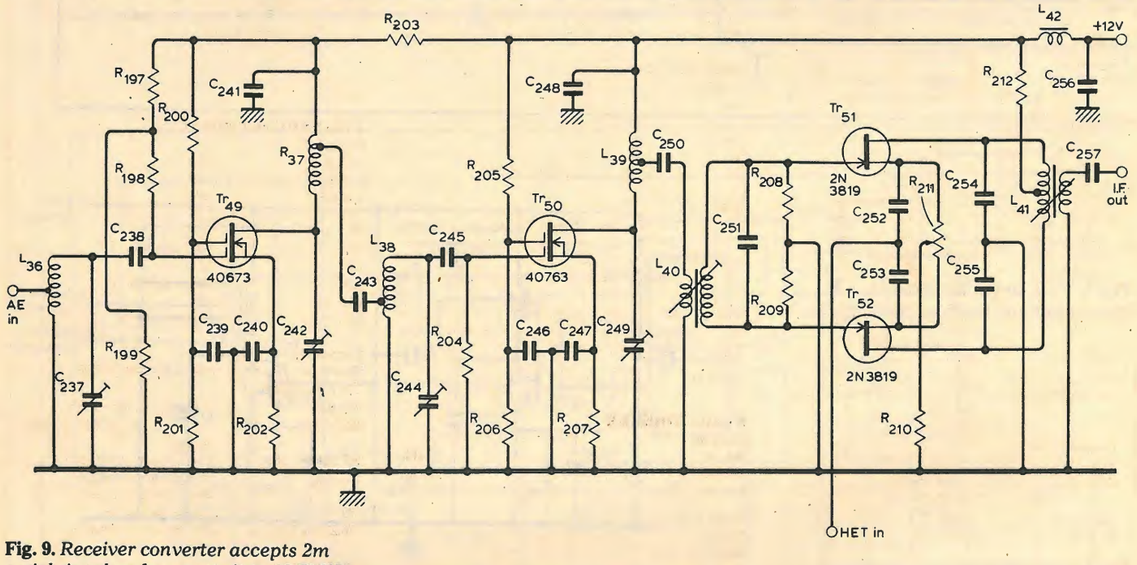
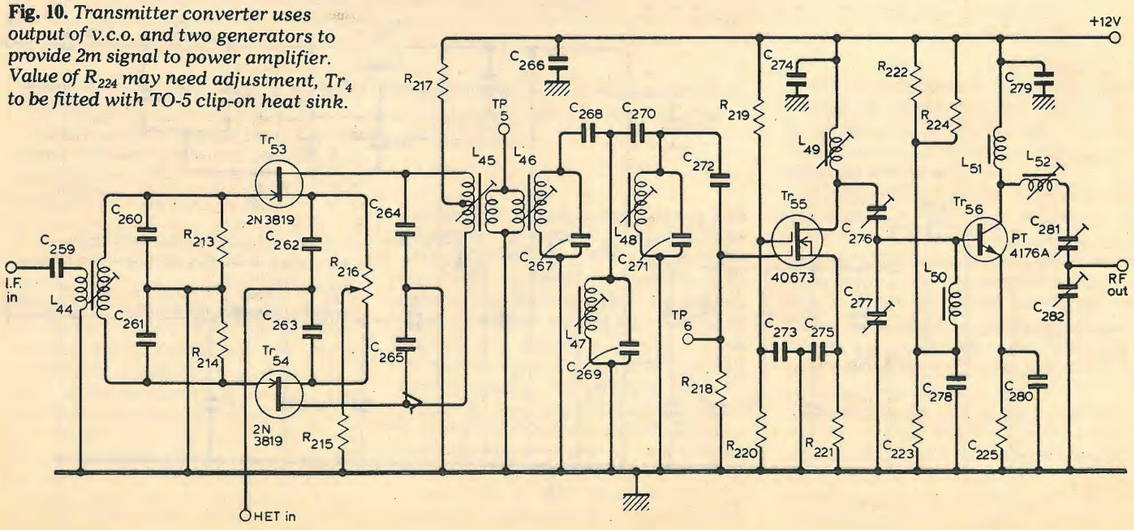


Fig. 9. *Receiver converter accepts 2m aerial signal and converts it to 10.7MHz i.f.*

Fig. 10. *Transmitter converter uses output of v.c.o. and two generators to provide 2m signal to power amplifier. Value of R_{224} may need adjustment, Tr_4 to be fitted with TO-5 clip-on heat sink.*



Components list

Phase-lock unit

Resistors (all ±10%, ½W)

138,170,171	33k
139,140,142,146,159,161	100k
226,181,183	330
141,153,169,182	470
144,148	47k
143,147,158,162	220k
145,149	270
150,151	10k
152	3k3
154	1k5
155	75
156,163,177,178	15k
157	150
160,164	220
165,166,168	6k8
167	27k
173,172	2k7
174,175,180	1k
176	180
179	680

Capacitors

151	1n polyester ±20%
154,153,157,159,160, 163,164,165,167	10n polyester ±20%
169,170,173,178,181, 183,184,185,187,194	
195,191,192	
196,197,198,202	100n polyester ±20%
199	470n polyester ±20%
155,156,176	2p2 tubular ceramic
158,161,162,166,186,190	11p tubular ceramic
168,174,179,180	3p3 tubular ceramic
175,188,189	33p tubular ceramic
177	9p4 tubular ceramic
182	100p polystyrene ±5%
171,172	25p Mullard trimmer
152	10p silvered mica
201	2μ2 16V electrolytic
205	22μ 16V electrolytic
200,206,203,204,193	1000p feedthrough, nut fixing

Transistors

30,31,41	2N3819
32,33,36,37	RCA 40673
34	BFW30
35,39,40,42	BSX19
38	BC108

Diodes

24	Hitachi BA111
25	BZY88 7.5V
26,27	1N914
28	BZY88 9.1V
30	BZX61 5.6V
29	red l.e.d.

Integrated circuits

2,4	SN7400
3	MC4044P
5	MC7805

Crystals

5	62.5MHz overtone
6	63.0MHz overtone
	both from P.M. Electronics

Inductors

21,23,24	3.5 turns 22 s.w.g. enamelled; spaced wire diameter
25	10 turns 22 s.w.g. enamelled, close wound
26	3.5 turns 24 s.w.g. enamelled, close wound All above on 5mm dia. former with dust core
28,29	30 turns 32 s.w.g. enamelled, close wound, on 0.3in dia. former, dust core
22	100μH 7BA Toko r.f.c.
27	1mH 7BA Toko r.f.c.

Switch

2	1 pole, 2 way, panel mounting

V.f.o.

Resistors

190	22k
191	1k
192,194	100k
193	470
195,196	330

Capacitors

216,236	1000p feedthrough, nut fixing
217	1n polyester ±20%
218	10p silvered mica
219	15p ceramic N750K (nominal value)
220	25p air-spaced trimmer
221	35p silvered mica
222	80p variable. Polar type C28-141 18/0.015in gaps
225	500p silvered mica
224	200p silvered mica
226,227	47p silvered mica
223,228,230, 233,235,229	10n polyester ±20%
231,234	100p tubular ceramic
232	220p tubular ceramic

Transistors

45,46,47	2N3819
48	BC108

Diodes

31	BA102
32	BZY88 9.1V

Inductors

32	11t. 22 s.w.g. enamelled, 1in. long on ⅝in dia. former, dust core, on 6BA screwed adjusting shaft, running into bush on former, locking nut. (Original from Marconi CR100 Rx)
33,34	30t. 28 s.w.g. enamelled, close wound on 0.3in dia. former, dust core (4.7μH)
35	1mH 7BA Toko r.f.c.

V.c.o. amplifier

Resistors

184,187	10k
185,188	1k8
186,189	150

Capacitors

207,211	47p polystyrene ±5%
208,209,214,212	10n polyester ±2%
210,213	11p tubular ceramic

Transistors

43,44	BSX 19

Inductors

30	3.5 turns 20 s.w.g. enamelled, 10mm long, tapped 1.5t. from cold end
31	3.5 turns 20 s.w.g. enamelled, 10mm long, two 2t. links 28 s.w.g. enamelled overwound at cold end of primary Both 20g. coils on No. 14 drill shank, sprung onto 5mm dia. formers, dust cores.

Receiver converter

Resistors

198,197,200,204,205	100k
199	22k
201,206	27k
202,203,207	270
208,209	4k7
210	2k2
212	1k2
211	1k miniature preset

Capacitors

237,242,244,249	35p ceramic trimmers
238,245	47p polystyrene ±5%
239,240,241,246,247, 248,257,256	10n polyester ±20%
243,250,254,255	130p polystyrene ±5%
251	5.6 tubular ceramic
252,253	1n polyester ±20% single-ended

Transistors

49,50	RCA 40673
51,52	2N3819

Inductors

36,37,38,39	4t. 24 s.w.g. enamelled, 10mm long. Wound on 3/16in drill shank. Tap 1t. from cold end. Self supporting.
40	4t. 24 s.w.g. enamelled, 10mm long. 1t. primary over centre of secondary.
41	34t. 36 s.w.g. enamelled, close wound. 7t. secondary over centre of primary. L_{40} and L_{41} on 5mm dia. former, pin spacing 9mm square. With screening can 14mm square 20mm high, dust core
42	2.5t. 24 s.w.g. enamelled on FX1115 ferrite bead.

Transmitter converter

Resistors

213,214	47k
215,217	2k2
218,219	100k
220	27k
221	220
222	470
223	27
224	1k8 nominal
225	10
216	1k min. preset

Capacitors

259,266,273,275, 274,278,279,280	10n polyester ±20%
260,261	130 polystyrene ±5%
262,263	1n polyester ±20%, single-ended
265,264,267,269	6p8 tubular ceramic
268,270	1p tubular ceramic
271	2p2 tubular ceramic
272	47p polystyrene
276,277,281,282	35p ceramic trimmer

Transistors

53,54	2N3819
55	RCA 40673
56	PT 4176A (alternative is BLY33)

Inductors

44	36t. 36 s.w.g. enamelled, close wound 7t. 36 s.w.g. enamelled primary over centre of secondary
45	9t. 24 s.w.g. enamelled, close wound, centre tapped. 2t. 28 s.w.g. enamelled secondary over centre of primary
46	4.25t. 24 s.w.g. enamelled, close wound. 2t. 28 s.w.g. enamelled primary overwound at cold end of secondary
47,49	4.25t. 24 s.w.g. enamelled, close wound
48	3.75t. 24 s.w.g. enamelled, close wound
52	5.25t. 24 s.w.g. enamelled, close wound L_{44} to L_{52} on 5mm former, 9mm square pin spacing. Can 14mm square 20mm high, dust core
50	2.5t. 24 s.w.g. enamelled on FX1115
51	3.5t. 24 s.w.g. enamelled on FX1115

Electronic speedometer

Design operates from 1 pulse per road wheel revolution

by A. J. Ewins

A disadvantage of electronic speedometers which use gear-wheel detectors is that activator and detector must be in close proximity to each other for acceptable results, while photoelectric methods can only function effectively in clean environments. This article outlines a design in which the operating distance between activator and sensor can be as great as 1 inch (25mm). The circuit operates on the basis of one pulse per revolution of the road wheel and the design is simple enough to permit quick attachment to or removal from the vehicle.

WHERE FREQUENCY-TO-VOLTAGE converters are in use in an electronic speedometer circuit, many pulses may be generated per revolution of the road wheel. Such circuit approaches often involve the use of marked black and white areas on the axle or other rotating component, giving rise to problems from dirt, or, in the case of gear-wheel pick-ups, the surface must be carefully prepared. A system which operates from one pulse per road wheel revolution and which requires no special preparation of surfaces is therefore an attractive one.

A further problem in conventional systems is that a restriction to one pulse per revolution, i.e. at speeds lower than 10 mph and a wheel diameter of 30in or more, rules out the use of the pulse width modulation frequency-to-voltage converter due to its incapacity to provide a ripple-free analogue voltage or a useful response time.

Principle of operation

The technique employed in this case is one where a small rotating magnet generates a signal which is used to "count" revolutions of the road wheel. Each revolution is marked by a pulse, the period between consecutive pulses being measured by a digital timer and then stored until the next pulse arrives. The period between pulses is thus updated every wheel revolution, causing the pulse repetition rate, and therefore the speed of the vehicle, to be inversely proportionaly to the time between pulses.

A digital period-to-voltage converter generates a voltage which is directly proportional to the speed of the vehicle. In this manner an average speed for the vehicle is obtained for each wheel revolution, and because the measured period between pulses is stored until the next pulse arrives, the output voltage will be constant so long as the vehicle's speed is constant, even at very low speeds. Steps in the output voltage will occur only when the vehicle accelerates or slows down.

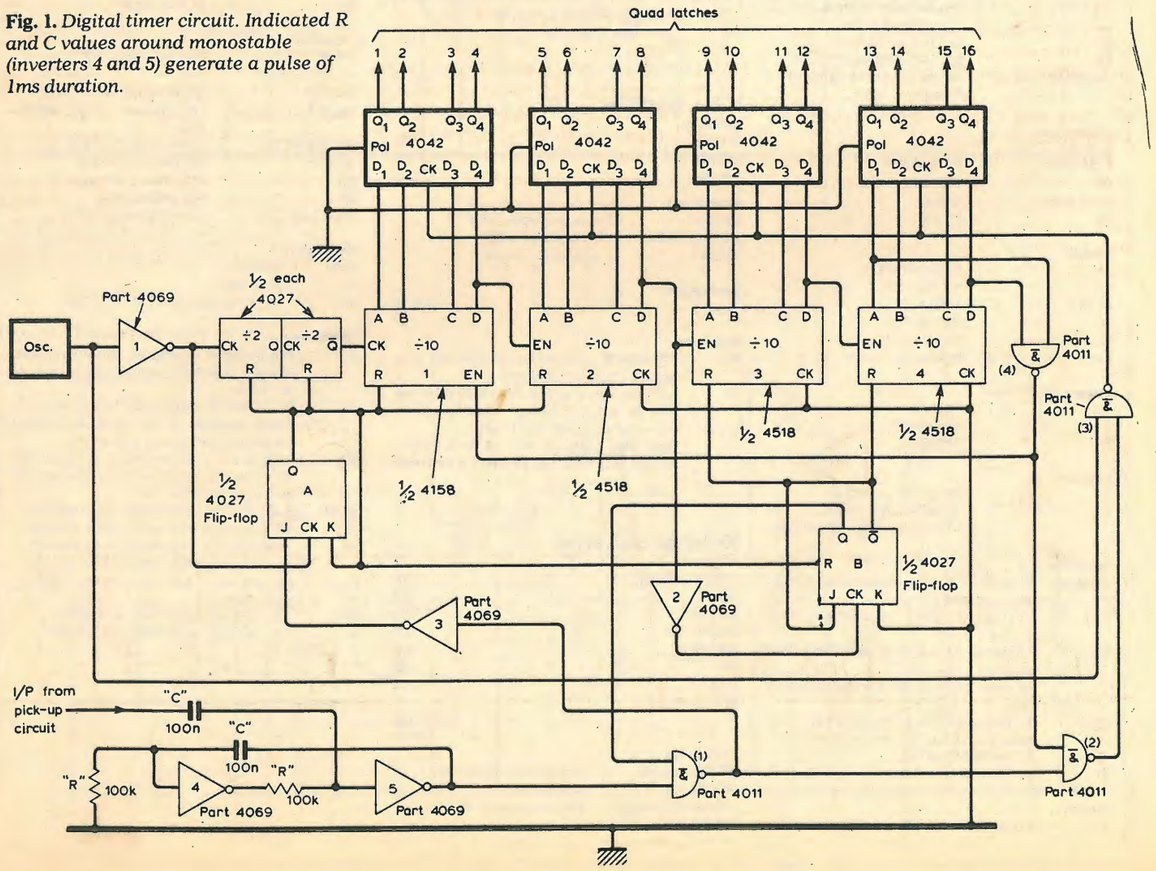


Fig. 1. *Digital timer circuit. Indicated R and C values around monostable (inverters 4 and 5) generate a pulse of 1ms duration.*

Main circuits

The circuit of the digital timer, consisting of an oscillator driving four decade counter stages via a divide-by-four counter, is shown in Fig. 1. This divide-by-four counter is included to ensure that the clock pulses from the oscillator, which operate latching and reset functions, are of much shorter duration than the least significant bit of the timer. Outputs from the four decade counters are passed to latches which store and hold the count between pulses from the pick-up transducer.

Operation of the timer is as follows. A negative-going pulse from the pick-up transducer circuit triggers the monostable comprising inverters 4 and 5 and their peripheral components. Clock pulses are fed via each NAND gate to the D inputs of the four quad latches, where they are transferred to their Q outputs and subsequently "frozen." Inverter 1 clocks flip-flop "A" which resets the divide-by-four counter, decade counters 1 and 2 and flip-flop "B".

Further processing results in the divide-by-four and decade counters 1 and 2 being reset and made ready to start counting again. Flip-flop "B" also becomes free to respond to its first clock pulse from the output of decade counter 2. Flip-flop "B" is included so that the first 100 pulses to the input of decade counter 2 may be ignored. Not until the D output of decade counter 2 goes low (after exactly 100 pulses to the input of decade counter 1) does the Q output of flip-flop "B" go low, releasing the reset inputs to decade counters 3 and 4. Maintaining the Q output of flip-flop "B" in a low state during the first 100 pulses ensures that further pulses from the pick-up transducer are locked out, for reasons which will be explained later in the description of the period to-voltage-converter.

As the divide-by-four counter is reset for the duration of one clock pulse, it is arranged that the interconnections between the two flip-flop sections of the divide-by-four counter, and the first decade counter are such that only a further three clock pulses are needed before the first decade counter is clocked. For this reason the Q output of the second half of the divide-by-four counter is used to clock the input of decade counter 1.

The clock and enable inputs of the decade counters are interchangeable as clock inputs. With the "en" input high the counter advances one count for a positive-going transition of its "ck" input. Conversely, when the "ck" input is low, the decade counter advances one count for a negative-going transition of its "en" input.

Period to voltage converter

Fig. 2 shows the circuit diagram of this section of the speedometer. The sixteen outputs from the four quad latches each connect to the base of an inverted n-p-n transistor through a 12k-resistor. A "low" state at the Q output of any of the latches causes the appropriate transistor to conduct, switching its emitter resistor to the 0 volt line. Each transistor is used in the inverted mode in order to take advantage of the much reduced V_{ce} (<2mV) which results from this approach. The value of each of these resistors is arranged to be inversely proportional to the value of the appropriate Q output from the latches. The total value of each resistance switched to 0V is given by $600k\Omega/N$, where N is the decimal value of the output from the timer. The output voltage, V_o, of the potential divider formed by R_1, R_2, R_3 and the switched value is given by $V_o = 12R/(R_1+R)$, *where* $R = R_2/R_3/600k\Omega/N = 15k\Omega/15k\Omega/600k\Omega/N$.

Evaluated, R becomes $4.5\times10^9/(7500N+6\times10^5)$ and V_0 becomes

$$V_0 = 12\frac{(4.5\times10^9/(7500N+6\times10^5)}{3\times10^4+(4.5\times10^9)/(7500N+6\times10^5)}$$

$$= 12\frac{(20)}{(N+100)}$$

The actual count value of the timer, N is always 100 counts short of the true value, M. Thus $N=M-100$, and substituting for N in the above equation gives $V_O = 12.20/M$. M is directly proportional to the period between pulses, T, and therefore V_O is inversely proportional to T and directly proportional to frequency, F.

In practice, the value of N cannot be less than zero and therefore V_o has a maximum value of $V_o = 12.20/100 = 2.4V$. The gain of the first stage op.amp. is adjusted to be exactly 0.833 so that the maximum signal output corresponding to full scale deflection (f.s.d.) for the speedometer, is 2V.

It is convenient for the maximum f.s.d. of 2V to be equivalent to a speed of, say, 100m.p.h. The speed of 100m.p.h. results from a period between pulses related to a timer count of 100 ($N=0000$). The maximum number of counts that the timer will run to is 9000 ($M=9100$) since, when the fourth decade counter reaches a value of 9 (A and D outputs high) the "en" input of the

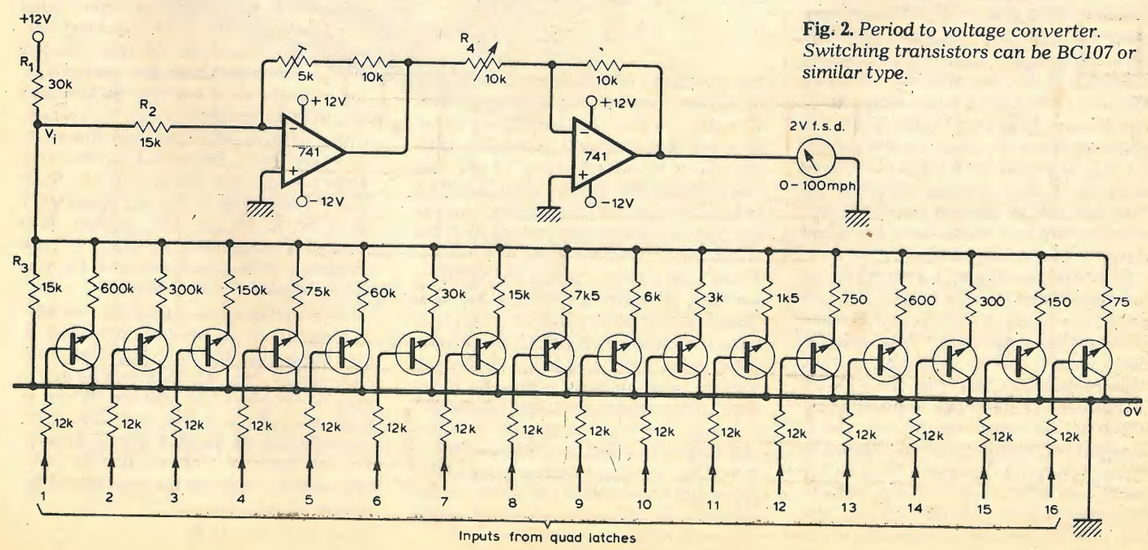


Fig. 2. *Period to voltage converter. Switching transistors can be BC107 or similar type.*

first decade counter becomes low (output of NAND 4 becomes low) inhibiting the counter, and hence the timer, from advancing further. The minimum speed that may be indicated by the speedometer is therefore related to a count of 9100 and is equal to 1.099m.p.h.

Because the analogue voltage output of speed is inversely proportional to an integer value of time that increases or decreases with a minimum step of 1, the speedometer will have a finite resolution. However, as the minimum value of the integer is 100 and the step value is 1, the resolution is never worse than 1% of f.s.d. The actual f.s.d. of the speedometer may be adjusted to any value greater than 1.1m.p.h. and less than 100m.p.h. For this purpose, the second op.amp. stage in Fig. 2 has been included. The value of the variable resistor is directly proportional to the f.s.d. of the speedometer. By making R4 a ten-turn variable resistor with a ten-turn indicator, any convenient f.s.d. may be 'dialled in'. Regardless of the f.s.d. selected, the resolution of the output signal is never worse than 1% of the total deflection.

Oscillator

The circuit of the clock oscillator is shown in Fig. 3. The frequency that the clock oscillator must run at is determined by the diameter of the vehicle's road-wheel and the required maximum f.s.d. of the speedometer. For a wheel circumference of πD (where D is the diameter of the wheel in inches), the frequency of the pulses generated at an f.s.d. of 100m.p.h. (for one pulse per wheel revolution) will be $100(88/60)(12/\pi D)$ per second. For 100 pulses to be counted by the timer, the frequency of the oscillator must be (4x100) times this value. i.e. Oscillator frequency $= 400\times100\times(88/60)(12/\pi D) = 704{,}000/\pi D$. Thus the period of the oscillator (T) equals $\pi D/704{,}000$. For the oscillator of Fig. 3, this period is given by $0.693\ C.\ (R_1+2R_2)$. Therefore $\pi D/704{,}000 = 0.693\ C(R_1+2R_2)$. This is very convenient for (R_1+2R_2) can be made directly proportional to the wheel diameter, D. By choosing $R_1 = 2k\Omega$ and $R2 = 1k\Omega + 10k\Omega$ var. a useful range for D can be made from 10in to 60in. From the above equation, the value for the capacitor, "C_0" works out at 16.1nF which can be made up of from selected capacitors of 15nF and 1nF. By making the 10kΩ resistor a ten-turn type, the value of the wheel diameter can be easily dialled in.

Before proceeding to a description of the circuit and design of the pick-up transducer there is one further feature of the digital timer circuit that must be mentioned. It will be remembered that negative-going pulses from the pick-up transducer trigger the monostable, which in turn causes the data on the D inputs of the latches to be transferred to their Q outputs, provided that other conditions are correct. If the vehicle decelerates quickly, it may be that the last time interval to be transferred to the Q outputs of the latches is not the minimum speed measurable (i.e. 1.1m.p.h.). In that case, the higher value of speed would remain indicated until the vehicle moved off again. To get over this problem, the output from NAND 4 (which disables decade counter 1 and at the end of an equivalent count of 9100) is also fed to the other input of NAND 2. When either of the inputs to NAND 2 are low, its output will also be low. Thus, information from the latch D inputs is transferred to the Q outputs when either a pulse is produced by the pick-up transducer *or* when the timer runs to its maximum count. However, although the transducer pick-up pulse also resets the timer, it is not reset upon reaching its maximum count. This procedure ensures that the speedometer indicates its minimum value of speed when the vehicle is stationary.

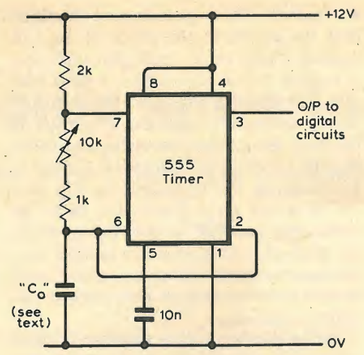


Fig. 3. *Clock oscillator circuit.*

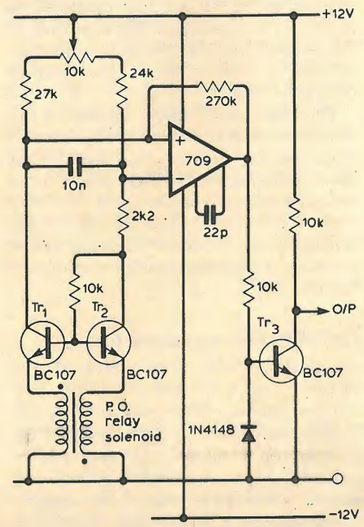


Fig. 4. *Detector circuit. Tr_1 and Tr_2 collector voltages are "balanced" by the 10k potentiometer in the 12V line.*

Transducer and detector circuit

Fig. 4 shows the circuit of the pick-up detector. A standard G.P.O. relay, with two 1kΩ (d.c.) windings, is used as the pick-up sensor, Tr_2 is self-biased by the 10kΩ resistor connected between its collector and base terminals. At the same time, this resistor provides the bias voltage for the base of Tr_1. Provided that the two transistors are fairly well matched, and the impedances of the solenoid windings in their emitter lines are the same, similar collector currents will flow through both transistors. The 10kΩ balance potentiometer is adjusted so that the collector voltage of both is the same at a value of about 1V. The potential on the positive terminal of the 709 op.amp. is thus 1V, and that on the negative terminal about 1.8V. The relay solenoid windings are connected into the emitter lines of the two transistors in such a way that the direction of the windings oppose. Thus when a negative voltage is induced in one, a positive voltage is induced in the other.

Voltages are induced in the windings by the passage of a small magnet producing a magnetic field perpendicular to the face of the solenoid. Ideally the magnet, attached to the axle or wheel of the vehicle, is orientated in such a way that a positive voltage is induced in the winding of Tr_1 as the magnet approaches the solenoid, and a negative voltage induced as it moves away. Because of the 10kΩ feedback resistor around Tr_2 its base voltage will follow its emitter voltage. Thus, as Tr_1's emitter goes positive, its base goes negative, resulting in a positive-going voltage on its collector. Because the collector resistor of Tr_1 is some 30 times greater than its emitter impedance, the small induced voltage on its emitter is greatly amplified at its collector. Tr_2 has only unity voltage gain by virtue of the 10kΩ feedback resistor. Thus as the inverting input of the op.amp. goes negative by an amount equal to the small induced voltage, its non-inverting input goes positive by an increased (induced) voltage. The magnitude of the induced voltage depends upon the strength of the magnetic field cutting the solenoid and the rate at which it cuts it. A small, round magnet of about ¾in diameter and ½in thick, induced a sufficiently large voltage at a distance of 1in from the solenoid and a cutting speed of 1 foot/sec to trigger the op.amp. into changing state. The strength of the magnet's field at a distance of 1in was later measured as 20 Gauss.

As we have seen, a positive voltage induced in Tr_1's winding produces a positive-going pulse at its collector. The magnitude of the pulse cannot be more than the positive rail voltage. When a negative voltage is induced into Tr_1's winding (as the magnet moves away), Tr_1 will 'bottom' with a collector voltage only a little less than its normally biased value of 1V.

Continued on page 86

LETTERS TO THE EDITOR

"GOOD, CLEAN FUN"

After reading your September editorial on c.b. radio I wonder if it is to be future policy of *Wireless World* to provide free publicity for any other type of illegal activity, provided only of course that its supporters claim their number are such as to render legalisation imperative.

I would be happy to provide details of several groups of people at present operating outside of the law who would welcome the support of a long established periodical in order to have their activities legalised. Each of these groups, I am sure, would claim equal ability at least with the c.b. pirates, to meet the qualificatory standards apparently acceptable to *Wireless World*.

I am not particularly opposed to c.b. I am opposed however to modification of law by blatant disregard for it. Presumably it should not be too difficult in the near future to secure abolition, for instance, of the driving test, assuming a handful of people can obtain sufficient publicity for their "freedom of the road" philosophy. There is no difference of principle; it is merely a question of degree. Good clean, fun, in fact!

Your (unintended, I am sure) equation of c.b. with some of the current tv programmes may well be apt. But your contention that many megahertz of airspace are occupied by trash, as you call it, as justification for an extension of the situation, is surely as specious as your statement that an argument based on the necessity to legalize the activities of lawbreakers "does carry a certain force."

If your editorial is a representative sample of the calibre of the arguments being advanced in support of c.b., I find "the Home Office's blank and uncomprehending disapproval" not in the least surprising.

J. D. Pearson G3KOC
New Holland,
South Humberside.

RELATIVITY AND TIME SIGNALS

The letter of mine on this topic in the September issue was written quickly on holiday and withdrawn from publication equally quickly when I returned to my textbooks. because it contains an elementary error. However, because Murphy's Law intervened and it was published anyway* I feel bound to try again.

First, let me say that the relativistic part of the frequency (or time) correction for a moving square, unlike the classical Doppler part, of course, contains no angular term and is therefore independent of the direction of the source's motion relative to any observer.

Unfortunately for Dr Essen's critics this correction must be applied symmetrically to the observations of all observers in order to preserve the strict equivalence of their measurements of the velocity of light, c. To illustrate this, I will borrow Prof Fremlin's example (Letters, April 1979) of a "Traveller" between Earth and Sirius (12 light years away) at a velocity $v = 0.9999905\ c$ relative to Earth. His discussion of this example is correct up to the end of the paragraph containing the reference to the footnote. However, in the footnote, distance in the moving universe seen by Traveller is given as 12×0.0044 light-years, whereas light-years are invariant under the Lorentz transformation. (This is so because the light-year is a statement of the velocity of light, as distance per year.) If Traveller really saw his own clock showing only 19 days for the journey to Sirius he would know that something was very wrong without having to look out of the window at the foreshortened universe. All his velocity measurements inside his, to him, apparently normal-length space-ship would be wrong, including the local value of c. It would take him 0.0044 of the usual time to boil a kettle or walk the length of the cabin, for example.

His clock appears slowed by this factor only to observers at rest relative to the Earth, so that the velocity of light can remain correct as measured inside his (to them) foreshortened space-ship: $c = (d \times 0.0044) / (t \times 0.0044)$, where d and t are corresponding distance and time intervals in rest co-ordinates. Similarly, when he looks out at the shrunken universe he will conclude that the clocks out there are slow by the appropriate factor to preserve the value of c in moving co-ordinates. His own clock will be running suitably to give the same numerical value of c inside the vessel and in co-ordinates fixed relative to it, and moreover, giving a journey time of 12 years 1 hour each way!

It is not too hard for us to accept that Traveller's volume, and even, superficially, his absolute temperature only appear to be reduced by the factor $\sqrt{(1 - v^2/c^2)}$ during his journey and no-one would contend that his reading of our apparent ambient temperature of about 1.3 K represented any kind of reality for us. If it did, we would certainly not get much older. The difficulty lies in the time-dimension effect, which to our intuition is not so easily reversible as are steady-state parameters like length and temperature; when ticks, heartbeats, atomic vibrations and decay events of elementary particles have been lost, they cannot be so readily restored. (The relativistic effect on apparent temperature is in fact a consequence of the apparent time dilation, and so similarly represents "missing" vibrations.)

Relativistic corrections for apparent mass, length and time scales of high-energy elementary particles are certainly in everyday use in many fields: in conjunction with Maxwell's equations they "work" to the ultimate limits of measurement. However, this only proves the internal self-consistency of a scheme which was, after all, devised in its numerical form by Lorentz for the very purpose of saving Maxwell's equations from the consequences of an undetectable "ether".

The unexplained "missing ticks" effect, as pointed out by Dr Essen (October 1978 issue), is clearly intrinsic to the Special Theory of Relativity. This fact is at variance with our notions of the nature of "events" and their countability.

W. T. Morris
Teddington
Middlesex

* Apologies to Dr Morris and to readers for this mistake — Ed.

DISPLACEMENT CURRENT

Professor Bell's article "No radio without displacement current" in the August issue raises so many issues it is difficult to know where to start. Rather than deal with the details, I will start with a consideration of the purpose of the article. The title of the article makes this clear; it is an attempt to defend Maxwell's theory against recent criticisms with particular reference to displacement current.

I understand that Aristotelians believed that a force was necessary to keep bodies in motion and that, in the absence of this force, the motion would cease. This theory led them into certain difficulties. For instance a spear, once thrown, appeared to continue to move without a force being present. The philosophers rose to this challenge magnificently with a theory that air, displaced from ahead of the spear, rushed to the rear and generated the requisite force – the theory was saved. Unfortunately they missed the simple point first noted by Newton, that it is in the nature of a moving body to continue to move.

In the same way I fear that Maxwell invented a complex explanation for a very simple phenomenon, ie that electromagnetic radiation, or energy current, moves at the speed of light – and that's all, because that is what energy current does. No mechanism invoking E producing H and H, in return, producing E is required. As for the details of Bell's article – they do not stand up well to close examination.

In the first place, it is unwarranted to suggest, as Bell does, that since Maxwell *introduces* the idea of displacement current early in his treatise (the correct title, incidentally, is "A treatise on electricity and magnetism" and Bell appears to be referring to the third edition first published in 1891), this is a proof that he thought of it in connection with simple phenomena. This is just too simplistic; the way Maxwell presents his ideas cannot be taken as a guide to how he thought of them. Much has been written and many papers have been published on the genesis of Maxwell's thought and it is inadmissable for Bell to treat the subject in this superficial way. I would be happy to provide a list of references (about 20) to anyone who would like to study the development of Maxwell's thinking in detail. I suggest Joan Bromberg's paper[1] as a good start to the subject.

There are many errors of detail in the article. Perhaps I could draw attention in particular to the statement that "Maxwell ... was at home with vectors." Vector algebra was not invented in Maxwell's time and he never used it. He made some use of Quarterninic formulation of his equations but was not consistent in its use – Maxwell, in fact, never formulated his theory in terms of four equations – this was left to Heaviside who also introduced vector calculus more or less as we know it.

The rest of Professor Bell's article can be found in any elementary textbook on electromagnetic theory; its testament, however, does nothing to establish that theory which is in the process of being replaced by a simpler formulation.

D. S. Walton
CAM Consultants
St Albans
Herts

Reference

1. Bromberg, J. "Maxwell's Electrostatics," *American Journal of Physics* 36, 145-151 (1968).

The author replies:

First, Dr Walton's reference to Aristotelian philosophers is a red herring. I mentioned early speculation about the planets because Newton's theory of gravitation was based on the hypothesis that the same force accounted for objects "falling" to earth (the notorious apple!) and for planets describing *closed orbits* about the sun. It then involves the conceptual difficulty of action at a distance, unless one prefers to postulate fields of force. Incidentally Newton was *not* the first to suggest that a body in motion would so continue if undisturbed. Hobbes in his book "The Leviathan" mentions that it was a subject of discussion whether this be so or not, and himself unhesitatingly chose Newton's answer. Newton's achievement was to formulate the precise law and "prove" it by incorporating it in his complete system of mechanics which was supported by experimental evidence.

In considering the proposed alternative to Maxwell's theory of electromagnetic waves, there are two questions. First, what is an "energy current"? "Current" usually means flow of something; and "energy" seems to me entirely abstract unless qualified by some adjective such as kinetic, electrostatic etc. So what flows? Second, is there a relation, and if so why, between this "energy current" and the observable electric and magnetic effects? For example, the creation of a spark in air by a focused laser beam is consistent with the electromagnetic theory of light.

As regards the chronology of Maxwell's different uses of displacement current, the main point is that he did find use for it other than in the derivation of a wave equation. Others have since found its use in "electrostatics" convenient or even essential. (See footnote to article.) It may be that the logical train of development which I suggested is a *post hoc* rationalisation, but one cannot prove whether or not this was how Maxwell saw it.

The article by Joan Bromberg is entitled "Maxwell's Electrostatics" and details Maxwell's difficulties in arriving at a satisfactory formulation of 'displacement' in electrostatics, based largely on the concept of polarisation. So it is in agreement with the point which I was making: Maxwell regarded 'displacement' as an essential part of the description of electrical phenomena, not just as a device to facilitate the formulation of a wave equation.

Of course most of the content of my article in the August issue is to be found in standard text books. It was written on the supposition that there are many readers of *Wireless World* who have not studied a text book on electromagnetism.

D. A. Bell

WHAT IS AN ELECTRON?

For the past decade or more I have been saying that mechanical force is that component of electromagnetism which is radiation pressure. Since Professor Jennison (June issue) appears to agree with that concept, at least insofar as the internal forces of a system are concerned, might I be allowed to point out certain errors in the basis of his argument which arise out of the concept itself?

First let me say that I agree to the possibility of the 'phase locked cavity' idea of an electron. It is the basis of the mathematics which is questionable.

Clearly, from his argument, the alteration of motion and kinetic energy of the electron is related to the laboratory in which the experiment is conducted. Within the context we must ask the question – what is kinetic energy? Part of the mathematics is based upon the answer.

Since force is radiation pressure then the source of the radiation is undoubtedly related to the laboratory; the radiation has some specific velocity. Let us consider the Newtonian case; here the maximum velocity is infinite and the effect of the force (the origin of which is with the laboratory) will diminish linearly as F/v, where v is the velocity relative to the laboratory. This is a first order Doppler effect and quite readily understandable.

To cause a change of momentum from 0 to v the force will need to be applied to the mass over some distance L. We therefore have

$$F \,.\, L/\tfrac{1}{2}v \qquad (1)$$

to cause a change of motion

$$M \,.\, v \qquad (2)$$

thus

$$F \,.\, L/\tfrac{1}{2}v = M \,.\, v$$

or

$$E = \tfrac{1}{2}M \,.\, v^2 \qquad (3)$$

Any explanation which purports to describe inertia in terms of radiation pressure, and at the same time ignores this fact, must surely be ill founded. Where the radiation travels at the velocity c then, due to Doppler, the maximum velocity possible is c and the second order term appears in the form of the Lorentz transform.

In either the Newtonian case or the relativistic case, we may be sure that the energy equations depend upon factors that are *external* to the mass under consideration. The mass increase hypothesis is therefore no longer tenable; special relativity thus fails.

My second objection to the Professor's argument is of a more practical nature. It is known from experience with communication that e.m. waves do *not* interfere each with the other in empty space. How then is it suddenly possible for those same waves, in a particular configuration, to be affected by similar waves external to that configuration?

We may be quite certain that even though the electron might be a 'phase locked cavity' the boundaries of the cavity comprise material particles.

Alex Jones
Paimpol
France

The author replies:

I can understand Mr Alex Jones being worried that I had apparently forgotten about kinetic energy related to the laboratory. It is quite impossible to cram all the analyses from many scientific papers into one article in *Wireless World*. I can reassure him that, in *J. Phys. A*, 11, 1525-1533, I treated the electron as a phase-locked cavity and rigorously derived the correct relativistic kinetic energy and momentum for the electron scattered in the Compton effect – the first classical explanation of this phenomenon. Contrary to Mr Jones's statement, the result is perfectly consistent with the relativistic increase of mass and there is no question of the failure of special relativity. Mr Jones then wonders how it is that waves which normally propagate without a "photon-photon" interaction in free space should have different properties when locked in a particular configuration. All that I can say to this is "Why not?". The travelling waves have no inertial mass but the treatment shows that standing waves acquire this property and thereby become tangible entities.

Mr Jones's final conclusion "we may be quite certain that even though the electron may be a phase-locked cavity the boundaries of the cavity comprise material particles" does not stand up to a full analysis of the energy distribution of an electron. All that is required is for the wave system to loop on itself under particular circumstances at this particular wavelength. I wonder also of what substance these 'particles' are to be made? It is possible to derive the relationships for inertial force and mass without mentioning the boundaries. Consider a centrally noded $\lambda/2$ standing wave system, of energy E, in which the node is moved to the right. The force from the right is, very closely.,

$$F_R = \frac{E/2}{\lambda/4}(1+v/c)$$

and that from the left is

$$F_L = \frac{E/2}{\lambda/4}(1-v/c) + \delta F$$

where δF is the impressed motive force. The system is in kinematic equilibrium and therefore $F_R = F_L$, hence
$\delta F = 2E/\lambda[(1+v/c)-(1-v/c)] = 4Ev/\lambda c$ but
$\lambda/2 = c\delta t$ where δt is the feedback time and, from Galileo, the acceleration is
$a = 2v/\delta t = 4vc/\lambda$
Therefore the impressed motive force

$$\delta F = \frac{E}{c^2}a$$

whence we obtain at the same time

$E = mc^2$ and $\delta F = ma$.

R. C. Jennison

THE MILLIBEL

Mr P. Marks's call in a recent letter (June issue) for recognition of the millibel was very special pleading indeed. This tiny unit is unlikely to find application outside the laboratory, or even inside most such places.

In my current work in acoustics, the uncertainty of accuracy of a precision grade sound level meter will probably exceed ±0.5dB (i.e. ±50mB at a calibration level around 10,000mBp). The overall uncertainty of measurement will far exceed this value, as meter readings fluctuate widely for small changes of reading position other than in free field conditions. Even if the last-mentioned conditions can be established in anechoic chambers, the angular variation of sound radiation is likely to be at least of the dB order for most practical sources. Lastly, it might be thought than in audiometric work such as hearing assessment greater accuracy would be needed. But it is well-known that 1dB is about the smallest sound level change that most people can detect. From past experience, I believe that similar arguments could be advanced in the radio and line transmission fields.

As a ratio, a variation of power level of 1dB is equivalent to a 26% change, while 1mB corresponds to 0.23%. In percentage terms the first value seems large, while the latter is by no means negligible. But in the fields where such changes are significant they are not expressed logarithmically, at least at present.

But perhaps in Mr Marks's home he switches on a second bar of his electric fire to obtain a 300mB increase of heat output. I suppose that even a 5 millibel (le) increase in the warmth of my personality would make me more attractive. Nevertheless, it would be interesting to know the fields in which Mr Marks sees an application for his tiny protegé, the millibel.

Anne King
London W4

UNIONS AND ELECTRONICS

Unlike a recent contributor to the letter columns (July issue, p. 76), I was pleased to read a contribution by Ken Gill from AUEW-TASS on the role of the specialist in microelectronics. While I support his concern with the need to use new technology such as microelectronics to provide a higher quality of life, less boring work etc., I feel he has a rather simplistic view of technology itself. A good technology is viewed by him as being productive; a bad technology, in its applications at least, would be a weapons system. But in real life the technology we use is a great deal more subtle both in its form and its effects.

Furthermore these effects, the potentially progressive social consequences and the damaging side-effects, do not just simply appear alongside one another without a great deal of assistance from us, the engineers. Economic and political factors have their part to play too. For example a microprocessor has to be engineered to function in a guided weapons system by someone; similarly the functions of a word processor are defined prior to its fabrication. A word processor system can be built to displace largely female typing labour with a few less skilled keyboard pushers who have even less interest in or control over their work. But it should be feasible to design a microprocessor based office system which, while relieving both typists and managers of boring work, at the same time creates a new division of labour in which office workers could participate more fully in the organisation of their work, instead of being pure paper or button pushers.

Ken Gill uses the analogy that technology must be our slave and not the master, but while the master can determine what sort of slave he or she will employ, in turn the actions of that slave (in this case microelectronics) play a part in shaping the life of the master.

As engineers in our unions and professional institutions we should discuss what *sort* of technology we wish to design and use, and how to use it, in an effort to solve Britain's continual crisis. Much depends on our ability to organise society in a more rational manner to eliminate unemployment, pollution etc. Microelectronics could assist in the creation of a new society. This cannot happen overnight, but where I am now, in Mozambique, engineers and technicians are beginning to participate in creating a society which is a significant improvement on the old one.

Alan Taylor
Maputo
People's Republic of Mozambique

CITIZENS' BAND SYSTEM

The letter from Mr Bryant in the October issue discusses alternatives to the citizens' band communication system proposed in my article (August issue, p.61). Mr Bryant is kind enough to admit the proposal as a useful addition to the facilities which the Citizens' Band Association wish to be legalised in this country. Whilst it would be possible to debate the relative merits of the many alternatives, I suspect that it would be pointless because that which seems best is a matter of opinion and perspective. Try to convince a motor-cycle enthusiast that his beloved machine is impractical just because it will not carry a family of four. Similarly, users of radio and enthusiasts have different aspects of the potential of the medium as their main interests.

As it is unlikely, if not undesirable, that all of the alternatives will be legalised, the problem is one of choice. It is my concern that the system chosen should be of greatest benefit to the greatest number of people. Conventional c.b. is known, understood and attracts a following of enthusiasts who lobby for its legalisation. The system which I proposed is not widely known and and understood and therefore demanded by those it would benefit, and in my opinion such a system would be of most benefit to the non-enthusiast. I have in mind the person whose interests are occupied on other matters and has no desire to make a hobby of talking to complete strangers by radio. Most such people need to get messages to other people and the more quickly and efficiently it can be done the better. My proposal is simply to let the technology do all the work of tracking down the person, delivering the message, and confirming that it has been delivered. Because the system does all the work it is unlikely to have much appeal for the enthusiast.

Howard T. Tillotson
University of Birmingham

WHAT'S WRONG WITH TELETEXT

The analysis in your columns of the failure of teletext to 'take off' seems to ignore the fact that the system, as at present implemented, has very limited usefulness (July issue p. 61, August issue p. 33). The tv transmitted versions (Ceefax and Oracle) have bit rates which are far too slow for the transmission of large bodies of randomly accessible information. While this could be alleviated to some extent by the inclusion of more memory in the decoders, it seems to me to be a pretty fundamental limitation. Indeed, I suspect that broadcast teletext will eventually be relegated to providing optional programme inserts such as subtitles for the deaf and for language minorities, and news flashes.

The Post Office's Prestel viewdata system, with its almost infinite information capacity, is a much more practical and useful system and when it finally becomes generally available, sales of teletext/viewdata sets should begin to 'take-off'. Unfortunately it seems that the decoder manufacturers are running up against Post Office monopolism with lengthy beaurocratic procedures necessary to gain approval for equipment to be connected to the telephone system.

This is primarily a political problem, and the view that the P.O. monopoly and responsibility should end with the provision of a line to a point specified by the user and not include equipment connected to that line has great merit. It should not be beyond the technical resources of the P.O. to install devices to protect their equipment from that of the user. The relaxation of P.O.restrictive practices would also encourage the development of 'private sector' telephone-accessible data bases. How convenient it would be if one could call up Encyclopaedia Britannica and purchase directly the few kilo-bits one required instead of having to buy the complete giga-bit hard-copy package!

John Hind
Belfast

With reference to the future of teletext, which is selling slowly because we are all waiting for the price to drop, what is required is a complementary "Telepix" system. Two of the other spare lines could be used to transmit full definition colour still pictures to go with the words.

I invite other readers to describe an electronic system capable of storing and then displaying a complete picture.

R. N. Soar
Mexborough South Yorkshire

With reference to Mr Brewster's letter (September) on the need for a smaller teletext receiver may I refer him to the Pye Visa model? Although primarily intended as a desk-top viewdata terminal for the Post Office's Prestel service it does have full television and teletext facilities. It has a 9-inch monochrome c.r.t. The Pye Visa is currently in production here in Malmesbury.

L. Williams
Pye TMC Limited
Malmesbury Wilts

MILITARY ELECTRONICS

Having read C. D. Johnson's letter in the August issue I feel that there is now hope that this brief account will be published.

During the years before the Second World War it was widely believed that the only way to have peace was to disarm. This folly was pursued by the peace-loving nations until the outbreak of war in 1939.

My generation in this country has never seen war, and thankfully never will, but most of us know it is bloody, it is ruthless — but most important — human beings die. Think of the fighter pilots or the rear gunners in World War II; young men who gave their lives for the sake of personal freedom, and gave them horribly. Churchill said in a wider sense "Never, in the field of human conflict has so much been owed by so many, to so few."

Have we the effrontery to say 'we in the West no longer need to be technically superior.' If man makes a third mistake it will most certainly be his last.

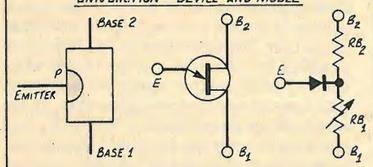
Peter Gregory
Ashton-under-Lyne, Lancs.

Letters continued on p.84

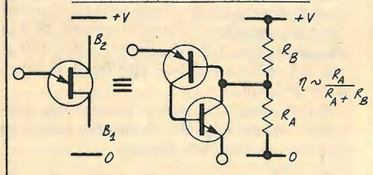
Unijunction astables

by Peter Williams, Ph.D., Paisley College of Technology

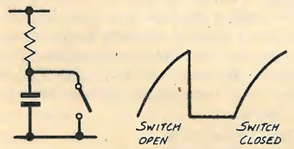
UNIJUNCTION - DEVICE AND MODEL



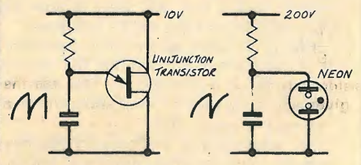
UNIJUNCTION / COMPLEMENTARY PAIR



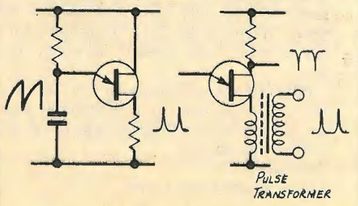
EXPONENTIAL RAMP - DRIVEN



EXPONENTIAL RAMP - FREE-RUNNING



UNIJUNCTION OSCILLATOR - ALT. OUTPUTS



A device frequently used in simple pulse circuits such as for firing thyristors is the unijunction transistor. It is of interest here for its relationship with other oscillators such as those based on 555 type circuits and transistor complementary pairs. It consists of a conducting region between base 1 and base 2 generally through n-type material with an emitter junction of p-type material. The resistance base 1-base 2 with the emitter open-circuit is a few kilohms. Base 2 is taken to a positive potential and the n-type material adjacent to the emitter takes up an intermediate positive potential by virtue of the potential divider action of the resistances represented as R_{B1}, R_{B2}. For emitter voltages below this level p-n junction is reverse biased, draws no current and has no effect on the conductivity in the base region. As soon as the diode is forward biased by making the emitter potential sufficiently positive, current carriers are injected into the base 1 region. This increases its conductivity i.e. reducing its resistance and reducing the proportion of the supply voltage dropped across it. This increases the current drawn through the emitter still further regeneratively decreasing the resistance and the E-B_1 path becomes almost a short circuit.

If the current source is removed then R_{B1} rises and the device is restored to its initial state. This characteristic exhibits negative slope resistance and is very similar to that obtainable with the complementary switch shown. This has been used in the past to model the behaviour of a thyristor in that it can be triggered into conduction by a positive voltage at the n-p-n base; provided current continues to flow through the p-n-p emitter this on-state is maintained. In this mode the n-p-n collector/p-n-p base junction is assumed to be open. By tying the junction, as here, to a potential divider across the supply the input emitter has no effect until that voltage is exceeded. Once that happens the transistors switch regeneratively into conduction, the collector of one driving the base of the other ever more strongly into saturation depending on the current limit imposed by the source connected to the input emitter. The ratio $R_A/(R_A+R_B)$ corresponds to that of the intrinsic stand-off ratio of the unijunction transistor $=R_{B1}/(R_{B1}+R_{B2})$. The behaviour is not identical: there is no equivalent to terminal B_2. On the other hand, the stand-off ratio is easily controlled and modulated externally. Nonetheless circuits using the unijunction transistor and the complementary pair are broadly similar.

The configuration most usually met involves an RC charging circuit with the active device taking the place of the switch. As shown, the switch interrupts the charging cycle returning the voltage to zero until it is opened again. The function of sensing when the appropriate voltage (or time) has been reached is quite separate and in other circuits such as the 555 is performed via a separate pin on the package separately connected to the capacitor. Similarly sensing that the minimum voltage has been reached (or that sufficient time has elapsed) is a distinct requirement and can be performed via a third terminal (of the 555 circuit where pin 7 performs the switching action, pin 6 detects the upper level and pin 2 the lower level). In the unijunction transistor one terminal has to serve all three functions. Its behaviour has to change sharply from virtual open-circuit to short-circuit when an upper threshold voltage is exceeded and this has to reverse when the external circuitry is no longer able to supply sufficient current again. Thus the unijunction transistor cannot readily provide a driven function as above though external pulsing of base 2 is a possibility.

It is well-suited as a free-running generator for which it provides the simplest possible circuitry. The capacitor charges exponentially until the voltage at the emitter brings the pn junction into conduction. The device is switched into its negative resistance region and rapidly discharges the capacitor. As the voltage falls to a value just above the diode on-voltage no further charge can be extracted from the capacitor and the current falls to a value limited by the charging resistor. This resistor is chosen to have a high enough value so that the current is insufficient to keep the device in its low resistance state and it rapidly switches back to its original condition. Input voltage is now too low to inhibit this, being far less than the standoff voltage, $V_s+0.6$V. The charging cycle recommences. The charging resistance cannot be made too great or the current available for initiating the switch-on action may not be sufficient. Resistance is typically tens or hundreds of kilohms. The unijunction transistor can be replaced by any other device exhibiting similar negative resistance characteristics and in the past neon lamps were used for just such a purpose. Certain pnpn diodes have similar switching characteristics.

Current is drawn from the capacitor in a short, sharp burst. It leaves the capacitor voltage as an exponential ramp followed by a very rapid discharge and this waveform, approximating as it does to a sawtooth, has been used as part of alarm systems, and simple musical instruments. For other applications the short duration current pulse is more useful, and it can be converted into a voltage by inserting a low resistance in the base 1 path. A compromise has to be struck between maximizing the pulse peak voltage and increasing the pulse width too greatly; both of which follow as the resistance is increased. The waveform is convenient for triggering other circuits, and in particular is used with thyristor power-control circuits. Where the thyristor has to be electrically isolated from the control circuits a pulse-transformer is inserted in the base 1 lead. This has the further advantage that the turns ratio can be adjusted to obtain the optimum pulse for the particular thyristor being driven. Pulse currents of up to 600mA are possible by this means. Antiphase pulse outputs can also be obtained; a resistance inserted in the base 2 lead will experience some current change since then the supply voltage is largely dropped across RB_2.

Unijunction astables

THEORY

● The upper threshold is set by the initial values of R_{B1}, R_{B2} i.e. the device triggers when the emitter voltage reaches

$$\eta V_s+0.6 \text{ where } \eta=\frac{R_{B1}}{R_{B1}+R_{B2}}\approx 0.63 \text{ for many devices.}$$

The lower threshold is close to zero, though is clearly >0.6V as below that level there is no injected current to keep R_{B1} in its low state.

● In the transistor circuit external resistors take the place of R_{B1}, R_{B2} and the upper threshold is again

$$\eta V_s+0.6 \text{ with } \eta=\frac{R_A}{R_A+R_B}$$

● If the switch is open from time t_1 to t_2, where $t=t_2-t_1$

$$t=\tau \log_e\left(\frac{V_s}{V_s-V_c}\right)$$

For $t=\tau$ which is a conveniently memorable condition,

$$\frac{V_s}{V_s-V_c}=e$$

$$V_c=V_s\left(1-\frac{1}{e}\right)$$

$$V_c\approx 0.63V_s$$

● This suggests that one of the reasons for using $\eta=0.63$ in the design of unijunction transistors is to simplify calculation. The main reasons for making η of this order if that is much larger, the time at which triggering takes place if affected by small shifts in V_s or η while if too small the long periods would demand excessively large time-constants.

Discharge time is governed by the minimum value of R_{B1} together with any external resistor in the B_1 lead. The combination is usually $\ll R$ and the last can be ignored during the discharge.

The current pulse is narrow and it is useful to know its width. This obviously varies along the discharge path but it is convenient to estimate it at some fraction of the supply kV/s.

The discharge is assumed to be due to a linear resistor R comprising any external resistance together with the R_{B1} value during its low-resistance state.

$$t_2-t_1=\tau' \log_e\left(\frac{-\eta V_s}{-kV_s}\right)$$

$$=\tau' \log_e(\eta/k)$$

Hence for $t_2-t_1=\tau'$

$$\eta/k=e$$

Now $\eta\approx(1-1/e)$ for many unijunction transistors

$$\therefore k=\eta/e=\frac{1}{e}-\frac{1}{e^2}$$

$$k\approx 0.23$$

i.e. the pulse width is around $\tau'=R'C$ when the pulse has fallen to $1/e$ of its initial height, corresponding to about 23% of V_s

EXAMPLES

1. A complementary pair of transistors is used with a pair of equal resistors to simulate a unijunction transistor. Show that it will behave as a Schmitt trigger if the n-p-n emitter is grounded. Estimate the threshold voltages and indicate any problems. Assume the supply voltage to be 9V.

If the input voltage exceeds $(V_s/2+V_{BE})\approx 5.1$V then the n-p-n transistor begins to conduct. It drives the n-p-n device into conduction and low resistance paths develop between source and ground and between the resistor junction and ground. The last falls to ≈ 0.2V, the first to ≈ 0.9V, assuming $V_{BE(sat)}\approx 0.7$V; and $V_{CE(sat)}\approx 0.2$V.

If either the source voltage falls below 0.9V or the current flow is severely limited by high source resistance, the n-p-n device comes out of saturation, the resistor junction rises and both devices switch off i.e. the thresholds are about 5.1V and 0.9V.

Series resistance is needed in one or both of the emitters to limit the current flow in the on-state.

2. The previous circuit is used with an RC timing circuit to obtain a pulse train in the n-p-n emitter of repetition frequency ~5kHz and with a charge transferred to the emitter load of >0.1 micro coulombs per pulse. Choose suitable values of R and C.

Charge in voltage across capacitor ≈ 4.3V

$$\Delta Q=C\Delta V$$

$$\therefore C=\frac{\Delta Q}{\Delta V}=\frac{0.1\times 10^{-6}}{4.3}=23.2\text{nF}$$

Nearest preferred value to ensure the specified minimum charge is 27nF.

Discharge time$\rightarrow 0$.

Charging time $t_2-t_1=\tau \log_e\left(\frac{V_1}{V_2}\right)$

and $V_1\approx(9-0.9)$V

$$V_2\approx(9-5.1)\text{V}$$

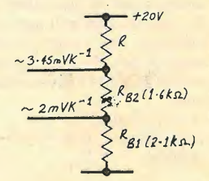
$$\text{But } f=\frac{1}{T}\approx\frac{1}{t_2-t_1}$$

$$5.10^3=\frac{1}{R.27.10^{-9}\log_e\left(\frac{8.1}{3.9}\right)}$$

$$R=\frac{10^6}{135\log_e\left(\frac{8.1}{3.9}\right)}\approx 10\text{k}\Omega$$

3. A unijunction transistor with R_{B1} 2.1kΩ and R_{B2} 1.6kΩ has the equivalent circuit as given in the text. These resistors have a temperature coefficient of $+0.3\%\ K^{-1}$ while the p-n junction drifts by $-2\text{mV}K^{-1}$. An external low-drift resistor added in the B_2 lead is found to compensate the frequency of oscillation when used with a 20V supply. Estimate its value.

Assume that $R_{B1}+R_{B2}\gg R$ for simplicity



Then the voltage change across R is $-3.45\text{mV}K^{-1}$ and must be due to a $-0.3\%K^{-1}$ change in current.

Thus the voltage across r is given by

$$\frac{0.3V_R}{100}=\frac{3.45}{1000}$$

$$\text{i.e. } V_R=\frac{345}{300}=1.15\text{V}$$

This meets the above assumption leaving 18.85V across $R_{B1}+R_{B2}$

$$\therefore R=\frac{1.15}{18.85}.3.8\text{k}\approx 232\Omega$$

Letters continued

CARFAX DELAY

At the recent IERE Land Mobile Radio conference at Lancaster University a BBC spokesman discussed their Carfax cellular mobile information service which is at present undergoing trials. The following points emerged:

1. Suitable receivers for Carfax should cost the public less than £10 each.
2. The cost of the system is under £3 million to install and about £600,000 p.a. to operate.
3. The quantifiable saving to the country (in fuel and man-hours) if Carfax were in use by the majority of motorists is thought to lie between £14 million and £60 million p.a.
4. Even if the trials are successful it will be five years before Carfax is introduced.

Such a delay seems disgraceful. Most developed countries already have dedicated traffic information systems — why should we always be ten years behind?

If the Government really cannot afford to invest £3 million to save the country an annual £14 million-plus perhaps the manufacturers of Carfax receivers could fund the system's installation. Five years' delay is intolerable.

James Bryant
President, Citizens Band Association
Cheltenham, Glos.

BROOKMANS PARK TRANSMITTERS

It was with some surprise that I recently heard of the dismantling of the Brookmans Park radio transmitters. It would seem that the BBC has no thought of the historic importance of this equipment, built in 1929 for the dual programme networks.

These transmitters formed the link between our statesmen and the populace during the last war and indeed for many crises before and since then. Who has not, at some time over the years, tuned into one or other of the BBC radio transmissions and given some passing thought to the miracle of wireless? Quite possibly they were listening to the output of one of these transmitters now quietly dismantled after fifty years of service.

A great shame, then, that the BBC should destroy its own heritage and, indeed, that of the nation. With such a history conscious country as ours, surely it is not beyond the wit of the BBC to see that a further source of income has been thrown away. With the vast range of abilities within the BBC, surely even an apparently dull engineering museum could have been made attractive at very little cost.

The BBC seems to have missed the boat, unless some of the other transmitters built for the scheme still survive elsewhere, unheralded, and await the scrap man's hammer? If they do then surely this early technology should be saved rather than be lost for ever.

G. H. L. Childs
Felixstowe
Suffolk

The BBC replies:
We are also sorry to see the passing of such reliable and well-known machines. A difficult decision has to be faced when the time comes for the replacement of old equipment, particularly that having significant historical associations. There are many of us who would like to see such things preserved for posterity but not many who are able to provide the required space and cost of upkeep. Much of the equipment used in high power broadcast transmissions is both large and heavy, and it has to be accepted that interest in them is limited to a comparatively small number of specialists. However, the situation is not quite so bleak as Mr Childs thinks.

Part of one transmitter (incorporating the low-power drive and modulator stages) has been presented to the manufacturers (Marconi) who, we understand, will preserve it, and other valves and components have been passed to the British Vintage Wireless Society. Furthermore, there are two similar transmitters, manufactured slightly later, at Moorside Edge and Washford which for the present continue to serve as standbys.

Geoffrey Sturge
Engineering Information Department
BBC, London W1

FAILURE OF DISTRESS SIGNALS AT SEA

I agree totally with Mr Wiseman's remarks in June letters about salt spray on aerial insulators at sea. There have been times in rough weather when I have been unable to operate properly on 500kHz due to salt on the aerial insulators — a nominally 1.8kW output transmitter only putting out a few watts and having difficulty in contacting a coast station only a hundred or so miles away.

This effect has been aggravated by the tendency of modern ship owners to fit high power transmitters but shorter and less efficient aerials. A few years ago a ship would be fitted with a good T or inverted-L aerial, often extending the entire length of the ship and as high as the masts would allow. Nowadays we are lucky to have 80 feet of wire around the funnel. This is not very efficient on h.f., let alone on 500kHz. The larger aerials did not suffer so much from insulator problems due to their higher radiation resistance and capacity. Cleaning insulators is only a temporary solution as an hour or so later in heavy weather the problem reappears. Even with new, clean insulators the effects are similar, if not quite so bad.

It is certainly high time someone had a close look into merchant marine aerials and insulators and a means found whereby shipowners could be pressed to fit better aerial systems. As Mr Wiseman has stated, it is not normally possible to go outside in a force 9 or 10 gale and wash down the insulators with fresh water before a distress message can be sent!

R. Philpot
Offenburg
West Germany

CAPACITANCE METER

With regard to the capacitance meter I described in the October issue, the error in the indicated value of the capacitance, due to measurement non-linearity, is basically not usually more than about 3%. However, on the 1000pF range, 20% errors have occurred with some HEF4049 i.c. samples, together with higher than normal sensitivity on this and the 100pF range. This is caused by ringing after the square wave edges on the wires to the measuring terminals. The ringing is excited by the fast edges of the square wave produced by the i.c. and if the output impedance of the i.c. is low enough, the measured capacitor can charge and discharge during the ring, as indicated in the second paragraph on page 62 of the article. Since the ring is capacitor size dependent, this gives rise to the non-linearity. In practice, the effect is only significant on the 100pF and 1000pF ranges.

This error/excessive reading can be corrected fairly simply by increasing the output resistance of the offending i.c. with a resistor of about 100 ohms, fitted at the common i.c. pins 2, 4 and 10 to which the lead to S_1 connects.

A second effect has occurred in circuits with rather long wiring which can be noticed by the CAL control not always working smoothly such as perhaps only on the 10,000pF range. This was traced to parasitic oscillation which caused the square waves to be produced in bursts and to be CAL setting dependent. It ceases if a 1k resistor is fitted by the i.c. at pins 11 and 15 to which the lead which goes to S_2 connects.

The resistors have little effect upon calibration accuracy, once the present calibration resistors have been readjusted and so are worth fitting as standard practice.

K. Holford
Crawley
Sussex

PROGRAMMABLE NOTES FOR MUSICAL INSTRUMENTS

Keyboard instruments have hitherto been generally confined to the equal tempered scale. This scale is an approximation to the 'true' or 'natural' scale in which each note bears a simple mathematical relationship to either the keynote (or tonic) or to the fifth note (or dominant). Music played using an instrument tuned to the true scale is more harmonious than when played on an instrument tuned to equal temperament. Unfortunately, the true scale produces problems when modulation is attempted, requiring several different pitches for the same note depending on the key in question. This produces problems in instrument design and playing problems due to the bewildering array of keys present.

An alternative electronic solution must now be possible by using programmable tone generators and recalculating the frequencies required for modulation into the new key, thus allowing a standard keyboard layout to be used. The major problem with this approach comes from the need to inform the machine of the required key as the piece of music is being played. This could possibly be solved by pre-programming the key sequence of the piece of music and using a pedal to initiate the key change.

I am sure there are many other problems that will require attention, but the end result when all are solved would be a keyboard instrument sounding smoother and more harmonious than anything we have at present.

M. Robins
Bilton
Rugby

Hall-effect magnetic field detection

Simple circuit for use in fields down to 10^{-3} tesla

by D. Wedlake, University College, Cardiff

A HUNDRED years ago in November 1879, E. H. Hall, Fellow of the Johns Hopkins University in America, discovered the effect bearing his name.[1] Basically, it is the generation of a voltage at right angles to a current in a conductor or semiconductor when placed in a magnetic field applied perpendicular to the current. The effect is illustrated in Fig. 1.

The open-circuit Hall voltage is given by:

$$V_H = K I_c B \sin\theta$$
$$= K I_c B \text{ if } \theta = 90°$$

where K is a constant at one particular temperature, I_c is the control current, B the magnetic flux density and θ is the angle between the magnetic flux direction and the plane of the Hall element.

Any non-symmetry in the Hall effect device will lead to a voltage offset in the absence of any magnetic field and it will be necessary to cancel out this offset by external circuitry. Adjustment will, however, have to be carried out with each change of temperature, since the offset voltage varies considerably with temperature.

Until recently, most equipment for the measurement of magnetic field strength has not been readily available to the amateur, probably owing to the high cost of the sensors and rather complex electronic circuitry. Nevertheless, the circuit shown in Fig. 2. shows how relatively low-cost ferrite Hall effect devices, when driven by constant current, can be used to build a simple magnetic fluxmeter. The probes themselves are Siemens Type SBV566, obtainable from Electrovalue. Care should be taken when mounting them and it is probably best to fix them on to a small piece of Veroboard and then to make connexions to the copper strips.

The Hall probes are driven by a constant-current regulator, capable of delivering up to 70mA, which is their maximum rating: a suitable regulator is shown in Fig. 3. The Hall output voltage between terminals 3 and 4 is fed to a differential-input 741 amplifier, which has a voltage gain of 10. It should be noted that the Hall voltage leads and control-current leads can be interchanged and that the direction of the control current does not matter. This means that when driven by a constant current damage to the probes is unlikely.

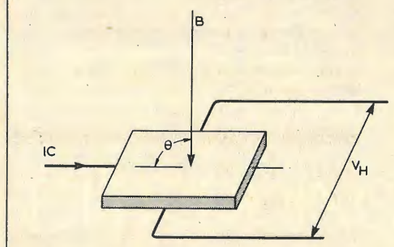


Fig. 1. *Hall effect.* $V_H = KI_cB\sin\theta$

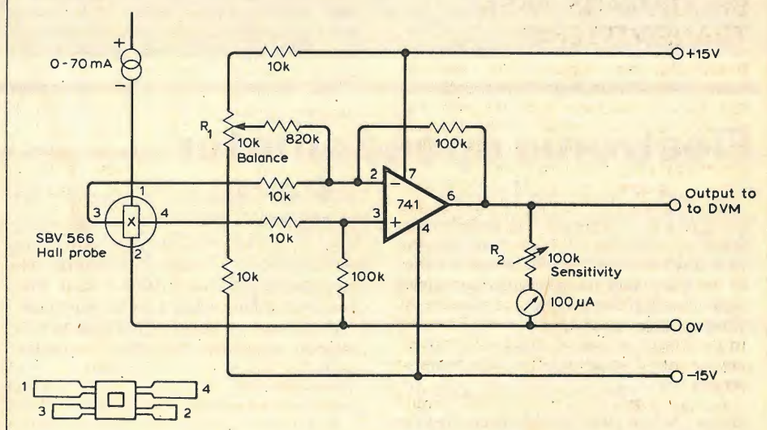


Fig. 2. *Fluxmeter circuit diagram,* RV_1 *is the offset adjustment.*

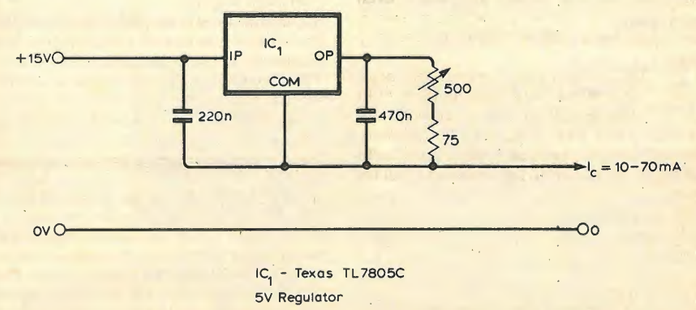


Fig. 3. *Constant-current regulator to drive Hall probe.*

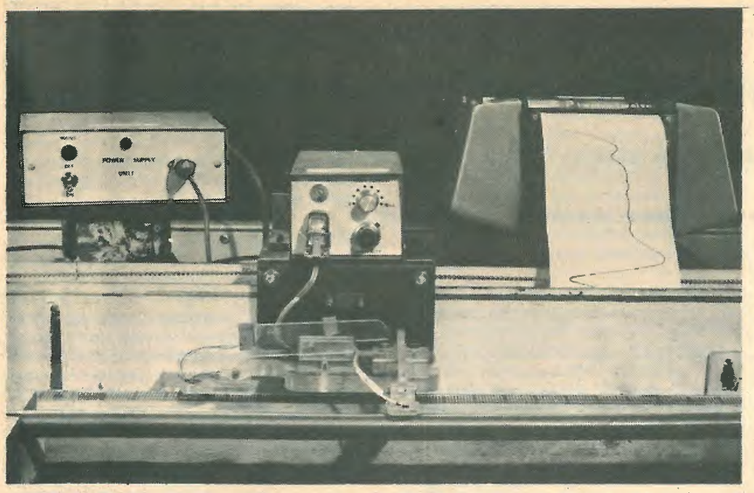


Fig. 4. *Equipment described being used to plot the magnetic field distribution along an iron rod. Result is plotted by pen recorder. Power supply on left, amplifier in centre and Hall probe in middle of rod.*

The output from the amplifier may be monitored on a d.v.m. or 100μA meter, as required. The standing offset voltage is cancelled out with R_1, and R_2 acts as a sensitivity control for the meter.

With the circuit shown it was found that magnetic field strengths as low as 10^{-3} tesla could easily be detected, giving a final output of about 300mV. With exceptionally strong fields it might be necessary to reduce the control current to prevent saturation. The only disadvantage with the circuit was the relatively high temperature coefficient of the probes themselves. If this is likely to be a problem it is best to obtain several and select one with a near zero temperature coefficient.

1 tesla = 10,000 gauss. As a guide, the flux density produced by an R.S. Components reed magnet (Type 349-052), 3mm from the surface is about 13 × 10^{-3} tesla. Or, the horizontal components of the Earth's magnetic field in Britain is about 18× 10^{-6} tesla.

THE HALL EFFECT

Hall's original paper was published in the *American Journal of Mathematics* in November, 1879. He had been intrigued by reading two contradictory accounts, by Prof. Rowland and Prof. Edlund, of the effect of a magnetic field on the current in a conductor. Rowland maintained that the resultant force acted on the conductor, while Edlund believed that the mechanical force was directed at the current in the conductor.

Hall determined to experiment and, with Rowland's approval and assistance, conducted a series of tests on metal. In the belief that, if the current were drawn to one side of the conductor, the resistance of the conductor would appear to decrease, he made the tests with German silver wire in the form of a spiral. The wire was of 0.5mm diameter and possessed a total resistance of 2Ω. The result was far too small a variation in resistance for the tests to be conclusive (about one part in five million).

Going on to test for a potential difference between the surfaces of the conductor — a piece of gold leaf — Hall found a galvanometer deflection, which reversed when the field was reversed, and proved that it was the current that moved.

References

1. Hall, E. H., "On a new action of the Magnet on Electric Currents," *American Journal of Mathematics* 1879, Vol. 2 p.287.

Electronic speedometer

continued from page 76

Although it seems more correct to orientate the magnet so that a positive voltage is induced in Tr_1's winding as the magnet moves towards the solenoid, the pick-up circuit appears to work satisfactorily if the magnet is orientated in the opposite direction.

The 270kΩ positive feedback resistor around the op.amp., introduces a small amount of hysteresis into the circuit which reduces its susceptibility to induced spurious pulses.

Finally, the transistor stage (Tr_3) following the 709 op.amp. is included to produce an output pulse compatible with the c.m.o.s. input stage of the digital timer.

Practical details

In the circuit of the digital timer, the duration of the monostable pulse must be greater than the longest pulse generated by the clock oscillator, but shorter than the time taken for an output pulse to occur at the D output of the second decade counter when the oscillator is running at its highest speed. For a maximum f.s.d. for the speedometer of 100m.p.h. and a range of wheel diameters from 10in to 60in, the highest frequency of the oscillator will be $704{,}000/10\pi = 22.4$kHz. The lowest frequency of the oscillator will be $704{,}000/60\pi = 3.73$kHz. The duration of the monostable pulse must be greater than 1/3.73kHz (=0.27ms) and less than 400/22.4kHz (=17.8ms). By making the monostable resistors 100kΩ and the capacitors 100nF each a pulse duration of about 1ms is obtained, which satisfactorily meets the frequency requirements.

A 'polarity' input to the quad latches determines whether they are clocked by positive-going or negative-going pulses. In the circuit of Fig. 1 they are clocked by negative-going pulses and the 'polarity' input is therefore connected to ground. The read-out meter may be any robust, moving-coil meter with a f.s.d. of 2 volts.

Books Received

Microprocessors and Microcomputers, by Eric Huggins, is one of the series of Macmillan's Basis Books in Electronics. It is not related to any particular course of instruction, but assumes that the reader is innocent of any electronic or computing knowledge, starting with a few words of historical explanation and finishing with the loading and running of programmes. Along the way, Mr Huggins covers most of the essential knowledge for the successful application of small systems, even a little Boolean algebra, so that the AND and NOR instructions in a program can be understood. The book is better than most at this level, but the author gives way too readily to the temptation of the 'chummy' approach. A difficult subject is not made easier by finding one's teacher metaphorically sitting with the class instead of standing at the blackboard, and the use of the pronouns 'we' and 'us' throughout is not a good idea. Little drawings of fairies and elves do nothing to help his purpose, either. The book is published in paperback at £4.95 (£12.00 hard back) and has 224 pages.

A World in Your Ear is the autobiography of the late Robert Wood, who has been in charge of the technical aspects of BBC outside sound broadcasting from the early days. It is very personal, completely non-technical and is full of background to well-known events of the last 50 years. There is, for example, reference to the famous broadcast by Tommy Woodroffe of the Spithead Review, when the phrase 'The Fleet's lit up!' took on a new significance. Mr Wood handled broadcasts by Sir Winston Churchill and many other politicians and ran so many broadcasts by the Royal Family that he became 'one of the family'. The book is published by Macmillan at £6.95.

CIRCUIT IDEAS

Radio clock 12-hour display

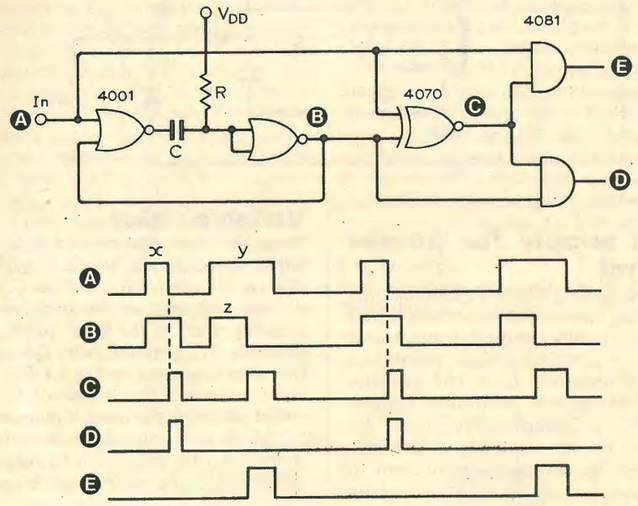
Constructors of 24-hour radio clocks (or their wives) may prefer the more common 12-hour display. This circuit converts the Rugby time code to a 12-hour coding with an optional BST display. IC_1 detects 00 hours and adds 1 to the tens of hours and 2 to the units. If the BST marker is high, 1 is added to the units via the connection to the 2^0 input on the adder. Gates IC_{2a}, IC_{3a} and IC_{3b} detect 13 to 19 hrs, add 14 and suppress the tens of hours output so that 12 is subtracted from the hours. IC_{4a} allows 12 hrs in BST to be included. The remaining gates convert 09 hrs and 21 hrs in BST and 20 hrs to 23 hrs. The inverter connected to the tens of hours output prevents a zero in multiplexed displays by generating an invalid input code for the 7-segment decoder. In non-multiplexed displays using a 4511, the 2^0 output can be connected to the $\overline{B}_1$ pin. If the BST option is not required, IC_4, IC_{5a} and the connections to the BST marker can be omitted.

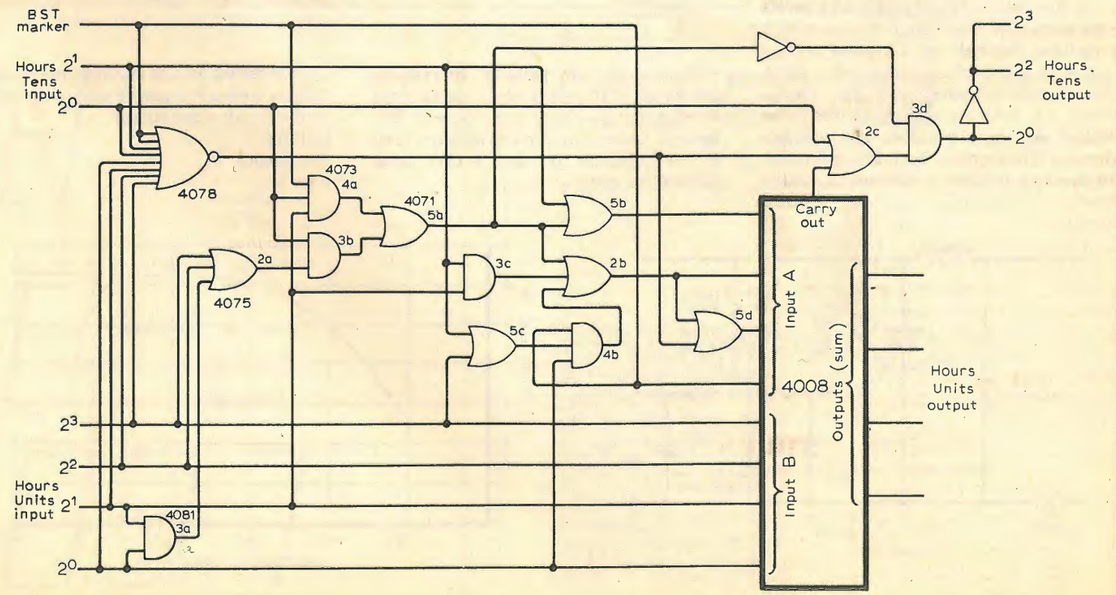
A. M. Tucker
Charminster
Dorset

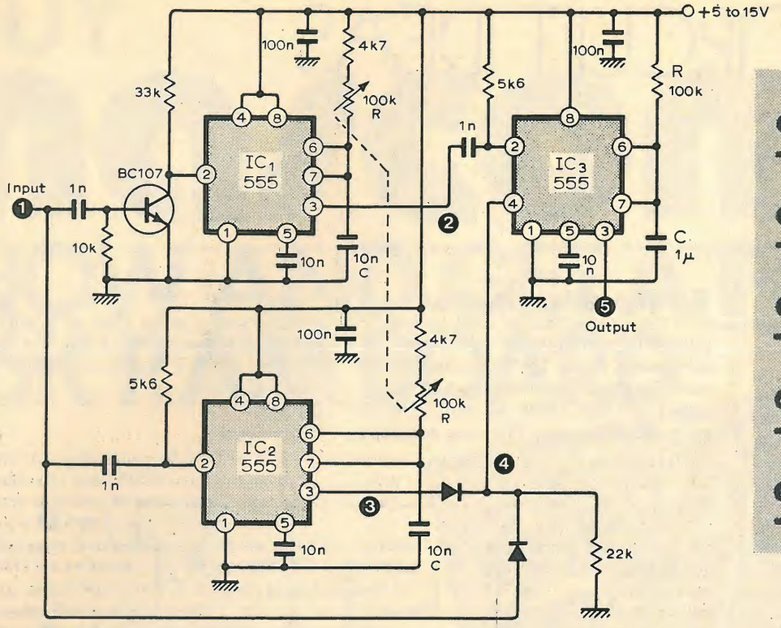
Simple pulse splitter

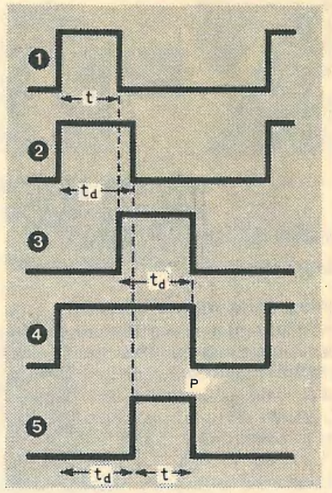
Five logic gates can be used to split a pulse-width modulated signal into its component parts. The basic circuit can only distinguish between two different pulses but can easily be expanded to accommodate more. The time constant is set to give a pulse train at B with a pulse width greater than x and less than y. Pulse width z is approximately 1.4 RC.

D. Flatt
Birkenhead









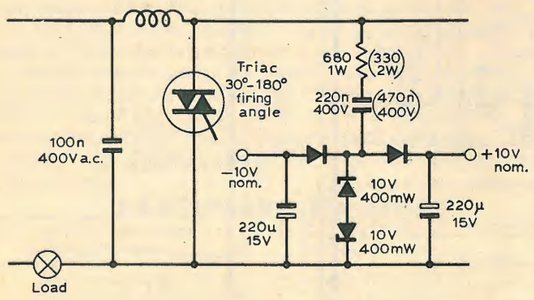
Dual supply for power control

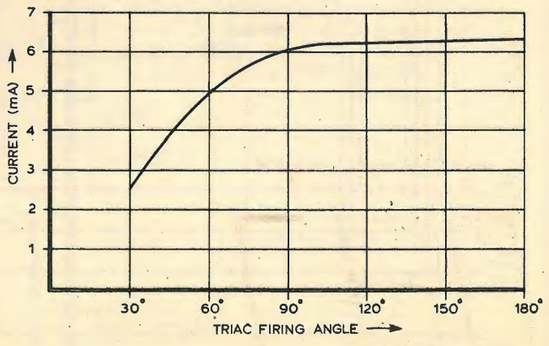
When designing power control circuits which use operational amplifiers, a dual supply is usually required. If the unit is to replace a normal switch, power can only be obtained from the voltage across the switch terminals. Consequently, a compromise must be accepted for the maximum power into the load. In practice a reduction in maximum power is not discernable provided that the phase angle at which the triac fires is not less than 30°.

In the circuit R_1 and C_1 act as a series impedance to the Zener diodes which regulate the voltage supplied to the smoothing capacitors. Just over ± 2mA can be drawn under worst case conditions, i.e. with maximum power. The values shown in brackets are suitable for a ± 5 mA supply. Ripple is about 0.1 V pk-to-pk and this is difficult to reduce without a current penalty. Increasing the value of the electrolytic capacitors does not make any significant difference. Quiescent current into the load is just sufficient to cause a 15W lamp filament to glow.

This circuit is not suitable for applications where it is possible to come into contact with a conductor.

D. Price
Sevenoaks
Kent





Variable delay

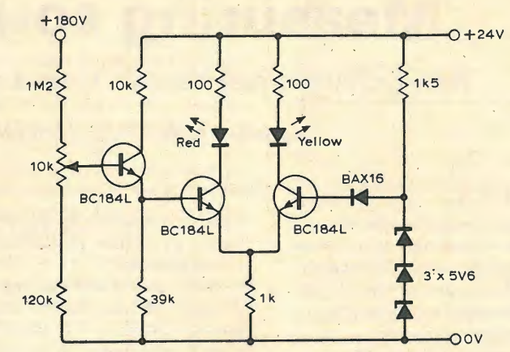
Three 555 timers can be used to delay a pulse of unknown width t without altering the width. Monostables IC_1 and IC_2 are triggered at the positive and negative edges of the input pulses respectively. The required delay t_d is set by two time constants and is 1.1 RC. The input pulse and the output of IC_2 are added and fed to the reset of monostable IC_3 whose time constant must be larger than $(t+t_d)$. IC_3 triggers on the negative edge from IC_2, i.e. after t_d, and is reset at point P as shown in the waveforms. The output waveform is therefore delayed by t_d and its duration is preserved. With the component values shown, delays from 50µs to 1.15ms are available. Other delays can be obtained by altering the time constants, but the input pulse period must be equal to or larger than the delay.

S. Bhat
Bangalore
India.

Reference voltage indicator

This circuit makes adjusting the anode voltage on cold-cathode displays both quick and accurate. The differential pair compares a fraction of the h.t. voltage with a nominal 16.8 V reference. In this example the h.t. is 180 V ± 1V. The red l.e.d. is illuminated if the sample voltage is above the reference level and the yellow l.e.d. if below. There is a 2V tuning range where both l.e.ds are on and equal brightness indicates the balance point. The circuit can operate with a wide range of voltages by changing the appropriate component values, but the narrowest tuning range is obtained when the ratio of h.t. volts/reference voltage is less than fifteen. Accuracy is within 0.1% and drift is 0.05% over a six month period.

C. J. Challender
Wolverhampton



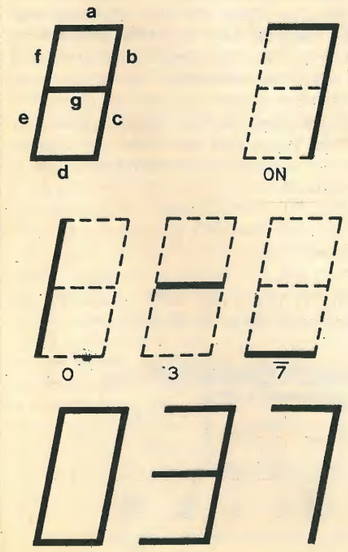
Reversible ternary prescaler

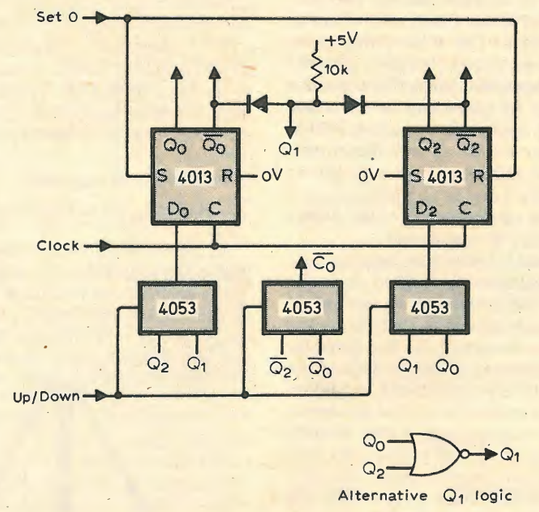
During the development of a digital Wattmeter it was necessary to prescale a synchronous reversible decimal counter by three to obtain appropriate values on a display. The main counter comprised a set of parallel-clocked 4029s with sign-reversal logic to control the state of the up/down pins. Therefore, a reversible synchronous ternary counter with a 4029-compatible up/down control, preset and carry-out was required.

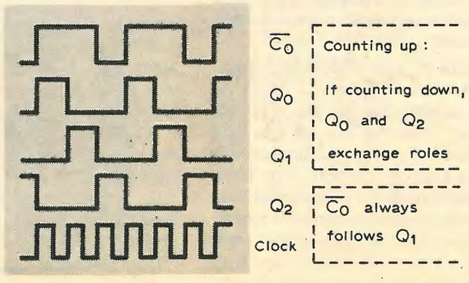
The original idea was three bistables connected as a bi-directional circular shift register with 0 1 0 circulated as appropriate. This system requires at least three i.cs and has several unwanted states. However, as the state of any bistable will be the NOR of the other two, the output Q_1 of one bistable can be obtained by using diodes to form the AND of the $\bar{Q}$s from the remaining two. This was achieved using a 4013B with each D pin driven from one of the other two Qs selected by a 4053B analogue multiplexer. A third part of the 4053 selects an appropriate $\bar{Q}$ for the carry-out signal. This circuit operates up to 1MHz with a 5V supply, but higher frequencies can be achieved by using a normal NOR gate to generate Q_1. The circuit may be preset to any of its three states, or to a fourth which represents zero.

If the states are called 0, 3 and 7, which are rounded thirds of 10, the circuit can drive a seven-segment display where a=b=c=on, d=7, e=f=0 and g=3. If the ternary counter does not drive a display digit, the value displayed from the decimal stages will effectively be truncated. As the display is in sign and magnitude form, the truncation is converted into a rounding by incrementing the whole counter by one before transferring the contents of the decimal section to the display latches.

J. R. Stockton
National Physical Laboratory
Teddington







Measuring sound power

New technique may replace those now specified in standards

by James Moir F.I.E.E. James Moir & Associates

During the past few years sound power output has been increasingly specified as a measure of acoustic noisiness because of its more fundamental character. In the hi-fi field it is becoming customary to specify both the electro-acoustic efficiency of loudspeakers and the directivity in terms of "Q" or the Directivity Index (see the author's article in the October issue). In all these applications it is necessary to measure sound power. This article describes a new technique that makes sound power easier than electrical power to measure. It is highly probable that this technique will replace the classical methods currently specified in national and international standards.

SINCE the development of sound pressure level meters early in the 1930s a statement of the sound pressure level has generally been used as an indication of the 'noisiness' of industrial plant, usually without recognising that the sound pressure level was a function of the distance of the measuring point from the source. It might also be critically dependent upon the acoustics of the space in which the noise source was being operated. A statement of sound pressure level as an indication of noisiness is just about as sensible as quoting the terminal voltage of a generator as an indication of the power available from the generator.

In the early 1960s the heating and ventilating industry moved towards quoting sound powers as an indication of noisiness, recognising that the sound power is independent of the distance from the source and independent of the acoustics of the environment. However, it should be remembered that loudness, noisiness or annoyance is not directly proportional to sound power and that data on the noise spectrum, the distribution of the sound power over the frequency band, is necessary if either sound pressure or sound power data is being provided.

Sound power, the acoustical equivalent of electrical power, cannot be measured directly for we have no instrumental method of measuring volume velocity, the acoustical counterpart of electrical current. Nor have we any commercially available method of measuring acoustical impedance or its components, though laboratory techniques are available. The only acoustical parameter that can be directly measured by current commercially available instrumentation is sound pressure.

In the absence of volume velocity or acoustical impedance data, sound power can only be calculated from sound pressure data by making assumptions about the acoustical impedance presented to the source of sound power. Though volume velocity or acoustical impedance cannot be measured directly, there are two techniques that have been widely used, at least in university laboratories, for measuring sound power by semi-indirect methods.

One of the earliest methods of measuring sound power, well covered in the literature, is to measure the sound pressure distribution over the surface of a notional sphere or hemisphere centred on the sound source. In the simplest situation when the source is small and radiates uniformly and spherically into free space, the sound power can be calculated from the measured sound pressure averaged over the surface of a sphere of one or two metres radius centred on the source.

In this simple case it can be shown that the sound power is related to the measured sound pressure by the relation:

$$\text{PWL} = \text{SPL} + 10\log_{10} 4\pi d^2 \qquad (1)$$

d = distance to measuring point in metres.

In the more practical situation where the sound source stands on an extended plane surface, the radiation is confined to a hemisphere above the plane and the sound power flow through the notional enclosing hemisphere is doubled and can be calculated from equation 2. Measurements of the sound pressure distribution must be made in the open air or in an anechoic space.

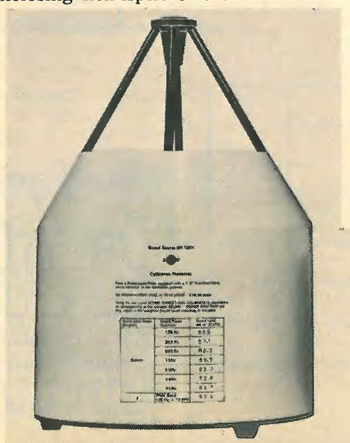
$$\text{PWL} = \text{SPL} + 10\log_{10} 2\pi d^2 \qquad (2)$$

Both these procedures are covered by a British Standard No. BS 4196, so the techniques need not be further discussed except to note that they are largely irrelevant in practice. Few devices radiate uniformly and in consequence a true average sound pressure cannot be obtained without taking between ten and thirty readings round the source. The sound pressure level usually varies so widely over the measuring surface that the sound levels cannot be directly averaged and the readings must be converted to sound pressures before averaging and re-converting to sound pressure level in dB.

While the technique can be used to measure the sound power output of small simple sources, it cannot be used to measure the sound power output of a large industrial machine that may be required to drive, or be driven, by a second machine or may require a supply of air, water or gas to allow it to function under load.

A second sound power measuring technique is based on the measurement of the sound pressure produced in an environment offering a known acoustic load to the power source. The sound source to be measured is installed in a room for which the absolute values of the reverberation time/frequency relation are known, generally obtained from measurements of the reverberation time at the standard third octave frequencies in the audio frequency band. From this data and the dimensions of the room a parameter R is obtained:

$$R = \frac{S\alpha}{1-\alpha} \qquad (3)$$



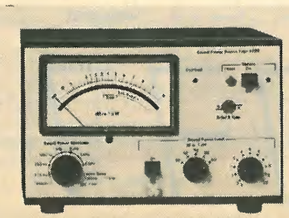


Fig. 1. *The Type 4205 Sound Power Source made by Brüel & Kjaer.*

where $S\alpha$ is the total absorption in Sabines, and α is the average absorption coefficient for all the room surfaces.

R is indicative of the acoustical 'load' presented to the sound source. From this data the sound radiated can be obtained from Equation 4.

Sound power =

$$\text{Sound pressure} - 10\log_{10}\left(\frac{1}{2\pi d^2} + \frac{4}{R}\right) \qquad (4)$$

The first term inside the bracket is the contribution to the total sound pressure of the sound directly emitted by the source, decreasing by 6dB each time the distance to the source is doubled. The second term is the contribution to the total sound pressure due to the generally reverberant sound reflected many times between the boundary surfaces.

The sound pressure level must be measured in the far field at a distance greater than that at which the two terms inside the bracket are equal, for beyond this point the sound pressure is substantially constant and independent of the distance to the source.

This is the technique that has generally been used in laboratory determinations of the sound power output of small devices for given a special room for the purpose, the values of R and the position of the microphone need be determined once only. With the room parameters established there is a fixed relation between total radiated sound power and the SPL measured at one point, so the sound power can be read off a simple calibration chart.

The technique has many of the disadvantages of the methods of BS4196. The machine must be taken to a special room and must be provided with any necessary gas, water and air supplies, an impossible requirement in most cases, so the method is only applicable to the measurement of the sound power output of small machines. Engineering equipment manufacturers really require a sound power measurement technique that allows them to make measurements on machines while they are running on the test bed at the end of the production line in an open shop.

A problem that will not be obvious to those who have not actually been involved in sound power measurements is the need to know the reverberation time/frequency relation for the room. In principle this is a simple measurement that is generally thought to be well understood but in practice any measurement of reverberation time is a tedious and inaccurate business. Decay curves are rarely the linear relation suggested by simple theory and in consequence a very large number of decay measurements are necessary to achieve any average curve that can be confidently supported. Indeed the reverberation time as normally defined may not be the reverberation time that is effective in integrating the non-uniform radiation of the noise from a typical machine.

Thus in general the two techniques covered by existing national and international standards require the apparatus being measured to be taken to a special room of accurately known acoustical characteristics. The disadvantage of the techniques are such that neither method is widely used in practice except for the measurement of the sound power output of small items such as domestic appliances.

All the practical disadvantages and limitations of the standard method can be avoided by the use of a substitution technique in which a source emitting an accurately known and adjustable amount of sound power is substituted for the machine under test. This eliminates the need to obtain accurate data on the acoustic characteristics of the enclosure for the room reacts on the sound power source in the same way as it does on the equipment being measured. Thus the sound power output of a machine can be measured in almost any location. The need for air, water or gas supplies presents no particular problem as the sound power output can be measured while the machine is mounted on the production test bed in an area which generally has very indeterminate physical boundaries that cannot be acoustically defined.

In *Applied Acoustics* for January 1974 the writer described a relatively simple solution to the sound power measurement problem. The instrumental power source consists of a loudspeaker in a special housing driven by a source of shaped white noise and directly calibrated in terms of sound power output with respect to the standard reference zero level of 10^{-12} watts. A commercial model of the device is now available as the Brüel & Kjaer Type 4205 Sound Power Source, illustrated in Fig. 1.

It is arranged to radiate acoustic power having the frequency spectrum shown in Fig. 2 and typical of the noise spectrum that characterises a number of domestic appliances, but the accuracy of measurement is not significantly affected by large differences between the spectra of the source and the machine being tested. The 4205 unit will also radiate noise in each of the standard octave bands between 125Hz and 8kHz. The speaker system design ensures a substantially uniform hemispherical radiation.

The power source can be used to measure the sound power output of a machine or a loudspeaker in several different ways. When the machine can be shut down the simplest possible technique is adequate.

The machine is run and the sound pressure level measured at some point sufficiently far from the source to ensure that the microphone is in the distant field where the SPL is substantially independent of the distance to the source. In most environments a point 2-3 metres from the machine is satisfactory. The machine is then shut down and replaced by the Sound Power Source and, using the sound pressure level meter at the same measurement position, the output of the power source is adjusted to reproduce the sound pressure level achieved by the machine being assessed. The sound power output of the machine can then be read directly off the meter scale on the sound power source. If octave band data are required the process is repeated, selecting the same octave band on the sound level meter and the sound power source and reading the power output directly off the meter scale when the machine and power source achieve the same sound pressure level. It is worth noting that the accuracy of the sound pressure level measuring instrument is not involved in the sound power assessment for it is only used to indicate the identity of two SPL measurements.

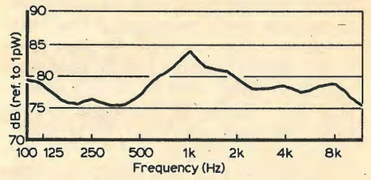


Fig. 2. *Typical sound power spectrum for the 4205 Sound Power Source operating in the wide band mode, measured in third octave bands.*

If the machine cannot be shut down, an alternative technique can be employed. The arrangements are exactly as before but the sound power output is adjusted to increase the sound pressure level due to the machine by 3dB and the power output read off the meter.

The accuracy that is achievable is generally higher than is commercially necessary. Table 1 illustrates the degree to which the method is independent of the acoustics of the environment. A domestic vacuum cleaner was measured in all the situations briefly described in the table with the results shown, but obviously some care and experience is necessary to achieve such results.

TABLE 1

Room	Sound power (dB)
1. Open air — two acre field	84
2. Well-furnished lounge 20ft×14ft×8ft high	83.9
3. Typical laboratory 20ft×12ft—no carpet	84.4
4. Laboratory/office 14ft×12ft—part carpeted	84.1
5. Small office 13ft×9ft—carpet and curtains	83.6

The precautions that need to be taken when measuring sound power are few and are largely common sense. Where most of the noise is radiated from an opening or a small area of the machine being measured then the sound power

source should be placed as near this opening as can be managed. If the noise is radiated from several openings then either several sound power readings should be taken with the sound source near each opening or the sound source should be positioned near the acoustic centre of the machine.

Neither the machine under test nor the sound power source should be located in any corner of the room, but if this cannot be avoided then two readings of the sound power emission should be taken with the machine and sound power source interchanged and the average taken. The advisability of avoiding corner locations for either sound source or the device under test applies also when making sound power output determinations on loudspeakers, for the low frequency power output of any ordinary speaker is very dependent on its position in a room and is significantly changed by standing the speaker system close into a corner.

The basic accuracy of the source can be checked in a simple manner. The tripod seen on top of the source in Fig.1 is provided to hold the microphone of a calibrated sound level meter. Each octave band and the wide band outputs can be adjusted by separate controls to a set of scale values provided with each instrument. With the sound pressure levels adjusted to these values the sound power output can be read directly off the meter scale with the accuracy typical of an analogue meter system and the care taken to calibrate the sound level meter. However, the stability of the system is more than adequate. Calibration of our first model at intervals of two years indicated a change or less than 1dB.

We use the sound power meter in a wide variety of industrial situations where it is necessary to measure the noise power of a machine working in an industrial environment, but the determination of the efficiency or Directivity Index of a loudspeaker are typical sound reproducer applications. The electro-acoustic efficiency of a loudspeaker is the ratio:

$$\frac{\text{Acoustic power output}}{\text{Electrical power input}} \times 100\%$$

Determination of the electrical power input presents a greater problem than the determination of the acoustic power output, an interesting reversal of the situation that has held for many years. The power input to the loudspeaker is given by the standard relation:

$$\text{Power (watts)} = EI\cos\theta$$

where E = voltage across load, I = current into load and $\cos\theta$ = power factor.

The voltage across, and the current into, the loudspeaker voice coil are easily measured, but the power factor $\cos\theta$ is indeterminate or meaningless when a wide band signal is used. Pink noise is a representative wide band signal and as the power factor cannot be measured the usual procedure is to ignore the complications inherent in its consideration and assume that the input power is given by the product of voltage and current. Though not quite so obvious but for similar reasons, the substitution technique for measuring the sound power output also ignores the acoustic power factor.

We measure the acoustic output of the loudspeaker in a normally furnished listening room, the loudspeaker standing in the middle of the floor with the sound level meter about two metres away. The voltage across, and current into, the speaker system are measured with true r.m.s. instruments at a power level usually around 1 watt and using both the wide band pink noise and octave bands of pink noise. It is worth

pointing out that the power output at the low frequency end of the spectrum varies with the position of the loudspeaker in the room, being greatest with the speaker on the floor in a corner.

Data on the electro-acoustic efficiency of the loudspeaker is of direct value, but it is also necessary when measuring the Directivity Index (British) or "Q" (American) of a loudspeaker system. "Q" is the ratio of the sound power actually radiated to the sound power that would be radiated if the sound pressure level measured on the axis of the speaker system was representative of the sound pressure distribution all round the loudspeaker. The Directivity Index is 10 $\log_{10}$ Q. The significance of this parameter in determining the sound quality of a system has been discussed in the October issue of *Wireless World*, so readers are referred to this for a more complete discussion of the subject.

A determination of the "Q" and the Directivity Index requires the measurement of the acoustic power output and the sound pressure level at some point on the axis of the loudspeaker when it is driven by a known amount of power. To be of real value the parameter should be measured in the standard octave bands over the audio frequency range. The axial sound pressure should be measured in the open air or in an anechoic space, but it can be measured with the loudspeaker in a normally furnished room if the longest dimension of the speaker does not exceed about 1 metre. It is convenient to measure the axial sound pressure level at a distance of either one or two metres, the power (ref. 10^{-12} watt) radiated into a hemisphere by an isotropic radiator being 10.5dB higher than the sound pressure level at one metre and 17dB higher than the sound pressure level at two metres.

The sound power output is measured by the substitution technique already described with the loudspeaker standing on the floor in the middle of the room. The sound pressure level produced at some reference point not closer than about 3 metres to the speaker is duplicated by adjustment of the output from the sound power source standing in the same position and the power level read directly off the meter in the sound power source. "Q" is then:

$$Q = \frac{\text{Calculated sound power}}{\text{Measured sound power}}$$

In the frequency range below about 1000 to 1500Hz the "Q" is generally below about four, but it usually climbs rapidly at frequencies above 1500Hz.

This technique for measuring sound power employing the Type 4205 Sound Power Source makes acoustic power measurement almost as simple as a measurement of electrical power. It is under consideration by two committees of the British Standard Institution and by the appropriate committees of ISO and IEC for adoption as an international standard.

It makes possible the measurement of sound power in industrial situations where previously this was almost impossible, and provides results of adequate accuracy in about 1% of the time required to set up and operate either of the two classical methods of measuring sound power.

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How I invented the thermionic diode

by J. A. Fleming, M.A., D.Sc., F.R.S.

Our front cover this month is a reference to the fact that November is the 75th anniversary of the invention of the thermionic diode, for it was on November 16, 1904, that Fleming filed his patent for "a two-electrode valve for the rectification of high-frequency alternating currents". It would be rash to attribute the birth of electronics to any particular device, but there is no doubt that Fleming's diode ushered in the thermionic valve era and, as distinct from earlier scientific work on electrical discharges through gases and vacua, was invented for a practical purpose in communications technology. The following account by Professor Fleming himself, extracted from his book "Fifty years of electricity" published by Wireless World, *shows how he saw the possibility of using the Edison effect for the particular requirement of detecting oscillations in wireless telegraphy receivers.*

"There is a fourth method for creating continuous waves of steadily increasing importance, called the valve method, which has developed out of an invention made by the author in 1904 of the *oscillation valve* for the detection of electric waves.

"We have already explained that in the spark system of wireless telegraphy the electric vibrations in the aerial wire are created by the discharge of a condenser across a spark gap. These oscillations, therefore, come in groups or trains corresponding to each spark, and as there may be from 50 to 500 sparks per second there are 50 to 500 trains of oscillations and, therefore, of radiated waves, each of which may contain 20-100 oscillations or waves. The interval of time between two successive movements of electricity or waves may be of the order of a millionth or a half a millionth of a second. These vibrations are too quick to affect a Bell telephone or even the human ear. If we convert the oscillatory movements of electricity in each train into a single gush or flow of electricity in one direction, then we change the trains into short flows of electricity all in one direction, these gushes coming at the spark frequency viz., 50-100 per second. For such intermittent currents the telephone is very sensitive. Accordingly, it appeared to the author in 1904 that if we could find some kind of conductor which would act like a valve for high frequency currents and let currents in one direction pass, but stop currents in the opposite directions, we should be able to rectify the trains of high frequency oscillations set up in a receiving aerial and detect them by a telephone or any equivalent direct-current instrument. Meditating on this problem the author found the solution by making use of an incandescent electric lamp with a plate of metal sealed into the bulb.

"The author had carefully studied in 1883 and 1896, as already mentioned in Chapter III, the so-called "Edison effect" in glow lamps discovered by Edison in 1883, and by 1904, as a consequence of the researches of Sir J. J. Thomson, it was well known that an incandescent filament of carbon in a high vacuum was giving off torrents of electrons or particles of negative electricity. Also, it had been found by the author that the space in a high vacuum between an incandescent cathode and a cold anode could conduct negative electricity from the hot to the cold electrode, but not in the reverse direction. It was not at all obvious, however, that a carbon filament incandescent lamp with a plate sealed into the bulb could be used to rectify high-frequency alternating currents; that is, to convert them into continuous or direct currents. Mr Edison had made no such use of his "Edison effect" lamps, nor had it occurred to anyone, until the author pointed it out, that such a lamp, having a metal cylinder surrounding the filament and carried on a wire sealed through the bulb, could be used to rectify high frequency currents and, therefore, as a detector of electric waves in wireless telegraphy.

"The author, however, constructed in 1904 some carbon filament incandescent lamps in which the filament was surrounded by a metal cyliinder carried on a platinum wire sealed through the bulb. These lamps had their filaments made incandescent by a six-cell storage battery, and they were connected ..... with the receiving circuit of a wireless telegraph apparatus. The electric waves striking the aerial wire set up in it rapid electric oscillations or electric currents running up and down the wire. These created, by induction, other electric currents in the condenser circuit connected to the aerial wire. To one terminal of the condenser the metal cylinder of the lamp was joined, and the end of the carbon filament in connection with the negative terminal of the battery of cells was connected through a galvanometer or a telephone with the second terminal of the receiving condenser.

"Hence, as the electric oscillations took place in the condenser, electric currents would flow through the telephone and through the vacuous space, but, as already stated, negative electrons are being given out by the hot filament, and, therefore, negative electricity only can pass from the filament to the cylinder in the bulb, but not in the opposite direction. Hence such a bulb operates to stop all current flow in one direction, but permits it in the opposite; in other words, it acts like a valve for electricity. The author, therefore, called it an *oscillation valve* and it has generally been named a *Fleming valve* or *thermionic valve*. The result is to convert the trains of rapid oscillations produced in the condenser circuit into gushes of electricity all in the same direction through the telephone. These gushes come at intervals corresponding to the spark frequency, viz., 50-500 per second, and, therefore, produce in the telephone a uniform sound. This is cut up into short or long periods corresponding to the dot and dash of the Morse Code, when the signalling key in the transmitter is manipulated properly.

"It was at once found that this thermionic valve gave us a very simple, easily managed detector of electric waves in radiotelegraphy".

The above was written a good while after the events described, in about 1921. Fleming does not mention that at the time of making his invention he wrote to Guglielmo Marconi telling him about it and adding, as an afterthought, "I have not mentioned this to anyone yet as it may become very useful."

Two-metre s.s.b. and f.m. transceiver — 2

continued from page 72

compromise to meet all of the requirements.

Receiver converter

In Fig. 9, input from the aerial changeover relay is amplified by the low-noise m.o.s.f.e.t. r.f. stages Tr_{49} and Tr_{50} – the use of four resonant circuits at signal frequency greatly improves the second-channel rejection. L_{39} couples to L_{40} at low impedance and the push-pull output at high impedance is applied to the gates of the f.e.t. balanced mixers Tr_{51} and Tr_{52}. The heterodyne frequency injection at low impedance drives the source of each f.e.t. in parallel. Push-pull output circuit L_{41} is resonated at the 10.7MHz i.f. and offers considerable attenuation to the heterodyning input. However, the two f.e.t.s can be balanced to give a further 20dB or so attenuation to the oscillator injection by adjustment to the balancing pre-set resistor R_{211}.

Transmitter converter

The 10.7MHz input at low impedance is applied to the primary of L_{44} in Fig. 10. Push-pull output at high impedance feeds the gates of the f.e.t. balanced mixer Tr_{53} and Tr_{54}. Heterodyne frequency injection at low impedance drives the source of each f.e.t. in parallel. Push-pull output circuit L_{45} is resonated at 145MHz, but can only offer limited attenuation to the strong heterodyning input which is only 10.7MHz removed. This difficulty is overcome by adjustment to R_{216} to balance the mixer and by the additional selectivity of three signal-frequency tuned circuits, L_{46}, L_{47} and L_{48}. The wanted 2m band signal is further amplified by a class A m.o.s.f.e.t. stage Tr_{55}. Input to the power amplifier Tr_{56} operating in class A is impedance matched by C_{276} and C_{277}. Forward bias for Tr_{56}, which needs a heat sink, is determined by the potential divider R_{222} and R_{223}. Power output across 75 ohms is approximately 100mW p.e.p.

This unit must be fully screened to prevent stray r.f. pick up, and is mounted on stand-off pillars in a standard aluminium box 5¼in by 2¾in by 1½in high. □

To be continued

Books Received

Hi-fi Choice No. 15 is the third collection of loudspeaker reviews in the series, and is written by Martin Colloms. The books in the series are consistent in form, being part laboratory reports, part listening tests, and are probably the best source of information for anyone looking for the most suitable equipment to buy. Loudspeakers are extremely difficult to test and describe — one often has to fall back on ambiguous and imprecise expressions such as 'boxy' and 'boomy' — but, even so, the author has explained all this in the introduction, together with the methods of testing used.

Sixty speakers are reviewed, some of them for the second time (reasons given) and the best are given the "recommended" tag. The chaotic state of speaker measurement is indicated by the last sentence of the editorial, which says " ... standards and conditions vary so much within industry that it is thoroughly misleading to try to compare these results with those quoted by manufacturers, or indeed to try and compare one manufacturer's quoted performance with another's, or perhaps another reviewer's." Hi-fi Choice circumvents this problem by subjecting all the speakers to the same tests in the same conditions, so that while results will not be absolute, they at least enable comparison. The book has 200 pages, costs £2 and is obtainable from booksellers. It is published by Sportscene Publishers Ltd.

Amateur Radio Operating Manual, edited by R. J. Eckersley, G4FTJ, is a completely practical text on the setting up and running of various kinds of amateur activity. It is not a 'technical' book, in that there is little discussion of equipment, and concentrates on procedures and practices, giving advice on the most effective ways of organizing stations and contests. There are sections on DX, with an extensive description of conditions and frequencies, satellite working, r.t.t.y. and slow-scan television. Five appendices provide maps, international call-signs and world time relative to GMT and departures from this standard time. The book is published by the RSGB at £4.83 (by post) and contains 192 pages. It can be obtained from the RSGB at 35 Doughty Street, London WC1N 2AE.

Microprocessor sales

Worldwide sales of microprocessors will grow from $430 million (about £215 million) to over $1300 million (£650 million) by 1983, a compound annual growth rate of 25%, according to Creative Strategies International (CSI), a California-based market research and consulting firm.

Most of the growth in processor sales will be in 8-bit and 16-bit units, with a 24% growth rate in 8-bit processors and a 62% growth rate in 16-bit processors, compounded annually over the next five years. Throughout this five-year period, 16-bit processors will continue to dominate the marketplace with over 60% market share. The 16-bit processor will, according to CSI, increase its market share from 6% to 23% by 1983, due primarily to new applications in computer peripherals and communications. The growth in the 16-bit market share is expected to offset the decline in the 4-bit share. In dollar terms, sales of the 4-bit processor will remain flat from 1978 to 1983, but its market share will drop from 26% to 9%. This, says CSI, will be due to the large growth of the overall market and the reduction of the average selling price of 4-bit units.

Like semiconductors, processors will continue to experience price erosion over the next five years, predicts CSI. Units currently selling at from $2.00 to $15.00 will drop in price to between $1.50 to $5.00 in the early 1980's.

The Microprocessors Application Group of the IEE is to hold a colloquium entitled 'Teaching and software design techniques for microprocessors' on November 21. It is hoped that the meeting will include contributions from Dr R. D. Baker of the University of Sussex, Dr F. Duncan of the University of Leeds, Mr B. Cohen of STL, Harlow, and Mr F. Pettit of the University of Oxford. Anyone wishing to contribute to the colloquium is invited to contact Dr A. C. Davies at the City University, London, (01-253-4399) or the IEE Secretariat quoting reference LS (CG). Registration forms are available on application to the IEE quoting reference LS (DA).

SIXTY YEARS AGO

In a report, published in the November 1919 issue of *Wireless World,* of a British Association Meeting, a paper entitled "A trigger-relay utilizing three-electrode thermionic vacuum tubes" by W. H. Eccles and F. W. Jordan was recorded. This is the famous Eccles-Jordan flip-flop, without which computers would not exist.

"'In a well-known method of using a triode for the amplification of wireless signals an inductive coil is placed in the filament-to-anode circuit, and another coil magnetically coupled with this is introduced into the filament-to-grid circuit. This "back-coupling" as it is sometimes conveniently called, if it is arranged in the right sense, greatly exalts the magnification produced by the tube in any alternating E.M.F. applied to the grid; for the induced E.M.F. passed back to the grid is in correct phase relation to add directly to the original alternating E.M.F. applied there. If instead of using inductive retroaction of this kind we attempt to use resistance back-coupling, then the retroactive E.M.F. applied to the grid is exactly opposite in phase to the original alternating E.M.F., and the amplifying action of the triode is reduced. Since, however, one triode can produce opposition in phase in the manner indicated it is clear that two or any even number of similar triode-circuits arranged in cascade can produce agreement in phase. Hence we conclude that retroactive amplification can be obtained by effecting a back-coupling to the first grid from the second, fourth, and so on, anode circuit of a set of triodes arranged in an ohmically-coupled cascade.

'It is possible to take advantage of the fact above stated for obtaining various types of continuously-acting relay.

'The paper described a one-stroke relay, which, when operated by a small triggering electrical impulse, undergoes great changes in regard to its electrical equilibrium, and then remains in the new condition until re-set.' "

Soundfield microphone — 2

Detailed functioning of control unit

by Ken Farrar, Calrec Audio Ltd

Ambisonics and surround sound technology based on psychoacoustic theory form the nucleus of the design of the soundfield microphone (News, Aug. 1978). The design combines advanced acoustical, mechanical and electrical precision engineering in a new way. Recordings made with the microphone and reproduced through a minimum of loudspeakers produce images which are stable and uncoloured, while additional loudspeakers, which need not be full range, allow reproduction of valuable height and reverberant information. The soundfield microphone enables the recording engineer not only to record the total field sound and thus protect his recording from obsolescence, but to compare and dub to conventional forms, adjusting, panning and steering his synthesized, truly coincident "microphones" after the event.

THE MICROPHONE INPUTS to the Soundfield control unit are electrically balanced having a common mode rejection to interfering signals better than −60dB, 20Hz to 20kHz. The input preamplifiers have a gain of +14dB but may be preceded by a −20dB attenuator (A−20) if the microphone is used in very loud conditions.

Following the AB matrix, the B-format signals are controlled by a four-gang rotary fader and additional gain of +6dB, +14dB and +30dB (fader max.) may be added to allow a maximum microphone sensitivity of 68dB s.p.l. for 0dBm levels at the recording outputs. These amplifiers are designed to withstand overloading to +24dBm.

The recording output level may be monitored by a peak programme meter which may be switched to X, W, Y, or Z and having facility to increase meter sensitivity by 20dB.

The recording signal and the replay signal from the four-track tape recorder may be monitored, (thus allowing checking of recording quality) by a chain of amplifiers contained in a series of modules in the same manner as the input circuits (Fig. 9).

The first two modules in the output (monitor) chain are soundfield control modules. Soundfield-1 provides azimuth and elevation adjustments and soundfield-2 provides dominance to the sound sphere either up/down or front/back. These controls are operative on replay or dubbing unless the outpts are used for recording.

Azimuth control

Consider the horizontal directional components of the B-format signals X and Y, Fig. 10. Suppose that they are passed through a circuit such that X' (output) $= -Y$ and Y' (output) $= X$. This gives results equivalent to the microphone being turned to face C_R.

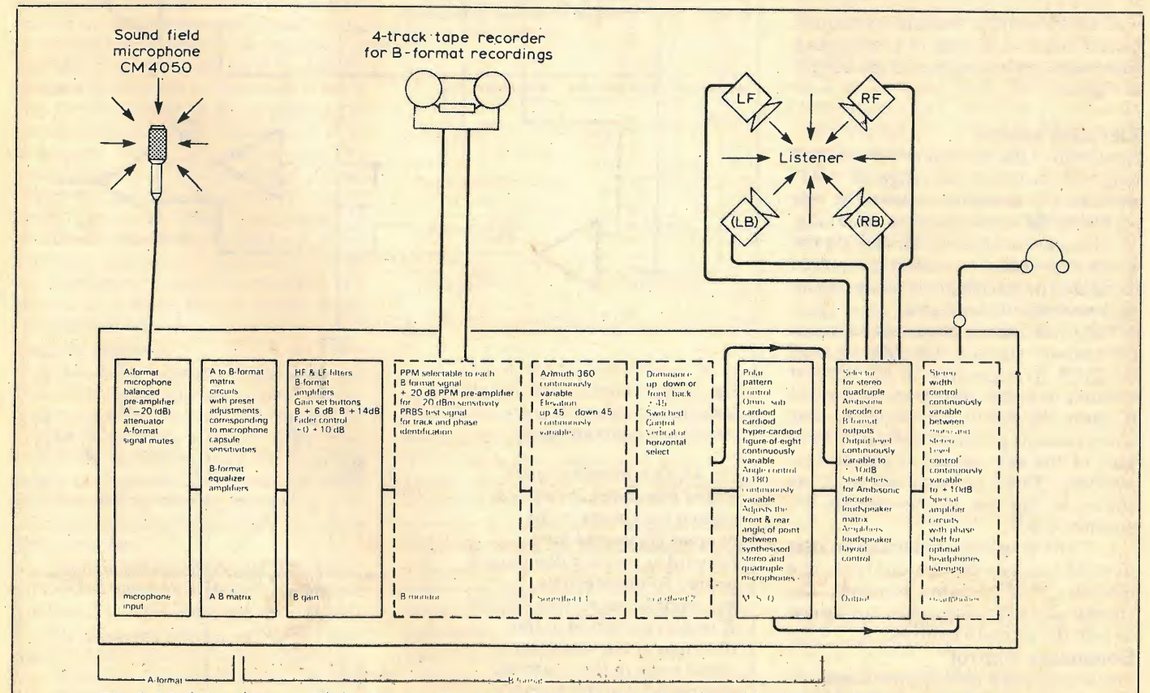


Fig. 9. *Modules shown with broken outlines may be omitted with reduced facilities. With all possible modules left out equipment operates as a "Super Stereo" microphone with steerable facilities. These controls may still be operated post session on B-format material.*

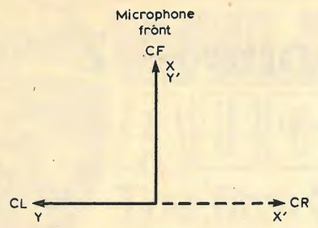


Fig. 10. *Principle of azimuth control.*

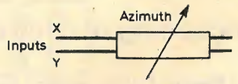
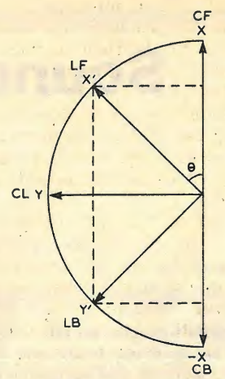


Fig. 11. *Azimuth co-ordinate components. (Right).*



Similarly if $X' = Y$ and $Y' = -X$ the microphone would behave as if it faced the C_L direction. $Y' = -Y$, $X' = -X$ corresponds to the microphone facing C_B and so forth.

If the microphone is required to face, say, L_F (Fig. 11) then X' needs to be composed of components X and Y but with the same overall sensitivity as X (or Y). The peak sensitivity of X' (and Y') is required to remain constant and the orthogonal components must satisfy the following sine/cosine relationship

$$X' = X\cos\theta + Y\sin\theta$$
$$\text{and } Y' = Y\cos\theta - X\sin\theta$$

In the example given

$$X' = X\cos 45° + Y\sin 45°$$

$$\text{so that } X' = \frac{X}{\sqrt{2}} + \frac{Y}{\sqrt{2}} \quad (7)$$

$$\text{and similarly } Y' = \frac{Y}{\sqrt{2}} - \frac{X}{\sqrt{2}} \quad (8)$$

A continuously variable azimuth control requires the use of a twin-gang sine/cosine potentiometer in the circuit of Fig. 12.

Fig. 12. *Azimuth circuit.*

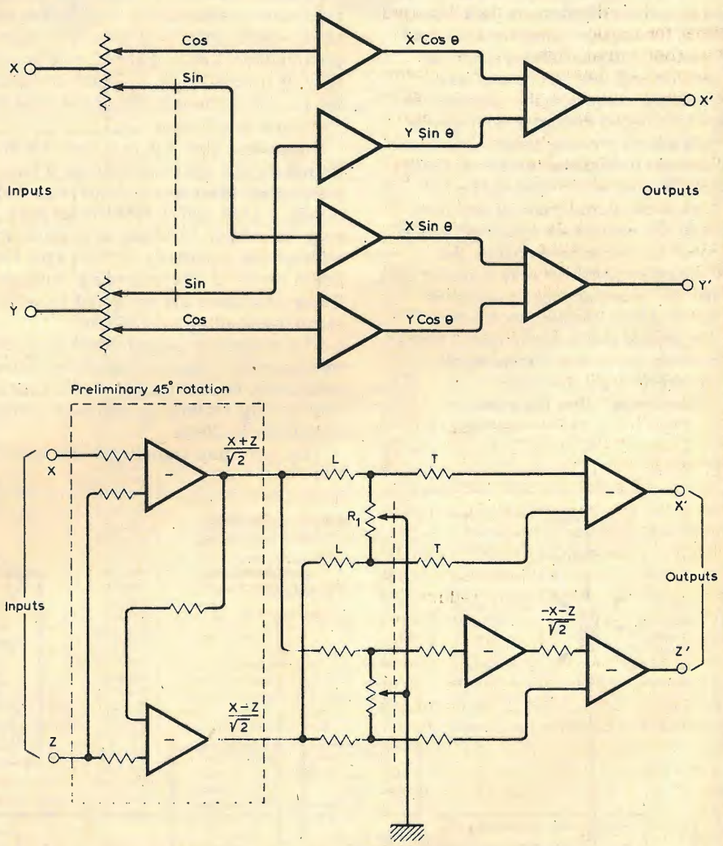


Fig. 13. *Elevation circuit. Amplifiers indicated schematically are used in the virtual earth mixing mode.*

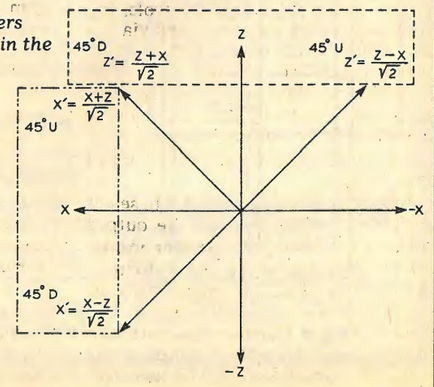


Fig. 14. *Dominance control. Sound directions are moved around the sphere in the manner illustrated for a forward or upward dominance angle. Simultaneously microphone sensitivity (W and X or Z) is increased in the direction of the dominance (front or up in the example) and reduced in the opposite direction (back or down in the example).*

Elevation control

If rotation of the microphone is required only over a restricted range of ±45° such as the elevation control, a less sophisticated circuit may be used, Fig. 13. This control needs to act only on the X and Z co-ordinates since it is required to rotate the microphone forward and backward about the Y-axis.

The circuit firstly produces sum and difference signals $(X+Z)\sqrt{2}$ and $(X-Z)\sqrt{2}$ corresponding to 45° vertical rotation in either direction. A control R_1 varies the mix to X' (output) so that at the extreme positions 45°U and 45°D each of the two signals is passed respectively. These corresponde to X' as shown in Fig. 14. In the centre, 0°, position $X' = X$.

L, T and R values are chosen so that over the range of the control, the modulus of X' remains constant, the components following a sine/cosine law as with the azimuth control.

Dominance control

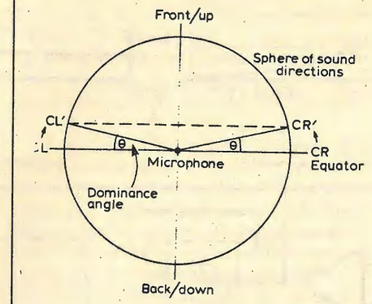
The soundfield-2 module introduces an effect called dominance. To see its effect, imagine the incoming sounds as arriving from different points on the surface of a large sphere centred at the

microphone. The dominance control modifies the effective directions of arrival of sounds, and also their loudness. In the case of vertical dominance, the control effectively displaces all sound on the sphere upward or downward, also making the microphone more sensitive to sounds in the direction (up or down) toward which the sounds are displaced.

The extent of the displacement is marked on the control as an angle which is the extent by which the "equator" of the sound sphere is displaced above (or below) its normal horizontal position, Fig. 15. The control provides nine selected positions, four either side of normal, 0°, the maximums being ±45°: the control can be used either for up/down (vertical) or front/back (horizontal) dominance.

Increasing dominance in the circuit progressively changes the pressure (omni-directional) component W into a sub-cardioid by adding an increasing amount of corresponding pressure-gradient component. That is Z for up, —Z for down, X for front and —X for back. At 45°, W is still not quite a cardioid. Simultaneously Z (for up/down) or X (for front/back) has an increasing component of W added to it or subtracted from it to convert Z or X from figure-of-eight to hyper-cardioid. At 45° Z or X is a cardioid. Fig. 16 shows the condition for +30° up.

Compensation is simultaneously provided in each case such that the ratio of the energy in the velocity signals to the energy in the pressure signal remains unchanged although a use of the control is to emphasize particular directions and/or de-emphasize others so a change in programme level is usually heard. For example a typical use is to set for UP dominance so as to reduce the sensitivity of the microphone to audience noise. Alternatively the microphone may be apparently moved closer to the sound stage by the use of front dominance. What in fact happens is that the sensitivity to front or direct sounds is increased whilst that to back or reverberant sound is reduced. The circuit to achieve this is shown schematically in Fig. 17.



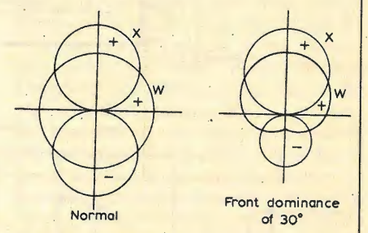


Fig. 16. *Effect of dominance control on B-format components.*

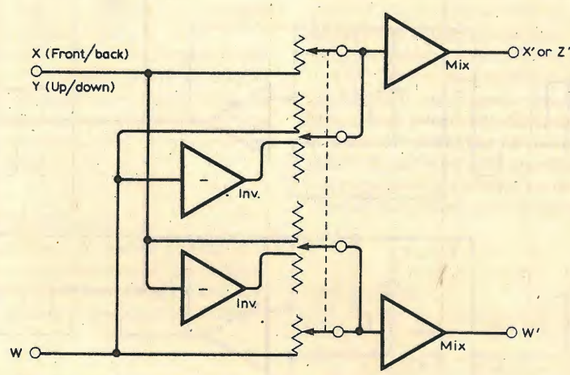


Fig. 17. *Dominance circuit schematic.*

Output controls

Following the soundfield controls, the B-format signals may be passed via the gain control to the output sockets if "B" output is selected, at 0dBm level. This condition would be used for dubbing using the soundfield controls to make adjustments or during recording if it was felt necessary to use the controls in this condition.

A more likely arrangement is to select Ambisonic decode and use the output sockets for four-loudspeaker monitoring thus recording the B-format signals from the microphone directly and allowing experimental use of the soundfield and other controls in the monitor chain during the recording.

When Ambisonic decode is selected, the B-format signals are passed from the gain control into shelf filters in the output module. The shelf filters are all-pass circuits with identical phase shifts of 90° at 400Hz. The effect of the shelf filters is to boost the gain of W relative to that of X or Y by 3dB at high frequencies. The subsequent loudspeaker matrices thus produce 120° hyper-cardioids at low frequencies at the four corner positions and 135° hyper-cardioids above about 1kHz. This produces optimum psychoacoustic performance in accordance with the theory of references 1, 4, 7 to 10.

If the listening loudspeakers cannot be placed in a regular format, a loudspeaker layout control shown in Fig. 18: allows variation of the X:Y aspect ratio from 1:2 to 2:1 to compensate. Fixed *distance compensation* in the form of RC high-pass filters of pressure gradient components X and Y is provided for typical monitor loudspeaker distances of 2 to 3 metres from the listeners to compensate the increase in velocity components at very low frequencies due to sound wavefront curvature.

The loudspeaker matrix formulae at low frequencies and at mid-band and above for a square loudspeaker layout are given in Table 1.

Table 1: Effective matrix equations for Ambisonic B-format decoder with square loudspeaker layout.

Low frequencies	Mid and high frequencies
$L_B = W - X + Y$	$L_B = W - \frac{X}{\sqrt{2}} + \frac{Y}{\sqrt{2}}$
$L_F = W + X + Y$	$L_F = W + \frac{X}{\sqrt{2}} + \frac{Y}{\sqrt{2}}$
$R_F = W + X - Y$	$R_F = W + \frac{X}{\sqrt{2}} + \frac{Y}{\sqrt{2}}$
$R_B = W - X - Y$	$R_B = W - \frac{X}{\sqrt{2}} + \frac{Y}{\sqrt{2}}$

If the outputs are selected to quadruple or stereo/mono the shelf filters and loudspeaker layout control are bypassed and the output matrix is set for corner cardioids i.e.,

$$L_B = W - \frac{X}{2} + \frac{Y}{2}$$
$$L_F = W + \frac{X}{2} + \frac{Y}{2}$$
$$R_F = W + \frac{X}{2} + \frac{Y}{2}$$
$$R_B = W - \frac{X}{2} + \frac{Y}{2}$$

On stereo/mono and L_B and R_B are switched off.

The controls of polar pattern and angle are now operative and work as follows. At 0° angle Y is reduced to zero and X enhanced 3dB to maintain proper levels. Similarly, at 180° X is removed

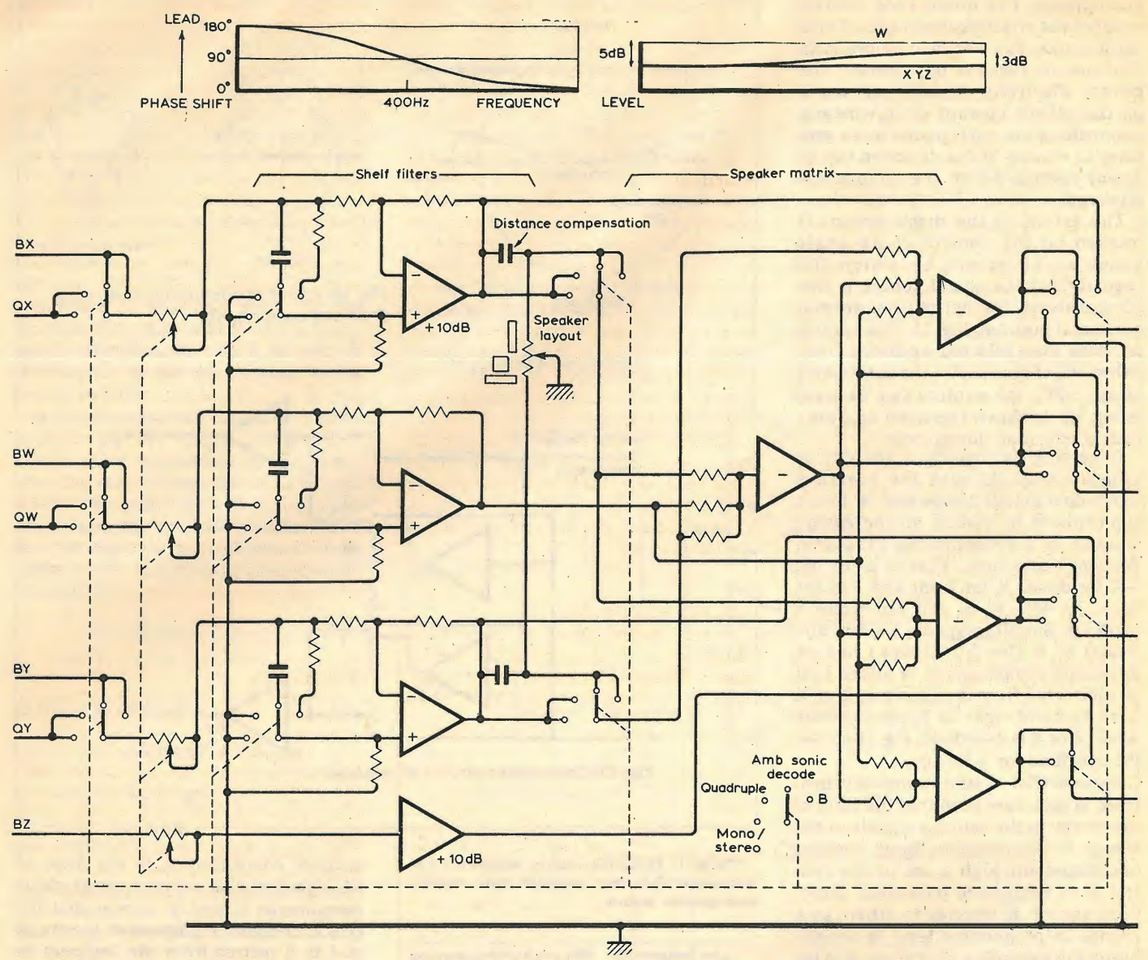


Fig. 18. *Circuit of output module showing shelf filters, low frequency distance compensation, louspeaker layout control which follows a sine/ cosine gain law and loudspeaker matrix.*

and Y increased 3dB. The control follows a sine/cosine law similar to the elevation and layout controls, Fig. 19. The polar pattern control provides unity gain to X, Y and W at the cardioid position. For omni, W is increased 6dB and X and Y turned off. Similarly, at figure-of-eight X and Y are increased 6dB and W turned off. Intermediate settings provide continuously adjustable patterns such as sub-cardioids and hyper-cardioids.

Typical microphone conditions can be set up as follows.

● Angle θ, output stereo/mono. This corresponds to mono and the synthesized single microphone can be set for any pattern from omni-directional through cardioid to figure-of-eight. It can of course be panned and tilted as previously described, using the soundfield 1 controls, Fig. 20(a).

● Angle 90°, output stereo/mono.

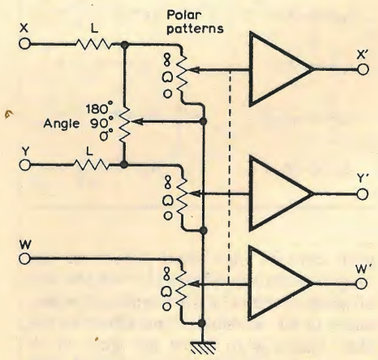


Fig. 19. *Microphone angle and polar pattern circuit.*

This corresponds to a truly coincident stereo pair whose patterns may be varied as above, set in the familiar 45°/45° configuration. They may as a pair be tilted down or up and turned as required, Fig. 20(b).

● Variation of the angle control now adjusts the angle between the pair of microphones which can be as much as 180° if desired. This together with the polar pattern control, azimuth and elevation gives infinite stereo flexibility, Fig. 20(b).

● With the output set to quadruple, four such microphones may be synthesized Fig. 21. This configuration may be changed as shown.

The angle control now changes the angle between the front and rear pairs of "microphones" simultaneously.

All polar patterns may be varied together and identically, The whole array may be panned and tilted as before.

The left and right front stereo output signals may be monitored continuously using stereo headphones irrespective of the output mode selected. Thus what is heard in the headphones is subject to the angle and polar patterns controls all the time. These controls may be set for a particular output condition and in this event, there is a separate headphones stereo width control which may be set down to mono if required. The headphones employ a unique circuit with a phase advance applied to the Y signal (this is equivalent to $S(=L-R)$ in the M/S format). The result is a more natural, sharper stereo presentation.

Conclusions

Clearly the soundfield microphone and master recording of the four B-format signals would appear to fulfil the need for a new and versatile standard but is necessary to consider the inclusion of pan-potted material. In some situations emphasis needs to be given to an individual or section. Single microphones may, for this purpose, be panned into a B-format presentation using special, but fairly simple, circuit techniques although it should be stressed that such enhancement microphones should be used with discretion so as not to confuse and distort the "acoustic hologram" of the soundfield microphone.

It is necessary to have encoding standards for public use which preserve as far as possible the qualities of the system. They must allow proper mono and stereo compatibility and, because of the existing commercial outlets, include the possibility of encoding the surround sound effect into just two audio channels. Whatever system is chosen should, however, be adaptable to three of four-track systems in such a way that additional features such as height may be included.

The term for a system of this type is C-format (consumer format) and there are a number of proposals in existence, the Ambisonic proposal being System UHJ (12) in which the basic two-channel is HJ (or BHJ). This matrix specification is the now-accepted two-channel standard superceding the earlier NRDC system 45J and BBC System H.

In system THJ a third channel (T) which can be band limited may be added to improve directionality. In the case when the third channel is band-limited the system is termed a 2½-channel system. The UK Independent Broadcasting Authority is undertaking experimental 2½-channel HJ broadcasts. When available a fourth channel may be used for either to emphasize loudspeaker positions in a square layout; QHJ, or to present a full soundfield with-height directional effects, HHJ.

The last-mentioned specifications are kernel not matrix specifications and as such may be applied to multi-track as well as B-format or other four-track recorded material. See references for further details.

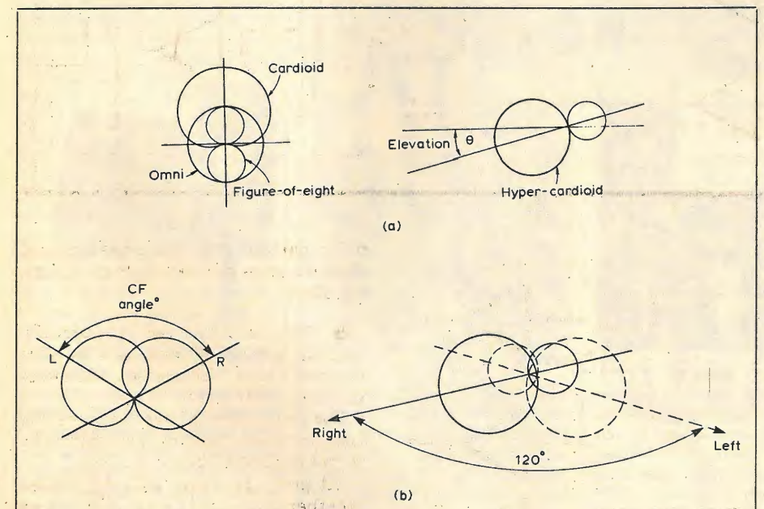


Fig. 20. *Two polar patterns (a) above, and two stereo configurations (b), below. Synthesized cardioid microphones are shown left and a stereo pair of synthesized microphones set hypercardioids at an angle of 120° and tilt downward seen from direction C_F are shown right.*

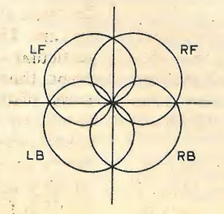


Fig. 21. *Typical quadruple configuration.*

Acknowledgements

The tetrahedral array of capsules is based on an application of the mathematical theory of sampling on the surface of a sphere developed by Michael Gerzon at the Mathematical Institute of Oxford who devised much of the basic design architecture described. Ambisonics technology was developed by Professor Peter Fellgett of the University of Reading, John Wright of IMF Electronics and Michael Gerzon of the Mathematical Institute of Oxford under the auspices of the National Research Development Corporation. Thanks to Geoffrey Barton of the University of Reading for invaluable design assistance, notably his computer simulations of the acoustical performance and the resulting design of spaced-to-coincident conversion filters. I am indebted to co-director Clem Beaumont without whose devoted expertise in the production of superb capacitor capsules and associated acoustical design work this project would not have been possible.

The Calrec Soundfield microphone and NRDC Ambisonic technology are the subject of the United Kingdom patent No. 1494751 and US patent Nos 3997725 and 4042779 together with all corresponding patents in other countries and all other patents pending.

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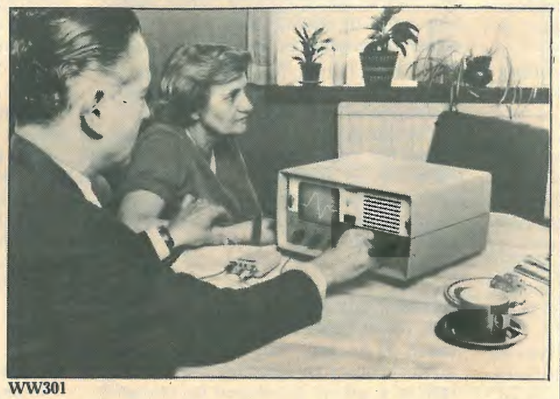
The Audio Engineering Society is calling for papers to be presented at their 65th Convention to be held in the London Hilton from February 25 to 27, 1980. Contact Dr J. M. Bowsher, Audio Engineering Society, Physics Department, University of Surrey, Guildford, Surrey.

NEW PRODUCTS

Portable electromyograph

Monitoring of muscular responses and nerve functions can sometimes provide advance information concerning neural disorders. The myograph provides a clear indication of the related changes and Medelec Ltd have just introduced their MS9 portable electromyograph with the intention of making monitoring possible in the home or workplace as well as in a clinical centre. This unit is a single channel instrument with a stimulus intensity continuously variable between 0 and 300V and a duration of either 0.05, 0.2 or 1.0ms. Repetition rate is either variable between 1 and 100 p.p.s. in a 1-2-5 sequence or is controlled by an external trigger. Input is read as a trace and is also converted into an audible output via a built-in loudspeaker. The trace is displayed on a 100×80mm medium persistence c.r.t. with the usual "scope" controls such as vertical and horizontal shift, focus and brilliance. The timebase may be triggered, free running or externally triggered with sweep velocity variable between 200ms and 500ms per 10mm in 1-2-5 sequence. A conduction time indicator is included and this is continuously variable between 0 and 99.9ms, the setting being indicated by a three-digit index display on the instrument's front panel. A calibration facility is included with the preamplifier to permit quick setting-up. Overall dimensions of this portable instrument are 320mm wide×168mm high×284mm deep and the total weight is 8kg. A padded carrying holdall is supplied with the unit which includes pockets for mains cable, preamplifier, electrodes and connecting cables. All standard mains voltage types are available. Medelec Ltd, Manor Way, Old Woking, Surrey GU22 9JU.

WW301



WW301

Miniature float switch

Vending machines, automotive and general industrial applications are the areas of activity in which the P219 miniature float switch can be employed, according to the manufacturer, Hamlin. The fully encapsulated switch measures 24mm × 45mm (length) including mounting thread and can switch up to 500V at 10W. A switching current of 0.5A is also quoted and a life span of over 50 million operations. Hamlin Electronics Europe Ltd, Diss, Norfolk IP22 3AY.

WW302

WW302

Hand-held vibration meter

Deteriorating bearings in factory machinery or vehicle moving parts and fouling of rotating parts can be checked in advance by the use of a vibration meter. The VTM31 hand-held vibration meter, manufactured by Rostol Ltd, consists of a velocity transducer with probe, connecting cable and true r.m.s. meter, supplied as a portable unit in a leather carrying case and weighing 1 kg. The meter conforms to international and British standards and covers the frequency range 10Hz to 1kHz. Only one control knob is used, indicating switched velocity ranges of 0 to 1, 3,10,30 and 100mm/s as well as battery monitor and "off" positions. The only power supply required is a 9V transistor battery and battery life is claimed to be in excess of six months in normal use. An instruction manual is also provided which gives a guide to expected vibration levels for different classes of rotating machine together with a method for balancing them. Rostol Ltd, Lysons Avenue, Ash Vale, Nr. Aldershot, Hants.

WW303

WW303

Sound level controller

Excessive sound levels can not only damage human hearing, they can limit useful conversation and also result in the law being broken in workplaces or areas where only moderate levels of sound are permitted. The Minim "noise" controller, manufactured by Audio Installation and Maintenance Services, is a sound-operated mains cut-out device which senses the local sound level by microphone and indicates visually three actual sound intensity levels. At a threshold level the green warning light of three display lights is illuminated. If the sound level increases the amber light is lit and if a further increase occurs over a period which exceeds the set "on-delay" of the next indicator to be lit, i.e. the red light, then power is automatically severed. A manual override is provided to exclude the mains disconnection but at the same time maintaining visual indication. Calibrated preset controls may be used to select the sound level in dBA at which power will be cut, the time for which this sound level may be maintained before it is cut, and the time taken for the power to be restored when "auto" mode is selected. Current switching capacity is 30A at line voltages between 220 and 250V a.c. Audio Installation and Maintenance Services Ltd, 27 Potters Lane, Kiln Farm, Milton Keynes, Bucks MK11 3HG.

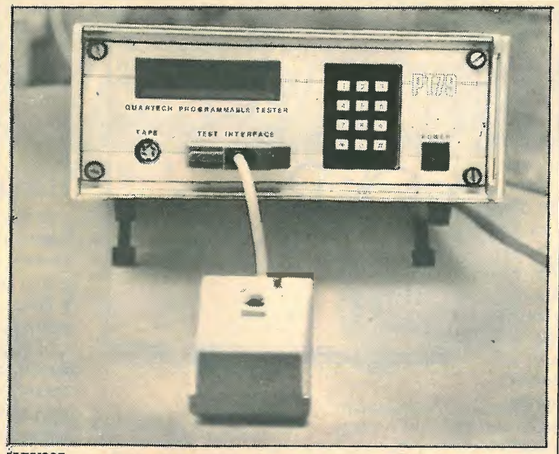
WW304

WW304

Programmable digital i.c. tester

Truth table testing of digital i.cs is the prime function of the PT79 microprocesor-controlled instrument now in production by Quartech Ltd. Various supply voltages are catered for, c.m.o.s. devices can be checked and the unit may be used manually or with an automatic component handler. Test programs are resident in r.o.m., eliminating the need for plug-in program cards. Individual test sequences are selected by entering the device type number on the keyboard. Up to 24 test lines are available, either as an input or an output. Devices in d.i.l. configuration up to 24 pins are accommodated by means of plug-in test jigs. Quartech Design and Development Ltd, 14 Kingsgate Place, London NW6 4TA.

WW305

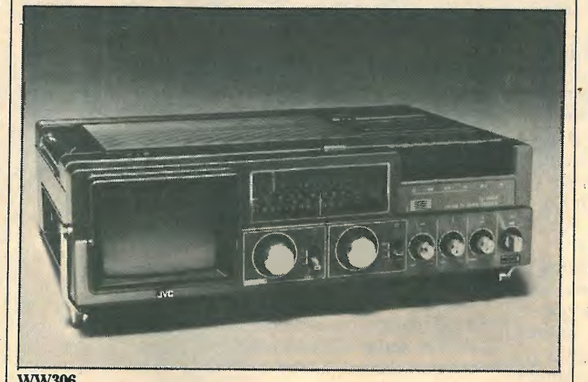


WW305

Combined colour tv, radio and cassette recorder

A 4½in screen colour tv, a three-band radio receiver and a cassette recorder are the features combined to produce the CX-500 portable from JVC (UK) Ltd. The colour tv circuits are switchable between PAL and SECAM (except SECAM in France) and the sound i.f. is also switchable. The radio sections cover the conventional broadcast band ranges of 88 to 108MHz on f.m., 510 to 1600kHz on medium wave and 150 to 350kHz on long wave. Other standard features are a.f.c., to limit tuning drift, and a capacitor microphone to feed the cassette recorder section. This part of the instrument apparently offers a s/n ratio of 48dB with wow and flutter less than 0.3% w.r.m.s. The frequency range is 80Hz to 10kHz. Optional extras are an a.c. adaptor, a car cord (for connection to a car or boat battery) and a rechargeable battery pack. The retail price of the combined unit is £355 inc. v.a.t. and it is available in October 1979. JVC (UK) Ltd, Eldonwall Trading Estate, Staples Corner, 6-8 Priestley Way, London NW2 7AF.

WW306

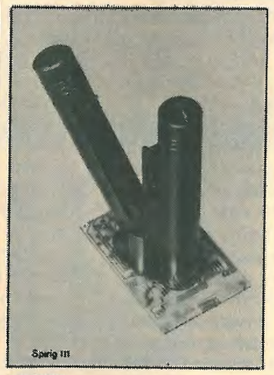


WW306

Pocket microscope

Image magnification of 30 and a self-contained battery for illumination are the main features of the Spirig III pocket microscope. The marketing agents suggest that the microscope will find a particular application in the field of quality inspection. Retail price is £18.90, excluding v.a.t. Cobonic Ltd, Knapton Mews, Seely Rd, London SW17 9RL.

WW307



WW307

Dynamic / electrostatic headphone

Embodying a technique which the manufacturer terms the "two-way principle," the K340 stereo headphone from AKG offers a frequency response of 16Hz to 25kHz. A moving coil transducer is employed for low frequencies and an electrostatically-activated diaphragm for high frequencies. Further operating details include a nominal impedance of 400Ω per channel and a maximum handling level of 200mW (DIN 45582). Harmonic distortion is claimed to be less than 0.2%; the coiled connecting cord extends to a length of 3m and the weight of the complete headphone (excluding cable) is 380g. Retail price is £80.80 (excl. v.a.t.). AKG Acoustics Ltd, 191 The Vale, London W3 7QS.

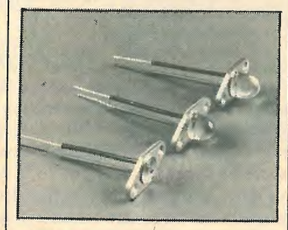
WW308

WW308

Infra-red diodes

Typical output power of 45mW at a current of 500mA is one of the main specification points which Plessey quotes for its new range of infra-red emitting diodes classified in three types as GAL10, GAL11 and GAL12. Angles of emission are 20°, 60° and 150° for the three devices respectively and they are mounted on TO37 headers with moulded lens structured to obtain the different emission angles. A low degradation rate is quoted, giving an expected life of 20,000 hours. Emission wavelength is 940nm which aligns with the peak sensitivity of silicon photocells, thus giving, according to Plessey, efficient detection. Plessey Optoelectronics and Microwave Ltd.

WW309



WW309

Doppler transceiver

A fixed tuned c.w. source and diode mixer assembled into a compact waveguide package form the basis of the MA-86501 Doppler transceiver which, according to the makers, Microwave Associates Ltd, is especially suitable for use in microwave intruder alarm systems. A Gunn oscillator and Schottky barrier mixer diode are employed in the unit, these being replaceable in the field in the event of accidental damage or r.f. overload from an external source. The transceiver delivers an audio frequency output whenever a radio reflective object moves towards or away from its antenna. The oscillator is supplied factory-tuned to the permitted frequency and it delivers 5 to 10 mW output. The makers say that the unit is built to professional standards, and that it conforms to statutory microwave regulations in all European countries. Frequency stability is better than 40 p.p.m. per degree centigrade and spurious output signals do not exceed —35dBm. An 8.5V power supply is required, and the normal operating current is less than 150 mA. A suitable horn antenna for wide angle operation is also available. Microwave Associates Ltd, Woodside Estate, Dunstable, Beds LU5 4SX.

WW310

Che sera, sera

What I can't fathom is this passion for wanting to see into the future. Only a few months ago (I was going to say 'a few short months' but, apart from it being a cliché, they've probably been long ones for Socialists) everyone was going mad trying to forecast the result of the election — a process which, for two reasons, I deeply deprecate. Firstly, forecasting election results is only slightly less stupid than pole squatting: if everyone would just wait until the votes were counted, they would know the result. Secondly, while pole squatting is not a very productive way of passing a spare fortnight or so, it doesn't actually do any harm: election forecasting I'm not so sure about. I have a feeling that press and broadcast comment on elections is a process in which Heisenberg (The Uncertain) would have been interested, in that you can't examine something like public opinion, broadcast the result and not affect the opinion you were examining. You have therefore influenced the election. If, for example, a Liberal vote weren't publicly branded a 'wasted' vote, we could have the Member for Roxburgh, Selkirk and Peebles in No. 10 today, elected on his politics, not his chances of election.

But I digress. I was really wanting to make a point about that hard-working and prolific body of economic gurus called marketing consultants, among other things. Barely a week goes by without the publication of an extremely expensive compilation of statistics and predictions on the history and future of companies and products, which is immediately seized upon by commentators and its gloomy bits given headline treatment.

I don't think it can help but affect the prospects of a product. There must be, in effect, a positive feedback process brought into play: if companies are told that the sales of product X are going to disappear in a year's time, they are not going to lose much time in switching to a different product, the report having made its own prediction come true.

This is not prediction, it is conditioning. I wonder what would happen if a researcher came up with the notion that the economy was all set for a 10% growth next year and that we were due for a four-dollar pound and an export surplus of something like the Japanese figure. I suppose no one would believe him and the feedback loop wouldn't operate.

Gossip from the train

In keeping with my policy of disseminating the latest information from the 17.33 to Epsom, I thought I'd bring you up to date on the Southern Railway hi-fi scene.

There I am, peacefully reading the evening paper, when the chap next to

SIDEBANDS by Mixer

me pulls out an audio magazine and starts looking at the ads. Well, I don't mind admitting that at that point, I averted my eyes, because quite honestly it had been one of those days and I didn't really want to know about such things. It wasn't to be, though. A man on the other side of my golden-eared neighbour was evidently a hi-fi nu . . . enthusiast and was intent on bending his ear about loudspeaker cables. The one with the magazine was looking for a speaker and was informed that if he didn't get hold of a set of special, high-definition, low-distortion, gold-plated, blue-and-white striped cables, he would need much more sensitive speakers, so he'd be better off with the cables. As an encouragement, a 50W speaker, he was told, would sound more like a 75W one if he used high-gain loudspeaker wires.

At this, I caught my breath. Also, my pulse raced. If only I knew anything about shop-keeping, I said to myself, I could be worth millions in a couple of years with customers like these. The shop could be stocked with enormous teak and chrome boxes with a couple of i.cs in each and any amount of trend-setting products like high-resistance aerial co-ax to stop the Yagi vibrating in the wind and modulating the signal, and black paint for the inside of speaker enclosures to eliminate reflections. An add-on super-tweeter, with a l.e.d. indicator to show when it was working, would surely be well received, enabling those vital, ultrasonic musical components to contribute fully to the subjective experience, or something.

But really, it all comes back to something I was saying some time ago. In an age when the products people buy are far outside the understanding of untrained people, there ought to be some way of restraining manufacturers from selling them things they don't need. It isn't that people are gullible — they simply don't know about technical things, and have a right to expect that they won't be conned by makers of expensive equipment who keep on upping the technicalities beyond all reason. Fine for the buffs, who know whether they need it or not, or think they do, but the average listener to music who just wants something better than a transistor radio doesn't know whether all this technology is needed or not.

Hands off cassettes!

I've just been sitting here, wondering whether to become one of the criminal classes. Nothing as dire as g.b.h. or grand larceny, you understand, but just a little quiet tape-recording. That cassette deck I was wanting — I went out, and bought it before guilt set in and a new dining table took precedence. So there I was, all set up to start a collection of Vivaldi, Mozart and Louis Armstrong when *The Observer* put a stop to the euphoria.

Not that *The Observer* is directly to blame — it was simply doing its job of reporting earthquakes, revolutions, air crashes and statements from the British Phonographic Industry Ltd that they are to lobby the D.o.T. for a levy on blank tape cassettes and recorders, with a view to compensating the record makers for the money they claim to lose in record sales because of the activities of people like me. Now I've got my cassette deck, I must admit that they can go ahead and impose a levy on decks for all I care, but to attempt to dip their hands into my pocket when I want some cassettes is an activity I take exception to.

How does the BPI know what a cassette is to be used for? Their p.r. man informs me that, since 50 million cassettes are sold each year, the recording industry is consequently losing £150 million a year in sales. It is not possible to check that figure, and it must be assumed to be a guess, possibly inflated to dramatise the situation. It seems that, since the Mechanical Copyright Protection Society introduced the licence for copying records five or six years ago, only 10,000 have been sold. This does seem to indicate that one or two tape recorder owners may have forgotten to pay the licence fee, but to assume that the 12 million owners of equipment (BPI's figure) are depriving the record makers of their bread and butter is hardly justifiable on the available facts. What about all the cassettes used in offices, in industry and for capturing the sound of the lesser, speckled lettuce-cruncher smacking its lips? It would be just as reasonable, and stand just about as much chance of being accepted, to ask for a levy on reams of blank paper, on the grounds that millions of photocopies of newspaper and magazine pages are driving publishers to turn to busking for a living.

If the industry wants to stop people copying records, perhaps they should make recorded cassettes available at a lower price and with a rather better quality and consistency than at present provided.

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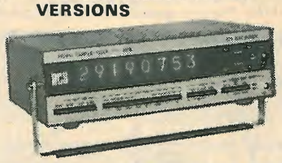

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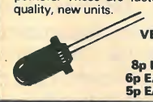

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Model 8000.1A
8 DIGITS 10Hz to 600MHz
ONLY £299.00 inc. (was £351)
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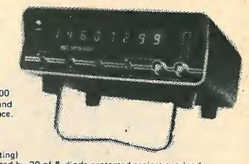
Complete with built-in NiCads & charging circuits.



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7 DIGITS 10Hz to 600MHz
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Input Voltage	120/240	120/240
Output Voltage	0-40 VDC	0-40 VDC
Output Current	1.5/3A	1.5/3A
Load Regulation	.1 volts	.1 volts
Line Regulation	.1 volts	.1 volts
Ripple Max. RMS	.005V	.005V

Specifications	XP-700	XP-600
Current Protection	.05-3A lim	.05/3A lim
Short Protection	.05-3A lim	.05/3A lim
Crowbar Protection	none	none
Output Impedence	.025 ohms	.025 ohms
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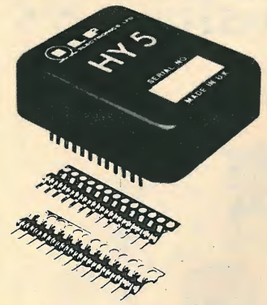
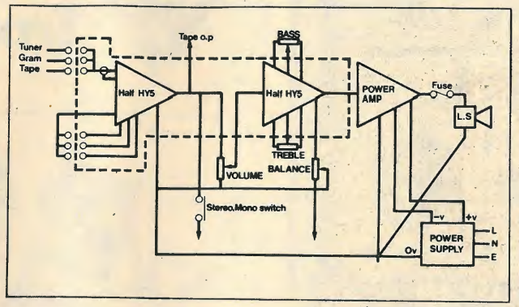
HY5 PRE-AMPLIFIER





The HY5 pre-amp is compatible with all I.L.P. amplifiers and P.S.U.'s. It is contained within a single pack 50 x 40 x 15 mm. and provides multi-function equalisation for Magnetic/Ceramic/Tuner/Mic and Aux (Tape) inputs, all with high overload margins. Active tone control circuits; 500 mV out. Distortion at 1KHz—0.01%. Special strips are provided for connecting external pots and switching systems as required. Two HY5's connect easily in stereo. With easy to follow instructions.

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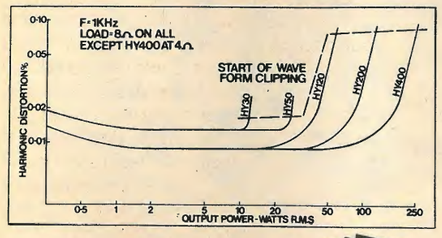
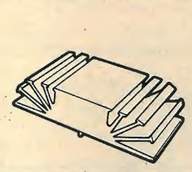
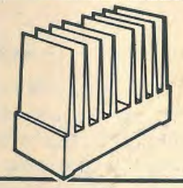
THE POWER AMPLIFIERS



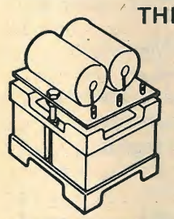
Model	Output Power R.M.S.	Distortion Typical at 1KHz	Minimum Signal/Noise Ratio	Power Supply Voltage	Size in mm	Weight in gms	Price + V.A.T.
HY30	15 W into 8 Ω	0.02%	80dB	-20 -0- +20	105x50x25	155	**£6.34** + 95p
HY50	30 W into 8 Ω	0.02%	90dB	-25 -0- +25	105x50x25	155	**£7.24** + £1.09
HY120	60 W into 8 Ω	0.01%	100dB	-35 -0- +35	114x50x85	575	**£15.20** + £2.28
HY200	120 W into 8 Ω	0.01%	100dB	-45 -0- +45	114x50x85	575	**£18.44** + £2.77
HY400	240 W into 4 Ω	0.01%	100dB	-45 -0- +45	114x100x85	1.15Kg	**£27.68** + £4.15





Load impedance — all models 4 - 16 Ω
Input sensitivity — all models 500 mV
Input impedance — all models 100 K Ω
Frequency response — all models 10Hz - 45KHz - 3dB

THE POWER SUPPLY UNITS



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LM380N/SL6051 14 D.I.L. 2 watt A.F. amp 80p each 8 for £6.00
CA3028B DC. 120 MHZ differential/cascode amp £1.00 each 3 for £2.50
CA3011 20 MHZ wideband amp TD99 case 65p each 2 for £1.00
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NE555 10 for £2.55
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FSA2719 8 independent diodes IN4148, IN914 type in 16 D.I.L. pack 38p each 3 for £1.00
FPQ3725 4 NPN 50v 500ma transistors in 14 D.I.L. pack 70p each 2 for £1.00

SCOOP OF THE YEAR HAZELTINE H1200 V.D.U. TERMINAL

Due to a fantastic bulk purchase, we are now able to offer this superb terminal at a price almost below the cost of manufacture!! Features include: 12" screen, 55 key TTY keyboard, full ASCII, RS232 interface, adjustable baud rate 75 to 9600, 12 lines x 80 characters (upgradable to 24 x 80), cursor control, lower case option, plus many other features.

Brand new at only **£250** CARR. + VAT.

FULL Technical Manual available

POWER SUPPLY UNITS

5 VOLT 2.5 AMP T.T.L. P.S.U.

Made for T.T.L. this compact ex computer systems unit features a 10 amp transformer with D.C. outputs of 5 volts @ 2.5 amps and 7.5 volts @ 5 amps. The 5 volt output is fully regulated and smoothed and has electronic current limiting. May be easily moded for 5 volts @ 7.8 amps, believed working but untested. 240v A.C. input

Complete with circuit **£8.25** P.P. **£1.60**

KEYBOARD

A special bulk purchase enables us to offer the above keyboard at a lowest ever price. 48 coded keys encoded into a direct TTL compatible 7 bit output. Features such as delayed strobe, 5 volt D.C. single rail operation and rollover protection make this an absolute must for the MPU constructor! Supplied complete with connection diagram and edge connector, at a secondhand "no time to test" price of only **£20.00** + P.P. **£1.60**

SUPER CASED VERSION Same as above spec. but housed in attractive two tone moulded, free standing case. Unit also includes an all TTL parallel to serial convertor (no details) etc.

£27.50 + P.P. **£1.85**

MPU EXPERIMENTORS POWER SUPPLY

Once again we are very pleased to offer this superb Power Supply Unit, and hope to satisfy most of our previous customers who were disappointed when we sold out due to demand, last time they were advertised! These units may just have well been made for your lab., they consist of a semi-enclosed chassis measuring 160mm x 120mm x 350mm containing all silicon electronics to give the following fully regulated and short circuit proof outputs of:

+5v @ 2 amps D.C. +12v @ 800ma D.C.
−12v @ 800ma D.C. +24v @ 350ma D.C.

and if that's not enough a fully floating 5v output @ 50ma D.C. which may be seriesed to give a host of other voltages. All outputs are brought out to the front panel via miniature jack sockets and are also duplicated at the rear on short flying leads. Units accept standard 240v AC mains input. They are ex-GPO and may have minor scratches on the front panels, they are sold untested but in good internal condition. Our original price of £16.50 and the recent VAT increase makes these an absolute snip at only **£15.50** each + £2.25 P & P. Complete with circuit and component list.

HURRY WHILE STOCKS LAST!!

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Due to our massive bulk purchasing programme which enables us to bring you the best possible bargains, we have thousands of I.C.'s Transistors, Relays, Cap's., P.C.B.'s, Sub-assemblies, Switches, etc. etc. surplus to our requirements. Because we don't have sufficient stocks of any one item to include in our ads., we are packing all these items into the "**BARGAIN PARCEL OF A LIFETIME**" Thousands of components at giveaway prices! Guaranteed to be worth at least *3 times* what you pay plus we always include something from our ads. for unbeatable value!! Sold by weight

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Interface your MPU etc, with the outside world made by the famous "Astralux" Co. They consist of a miniature plastic module with mounting holes containing a reed relay for isolation, choke and triac. 12-20 volts D.C. at a few milliamps enable on/off control of A.C. loads up to 10 amps! The 10 amp version should be mounted on a heatsink. 100's of uses including power control, lighting, etc, etc.

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PLESSEY EDGE STACKABLE DECADE THUMBWHEEL SWITCHES. Gold plated contacts dimensions 2" x 2" x ¾" 85p each 8 for £5.35.

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S.B.C. Bulb Holders All steel cad. plated panel mount easily fixed via nut and round hole, ideal disco displays, scoreboards, etc. 4 for £1.10.
Xtal filters S.E.1 QC1121t/B miniature low insertion loss P.C. mount. C.F. 10.7mhz with B.W. of 7.5khz 2000Ω imp in-out. Brand new @ £7.99.
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TO5 HEATSINKS "Thermaloy" black anodised press on aluminium finned type 18p each. 8 for £1.00.
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2.00 MHZ	HC6/U	£2.35
2.50 MHZ	B7G	£2.35
5.00 MHZ	HC18/U	£2.25
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10.25 MHZ	HC18/U	£2.25
11.20 MHZ	HC18/U	£2.50
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40 KHZ* UART Xtal 38.40 KHZ* SAE for latest XTAL stock list.

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Just what you have been waiting for, made for a major electronics co. this miniature toroidal transformer accepts 240v AC input and gives AC outputs of 0-10v @ 1.8 amps and 2 x 0-20v @ 750ma. Intended for an MPU supply of +5 and + and −12v, its small physical size of only 2¾" x 1¾" and negligible hum field make it a snip at only £4.25 + pp 60p.

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Are your hot parts sweltering? Then keep them cool with our high efficiency radial snail type blowers. Made by Smiths, designed for continuous use in expensive electronic equipment very powerful and quiet, gives massive air flow to prolong component life and reliability. Easily mounted, air aperture 2¾" x 3". Ideal linears etc. Please state 240v or 110v operation. 50hz only.

BRAND NEW **£4.55** P.P. £1-10

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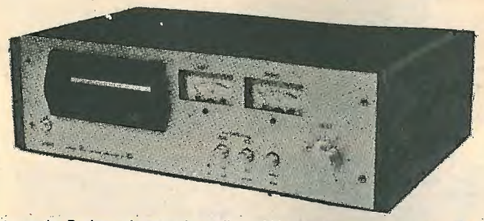
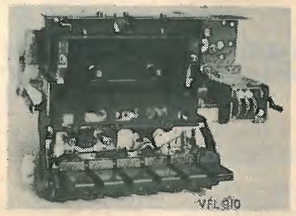
J. L. Linsley-Hood High Quality Cassette Recorders

LINSLEY-HOOD CASSETTE RECORDER 1



We are the Designer Approved suppliers of kits for this excellent design. The Author's reputation tells all you need to know about the circuitry and Hart expertise and experience guarantees the engineering design of the kit. Advanced features include: High quality separate VU meters with excellent ballistics. Controls, switches and sockets mounted on PCB to eliminate difficult wiring. Proper moulded escutcheon for cassette aperture improves appearance and removes the need for the cassette transport to be set back behind a narrow finger trapping slot. Easy to use, robust Lenco mechanism. Switched bias and equalisation for different tape formulations. All wiring is terminated with plugs and sockets for easy assembly and test. Sophisticated modular PCB system gives a spacious, easily built and tested layout. All these features added to the high quality metalwork make this a most satisfying kit to build. Also included at no extra cost is our new HS15 Sendust Alloy record/play head, available separately at **£7.60** plus VAT, but included FREE as part of the complete kit at **£81.50** plus VAT.

REPRINTS of the 3 articles describing this design **45p** No VAT.
REPRINT of Postscript article **30p** No VAT.



VFL 910. Vertical front loading Super Hi-fi deck, as used in our new Linsley-Hood Cassette Recorder 2. **£31.99** + VAT. Set of knobs **£1.46** + VAT.

LENCO CASSETTE MECHANISMS

We hold stocks of a range of Lenco tape transports for all uses, we can also supply spare parts. For example:
CRV Motors complete **£4.00** plus VAT.
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A large range of cassette heads for domestic, industrial and audio visual purposes is available from us. The very best stereo head that we can find is our HS15 Sendust Alloy Super Head. This has an even better high frequency response than our HS14 which it replaces. Unlike cheaper and ferrite types this excellent high frequency performance is combined with a high output, thus maintaining the best possible signal to noise ratio. **Price £7.60** plus VAT.
4-TRACK Record/play head. Scans all 4 tracks on cassette tape. Suitable for auto-reverse mechanisms, film sync, quadrophonics and many other purposes. Standard impedance **£7.40** plus VAT.
Full details of these and other heads are in our lists.

ALL UK ORDERS ARE POST FREE
Please send 9x4 SAE for lists giving fuller details and price breakdowns.

LINSLEY HOOD CASSETTE RECORDER 2

Our new improved performance model of the Linsley Hood Cassette Recorder incorporates our VFL 910 vertical front mechanism and circuit modifications to increase dynamic range. Board layouts have been altered and improved but retain the outstandingly successful mother and daughter arrangement used on our Linsley Hood Cassette Recorder 1.
This latest version has the following extra features: Ultra low wow-and-flutter of .09% — easily meets DIN Hi-fi spec. Deck controls latch in rewind modes and do not have to be held. Full Auto stop on all modes. Tape counter with memory rewind. Oil damped cassette door. Latching record button for level setting. Dual concentric input level controls. Phone output. Microphone input facility if required. Record interlock prevents re-recording on valued cassettes. Frequency generating feedback servo drive motor with built-in speed control for thermal stability. All these desirable and useful features added to the excellent design of the Linsley-Hood circuits and the quality of the components used makes this new kit comparable with built-up units of much higher cost than the modest **£94.90** + VAT we ask for the complete kit.

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LENCO FFR CASSETTE DECK

For those who missed our recent bargain CT4s we now are delighted to be able to offer Brand New Lenco FFR Decks complete with motor speed and auto-stop control board fitted and tested. These will operate with any supply between 9 and 16 volts. This deck can be used for both record and playback applications and is fitted with an erase head. A mono record/play head is fitted and we can supply an extra stereo head, if ordered with the deck at the very special price of £2 plus VAT. We also supply, with each deck and completely FREE, one of our specially moulded escutcheons. This deck would normally cost about £25 but we are able to offer them, while they last, at only £9.99 plus VAT.

CASSETTES

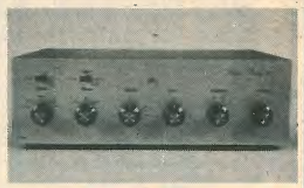
Our laboratory tests on recorders made us realise how important the choice of cassette is. Wow and flutter is obviously affected by the quality of the housing but the performance differences caused by the tape are enormous. It is possible to record a signal at the same level on two different cassettes one of which will replay at a VU level 10db higher than the other. Poor tape can also lose all signals above 8khz! These tests enable us to offer what we think is the best value available. The tape is a Super Ferric High Energy Low noise formulation.

C90 85p
C60 65p
Complete with library case and index card.

C10 35 Complete in library case. Suitable for Micro Programming.

BAILEY 30 WATT AMPLIFIER

We have now completed our redesign of this popular amplifier to make it as easy to build as our latest kits. The power amplifiers are complete modules plugging into a power supply master board, all possible wiring has been eliminated but faith has been maintained with the existing metal work to enable owners to update if they wish. Send for full details in our list.



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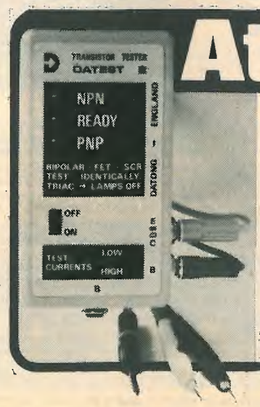
At last...



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Previous Testers have been too easily fooled by low shunt impedances resulting in false alarms on perfectly sound transistors. Designed for fast IN-CIRCUIT testing the new DATONG DATEST 2 tests transistors, FETs SCRs and Triacs even when shunted by resistors as low as 20 ohms!

Automatic NPN/PNP indication, foolproof three-LED display, and unique test probes allow a very high rate of testing even by unskilled users. Very competitive price includes probes and the DATEST 2 is available from stock. Full data sheet free on request.

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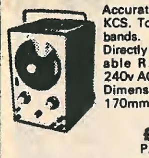
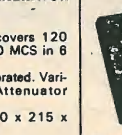
TE20D R.F. SIGNAL GENERATOR



Accurately covers 120 KCS. To 500 MCS in 6 bands. Directly calibrated. Variable R.F. Attenuator 240v AC. Dimens. 140 x 215 x 170mm.

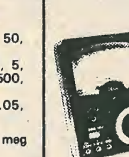
£52.95 P.&P £1.25



Y7206 EN 20,000 OPV

AC Volts: 0-10, 50, 250, 500, 1000. DC Volts: 0-0.5, 5, 25, 125, 250, 500, 1000. DC Current: 0-0.05, 5, 250 mA. Resistance: 0-3k ohms, 300k ohms, 3 meg ohms. Decibels: —20—+63 db. Dims: 127 x 90 x 32 mm.

£10.95 P.&P. 75p



IT 1/2 20,000 OPV

AC volts: 0 to 10, 50, 100, 500, 1000. DC volts: 0 to 5, 25, 50, 250, 500, 2500. DC current 0 to 50 ua, 2.5 ma, 250 ma. Resistance: 0 to 6K ohms, 6 meg ohms. Decibels: —20 to +22 db. Capacitance: 10 pf, 0.01 uf 0.1 uf. Size: 4½ x 3¼ x 1 inch.

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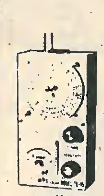
TMK500 MULTITESTER 30,000 OPV

A sturdy and reliable instrument. Has internal buzzer. AC volts: 0 to 2.5, 10, 25, 100, 250, 500, 1000. DC volts: 0 to 0.25, 1, 2.5, 10, 25, 100, 250, 1000. DC current: 0 to 50 ua, 5 ma, 50 ma, 12 amp. Resistance: 0 to 6K, 60K, 6 meg, 60 meg. Decibels: —20 to +56 db. Short test: Internal buzzer. Size: 160 x 110 x 55 mm.

£20.50. P.&P. 75p



TX17 TE15 GRID DIP METER

"TRADIPER". Covers 440 KCS to 280 MCS in 6 ranges. 6 coils supplied. Chief applications:
- (a) Measuring tuning frequencies.
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- (c) Earphone monitoring — Heterodyne — frequency meter.
- (d) Frequency meter.
- (e) Substitution as a test oscillator.
- (f) Relative field strength meter.

Dims: 150 x 80 x 45 mm.

£32.50 P&P £1

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These batteries are virtually indestructible. Can be overcharged, short-circuited, or left uncharged for long periods without deterioration. Each cell is in a polystyrene container and in an outer wooden casing with lid for laboratory or industrial use.
Each cell is 1.2V E.M.F.
Approx. average size of single cell in wood case is 10in. high x 5in. x 3¼in.
The batteries are new and unused and offered at approx. 40% off current list prices.
Items 1, 2 and 3 are with solid electrolyte. Items 4, 5, 6, 7 and 8 are with liquid electrolyte (will not spill in transit).

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3	1 Cell 16 AH	£10.50 P&P £1.00	7	1 Cell 23 AH	£11.50 P&P £1.50
4	1 Cell 32 AH	£13.50 P&P £1.50	8	2 Cell 23 AH	£19.50 P&P £2.50

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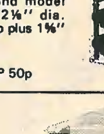

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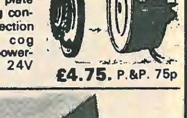
Superb example of electro-mechanics. Main body in two sections, coil section fixed with ⅜" sleeve, drive section rotating on outer perimeter. Uniting plate has ⅜" ID bearing concentric with main section and 18-tooth cog wheel. Extremely powerful transmission. 24V D.C. 240 m/a.

Dozens of uses in Home, Farm, Workshops & Lab.



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Consider the following features:
6 resistance ranges from 200 ohm - 20 mohm.
8 current ranges from 2mA-2A AC/DC.
10 voltage ranges from 200 mv - 1000v DC, 200 mc - 750V AC.
Pocket size—weighing only 370 gms.
Full overload protection—will withstand 6kv spikes.
Rugged construction—virtually indestructable.
Meets tough military specs—drop proof.
In line push-button operation for single-handed useage.
Incorporates low power cmos chip for low power consumption.
All this plus a 2-year full guarantee.

For only £89.00
Carriage and insurance £3.00

Even more sophisticated the Fluke 8020A.
Identical in most respects to the 8022A but in addition incorporates a conductance range from 2mS-200nS.

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Carriage and Insurance £3.00
A handsome soft carrying case is available for the 8020A and 8022A at **£7.00**

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DIGITAL MULTIMETERS

The following accessories are in stock now

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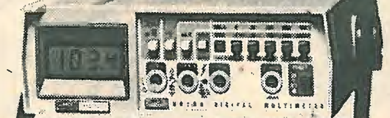
801-600 Clamp-on AC Current Probe	**£50.00**



8010A AND 8012A BENCH MODEL D.M.M.s

The 8010A is a general purpose, bench/portable digital multimeter with more functions and features than ever offered for such a low price. Its companion, the 8012A, has identical charecteristics except that it has two additional low resistance ranges, 2Ω and 20Ω to replace the 8010A's 10 ampere current range.
The 8010A and 8012A feature:
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6 resistance ranges from 200Ω - 20mΩ - the 8012A has two additional resistance ranges 2Ω and 20Ω.
10 current ranges from 200μA - 2A AC/DC — the 8010A has two additional current ranges 10A AC and 10A DC.

8010A £159.00 8012A £179.00
Carriage and Insurance £3.00
The 8010A is also available with two rechargeable Nicad size C batteries installed in option 01 at **£179.00.**

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5	24-30-40-48-60v	3	**£10.35**	£1.00
6	24-30-40-48-60v	2	**£7.30**	£1.00
	6-8-10-12-16-18-20-24-36-40-48-60v CAN BE OBTAINED FROM THE ABOVE RANGE			
7	19-25-33-40-50v	10	**£27.58**	£2.00
8	19-25-33-40-50v	6	**£16.75**	£1.50
9	19-25-33-40-50v	3	**£10.35**	£1.25
10	19-25-33-40-50v	2	**£7.35**	£1.00
	5-7-8-10-13-15-17-20-25-30-40-50v OR 25-0-25v OR 20-0-20v CAN BE OBTAINED FROM THE ABOVE RANGE			
11	12-15-20-25-30v	10	**£16.45**	£1.75
12	12-15-20-25-30v	5	**£9.45**	£1.25
13	12-15-20-25-30v	2	**£5.35**	£1.00
	3-4-5-6-8-9-10-12-15-18-20-24-30v OR 12-0-12v OR 15-0-15v CAN BE OBTAINED FROM THE ABOVE RANGE			
14	12-24v	12v 60A, 24v 30A	**£32.50**	£3.00
15	12-24v	12v 30A, 24v 15A	**£16.85**	£2.00
16	12-24v	12v 20A, 24v 10A	**£13.35**	£2.00
17	12-24v	12v 10A, 24v 5A	**£7.95**	£1.00
18	12-24v	12v 4A, 24v 2A	**£3.95**	£1.00

HEAVY DUTY OP TRANSFORMERS

Type OT28EL 100 watts. 3.75Ω, 7.5Ω, 15Ω, 1.75K CT, 4 EL34. 2×250 m/a dc max, **£13.86,** pp £1.25. Type OT29EL 50 watts, 3.75Ω, 7.5Ω, 15Ω, 3.5K CT, rated 2×125m/a dc max, **£8.75,** pp £1.

LOW POWER LT TRANSFORMERS CLAMPED OPEN FRAME. TAG CONNECTIONS. ALL PRIMARIES 240V

Type	Sec Taps	Amps	Price	Postage
1	15V twice	200 m/a ea.	**£2.00**	75p
2	6V twice	500m/a ea.	**£2.00**	75p
3	6V twice	4 amps ea.	**£3.95**	£1
4	6-9V twice	1 amp ea.	**£2.75**	75p
5	6V twice	1½ amp ea.	**£2.75**	75p
6	12-0-12V	12VA	**£2.00**	75p
7	15-24-30V	2 amps	**£4.75**	£1
8	28V twice	1.3 amps ea.	**£4.75**	£1
9	15-0-15V	60VA	**£3.75**	£1
10	12V	4 amps	**£4.75**	£1
11	12V	1½ amps	**£2.00**	75p

AUTO STEPDOWN TRANSFORMERS FOR AMERICAN EQUIPMENT 240-110V 80-2250 WATTS

Fully shrouded, fitted with American two or three pin outlet and three core 240V mains lead. Send sae for latest price list. American plugs, sockets, adaptors also available. Open frame types. Tag connections by famous makes, fraction of list price, tapped 240-220-200-120-110-100V, 750 watts, **£12.00** carr £2. 500 watts **£8.25** carr £2. 80 watts 240-110V, wire ended **£3.95** pp £1.

HEAVY DUTY ISOLATION TRANSFORMERS 240-240V OR 240-110V UP TO 15 AMPS

Large selection available, all by famous makers, fraction of list price. Please telephone us for further details.

E.H.T. TRANSFORMERS

CUMBERNAULD Pri. tapped 240-260-285-300-315-330-350-387V Sec. 2500V 0.11A. Open frame terminal board connections, fraction of maker's price **£15** carr £3. PARMEKO potted type Pri. 220-240V Sec. 1875V 60 m/a and 500V 31 m/a **£5.95** carr £2. GRESHAM open type terminal board connections Pri. 240V Sec. 2300V 10 m/a and 6.3V 1.5A **£4.50** carr £1.50.

SPECIAL PURCHASE BY FAMOUS MAKERS L.T. TRANSFORMERS IDEAL FOR UP-TO-DATE POWER SUPPLY CIRCUITS

No 1 GRESHAM Pri. 240v Sec. 43v 3 amps. Fully tropicalised. Open type wire connections **£3.95** pp 75p. No 2 HINCHLEY Pri. 240v Sec. 33v 5 amps and 18-0-18v 1A. Tropicalised open frame. Wire connections. Two in series will give 33-0-33v 5A and 18-0-18v 2A **£3.95** each, pp 75p. No 3 PARMEKO Pri. 240v Sec. 30v 5A and 12v 2.2 amps. Table top connections **£4.95** pp £1. No 4. AEG open type tag board connections Pri. 220-240v Sec. 10v 13.8A and 22.8v 10.5A **£8.50** carr £2. No 5. 'C' core tag board connections Pri. 220-240v Sec. 27v, 9v, 3v, 1v separate windings, 10 amps each **£6** carr £1.50. No 6 Pri. 120-240v Sec. 60-0-60v 10A open type cable lead connections, size 6×6×6in **£19.50** carr £3. No 7 Pri. 220-240v Sec 36v 6A. Open type, tag board connections **£7.50** carr £1.50, two will give 36-0-36v 6 amps **Special offer for two £15** inc carriage.

L.T. TRANSFORMERS NEW SURPLUS FAMOUS MAKERS. FRACTION OF MAKER'S PRICE

Limited number **£4** No 3 Pri. 115-220-240v. Sec. 9v 2A and 9v 1A open type terminal block connections **£2.50** pp £1. No 4 Pri. 230v Sec. 80v 1.1A open typa tag board connections **£3.00** pp £1. No 5 Pri. 120-240v Sec. 13v 3A and 15v 1A open type terminel block connections **£3.00** pp £1. No 6 Pri. 240v Sec. 30v 5.5A and 12v 2.2A open type table top connections **£5.75** carr £1.50. No 7 Pri. 230v sec tapped 24-30-32v 2A potted type **£3.00** pp £1. No 8 Pri. 220-240v. Sec. 6v 1A twice shrouded GPO type **£2.00.**

AEI 20 AMP CONTACTORS BRAND NEW BOXED FRACTION OF MAKER'S PRICE

Type	Coil voltage	Contacts		Price
0652	415vAC	3M	1B	**£1.50**
0655	415vAC	4M		**£1.50**
0648	110vAC	4M	4B	**£1.50**
0650	110vAC	6M	2B	**£1.50**
0653	110vAC	4M		**£1.25**
0654	110vAC	2M	2B	**£1.25**
0651	110vAC	3M	1B	**£1.25**
0649	42vAC	6M	2B	**£1.50**
0647	42vAC	4M	4B	**£1.50**

P&P 25p each

AC WKG BLOCK CAPACITORS BY FAMOUS MANUFACTURERS

MFD	Volts	Price
0.75	440vAC	**50p**
1	470vAC	**60p**
1.25	360vAC	**65p**
2	400vAC	**75p**
2.4	360vAC	**75p**
2.5	360vAC	**75p**
2.7+0.1	700vAC	**£1.25**
3	440vAC	**£1.00**
3.5	250vAC	**£1.00**
4	250vAC	**£1.00**
5	360vAC	**£1.25**
6	440vAC	**£1.50**
7.2	440vAC	**£1.50**
8.4	250vAC	**£1.00**
15	250vAC	**£1.75**

PP up to 2.5 MFD **25p,** 2.7 to 15 MFD **50p** +8% on total.

OIL FILLED PAPER BLOCK CAPACITORS BY FAMOUS MAKERS. UNUSED

MFD	DC volts WKG	Price
8	600v	**£1**
8	400v	**75p**
8	350v	**65p**
8	200v	**50p**
4	600v	**65p**
4	500v	**50p**
2	800v	**65p**
2	600v	**50p**
1	1500v	**75p**
1	1000v	**60p**
1	600v	**50p**
1	350v	**35p**
0.5	1000v	**50p**
0.1	3000v	**50p**
6	300vAC	**£1**

Post 0.1 to 2 MFD 25p. 4 MFD to 8 MFD 50p.

STANDARD OPEN TYPE RELAYS SINGLE HOLE FIXING 7 AMP CONTACTS BY FAMOUS MAKERS

Coil voltage	Contact	Price
240vAC	3 CO	**85p**
240vAC	2 CO	**75p**
240vAC	1 CO	**65p**
110vAC	2 CO	**65p**
48vDC	3 CO	**50p**
24vDC	2 CO	**75p**

P&P 10p per relay. Please add VAT 15% on total

L.T. SMOOTHING CHOKES

By famous makers. "C" core types 10 M/H 25 amps **£8.75** carr £2.50. 14 M/H 6 amps **£3.95** pp £1.25. 4 M/H 12 amps **£3.95** carr £1.50. Swinging 'C' core type, 10 M/H 4A — 100 M/H ½A **£4.50** carr £2. Potted type, 100 M/H 2A **£3.95** carr £1.50. 13 M/H 1A **£1.95** pp 75p. Open types 4.8 M/H 10 amps **£3.95** pp £1.50. 'C' core types, 20 M/H 10A **£4.50** carr £1.50. 50 M/H 2½ amps **£3.75** pp £1. 15 M/H 3½ amps **£3.75** pp £1. Heavy Duty open type 24 M/H 46 amps **£25** carr £4.

H.T. SMOOTHING CHOKES

Potted types, 15H 75M/A **£1.50** pp 75p. 50H 25M/A **£1.50** pp 75p. 10H 75M/A **£1.50** pp 75p. 1H 75M/A **£1.50** pp 75p. 4.5H 280M/A **£3** pp £1. 'C' core 10H 350M/A **£4.50** pp £1.50. 40H 40M/A **£2.25** pp £1.

CRESSALL RHEOSTATS

Built-in ventilated 6 inch metal surround with control knob. 10100Ω 0.15A, 980Ω 0.48A, 3250Ω 0.24A **£3.95** pp £1.25. 3 inch size 9000Ω 0.1A **£2** pp 75p. ZENITH heavy duty fixed wire resistors, enclosed, size 18×5×3½in, 136Ω 1.7A **£3** carr £1.50.

HEAVY DUTY 'C' CORE L.T. TRANSFORMERS BY FAMOUS MAKERS, FRACTION OF LIST PRICE ALL PRIMARIES 220-240V

No 1 12 volts 40 amps cont. **£19.50** carr £3. No 2 14+3+1½V 40 amps cont **£22.50** carr £3. 1½V 3V 4½V 14V 15½V 17V 18½V 40A can be obtained.

HEAVY DUTY L.T. TRANSFORMERS BRAND NEW, FRACTION OF LIST PRICE ALL PRIMARIES 220-240V

Open frame type, Sec. 17+2+1½+1 separate windings, all at 20 amps **£9.50** carr £2. No 2 as above, 10 amp rating **£6.50** carr £1. No 3 65V 2.2A and 30-0-30V 100 m/a **£3.95** pp £1. 'C' core types 12V 10A and 30-0-30V ½A **£5.50** pp £1. 12V 5A and 30-0-30V 250 m/a **£3.75** pp £1. Sec. 18-22-27V 250 m/a twice **£2.75** pp 75p. Sec. 24V 480 m/a twice **£2.75** pp 75p. Sec. tapped 3-9-12-27-30-36V 1.8A **£3.75** pp £1.

H.T. TRANSFORMERS BY FAMOUS MAKERS. ALL PRIMARIES 240V

Type MT33 300-0-300v 150M/A 6.3v ct 4A 5-6.3v 2A **£4.50** pp £1. MT12 Sec. 300-0-300v 120M/A 6.3v ct 4A 5-6.3v 2A **£4.00** pp £1. MT11 Sec. 300-0-300v 100M/A 6.3v 3.5A 5v 2A or 6.3v 1A **£3.75** pp £1. MT7 Sec. 350-0-350v 100M/A 6.3v 3.5A 5v 2A or 6.3v 1A **£4.00** pp £1.

WODEN POTTED TRANSFORMERS

Pri. 230v sec. tapped 40-41-42-48-49-50v, very conservatively rated at 10 amps and 60v 100M/A. Size 9×7×6in **£15** carr £3.

Hundreds of bargains for callers. Huge stocks of high capacity electrolytics. Heat sinks. Ex computer bits.

U.K. RETURN OF POST MAIL ORDER SERVICE, ALSO WORLDWIDE EXPORT SERVICE

BSR DE LUXE AUTOCHANGER

Plays 12", 10" or 7" records, Auto or Manual. A high quality unit backed by BSR reliability. Stereo Ceramic Cartridge. AC 200/250V. Size 13½-11¼in. 3 speeds. Above motor board 3¾in. Below motor board 2½in. with Ceramic Stereo cartridge.

£20 Post £1.60

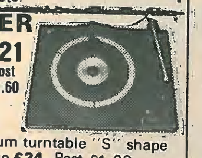
HEAVY METAL PLINTHS ONLY

Cut out for most BSR or Garrard decks. Silver grey finish. Post £1.60
Model "A" Size 14½ x 12½ x 3in. **£3.50**
Model "B" Size 16 x 13¾ x 3in. **£4.50**

TINTED PLASTIC COVERS ONLY
Sizes: 14½ × 12½ × 4¼in. **£3.50** each.
14½ × 12½ × 3in. **£3.50** each.
15¼ × 13½ × 4in. **£4.** 18 × 13¼ × 4in. **£6.**
17¼ × 9½ × 3½in. **£3.** 18 × 12½ × 3in. **£6.**
14½ × 14¾ × 2½in. Rosewood sides **£4.** Post £1.60
Ideal for record decks, tape decks, etc.

BSR SINGLE PLAYER

Ideal replacement or disco deck with cueing device and stereo ceramic cartridge. 3 speeds. Large turntable, modern design **£21** Post £1.60



TWO-SPEED BUDGET MODEL £15.

BSR P182 3 speeds flared aluminium turntable "S" shape arm, cueing device, ceramic cartridge **£24.** Post £1.60
BSR MP60/P128 Stereo Ceramic, balanced arm, cueing device. Bias compensator **£26.** Magnetic **£5** extra.

GARRARD HI-FI AUTO CHANGER Model 2025

3-speed stereo cartridge. **£16.50**
Cueing devices Post £1.60

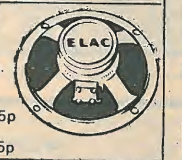
B.S.R. P163 BELT DRIVE QUALITY DECK

Manual or automatic play. Two speeds. Precision balanced arm. Slide in head, cueing device. Bargain price

£30 Post £1.60

Suitable magnetic cartridge **£6.50.**

ELAC HI-FI SPEAKER 8in. TWIN CONE



Large ceramic magnet. 50-16,000 c/s. Bass resonance 40 c/s. 8 ohm impedance.
10 watts. RMS. **£5.95** Post 75p
20 watt woofer bass unit only **£7.95** Post 75p

LOW VOLTAGE POWER PACK for MODELS

Ready made. Famous make. Will supply 10 volts D.C. at 400mA. With terminals and mains lead. **£2.75** Post 50p

POTENTIOMETERS

5kΩ to 2MΩ. LOG or LIN.
L/S **35p.** DP **60p.**
Stereo L/S **85p.** DP **£1**
Edge Pot 5K. SP **45p**

80 Ohm Coax

FRINGE LOW LOSS **15p** yd.
PLUGS **10p.** SOCKETS **10p.**
LINE SOCKETS **25p**
OUTLET BOXES **80p**
300 ohm FEEDER **5p** yd.

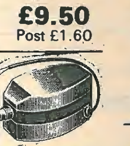
EMI 13½ x 8in. LOUDSPEAKERS

With tweeter and crossover. 10 watt. 3 or 8 ohm. **£9.95** Post 75p
Bass woofer only 8 ohm. 15 watt. **£10.95** Post 75p
Bass woofer only 15 ohm. 20 watt. **£11.95** Post 75p

Suitable Bookshelf Cabinet
Teak finish. For EMI 13 x 8 speakers. Size 16 x 11 x 8 inches approximately. **£9.50** Post £1.60

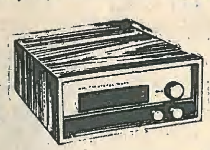
THE "INSTANT" BULK TAPE ERASER

Suitable for cassettes, and all sizes of tape reels. A.C. mains 200/250V. Leaflet S.A.E. Will also demagnetise small tools **£6** Post 50p
Head Demagnetiser only £5.00



RELAYS. 12V DC **95p.** 6V DC **85p.** 240V AC **95p.**
BLANK ALUMINIUM CHASSIS. 6 x 4—**95p;** 8 x 6—**£1.40;** 10 x 7—**£1.55;** 12 x 8—**£1.70;** 14 x 9—**£1.90;** 16 x 6—**£1.85;** 16 x 10—**£2.20. ANGLE ALI.** 6 x ¾ x ¾in—**20p.**
ALUMINIUM PANELS. 6 x 4—**24p;** 8 x 6—**38p;** 14 x 3—**40p;** 10 x 7—**54p;** 12 x 8—**70p;** 12 x 5—**44p;** 16 x 6—**70p;** 14 x 9—**94p;** 12 x 12—**£1;** 16 x 10—**£1.16.**
PLASTIC AND ALI BOXES IN STOCK. MANY SIZES
VARICAP FM TUNER HEAD with circuit & connections. Some technical knowledge required **£4.95.**
TAG STRIP 28-way **12p.**
TAPE OSCILLATOR COIL. Valve type, **35p.**
BRIDGE RECTIFIER 200V PIV ½ amp **50p.** 8 amp **£2.50.**
TOGGLE SWITCHES SP **30p.** DPST **40p.** DPDT **50p.**
MANY OTHER TOGGLES IN STOCK. Please enquire.
PICK-UP CARTRIDGES ACOS, GP91 **£2.00.** GP94 **£2.50.**
SONOTONE 9TAHC Diamond **£3.75.** V100 Magnetic **£6.50.**
WIRE-WOUND RESISTORS 5 watt, 10 watt, 15 watt **15p.**
CASSETTE MOTOR. 6 volt **£1.00.**
CASSETTE MECHANISM. Mono heads, no motor **£3.00.**

MAINS OPERATED SOLID STATE AM/FM STEREO TUNER



200/240V AC Mains. F.M./A.M. Stereo Tuner. Covering M.W., A.M. 540-1605KHz. V.H.F., F.M. 88-108MHz. Ferrite rod aerial for M.W. Full AFC and AGC on A.M. and F.M. Stereo Beacon Indicator. Built-in Pre-amps with variable output adjustable by pre-set control. Max. o/p Voltage 600mV R.M.S. into 20K. Simulated Teak finish cabinet. Will match almost any amplifier. Size 8¼in wide, 4in. high x 9½in. deep approx.
Only **£28** Post £1.60

RCS SOUND TO LIGHT KIT Mk. 2 £18

Kit of parts to build a 3 channel sound to light unit 1,000 watts per channel. Suitable for home or disco. Easy to build. Full instructions supplied. Cabinet **£4.50** extra. Will operate from 200MV to 100 watt signal. Post 50p

RCS "MINOR" 10 watt AMPLIFIER KIT

This kit is suitable for record players, guitars, tape playback, electronic instruments or small PA systems. Two versions available: Mono, **£12.50;** Stereo, **£20.** Post 45p. Specification 10W per channel; input 100mV; size 9½ x 3 x 2in. approx. SAE details. Full instructions supplied. AC mains powered. Input can be modified to suit guitar.

R.C.S. STEREO PRE-AMP KIT. All parts to build this pre-amp. Inputs for high, medium or low imp per channel. With volume control and P.C. Board **£2.95**
Can be ganged to make multi-way stereo mixers Post 35p

MAINS TRANSFORMERS — ALL POST 75p.

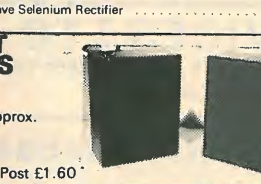
250-0-250V 70mA, 6.5V, 2A	**£3.45**
250-0-250V 80mA, 6.3V 3.5A, 6.3V 1A	**£4.60**
350-0-300V 100mA, 6.3V 3.5 amp	**£5.80**
300-0-300V 120mA, 2×6.3V 2A C.T.; 5V 2A	**£8.50**
220V 45mA, 6.3V 2A	**£2.50**
HEATER TRANSFORMER. 6.3V ½ amp **£2.00** 3 amp	**£2.20**
GENERAL PURPOSE LOW VOLTAGE. Tapped outputs available	
2 amp. 3, 4, 5, 6, 8, 9, 10, 12, 15, 18, 25 and 30V	**£6.00**
1 amp. 6, 8, 10, 12, 16, 18, 20, 24, 30, 36, 40, 48, 60	**£6.00**
2 amp. 6, 8, 10, 12, 16, 18, 20, 24, 30, 36, 40, 48, 60	**£9.50**
3 amp. 6, 8, 10, 12, 16, 18, 20, 24, 30, 36, 40, 48, 60	**£12.50**
5 amp. 6, 8, 10, 12, 16, 18, 20, 24, 30, 36, 40, 48, 60	**£16.00**

12V, 100mA	**£1.30**	20V, 40V, 60V, 1 amp	**£4.00**
12V, 750mA	**£1.75**	12V, 3 amp	**£3.50**
10-0-10V 2amp	**£3.00**	10V, 30V, 40V, 2 amp	**£3.50**
30V, 5 amp and 17V-0-17V, 2 amp	**£4.00**	40V, 2 amp	**£3.50**
		20V, 1 amp	**£3.00**
0, 5, 8, 10, 16V, ½ amp	**£2.50**	20V-0-20V, 1 amp	**£3.50**
9V, 3 amp	**£3.50**	30V-0-30V, 2 amp	**£8.00**
25-0-25V 2 amp	**£4.50**	2 of 18V, 6 amp, each	**£11.00**
30V, 2 amp	**£3.50**	12-0-12V, 2 amp	**£3.50**
30V, 1½ amp	**£3.30**	9V, ¼ amp	**£1.50**

AUTO TRANSFORMERS, 115V to 230V or 230V to 115V 150W **£7.00**
250W ... **£8.00** 400W ... **£9.00** 500W **£10.00**
FULL WAVE BRIDGE CHARGER RECTIFIERS.
6 or 12V outputs, 2 amp.....**75p.** 4 amp.....**£4.25**
CHARGER TRANSFORMERS: 1½ amp.....**£1.60.** 3 amp.....**£4.00**.....4 amp **£6.50**
12V, 1½ amp Half Wave Selenium Rectifier **25p**

COMPACT SPEAKERS

Teak 4 or 8 ohm
White 4 ohm only
13 × 10 × 6in. approx.
50 to 14,000 cps.
10 watts.

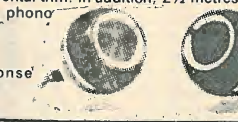


£16 pair Post £1.60

EXTENSION SPEAKERS £3.95 ea.

Globe shaped cases in high gloss mouldings of red or green, are finished with chrome frontal trim. In addition, 2½ metres of twin lead already fitted with phono plug is supplied.

Full Range Quality
Frequency Response
Impedance: 8 ohms
Power Peak: 5 watts



LOW VOLTAGE ELECTROLYTICS
1, 2, 4, 5, 8, 16, 25, 30, 50, 100, 200mF 15V **10p.**
500mF 12V **15p;** 25V **20p;** 50V **30p;** 420mF/500V **£1.30.**
1000mF 12V **17p;** 25V **35p;** 50V **47p;** 100V **70p.**
2000mF 6V **25p;** 25V **42p;** 40V **60p;** 1200mF 76V **80p.**
2500mF 50V **62p;** 3000mF 25V **47p;** 50V **65p.**
4500mF 64V **£2;** 4700mF 63V **£1.20.** 2700mF/76V **£1.**
5000mF 35V **85p.** 5600mF/76V **£1.75.**

HIGH VOLTAGE ELECTROLYTICS

8/350V	**22p**	8+8/450V	**50p**	50+50/300V	**50p**
16/350V	**30p**	8+16/450V	**50p**	32+32/450V	**75p**
32/500V	**75p**	16+16/450V	**50p**	100+100/275V	**65p**
50/500V	**£1.20**	32+32/350V	**50p**	150+200/275V	**70p**

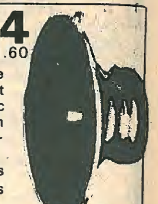
MANY OTHER ELECTROLYTICS IN STOCK

SHORT WAVE 100pf air spaced gangable tuner, **95p.**
TRIMMERS 10pF, 30pF, 50pF, **5p.** 100pF, 150pF, **15p.**
CERAMIC, 1pF to 0.01mF, **5p.** Silver Mica 2 to 5000pF, **5p.**
PAPER 350V-0.1 **7p;** 0.5 **13p;** 1mF 150V **20p;** 2mF 150V **20p;** 500V-0.001 to 0.05 **12p;** 0.1 **15p;** 0.25 **25p;** 0.47 **35p.**
MICRO SWITCH SINGLE POLE CHANGEOVER 20p.
SUB-MIN MICRO SWITCH, 25p. Single pole change over.
TWIN GANG, 385 + 385pF **80p;** 500pF slow motion **75p.** 365 + 365 + 25 + 25pF, Slow motion drive **85p.** 120pF **50p.**
TRANSISTOR TWIN GANG, 50p.
NEON PANEL INDICATORS 250V. Amber or red **30p.**
ILLUMINATED ROCKER SWITCH. single pole. Red **65p.**
RESISTORS. 10Ω to 10M. ¼W, ½W, 1W, 20% **2p;** 2W, **10p.**
HIGH stability. ½W 2% 10 ohms to 1 meg., **12p.**
Ditto 5%. Preferred values 10 ohms to 10 meg., **5p.**

ELECTRO MAGNETIC PENDULUM MECHANISM 95p Post 30p.
1.5V DC operation over 300 hours continuous on SP2 battery, fully adjustable swing and speed. Ideal displays, teaching electro magnetism or metronome, strobe, etc.

BAKER SUPERB 12in 25 watt £24

Post £1.60



Quality loudspeaker, low cone resonance ensures clear reproduction of the deepest bass. Special copper drive and concentric tweeter cone. Full range reproduction with remarkable efficiency in the upper register.
Bass resonance 25 c/s
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'Group 100'	'Disco 100'	'Group 50/15'
12 inch 100 watt 8 or 16 ohm **£29**	12 inch 100 watt 8 or 16 ohm **£29**	15 inch 75 watt 8 or 16 ohm **£35**

BAKER LOUDSPEAKER, 12 INCH. 60 WATT.
GROUP 50/12, 4 OR 8 OR 16 OHM HIGH POWER.
FULL RANGE PROFESSIONAL QUALITY. **£25**
RESPONSE 30-16,000 CPS
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R.C.S. 100 watt VALVE AMPLIFIER CHASSIS

Four inputs. Four way mixing, master volume, treble and bass controls. Suits all speakers. This professional quality amplifier chassis is suitable for all groups, disco, PA, where high quality power is required. 5 speaker outputs. AC mains operated. Slave output socket. Produced by demand for a quality valve amplifier. 100V line output to order £10 extra. Send for leaflet.
Suitable carrying cab **£21** Price **£105** carr. £6.00

GOODMANS TWIN AXIOM 8 inch dual cone loudspeaker. 8 ohm, 15 watt hi-fi unit **£10.50.**
CROSSOVERS. TWO-WAY 3000 c/s 3 or 8 or 15 ohm **£1.90.** 3-way 950 cps/3000 cps, **£2.20.**
LOUDSPEAKERS PM 3 OHM 7x4in. **£1.50;** 6½in., **£1.95;** 8x5in., **£1.90;** 8in., **£2.50.**
SPECIAL OFFER: 80 ohm, 2¼in., 2¾in., **35 ohm,** 3in., **25 ohm,** 2½in., 3in., 5x3in., 7x4in., **8 ohm,** 2½in., 3in., 3½in., 5in., **15 ohm,** 3½in. dia, 6x4in., 7x4in., 5x3in., **3 ohm,** 2½in., 2⅝in., 3½in., 5in. dia. **£1.50 each.**
PHILIPS LOUDSPEAKER, 8in., 4 ohms, 4 watts, **£2.50.**
RICHARD ALLAN TWIN CONE LOUDSPEAKERS
8in. diameter 4W **£2.50.** 10in. diameter 5W **£3.50;** 12in. diameter 6W **£4.50.** 3/8/15 ohms, please state.
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Handles up to 100 watts. No crossover required.
BLACK PLASTIC CONSTRUCTION BOX with brushed aluminium facia. Sturdy job. Size 6¼ x 4¾ x 2in. **£1.50**

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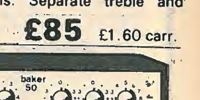
All purpose transistorised. Ideal for Groups, Disco and P.A. 4 inputs speech and music. 4 way mixing. Output 4 8/16 ohms. A.C. Mains. Separate treble and bass controls. Master volume control.
100 volt line model **£99** **£85** £1.60 carr.

BAKER 50 WATT AMPLIFIER



£65 Post £1.60

Superior quality ideal for Halls/PA systems, Disco's and Groups. Two inputs with Mixer Volume Controls. Master Bass, Treble and Gain Controls. 50 watts RMS. Three loudspeaker outlets 4, 8, 16 ohm. AC 240V (120V available). Blue wording on black cabinet.

GOODMANS RUBBER SURROUND BASS WOOFER

Standard 12in. diameter fixing with cut sides 12" x 10". 14.000 Gauss magnet. 20 watts R.M.S. 4 ohm imp. Bass resonance = 30 c.p.s. Frequency response 30-8000 c.p.s.
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Sizes 5" x 4" x 1" **95p.** 6½" x 2" x 2¼" **45p**
JACK PLUGS Mono Plastic 25p; Metal 30p.
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Sockets 3-pin, 5-pin 10p. Free Sockets 3-pin, 5-pin 25p.
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TV CONVERGENCE POTS 15p each.
Values = 5, 7, 10, 20, 50, 100, 200, 250, 470, 2000 ohms.

MONO PRE-AMPLIFIER. Mains operated solid state pre-amplifier unit designed to complement amplifiers without low level phono and tape input stages. This free-standing cabinet incorporates circuitry for automatic R.I.A.A. equalisation on magnetic phono input and N.A.B. equalisation for tape heads. Phono sockets for input and output.

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BECKMAN TURNS COUNTER DIALS

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

Wandel & Gotterman Equipment
Level Meter 0.2-1600KHz
Level Oscillator 0.2-1600KHz
Level Transmitter 0.3-1350KHz
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ADVANCE CONSTANT VOLTAGE TRANSFORMERS
Input 190-260V AC. Output constant 220 Volts. 250W. **£25.** (£2 carriage)

PYE RESISTANCE BOXES
5 decade resistance boxes measuring from 11.11.1 ohm to 0.001 ohm **£20**

LABORATORY OVENS. — Gallenkamp, 3 cu. ft. **£145.** Also Morgan Grundy 1 cu. ft. **£55.**

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AIRMEC Display oscilloscope. 4 beam.
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TELETYPE KSR. One remaining.
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TEKTRONIX 555 scope with plug-ins types CA (2 off), 21, 22
TEKTRONIX 515A Oscilloscope
TEKTRONIX 545 main frames. **£210.** Choice of plug-in units extra
TEKTRONIX 585A oscilloscope with '82' P.I. DC-80MHz

NOTICE. All the pre-owned equipment shown has been carefully tested in our workshop and reconditioned where necessary. It is sold in first-class operational condition and most items carry our three months' guarantee. Calibration and certificates can be arranged at cost. Overseas enquiries welcome. PLEASE ADD 15% VAT TO ALL PRICES.

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*APT 10459/8 12-14V. 5 Amps. **£25.** (+£1 pp).
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*LAMBDA Brand new with book. 5V.4A. (110 AC Input through, so) **ONLY £10.** (+£1 pp).
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All the above power supply units are 230V. AC input (except Lambda type) and are stabilised and regulated and fused. All are fully tested before despatch and guaranteed in first class order throughout. As with all our equipment, there is a money back guarantee.

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AIRMEC 210 3-300MHz. AM/FM.
RADIOMETER AFM/1 3.5-320MHz. AM/FM.
RACAL 409 3-600MHz. AM/FM.

'CENTAUR' INSTRUMENT COOLING FANS

Made by Rotron Holland. These are very high quality, quiet running fans, specially designed for the cooling of all types of electronic equipment. Measures 4.5x4.5x1.5in. 115VAC. 11 Watts. The list price of these is over £10 each. Also 230V. AC available. 15V. **£4.50.** (postage 25p). 230V **£5.**

Finger guards for above — 50p each. Also small type Papst fans as above measuring 8x8x3.8cms. 26 cu. ft/min. 110V only **£4.00** (PP 25p). RS price for all these fans are now around £12.50 each!!!

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SPECIAL OFFER OF BRAND NEW USSR MADE MULTIMETERS

TYPE	U4313	U4315
Sensitivity D.C.	20,000 o.p.v.	20,000 o.p.v.
Sensitivity A.C.	2,000 o.p.v.	2,000 o.p.v.
D.C. Current	60μA-1.5A	50μA-2.5A
A.C. Current	0.6mA-1.5A	0.5mA-2.5A
D.C. Volts	75m V-600V	75mV-1000V
A.C. Volts	15V-600V	1V-1000V
Resistance	1K-1M	300Ω-500kΩ
Capacity	0.5μF	0.5μF
Accuracy	1.5% D.C. 2.5% A.C.	2.5% D.C. 4% A.C.

Price complete with pressed steel carrying case and test leads £10.50 £10.50
Packing and postage £1.50 £1.50

TYPE U4324

D.C. Current:	0.06-0.6-60-600mA-3A
A.C. Current:	0.3-3-30-300mA-3A
D.C. Voltage	0.6-1.2-3-12-30-60-120-600-1200V
A.C. Voltage	3-6-15-60-150-300-600-900V
Resistance:	500Ω-5-50-500kΩ
Accuracy:	D.C. 2.5%. A.C. 4% (of F.S.D.)

PRICE complete with test leads and fibreboard storage case **£9.50** Packing and postage £1.20

TYPE U4323
COMBINED WITH SPOT FREQUENCY OSCILLATOR

Sensitivity	20,000Ω/V
Voltage ranges	2.5-1000V A.C./D.C.
Current ranges	0.05-500mA D.C. only
Resistance	5Ω-1MΩ
Accuracy	5% F.S.D.
Oscillator output	1kHz 50/50 squarewave 465KHz sinewave modulated by 1KHz squarewave

PRICE, in carrying case, complete with leads and manual **£8.00**
Packing and postage £1.00

TYPE U4341
COMBINED MULTIMETER AND TRANSISTOR TESTER

Sensitivity:	16,700Ω/V D.C., 3,300Ω/V A.C.
Current:	0.06-0.6-6-60-600mA D.C., 0.3-3.0-30-300mA A.C.
Voltage:	0.3-1.5-6-30-60-150-300-900V D.C. 1.5-7.5-30-150-300-750V A.C.
Resistance:	2-20-200kΩ-2MΩ
Transistors:	Collector cut-off current 60μA max D.C. current gain 10.350 in two ranges

PRICE, complete with steel carrying case, test lead, battery and instruction manual **£9.50**
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8K ON BOARD MEMORY!
5K RAM, 3K ROM or 4K RAM, 4K ROM (link selectable). Kit supplied with 3K RAM, 3K ROM. System expandable for up to 32K memory.

2 KEYBOARDS!
56 Key alphanumeric keyboard for entering high level language plus 16 key Hex pad for easy entry of machine code.

GRAPHICS!
64 character graphics option — includes transistor symbols! Only £18.20 extra!

MEMORY MAPPED
High resolution VDU circuitry using discrete TTL for extra flexibility. Has its own 2K memory to give 32 lines for 64 characters.

KANSAS CITY
low error rate tape interface.

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Z80 the powerful CPU with 158 instruction, including all 78 of the 8080, controls the MM57109 number cruncher. Functions include +, —, *, /, squares, roots, logs exponentials, trig functions, inverses, etc.
Range 10^{-99} to 9×19^{-99} to 8 figures plus 2 exponent digits.

EFFICIENT OPERATION
Why waste valuable memory on sub routines for numeric processing? The number cruncher handles everything internally!

RESIDENT BASIC
With extended mathematical capability. Only 2K memory used but more powerful than most 8K Basics!

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Resident in EPROM

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Even keyboards and power supply circuitry on the superb quality double-sided plated through-hole PCB.

COMPLETE KIT

Only
£275.00
+ VAT

Cabinet Size 19.0" × 15.7" × 3.3" Television by courtesy of Rumbelows Ltd., price £58.62

POWERTRAN

PSI Comp 80 Z80. Based powerful scientific computer.
Design as published in Wireless World, April-September, 1979.

The kit for this outstandingly practical design by John Adams being published in a series of articles in Wireless World really is complete!

Included in the PSI COMP 80 scientific computer kit is a professionally finished cabinet, fibre-glass double sided, plated-through-hole printed circuit board, 2 keyboards PCB mounted for ease of construction, IC sockets, high reliability metal oxide resistors, power supply using custom designed toroidal transformer, 2K Basic and 1K monitor in EPROMS and, of course, wire, nuts, bolts, etc.

PSI COMP 80 Memory Expansion System

Expansion up to 32K all inside the computer's own cabinet!

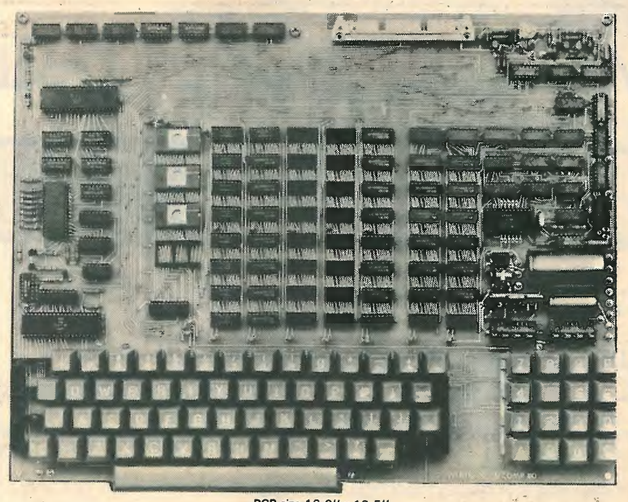
By carefully thought-out engineering a mother board with buffers and its own power supply (powered by the computer's transformer) enables up to 3 8K RAM or 8K ROM boards to be fitted neatly inside the computer cabinet. Connections to the mother board from the main board expansion socket is made via a ribbon cable.

Mother Board: Fibre glass double sided plated through hole P.C.B. 8.7" x 3.0" set of all components including all brackets, fixing parts and ribbon cable with socket to connect to expansion plug **£39.90**

8K Static RAM board Fibre glass double sided plated through hole P.C.B. 5.6" x 4.8" **£12.50**
Set of components including IC sockets, plug and socket but excluding RAMs **£11.20**
2114L RAM (16 required) **£5.00**
Complete set of board, components, 16 RAMS **£89.50**

8K ROM board Fibre glass double sided plated through hole P.C.B. 5.6" x 4.8" **£12.40**
Set of components including IC sockets, plug and socket but excluding ROMs **£10.70**
2708 ROM (8 required) **£8.00**
Complete set of board, components, 8 ROMs **£78.50**

Floppy Disk, PROM programmer and printer interface coming shortly!



PCB size 16.0" x 12.5"

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NRDC-AMBISONIC UHJ

SURROUND SOUND DECODER

The **first ever** kit specialy produced by Integrex for this British NRDC backed surround sound system which is the result of 7 years' research by the Ambisonic team. W.W. July, Aug., '77.
The unit is designed to decode not only UHJ but virtually all other 'quadrophonic' systems (Not CD4), including the new BBC HJ 10 input selections.
The decoder is linear throughout and does not rely on listener fatiguing logic enhancement techniques. Both 2 or 3 input signals and 4 or 6 output signals are provided in this most versatile unit. Complete with mains power supply, wooden cabinet, panel, knobs, etc.

Complete kit, including licence fee **£49.50** + VAT
or ready built and tested **£67.50** + VAT

NEW S5050A STEREO AMP

50 watts rms-channel. 0.015% THD. S/N 90 dB, Mags/n 80 dB.
Output device rating 360w per channel
Tone cancel switch. 2 tape monitor switches.
Metal case—comprehensive heatsinks
Complete kit only **£63.90 + VAT.**

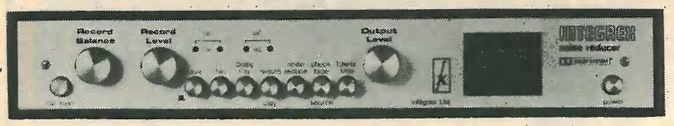
INTRUDER 1 Mk. 2 RADAR ALARM

With Home Office Type approval

The original "Wireless World" published Intruder 1 has been re-designed by Integrex to incorporate several new features, along with improved performance. The kit is even easier to build. The internal audible alarm turns off after approximately 40 seconds and the unit re-arms. 240V ac mains or 12V battery operated. Disguised as a hard-backed book. Detection range up to 45 feet.
Complete kit £49.50 plus VAT.

Wireless World Dolby noise reducer

Trademark of Dolby Laboratories Inc.



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.

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.

Complete Kit **PRICE: £43.90** + VAT

Also available ready built and tested . . . . . **Price £59.40** + VAT

Calibration tapes are available for open-reel use and for cassette (specify which) . . . . . **Price £2.40** VAT

Single channel plug-in Dolby™ PROCESSOR BOARDS (92 x 87mm) with gold plated contacts and all components . . . . . **Price £9.00** + VAT

Please add VAT @ 15%

'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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All kits are carriage free

INTEGREX LTD.

'Please send SAE for complete lists and specifications

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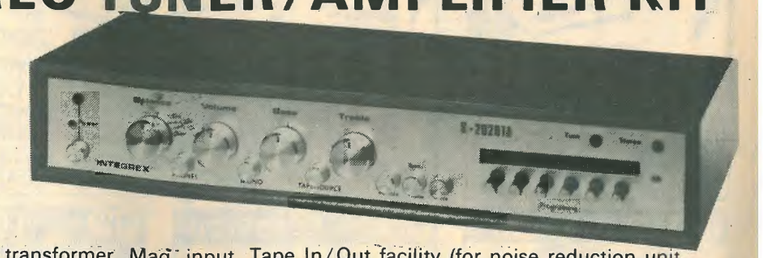
Burton-on-Trent (0283) 215432 Telex 377106**

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: £59.95** + VAT

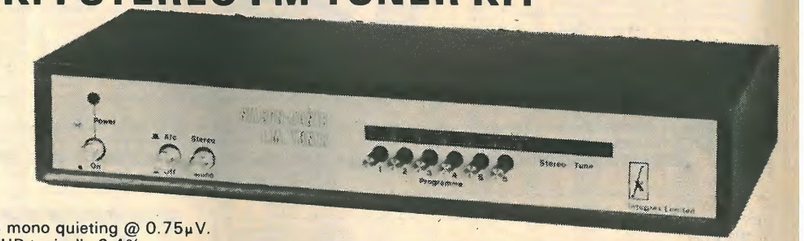
NELSON-JONES MK.2 STEREO FM TUNER KIT

Price: **£69.95** + VAT.

Improved performance with linear phase IF and second generation IC decoder.

NELSON-JONES MK. I 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 £36.40 + VAT
With ICPL Decoder £40.67 + VAT
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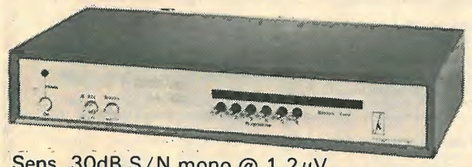

Sens. 30dB S/N mono @ 1.2μV
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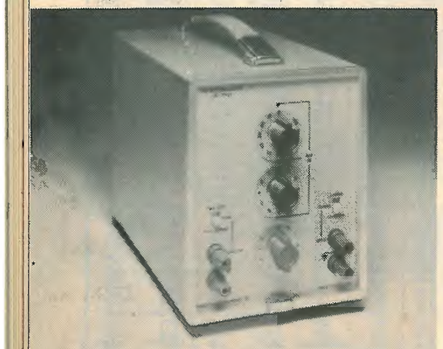

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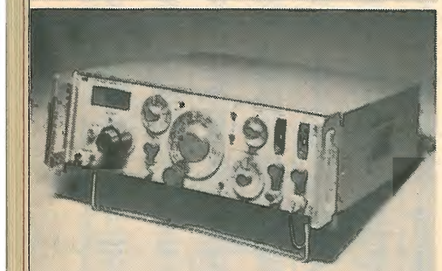

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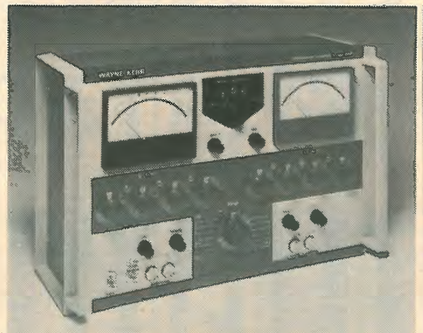

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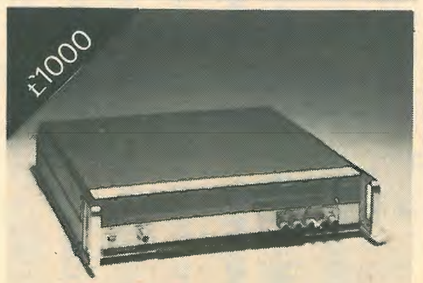

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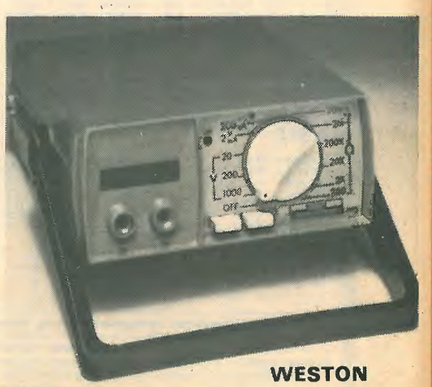

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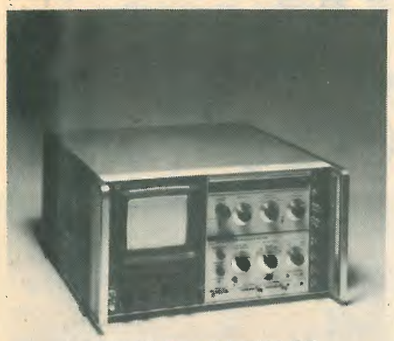

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500KHz-1250MHz

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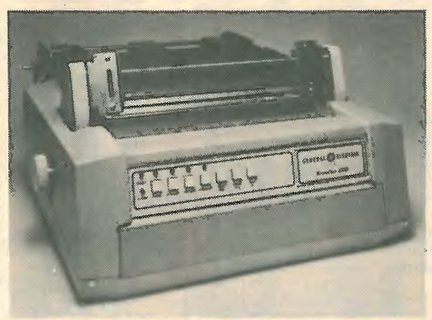

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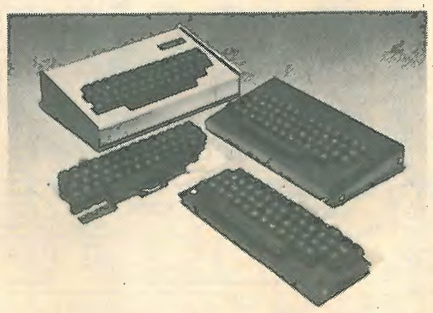

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Model H-1200 (24 lines of 80 characters) **£375**

ICL TERMIPRINTER 7075

TYPEWRITER-QUALITY Keyboard Send/Receive Impact Printer providing full upper and lower case character set, switch-selectable print speeds of 10, 15 and 30cps, 118-column print line with pin-feed platen suitable for paper rolls or continuous stationery (paper width 12.85") Standard V.24 (RS232) interface. **PRICE: £575**

DIGITRONICS PAPER PUNCH TAPE

Solenoid-actuated unit capable of punching 5 to 8 channel tapes asynchronously. Basic punch contains 8 data, 1 sprocket and 2 transport solenoids plus end-of-tape switch. Pulse amplitude 27V DC. Very compact unit measuring only 6½"×8"×5½", weight 9½lbs.
Model P120 (20cps) **£75.** Model P135 (35cps) **£95**

NEW ASC II

		(mail order total)
KB756 56 key-stations mounted on PCB ...	**£49.50**	**£58.65**
KB756MF, as above, fitted with metal mounting frame for extra rigidity	**£55.00**	**£64.98**
Optional Extras		
KB15P Edge Connector	**£3.25**	**£4.31**
KB701 Plastic Enclosure	**£12.50**	**£15.24**
KB702 Steel Enclosure	**£25.00**	**£30.48**
KB710 Numeric Pad	**£8.00**	**£9.78**
KB2376 Spare ROM Encoder	**£12.50**	**£14.95**
DC512 AC-DC Convertor	**£7.50**	**£9.20**

LATEST ADDITION TO THE RANGE
KB771 71 Station keyboard incorporating separate numeric/cursor control pad and installed in custom-built steel enclosure with textured enamel finish. Case dimensions: 17¼"×7½"×3⅜". Total weight: 4kg.
PRICE £95 (mail order total **£115**)
D25S Connector for KB771 ..... **£4.25** **£5.46**
Quantity Discounts available
NEW KEYTOP/KEYSWITCH KITS — ACSII CHARACTER SET.
BRAND NEW SURPLUS
Pack of 58 keytops and keyswitches comprising 49 "Qwerty" set, TTY format + 9 Edit/Function keys.
PRICE £15 (mail order total **£18.98**)

Electronic Brokers

WW—120 FOR FURTHER DETAILS

[illegible]

74182	90p	4000 SERIES		75325	375p
74184A	150p	4000	15p	75361	300p
74185	150p	4001	17p	75363	400p
74186	500p	4002	17p	75365	350p
74188	325p	4006	95p	75451	72p
74190	80p	4007	18p	75491/2	98p
74191	90p	4008	80p	8T26	250p
74192	90p	4009	40p	8T28	300p
74193	90p	4010	50p	8T95	200p
74194	90p	4011	17p	8T97	200p
74195	95p	4012	18p	81LS95	140p
74196	95p	4013	50p	81LS96	140p
74197	60p	4014	84p	81LS97	140p
74198	150p	4015	84p	81LS98	140p
74199	180p	4016	45p	9601	110p
74200	£10	4017	80p	9602	220p
74221	160p	4018	89p	9603	160p

DATA BOOKS

TTLs, CMOs, Linears, Memories, etc, by Mfrs stocked. Please send S.A.E. for details.

BREADBOARDS

EXP350 3.6" x 2.1" (Up to 3 x 14 pin ICs)	£3.15
EXP650 3.6" x 2.4" (Up to 1 x 40 pin IC)	£3.60
EXP300 6" x).1" (Uto 6 x 14 pin ICs)	£5.75
EXP600 6" x 2.4" (Up to 1 x 40 pin DCs)	£6.30

IC TEST CLIPS

14 pin	£2.60	24 pin	£2.90
16 pin	£2.75	40 pin	£2.90

PROTOBOARD (R) SOLDERLESS BREAD-BOARDS

Socket Strips/Bus Strips/Binding Posts mounted on sturdy base plate.

PB6 6 x 14 DIL ICs	£9.20
PB100 10 x 14 DIL ICs	£11.80
PB102 12 x 14 DIL ICs	£22.95
PB103 24 x 14 DIL ICs	£34.45
PB104 32 x 14 DIL ICs	£45.95

(The above boards are suitable for all DIL ICs.)

16 KEY KEYPAD (Reed Switches)	£4.00
UHF Modulators	£3.75
Reed Switches (12VA)	£0.25
LOGIC PROBE	£16.00
MULTIMETERS	
SUPERTESTER 680R	£33.00
MICROTEST 80R	£17.00
TMK500	£22.00
Pocket multimeter	£4.75

COMPUTER KITS

MEMORY MAPPED VDU INTERFACE KIT	£45.00
SERIAL I/P VDU INTERFACE KIT	£56.00
ELF II MICROCOMPUTER KIT	£79.95
ELF II WIRED AND TESTED	£99.95
GIANT MONITOR BOARD KIT FOR ELF II	£35.00
4K STATIC RAM BOARD FOR ELF II	£69.44
ASCII KEYBOARD KIT	£50.58

(Please add 75p p&p to all above items).

We carry a large stock of 74 and 74LS TTLs, CMOS, Linears, Memories, etc. and can normally offer ex-stock deliveries. We welcome inquiries for volume quantities both from local and overseas buyers.

VAT RATE: Please add VAT at 15% on total order value.
Access and Barclaycard accepted
Please send SAE for list

Please add 30p p&p & VAT.
Government, Colleges, etc: Orders accepted.
CALLERS WELCOME — Mon.-Fri. 9.30-5.30 Saturday 10.30-4.30

TECHNOMATIC LTD.

17 Burnley Road, London NW10
(2 minutes Dollis Hill tube station) (ample street parking)
Tel: 01-452 1500 Telex: 922800

25 WATT SPEAKERS. Comprising 8" woofer and 3" tweeter with crossover and terminal connection panel, all mounted in good quality non resonant cabinet. These are extremely good quality units comparable with those selling at twice the price. Cabinet size approx. 20" high, 10¾" wide and 8½" deep, heavy cabinet made of thick blockboard. Price **£22.00** + £3.75 the pair, well worth your coming to collect but if you cannot collect they are still worth this £5.00 extra for carriage.

TWIN PADDED FLEX. 5 amp ideal for some electric irons and appliances that require very flexible lead, 10 metre lengths. Price **£1.00** + 15p. Post 45p.

ROD THERMOSTAT. Suitable for high temperatures up to 550°F. This is adjustable either at the head or remotely by a length of flexible drive. Price **£2.50** + 38p.

DRY FILM LUBRICANT. In aerosol can for easy application and for putting lubricant into places where the normal oil-can cannot reech. Offered at about half the original list price. **50p** + 7p per can (8 oz) or 12 cans for **£4** + 60p post £1.50. The lubricant is I.C.I. Fluon L169.

ASSORTED MICROSWITCHES. 10 different small, medium and large sizes to suit most projects and repair jobs. Price **£1.50** + 22p. If this pack does not contain the one you want give us a ring we may have it.

PUSH SWITCHES. That really stand out, its large dished knob also makes this extra easy to operate, sprung to return to normal when pressure is removed. 10 amp 250 volt changeover contacts. Type 1, 1 c/o **40p** + 60p. Type 2, 2 c/o **60p** + 9p. Type 3, 3 c/o **80p** + 12p.

NEW KIT. Light Tracer and Strobe for disco's or parties. 2 running light patterns and a strobe. Was described with full constructional details in September Everyday Electronics. Our price for complete kit including case **£14** + £2.10.

SPRING LOADED ROCKER SWITCH. Made originally for car dash. This is a simple on/off for up to 10 amps. Price **25p** + 4p.

DP PANEL SWITCH. Arco made. This is a handsome switch, it has a long flat-ended toggle, black and chrome finish. Rated 2 amps at 250 volts and double-pole on/off. Price **10p** + 6p.

5 PUSH BUTTON SWITCH Suitable mains audio or RF. Each switch rated at 250 volts 15 amps. 1st (black push button) closes 2 circuits; 2nd (white push button) operates one changeover; 3rd (white push button) operates one changeover; 4th (white push button) opens one circuit. **Note:** All depressed buttons remain down until cleared by the 5th (red button). **Further note:** It is a relatively easy job to alter the position of the tags, thus making the switches suit your circuit. Fitted with 3 white, 1 red and 1 black button. Price **75p** + 11p.

COMBINATION SWITCH. This comprises 12 miniature changeover micro switches joined in banks of 3 and mounted on frame with four digital numbered thumb wheels and a removable lever for locking the thumb wheel, the thumb wheel operates 3 banks. Over 4,000 combinations are possible, by re-wiring the switch connections underneath thousands more variations are possible. If you are making equipment which should not be switched on accidentally or without authority, then this is a switch to consider. It can be used as a coding switch for many other operations. Very neat and compact, measuring approx. 4"x1¼" and 1½" deep. Price **£1.75** + 26p.

BALANCED ARMATURE INSERTS. 600 ohm impedance, use as either speaker or mike. Price **50p** + 7½p.

PHOTO TRANSISTOR. First class maker, will respond to light or infra-red. 5 for **£1** + 15p, 100 for **£15** + £2.20, 1,000 for **£125** + £18.75.

CONTACT STAT. This is a skeleton thermostat with control knob calibrated 90°F — 190° F. Put it into a box and you have calibrated wall stat or fix its flat base in close contact with the item to be controlled, for instance, bolt it to the casing of an electric motor, heat sink of semi conductor or other device which must not be allowed to overheat or strap it to a water tank etc, etc. The switch will make and break 15 amps at normal mains voltage. Price **£1.50** + 22p.

MEDIUM WAVE PERMABILITY (2 Stage). Made for car radios, could be the basis of a simple radio on medium waves. Basically the tuner comprises an aerial coil and an oscillator coil tuned by moving slugs in and out of the coils. In a simple radio the tuning could be done by thumb on the geared drive wheel which protrudes through the side of the tuner. A TRF circuit tuning the medium wave band should be possible with the minimum of components. Price **75p** + 11p.

POWERFUL REVERSIBLE MOTOR WITH GEARBOX. Final speed 56 rpm. Has a pull of 50lb to the inch, which makes it suitable for opening doors, ventilators etc. Made by Framco. For vks operation and supplied complete with capacitor. Price **£15** + £2.25, carriage £2.

LIMIT SWITCHES. Neat hard polished plastic lever suitable for 230 volts at 10 amps, changeover contacts. Price **50p** + 7½p.

PROJECT BOXES. Neat hard polished plastic boxes with lids now available in four sizes.

1. 76x58x35 mm. Price **75p** + 11p.
2. 96x72x35 mm. Price **88p** + 13p.
3. 115x95x40 mm. Price **£1** + 15p.
4. 210x122x75 mm. Price **£2.30** + 30p.

Note: The lid is held by four screws which thread into brass insets. Altogether these are very well made.

7" TAPE SPOOLS. For reel machines using ¼" tape. Price 5 for **£1** + 15p + 50p post.

24 HR TIME SWITCH. With 2 on/offs 13 amp contacts in neat wall mounting plastic case, the movement is made by Smith's Industries, almost identical to that used in the Smith's Autoset. Setting up is very easy and completely visible behind a clear plastic cover. Ideal for controlling up to 13 amps of water or other heating, or lighting if you wish, carries on switching on and off until re-programmed. Price **£7** + £1.05.

HAVE YOU AN UGLY FIREPLACE? Even if it is not ugly it will look much nicer with our log effect piece. A big purchase enables us to offer these very realistically painted fibre glass mouldings for only **£1** + 15p, but unfortunately these require special packing so we must charge £1 for this, but it would only be £1 regardless of the quantity you order up to ten when they would be post free.

EXPERIMENTERS PRINTERS CIRCUIT KIT. Build 50 interesting projects with components from your junk box. Contents of the kit include, 4 small boards to suit the suggested designs, etching powder, resistant paint, solvent, degreaser and etching instructions. Also 50 circuit diagrams, chassis plans and layouts for simple radio receivers, transmitters, intercoms, amplifiers, instruments, gadgets, etc. You can build at negligible cost with surplus or reclaimed parts and transistors you may already have. Price is **£1.70** + 30p.

LOW PROFILE RELAYS. Polarised for printed circuits with medium-duty changeover contact. Like all "Flatform" (low profile) relays it features a height of less than 11mm, plastic cover for dust protection and pins for direct PC soldering conforming to the international spacing. Provided with 2 coils with 1 common tap, and relay picks up on a brief impulse of 10 msec to one coil and drops out only when another brief impulse is applied to the second coil. It remains in either end position even if supply is cut off. Both coils are operated at the same voltage and can be directly controlled from solid-state circuits. It is ideally suited for logics in industrial controls, like machine tools, etc, no loss of information in case of power failure as with semi-conductor storage elements. excellent overload capability, full galvanic separation are some of the oustanding qualities of this inexpensive storage element. The operation of this relay is based on remanence magnetism and the core made of special material which is carefully selected. Thus, power failures or brief stray impulses do not effect it while at the same time it is nearly vibration and shock-proof. Ref. AZ630-10-3, with 12 volt operating coils, or AZ630-05-1 with 48 volt coil. Price **£1** + 15p each.

CAR BATTERY POWER UNIT. Made for Rank Radio. This unit has been designed to operate 6 volt battery powered equipment from a 12V car battery, it provides a reliable source of stabilized voltage and gives protection to your equipment in case of accidental reversel of connection also against excessive car battery voltage should this occur. The unit is very robust and virtually everlasting if used sensibly. It uses a negative earth circuit but it will operate in a positive earth car providing the instrument being played is hot connected to the car chassis. A real bargain at **£2.50** + 37p.

DELAY SWITCH

Mains operated — delay can be accurately set with pointer knob for periods of up to 2½ hrs. 2 contacts suitable to switch 10 amps — second contact opens few minutes after 1st contact. **£1.25.**

SOUND TO LIGHT KIT. Based on the Everyday Electronics circuit this is a very efficient unit and when made up is in every way equal to professional models costing many times the price. This unit is not tuned to any particular frequency, it is simply dependent upon volume. This is no disadvantage, in fact the effect is very pleasing. It will control up to 750w of lighting and it works well with amplifiers with outputs of 250 watts. The kit complete with leads and plastic case is **£4.25.**

MULLARD UNILEX

A mains operated 4+4 stereo system. Rated one of the finest performers in the stereo field this would make a wonderful gift for almost anyone in easy-to-assemble modular form and complete with a pair of speakers this should sell at about **£30** — but due to a special bulk-buy and as an incentive for you to buy this month we offer the system complete at only **£15** including VAT and postage.

INDUCTION MOTORS

One illustrated is our reference MM11 made for ITT ¾ stack 1½ spindle **£2.26,** ½ stack model **£1.75,** 1 stack **£2.75.** 1½ steck **£3.25.**

MAINS BLOWER

The Torrin — quiet but powerful outlet size 2½ × 1¾ for cooling equipment, etc. will extract if outlet is blowing outwards price **£5.50.**

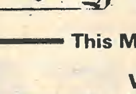
Other models from £2.00.

HUMIDITY SWITCH

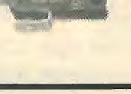
American made by Honeywell. The action of this device depends upon the dampness causing a membrane to stretch and trigger a sensitive micro-switch, quite sensitive — breathing on it for instance will switch it on. Micro 3 amp, at 250V a.c. **£1.15.**

25A ELECTRIC PROGRAMMER

Learn in your sleep. Have radio playing and kettle boiling as you wake — switch on lights to ward off intruders — have a warm house to come home to. All these and many other things you can do if you invest in an electrical programmer. Clock by famous maker with 15 amp on/off switch. Switch-on time can be set anywhere to stay on up to 6 hours independent 60 minute memory jogger. A beautiful unit. **£4.50.**



This Month's Snip



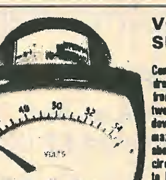
V3 MICROSWITCHES

Very popular and widely used, we have 30,000 in stock in five types (1) 10A 250V change over contacts **25p** each **£15** per 100, **£140** per 1,000. (2) 15A-250V change over contacts **30p** each, **£20** per 100 or **£180** per 1,000. All prices plus V.A.T.

DRILL CONTROLLER

Electronically changes speed from approximately 10 revs to maximum. Full power at all speeds by finger-tip control. Kit includes all parts, case, everything and full instructions. **£3.45**

We can supply this ready to use £2 extra.



VOLTMETER/ SENSITIVITY RELAY

Consists of a large, extremely readable, 4½" square drop through panel volt meter, 0/0-1 fsd. Built into the front of the meter are two screw adjusters which move two separate pointers, one red and one green, up and down the scale, the purpose being to set a minimum and maximum level so that when needle falls below or rises above the preset levels a unique 'under' and 'over' circuit inside the meter operates one of two reed relays to bring an 'under' or 'over' circuit into action. The scale plate is detachable via two screws to be calibrated to your own individual requirements. The 10 transistor 'under' and 'over' circuit is completely separate from the meter movement so does not have to be connected to use this as a standard 0-1 meter. Many uses including lever controls, light controls, auto battery charger, alarm units, etc, etc. Manufacturers list price of our £120 each. An unbelievable snip at £7.75 + 62p p&p 80p. (Less than value of the meter alone.) Circuit diagram included.

TANGENTIAL HEATER UNIT

3KW MODEL **£6.95** + £1.50 P&P

A most efficient and quiet running blower heater by Solatron — same type as is fitted to many famous name heaters — Comprises mains induction motor — long turbo fan — split 2kw heating element and thermostatic safety trip — simply connect to the mains for immediate heat — mount in a simple wooden or metal case or mount direct onto base of say kitchen unit — price **£5.98** post £1.50, control switch to give 2kw. 1kw cold blower or off available **60p** extra.

MOTORISED DISCO SWITCH

with 10 amp changeover switches, multi adjustable. Switches are rated at 10 amps each so a total of 200w can be controlled and this would provide a magnificent display. The motors are 50V but they are of such low wattage only 2 watts that they can be driven by a resistor or condenser, voltage dropper, 8 switch model **£5.25.** 10 switch model **£5.75.** 12 switch model **£6.75.**

TERMS: Send post as stated plus orders under £6.00 please add 50p to offset packing etc. Bulk enquiries please phone for generous discount 01-688 1833.

Access and Barclaycard welcomed

J. BULL (ELECTRICAL) LTD.
(Dept. WW)
103 TAMWORTH ROAD
WEST CROYDON, SURREY
Tel: 01-688 1833

IT'S FREE!

Our monthly Advance Advertising Bargains List gives details of bargains arriving or just arrived — often bargains which sell out before our advertisement can appear — It's an interesting list and it's free — just send S.A.E. Below are a few of the Bargains still available from Sept. List.

SPECIAL NOTES: The "+" sign after the amount shows the amount of V.A.T. The postage is based upon the amount the article costs to send if the same article forms part of a larger parcel. Would your order be less than £6 however, you must send an additional 50p to offset packing and other expenses.

IMPORTANT NOTES.

2. In some advertisements the Delta siren/bleeper was specified as suitable for AC only, it will, however, work from 6-12 volts DC or 12-24 volts AC.

12V SUBMERSIBLE PUMP. Just join it to your car battery, drop it into the liquid to be moved and up it comes, no messing about, no priming etc. Suitable for water, paraffin and any non explosive, non corrosive liquid. One use if you are a camper, make yourself a shower. Price **£6** + 90p. A free gift, first 100 purchasers will get tap with built in switch and length of plastic tubing.

PRECISION RESISTORS. A fortunate purchase enables us to offer almost a complete range of Mullard metal film precision resistors, 1% tolerance. Values start at 5r and go right through to 976k. Most values are available in ½ watt and ¼ watt rating. Price **25p** + 3½p each in small quantities, or **20p** + 3p each where supplied not less than 10 of a value, **15p** + 2½p each not less than 100 of a value.

THIS MONTH'S ELECTRICAL SNIP. Parcel of M.E.M. White flush 13 amp sockets, switches etc. Total retail value over £56 + VAT for only **£28** + £4.20. You get 10 double 13 amp sockets and 6 single 13 amp S. sockets with neons, 14 power (20 amp dpt switches and spurs some with neons), 20 single ganged one way, two way and intermediate switches, and super free gift (worth £3). If not collecting please add £2.

M.E.M. WHITE FLUSH SOCKETS ETC. We have picked out the popular items for the snip parcel described above but a list of other parts available is as follows (makers lists nos) 220, 224, 240, 242, 244, 711, 712, 813, 1000, 1005, 1010, 1011, 1020, 1021, 1022, 1024, 1025, 1033, 1400, 1400WH, 1401WH, 1402, 1402WH, 1403, 1403WH, 1404, 1404WH, 1405, 1405WH, 1407, 2025, 7092. Electricians and Contractors using these accessories should send for our M.E.M. Electrical List where prices and quantity discounts will be quoted.

VARI-CAP TV PUSH BUTTON TUNER. W. German make but fitted to several popular colour TVs, makers ref no 2357 0076. This has 6 push buttons, each of which is in effect a multi turn pot. Total resistance is 15k. The buttons are black with chrome metal tops. Price **£1** + 15p, post 25p. Good quantity available at usual discount rates.

MULTI TURN POT WITH KNOB. 100k 1in, 20 turn used in many TV receivers, makers ref. 7802 412-00051. Suitable for fine control of resistance in general circuitry. Price **40p** + 6p.

TV DIPLEXER. On plastic moulding size 2¼"×1¾". We are able to offer these at such a low price that they can be used as TV aerial sockets only. Price 10 for **£1** + 15p.

TRANSDUCERS. As used remote control TV receivers. Price **£1.50** + 22p.

BURGLAR ALARM. Mains operated new circuit available, this is simple to install and trouble free. Price list and diagram free on request.

ARMY 46 SETS. As made for and used in the Second World War, we have a few of these in mint condition, complete with carrying satchels, headphones, throat mikes and instruction cards. In unopened boxes. Price **£30** + £4.50, post £2.

MUSIC CENTRE COVER. Size 20"×13¾"×4". Clear plastic **£3.50** + 52p, carriage and special packing £2.

25 AMP DC METERS. Flush panel mounting, wide angle, extra long, 320° scale made for GPO. Really beautiful instrument, brand new in original cartons. Limited quantity only so no discounts. Price **£8** + £1.20. (Less than half maker's price).

BIG BLOWER. Driven by 1/10 HP mains motor but compact and quiet running. This is ideal for air conditioning, fume extraction, pressurizing and many other applications. Overall size 10½"×10½" dia. outlet size 10½"×4⅜". Price **£15** + £2.25, carriage £3. Note this is the largest of our 'Snail' shaped blowers, we have smaller ones right down to 10 watt motors with outlets as small as 2"×2" in fact we can cover almost any application and welcome your enquiries. Prices are from **£3** complete with motor.

DOLLS HOUSE SWITCH. Time is fast approaching when you may be thinking of making toys. Small surface mounting switches are often a problem and this is why we are now offering this plastic bodied rotary switch suitable for low voltage applications. Price 10 for **£1.50** + 22p.

CASSETTE STORAGE CASE. With dust cover, holds 5 cassettes and comes complete with clip for joining to another, so you can make up in lengths to suit yourself. Price **50p** + 7½p + 50p post or ten for **£4** + 60p post £1.50.

TELEPHONE ANSWERING MACHINES. Grade 2 machines are in stock ready for immediate despatch or collection, (if coming specially to collect please telephone first). For the benefit of new readers we supply these machines on the understanding they are broken up or at least not used for their original purpose. The machines are secondhand but so far as we can see they are complete and quite possibly in good working order. We do not test them but guarantee to replace any part of the machine should it be missing or faulty, providing we are notified within 7 days of receipt. Prices for the machines are as follows: Grade 2, that is in very good condition, **£15.50** + £2.25, and Grade 1 which are top grade machines and are our very best almost perfect **£20** + £3 each, but there is likely to be one month's wait. To these prices must be added £2.50 to cover carriage.

MAINS POWER PLUG IN PLASTIC CASE. For telephone answering machines. Price **£4.50** + 63p. Post 50p.

POT CORES. We now have good stocks of Ferrite pot cores. These are ex unused equipment and contain the bobbin and have been opened ready to use.

	Diameter	Thickness	Price	
FX 2243	4.5 cm	3.0 cm	75p + 12p	Per pair
FX 2242	3.5 cm	2.3 cm	60p + 9p	
FX 2240	2.5 cm	1.6 cm	50p + 7p	

COMPONENT BOARD 421. Again from unused equipment, major items on these are two power silicon transistors, Motor Rola ref. SJ 5433 mounted on a heat sink with mica insulators, also behind the panel are two power rectifiers ST NS 100B. Price **90p** + 6p.

HEAVY DUTY 3 CORE APPLIANCES LEAD. 15 amp wire 6ft. long, conventional yellow green, brown and blue cores, grey pvc outer, prepared ends, this flex normally sells at 30p per metre. 10 leads for **£2.50** + 40p. Post £1.50.

LOUDSPEAKER GRILL. Good quality rigid plastic, ideal for use in car or home extension speakers. Two sizes available 12"x12", price **75p** + 13p, 18"x18" **£1.50** + 23p.

6 DIGIT COUNTER — RESETTABLE. Coil voltage 48 DC or 115V AC, current 100mA approx. Price **£1.95** + 30p.

10 DIGIT SWITCH PAD. Made we believe for GPO push button telephones, each button operates 2 pole switch which returns automatically, panel size 2½"x3½"x1½", push buttons with clear plastic protected digits 0-9, price **£1.95** + 30p.

MAINS BLOWER. Real bargain this month is a blower made by Smiths, the mains motor is let right into the turbulator and takes up the minimum of space. Overall size of the blower is 7" dia. x 2¼" and the air outlet 1¾"x2¾". Price only **£2.50** + 33p + p&p 50p.

DIAL INDICATOR. As used in tool making and other precision measuring operations, the famous John Bell accurately shows differences of .01mm. A beautifully made precision instrument, price in most tool shops would be £12-£15. Price **£8.00** + £1.20.

WATERPROOF SWITCH. Ideal for greenhouse or outdoor, plastic body. Price **60p** + 9p.

CAR SPEAKER. Elliptical size 7½"x5", 4 ohm. Price **£1.50** + 12p, post 20p + 2p.

7 SEGMENT DIGITAL DISPLAY. TIL 302, led, com. anode — character size 4" approx. Price **£1.15** + 16p.

USEFUL BREAKDOWN UNIT. We do not normally offer second hand equipment for breaking down but this particular item contains so many useful pieces that we have decided to break our rule. The unit is in fact a pocket "bleeper" in a most useful case, size about 2¼" wide by ¾" thick by 5½" deep, ideal size to fit into the top jacket pocket. Case comes apart by undoing two screws, inside is printed circuit board upon which are mounted a miniature loud speaker, three rechargeable nicads diec type 150 — 4 ferrite potted coils, three of which are tunable, 4" ferrite rod. Mercury tilt switch and when case is upright, 4 electrolytic condensors, one micro switch, 8 transistors all with usable length leads, 4 polystyrene capacitors, 2 pin plug for charging batteries without uncasing and approximately 4 diodes and approximately 30 various capacitors and resistors, most of the resistors being ⅛ watt type, truly a very useful unit although secondhand, still in reasonable condition. Price **£1.50** + 22p.

VALVES

Minimum Order £1.00 — VALVES VAT IS INCLUDED

	£										
A1065	1.40	EL82	0.70	PY81/800	0.70	5R4GY	1.30	6L6GT	1.75	25L6GT	0.95
A2293	8.50	EL84	0.90	PY82	0.60	5U4G	1.10	6L7G	0.75	25Z4G	0.85
A2900	8.00	EL86	1.05	PY83	0.60	5V4G	0.80	6L18	0.70	30C15	1.15
AR8	0.70	EL90	1.50	PY88	0.80	5Y3GT	0.80	6LD20		30C17	1.35
ARP3	0.70	EL91	3.25	PY500	1.55	5Z3	1.15	6Q7G	0.95	30C18	2.10
ATP4	0.60	EL95	0.80	PY809	6.45	5Z4G	0.85	6SA7	0.65	(See PCF805)	
B12H	3.35	EL504	1.85	PY801	0.70	5Z4GT	0.90	6SG7	0.90	30F5	1.15
CY31	1.20	EL802	1.70	QQV03/10		6AB7	0.70	6SJ7	0.80	30F12	1.70
DAF96	0.70	EL822	7.50		2.85	6AC7	0.70	6SJ7GT	0.60	30FL12	1.45
DET22	21.95	EM31	0.85	QQV03/12		6AH6	1.15	6SK7	1.05	30FL14	2.05
DF96	0.70	EM80	0.70		2.85	AK5	0.65	6SL7GT	0.85	30L15	1.15
DK96	1.05	EM81	0.70	QQV06/40A		6AK8	0.60	6SN7GT	0.85	30L17	1.15
DH76	1.00	EM84	0.60		16.10	AL5	0.50	6SQ7	0.85	30P12	1.15
DL92	0.60	EM87	1.15	QV03-12	2.80	6AL5W	0.80	6V6GT	0.95	30PL1	1.15
DY86/87	0.65	EY51	0.55	SCL/400	4.50	6AM5	1.85	6X4	0.70	30PL13	1.25
DY802	0.65	EY81	0.55	SCL/600	4.50	6AM6	0.75	6X5GT	0.85	30PL14	1.25
E55L	13.80	EY86/87	0.65	SP61	0.95	6AN8	3.60	6Y6G	1.10	35L6GT	1.15
E88CC/01	1.60	EY88	0.65	TT21	11.80	6AQ5	0.90	6Z4	0.75	35W4	0.80
E180CC	1.60	EZ80	0.55	U25	1.15	6AQ5W	1.45	6-30L2	2.05	35Z4GT	0.85
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E182CC	3.95	GY501	1.05	U27	1.15	6AT6	0.85	7V4	0.90	50CD6G	1.45
EA76	2.25	GZ32	0.75	U191	0.85	6AU6	0.65	9D2	0.70	75	1.25
EABC80	0.60	GZ33	3.95	U281	0.65	6AV6	0.60	9D6	0.85	75C1	1.05
EB91	0.65	GZ34	2.30	U301	0.65	6AX4GT	0.95	10C2	0.70	76	0.95
EBC33	1.15	GZ37	2.80	U600	11.50	6AX5GT	1.15	10F18	0.70	78	0.95
EBF80	0.60	KT66	5.75	U801	3.80	6B7	0.85	10P13	0.70	80	0.90
EBF83	0.60	KT88	7.20	UABC80	0.90	6BA6	0.50	11E2	12.40	85A2	2.55
EBF89	0.80	MH4	1.15	UAF42	0.85	6BE6	0.60	12A6	0.70	723A/B	12.80
EC52	0.50	ML6	1.15	UBF80	0.70	6BG6G	1.15	12AT6	0.55	803	6.95
ECC81	0.65	N78	10.45	UBF89	0.60	6BJ6	1.25	12AT7	0.65	805	20.70
ECC82	0.60	OA2	0.85	UBL1	1.15	6BQ7A	0.70	12AU7	0.60	807	1.15
ECC83	0.65	OB2	0.70	UBL21	2.50	6BR7	2.70	12AV6	0.80	813	13.30
ECC84	0.55	PABC80	0.60	UCC84	0.75	6BW6	3.20	12AX7	0.85	829B	16.00
ECC85	0.60	PC85	0.60	UCC85	0.80	6BW7	1.15	12BA6	0.80	832A	5.20
ECC86	1.40	PC86	0.95	UCF80	0.90	6C4	0.70	12BE6	1.25	866A	3.20
ECC88	0.75	PC88	0.85	UCH81	0.70	6C6	0.70	12BH7	1.10	931A	6.90
ECC189	0.95	PC900	1.45	UCL82	0.85	6CH6	7.50	12C8	0.85	954	0.60
ECF80	0.60	PCC84	0.75	UF41	0.90	6CL6	1.70	12E1	4.95	955	0.70
ECF82	0.55	PCC89	0.65	UF80	0.60	6CY5	1.15	12J5GT	0.55	956	0.60
ECF801	0.90	PCC189	0.75	UF85	0.70	6D6	0.85	12K7GT	0.70	957	1.05
ECH34	1.15	PCF80	0.95	UL41	0.85	6EA8	3.20	12K8GT	0.80	1625	1.15
ECH35	1.70	PCF82	0.50	UL84	0.85	6F6GB	0.85	12Q7GT	0.65	1629	0.85
ECH42	0.95	PCF84	0.75	UM80	0.70	6F8G	0.85	12SC7	0.65	2051	1.20
ECH81	0.60	PCF86	0.80	UM84	0.70	6F12	0.90	12SH7	0.85	5763	4.40
ECH84	1.20	PCF200	1.05	UY82	0.65	6F14	0.90	12SJ7	0.85	5842	7.50
ECL80	0.70	PCF201	1.05	UY85	0.60	6F15	1.30	12SQ7	0.85	5933	3.50
ECL82	0.65	PCF801	1.05	VR105/30	2.15	6F17	1.15	12Y4	0.55	6057	1.05
ECL83	1.40	PCF802	0.75	VR150/30	1.45	6F24	4.75	13D6	0.70	6060	1.05
ECL85	0.75	PCF805	2.10	X66	1.05	6F33	4.75	14S7	1.15	6064	1.05
ECL86	0.75	PCF806	0.95	X61M	1.70	6H6	1.90	19AQ5	0.90	6065	1.40
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EF80	0.50	PCL84	0.80	1L4	0.50	6J7	0.90	20F2	0.75	6360	2.30
EF83	1.70	PCL86	0.80	1R5	0.65	6J7G	0.60	20E1	1.30		
EF85	0.55	PCL805/85		1S4	0.45	6K7	0.80	20P1	0.85		
EF86	1.40		0.85	1S5	0.45	6K7G	0.50	20P3	0.80		
EF91	1.30	PD500	4.35	1T4	0.45	6K8GT	0.65	20P4	1.30		
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Harmonic Distortion	Better than	0.03% Ref 1KHz
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70	6	3	**6.99**	1.10
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72	10	5	**8.93**	1.31
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226	60	30	**40.41**	OA

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103	1.0	**5.03**	1.10
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105	3.0	**9.15**	1.52
106	4.0	**12.55**	1.73
107	6.0	**16.57**	1.89
118	8.0	**22.29**	2.39
119	10.0	**27.48**	OA
109	12.0	**31.79**	OA

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20	3.0	**6.82**	1.31
21	4.0	**8.79**	1.31
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117	6.0	**12.29**	1.67
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Ref.	Amps	£	P&P
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126	1.0	**6.50**	1.10
127	2.0	**8.36**	1.31
125	3.0	**12.10**	1.39
123	4.0	**13.77**	2.12
40	5.0	**17.42**	1.89
120	6.0	**19.87**	2.12
121	8.0	**28.12**	OA
122	10.0	**32.55**	OA
189	12.0	**37.47**	OA

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Ref.	mA	Volts	£	P&P
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212	1A, 1A	0-6, 0-6	**3.14**	.90
13	100	9-0-9	**2.35**	.44
235	330, 330	0-9, 0-9	**2.19**	.44
207	500, 500	0-8-9, 0-8-9	**3.05**	.85
208	1A, 1A	0-8-9, 0-8-9	**3.88**	.90
236	200, 200	0-15, 0-15	**2.19**	.44
239	50MA	12-0-12	**2.83**	.37
214	300, 300	0-20, 2-20	**3.08**	.90
221	700 (DC)	20-12-0-12-20	**3.75**	.90
206	1A, 1A	0-15-20, 0-15-20	**5.09**	1.10
203	500, 500	0-15-27, 0-15-27	**4.39**	1.10
204	1A, 1A	0-15-27, 0-15-27	**6.64**	1.10

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1000	250	**45.94**	OA

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64	75	0-115-210-240V	**4.41**	1.10
4	150	0-115-200-220-240V	**5.89**	1.10
67	500	" "	**12.09**	1.91
84	1000	" "	**20.64**	2.39
93	1500	" "	**25.61**	OA
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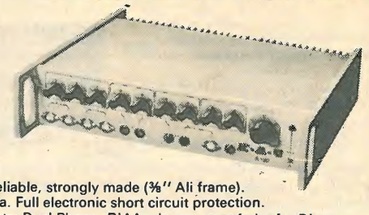

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WW7

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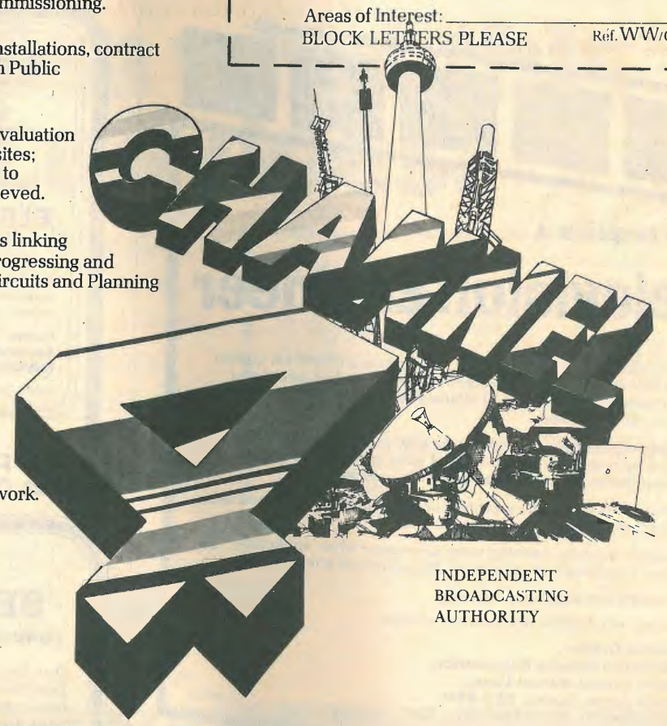

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Department of Psychology

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(9738)

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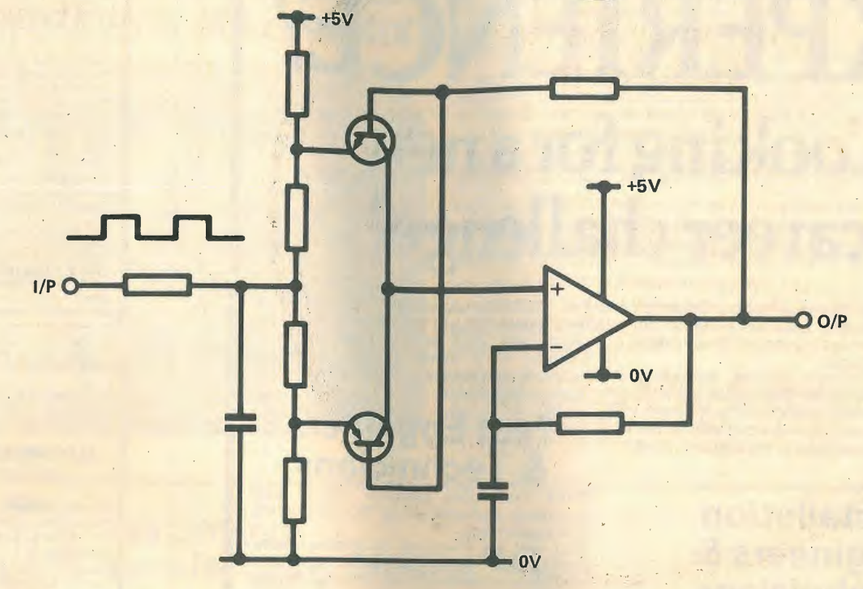


any idea what this circuit does?

Either way, if you're interested, we'd like you to contact us. We'll send you by return, a package of information to study at your leisure, which will tell you about us, and how you can develop your career with us.

We have vacancies for:
Computer Peripheral Circuit Designers,
Switched Mode Power Supply Designers,
Analogue Test Gear Designers.

Open to male and female applicants.

Send to:
FERRANTI COMPUTER SYSTEMS LIMITED,
PERSONNEL DEPARTMENT,
WESTERN ROAD, BRACKNELL, RG12 1RA

B/42/WW MAIL OPPORTUNITIES PACKAGE 'C' TO:

.....

.....

.....

(9751)

FERRANTI
Computer Systems

ELECTRONICS EXPERIENCE?

Looking for a new career challenge?

Join Marconi Communication Systems and you could find yourself working on some of the most advanced electronics equipment around.

We currently require additional Installation and Test Engineers and Technicians, to work on radio communications, sound and TV broadcasting equipment and systems.

Installation Engineers & Technicians

These positions offer the challenge and variety of work abroad. We have a continuing requirement for Engineers and Technicians to work on a wide variety of projects, but at the moment we specifically want people to work on overseas contracts for TV and sound broadcasting transmitters and broad band microwave systems.

You could be spending anything from a few weeks to six months abroad, on permanent staff status, working as a member of a team enjoying excellent overseas allowances. A current driving licence is essential.

Test Engineers & Technicians

Work on highly complex digital and analogue systems, using the very latest test equipment.
You will be involved in testing, fault-finding and rectification at all stages of production through to testing entire systems prior to commissioning. Your work can lead to the ironing out of manufacturing faults and the initiation of design changes.
Applicants for all posts should have several years' experience, in the maintenance and repair of electronic equipment, and be qualified to City & Guilds final, Full Tech. Cert., HND, HNC, a Degree in an Electronics discipline or H.M. Forces equivalent.
To find out more about the work, conditions, salaries and benefits, contact Roy Humphries without delay, either by telephone on Chelmsford (0245) 353221, or by writing to him at Marconi Communication Systems Limited, New Street, Chelmsford, Essex.

(9734)

MARCONI COMMUNICATION SYSTEMS
A GEC-Marconi Electronics Company

UNIVERSITY OF SHEFFIELD

RESEARCH TECHNICIAN (GRADE 5)

A vacancy exists for a research technician for an initial period of 3 years for duties associated with the activities of the Space Physics Group within the Department of Physics. The work will cover a wide variety of interesting and challenging tasks related to studies of very low frequency radio waves. The group has an interest in the British Antarctic Survey's base at Halley Bay and part of the duties will be concerned with the preparation of equipment for use there and the analysis of data obtained from it in which microprocessors are playing an increasing part. Qualifications or experience should be of H.N.C. or equivalent standard, a current full driving licence is required and duties may include some travel both within the U.K. and Europe for periods of up to several weeks.
Salary on scale £3700-£4320 p.a.
Please write to the Administrative Officer (Personnel) (Ref. S1372/WW), the University, Sheffield, S10 2TN. (9774).

Applications are invited from experienced

ELECTRONIC ENGINEERS
(graduates or equivalent)

to participate in development and research projects within the Department of Physiotherapy, primarily in measurement of muscle function. Ongoing activities in which he/she would be expected to play a role including development of a chair to measure isokinetic work, and general duties in connection with these projects. A knowledge of torque and velocity transducers would be an advantage.

The salary range for this appointment is on the Technical Officer scale and is dependent on experience.

Applications should be made to Mr G. Smith, Assistant Personnel Officer, Hammersmith Hospital, Du Cane Road, London W12 0HS. (9766)

Electronic Test Engineers

TO £4800 p/a

We manufacture and market audio noise reduction equipment which is used by major recording companies, recording studios and broadcasting authorities throughout the world and have enjoyed successful growth since incorporation in 1968.

The increased demand for our equipment in the recording and cinema industries has necessitated the recruitment of experienced test engineers.

If you have practical knowledge and experience of electronic testing, think you can test, calibrate and troubleshoot our sophisticated equipment and enjoy the challenge of quality and delivery pressures telephone Tony Hill 01-720 1111.

Dolby

Dolby Laboratories Inc
346 Clapham Road
London SW9 9AP
Telephone 01-720 1111

(9372)

UNIVERSITY OF SURREY
DEPARTMENT OF MUSIC

TECHNICIAN GRADE IA

A vacancy exists for a technician to assist in the routine maintenance and alignment of sound recording equipment in the Music Studio and Mobile Recording Vehicle, checking of microphones, loudspeakers, tape machines and record players, building of electronic processing units and helping staff and students with music recordings and demonstrations.

On-the-job and day release training will be given in all relevant subjects, including electronic and acoustic testing, electronic wiring, microphone procedures and subjective evaluation of the quality of recordings.

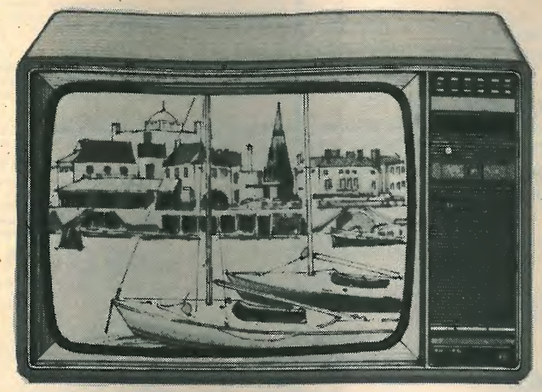
A basic knowledge of electronic and workshop practices and an interest in music or sound recording is desirable.

Salary on a scale £2,547-£2,723 (under review) according to experience.

Application forms for this post must be submitted to the Staff Officer, Senate House, University of Surrey, Guildford, Surrey GU2 5XH, or telephone Guildford 71281 ext. 452 for further details and application forms.

Test Systems Engineers

Your prospects will take on a new outlook at Lowestoft



Lowestoft: a pleasant seaside town of some character, with a busy fishing quarter and narrow lanes running down to the beach. Close to the extensive leisure and recreational facilities offered by Oulton Broad, and the Suffolk Wild Life and Country Park, with housing offering really excellent value for money.

So might run the guide book entry, but for skilled test engineers, Lowestoft offers even more than that — it is also the location of the Manufacturing Division of Pye Ltd., a member of the international Philips Video Group.

We're currently looking for additional men and women with a sound knowledge of television systems and measurement techniques to join a team involved in the design and construction of specialist test equipment for use within the production facility. The work is extremely varied, covering monochrome and colour receivers, teletext and viewdata systems, and remote control units for the UK and European markets.

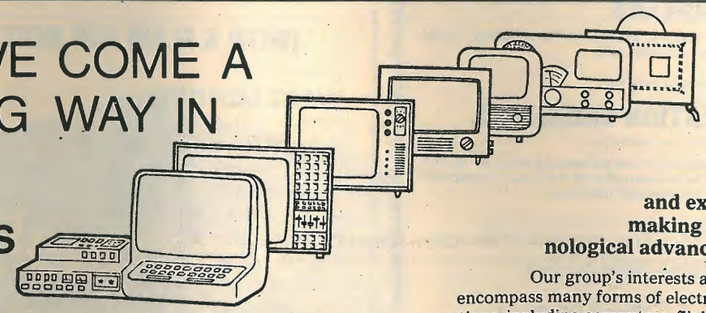
As well as the splendid location, these positions offer attractive salaries and a first-class range of benefits including removal expenses where appropriate.

If you're qualified to degree level or equivalent and are looking for a new way of life, contact Richard McMullan, Staff Personnel Officer, Pye Ltd., Manufacturing Division, Oulton Broad, Lowestoft. (0502) 62222.

(8923)

PYE **Pye Limited Manufacturing Division** PHILIPS

WE'VE COME A LONG WAY IN 50 YEARS



and expect to continue making significant technological advances in the next 50

Our group's interests are wide ranging, and encompass many forms of electronics and communications, including computers, flight simulators, marine radio, satellite navigation and all aspects of television from receiver design and manufacture to cable systems and the supply of complete TV studios and outside broadcast vehicles.

Our Post Design Service on TV receivers offers technical assistance to our factories and rental companies throughout the UK, aimed at securing the best return on the huge investment in over 1 million operational television receivers. We require additional engineers for this important section, who are able to tackle a wide variety of re-design projects working very much autonomously and seeing their projects through to completion.

Formal qualifications in electronic engineering would be an asset, but most importantly we are looking for men and women with sound technical experience in some of the following areas: — colour and monochrome receiver re-design, detailed circuit fault investigation, safety investigations and approvals to BS415, component evaluations and receiver quality assurance and evaluation.

Career opportunities within this large and successful group are excellent, offering you the possibility of eventually designing a new generation of colour TVs or entering an allied field. You can expect an attractive salary, in line with your experience, together with generous benefits and relocation assistance to the Chessington area of Surrey, ideally situated for both London and the South Coast.

For further information please write or telephone:—

REDIFFUSION

Mr J. Sinclair,
Rediffusion Consumer Electronics Limited,
Fullers Way Sth., Chessington, Surrey KT9 1HJ
Telephone No. 01-397 5411

(9789)

Test Development Engineer

Our Test Projects Section has an opening for a Test Development E .ıeer. In this job he/she will be developing practical production test methods .r our broad range of integrated circuits.

The work covers evaluating test methods with the designers and producing test hardware and software, through to the production of efficient test facilities for use on sophisticated computer-controlled test equipment. This requires interfacing with the production, QA and circuit design functions of our business and thus offers a unique opportunity for those who wish to broaden their knowledge of electronics.

Applicants must have a minimum qualification of HNC plus a practical engineering background.

Write or phone for an application form to Shirley Cave, Resourcing Officer, Plessey Semiconductors Limited, Cheney Manor, Swindon, Wilts. SN2 2QW. Tel: Swindon 36251.

PLESSEY

(9781)

CHELSEA COLLEGE
University of London

ELECTRONICS WORKSHOP

DEPUTY SUPERVISOR
(Grade 6) and

ELECTRONICS TECHNICIAN ENGINEER

(Grade 5) required for interesting work for Electronics and Physics research and teaching. Includes prototype instrument design, development and construction and the servicing and repair of commercial electronic equipment.

Experience and qualifications in Electronics at an appropriate level are essential. Generous holidays. Inclusive salaries (under review):

Grade 6: £4,767 to £5,592 per annum
Grade 5: £4,224 to £4,844 per annum.

Further details and application forms from: Mr. M. E. Cane (EW), Chelsea College, Pulton Place, London SW6 5PR.

(9769)

SAUDI ARABIA

We require a **Qualified Electronic Engineer/Technician.** Some knowledge of colour TV and VCR servicing. Excellent remuneration — preferably single.

Apply to the Manager
United Electronic Company
PO Box 7520 CR15873
Ryiadh
Saudi Arabia (9799)

ROHDE&SCHWARZ

Independent concern represented in 80 countries

SENIOR TEST AND CALIBRATION ENGINEERS

With a background in RF and microwaves, experienced in analogue, digital techniques, logic and microprocessor controlled ATE.

also vacancies exist for

TEST & CALIBRATION ENGINEERS

with knowledge of one or more of the above techniques.

We offer an exceptional salary ★ Performance related bonus scheme ★ Training abroad ★ Prospects of promotion ★ A wide variety of work ★ A happy atmosphere ★ Non-contributory pension scheme ★ Subsidised restaurant.

Please write or phone to:
Mr. Z. Eres (Technical Manager) extension 43.

Electronic Instruments & Communications Equipment

aveley electric LTD
Roebuck Road
Chessington
Surrey KT9 1LP
01-397 8771

(9757)

ELECTRONICS ENGINEER

(WITH A FLAIR FOR INSTRUCTION)

WEST LONDON **c. £6,000**

You will be capable of designing and building circuits for training purposes in microelectronics courses. Only people with a keen interest in helping students to learn by designing and constructing their own circuits should apply.

The successful applicant will also have the opportunity to develop his/her own knowledge of microprocessors in conjunction with other members of the team.

Interested?

The please contact: **Box No. WW9747.**

Electronics & Computer Test

To £7,500

Use your C&G/ONC/HNC/Forces Training and good DIGITAL/ANALOGUE/RF experience to advantage. Working with state-of-the-art MINI/MICRO PROCESSOR; LASER; ATE; COMMUNICATIONS; NUCLEONIC; CCTV and similar equipment. Most UK areas; from Technician to Manager.

For free confidential counselling and practical career advice contact GRANT WILSON ref: GW470.

TECHNOMARK, 11 Westbourne Grove, London W2 4UA.
Tel: 01-229 9239 (01-229 4218—24 hrs).
Engineering Recruitment Consultants.

The University of Sussex

Electronics Technician
(Male/Female)

Grade 3, in the Social Psychology Laboratory, starting as soon as possible. The vacancy in a small growing department is for a technician with experience of transistor circuits, capable of developing and constructing simple apparatus and preferably interested in C.C.T.V.

Salary scale: £3122-£3553 per annum (under review, to be increased from 1.4.80 to at least £3313-£3770 per annum).

Further particulars and application form, returnable as soon as possible, are available from the Assistant Secretary (Establishment), Office of Arts & Social Studies, University of Sussex, Falmer, Brighton BN1 9QN (606755, ext. 1050, Miss Pratt).

(9800)

Radio Officers
Sea Sick?

If you've seen quite enough of the sea, and are thinking now of a shore-based job that suits your qualifications, the Post Office Maritime Service can offer you interesting work, job security, good pay, plus the pleasure of enjoying all the comforts of home where you appreciate them most – at home!

Vacancies exist at several coast stations for qualified Radio Officers to carry out a variety of duties that range from Morse and teleprinter operating to traffic circulation and radio telephone operating. And for those with ambition, the prospects of promotion to senior management are excellent.

You must have a United Kingdom Maritime Radio Communication Operator's General Certificate or First Class Certificate of proficiency in Radio-telegraphy or an equivalent certificate issued by a Commonwealth Administration or the Irish Republic. Preferably you should have some sea-going experience.

The starting pay at 25 or over will be about £4450; after 3 years service this figure rises to around £5750. (If you are between 19 and 24 your pay on entry will vary between approximately £3500 and £4050). Overtime is additional, and there is a good pension scheme, sick-pay benefits and at least 4 weeks' holiday a year.

For further information, please telephone Andree Trionfi on Freefone 2281 or write to her at the following address: ETE Maritime Radio Services Division (WW), ETE17.1.1.2, Room 643, Union House, St. Martins-le-Grand, London EC1A 1AR.

(9741)

Electronic Engineers

Make The Centre your next stop

The Government Communications Centre at Milton Keynes now requires several of the above qualified staff to contribute to the Centre's growing reputation. Our work is often novel, always challenging and requiring a high level of dedication and application to the task. The fields of work are increasingly offering new opportunities for career development and experience in VHF, HF general and digital circuitry, design and development.

Minimum qualification needed is HNC.

Salaries ranging up to £6737 per annum depending on qualifications and experience.

We are situated close to Milton Keynes, a fast growing town with many modern entertainment, shopping and sporting facilities. The area is crossed by several main travelling routes and reasonably priced housing is available.

Please apply for an application form to the Recruitment Officer, HM Government Communications Centre, Hanslope Park, Hanslope, Milton Keynes, MK19 7BH.

The Centre — is vital to your career. (9724)

THE WELDING INSTITUTE
POWER SUPPLY AND DIGITAL ELECTRONIC DESIGN ENGINEERS

A department of Control Engineering has been set up in The Welding Institute Research Laboratory, the largest such laboratory in the western world, to deal specifically with the overall field of control in welding systems. This will cover both low and high power electrical/electronic engineering, computer control (including dedicated microprocessors) as well as mechanical and hydraulic machine design.

Two vacancies exist for qualified engineers to work in modern well-equipped laboratories in a pleasant rural setting.

One post will involve the design and development of power supplies up to 30 kilowatts in output rating, for which an interest in heavy electronics and experience in the application of thyristors are essential requirements.

The other post will involve the design of digital measuring and control equipment, and of peripheral interfaces within microcomputers. Previous experience with microprocessors would be useful, but not so important as a solid background of digital hardware design.

The Institute operates a 35 hour week, with four weeks' annual leave, negotiable progressive salary, excellent pension and life assurance scheme, subsidised restaurant and sports and social club facilities.

Application forms from: **The Personnel Officer, The Welding Institute, Abington Hall, Abington, Cambridge CB1 6AL.** (9755)

Audio + Video
VTR ENGINEERS
c. £10,000

We require VTR Engineers, preferably with broadcast experience, to service and maintain RCA and Ampex 2" quad machines. A working knowledge of the Rank Cintel Mark III Telecine equipment would be an advantage.

Our other excellent in-house facilities include Marconi DICE standards converter, TBCs and a multitude of Helican Scan machines, leading to an interesting and varied workload.

If this sounds like you please ring Mr. C. J. Carroll and have an informal chat about the work, the salary and the holidays etc., on 01-580 7161 or write:

AUDIO + VIDEO LTD.
VIDEO HOUSE
48 CHARLOTTE STREET
LONDON W1P 1LX

(9760)

ELECTRONICS REPAIR TECHNICIANS
Kingsbury c. £5500

What do you know about digital equipment? Enough to repair microprocessor-based systems, disc drives, VDU's, PCB's and PSU's? If so, we have some excellent opportunities for you at Kingsbury.

We're Linotype-Paul, designers and manufacturers of sophisticated electronic hardware and software for the printing and publishing industries.

We're looking for men and women, aged 25+, qualified to HNC/ONC or equivalent, who are seeking first class job opportunities. We're offering a salary negotiable around £5500 and excellent benefits, plus ample overtime, a subsidised canteen, and up to 26 days holiday a year.

For full details, ring or write to The Personnel Department, Linotype-Paul Ltd., Kingsbury Road, London NW9 8UT.
Tel: 01-205 0123.

(9785)

Linotype-Paul

TOP SALARIES FOR RADIO TELEPHONE ENGINEERS

Field and Bench positions
VHF and UHF equipment
Salary £5000 p.a.
(inclusive of bonus)

Plus — Company cars are supplied for Field Service Engineers. We are London's largest independent radio-telephone company and expanding fast! If you have the necessary knowledge and aptitude we need you now. Call Mike Rawlings or Bill Clarke on 01-328 5344.

London Communications (Equipment) Ltd
30 Boundary Road, London, NW8
Telephone 01-328 5344

(9797)

possum
Possum Controls Limited

Electronic Engineers and Electronic Hobbyists

Possum Controls have vacancies for the electronic engineers and the electronic hobbyists in the research and development departments.

Interesting posts using the latest technology in aids for the disabled.

The company future expansions offer excellent career prospects to the engineer and the chance for a good amateur to join the electronics industry.

Contact Mr. A. Longley — Technical Manager. Telephone Aylesbury 81591. Or write to Possum Controls Ltd., 63 Mandeville Road, Aylesbury, Bucks. (9782)

TOP JOBS IN ELECTRONICS

Posts in Computers, Medical, Comms, etc. ONC to Ph.D. Free service.

Phone or write: **BUREAUTECH AGY, 46 SELVAGE LANE, LONDON, NW7. 01-959 3517.**

(8994)

THE UNIVERSITY OF LEEDS. Department of Anaesthesia. Technician Grade 5 (Electronics). The Department of Anaesthesia has a vacancy for a Grade 5 Technician (Electronics). The work involves the design, modification and servicing of biomedical electronic equipment used for patient care, research teaching by the Department within the University and at the two Teaching Hospitals. The post is a senior one and the appointee will work directly with senior academic staff. Previous training and experience in electronics essential. Salary on the scale £3,700-£4,320. Applications in writing (giving full details of age, qualifications and experience, and the names of two referees) to Professor D. G. McDowall, University of Leeds, Department of Anaesthesia, 24 Hyde Terrace, Leeds LS2 9LN. (9744

THE UNIVERSITY OF LEEDS. Department of Anaesthesia. Technician Grade 5. (Electronics). The Department of Anaesthesia has a vacancy for a Grade 5 Technician (Electronics). The work involves the design, modification and servicing of biomedical electronic equipment used for patient care, research teaching by the Department within the University and at the two Teaching Hospitals. The post is a senior one and the appointee will work directly with senior academic staff. Previous training and experience in electronics essential. Salary on the scale £3700-£4320. Applications, in writing (giving full details of age, qualifications and experience, and the names of two referees) to Professor D. G. McDowall, University of Leeds, Department of Anaesthesia, 24 Hyde Terrace, Leeds LS2 9LN. (9783

UNIVERSITY OF LEEDS. Electronics Technician (Grade 3). The person appointed would be required, under the supervision of the Electronics Engineer, to assist in the construction and maintenance of electronic equipment associated with the research and teaching of biological studies. Must be capable of working from circuit diagrams and sketches. Applicants should hold ONC or equivalent qualifications and relevant experience. Salary on the scale £3,122-£3,553 (under review) according to age and qualifications. Applications stating age, qualifications and full experience, together with the names and addresses of two referees, should be addressed to: Mr E. French, Departmental Superintendent, Department of Physiology, The Worsley Medical and Dental Building, University of Leeds, Leeds LS2 9NQ. (9792

Space Technology
South Coast Engineering Opportunities

Among the international leaders in space technology, we offer a wide range of career prospects for experienced engineers and enthusiastic graduates alike.

The spectrum of design and development provides immediate and rewarding opportunities for men or women in the following disciplines:

Satellite Systems
Communication Systems
Microwave Systems
Control and Propulsion Systems
Mechanical Design
Satellite Assembly Integration and Test
Thermal Design
EMC
Quality Assurance
Digital Analogue and Circuit Systems

If you wish to know more of the openings, facilities and training we can offer and would be interested in working in this favoured location, please telephone Jack Burnie for an application form, quoting ref. P116, on Portsmouth 699414.

Marconi Space & Defence Systems Limited, Browns Lane, The Airport, Portsmouth.

(9770)

Marconi Space & Defence Systems (Portsmouth)
A GEC·Marconi Electronics Company

Dixons Technical Ltd

VIDEO AND CCTV ENGINEERS

Dixons Technical are importers and distributors of a wide range of broadcast, video and CCTV equipment. Due to expansion they are seeking:

ASSISTANT SERVICE MANAGER
with general video experience

VIDEO ENGINEER
with experience of VCR and basic colour TV equipment based at Croydon or Soho Square.
Attractive salary and the usual large company benefits.

Apply to John Street, General Manager, DIXONS TECHNICAL LTD. 68-70 Windmill Road, Croydon, Surrey.
Tel: 01-689 6021

(9753)

CTVC

VISION ENGINEER

CTVC require a vision engineer for their broadcast standard TV studios in Bushey. Applicants should have operational and maintenance experience preferably with a broadcast or facilities company. Please phone or write for an application form to **Carol Moxon, CTVC, Hillside, Merry Hill Road, Watford WD2 1DR. Tel: 01-950 4426.**

(9730)

WE NEED EVEN MORE

ELECTRONICS ENGINEERS AND TECHNICIANS

CIRCA £7500

Our continued expansion as Britain's largest component supplier means we require engineers in the areas of design, evaluation, test, applications and quality approval.
An unparalleled opportunity to gain experience in these fields and develop your potential with a company committed to exciting new developments.
Interested?
Telephone to write to our **Chief Engineer, Bob Rambridge,**

R. Rambridge
Chief Engineer
RS Components Limited
Maple House
PO Box 52
37/45 City Road
London EC1P 1HX
Tel. 01-253 1222

An Electrocomponents Group Company (9756)

OVERSEAS ELECTRONICS TECHNICIANS

We operate and maintain Decca Navigator Low Frequency transmitting stations in S. Africa, Abu Dhabi, Qatar, Iran and Nigeria. The work is varied and encompasses a broad sphere of Engineering and AC power generation, standby power systems, LF transmitters and antenna systems.

Whilst applicants should preferably possess a HNC/ONC/Service Training in Electronics they should also have a good understanding of general engineering principles and be able to work with minimal supervision.

Staff engaged will undergo a period of equipment training on one of our U.K. Stations and at the Decca College in Devon prior to going overseas.

These appointments are superannuated and there are good prospects for promotion. Commencing salaries are competitive and are commensurate with age and experience. Whilst overseas we supply food, accommodation and medical attention free of charge, together with regular paid trips to the U.K. for leave.

Providing you are unmarried, medically fit, in the age group 25-35 and hold a valid U.K. driving licence please send a resumé of your career to the Overseas Operations Department at:

The Decca Navigator Company Limited
Wymondley House
Little Wymondley
HITCHIN
Herts
SG4 7JB.

(9767)

Kiribati (formerly Gilbert Islands)

Technical Officer-Telecommunications (Radio)

Up to £7,816 a year plus allowances

If you hold a City and Guilds Telecommunications Technician's Certificate or equivalent with radio specialisation, and have experience in the installation and maintenance of MF, HF and VHF equipment, you are invited to apply for this post.

You would be responsible for the installation, maintenance and repair of telecommunications equipment throughout the islands and for the supervision and practical training of local staff.

Salary includes a substantial tax-free allowance paid under Britain's overseas aid programme. Basic salary attracts 25% gratuity.

Benefits include free passages, generous paid leave, children's holiday visit passages and education allowances, outfit allowance, subsidised housing, appointment grant and interest-free car loan.

For full details and application form write quoting MX/320/WD.

Crown Agents

The Crown Agents for Oversea Governments and Administrations, Recruitment Division, 4 Millbank, London SW1P 3JD (9761)

EXPERIENCED TEST ENGINEER WISHING TO PROGRESS

Opportunity to join a London based company producing high quality sound mixing consoles for live media, professional recording and broadcast applications.

The individual most suitable for this responsible and interesting situation would be aged 25-35, with an H.N.C. (or similar) qualification and several years post-qualification experience in fault diagnosis with products designed to a high-reliability specification.

Ability to formulate test procedures, to appraise quality standards and to act on own initiative within an informal and enthusiastic team is essential.

In return we offer excellent remuneration, good conditions, and opportunity to gain basic design experience in this field.

Please phone Chas Brooke on 388 7060 or 387 7679 for an application form and company information, or write to him giving resumé of career to date.

MIDAS

Audio Systems Ltd.
54-56 Stanhope St., London NW1 3EX.

(9770)

Norwich Airport

Technical Officers

—RADIO/RADAR

Due to continued Airport expansion there are 2 vacancies for experienced persons as Technical Officers (Electronic Technician - Engineers) at Norwich Airport to assist the Senior Technical Officer in the maintenance and installation of a wide range of navigational, communications and airfield lighting equipment, including ACR 430, PLAN 17-18 ILS, ECKO, VDF, VHF/UHF AM/FM transmitters and receivers. Experience of Plessey ILS maintenance would be a distinct advantage.

National Joint Council Conditions of Employment apply, subject to the Norwich City Council's local variations and agreements. Grade T.5 £5,220 to £5,547 per annum. It is planned to introduce shift working shortly which will attract a shift allowance of 14% of basic salary, plus payments for working at weekends and on Public Holidays. Relocation expenses of up to £650 and temporary housing accommodation available in approved cases.

Norwich, situated amidst the Broads of Norfolk, surrounded by areas of outstanding natural beauty, offers a stimulating mixture of the old and new with a thriving shopping/commercial centre and lively theatre and arts.

For further details and an application form write to the Deputy Airport Manager, Norwich Airport, Fifers Lane, Norwich NR6 6JA. The Senior Technical Officer can be contacted on Norwich 411923 for informal discussion about the nature of the work involved.

(9787)

HE SMELLS GOOD!!

How often we have repeated these words to a technical director or a chief engineer for a position when it is only our instinct that tells us this is the person for a key job. After nearly twenty years in the business human instinct reaches its peak but human memory begins to fail — so we have employed Einstein — a Compucolor II small business computer — for information retrieval and an ex-lecturer to interpret the information we feed to him.

Exceptional opportunity:—High flier for high technology company engaged in designing a new generation of word processing systems which involve the very latest multiprocessor and communication techniques. To £10,000 + car — Surrey/Sussex border.

Microprocessor hardware software development engineers for a wide range of communication systems. Good microprocessor experience. Knowledge of Z80 or RCA 1802 an advantage. To £8,500 — Wilts.

Young design engineer to work on phase-lock-loop techniques associated with RF oscillators, frequency counters and frequency synthesisers. Good theoretical background related to communications essential. Berks — to £7,500.

Sales liaison engineers for communication systems: voice and data scramblers. Background in radio communications and ability to negotiate with UK and foreign Government officials. Opportunity for overseas travel. West country — to £6,500.

Sales engineers for progressive young company marketing microprocessors, custom built LSI and development aids. Home Counties, Scotland and Midlands. Basic salary £6,500.

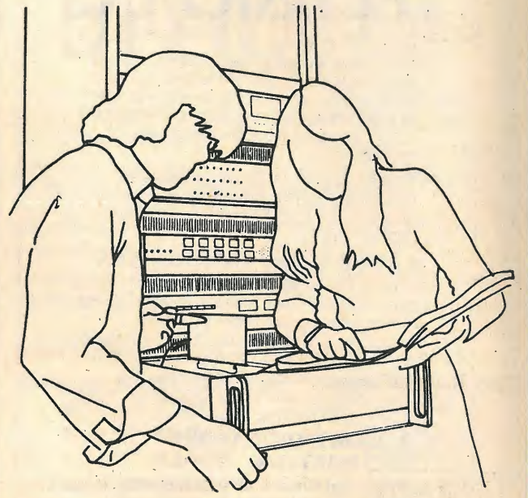
Young engineers with experience or wishing to gain experience in microprocessor hardware/software — join a new team engineering — the ultimate? — in test equipment. High level and low level languages employed. London — to £7,000.

Charles Airey Associates

"PROBABLY THE BEST KNOWN SUPPLIER OF ELECTRONICS ENGINEERS IN THE COUNTRY" FINANCIAL TIMES

155 KNIGHTSBRIDGE, LONDON, SW1. TEL: 01-581 0286 (9784)

Professional Careers in Electronics



All the others are measured by us...

At Marconi Instruments we ensure that the very best of innovative design is used on our range of communications test instruments and A.T.E. We have a number of interesting opportunities in our Design, Production and Service Departments and we can offer attractive salaries, productivity bonus, pension and sick pay schemes together with help over relocation.
If you are interested to hear more, please fill in the following details:-

Name _____ Age _____

Address _____

_____

Telephone Work/Home (if convenient) _____

Years of experience 0-1 ☐ 1-3 ☐ 3-6 ☐ Over 6 ☐

Present salary £2,500-3,500 ☐ £3,500-4,500 ☐ £4,500-5,500 ☐ over £5,500 ☐

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(9803)

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Applications stating age, qualifications, etc., should be forwarded to the Personnel Manager, Greater Glasgow Passenger Transport Executive, 46 Bath Street, Glasgow, G2 1HN, within ten days of this advertisement.

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(9773)

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(9758)

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SULTANATE OF OMAN

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(WOI) **Ref. No. 51**

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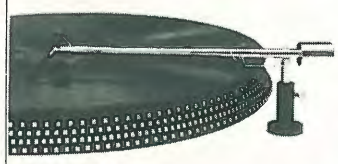

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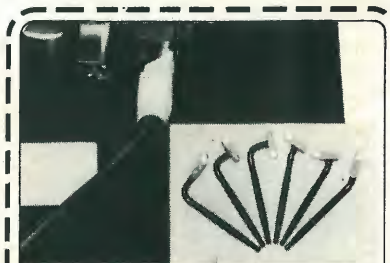

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