wireless world

SEPTEMBER 1979 50p

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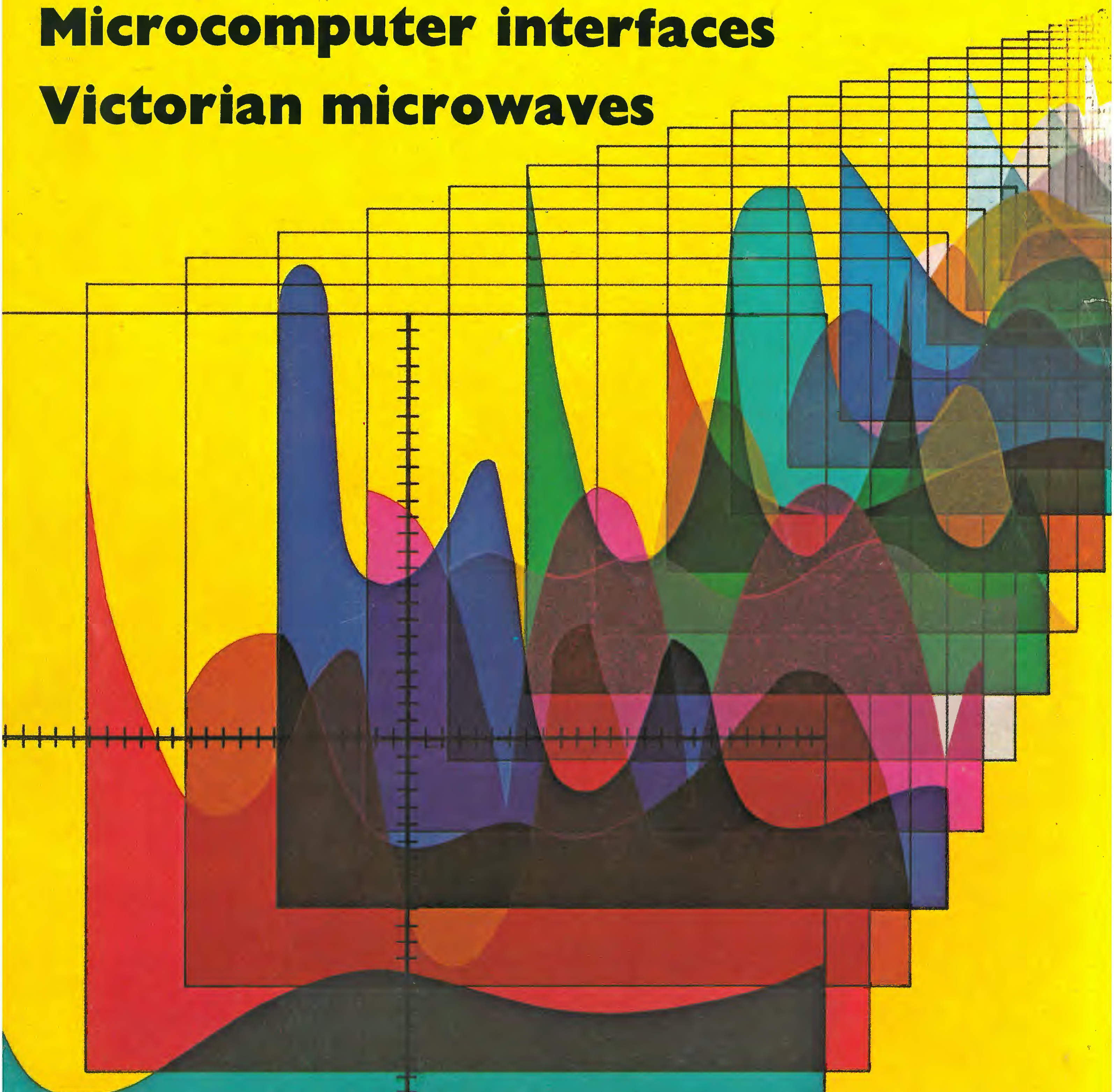

Log. sweep generator

Front cover is 'Wavestorm', an abstract design by Betty Palmer based on displays from Alan Ainslie's sweep generator, described in this issue.

Multimode two-metre transceiver. **Advanced design will operate in s.s.b., f.m. and c.w. modes over the 144-146MHz amateur band.**

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ELECTRONICS/TELEVISION/RADIO/AUDIO

SEPTEMBER 1979 Vol 85 No 1525

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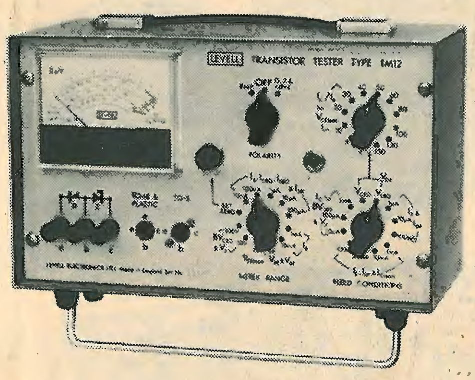

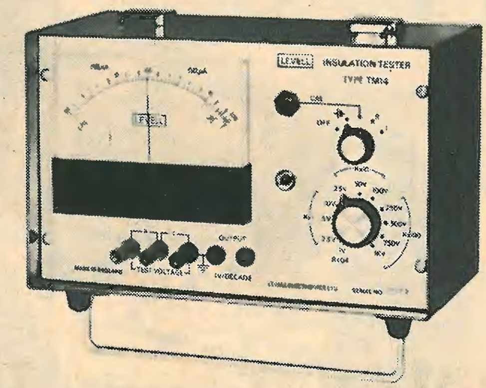

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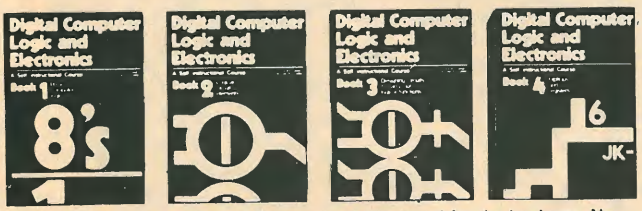

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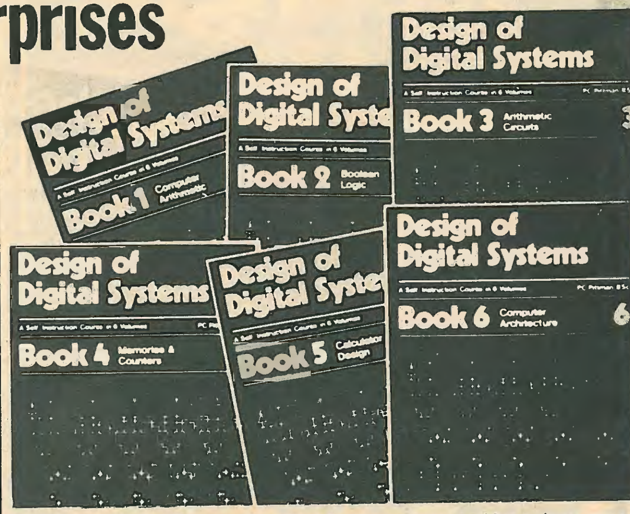

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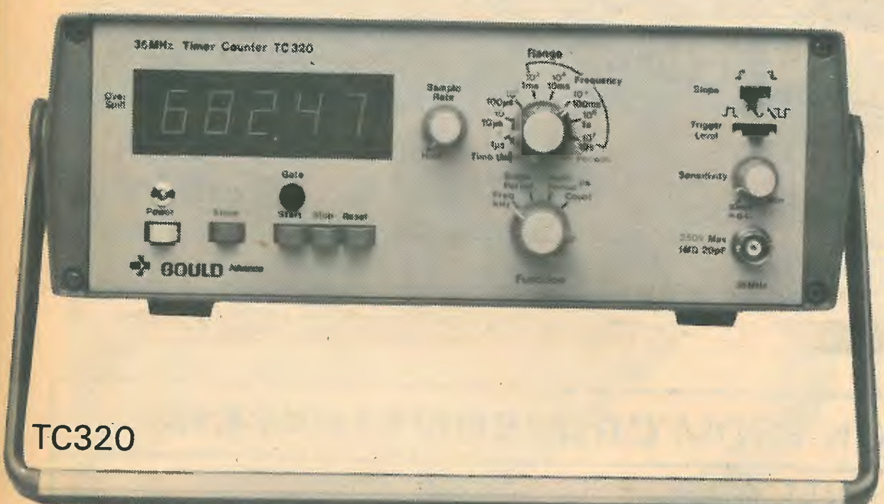

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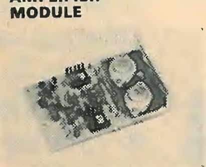

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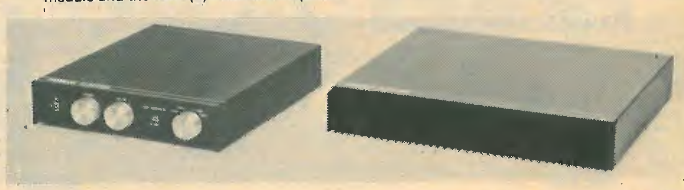

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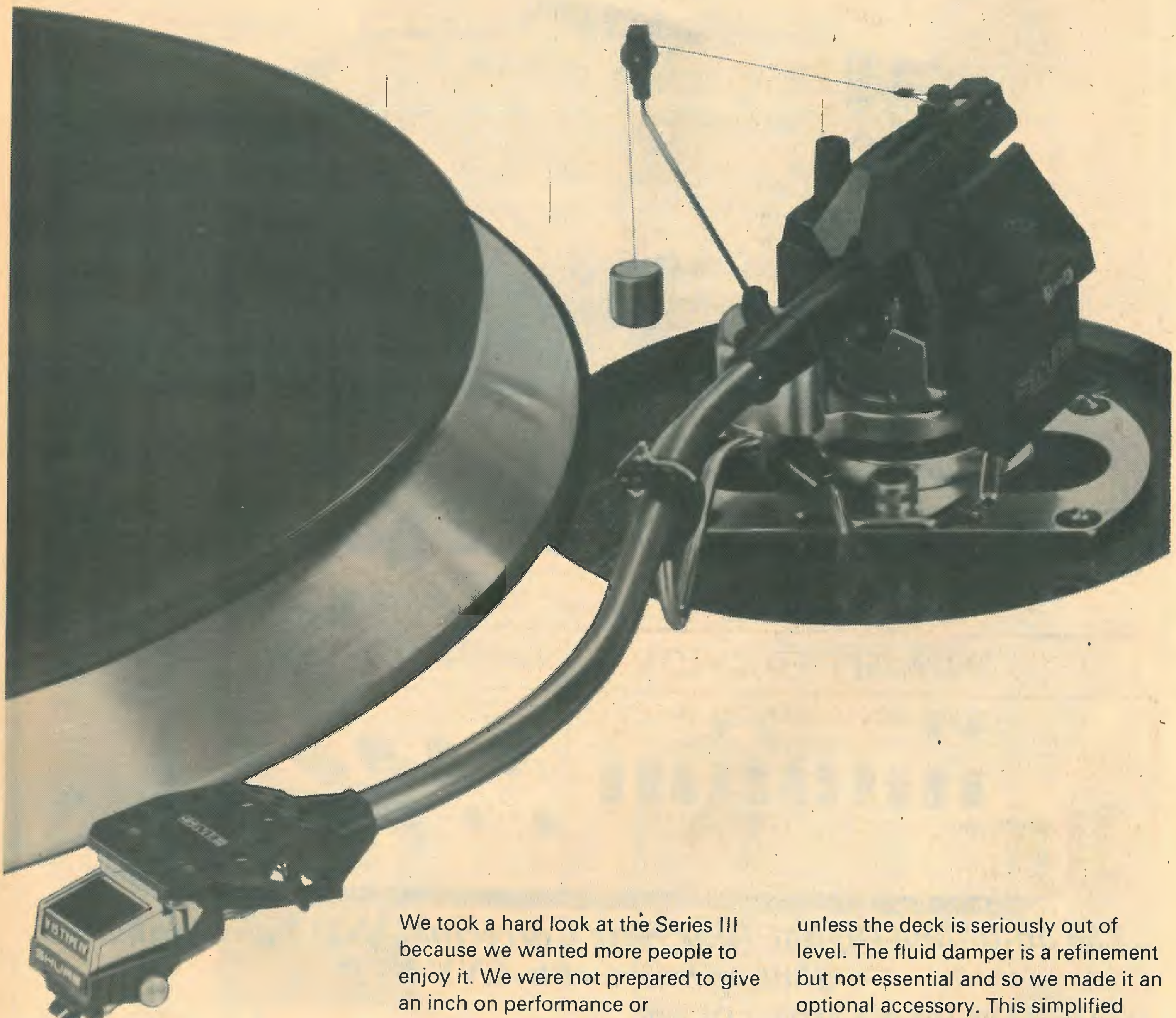

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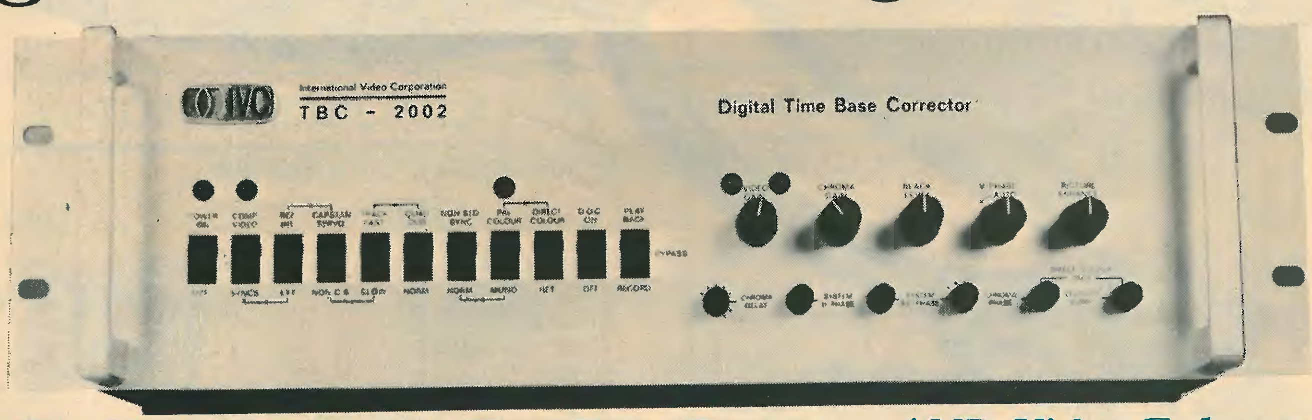

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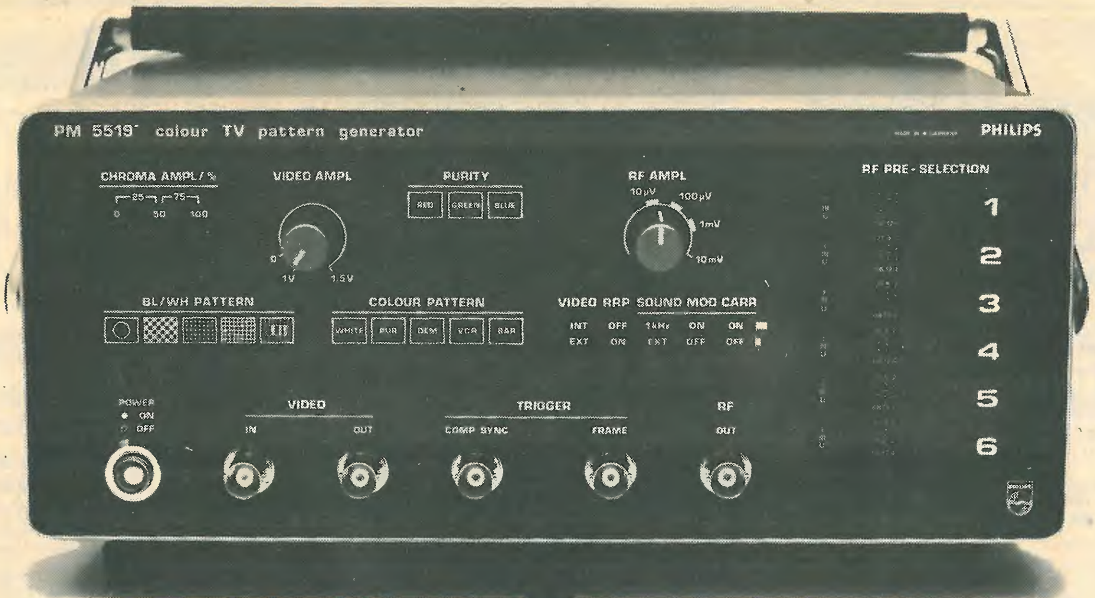

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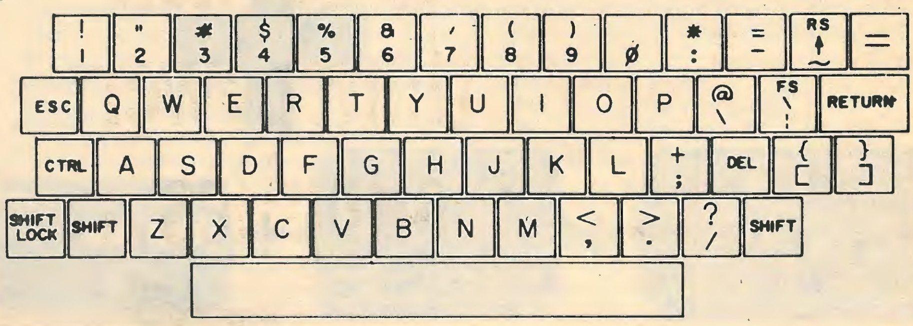
* Rugged mil. spec. G—10 PCB with plated through holes.
* 2-key roll-over
* DC level and pulse strobe signal for easy interface to any 8-bit input port microprocessor system, video display or terminal board. Strobe pulse width 1 ms.

User selection of positive or negative logic data and strobe output.



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NEW MODEL CS1577 30 MHz/2mV

CS1577

130mm DUAL TRACE TRIGGERED SWEEP OSCILLOSCOPE

£480 + VAT

PRICE INCLUDES TWO X10 FULL BANDWIDTH PROBES

★ 130 mm mesh PDA
★ DC - 30 MHz
★ 2 mV sensitivity
★ Signal delay
★ Auto level triggering
★ Display modes CH1, CH2, DUAL, ADD, X-Y
★ Single shot with variable hold off

SPECIFICATION

Bandwidth:	DC - 30 MHz (3 dB) 40 MHz (6 dB)
Sensitivity:	2 mV/cm - 10V/cm
Input R.C.:	1 M ohm 22 pF
Risetime:	11.7 nS
Overshoot:	less than 3%
Sweep time:	100 nS/cm - 0.5S/cm
Linearity:	better than 3%
Calibrator:	1 KHz 100 mV square wave
Trigger bandwidth:	DC - 40 MHz
Trace rotation:	Electrical
Phosphor:	P31
Power:	AC 100/120// 220/240V 50/60 Hz 40W
Dimensions:	260mm x 190mm x 375mm
Weight:	10 Kg

CS1352 DUAL TRACE 15 MHz/2mV PORTABLE

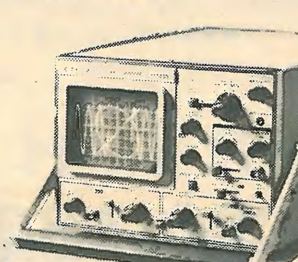
£350 + VAT

The CS1352 oscilloscope offers you not only dual trace, 15MHz bandwidth operation at sensitivities down to 2mV/cm but also use from 100-240 Vac mains **and** portable operation using the optional rechargeable battery pack. Automatic charging is carried out when the CS1352 is plugged into a mains supply. Now you can have top performance both on the bench and out in the field — and at an affordable price.

CS1575 DUAL TRACE 4 FUNCTION

The CS1575 is a unique tool for the audio engineer. It features the normal facility of dual trace display with sensitivity to 1 mV/cm but not only can it display the input signals on two channels, it can **simultaneously** display the phase angle between them and measure the phase angle referenced to a zero phase calibration display. In addition to these unique features, you also have independent triggering from each channel to give stable displays even with widely differing input frequencies.

Absolutely indispensable to the professional audio engineer, the CS1575 is now in use all over the world. See it in action or send for complete details.



£278 + VAT

TRIO OSCILLOSCOPES

The Trio range of oscilloscopes offer top quality at moderate cost. The brief specifications show the performance features which have made these oscilloscopes firm favourites in all parts of the world, with bandwidths to 30 MHz and sensitivities down to 1mV/cm on 130 mm screens. Prices are very realistic and we try to ensure that delivery is ex-stock at all times — quite a change these days.

FOR FULL DETAILS ON THESE AND OTHER MODELS, CONTACT THE SOLE AGENTS, LOWE ELECTRONICS

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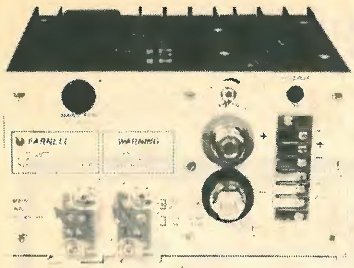

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Digital tachometers. Digital panel meters
Digital frequency meters. Digital timers
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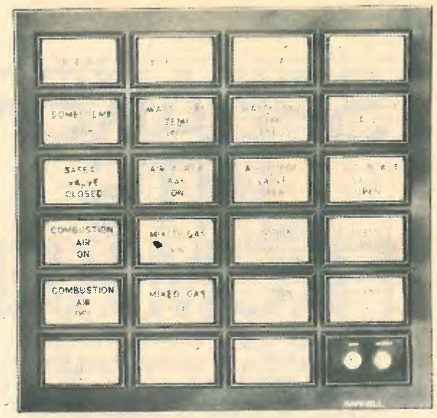

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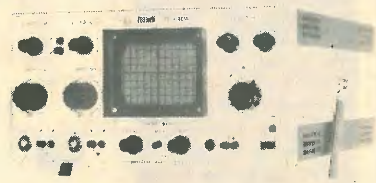

OSCILLOSCOPES

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30MHz bandwidth
Dual trace
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Rack mounting versions
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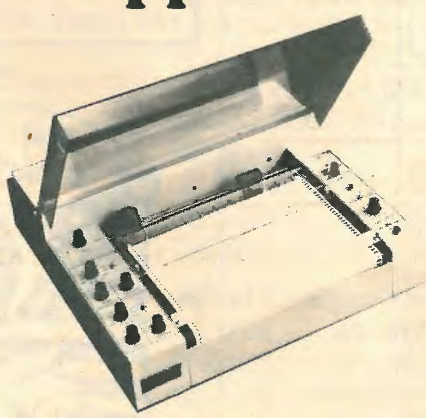
Carrying cases/protector muffs



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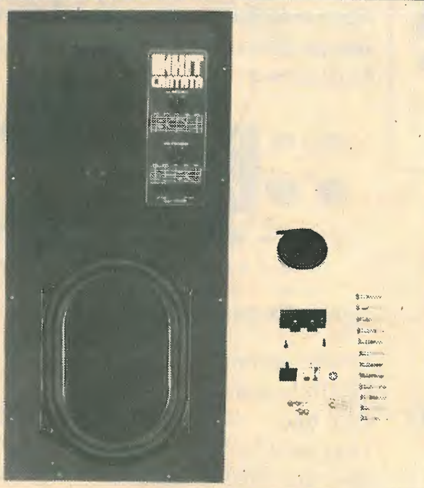

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The Cantata was developed by KEF using their concept of "Total System Design" whereby drive units, filters and enclosure are matched together to produce an acoustic response as near to the ideal as possible.

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KEF

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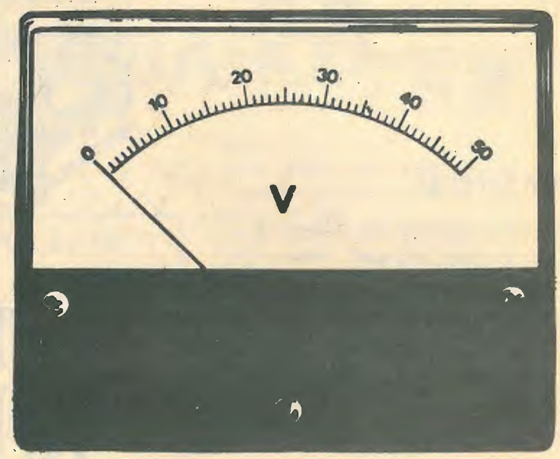

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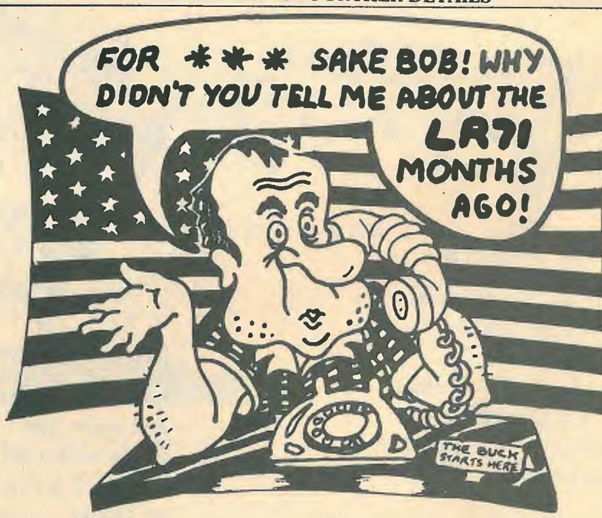

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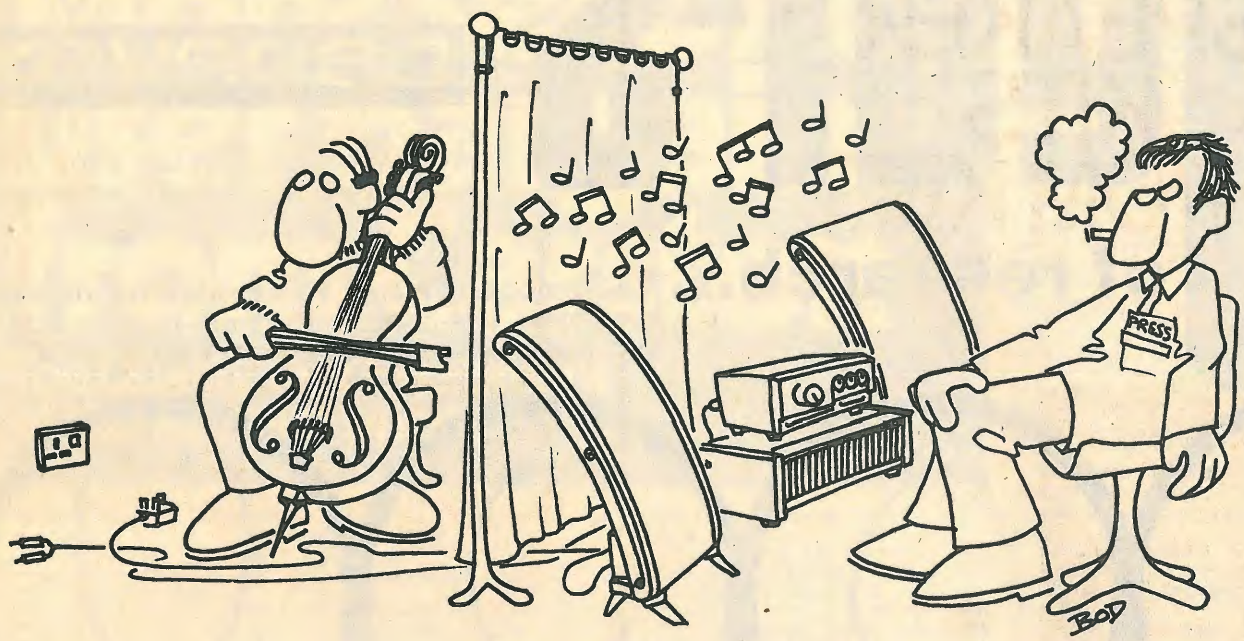

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4015	.76
4016	.28
4017	.57
4018	.65
4020	.67
4021	.67
4022	.65
4023	.15
4024	.48
4025	.15
4027	.31
4028	.54
4029	.70
4040	.65
4042	.53
4043	.57
4044	.57
4046	.82
4047	.95
4049	.28
4050	.31
4051	.51
4052	.51
4053	.51
4060	.94
4066	.33
4068	.15
4069	.15
4070	.15
4071	.15
4072	.15
4073	.15
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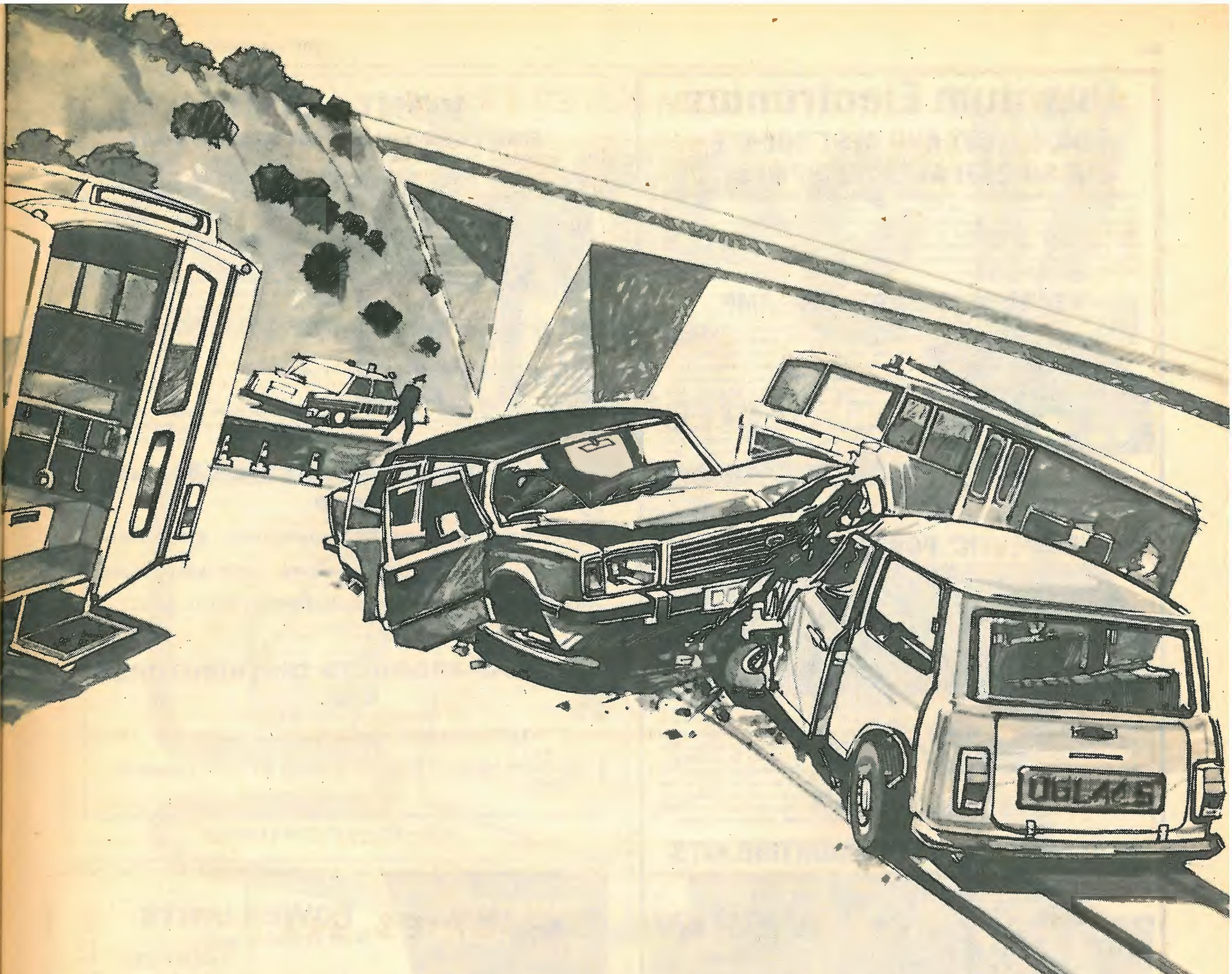

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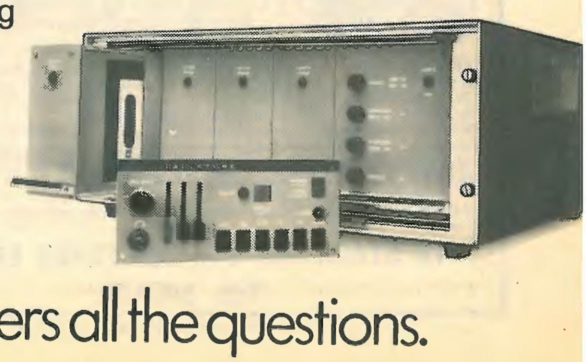

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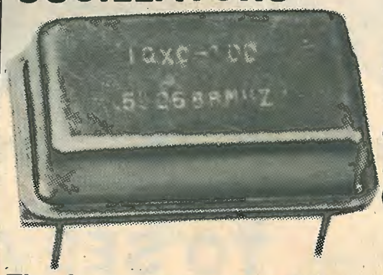

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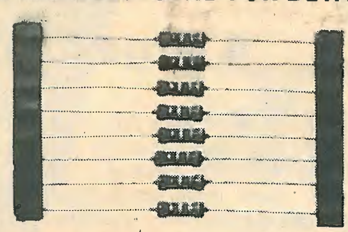

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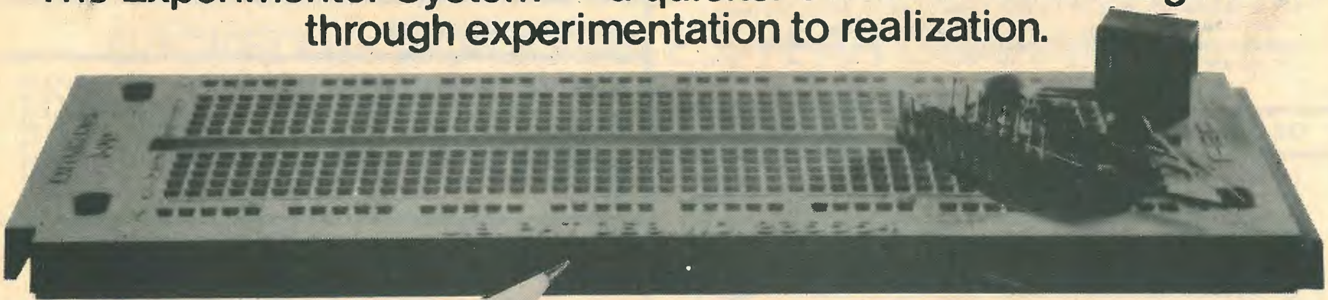

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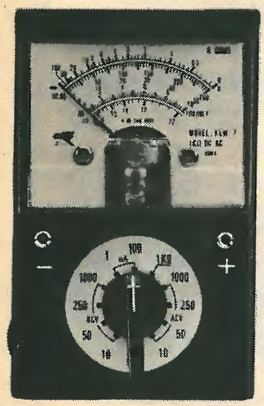
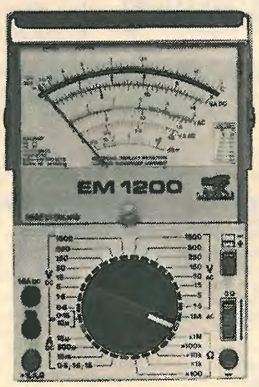
Eagle Test Equipment gives the right answers

The range covers general multimeters, high voltage probes, clamp meters, insulation testers. Here are just four. Send the coupon for details of all the rest.



KEW 7 Multimeter
1000 OPV. DC volts up to 1000, DC amps up to 100 mA. AC volts up to 1000. Resistance up to 150 Kohms. Pocket size. "Off" damping. Complete with leads & battery. R.R.P. £6.95 ex. VAT.



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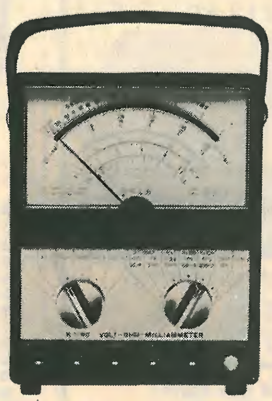

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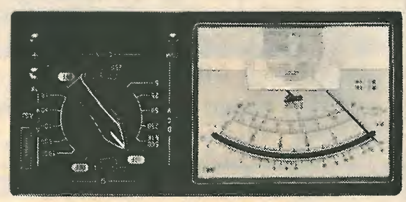

EM10, 20 & 30 Multimeters
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Address ____

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WW 9

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your favourite record may be a tangle of warps

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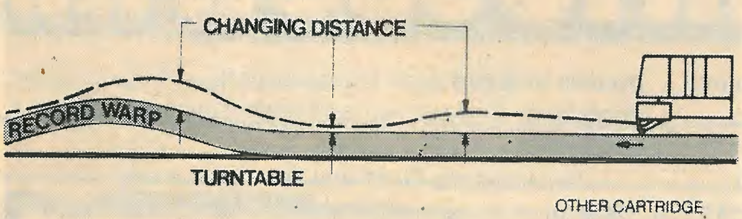

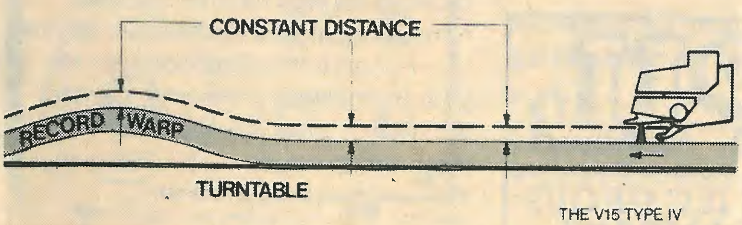

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Good, clean fun

The Home Office — or, at least, that part of it which is concerned with the regulation of radio transmissions — is evidently one of the more inductive arms of central government and, in its unexplained opposition to any change in the current of public opinion, begins to exhibit slight, but unmistakable evidence of a belief in the philosophy of King Canute, though it is said that even he only sat there on the beach to show how ill-conceived an idea it was to try to curb the tide.

If, by chance, the good king left any family over there in Denmark, let it be known that a further demonstration of the futility of that approach is overdue, the need for it being occasioned by the remarkable blandness of replies to reasoned requests for the right to operate personal radio transceivers on a citizens' band.

It is possible that the unsympathetic response to such demands stems from the unnecessarily righteous arguments put to the government by the supporters of the c.b. lobby. The suspicion lurks that, while the use of such equipment in the USA may have been the means of saving innumerable, isolated old ladies from the attentions of escaped man-eating tigers and while, in the absence of c.b., the roads of the Mid-West would be made all but impassable by the dried-up skeletons of long-distance truck drivers, the real reason for wanting the c.b. facility is that it is quite good fun.

If it is this aspect of the cult that bothers the Home Office, then there is nothing at all for them to worry about. There are several precedents which provide a stable platform for the assertion that entertainment is respectable, even when it relies on the use of natural resources — renewable or not.

Television has effectively commandeered many hundreds of megahertz of the usable spectrum, with sound radio a more moderate but still fairly grasping tenant. Much of the spectrum occupied by broadcasting carries identical programmes being transmitted to different areas on different frequencies – hardly an economical use of the broadcast bands. But, allowing that this is necessary and pretending that cable transmission has never been thought of, it all becomes well worth while, since every person in the land is provided with first-class entertainment and instruction: a highly respectable endeavour.

Or is it? One evening's examination of the aforementioned entertainment and instruction will rapidly demolish any pretence of an effective use of bandwidth. The content of broadcasts is not normally the province of *Wireless World*, but insofar as the imported trash (and some homegrown material of the same standard) is responsible for the annexation of so much of the available spectrum, and is considered worthwhile by the powers that be, it considerably reduces the impact of any argument based on the premise that c.b. operation is merely entertainment and consequently not to be encouraged.

The supporters of c.b. have their other argument to fall back on when faced with the Home Office's blank and uncomprehending disapproval; one which ought to appeal to bureaucratic self-interest, if nothing else. James Bryant of the CB Association has expressed the view that there will soon be so many illegal, and therefore unlicensed operators working with 27MHz, a.m. sets that a free choice of the specification to be officially adopted will not be possible. Mr Bryant's figures cannot be checked and may seem somewhat excessive, but his argument does possess a certain force, and deserves a more considered reply than has so far been made public.

The official attitude that the need for c.b. has not been demonstrated is not even up to the standard of regulation Civil Service double-talk. Has anyone ever demonstrated the need for 'Sale of the century' or 'Wonderwoman'?

Logarithmic audio sweep generator

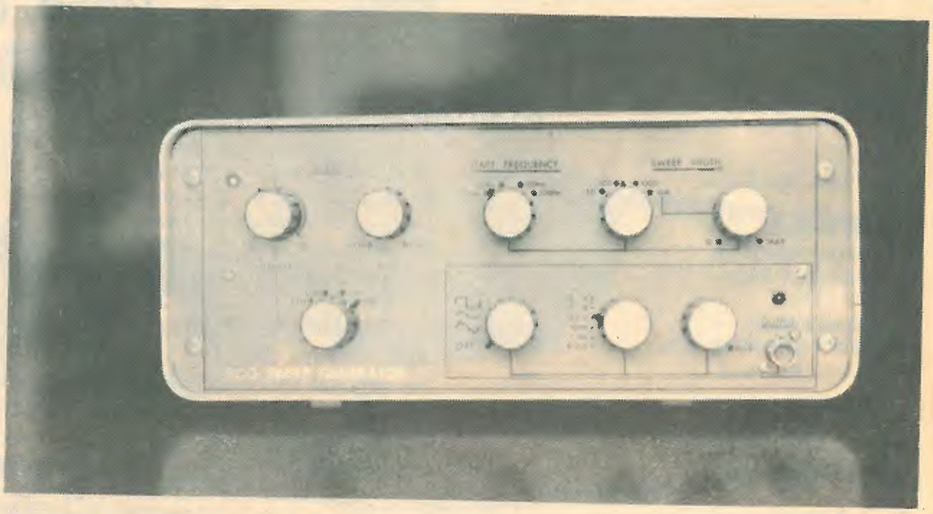
Unit for use with an oscilloscope to display l.f. response curves

by A. C. Ainslie

The log sweep generator to be described was developed primarily for the display of overall l.f. response curves on a conventional, d.c.-coupled oscilloscope. Sweeps are calibrated over a 10:1, 100:1 and 1000:1 range, with selectable start frequencies of 10Hz, 20Hz, 100Hz, 200Hz. This enables the "normal" audio band of interest of 20Hz-20kHz to be presented in a single sweep.

Linear sweep facilities enable the graticule divisions on the oscilloscope to indicate frequency directly without a law conversion, while an accurate "log" facility produces sweeps with a linear sweep on the c.r.t. for uniform brightness but with logarithmic frequency conversion.

Outputs up to 10V p-p are available into 600Ω loads from either sine, square or triangle sources. RIAA equalisation has been provided at a nominal 5mV 1kHz level for display of RIAA equalisation.



THE SIMPLIFIED block diagram of the unit in Fig. 1 shows the connexions to an oscilloscope and to the unit under test. Additionally, retrace blanking is provided to the c.r.o.

The ramp generator drives the X amplifier of the c.r.o., while simultaneously varying the frequency of the voltage-controlled oscillator. Low frequencies are arranged to be on the left hand side of the display, providing the c.r.o. conforms to the convention of an increasing positive voltage moving to the spot to the right.

An integrated logarithmic amplifier converts the linear sweep to a log. v.c.o. control voltage so that the rate of increase of frequency increases with frequency, enabling responses to be displayed conforming to the more common form of presentation.

Amplification of the v.c.o. output is necessary to drive loads as low as 600- with 10V p-p level. Clearly the output amplifier must be flat. A consequence of the v.c.o. used is that square and triangle waves are available simultaneously with the sine wave which is used for response sweeping. Selection is provided to enable these outputs to be used, giving a swept function-generator facility.

Y deflection of the oscilloscope is from the output of the device under test. The result of a sweep will be to display an envelope on the screen, the top of which is representative of the response of the device under test. Normally the lower half of the display would be lowered below the lower datum of the graticule to give a less confusing display. Several refinements to the display of the envelope will be discussed later on as an aside.

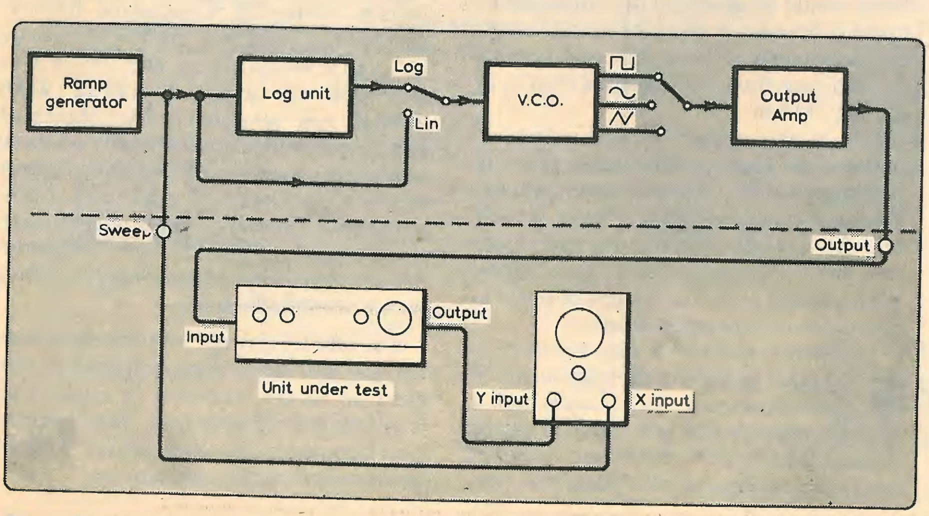


Fig. 1. *Basic principle of swept-frequency investigation.*

Sweep generator

The v.c.o. used in this design has a linear relationship between control voltage and frequency. The requirement for the sweep generator is, therefore, a simple linear ramp with variable repetition rate and the possibility of manual setting to any point in the sweep to enable frequency to be manually set. In Fig. 2, an astable 555 timer is used with a constant current source, Tr_1, to produce a linear sweep from the charging of C_1. The 555 is used between +15V and earth with the internal comparator levels, resulting in a sweep from +5V to +10V. The charging current for C_1 and hence the sweep repetition frequency is controlled by R_2, a panel control labelled 'SWEEP'.

Switch S_{1a} selects either the automatic sweep or a manual tuning voltage from R_9, 'MANUAL,' to be passed to various level shifters by follower, IC_2. The combination of R_{12} and C_4 removes high frequency jitter on the ramp from the 555. Amplifier IC_5 converts the ramp from S_{1a} to a 10V excursion, centred around 0V, to drive the oscilloscope at 1V/division maximum. Level shifter IC_3 drives the log. conversion circuit, which requires the ramp to be presented inverted, running from about 2.5V to just above earth. A linear, inverted ramp is also obtained from IC_4, sweeping from earth to —5V. The h.f. end of the ramp is set by R_{21}. Potentiometers R_{17} and R_{23} set the working levels of the two translators, establishing the h.f. end of the log. sweep and the l.f. point of the linear sweep.

Oscilloscope trace bright-up must be provided under control of the sweeper. Pin 3 of the 555 rises to +15V during the sweep, falling to 0V during retrace. This signal is used to turn on Tr_2 during sweep; in the retrace period Tr_2 is off and 'B.U. output' rises to +20V, cutting off the oscilloscope. The R_6/C_3 combination prevents ripples getting onto the 20V line, passing through the 15V regulator and giving problems.

The convention used above, in which positive-going voltages reduce beam intensity, seems to be a fairly common requirement for most modern oscilloscopes: it is an easy matter to introduce an inverter should the need arise. If a greater bright-up voltage than 20V is needed, it would probably be better to build a high-voltage amplifier into the mainframe, using its internal supplies and driving the amplifier with the bright-up output of the sweeper.

To produce a logarithmic change in frequency when displayed on a linear trace, an antilogarithmic distortion of the linear ramp is needed, which is provided in this case by an Intersil 8049, the principle being shown in Fig. 3.

The 8049 was used in this design because various discrete "textbook" designs proved too fussy in respect of temperature control or compensation over the requisite 10^3 range. This package is surprisingly inexpensive for its degree of precision and it is certainly simple to use. Setting up, once complete, is very stable.

The input presented to IC_6 is a ramp falling from 2.5V to about 0V, which must be turned into a 10^3 sweep voltage range. With a supply of 15V on the 8049, a maximum output of 10V seems reasonable, making the l.f. end of the sweep output 10mV. The scale factor of the device is approximately 1V per decade of output, actually trimmed during

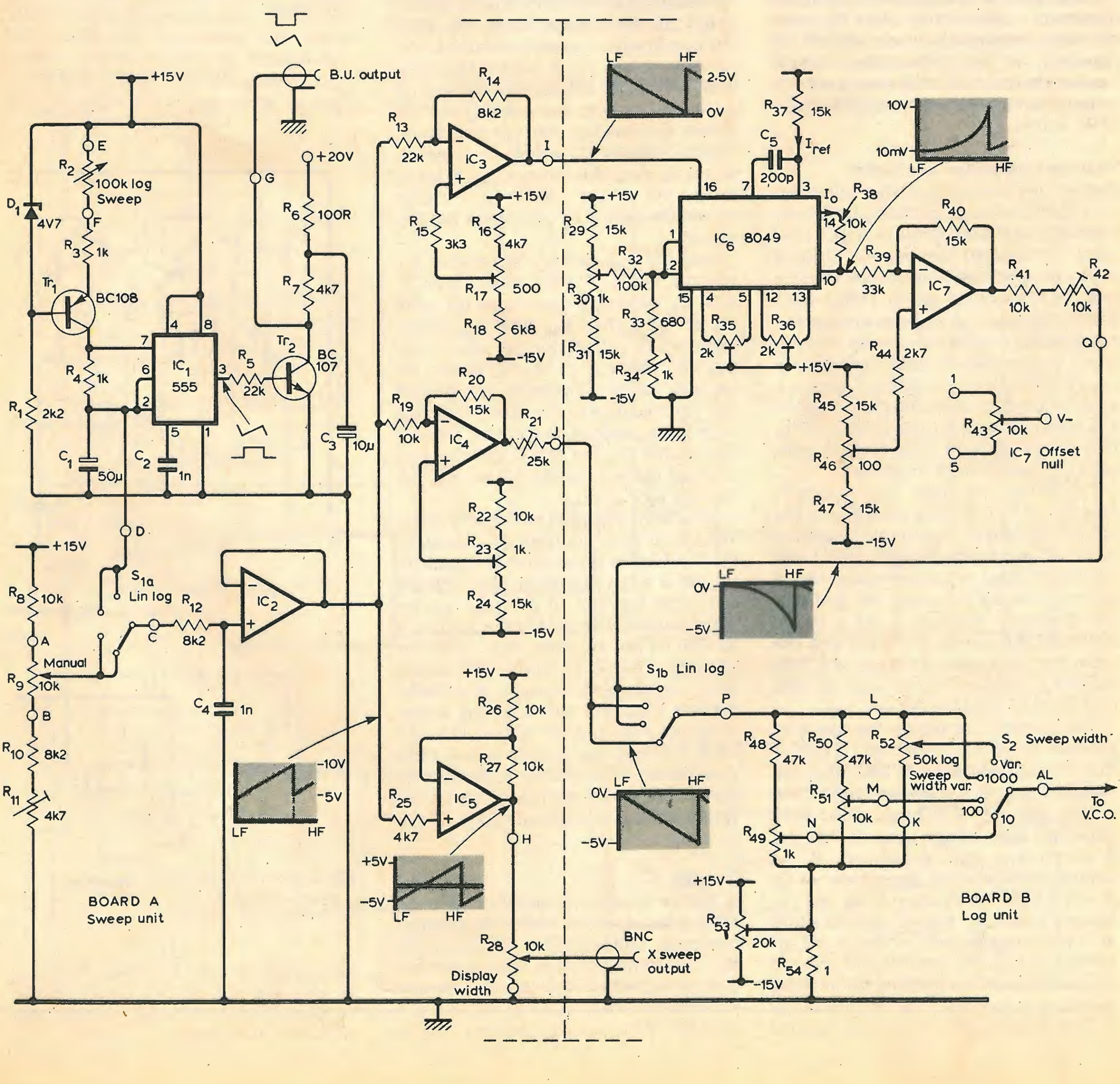


Fig. 2. *Ramp generator, logarithmic amplifier and sweep-width control. Letter code on connexions refers to author's p.c.b. layout. This may be made available if there is a demand.*

calibration to be less than this, and producing a 10^3 output range from the 2-5V input range. The 1mA reference current for the device is produced by R_{37} from the +15V rail.

The output from the package is obtained from one end of R_{38} — the external feedback resistor for the second internal op. amp. IC_7 is a level translator and inverter, putting the sweep into a 5V range, negative going, starting at 0V as is the case with the output of IC_4, the LIN sweep. R_{46} trims the l.f. end of the log. sweep with R_{42} setting the h.f. end to be in line with that set by R_{21}.

Sweep width. Both lin. and log, sweeps as selected by S_{1b} are negative-going from 0V over a 5V range. The sweep width selector, S_2, is connected to attenuators R_{48}/R_{49}, R_{50}/R_{51} and R_{52} to give control of the total sweep range, reducing the sweep to -50mV in the first instance for a 10:1 sweep and -500mV in the second for a 100:1 sweep. The variable sweep with control, R_{52}, gives continuous control up to a ratio of 1000:1; it is a log. component for maximum controllability. With R_{52} at its minimum setting, the v.c.o. should be running at its minimum sweep frequency. To trim this accurately, a pedestal voltage is applied to the bottom of R_{52} across R_{54}.

Voltage controlled oscillator

Rather than attempt to design a discrete v.c.o. (which would probably take the form of controlled astable with sine-wave conversion) the popular Intersil 8038 v.c.o. package was chosen for this unit. It is specified up to 1MHz with 1000.1 sweep and so appears to meet the requirements. However, even Intersil admit that operation with 1000:1 sweep range is full of problems and an application note breadboard certainly will not meet the intended specification. It is worth taking a little time to consider the operation of the device.

The 8038 contains two current sources, one producing a current I, the other, a current $2I$. The timing capacitor on pin 10 is initially charged with I and then discharged at a threshold by the $2I$ generator being switched on, giving a net discharge current, I. At a lower threshold the process reverses and the capacitor once again charges at I. The resulting symmetrical triangle is sine converted to yield the output.

The current I is set by the value of external resistors connected to pins 4 (for the constant source) and 5 for the switched source. Figure 4(a) shows the current generators internal to the 8038 which are also voltage controlled by pin 8, common to both generators. If the control voltage is $-V$, the emitter of Q_1 is $-(V+V_{be})$, the emitter of Q_2 and Q_3, being a single V_{be} higher, are therefore at $-V$. Unfortunately, there is no inherent feedback over this current-control mechanism internal to the 8038, resulting in unpredictable compression at low frequencies when the control voltage is approaching the 0V rail.

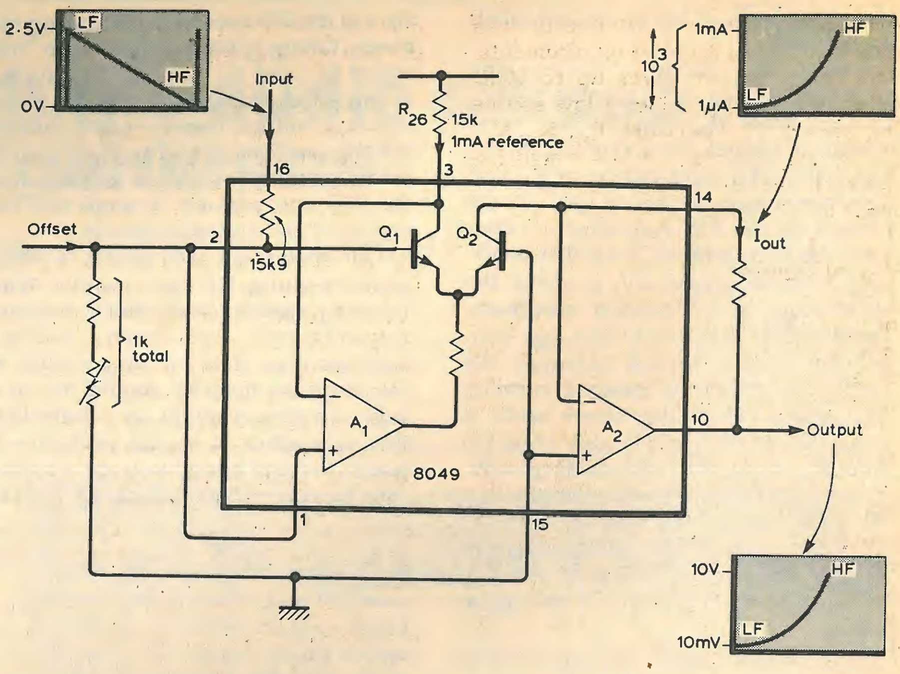


Fig. 3. *Principle of Intersil antilog. amplifier.*

By adding an op.-amp. round the internal current source; as in Fig. 4(b), this non-linearity is easily removed. The op.-amp. drives pin 8, taking feedback from pin 4, and forcing the voltage on pin 4, and current through R_{59} etc., to follow the control voltage precisely. Figure 5 shows D_2 which, in practice, serves to stop the control pin 8 being forced out of the linear v.c.o. range should the device be overswept for any reason.

Each of the four start frequencies are selected by S_3, START FREQUENCY, with S_{3a} selecting capacitors for each range. Switches S_{3b} and S_{3c} select appropriate calibration presets, enabling the symmetry to be individually set on each range. Symmetry can be lost due to unbalance of the current sources at low frequencies as control voltage approaches 0V, but this is corrected by drawing current on pin 5 with R_{67}, adjustable by R_{68}.

Internally, the 8038 buffers capacitor voltage to give the triangle output on pin 3, while an uncommitted transistor on pin 9 is switched by the charge/discharge flip-flop to give the square wave output. The sine wave output is produced by feeding the buffered triangle through an active attenuator with increasing attenuation as the level departs from the mean, giving a surprisingly pure output of less than 1% t.h.d. A preset, R_{72}, is used to make this non-linear attenuation symmetrical about the mean, giving symmetrical positive and negative half cycles.

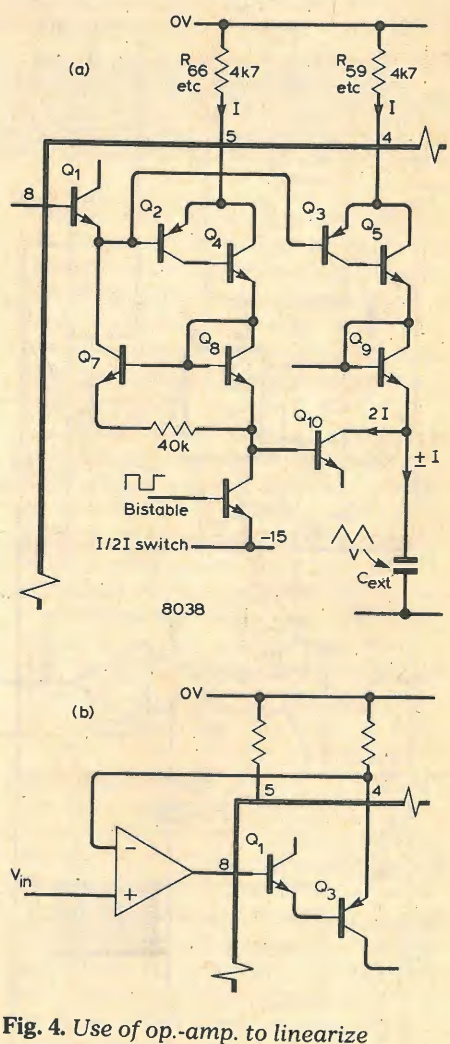


Fig. 4. *Use of op.-amp. to linearize output of 8038 v.c.o.*

Output

A simple push-pull amplifier delivers 10Vp-p into loads of 600Ω with minimal distortion and excellent flatness over the frequency range. The function switch, S_4, selects the appropriate output from the 8038, centred about a d.c. level of —7.5V, via appropriate resistors to equalize the gain. Feedback from R_{110} is also applied at the input of the amplifier. R_{82} serves to correct any zero effect that may occur.

Attenuator. A simple attenuator was judged to suffice for most requirements. The design shown gives up to 60dB attenuation and provides a low source impedance. The network R_{91}, R_{92}, C_{12}, C_{13} and R_{98} compose a RIAA weighting network, which enables checks to be made on pickup equalizers, etc.

Power supply

The instrument requires ±15V at around 125mA. Monolithic fixed voltage regulators are suitable, but the design shown uses two 723 packaged regulators with external pass transistors and with R_{101} and R_{107} setting the positive and negative rails respectively. A +20V supply is also provided for the b.u. amplifier. Clearly, any regulated power supply can be used but, since the calibration is very dependent on the supply rails, good long term stability is important. Hindsight makes the author favour monolithic regulators.

Construction

The prototype was built in a West Hyde 'Contil' case, approximately 10.5in × 4.5in panel size. Doubtless, the more patient could build the design on Veroboard — there is nothing especially critical — but p.c.bs are to be recommended. Five small boards were used in the prototype, as follows:

Board A sweep	4.5 × 3.5in
Board B log.	5 × 2.5in
Board C v.c.o.	3.75 × 2.5in
Board D output amp.	4 × 2in
Board E p.s.u.	3.5 × 3.25in

Care should be taken to avoid earth loops, which would give spurious output and affect v.c.o. control. A layout problem can occur with the edge of the squarewave breaking through to SINE. or TRIANGLE and producing a small pip at top and bottom. Should this occur in individual instruments the easiest cure is to use a spare pair of contacts on S_4 to connect 100nF between the square signal lead at this switch to ground on all but the SQUARE setting of the switch.

It is recommended that all presets be cermet and resistors 5 per cent film types, 1/3W being adequate. However, in view of the extended l.f. range of a log. sweep, an error of perhaps only a fraction of a per cent of full sweep is shown as a considerable portion of the X axis. To avoid errors here, it is essential to ensure low drift in IC_7. Good quality resistors must be used, preferably the metal-film type for R_{45} and R_{47}. The preset R_{46} was a miniature 15-turn type in the prototype, stuck behind a small hole in the panel with Araldite. It is simple to set the low-frequency end of the sweep to the correct frequency with this preset, should the calibration drift.

Setting up

There are many preset adjustments in the instrument and the use of a digital voltmeter is a good idea during the setting-up procedure. Providing good-quality components are used, subsequent calibration should only rarely be needed, and any single adjustment can often be carried out on a working instrument without test equipment.

1. Set R_{53} particularly and all other presets midway. Switch on and set R_{101} to give +15V on the positive rail. R_{107} sets the −15V rail.

2. Switch S_1 to AUTO LIN sweep. Verify that IC_2 gives the waveform shown in Fig. 2 at its output. Leaving the oscilloscope connected, switch to MANUAL LIN. Adjust the manual frequency control, R_9, anticlockwise and set R_{11} to give 5V at IC_2 output.

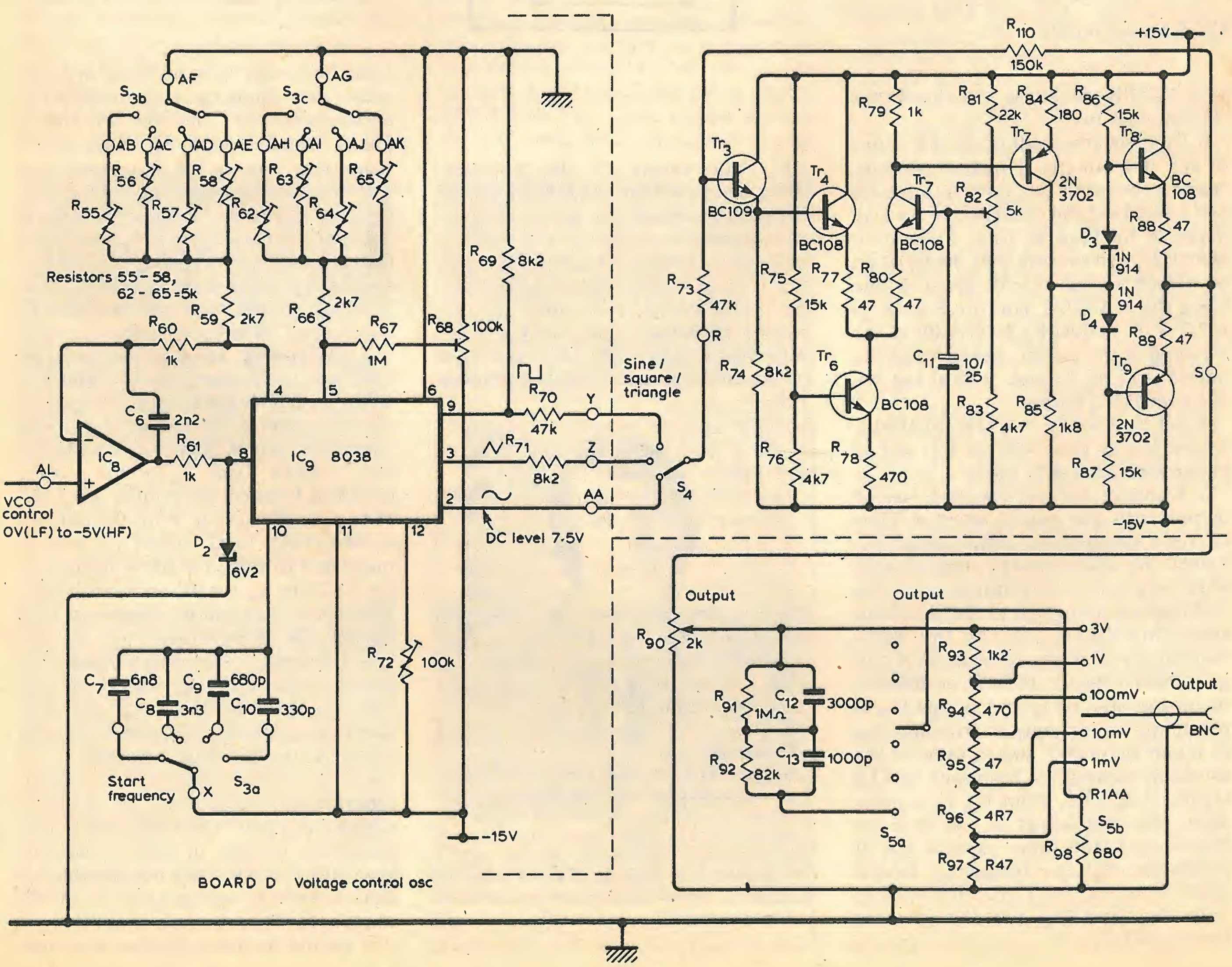


Fig. 5. *Voltage-controlled oscillator and output circuitry.*

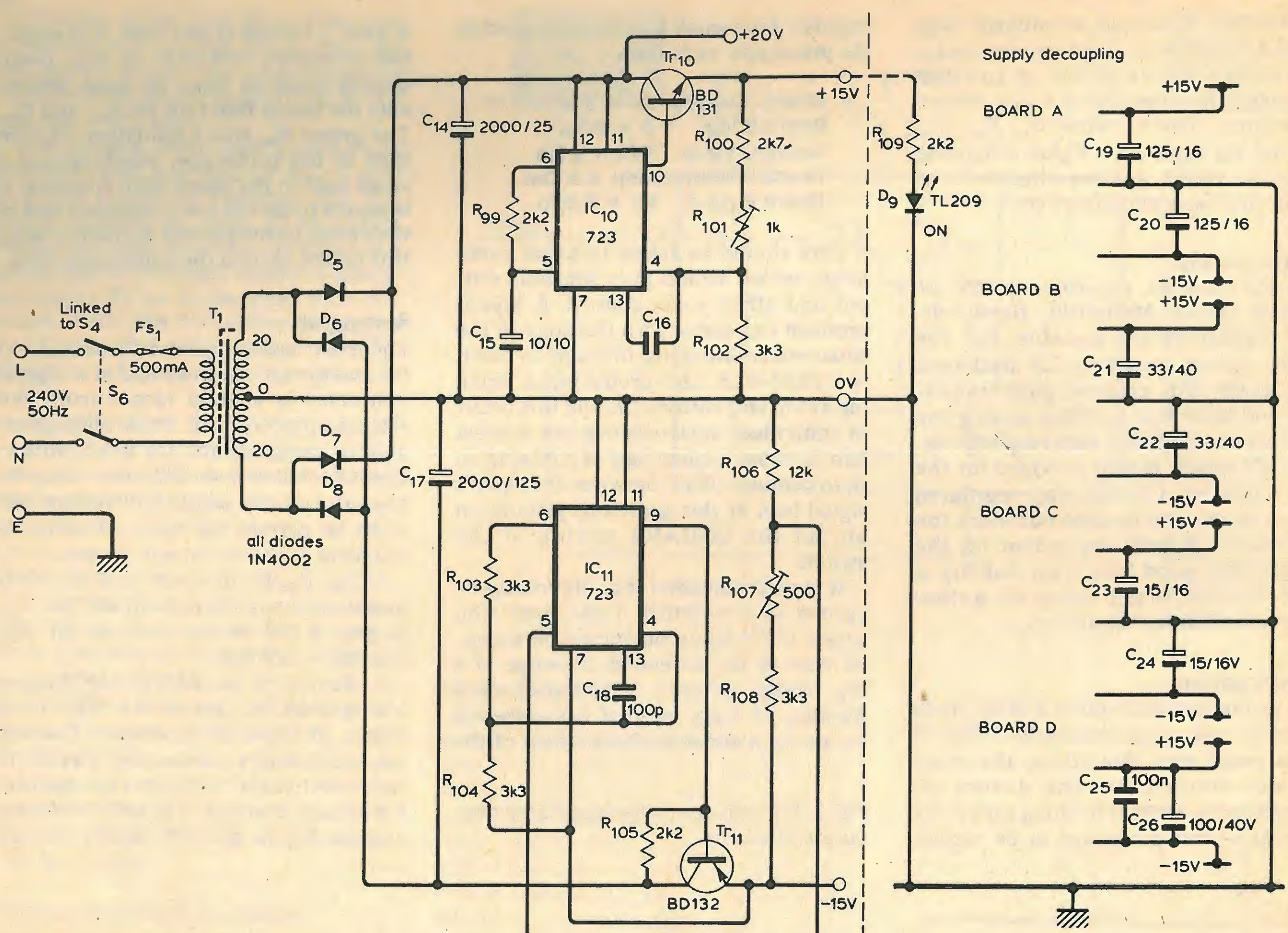


Fig. 6. *Power supply.*

Turn R_9 fully clockwise and check that IC_2 output is 10V.

3. Connect the oscilloscope's X input to the instrument X output socket, connect the bright-up, switch to AUTO LIN and adjust the oscilloscope for a 10 division horizontal line. Switch to MANUAL and confirm that the spot can be placed within the 10 division line using the MANUAL control. Switch to AUTO LIN. Adjust R_{23} to give 0V at the zero end of the sweep, measured at IC_4 output, and R_{17} to give zero at the h.f. end seen at IC_3 output.

4. Set S_2, SWEEP WIDTH, to 1000:1. Adjust R_{21} to give $-5V$ at h.f. end of sweep measured at S_2 wiper.

5. Connect the oscilloscope to the output, with sine output selected. Trim R_{82} for a symmetrical output about 0V. Select the square-wave output and, with R_{52} set a maximum, and the oscilloscope connected to the X output, select MANUAL LIN. At the high-frequency end of the ranges, set R_{21} to give 10kHz, 20kHz, 100kHz or 200kHz. At the low-frequency end, adjust R_{23} to obtain the correct output, trimming R_{68} to retain symmetry and to prevent the oscillator locking up. Approach this l.f. setting with care. Trim R_{52} to a minimum now and adjust R_{53} so that the frequency is the same as with R_{52} at maximum. Set the frequency to h.f. again, selecting 100.1 and 10.1 sweeps. Trim R_{51} and R_{49} for the correct frequencies.

6. Each range of the voltage-controlled oscillator has presets for the charging current.

start frequency	
10Hz	R_{55} and R_{62}
20Hz	R_{56} and R_{63}
100Hz	R_{57} and R_{64}
200Hz	R_{58} and R_{65}

Whichever range has been used for calibration this far is finally trimmed at a mid frequency to be perfectly symmetrical (view single cycle of square wave on oscilloscope). Then the h.f. end is finally trimmed with R_{21}. Each other range now has its h.f. frequency and symmetry set by adjusting the relevant presets together. Finally R_{68} (low frequency symmetry) is checked. R_{72} is trimmed for best wave shape (+ and — symmetry) on pin 2 of the 8038. Repeat 3, 4 and 5, paying particular attention to accuracy of low frequencies.

7. The antilog. amplifier can now be trimmed. Disconnect pin 16 from IC_3 output. Connect pin 16 to +15V. Adjust R_{36} for exactly 0V out (use d.u.m.). Disconnect pin 16 from +15V and connect to earth. Trim R_{30} for 10V output on pin 10. Connect the antilog. amp. pin 16 back to IC_3 output. With the unit set to MANUAL LOG, select l.f. end of range and trim R_{34} for 10mV output on pin 10. Trim R_{46} for 0V on wiper of S_{1b}. Then select h.f. end of range and trim R_{42} for $-5V$ on S_{1b} wiper.

8. Recheck 7. On MANUAL LOG check frequency of output at l.f. and trim R_{46} again so that LOG. and LIN. operation coincides. Similarly trim R_{42} so that h.f. end of range coincides.

Operation

Operation is quite self-explanatory. It is important to bear in mind, however, that high-Q circuits are not suitable for swift sweeps. It is always easy to switch to manual sweep to verify a display.

It should be quite obvious that only

The author
Alan Ainslie studied electronic engineering at Sheffield Polytechnic and Brunel University, before forming an electronic design consultancy in the fields of audio and instrumentation. He has published over thirty articles and is engaged in writing two books on computer programming.

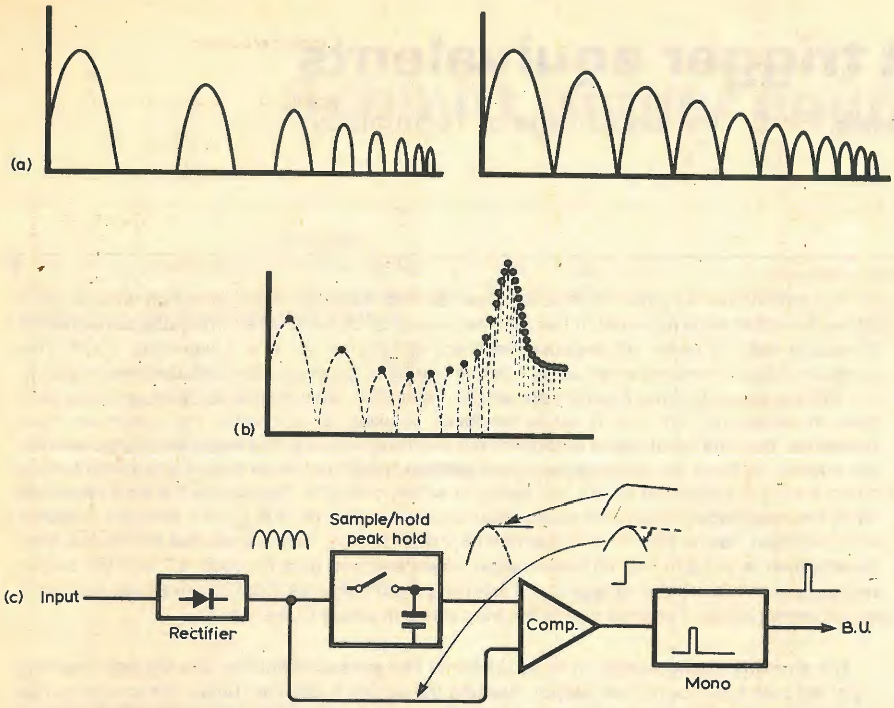


Fig. 7. *Full-wave rectifier improves appearance and resolution at l.f. end of sweep, as at (a). Display at (b) shows trace obtained when bright-up is at peaks of response only, dots being extended to a continuous line by sample/hold arrangement of (c).*

the sine wave output is suitable for sweeping to display a frequency response. It is important if sweeping a highly-sensitive filter, for example, to remember that the t.h.d. is worse than 0.1% (60dB down). This can lead to false rejection figures if a wide dynamic range, in the order of 60dB, is used in the display. Normally, however, the output signal purity is more than adequate.

Display

The simplest display technique is to use the top of the envelope displayed on the oscilloscope as the frequency response plot. Photographic records can be particularly satisfactory if the exposure covers several sweeps, since the sweep and v.c.o. are not synchronous. However, there are several options open to improve the display which will be discussed below.

Precision full wave rectifier. This effectively doubles the number of points on the display, and improves resolution dramatically at the l.f. end of the display as seen in Fig. 7(a). However, the circuitry used has to accommodate the dynamic range of the output of the unit under test and have a flat frequency response over the bandwidth in question: simple op.-amp. full-wave rectifiers run into the usual slew rate problems at higher frequencies.

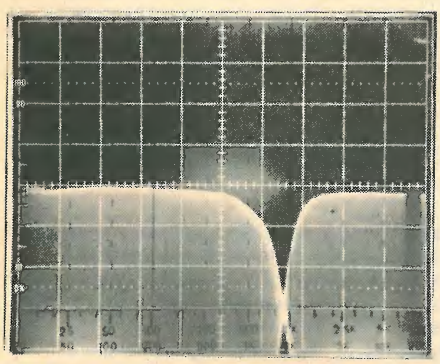


Fig. 8. *Swept display of a t.h.d. meter, set to 1kHz. In the final stages of calibration, an accurately-calibrated notch filter is useful for setting the scale factors.*

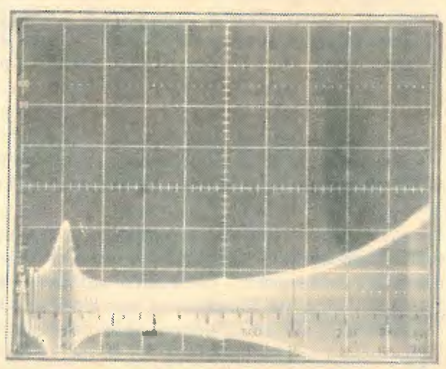


Fig. 10. *Impedance sweep of 8in bass driver in free space. Resonance is at 50Hz.*

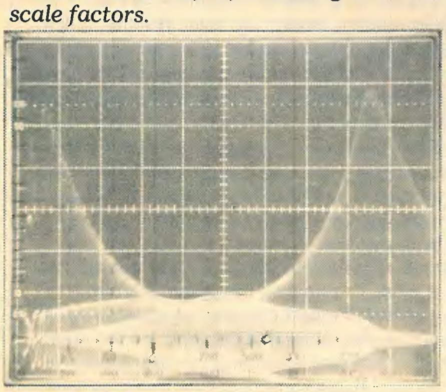


Fig. 9. *Tone control and filter responses of an audio amplifier.*

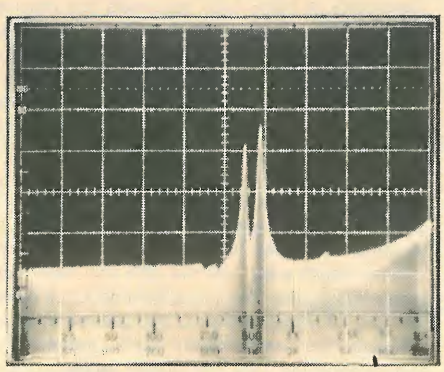


Fig. 11. *Impedance sweep of small treble unit.*

Bright up at signal peaks. By generating the bright up from the output of the device under test, so that for each peak the c.r.o. is under bright up for a small period of time, the display is comprised of a series of dots representing the response curve. As above, a full-wave rectifier doubles the resolution of the display. The result is as in Fig. 7(b).

Unfortunately, due to unpredictable phase shifts through the unit under test, which will probably vary with frequency, it is not possible to generate bright up from the sweeper, only the output of the unit under test as in Fig. 7(c). It is possible, using this technique, to display phase on the c.r.o. by using a constant-phase bright up.

Sample hold. By using a sample-hold to retain peak value, modifying this level with each subsequent cycle, the c.r.o. can be made to display a continuous envelope of response. This is possibly the most attractive display method but has the dynamic range and speed problems mentioned earlier.

Phase-locked loop. A phase-locked loop can be used to cause an oscillator to track the output of the unit under test and may be then used to bright up peaks. An 8038 is suitable for this task with a phase comparator, since the squarewave phase is suitable for generating the bright up without modification, or driving a sample/hold.

An interesting aspect of this technique is that it is possible to record the sweep on tape for example and play back after a delay to drive the scope display.

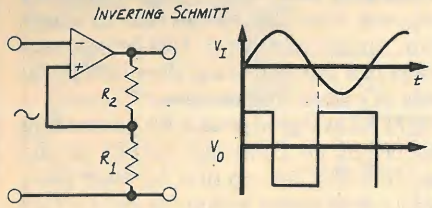
Log. amplitude display. Audio responses are usually displayed with a logarithmic vertical scale. This can be easily arranged with the Intersil 8048 log. amplifier package. a 10^3 range is easily accommodated with no requirements for temperature compensation.

It is obvious from the above discussion that many possibilities exist for an additional unit to assist the display of the information. A possibility not mentioned above, but probably the most useful of all, would be a form of display storage for the slow sweeps. It is the author's intention to complete development of a complementary display and storage unit which will possibly be described at a later date. □

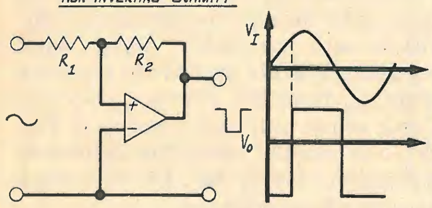
Schmitt trigger equivalents

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

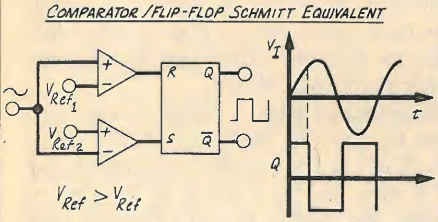
INVERTING SCHMITT



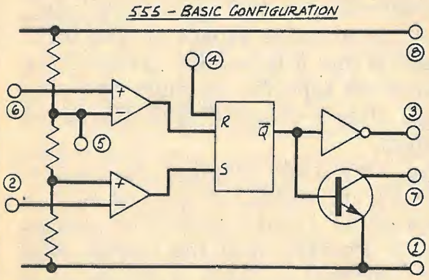
NON-INVERTING SCHMITT



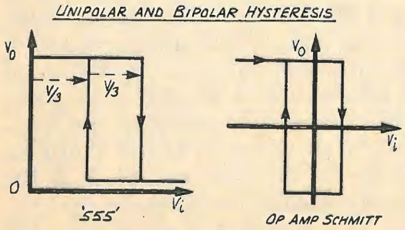
COMPARATOR/FLIP-FLOP SCHMITT EQUIVALENT



555 – BASIC CONFIGURATION



UNIPOLAR AND BIPOLAR HYSTERESIS



'555' OP AMP SCHMITT

The operational amplifier is used in linear circuits because of the precision with which it allows functions to be provided. It has a limited speed of response when internally compensated to ensure stability under all negative feedback conditions up to and including 100% This constraint can be removed when using positive feedback to switch it through the linear region in the shortest possible time. Even simple amplifiers in their uncompensated state can have slow rates in excess of $10V/\mu s$. If series feedback is used, as is needed for maximum input resistance, then the input signal is taken to the inverting input i.e. the amplifier connections are the reverse of those for a series negative-feedback amplifier. With recent amplifiers having c.m.o.s. output stages the output can swing to within millivolts. Failing this the time switching levels become proportional to the output saturated levels $[R_1/(R_1+R_2)](\pm V)$. With the output at $+V_0$ the input has no effect if it is less than $[R_1/(R_1+R_2)]\,V_0$. When it reaches this critical level the amplifier is brought into its linear range where the loop gain exceeds $+1$ and the output swings negative (since the voltage at the inverting input becomes more positive than that at the non-inverting input). For large inputs the output is anti-phase to the input.

The alternate configuration, in form similar to the see-saw amplifier, has the non-inverting input fed from both source and output. Assume the output is positive; unless the source swings sufficiently negative the output remains in this saturated state. When the threshold is reached the non-inverting input becomes more negative than the inverting input, the output swings negative and regenerative switching ensues, forcing the output to its most negative value. The source has no further influence until it becomes sufficiently positive to overcome the negative contribution of the output. The threshold levels are obtained by applying superposition to determine when the non-inverting input is driven through zero. This gives threshold levels $(-R/R_2)\,(\pm V_0)$. Again for stability of switching levels the output swing must be well-defined: if this is not inherent in the amplifier output stage as is the c.m.o.s. types then breakdown diode or other clamping methods can be applied. In this circuit the current drawn from the source is significant and in particular experiences a sharp step as the output switches. This makes the inverting form more widely useful.

The same function can be performed by the Schmitt trigger and an appropriate combination of comparators and a set-reset flip-flop. Other advantages need to be established in return for the apparent increase in complexity; the word apparent is included because the number of elements in a complete i.c. using this method is surprisingly small. Each comparator contains far fewer components than an op. amp. as the output it has to provide is both smaller and better defined — just sufficient current to set or reset a simple flip-flop. The last-mentioned needs to be reasonably fast but has a defined input and is buffered by an output stage so that it has few components. Thus for comparable performance to the Schmitt trigger based on an op.amp., this form can be simpler. Compared with a single high-speed comparator used with positive feedback it is slower, but much more flexible in that the thresholds can be precisely set and controlled. When the input goes more positive than $V_{REF\,1}$ the output of the comparator 1 resets the Q output to logic 0. It remains in this condition until the input swings more negative than $V_{REF\,2}$ when the second comparator sets the Q output to logic 1.

The first commercial i.c. embodying these ideas has since become the industrial standard. Designed by Signetics for mass production it is arguably the first universal successor to the operational amplifier — a circuit of sufficient flexibility to permit a very wide range of functions. In addition to the comparators and flip-flop it contains an inverting output stage which is t.t.l. compatible and an additional open-collector output. The inversion leads to the use of the Q connection of the flip-flop to retain the same overall phasing. By connecting the comparator inputs to tappings on a chain of equal resistors the reference levels are set at $V_S/3$ and $V_S/3$ respectively. The top comparator input is brought out to a separate pin 5 for decoupling against transients on the supply for changing the threshold levels while retaining a 2:1 ratio, or for modulating the switching points. Another re-set terminal to the flip-flop 4 allows its timing cycle to be over-ridden, as for example when synchronizing to a higher-frequency source. The availability of these extra terminals has inspired a continuing stream of novel designs. It is a challenge to the ingenuity of designers, while because of its low cost it has to be considered for even the simplest of monostable and astable functions.

The similarity between the operational amplifier and comparator/flip-flop forms is sometimes obscured by the different voltage levels. The op-amp. normally functions from dual polarity supplies, while the 555 and similar circuits are designed for single-supply operation (for compatibility with logic circuits and battery powered systems where two batteries are inconvenient). The difference is illustrated by considering the hysteresis of each circuit. The graph of output against input is traced out as the input first increases through the upper threshold and then back through the lower threshold. The output takes up only one of two values in each case. For the 555 the lower value is close to zero and the upper is around 1V below the supply. The transitions occur as the input passes through the positive voltages $V_S/3$ and $2V_S/3$, independent of the precise output levels. If the op.amp. is adjusted for the same hysteresis the thresholds are spaced equally on either side of zero (assuming the output positive and negative saturation levels are equal).

Schmitt trigger equivalents

THEORY

● Let the saturated output voltages be V_A, V_B where $V_A > V_B$ and where $V_A \rightarrow +V_S$, $V_B \rightarrow -V_S$ for standard op-amps. The two values of voltage at the non-inverting inputs are thus

$$V_1 = \frac{V_A R_1}{(R_1+R_2)} \text{ and } V_2 = \frac{V_B R_1}{R_1+R_2}.$$

These define the corresponding levels on the input wave at which the amplifier is driven into its linear region, raising the loop gain and initiating the switching action.
Typically

$$V_1 \approx \frac{R_1}{R_1+R_2} \cdot (+13)$$

$$V_2 \approx \frac{R_1}{R_1+R_2} \cdot (-13)$$

for a typical op.amp. operating from $\pm 15V$ supplies.

Certain comparators operating from a single-ended supply of say $+10V$ and have outputs capable of swinging between 0 and $+10V$, i.e. the thresholds are

$$V_1 = \frac{R_1}{R_1+R_2} \cdot 10$$

$$V_2 = 0$$

In all cases $$V_1 - V_2 = \frac{R_1}{R_1+R_2}(V_A - V_B)$$

where $V_1 - V_2 = \Delta V_{in}$ referred to as the hysteresis is a defined fraction of the change in output.

$$\text{i.e. } \Delta V_{in} = \frac{R_1}{R_1+R_2}\Delta V_{out}$$

● For the non-inverting Schmitt the thresholds again correspond to the points at which the amplifier is driven into its linear region i.e. when

$$\frac{V_1}{R_1} + \frac{V_B}{R_2} = 0$$

$$V_1 = \frac{-R_1}{R_2}V_B$$

$$V_2 = \frac{-R_1}{R_2}V_A$$

$$\Delta V_{in} = V_1 - V_2 = \frac{R_1}{R_2}(V_A - V_B)$$

Note that the input thresholds are of opposite polarity to the output voltage.

● The thresholds for the comparator/flip-flop combination are defined by a pair of independent threshold voltages

$$\text{i.e. } \Delta V = V_1 - V_2 = V_{Ref\,1} - V_{Ref\,2}$$

In certain cases it is convenient to apply the signal to one or both of the inputs via potentiometers so that $V_1 = k_1 V_{ref\,1}$, $V_2 = k_2 V_{ref\,2}$ of the signal transmitted by the potentiometers. This allows independent control of the hysteresis for fixed values of $V_{Ref\,1}$, $V_{Ref\,2}$.

● For this i.c. the reference levels are defined by a potential divider composed of three equal resistors, and the circuit normally operates from a single supply $+V_S$.

$$\therefore V_{Ref\,1} = \frac{2V_S}{3}$$

$$V_{Ref\,2} = V_S/3$$

The hysteresis $\Delta V = V_S/3$

Each of these terms is independent of any imperfections on the output stage that prevent the output swinging between 0 and $+V_S$.

EXAMPLES

1. A comparator has saturated output voltages V_A and V_B of $+12$ and $-11V$. For $R_2 = 20R_1$, in an inverting Schmitt determine the switching thresholds V_1 and V_2 and the hysteresis $V_1 - V_2$.

$$V_1 = \frac{R_1}{R_1+R_2} \cdot 12$$

$$= \frac{1}{20+1} \cdot 12 = \frac{12}{21} = 0.57V$$

$$V_2 = \frac{R_1}{R_1+R_2} \cdot (-11) = -0.52V$$

$$V_1 - V_2 = \frac{12-(-11)}{21} = \frac{23}{21} = 1.09V$$

2. Find the corresponding figures for the non-inverting Schmitt.

$$V_1 = \frac{-R_1}{R_2} \cdot (-11)$$

$$= \frac{11}{20} = 0.55V$$

$$V_2 = -\frac{R}{R} \cdot 12 = -\frac{12}{20} = -0.6V$$

$$V_1 - V_2 = 1.11V$$

3. With the component values of Ex. 1 determine the phase angles at which switching occurs for an input sinusoidal wave of 1V r.m.s.

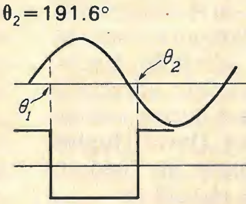
$V_1 = \sqrt{2}\sin\theta$

$\therefore$ switching takes place at V_1, V_2 where

$V_1 = 0.57 = \sqrt{2} \cdot \sin\theta$

$\therefore \sin\theta_1 = \frac{0.57}{\sqrt{2}}$ similarly $\sin\theta_2 = \frac{-0.52}{\sqrt{2}}$

$\therefore \theta_1 = 23.8°$ $\theta_2 = 191.6°$



4. A comparator/flip-flop combination has switching thresholds defined by a potential divider of three equal resistors placed across the supply lines of 0 and $+10V$. The input waveform is sinusoidal and initiates the switching action at phase angles of 30° and 240°. Find the mean and peak-peak values of the waveform.

Let the input be $V_m + V$ sine

The switch thresholds are $V_1 = \frac{2}{3}V$ and $V_2 = \frac{1}{3}V$

because of the given resistor values.

$$\therefore V_{av} + V\sin\theta_1 = \frac{2V}{3}$$

$$V_{av} + V\sin 30 = \frac{20}{3}$$

Similarly $$V_{av} + V\sin 240 = \frac{10}{3}$$

Subtracting, $V(\sin 30 - \sin 240) = 10/3$

$$V = \frac{10}{3\left(\frac{1}{2} + \frac{\sqrt{3}}{2}\right)}$$

$$= 3.85V$$

$\therefore$ Peak-to-peak value of sine wave $= 7.7V$

$$V_{av} + 7.7\sin 30 = 20/3$$

$$V_{av} = 6.67 - 3.85 = 2.82V$$

Mean value of input $= 2.82V$

WORLD OF AMATEUR RADIO

Century of amateur radio?

Few people think of 1979 as the centenary of amateur radio, yet a good case could be advanced in support of the view (put forward in the late John Clarricoats, G6CL "World at their fingertips") that "Britain's first radio amateur" was London-born, American-educated David E. Hughes, one-time professor of music but also a noted inventor of microphones and mechanical telegraphy systems. In 1879 Huges could have been found walking up and down Great Portland Street, London listening on a telephone earpiece and a detector consisting of a steel needle in loose contact with a piece of coke to clockwork-interrupted signals from a transmitter some 500 yards away. His experiments were virtually a discovery of Hertzian waves before Hertz, of the coherer before Branley and of wireless telegraphy before Marconi, as the *Globe* newspaper was later to record.

Hughes was convinced that his signalling was due to "aerial electric waves" but he was profoundly discouraged by an inability to convince well-known scientists, claiming in February 1890 that his experiments were "pooh-poohed" in an "unpleasant discussion" which ended with the scientists departing "very coldly." Even earlier than Hughes had been the efforts of an American dentist Dr Mahlon Loomis who in 1865 claimed to have spanned a distance of 18 miles using a kite "aerial" (it was Loomis who first named the aerial). It was left to Marconi to turn the whole host of early work by Hertz, Lodge and many others, into a practical communications system during the decade 1894 to 1904. But David Hughes came very close to this in his "pedestrian mobile" operation in 1879-80.

Polar-loop ssb transmitters

At a 21st anniversary symposium organized by South Midlands Communications Ltd, V. Petrovic of the University of Bath suggested that radio amateurs could benefit from the recent development of the v.m.o.s. power f.e.t. form of polar-loop s.s.b. transmitters (*Electronics Letters*, May 10, 1979). This interesting approach appears to overcome many of the problems of designing and building linear amplifiers of high performance as well as making possible the use of more efficient Class C and Class D amplifiers for all stages of power amplification.

The polar-loop technique is based on a form of s.s.b. transmission by envelope elimination and restoration orginally proposed by Leonard Kahn in 1951 *(Proc IRE*, July 1952). However the team at Bath University has combined the Kahn approach of splitting the s.s.b. signal at low level into its phase-modulated component and then restoring the amplitude envelope only in the final power amplifier stage with newly developed modulation techniques and the use of feedback to improve linearity. This has resulted in h.f. and v.h.f. (99.5MHz) s.s.b. transmitters with outputs of 20W and 13W respectively, with third-order intermodulation products typically over 50dB down on p.e.p. and power efficiency in excess of 55 per cent.

It is claimed that the r.f. circuits, using a combination of v.m.o.s. and bipolar devices are exceptionally simple, and can include Class C frequency multipliers. It is also suggested that the feedback arrangement makes the equipment unusually insensitive to power-supply variations, tuning, change of components and does not require criticial setting up; all these are characteristics of particular interest to an amateur building his own equipment. While the system is the subject of a patent application, V. Petrovic made it clear that there is no objection to the use of these techniques in home-built equipment.

The use of v.m.o.s. r.f. devices is becoming much more attractive to amateurs with the appearance of relatively low-cost devices such as the Siliconix VN88AF and VN67AJ. Work at Bath has shown that while v.m.o.s. successfully overcomes many of the destructive problems associated with bipolar transistor power amplifiers, care is still needed to avoid, for example, destruction of devices by the use of too high bias resistors. The v.m.o.s. amplifiers however are extremely easy to bias and can also be neutralised using traditional valve neutralising circuits in either single-ended or push-pull form.

Spanning the bands

A.R.R.L., commenting recently on the continuing problem of the Russian 'Woodpecker' over-the-horizon radar interference to communications, stated: "despite numerous complaints to the FCC by the users of several radio services in the United States, and despite the fact that the US State Department has been involved in this matter for nearly three years, the interference persists." The League suggests that American amateurs suffering from the interference should write to the Monitoring Branch of FCC at Washington DC.

During March a number of Australian amateurs worked N6CT and W6XJ in California on 52MHz, the first Australian-USA 50MHz contacts to be recorded in Solar Cycle 21. During January 7-11 many 144MHz and some 432MHz contacts were made across the Tasman sea between Australia and New Zealand. Late in June it appeared that the second of the four predicted peaks of Cycle 21 had been passed with the last two peaks expected in late-Autumn and early 1980.

The IARU Region 1 v.h.f. "records" suggest that it is becoming increasingly difficult to set up new "tropo" propagation records from the UK. Favoured stations would appear to be those along the Mediterranean where for example the 1977 144MHz contact between Israel and Malta spanned 1964km – and could conceivably be extended to the Tunisian coast or even Spain, comparable to the sea-path ducts that have occasionally occurred between Hawaii and California.

In brief

Listeners registered as members of the BBC World Radio Club have passed the 38,000 mark .... The next Radio Amateurs' Examination will be held on Monday, December 3, 1979 .... FCC has confirmed its decision not to issue special-event amateur station licences .... Bill Leonard, W2SKE, has been named president of CBS-TV news .... Amateurs in Spain, Balearic Islands, Canary Islands and Spanish Morocco have been granted permission to operate in the frequency band 1820-1835kHz while the USSR is opening the band 1850-1950kHz to amateurs .... The Italian amateur, Fausto Minardi, I4EAT, has contacted 50 countries on 144MHz using tropo, moonbounce, meteor scatter, Sporadic-E and auroral modes .... Angus McKenzie, the well-known blind amateur (G3OSS) and audio consultant, received an M.B.E. in the Queen's Birthday Honours List for his services to audio research, the blind and disabled .... A Morse recording "ad astra per aspera" made by W. R. Schoppe, WB2FWS, was included on space probes Voyager 1 and 2 .... There seems little likelihood of any further operation through the two Russian amateur satellites RS1 and RS2 following telemetry indications of battery troubles .... Mobile rallies include: August 26 Torbay Mobile Rally at Paignton; September 9 Telford Mobile Rally; September 16 Peterborough; September 30 Harlow.

PAT HAWKER, G3VA

Sidebands as phasors

Depicting the mechanism of modulation: 1 — a.m., d.s.b. and s.s.b.

by **J. M. Osborne,** M.A., F. Inst.P., South London Science Centre

The phasor is a useful visual aid to understanding sidebands that bridges the gap between simple amplitude/frequency graphs, as seen on a spectrum analyser, and the rigorous mathematical expressions from which they come. This first article, dealing with amplitude modulation, outlines the principles of phasor representations of carriers and sidebands, then illustrates points such as why carrier re-insertion in s.s.b. is not critical while in d.s.b. it is near impossible. A second article will deal with phasor representation of sidebands in frequency modulation.

FOR MOST electronic engineers who have to deal with modulation, the structure of sidebands in a.m., s.s.b. and d.s.b. is well recognized. The direct mathematical approach is well within the (university or poly) student's grasp. The requisite manipulation of trig. functions is relatively elementary. The same cannot be said of frequency modulation. The consequences of rather involved mathematics (see later for Bessel functions) show that we have sidebands stretching to infinity. Text books tell us that in practice we need not have infinite bandwidth since the more remote sidebands are likely to be negligibly small.

If we frequency modulate a carrier by 50kHz above and below the unmodulated carrier frequency, intuitively we might suppose that 100kHz bandwidth would be required. The mathematicians tell us that this naive thinking could be quite erroneous; it happens to be the right approximation for large modulation indices but not true for narrow band f.m. They are right, since their approach is rigorous. Can we lesser mortals understand why? Let us start with a.m. Fig. 1 shows a typical a.m. signal of 1MHz carrier 100% amplitude modulated with a 1kHz audio note.

Such an illustration as Fig. 1(b) is used to give an elementary explanation of diode demodulation. This is valuable in, say, the "Beginners book of radio" or "How does a crystal set work?" Fig. 1(a) is more difficult for the beginner but is really the next step in sideband conception. It presents the mathematician's work in a form suitable for considering bandwidth and selectivity in practice. It is easy to visualize the extended form of Fig. 1 when speech or music modulation is imposed on the carrier. I assume that the reader is familiar with the complex waveform seen on a c.r.o. when the y input is fed with an audio signal from a microphone or gramophone pickup; and that this complexity determines the required (audio) frequency response of associated amplifiers, loudspeakers etc. This is shown figuratively in Fig. 2(a) and (b). Here sidebands will be popping up and down like yo-yos. This may be used to discuss the hi-fi limitations of medium wave broadcasts.

What these figures fail to do, and what the mathematicians frequently fail to point out in their results, is the significance of phase. A plausible, though inadequate explanation is that each side band (in Fig. 1) heterodynes (beats with) the carrier to produce the difference frequency (1kHz); the two contributions add to give the required audio output. In particular the real problems of homodyne and synchrodyne reception are missing; the superficial explanations of such techniques along these lines are of little value.

It is at this stage that the phasor comes into its own. The phasor bridges the gap between the simple representation of Fig. 1 (a) and the pure rigorous maths from which it comes (see Appendix). It gives the electronic engineer a visual picture which rationalizes the significance of phase in the more sophisticated techniques of demodulation; e.g. why carrier reinsertion in s.s.b. reception is not critical while in d.s.b. it is near impossible. It also explains why a.m. works without such considerations, since everything starts right (in terms of phase) from the transmitter. When we amplitude modulate the carrier nothing is changed (no synthesized carrier is generated and inserted at the reception end) throughout the communication link. We gloss over selective fading in short-wave reception and its consequent distortion. Not only do 'phasors' rationalize the foregoing but, and this is perhaps the main point of this article, 'phasors' explain in Part 2 'f.m. sidebands'.

The explanation is best started by considering a.m. (see Fig. 3). This also has the spin-off in clarifying the relevance of phase in the examples mentioned above. "The 1MHz sinusoidal (sine wave) carrier has its amplitude varied sinusoidally at the very much lower modulating frequency of 1kHz." Here is the catch for the unwary. The fallacy is in suggesting that the amplitude of a sine wave is changed. This is a nonsense statement. Look at Fig. 4(a) and (b), two sine waves of different amplitude (same

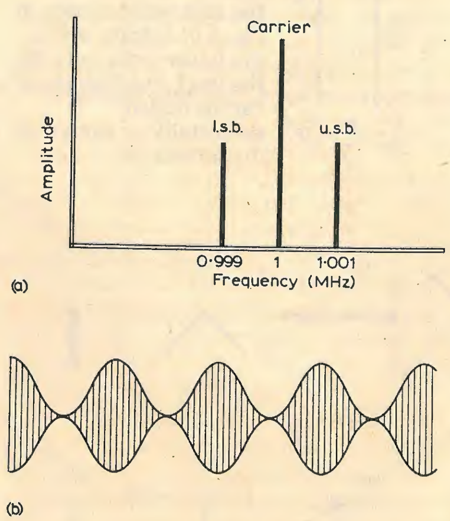


Fig. 1. *(a) One way of representing the sidebands of an a.m. signal consisting of a 1MHz carrier modulated 100% by a 1kHz tone (b).*

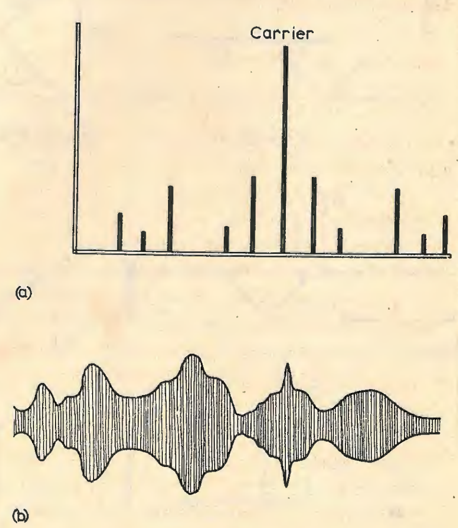


Fig. 2. *(a) Typical pattern of sidebands when a carrier is amplitude modulated by an audio signal from a microphone or pickup (b).*

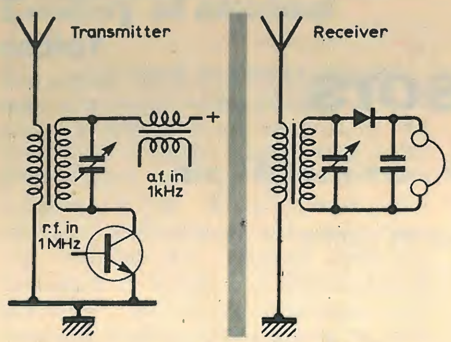


Fig. 3. *Transmitter and receiver using amplitude modulation.*

frequency). Now consider changing from one to the other as in Fig. 4(c), or for that matter in Fig. 1(b). (c) is neither (a) nor (b). At some stage, the shape or slope of (a) must change to get it to (b). While this change is taking place we have no simple sine wave, neither (a) nor (b). (c) is not part of an amplitude modulated "sine" wave.

When is a sine wave not a sine wave? Answer in this case – while it is changing amplitude.

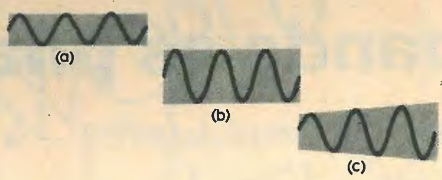


Fig. 4. *During the change from a sine wave of amplitude (a) to a sine wave of amplitude (b), the transitional waveform (c) is not a pure sine wave.*

To remind you of the sine wave, consider a radius, a, in Fig. 5 rotating at Ω_0 radians per second. ($\Omega_0 = 2\pi f_0$ is the revolutions per second or frequency in Hz). If the radius starts horizontally at time zero, rotating anticlockwise, then after t seconds, it makes an angle Ωt. with the horizontal. The projection onto the vertical axis is given by $y = a \sin \Omega t$. If the graph of y against t is plotted we get the familiar sine wave of alternating voltage to y input of c.r.o., with linear (x) timebase, of amplitude a and time for one cycle $1/f_0$. y may represent physical displacement, as in simple harmonic motion, or the instantaneous value of an alternating voltage or current. This is determined by the scale and label of the y axis. t along the x axis is usually chosen to show a few cycles.

The phasor representation of this is shown in Fig. 6(a). This shows a length a representing the generating radius which is supposed to be rotating anticlockwise at the frequency f_0. The attractive feature of this notation is that it shows phase. For example, if two sine waves, equal in amplitude and frequency, of different phases are combined, the resultant can be found by adding vectorially the phasors. This is shown in the examples of Fig. 6(b), (c) and (d); in (b) the signals cancel (180° phase difference) whereas in (d) the amplitude of the resultant is the sum of the two components (in phase), and (c) is an intermediate state of phase difference.

If the two above phasors have differing frequencies f_1 and f_2, instead of f_0, their instantaneous resultant (that is amplitude) will change with their relative phase. Suppose we consider the two sine waves such that f_1 is greater than the reference f_0, f_2 less by the same amount. This shown in Fig. 7 in a series of diagrams showing the time for f_1 to gain one cycle and f_2 to lose one cycle on the reference. Note the suggested modification to the phasor notation to show which way f_1 and f_2 phasors rotate with regard to the reference phasor, frequency f_0. Row 1 shows the two components while row 2 shows successively the instantaneous resultant. Note another suggested notation (double bar) to identify the resultant.

If we now add these to the component of frequency f_0 and amplitude equal to

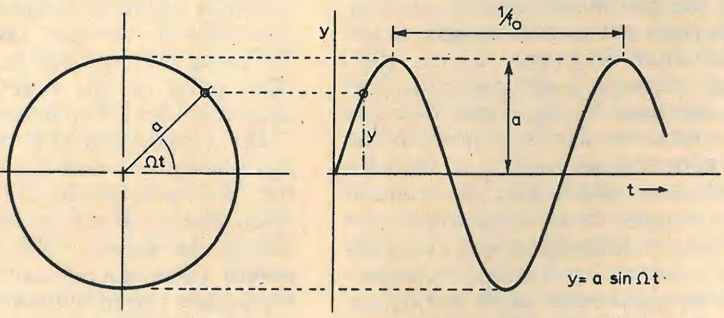


Fig. 5. *Formation of a sine wave y = a sinΩt from a radius, a, rotating at Ω radians per second. Capital omega is used to denote a reference wave. In the Appendix, lower-case omega refers to the modulating wave.*

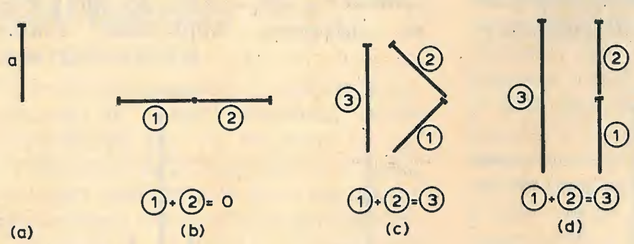
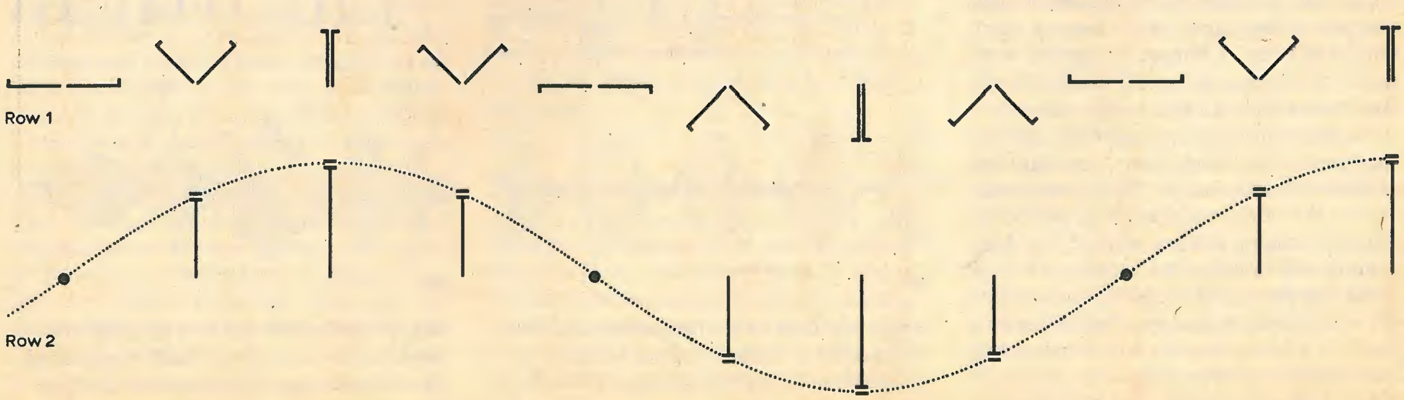


Fig. 6. *At (a) is a phasor representing the sine wave shown in Fig. 5 (it rotates about the lower extremity of the line). Such phasors can be added vectorially as shown in (b), (c) and (d).*

Fig. 7. *Effect of vectorially adding two phasors representing equal amplitudes but different frequencies. Row 1 shows the two phasors separately at successive instants of time (moving right on the page) while row 2 shows the resultants at those instants. (Small bars on moving ends of phasors in row 1 are modified from Fig. 6 to show directions of rotation. The double bars in row 2 identify the phasors as resultants.)* ▼



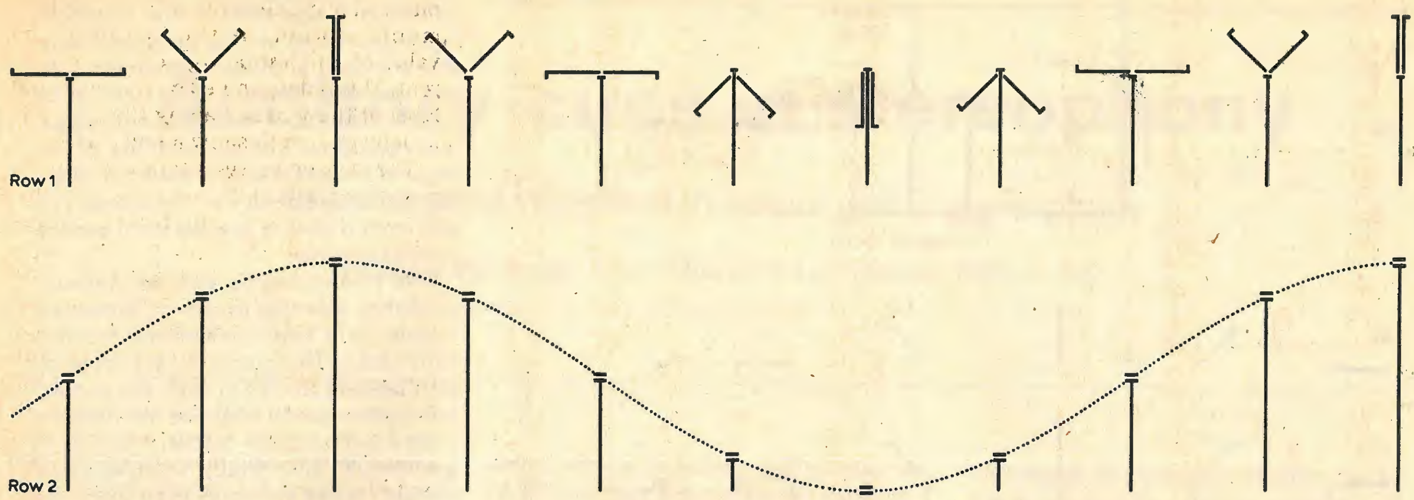


Fig. 8. *The phasors in Fig. 7, representing upper and lower sidebands, are added to a phasor representing a carrier of constant amplitude and phase. Row 1 shows the separate phasors and row 2 the resultants. This demonstrates the carrier being amplitude modulated as a result of adding the sidebands to it.*

the sum of the amplitudes of f_1 and f_2, we obtain the resultant shown in Fig. 8. Note that the instantaneous resultant remains precisely in phase with the reference. What this shows is that if two sine waves f_1 and f_2 are added to the reference sine wave the resultant is of frequency f_0 and amplitude varying at a frequency $f_1 - f_0$ (which is the same as $f_0 - f_2$). Phasors show that an amplitude modulation of a carrier f_0 results from adding to it an upper sideband f_1 and lower sideband f_2, *all three being pure sine waves.*

We can now see Fig. 1 (a) and (b) in terms of sine waves. Also it is not difficult now to visualize that imposing amplitude modulation on a carrier as in Fig. 3 distorts the 'pure' sine wave of the (c.w.) carrier to produce, in addition, the two sidebands.

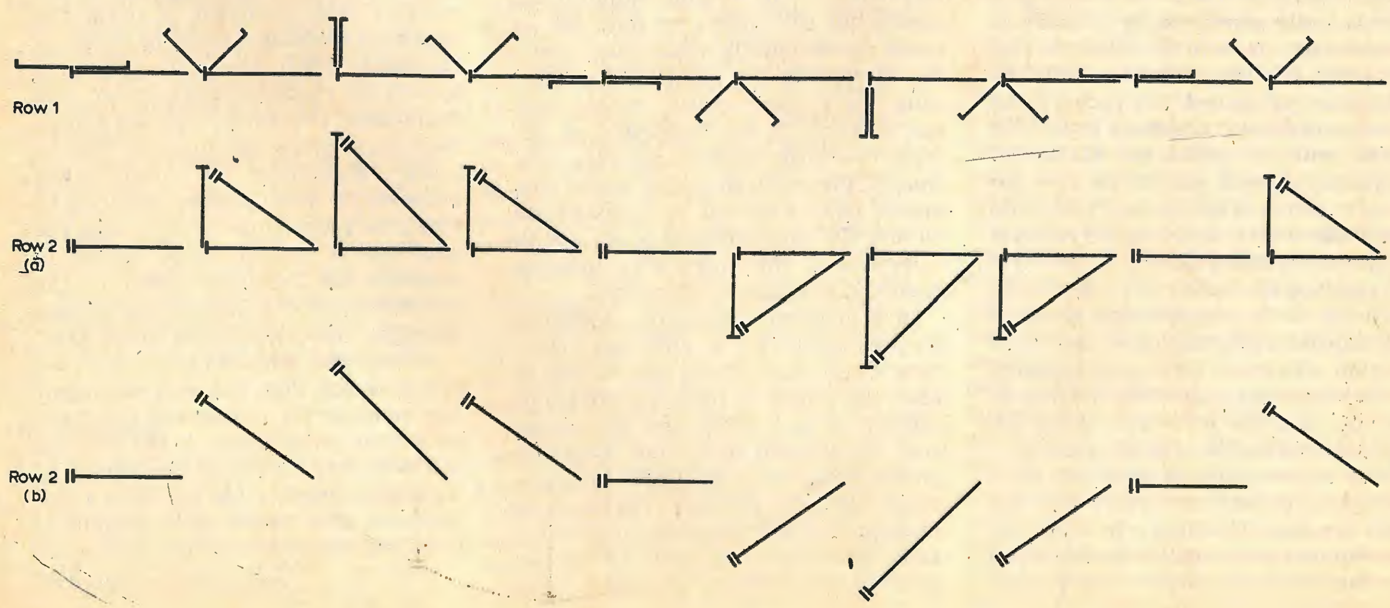
The example chosen has been deliberately simplified to modulation by a single (audio) frequency. It is not difficult to visualize, say, speech or music modulation producing a complex of sidebands as in Fig. 2. What should now be clear is that, however complex the signal, it consists only of sine waves; the carrier f_0 remains unchanged; the sidebands occur only in pairs, equally above and below the carrier frequency and that the final resultant remains exactly in phase with f_0 varying only in amplitude.[1]

The example of Fig. 8 (and Fig. 1) shows 100% modulation, the amplitude of the sidebands being half each the amplitude of the carrier. It is important not to over-modulate, which can easily happen if the transmitter of Fig. 3 is improperly adjusted. Not only does it become impossible to recover the modulation in the receiver, but the sudden discontinuities when the resultant falls to zero produce very high frequency sidebands (splatter), resulting in spurious signals, i.e. interference, over a very great bandwidth. In fact to accommodate speech and music modulation, the average amplitude of the sidebands must be kept very small to avoid over-modulation on peaks.

In terms of power and efficiency amplitude modulation is very poor. Bear in mind that doubling the amplitude quadruples the power (doubling the voltage in a circuit doubles the current and hence quadruples the power). For 100% modulation, each sideband is a quarter of the power of the carrier so that two-thirds of the total power goes in the 'reference frequency' carrier and only one third in the information bearing sidebands. This is the best case of 100% modulation; the general case of a typical broadcast station would probably show that over an extended period the average efficiency, that is the energy of the information bearing sidebands to total energy radiated, is only a few percent.

The radiation of vast amounts of carrier power, often 10 to 100kW in the case of broadcasting stations, has led to suppressed carrier systems for other

Fig. 9. *Phasor illustration of the effect of using a reinserted carrier in a receiver 90° out of phase with the suppressed carrier in Fig. 8. Row 1 shows this reinserted carrier phasor together with the sidebands, while row 2 shows the process of their vectorial addition (a) and the resultants (b) indicating changes in phase but little change in amplitude.*



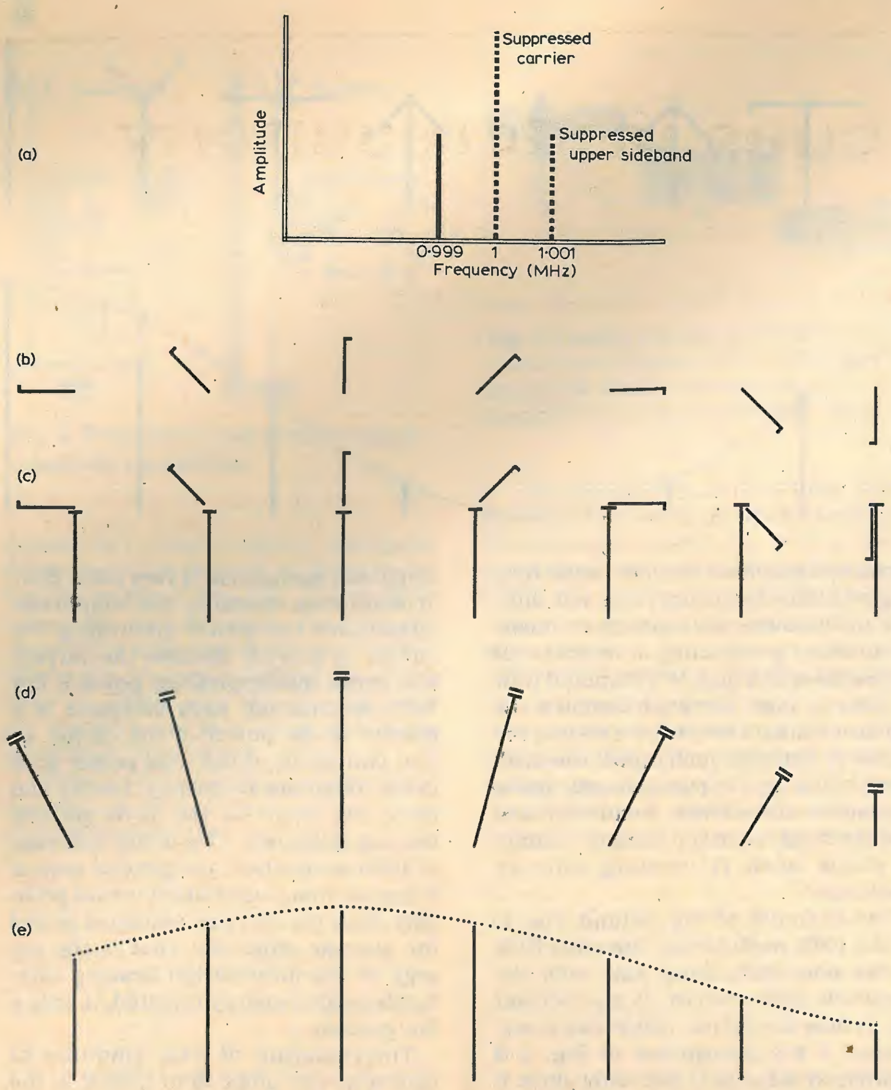


Fig. 10. *Phasor illustration of s.s.b. communication. At (a) is the s.s.b. equivalent of the Fig. 1 (a) spectrum; (b) radiated (lower) sideband; (c) carrier re-inserted at the receiver; (d) resultants from (c); and (e) resultants plotted as amplitude values to show waveform of amplitude modulated signal.*

communication, only the sidebands being radiated. Double sideband suppressed carrier (d.s.b.) is shown in Fig. 7. This is easily generated by a balanced modulator in which the carrier frequency is balanced out and only the sidebands produced. To receive the signal is, in theory, simplicity itself! One needs only a local oscillator of frequency f_0 and amplitude two (or more) times the peak sideband amplitude. This is added in the receiver (maybe a few milliwatts are involved) to the received sidebands and we proceed as in Fig. 8. The transmitted power is only sideband information so the transmission efficiency (effective radiated power) is theoretically 100% and only at the cost of a few milliwatts in the additional local oscillator in the receiver.

Such a system would obviously have come into general use years ago but there is a snag. The snag is in achieving the required performance specification for the local oscillator. The phasor approach makes the problem clear. Consider a local oscillator of the right frequency f_0 added to the sidebands of Fig. 7 but 90° out of phase with that shown in Fig. 8. If we redraw this new situation in Fig. 9 we see that the amplitude of the resultant hardly varies at all (and incidentally the phase no longer remains the same as the reinserted carrier). This shows the tight specification of the local oscillator; not only does f_0 have to be the same frequency as the original suppressed carrier but if it differs by only 90° in phase the amplitude modulation virtually disappears. No practical free running oscillator could meet this specification. If the frequency of the local oscillator differed by only 1Hz from f_0 the received signal would disappear twice a second, as it passed the 90° and 270° phase difference point with reference to the original f_0, making meaningful reception impossible.

In a dispersive medium, different frequencies travel at different velocities. Only small effects are needed to alter the phase of received sidebands relative to each other and the carrier with consequent distortion. Likewise phasor additions of multipath propagations can give garbled results. A.m. propagation via ionspheric reflection (s.w. broadcasts) is liable to fall far below "entertainment" standards while amateurs working long range v.h.f. by reflection of signals from the Northern Lights (aurorae), during periods of suitable sun spot activity, cannot use a.m. and use c.w. (morse code) for such communication. Variations in propagation conditions and the stability of the original transmitter f_0 would not allow the requisite stability of the whole system even if such a precise local oscillator was feasible.

The phenomenon can be demonstrated by listening to an a.m. broadcast station on a communications receiver with a b.f.o. The carrier is reinforced by zero beating the b.f.o. with the carrier. Intelligible speech might be obtained for even a few seconds before it begins to get 'rough' and finally unintelligible. Should results be better than predicted some form of pulling (i.e. tendency to lock) of the b.f.o. to the carrier frequency is almost certainly taking place. This would result in homodyne/synchrodyne reception[2] (by accident rather than design). The mode of operation of receivers intentionally using these techniques is easier to follow if the 'phasor fundamentals' are first digested.

One such system of a.m. demodulation available as an i.c. package is the phase locked loop (p.l.l.). The local voltage controlled oscillator (v.c.o.) locks onto the carrier frequency f_0. The signal with its sidebands and local oscillator are mixed in a product detector to give the audio output. It so happens that the locked v.c.o. runs 90° out of phase, i.e. in quadrature, with the carrier. An external 90° shift has to be incorporated in the system to achieve the Fig. 8 rather than the Fig. 9 situation.

We can now, using the phasor reasoning, continue the argument to show the viability of s.s.b. as an efficient means of communication. Fig. 10(a) shows the s.s.b. as an equivalent of the Fig. 1(a) spectrum, taking the lower sideband. (Exactly the same argument would apply had we taken the upper sideband.) Fig. 10(b) shows the radiated sideband while Fig. 10(c) shows also the carrier f_0 (1MHz) as reinserted at the receiver. The resultant is again the amplitude modulated signal as shown in Fig. 10(d). Only half a cycle is shown, as by now the reader will be familiar with the process. The resultant shows a small (spurious) phase modulation (hence phase distortion at modulating frequency). This can be reduced to negligible proportions by increasing the amplitude of the reinserted carrier. In practice the local oscillator in the receiver is so much more powerful than the signal that the problem solves itself.

As only one sideband is involved we can now see that the very stringent requirements for reinserting the d.s.b. carrier no longer apply. If the inserted carrier is, say, ± 10Hz off the original f_0, the consequence is that the 1kHz audio tone is in error by the same amount. If the original modulation had been

continued on page 60

Auditory cues in stereophony

Importance of transients in nature and in stereophony

by Philip Vanderlyn, Central Research Laboratories, EMI Limited

Now that the spate of new multi-channel stereophonic reproducing systems has decreased to a trickle, it seems timely to look again at the physical and psychological bases that govern directional hearing to discover why nothing has so far emerged to displace the familiar two-channel arrangement hitherto widely accepted.

This article emphasises the time difference cue to direction and the role of transients as "time tags" both in natural listening and in stereophony. Some experimental evidence is put forward in support of the conclusions which largely explains the failure of quadraphonic and other systems to make good their claims to "all-round" localization and total realism.

OVER THE LAST TEN years or so multichannel stereophonic systems have proliferated. The proponents of most of these systems have so far largely failed to spell out the objectives that they are pursuing, still less the means by which they hope to succeed. Not all of the systems aim at increased naturalness of reproduction: the so-called "surround" category in particular were only designed to produce a (hopefully) pleasing effect. Mostly, however, the implication is that they are trying to recreate the natural listening situation to a greater extent than is possible with the now conventional two-channel arrangement. Efforts have met with varying degrees of success but none can claim to have said the last word on this complicated subject.

One cause of failure is surely the lack of awareness of the auditory cues that have to be provided if nature is to be effectively imitated. This article summarizes the generally accepted facts concerning directional hearing of which architects of stereophonic systems must take note if they hope to achieve realism.

The Pioneers

Tribute is due to the illustrious workers who have contributed so painstakingly and rigorously over a very long period to piece together the now considerable body of knowledge that exists concerning the ear and hearing. From the pinna which receives the pressure variations that constitute an acoustic stimulus, through the transducing members comprising the eardrum, stapes, cochlea, basilar membrane and hair cells, the action potentials they generate, their coding and mode of transmission along the fibres of the eighth nerve and its pathways and interconnections between the higher centres of the brain where the semantic and other significant information is extracted and utilized, would be long enough in itself to fill an article. A short list might include Helmholtz, Rayleigh, Stewart, Banister, Firestone, Stevens, Newman, von Békésy, Fletcher, Snow, Wallach, Rosenzweig, de Boer, van Urk, Galambos, Davis, Jeffress, Wiener, Hirsch, Cherry, van Bergeijk and Deatherage, omitting many more, particularly of the most recent workers. Anyone who cares to follow the unfolding story through the medium of their published papers will find it a fascinating, if as yet incomplete one.

Before examining hearing in detail it is interesting to compare the sense of hearing with that of sight. Hearing, like sight, must have evolved primarily as a survival mechanism; the reaction to a sudden stimulus automatically posing the questions: "What is it?" and "Where is it?" In daytime the eye has a great advantage in that the geometrical laws of optics do a great deal of the work of locating and recognizing remote objects, a process employing large numbers of parallel channels which respond relatively slowly (fortunately for the cinema and tv). In the dark the ears become the first line of defence and by contrast provide only two channels, albeit capable of much more rapid response, and more processing is needed to extract meaningful information. From a complex sound stimulus the ears and brain together have to recognize which components cohere into groups identifying specific sources (the "gestalten" of Cherry[1]), their pitch and timbre, in which directions these lie, a rough idea of their distance and perhaps, from their reflections, something of the unseen environment. The process is essentially time-oriented, the response of the auditory complex being much more rapid than that of the visual. less than 100 discrete samples per second give an impression of visual continuity; to do the same aurally requires upwards of 20,000. At its most acute it can detect time differences of a few tens of microseconds.

Physical basis of localization

The simplest example of natural listening must be that of an observer exposed to sound from a single source a few metres distant, so that conditions in his vicinity approximate to plane wave propagation. If the direction of the source relative to the listener is arbitrary, i.e. it lies neither in the horizontal plane passing through his head nor in the median plane dividing his sphere of observation into left and right halves, the sounds reaching his eardrums will differ in time of arrival and will be modified spectrally by the effect of his own head as an obstacle in the sound field and by their passage through the convolutions of his pinnae. The spectral modifications depend on both frequency and direction of arrival and become increasingly large and complicated at high frequencies. The time difference, however, is invariant with frequency and depends only on the difference in length of the paths from the source to the two ears. This lack of dependence on frequency gives the interaural time difference an overriding importance in sound localization.

If the sound source emits a pure constant-amplitude sine wave the time difference manifests itself at low frequencies as a phase difference proportional to frequency. As frequency increases the phase difference becomes equal to π radians at about 700Hz for maximally left or right sources, when the path difference becomes half a wavelength. Above this, the phase shift in excess of π radians would lead to an ambiguous judgment were it not for the fact that at this frequency the head begins to be an obstacle in the sound field and introduces an amplitude difference that allows the ambiguity to be resolved[2] up to something like 1.2kHz. Above this point the only meaningful cue resides in this amplitude difference, which is by no means so precise an indicator of direction as the time difference, being subject to perturbations due to local obstacles or wax in the ears or, in closed spaces, reflections from the boundaries. It is considered to be of secondary importance: the ear relies on it when it has to.

When the sound is complex as, for example, in the case of human speech it will contain many transients, i.e. identifiable singularities in the waveform: these restore the possibility of using at high frequencies the time difference cue that already provides a firm indication at low frequencies. Not only that, but the increased resolution possible at high frequencies permits increased accuracy of localization. Evidence from everyday life supports this argument: try, for example, to detect the position of a blackbird uttering its alarm call, consisting of long pulses of tone at about 3kHz with long onset and decay times. The studied avoidance of sudden transients at the start and finish added to the choice of a frequency resulting in an ambiguous phase difference for large predators, leaves only the rather inaccurate amplitude cue which is subject to the confusing effects of obstacles and reflections. By contrast, its territorial and other song is rich in transients and presents little difficulty in locating the source.

It is difficult to overestimate the importance of transients in sound localization: a reliable mechanism clearly exists at low frequencies, but without transients it cannot be employed in that part of the frequency spectrum where the ear is at its most sensitive — from 1 to 6kHz. With their aid the interaural time difference, the most important single parameter in sound localization, can be evaluated over the entire audible frequency range.

The interaural time difference alone, however, will not determine direction: what it does is to define a surface on which the source must lie. This surface is, strictly, a hyperboloid of revolution about the axis through the listeners two ears, but negligible error results in practice from considering it as the asymptotic cone, and it is the apical angle of this cone that the time difference defines.

At this stage what have so far been considered as secondary cues come into play. The amplitude difference reinforces the left/right impression given by the time difference, whilst at frequencies for which its dimensions constitute a half wavelength or more the characteristic shape of the pinna, with its narrow and highly individual polar characteristic introduces spectral changes that every proud owner of a pair of ears will have learnt subconsciously to interpret as an indication of direction of arrival. In this connection a recent paper by Butler and Belenduik[3] throws some light on the use of spectral variation for estimating elevation in the median plane. A characteristic irregularity in the frequency response around 6kHz is identified that varies systematically as the source elevation changes.

These cues to localization are available to the observer without any conscious action on his part. If, additionally, he is free to move his head he can learn more about the position of the source. By observing the change in its apparent position as he turns his head from left to right he can immediately tell whether it is in front of or behind him. He can also use the first derivative — the rate of change of interaural time difference as his head turns — to estimate its elevation (Wallach[4], de Boer and van Urk[5]).

By these means the listener has localized the source to a unique direction in space. It only remains to estimate its distance.

This parameter is the one that he has the least satisfactory means of determining. Loudness is a possible cue, but postulates prior knowledge of the strength of the source: in the case of something familiar like a human voice a rough guess at distance can result. It has been suggested that the particle velocity/pressure ratio that increases during the approach to a small source could be instrumental — the difficulty here is that the ear has no obvious means of perceiving velocity. It is true that it could be done by the two ears acting in concert sensing it as pressure gradient, but the means by which the gradient could be derived from the pressures at the ears has not been disclosed. Moreover the method would be insensitive, the rise in particle velocity amounting to only 3dB for an approach to within one radian of the source frequency. At 50Hz a radian corresponds to about 1 metre, and at higher frequencies it is proportionately less. At one wavelength distant the rise is only 0.1dB and quite undetectable.

In a closed space such as a room, the ratio of direct to reverberant sound is a quantity that gives some idea of distance but it begs the question as to how the direct and reverberant components are differentiated. In view of the confusion caused by reflections the initial judgment of direction must rely almost entirely on transients of medium and high frequency since these are the only cues available in advance of the reflections. Perhaps the relative magnitude of transients to the total sound gives some idea of distance. Certainly these considerations give added emphasis to the importance of transients in localizing sound sources.

Having pinpointed the position of the source using the means outlined, the natural reaction – no doubt a relic of the primitive survival situation – is for the listener to turn and face it. This immediately brings it into the region of greatest perceptual acuity; all the asymmetries disappear and the accuracy of location is determined by the limiting angular discrimination in azimuth. Numerous investigators had experimented on this topic: typical results are those of Moir and Leslie[6], who found that less than 2° was detectable. This corresponds to an interaural time difference of a mere 22μs or so.

Psychophysiology of hearing

Nature of the Transducer

The foregoing describes the physical situation of a listener exposed to a sound source. If he is to be provided by artifical means with stimuli that affect him in the same way, it is necessary to discover something of the psychoacoustic processing that constitutes his response, so that a realistic impression may be created. We have to know what cues can be and must be provided.

It is not appropriate here to enter on a detailed discussion of the car complex: there is a very extensive literature on the subject should any reader wish to search more deeply than the present article allows. A good starting point is Fletcher[7].

In summary: the visible portion of the auditory mechanism, the pinna, plays a not very significant role in hearing. It probably performs an energy collecting function and from its convoluted shape introduces characteristic colorations that its owner has learned to interpret as front/back and/or up/down information. Its small size restricts these functions to high frequencies, say 4kHz and above.

Within the ear the sound impinges on a membrane – the eardrum – whose motion is transmitted by way of a linkage of small bones to a further membrane — the oval window — that in turn transmits the sound energy to a liquid-filled tapered canal known as the cochlea from its coiled configuration, similar to a snail shell. The small bones that form the linkage are so proportioned that they provide an impedance match between the eardrum and the cochlea.

Running centrally down the cochlea and dividing it into two parts lies the basilar membrane, narrow regions of which resonate in response to the different frequency components of the energy reaching the oval window, in a crude Fourier analysis. High frequency components cause resonance near the oval window at the basal end of the basilar membrane whilst progressively lower frequencies shift the activity down toward the apical end. There is thus a ready-made "place" mechanism of frequency discrimination, though the mechanical constants of the system are not in accord with the known discriminatory capability of a listener. If place alone were involved a "Q" of several hundred would be necessary instead of the value that actually obtains – about three. This low value is necessary to ensure a rapid response. One must therefore assume that critical frequency resolution results from neural processing higher in the chain.

Along the length of the basilar membrane and cooperating with it to produce the initial response to a sound stimulus is the organ of Corti, comprising the hair cells that are thought to play an important part in originating this response.

Neural response

The processing that takes place in the brain is electrochemical in nature and is thus not suitable to operate on an electrical signal corresponding to the sound pressure waveform. That being so, there is no reason why an electrical analogue of the waveform should appear during stimulation. Such an analogue, however, can be detected by electrodes suitably placed on the head and neck. This response is called the "cochlear microphonic", but it is not believed to play any part in subsequent processing. Possibly it is instrumental in initiating those neural signals that the brain does process, and which carry in coded form all the information subsequently extracted and recognized.

The eighth nerve, concerned with the sense of hearing, comprises at the peripheral (cochlear) level, a bundle of between 20,000 and 30,000 fibres, evenly distributed along the length of the basilar membrane, where they originate in the region of the hair cells. When the excitation of the basilar membrane adjacent to a nerve fibre ending reaches a certain threshold an "action potential" is generated, supposedly through the intermediary of the hair cells. This action potential, which propagates electrochemically along the fibre, bears little relationship to the stimulus waveform, consisting of a short pulse of the order of 1ms long, of standardized amplitude, repeated at intervals if the stimulus is maintained, at a rate depending on the stimulus intensity, but not exceeding 300 to 400 pulses per second in any single fibre. As the stimulus intensity is raised beyond the threshold, the fibre responds to an increasingly wide range of frequency, so that further processing must take place if the known fine limits of pitch perception are to be achieved. The behaviour of neural fibres was studied, notably by Galambos and Davis[8], who worked with cats: their results are therefore conditioned by the differences between cat and human physiology. The neural mechanisms, however, operate on the same principles.

The question inevitably poses itself – how can the brain, however cunningly organized, extract the detailed information that it does from signals that apparently bear so little relation to the incoming stimulus? We are here concerned mainly with the localization problem, so that it is proposed to discuss only those cues relevant to that purpose. For more general reading, an excellent review was written by Whitfield[9] in 1957, most of which appears still valid today.

To return to the action potential; let us examine some of its known characteristics in the light of the localization problem. It seems that although the rate of firing depends on stimulus intensity, successive firings of the same fibre are always separated by an integral multiple of the stimulus period. This strongly suggests synchronism, and in fact the firings relate to the zero-crossing times of the stimulus (in one direction only). As is usual in nature, things are not perfectly tidy, and there is a delay, known as "latency" between the onset of a stimulus and the generation of a spike action potential. The latency is least for strong stimuli and for high rates of zero-crossing, which suggests that a threshold has to be overcome — however the disturbance to synchronism is not great.

Additionally, it has been remarked already that transmission of the action potential impulses along the nerve fibres is not purely electrical, consequently we are not considering velocities of the same order as that of light. The process is more complex, involving ion exchange between the inside and outside of the fibre, and the speed is dependent on a number of factors, including the fibre diameter and the intensity of the original stimulus. It ranges from several hundred down to one or two metres per second in the fine fibres of the auditory cortex. This slow propagation is significant since it makes available the time delay parameter as one of the processing tools with which the brain can operate on the neural signals from the two ears. Significantly, innervation from both ears takes place quite early in the neural pathways, at the superior olivary complex. It is difficult to imagine any other purpose of such an arrangement than a close comparison of the two sets of neural signals.

Regrettably, at this point the trail peters out for the moment, and the processing that eventually results in localization itself is still a matter of conjecture. Models have been proposed by several workers, notably Jeffress[10] and van Bergeijk[11] and although these are interesting as far as they go, they are incomplete. They do, however, rely on the interaural time difference cue which is coded into the total neural response by the near synchronism of the spikes of action potential, with the vibrations of the sound stimulus as they appear at the basilar membrane. It seems that for all intensity levels well above threshold there will be at least one action potential pulse generated for every individual cycle of the incoming waveform by virtue of the large number of fibres involved. This holds good up to the limiting frequency at which one period of the stimulus is comparable with the duration of the spike: say 1kHz or so.

Nature has taken too much care over the preservation of the interaural time difference in the transcoding of the linear input signal into the non-linear neural response for this to be the result of a happy accident. It must surely indicate the importance of such a cue in the task of localization.

The stereophonic image

In the present context stereophony excludes systems that merely set out to make a pleasing effect, such as the quadraphonic class – some spatial correspondence between the sound sources in the recording studio and the images created in the reproducing room is implied. We have to consider how, and to what extent, the natural cues in directional listening can be provided artificially by stereophonic reproducing systems.

"Discrete" stereophony

As is well known, a minimum of two channels is needed to form any sort of sound image. The simplest arrangement envisages a pair of earphones driven through identical transmission channels from a pair of microphones mounted to simulate the ears on a dummy head. In this case the listener can be presented directly with the interaural time difference cues appropriate to the positions of the various sound sources around the dummy head. The arrangement does provide a good spatial impression, to which there are two main drawbacks.

First, because the headphones move with the head, those cues associated with head movement in a free field are absent, and although the time difference cue gives good directional information, listeners usually describe the sources as being "in the head" – which is, to say the least, unnatural. Second, the wearing of headphones is in itself unaesthetic: it is far preferable to receive the sounds through one's own two ears from freely propagating acoustic waves.

Free-field stereophony

When we consider reproduction from a pair of symmetrically spaced loudspeakers we have to take account of the fact that each loudspeaker communicates with both of a listener's ears. Thus, to produce an interaural phase difference it is not appropriate to drive the loudspeakers with signals differing in phase, as in the case of headphones. As Blumlein propounded in 1931[12], to produce phase differences at the ears, the loudspeakers must be driven by signals in-phase but of different magnitude. A recapitulation of his analysis can be found in a paper by Clark, Dutton and Vanderlyn[13] of 1957.

As a phase difference proportional to frequency is equivalent to a constant delay, a realistic interaural time difference cue can be simulated. The analysis postulates that the wavelength is long compared with the ear spacing and thus that the attenuation at the further ear due to the shadowing effect of the head itself is negligible. This condition is met at low frequencies but starts to break down at about 700 Hz, when the interaural path becomes half a wavelength: above this frequency it is necessary to seek some other mechanism of localization.

High frequency cues

Many workers in the field have, from the earliest days, looked to the interaural amplitude difference, which is most pronounced at high frequencies, to explain the undoubted directional capability of the ear in this region. Whilst a good impression of leftness or rightness in the horizontal plane can be produced by a simple amplitude difference there are two main difficulties in ascribing to it the entire mechanism of high frequency localization. First, stereo reproducing systems work much too well in the presence of room reflections and additionally they are much too sensitive to small displacements of the listener from the central position between the two loudspeakers. These considerations strongly suggest that transients play as important a role in stereo reproduction as they do in natural listening. Experiments carried out by Percival[14] in 1957 confirm this, and suggest the following hypothesis.

Localization using transients depends on the integrating capability of the ear. The situation is illustrated in Fig. 1(a). The left and right ear responses are juxtaposed to show the relative timings. At an arbitrary time the left ear, for example, receives an impulsive signal L_l from the left loudspeaker and simultaneously the right ear receives a signal R_r from the right loudspeaker. This follows from the symmetry of the listening geometry. An image to the left of the sound stage is assumed; hence L_l is shown greater than R_r. After an interval equal to the extra time taken by these sounds to travel to the contralateral ears, which, for a $\pm 30°$ loudspeaker spacing will be approximately 0.3ms, the left ear will receive R_l and the right ear L_r. This later pair of signals will be reduced in amplitude as a result of their diffraction round the head. It is now suggested that the integrating capability of the ear – that is, its failure to resolve two impulses monotonically presented at an interval of less than 2 to 3ms – will cause each ear to hear a single signal at a virtual time dependent on its component parts. The resultant summed signals S_l and S_r, shown in broken line in the diagram, will have virtual timings biased toward their larger components. The significant parameter is the equivalent interaural time difference Δt between S_l and S_r, which will determine the apparent direction when the ear-brain complex fuses them into a single stereophonic image at a direction determined by the loudspeaker amplitudes L and R.

The theory clearly holds for the central case when all is symmetrical, and for the limiting cases when one loudspeaker is silent and the delay corresponds to the direction of the energized one. However, the signals shown in the diagram are over-simplistic, since they represent impossibly short impulses that would be severely mutilated in passing through filters and transducers, not to mention the peripheral mechanisms of the ear itself. The figure is really no more than a timing diagram, showing the fixed time relationship between the variable amplitude component sounds at the two ears. What it implies is that at some time after the onset of the partial stimuli indicated by the thick arrows of Fig. 1, the integral of the energy received by one ear will reach a threshold value before the other, depending on the relative amplitudes of these partial stimuli, and an action potential will be generated at that ear earlier than at the other, as though it had resulted from a single virtual stimulus with a timing indicated by the thick broken arrow.

In Fig. 1(c) the position of the virtual stimulus may seem strange, but remember that if the second pair of partial stimuli are significantly delayed, the response tends to separate into two parts associated with the two components, and the second partial stimulus will have little effect on the first. This could indicate a time-weighting in the integration, the running integral having an effective decay time of a few milliseconds: clearly the integral cannot be allowed to build up indefinitely.

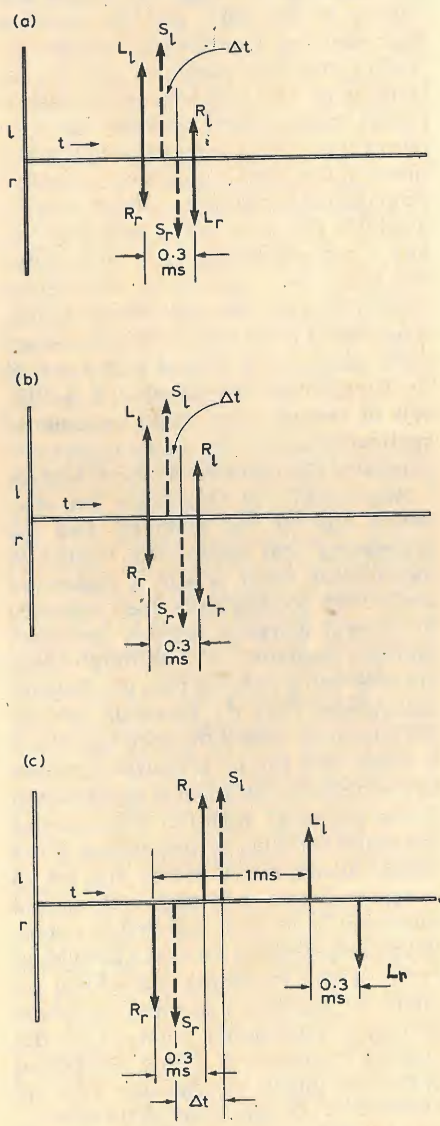


Fig. 1. *Timing diagram, shows generation of a virtual time difference Δt from components fixed in time but of variable relative amplitude.*

Experimental evidence

Some light is thrown on this theory by an experiment in which an attempt is made to recentralize the perceived image by delaying the signals to one or the other ear. Two symmetrically placed loudspeakers, driven in-phase at different amplitudes, produce signals at a pair of non-directional pressure microphones spaced 20cm apart, representing the relative ear positions of a hypothetical listener. To eliminate any effects due to head shadowing, no dummy head is used: the only variable is the relative amplitude of the fixed time components of Fig. 1(b) as determined by the loudspeaker signals. The amplified microphone outputs are fed to delay networks arranged to produce a differential delay in either sense up to a maximum of 0.35ms, and thence to the left and right receivers of a pair of stereo headphones. Assuming that integration takes place independently in each ear it should be unaffected by the interposition of the delays in the microphone channels, and it should be possible to shift the signals of Fig. 1(b) relative to each other by an amount $-\Delta t$ until the summed signals S_l and S_r synchronize to produce a central image.

Denote $(L-R)/(L+R)$ by x, and call this normalized amplitude difference the calculated position of the source. Against this is plotted the normalized angle of incidence of a sound wave at the microphone position which would give rise to the interaural time difference Δt determined experimentally. The full-line curve of Fig. 2 shows there is good correspondence between the theoretical and experimental values, which represent the average of six observers' results.

These results were not obtained without difficulty. It was pointed out previously that the signals of Fig. 1 are fictitious, and it was proposed initially to ensure that vestigial low frequency cues were absent by using a high frequency tone pulse with rapid onset and slower decay time. Difficulties were encountered with interference fringes due to the tone which, with the unavoidable small asymmetries of the experimental set-up, produced spurious amplitude differences at the microphones. To overcome this, random noise, band-limited by a 2kHz high-pass filter was substituted for the tone and modulated with the same pulse waveform. This improved matters considerably but the final image produced

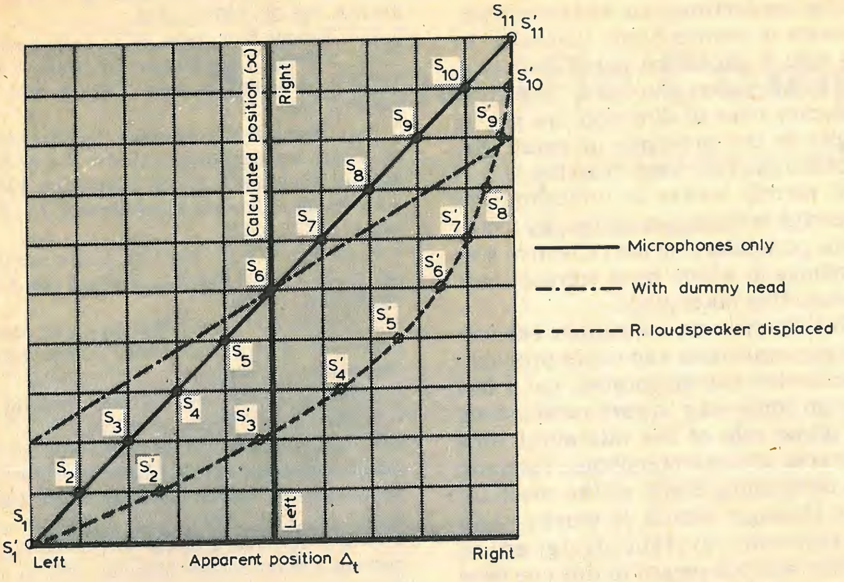


Fig. 2. *Central listening results in linear stage geometry as virtual sources S_1 to S_{11} from equal increments of x, require equal increments of Δt to restore centrality. Assymetric listening (broken curve) results in stage geometry distorted as the same virtual images are drawn towards the nearer loudspeaker. Dummy head (dot-dash curve) enhances the cue without affecting linearity.*

Philip Vanderlyn joined EMI in 1935, working under A. D. Blumlein and H. A. M. Clark from where he learned the facts of stereophonic life. Experience at EMI up to retirement in 1979 included work on stereophony, sound locators, radar, data transmission and the application of digital techniques to sound recording. Born in London in 1913, he was educated at Christ's Hospital and Northampton Polytechnic.

in the headphones was still not so well defined as the actual image at the microphone position in the anechoic room. The results, nevertheless, are sufficiently clear cut to show that an effective interaural time difference cue is produced when the loudspeakers are driven with high frequency transient signals, in-phase but of different amplitude, without benefit of any head shadowing effects.

The effect of the head

Because diffraction round the head undoubtedly plays a significant part in live listening the experiment was made more realistic by introducing a dummy head between the microphones. This was made of plaster, but wrapped in polyurethane foam so as to simulate human flesh a little more closely. The result of this was to enhance the angular sensitivity of the arrangement, requiring more compensating delay for a given amplitude difference at the loudspeakers, as shown by the dot-dash curve of Fig. 2. This additional delay must represent a trade-off of time differences against the intensity differences introduced by head shadowing.

The enhanced angular sensitivity of the stereo listening arrangement at high frequencies was noted in ref. 13 as an empirical finding. In those early experiments the angular displacement of the image at low frequencies as the speaker amplitudes were varied agreed closely with that found in the present case in the absence of the dummy head, although two quite different mechanisms are involved. At high frequencies the excess sensitivity is now shown to be due to the presence of the head with its attendant diffraction pattern. The magnitude of the increase is of the right order to account for the difference.

Before concluding the tests one further experiment of significance was performed to demonstrate the effect of asymmetrical listening. Reverting to the set-up without the dummy head, the right loudspeaker only was brought one foot nearer the microphones and the first experiment repeated. This is approximately the same as displacing the listener the same amount to the right of centre, but more convenient experimentally.

Fig. 1(c) shows how the timings are affected. The sound from the right loudspeaker clears both ears before that from the left reaches either, about 1ms later. By this time a fully right-handed cue is in course of establishment which the later sound from the left loudspeaker has difficulty in modifying. One can thus expect a strong bias to the right and this is indeed what happens, as is evident from Fig. 2. The broken curve shows that values of x corresponding to apparent sources S_1 and S_{11} for the central listening position, five to the left and five to the right of stage centre, now yield a distorted image with only two (S_1, S_2) to the left and eight (S_4 to S_{11}) on the right, crowding up toward the loudspeaker position.

Moreover, this effect is not one which scales up or down with the size of the reproducing set-up. The result of a foot of misalignment is the same whether we are operating in a domestic living room or the Albert Hall. It is one of the principal hazards in the way of mounting a large scale demonstration of stereophony, as anyone who has made the attempt will be only too aware.

The implications for quadraphonic systems are obvious, but their proponents seem never to have faced up to them. All two-channel systems have a locus on which it is possible for a listener to position himself equidistant from the loudspeakers. For three channels there will always be one point that meets this criterion, but four channels do not provide even this vestigial possibility unless great care is taken in siting the loudspeakers – errors must be small compared with a foot. Nevertheless this factor seems to be universally ignored: much effort is expended on analysing the energy distribution around a point-sized listener, tacitly assumed to be exactly equidistant from every reproducer. Yet a little matter of a foot of error in the placing of one of them can distort the image geometry out of all recognition. Consideration of the directional distribution of energy may perhaps be appropriate under steady-state conditions. Speech and music, however, together with most other everyday sounds conveying useful information to a listener do not fall in this category. In contrast they may be more realistically considered as a stream of connected transients.

It is more than probable that, given additional channels, better stereophony can be achieved than with the basic two which economic stringency has hitherto allowed us. However, before we adopt any alternative multichannel system as an industry standard we ought to be clearer than we are now about its psychoacoustic basis, its aims and objects and the means by which these are to be put into effect.

Conclusion

The practice of stereophony comprises two facets: the understanding of how a listener uses his ear/brain complex to locate the sources of sounds under natural conditions, and the engineering of means to reproduce enough spatial cues from a multiplicity of loudspeakers to recreate an effective image at another place or time.

We are still a long way from writing a full description of the total mechanism of localization. What is clear is that nature employs all the auditory clues available at all times, but they vary in effectiveness according to circumstances. The present article is intended to highlight the important role played by transients in nature and in stereophony – in the last instance it might well form an addendum to reference 13.

The experiments described are not proof that an actual interaural time difference is generated by the method described. Because the cue derived in Fig. 1(b) can be compensated by the introduction of a contrary time differential it is not rigorous to assume it consisted of a time difference in the first place: many workers (e.g. ref. 15) have shown that time differences can be traded directly with, for example, intensity differences. But the fact that the compensating delay in the experiment trades off linearly against the differential cue provided, arriving at the precise value of intermicrophone delay in the fully left or right condition when only one loudspeaker is operating, suggests strongly that an effective interaural time difference is indeed created.

Obviously, the additional intensity difference cue resulting from the insertion of the dummy head has to be traded off against an additional time delay (see the dot-dash curve of Fig. 2).

The experiment on asymmetric listening underlines an everyday experience in stereophonic listening. In this case it should be noted that only transients are involved; the low frequency cues to direction are not so fragile in the presence of small displacements. This very fragility, however, merely serves to underline the powerful influence exerted by transients, particularly in the reflective surroundings in which most stereophonic reproduction takes place.

The experiments are neither exhaustive nor conclusive and could probably be extended and elaborated, but I feel they go some way toward establishing the prime role of the interaural time difference cue in stereophonic listening and unravelling some of the mechanisms through which it works. Any stereophonic system designed to operate without regard to this cue does so at its peril.

Acknowledgments

My thanks are due to many colleagues, in particular Dr W. S. Percival, for numerous day-to-day discussions, mostly of some fifteen years ago, that have been responsible, along with the personal experience of living with stereo since its inception, for distilling the material of this article. Acknowledgements are also due to the Directors of EMI Limited for permission to publish it.

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Sidebands as phasors *continued from page 54*

speech or music, with a corresponding sideband structure as exemplified by the left-hand side of Fig. 2(a) the audio output from the receiver would be bodily shifted ±10Hz from the original. This would still give good "communication" quality speech. When, in a live news broadcast, a reporter from some remote part of the world sounds a little "rough" or "artificial" the explanation is probably due to a difference in frequency between the original and reinserted carriers, over an s.s.b. link.

It is worth noting that in suppressing the carrier in transmission, a source of interference, heterodyning, by adjacent carriers, disappears. Further, in the case of s.s.b., only half the bandwidth is used, enabling greater receiver selectivity to be employed. The absence of heterodyne interference from adjacent stations, twice the number of stations in the band, 100% efficiency in terms of the information content of the radiated energy, has made s.s.b. very popular for commercial and amateur usage.

Amplitude modulation is still the only system for broadcasting between 200kHz and 20MHz. The broadcasting of the very wasteful reference signal is necessary to enable the listener to use an elementary receiver requiring no sophisticated local oscillator and no skilled operating in the adjustment of a local oscillator. The increasing problems of heterodyne interference would be reduced if broadcast stations could use reduced (pilot) carrier working. The cost of the receiver and its operation will no longer be a factor with the potential use of specially designed integrated circuits in the future.

(To be continued)

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Appendix

Mathematical expression of a.m. (for 100% modulation of a carrier, amplitude a, frequency f_0, (angular frequency Ω_0), the modulating frequency f (angular frequency ω) is

$$a(1+\sin\omega t)\sin\Omega_0 t$$

or in terms of frequency

$$a(1+\sin 2\pi ft)\sin 2\pi f_0 t$$

This shows that the amplitude of the $a \sin 2\pi f_0 t$ (carrier) term is rising and falling between $2a$ and zero at the modulating frequency f. Rewriting, we have $a \sin \Omega t + a \sin \omega t \sin \Omega t$. Expanding the left-hand term (using the trig relation $\sin x \sin y = \frac{1}{2}\cos(x-y) - \frac{1}{2}\cos(x+y)$), this becomes $a \sin \Omega_0 t + a/2 \cos(\Omega_0-\omega)t - a/2 \cos(\Omega_0+\omega)t$

We are left with the unmodulated carrier (sine) and two cos terms of frequencies f below and above the carrier frequency – the lower and upper sidebands. There is of course no difference (except phase) between cos and sine. Hence we have three sinusoidals – the carrier, amplitude a, and the lower and upper sidebands, amplitude $\frac{1}{2}a$ – as depicted in Fig. 1(a).

We should still arrive at Fig. 1(a) had we started with any other appropriate expression, e.g. $a \sin \omega t \cos \Omega_0 t$ and the corresponding trig formula for the expansion. It all depends on the time we start (i.e. when $t=0$) and the relative phases of the sidebands with respect to the carrier at any instant. The phasor diagrams in the main text explain clearly the significance of the sideband phase as related to the carrier.

A Scientific Computer — 6

Final program examples, tv interface and radio teleprinter interface

By J. H. Adams, M.Sc.

THE FINAL TWO programs in Table 18 were used to ease the design of active filters for the teleprinter interface. The filters are based around the LM3900 quad Norton amplifier i.c. and a low-pass version is shown in Fig. 24. The display in Fig. 25 shows a run of the first program which computes the resistor values required for a given gain, Q and fixed capacitor values. The program will intervene if the ratio of the capacitors is too low for correct operation, and when presenting the results it uses two graphic characters to enhance the appearance. New values for C_1 and C_2 may be entered repeatedly until the resistors are near enough to preferred values for the accuracy required.

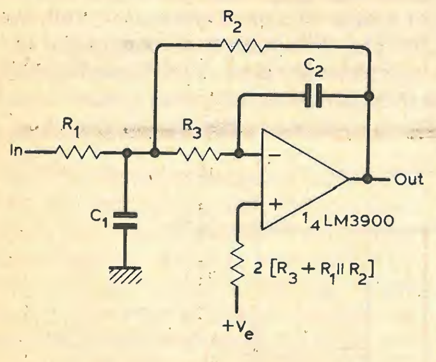

Fig. 24. *Low pass filter used for the teleprinter interface.*

```
002 PRINT "  LOW PASS ANALYSIS"
003 PRINT " INPUT R1, R2, C1; C2 NOW . . . "
005 INPUT R S C D
006 AXIS 125 8
008 LET F=1
011 GOSUB 232
014 LET E=60 G -
017 GOSUB 232  -
020 LET G=G E +
023 IF G<0 THEN 32
024 LET Z=F LOG
026 PRINT "F ="F1, "HZ"
027 GRAPH G Z
028 LET F=F 10 RT *
030 GO 17
032 HALT
034 ERASE
036 GO 1
232 LET X=1E12 2 / PI / F / C /
235 LET Y=1E12 2 / PI / F / D /
238 LET A=X Y / R S * X / Y / - 1 - SQ
241 LET B=X R S + - Y / SQ   -   -
244 LET G=A B + ROOT REC LOG 20 *
247 RETURN

ODDO
```

```
004 PRINT "   LOW PASS FILTER PROGRAM"
005 PRINT " INPUT GAIN + Q REQUIRED, CORNER FREQUENCY, C1 + C2"
020 LET W=2 PI * F *
023 LET C=C 1E12 /
026 LET D=D .1E12 /
029 LET S=1 K G / - ROOT 1 + 2 / Q / K / W / C / 1000 /
032 LET R=S A /
035 LET T=W C * SQ S * K * REC 1E06 /
038 PRINT "R1 ="R2, "kΩ,  R2 ="S, "kΩ,  R3 ="T, "kΩ"
039 INPUT C D
040 GO 11
041 END
050 PRINT "REDUCE THE RATIO OF C2 TO C1.  INPUT NEW VALUES NOW . . ."
051 GO 39
053 INPUT D
056 LET D=D 1E12 /
059 GO 29

ODCB
```

Table 18. Two programs for designing active filters based on the LM3900.

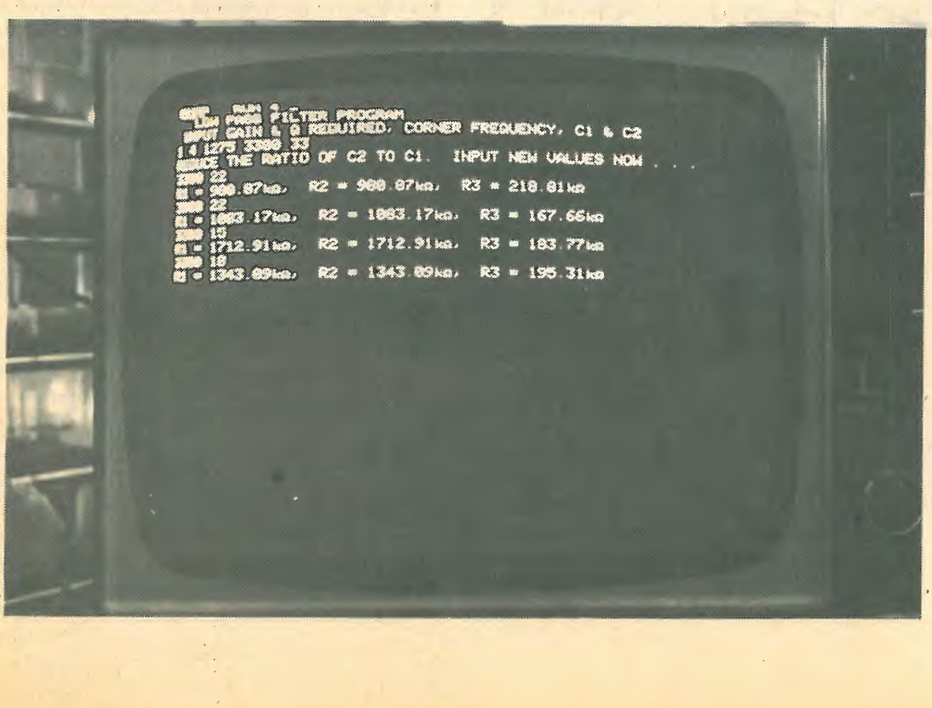

Fig. 25. *V.d.u. showing a computer run for the circuit in Fig. 24.*

The second program can then be used to give a gain versus frequency plot of the filter's characteristics. In Fig. 24, R_3 is assumed to be equal to R_1. The program terminates when the gain falls below unity, but it may be re-run by pressing the space bar as described in part 4.

A specific tv interface

It was mentioned in part 2 that if a live tv chassis is used for the v.d.u., a mains isolation transformer is necessary. This expense can be avoided by using a television set such as the Ferguson or Ultra model 3845 which has a fully isolated power supply. A simple interface for this set is shown in Fig. 26. All of the connections are made to the tube base except for the sync. input. Resistor R_{72} on the tv's p.c.b. is lifted at the end nearest to the back of the set, and a wire from the empty pad is taken to a changeover switch which connects the original sync, or that from the computer

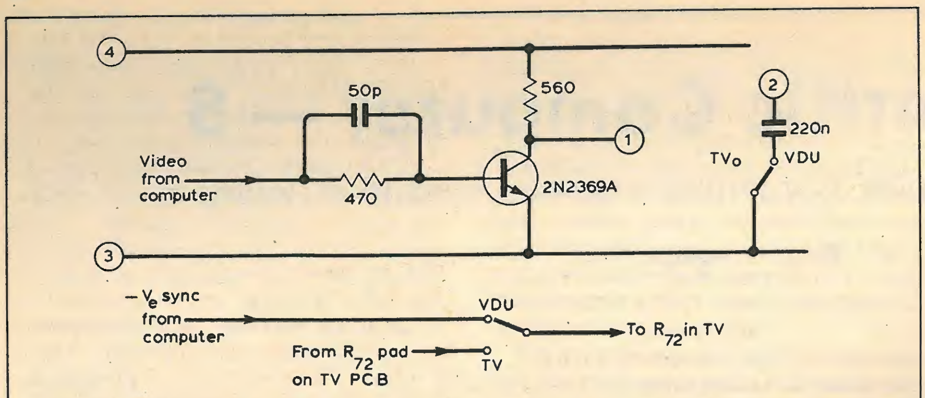

Fig. 26. *Tv interface for the Ultra model 3845. The numbers in circles are pin connections on the c.r.t. base.*

to the p.c.b. With negative going sync. supplied from the computer, a display should be obtained which, with the switch in the v.d.u. position, syncronises without any adjustment to either the horizontal or vertical holds. It is possible that the display will not completely fit onto the screen, but this can be rectified by the following alterations.

Loosen the polythene clamp which holds the scanning coils onto the neck of the tube and slide the plastic end of the width adjusting collar (this fits between the coils and the tube neck) to reduce the width of the picture. If the display is still too wide, connect a voltmeter between pins 3 and 4 on the tube base and adjust the preset resistor R_{69} which is just in front of the line timebase compartment. This sets the h.t., normally 11.3V, and should produce the required change with less than a one volt alteration. If the display is not horizontally centred, adjust the position of the core in the line oscillator coil (this can be found behind the line compartment nearer to the centre of the set than the "set h.t." preset). This must be done with a non-metallic tool.

If the television is tuned to a station whilst in use as a v.d.u., the tv picture may faintly modulate the display. This can be avoided by tuning off the station, unplugging the aerial or turning down the contrast control. If a brighter display is required, a higher supply voltage to the 2N2369A will be necessary. This can be supplied by the computer or from the 90V supply on pin 6 of the c.r.t. base. If the 90V is used, a potential divider must be connected because the maximum collector voltage of a 2N2369A is well below 90V. Whichever supply is chosen, the collector load should be increased proportionately from the 560Ω shown in this design.

Radio-teleprinter interface

One task for which this computer is well suited is the reception and transmission of radio teleprinter signals — RTTY. The system described here consists of hardware which converts f.s.k. (frequency shift keying) signals into digital levels, and software which is used to receive the serial stream of data, recognise the start of bytes and then frame, translate and display them. This software allows the Baud rate, the style of encoding and the code used to be controlled by the programmer.

The receiver should use a product detector or a b.f.o. so that the f.s.k. signals are available as two audio tones. The difference in frequency between the tones will depend upon the shift being used by the sender of the RTTY, but will usually range from 170 to 850 Hz. If the receiver's bandwidth can be reduced to this extent, the wanted/unwanted signal ratio will be improved and this will produce more reliable decoding. However, even with conventional bandwidths, the first two amplifiers in Fig. 27., which are connected as high and low-pass active filters with gains and Qs of one and a bandpass of approximately 1200 to 2100 Hz, will filter out the required tones to some extent. The filtered signal is then fed into a 565 phase locked loop. This i.c. compares the input signal with

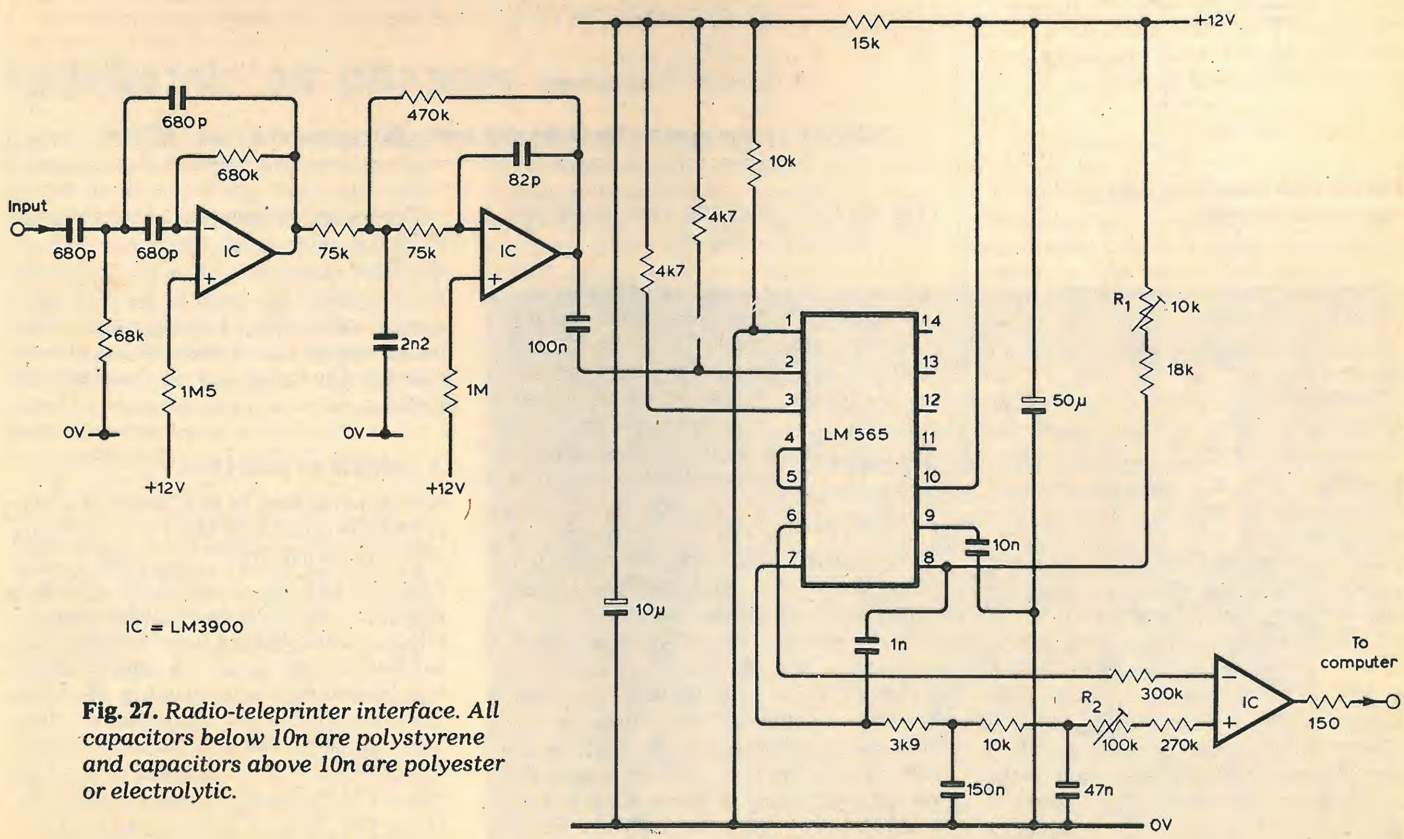

Fig. 27. *Radio-teleprinter interface. All capacitors below 10n are polystyrene and capacitors above 10n are polyester or electrolytic.*

1C00	11	40	80	21	80	1C	DB	00	E6	04	20	FA	CD	36	03	10
1C10	DB	00	E6	04	20	FC	06	03	CD	36	03	9B	10	[illegible]	01	[illegible]
1C20	05	DB	00	E[illegible]	[illegible]4	[illegible]	[illegible]7	4F	CD	36	03	[illegible]	C[illegible]	36	03	[illegible]
1C30	1[illegible]	EF	7[illegible]	0F	0F	0F	2F	E[illegible]	1F	FE	00	20	04	2E	80	1[illegible]
1C40	C5	FE	04	20	04	2E	A0	1[illegible]	B[illegible]	E5	85	6F	7E	E1	FE	EE
1C50	2[illegible]	B4	FE	FF	20	05	C[illegible]	C4	03	18	AD	12	13	FE	20	20
1C60	A5	7B	E6	3F	FE	37	D4	C4	03	7A	FE	89	20	98	CD	93
1C70	03	18	8D	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF
1C80	EE	0B	11	15	EE	0A	17	01	18	06	19	13	02	04	1A	05
1C90	16	03	10	09	07	12	0C	EE	0D	0E	08	20	0F	EE	14	EE
1CA0	EE	28	31	37	EE	EE	32	2D	2F	25	36	27	3F	EE	2B	33
1CB0	3D	3A	30	38	00	34	29	EE	2E	2C	64	20	39	EE	35	EE

%

Table 19. RTTY software to be run at 1C00.

that of a v.c.o. which has been set at a frequency between the two tones. The result of this comparison will contain a low frequency component which after filtering is used to pull the oscillator to the frequency of the incoming tone. This voltage therefore switches in sympathy with the tones and is fed to a comparator which produces the digital output.

If reception only of RTTY is required, the oscillator's free-running frequency should be set at the midpoint of the active-filters pass band. Alternatively, when a complete terminal is used and standard frequencies are required, e.g. 1275 and 1445 Hz for a narrow shift, the oscillator is set to the midpoint of these frequencies. Before this adjustment is made, R_2 should be set so that with no input to the unit the output is on the point of changing state. With an input of 10mV at the required change-over frequency, R_1 should be set in the same way.

A 12V supply is available from the computer and the output of the unit should be fed, via the serial input buffer IC_{53}, to the line which feeds data bus line D_2.

A RTTY byte consists of a start bit, 5 data bits and 1½ stop bits. The software makes two checks 1ms apart for a start bit, to improve the noise immunity, and when it is successful in finding a start bit the data byte is read in, translated into ASCII and displayed. As there are two sets of characters in the RTTY, Murray code numbers and letters, the computer is set initially to letters and section 1C39 to 1C48 of the program, see Table 19, recognises and acts upon the Murray bytes to draw the correct ASCII byte for display. Because most teleprinters have more than the v.d.u's 64 characters per row, the section 1C5D to 1C72 ignores conventional carriage return and line feed bytes, but looks for spaces in the last eight character positions on a row. When one is found a new line is called which avoids the split words and short lines that occur with most v.d.u. systems. If this facility is not required, e.g. when receiving lines of tabulated data, alter 1C5F to 18, 1C9D and 1CBD to FF to obtain a new line with every carriage return received. Section 1C80 to 1CBF contains the look-up tables for converting letters (1C80 to 9F) and numbers (1CA0 to BF) from Murray to ASCII. Note that without the graphics option, the Murray £ appears as a $. Tuning the receiver is most easily done by observing the output of the unit on an oscilloscope and tuning for the cleanest display, although after some practice the ear is quite adept at picking out the correct point. If after correct tuning the display is random, this may be due to the transmission rate being other than 50 or 45.5 Baud. In this case the byte XX following the calling of the software time delay (CD 36 03 XX) must be altered to change the delay length, see part 4 for details of the sub-routine. The time delay has been set at 21ms as a compromise between 45.5 and 50 Baud by calling two delays with an XX of A0 between data bits, and three delays of 9B at the beginning to clear the start bit when recognised, and to return half way into the first data bit. Three times 9B plus the 10 time delay called between the two start bit checks equals 1½ times two A0 delays. If the code makes no sense when receiving at the correct Baud rate, it is probable that the sense of shift is reversed which causes the computer to read 1s as 0s and vice-versa. This can be corrected by changing sidebands on a receiver using a product detector, or by tuning the b.f.o. to the tones on the other side of zero beat. This problem is most easily recognised by characters appearing regularly but without spaces which suggests that the timing is correct, or if the test signals often transmitted by such stations are received as SYSYSYSY . . . instead of RYRYRYRY. Narrow shift RTTY transmissions can usually be found between 14080 and 14100kHz during most of the day. □

Points arising

Unfortunately the following errors occurred in part 1 of the series. In the memory circuit of Fig.1. D_0-D_8 should read D_0-D_7. The 1k2 and 220Ω resistors on the base of Tr_1 in Fig. 2 should be transposed. For the kit, move R_2 to R_1 and fit a 220Ω in the R_2 position. Pin 15 of $IC_{4,5}$ should be connected to 0V and to maintain the correct order for D_0-D_7, the two outputs from $IC_{4,5}$ to IC_7 should be transposed. In the diagram on the left of Fig. 3, the NO arrow should be placed above the Read strobe box.

Two points have arisen from comments by constructors of the computer. Clock instability causing horizontal jitter on the picture can be eliminated by changing the 470Ω resistors at IC_{28} to 1kΩ. Due to manufacturing tolerances in some 4528 monostables, the tape reader may not function.

If this occurs replace the 27kΩ resistor connected to the 4528 with a 50kΩ preset, feed a 1V r.m.s. sine wave at 1800Hz into the tape reader and adjust the preset until the 4013 output which connects to the monostable is just changing state. The preset can then be replaced with the nearest preferred value resistor.

In conclusion

This section completes the scientific computer series. Due to a lack of space the firmware details have not been published but readers who wish to program their own r.o.ms can obtain a firmware list by sending a s.a.e. to this office.

We hope to support this design in the future with a floppy-disk drive and further practical programs. However, readers are invited to submit details of their own modifications or programs for publication.

We understand that John Adams is prepared to undertake the service or repair of computers built from a kit. Constructors experiencing difficulties should contact the author at 5 The Close, Radlett, Hertfordshire (Radlett 5723).

SIXTY YEARS AGO

After World War 1, amateur radio enthusiasts were left wondering for a time what was to happen to them. Then, as reported in the September 1919 issue, all pre-war licences were cancelled, preparatory to sweeping changes being introduced. In the present-day uncertainty about citizen's band, one hears remarks which could have applied to the situation of sixty years ago.

". . . said an official of the General Post Office to a Daily Express representative, we are very careful to see that applicants are not simply out for amusement. Before the war we had a good deal of trouble with silly fools who apparently asked their best girls to tea and amused them by sending out 'S.O.S.' signals on their wireless sets. Now that there have been such improvements in the apparatus inanities of this kind will be very obstructive to messages of commercial importance."

All we have to say with regard to that statement is that any practical wireless man knows how the "fools" could be soon discovered and eliminated; no ban has been placed upon private motor cars simply because a "fool" occasionally runs over a pedestrian. As for amusement, we should like to know why people may not amuse themselves in any way they please, provided they do not infringe the liberties of other citizens or transgress against the law. The amateur is willing to be supervised and to conform to reasonable regulations; he is even willing to act as a policeman of the aether amongst his own class, but judging from the look of things there exists a desire to obliterate him altogether. America has bowed — stiffly, it is true — to Prohibition, but she did not agree to the proposal to stifle amateur wireless telegraphy. Why should you? What are the Wireless Clubs doing to defend their rights? It was the American amateurs themselves who won their day, though they interested their legislators in the matter. Have our Wireless Clubs knowledge of any Member of Parliament who will stand up for them in the House?

Selecting stabilizer thermistors for Wien bridge oscillators

by **M. G. Salem** Ph.D

Assessment of the output voltage of thermistor-stabilized Wien bridge oscillators very often depends upon cut-and-try methods. Similarly, the temperature coefficient relative to output amplitude is normally not effectively predicted. The general formula to determine these factors is provided here and is allied to a specific oscillator circuit. Selection details are also included, covering three "popular" thermistors.

In the Wien bridge oscillator shown in Fig. 1 an amplifier with two feedback loops is used, the feedback to the non-inverting input being in phase with the input only at the frequency $f_0 = 1/(2\pi R_1 C_1)$. Negative feedback is independent of frequency but is arranged to increase as output increases, helping to maintain a constant output level. The final oscillator constitutes an amplifier with a gain of 3 and a constant amplitude sinewave output at a frequency determined as in the calculation above.

Amplitude stabilization is usually accomplished by making one of the negative feedback resistors sensitive to temperature and ensuring that the power dissipated by it is sufficient to raise its temperature well above the ambient level. Under such circumstances the resistance of the temperature-sensitive element will be determined by the oscillator output, with only slight dependence upon ambient temperature. The temperature-sensitive element may be a resistor or thermistor, in which case the symbol R is used, indicating a negative temperature coefficient, or R_f indicating a positive temperature coefficient device or filament lamp.

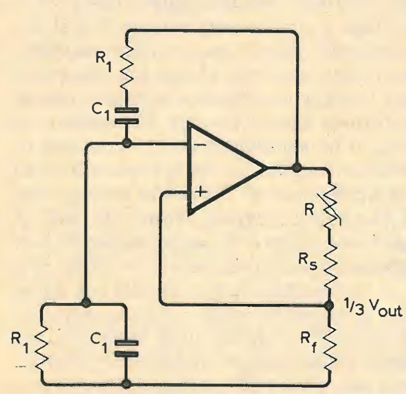

Fig. 1: Wien bridge oscillator, used as a thermistor test circuit

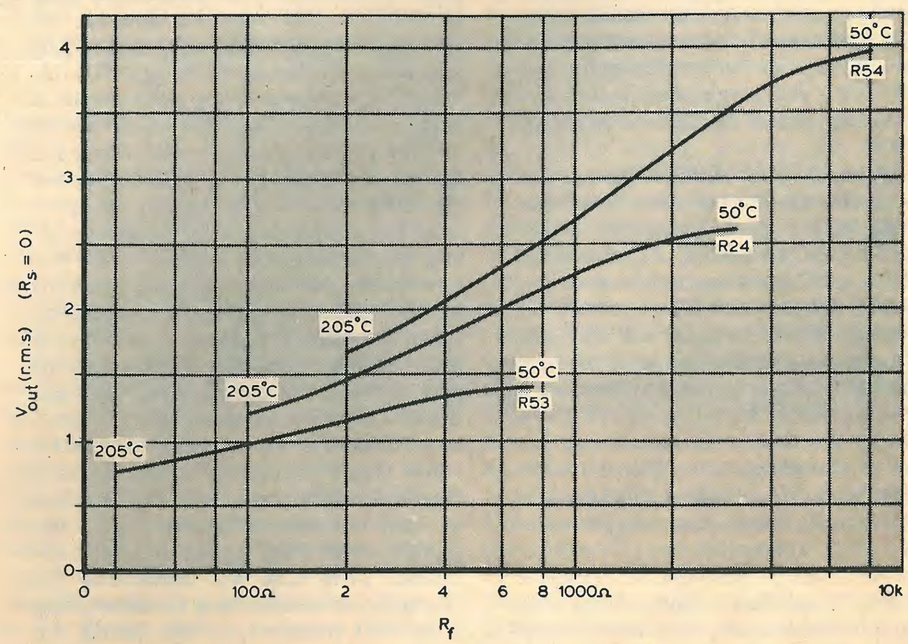

Fig. 2: graph showing V_{out} relative to R_f and operating temperature for three basic thermistor types

If the open loop gain of such an oscillator is much larger than 3 the voltage fed back to the inverting input will be close to ⅓ of the output voltage, giving $R + R_s = R_f$. It is convenient to set R_s at zero. The resistance of a thermistor is given approximately by $R = A \exp(B/T)$ where A and B are thermistor constants and T is the thermistor temperature in degrees Kelvin. Temperature rise above the ambient level is approximately proportional to the power dissipated and it is usual for manufacturers to quote the dissipation cofficient, which we will term D, in mW/°C.

For a given value of R_f (and R_s if used) the steady-state resistance of the thermistor must be $R = 2R_f - R_s$. Temperature will be $T = B/\ln(R/A)$ degrees Kelvin and the temperature rise $\Delta T = T - T_a - 273$, where T_a is the ambient temperature in degrees C, typically 20°C. Power dissipated by the thermistor is $P = D\Delta/1000$W, current is $I = \sqrt{(P/R)}$ in amps and output voltage is $3IR_f$. Combining these expressions gives V_o (r.m.s.) $= 3R_f$

$$\sqrt{\left[\frac{D}{1000R}\left(\frac{B}{\ln(R/A)} - T_a - 273\right)\right]}$$

$-T_a-273$ where R is usually equal to $2R$.

Table 1: principal operating details of each thermistor.

Thermistors with low dissipation factor

Type	R at 20° C	R at 220° C	I at 220°C	A	B
R53	5k	63	4·5mA	0·12	3100
R24	20k	150	7mA	0·17	3400
R54	50k	270	3·3mA	0·18	3650

All types: $T_{max} = 220°C$ $P_{max} = 3mW$

$D = 0{\cdot}016 mW/°C$

The relative temperature coefficient is $1/(2\Delta T)$ or $100/(2\Delta T)$%/°C, independent of thermistor or circuit. Such formulae should not prove daunting in these days of pocket calculators, but it may be worth remembering that $\ln(R/A) = 2.3 \log(R/A)$.

As a comparative test of the formula,

continued on page 95

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Microcomputer interfaces

Connecting input and output equipment

by **Ian H. Witten,** M.A., C.Sc., Ph.D., M.I.E.E.
Department of Electrical Engineering Science, University of Essex.

THE SAME information can be represented in different ways, like marks on paper, or speech sounds. An interface is a connexion between one information representation and another. Computer interfaces convert between the computer's representation, namely electrical signals on the bus, and another representation – like dots of light on a display screen, or a musical note. There is an obvious distinction between input and output interfaces. (What is not obvious is which is which: it is conventional to look at things from the computer's point of view, so that "input" means from the outside world to the computer.)

Interfaces provide a means of communication between the outside world and the computer. Contrast this with buses[1] which provide communication within the computer system itself. Communication along a bus is entirely in the form of binary electrical signals. The information to be transmitted falls naturally into logically separate groups: address, data and control. The control part is the most interesting, and depends on the protocol which is adopted for information transfer. Each control line has a different purpose, and each is necessary if the protocol is to be observed. All in all, the subject of buses is well-defined and satisfyingly logical.

Interfaces are a different matter. They are closer to the real world, with all its variety and hazards. For a start, there is a multitude of different representations of information. To interface to a car engine, the throttle position, mixture control, engine speed and temperature, and ignition timing all need to be converted or controlled. Where does interfacing end and mechanical engineering begin? To interface to smells, we need to study chemistry. What about transmission of information between the computer and a remote device which converts it to another representation – is this part of the interface? There is no clean logical structure to the subject of interfacing; no neat division between the interface and the real world. Nevertheless, interfaces must be understood, designed, and built, and this is probably the most important single area in the application of microprocessors to man-machine communication. For example, lack of a cheap car engine interface and smell interface is the chief reason why automatic anti-pollution controls for vehicle engines – which would benefit everyone by improving petrol consumption and reducing pollution – are not commonly used.

Simple i/p and o/p peripherals

The simplest output peripheral is a bank of on/off l.e.d.s (light-emitting diodes), which emit light when they conduct current. If eight l.e.d.s are provided, then one data word can be displayed. To keep the l.e.d.s alight, the data from the bus can either be latched into flip-flops, or periodically regenerated ("refreshed") by the processor. If l.e.d.s are refreshed twenty or more times a second for a millisecond or more each, an illusion of continuous illumination is achieved.

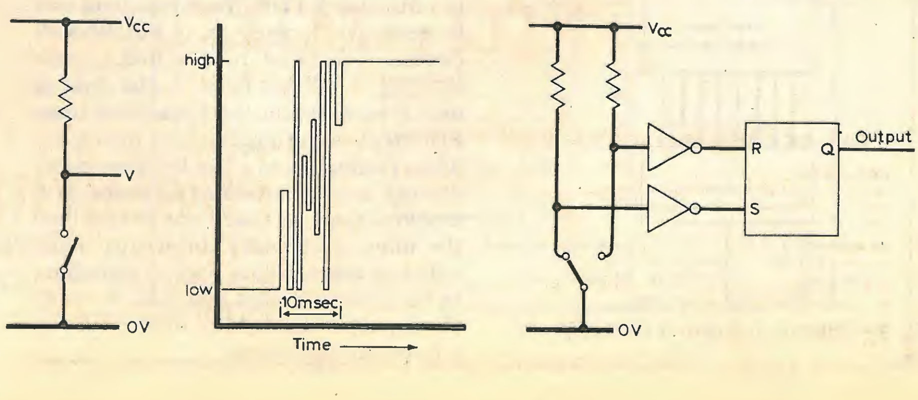
The input device corresponding to a bank of l.e.d.s is a row of switches, which are bi-stable devices, so latching is unnecessary. There is, however, a serious problem with contact bouncing. Figure 1 shows a typical waveform generated when a switch is changed from open to closed. The output does not change cleanly, as one might expect, but passes through a transition phase where it oscillates randomly. Unless appropriate precautions are taken, this will cause chaos if interfaced directly to a microprocessor. As with display refresh, the precautions can be taken in either hardware or software.

A hardware debouncing circuit is also shown in Fig. 1. It relies on a break-before-make switch action, so that no matter how unclean the switch output is as one contact is broken and as the other is made, the "breaking" is completely finished before the "making" begins. Then, the first "make" spike which exceeds the threshold for logic 1 will activate the latch, and it will remain in the new state throughout the rest of the "making" disturbance. Software debouncing uses a different principle. The program waits for a specified time (usually around 20 ms) after a change in switch value is detected, before reading the switch and returning the new value.

A 7-segment display contains seven l.e.d. segments arranged so that the numerals can be shown, the lights being connected to the appropriate bits in the data word. Again, the data may either be latched, or refreshed by the processor. The problems of latching are highlighted when several banks of 7-segment displays are used. If there are six displays in a bank, $6\times7=42$ latches must be supplied for each. With several banks, a fair-sized store is needed to hold the latched bits. But the microcomputer already has a store – accessible to the processor – which can be used providing the processor is prepared to undertake to refresh the segments regularly. The input device corresponding to a 7-segment display is a thumbwheel.

Computer systems often need to communicate with devices with analogue electrical inputs and outputs. A d/a converter (digital-to-analogue) takes a binary signal and produces an output voltage whose size is determined by the input. Usually the relationship between output and input is linear, although non-linear (e.g. logarithmic) d/as do exist. Suppose the output range is 0-10V, and the input is 8 bits. Then an input of <00000001> will give $1\times10/256=0.04$V output, <10000000> will give $128\times10/256=5$V output, and so

Fig. 1 — *Malformation of low-to-high edge produced by switch bounce, with anti-bounce circuit.*



on. The use of an 8-bit input implies a precision of 1/256 = 0.4%. If more accuracy is required by the analogue signal, then more input bits must be used – 10 bits, 12 bits, or even 14 bits. An a/d converter (analogue-to-digital) performs the opposite conversion, taking as input an analogue voltage (say between 0 and 10V) and producing the corresponding binary value as output.

Figure 2 shows the circuit of a simple d/a. It works by converting each "1" bit in the input to a current with a weighting appropriate to the position of that bit in the word, summing the currents,

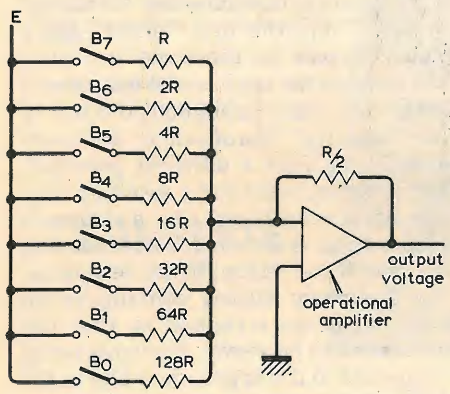


Fig. 2 – *Principle of digital-to-analogue conversion, using weighted resistors.*

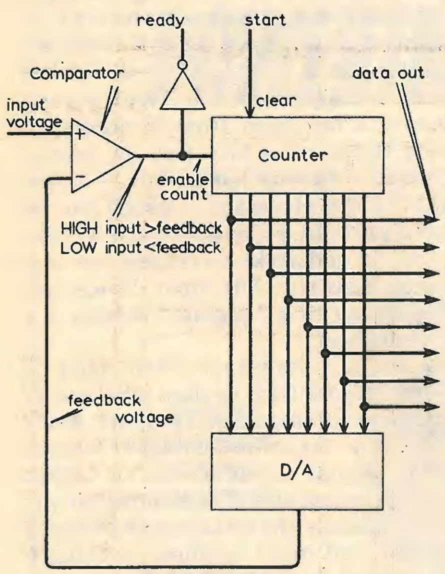


Fig. 3 – *D-to-a converter in feedback loop makes a-to-d converter.*

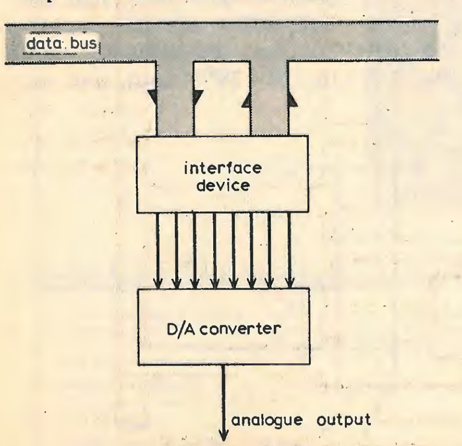


Fig. 4 – *Interfacing d-to-a converter to a bus.*

and converting the result back into a voltage. B_0 to B_7 are switches driven by the 8 bits of the input. When closed, they route the constant voltage E (say 10V) through a weighting resistor into an amplifier. The resistors are chosen to give each bit an appropriately large or small influence on the overall output. The operational amplifier sums the currents produced in the resistors, with the R/2 feedback resistor ensuring that the most significant bit (B_7) accounts for exactly half of the total analogue output range.

There are problems with the d/a of Fig. 2. Resistors do not come in binary-related values. Furthermore, if the overall accuracy is to be 0.4%, in accordance with the 8-bit input used, then the largest resistor must have 0.4% tolerance – a stringent requirement. There are better d/a circuits which circumvent these difficulties, but Fig. 2 shows the basic conversion principle.

The most common types of a/d converter are made from a d/a converter and a voltage comparator. Figure 3 shows one possibility, in which an 8-bit counter counts up from zero, its output being d/a converted continuously and compared with the input voltage. While it is smaller, the counter keeps counting. As soon as it exceeds the input voltage, counting is stopped and the "ready" line is activated to indicate that the conversion is finished.

Again, there are problems with the circuit. The inevitable transients during counting will produce terrible spikes on the d/a output. The most fundamental problem, however, is that the conversion takes a long time, especially if the input voltage is near the top of its range. Again, these difficulties can be overcome, but Fig. 3 illustrates one principle of a/d conversion.

Interface devices

The d/a converter in Fig. 4 is connected to a bus via an interface device. Since the bus is parallel, and the d/a converter needs a parallel input, why not connect it directly to the bus and dispense with the interface device? Consider the operations that must be performed:
–address decoding
–handling of read-write/address valid/data accepted/reset lines
–data latching
–electrical buffering
–interrupt logic.

The first two operations were described in reference 1. (The "reset" control line is asserted at power-up, to initialise all devices attached to the bus.) Data latching is needed because the data is only present on the bus for a short time. Electrical buffering is often necessary when reading from a bus because many devices may be attached to it and precautions must be taken not to overload the lines electrically. Interrupt logic, which is essentially a way of signalling to the processor that new data is ready (for input) or needed (for output), is not covered in this course.

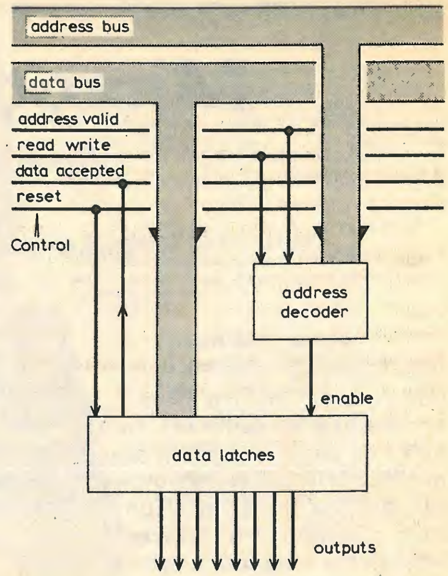


Fig. 5 – *Simple output port.*

An output interface that performs most of the tasks is shown in Fig. 5. The data latch assembly forms the basis of an interface device which goes under various names used by different manufacturers, such as "parallel output port", "PIA" (programmable interface adaptor), "VIA" (versatile interface adaptor), "PIO" (parallel input/output interface), "MILE" (microprocessor interface latch element). The address decoding function is not normally a part of the interface device, because with a 16-bit address bus, 32 extra pins would have to be provided on the integrated circuit – 16 for the address bus and 16 for the desired interface address – and circuits with lots of pins are difficult to manufacture and use.

Example. To drive a bank of six 7-segment displays, six separate parallel output ports could be used. A more elgant solution, which uses only two output ports, is shown in Fig. 6, where port 1 selects one of the six displays to be refreshed, while port 2 gives the data for the segments of that display. One of the six binary patterns

10000000
01000000
00100000
00010000
00001000
00000100

is written to port 1 to select just one of the displays, and the 7-segment code for that display is written to port 2. Care is taken to write zero to port 2 before changing the address, to prevent the transient appearance of the wrong pattern on the newly-selected display.

The simple output port of Fig. 5 is sometimes combined, on the same chip, with an input port. A more versatile interface allows each of the lines from the port to be programmed as an input or an output. A *data direction register* within the interface is used to indicate which are inputs and which are outputs. Each of the data direction register bits is set to 0 if the corresponding line is to be an input and 1 if it is to be an output. For example, if the data direction register held <01010011> then lines L7, L5, L3, and L2 in Fig. 7 would be inputs while L6, L4, L1 and L0 would be outputs. The data direction register can be written by the processor at any time.

The interface device shown has three registers within it: each can be read or written by the processor. When the data register is written, the bits in it which correspond to outputs appear on their respective lines. When it is read, the states of those lines which are configured as inputs appear in their respective bits. The control and status register, when written, affects the functioning of the device and the state of the extra output bit shown in the figure. When read, it gives the status of the interface and of the extra input bit. These two extra bits can be used for a variety of purposes, including handshaking of data with the input/output device connected to the interface. The functions of the control and status register can be summarised as:

[write] set/reset extra output bit
enable/disable handshaking
select data direction register or data register
enable/disable interrupts (i.e. should the processor be informed automatically when new data is present?)

[read] read extra input bit
read interrupt status (i.e. is new data present?)

Fig. 8 shows the block diagram of a commercially available interface device, the Motorola PIA, which contains two separate, 8-bit input/output ports. This is a relatively simple device! The MOS Technology VIA has 16 registers and is more complex than many processor chips.

Serial transmission

Serial transmission is used with remote devices, in which case the data rate will be relatively low, because cramming all the data down one wire is inherently slower than using a parallel connexion with many wires. Such devices are usually character-oriented input/

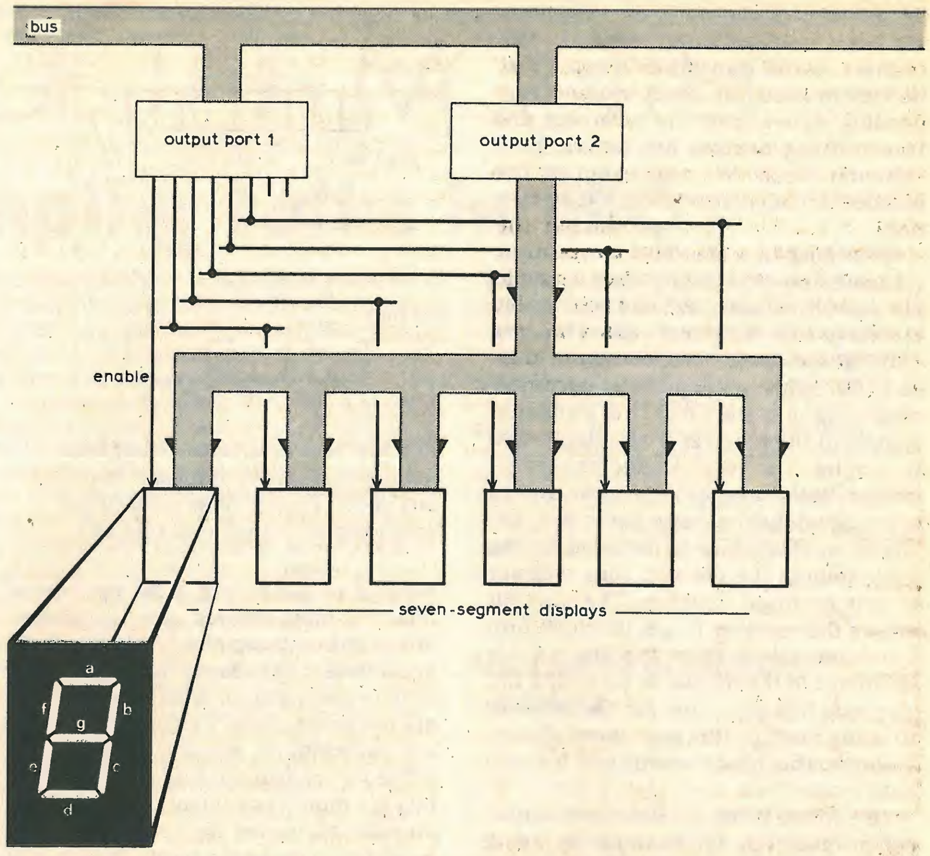


Fig. 6 – *Enable line allows sequencing of 7-segment displays, using only two ports.*

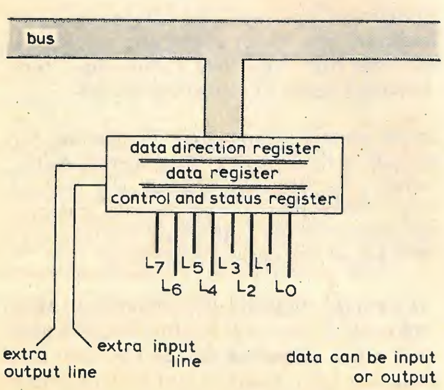


Fig. 7 – *Input and output in same port.*

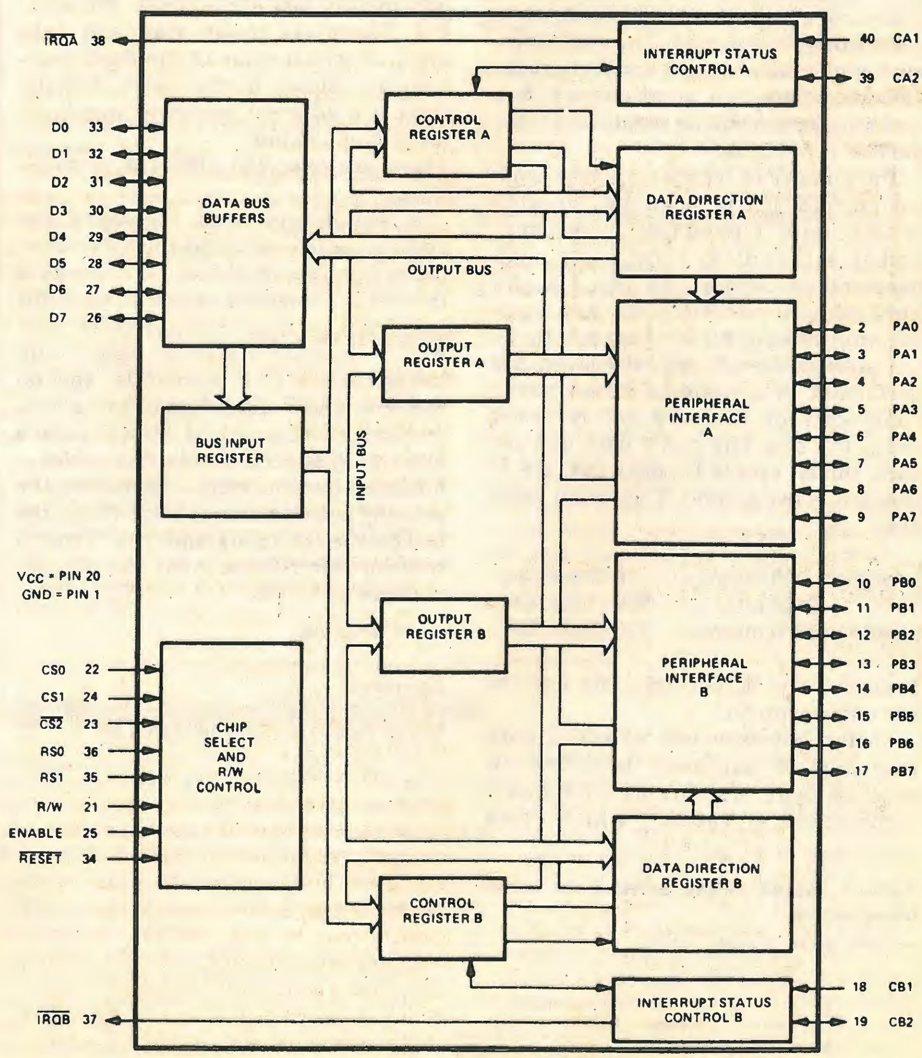


Fig. 8 – *Specimen block diagram of p.i.a. – Motorola MC6820.*

output terminals, such as teletypes, v.d.u.s (visual display units), and printers. Serial transmission can either be synchronous or asynchronous, depending on whether the receiving and transmitting devices are driven by a common clock. We will examine the protocol for asynchronous transmission only.

According to a standard convention, transmission of a serial data word is preceded by a "start bit" and terminated by one or two "stop bits". Start bits are LOW and stop bits HIGH, so a HIGH-to-LOW transition is guaranteed at the beginning of a start bit. This transition signals to the receiver that a data word is coming. The receiver and the transmitter will have clocks running at approximately the same rates but, because no clock line is included in the cable joining the devices, they will not be synchronised together. The start bit allows the receiver to get its clock into synchronisation. Then, the line state is examined in the middle of each data bit. The stop bits give time for the receiver to ready itself for the next word. Figure 9 shows the bits transmitted for one data word.

Of course, if the receiver gets out of synchronisation, for example by being switched on in the middle of a data word, it may mistake a HIGH-to-LOW transition between data bits for the beginning of the start bit. Then the first word would be misread. The same mistake could also occur subsequently; however, there is a good chance that synchronisation will be regained within the first few words.

The number of bits/second transmitted down the line is called the "bit rate" or "data rate". ("Baud rate" is also met, and is a technical term used with telecommunications systems. For the kind of transmission we are considering, the baud rate happens to be the same as the bit rate. However, the definition of a baud involves extra complications that are not relevant here.) If 2 stop bits and 8 data bits are used, the bit rate is 11 times the rate of characters per second. Typical bit rates are:

teletype	110 bits/sec	10 chars/sec
v.d.u.	9600 bits/sec	960 chars/sec
printer	1200 bits/sec	120 chars/sec

Note that the higher data-rate devices use only 1 stop bit.

So far, the principle of serial data transmission has been described. In practice there are various differences, summarised in Table 1, which often

Table 1. Some of the options for serial transmission.

stop bits	data bits	parity	bit rate	electrical
			110	
			300	
1	7	odd	600	voltage driven
			1200	
2	8	even	2400	current driven—20mA
			4800	current driven—60mA
			9600	

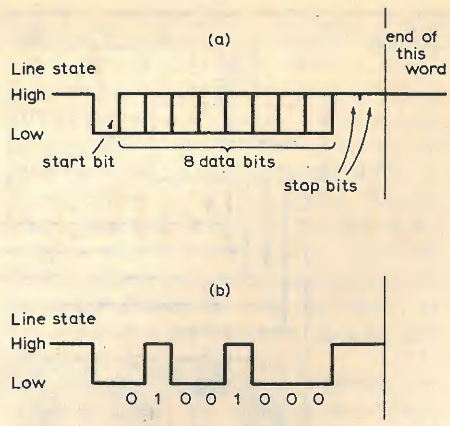


Fig. 9 – *Serial transmission of 8-bit word, showing one start and two-stop bits at (a). Typical 8-bit word at (b) combined with start and stop bits.*

confuse people trying to set up a serial link. We have already seen the alternatives of 1 or 2 stop bits. Similarly, there are different standards for the number of data bits used, of which 7 and 8 bits are the commonest. 7 bits (128 symbols) are sufficient to encode the alphabet, while for transmission of data words, 8 bits are more convenient. In either case an extra bit, called the "parity bit", can be added to make the parity (number of 1's in the transmission) even or odd, as an error-detection feature, so 8 or 9 information bits are actually transmitted. There are many standard data rates, of which some of the most common are shown in the Table. Finally, there are different electrical standards for driving the line.
There are over 150 different possibilities.

A commonly-used standard for coding alphabetic and numeric characters and symbols into 7-bit words is the ASCII (American Standard Code for Information Interchange) code. The ASCII characters include upper- and lower-case letters, numerals, special symbols, and a sprinkling of extra control codes with standard interpretations like "ht" (assists in formatting tables – horizontally tabulating – by moving the printing position along), "bel" (rings the bell on the terminal), and "etx" (end of transmission). These make the number of codes up to 128.

To be continued.

Reference
1. Witten, I. H., Computer buses, *Wireless World*, February 1979 and March 1979. □

LITERATURE RECEIVED

Report of **study on workplace exposure to man-made mineral fibres,** contains recommendations concerning inhalation of respirable fibres, etc. Report is available from HMSO, 49, High Holborn, London WC1V under title "Man-made Mineral Fibres" price 50p.

Catalogue of **books on microcomputer matters** called "Microdigital" from the "Microcomputer Bookshop", 25 Brunswick St., Liverpool 12 0BJ.

A general data booklet is available from IMF Electronics which is intended to explain the **UHJ surround-sound system,** developed by the N.R.D.C. in collaboration with the BBC and IBA. Interested parties should write, requesting information on "Ambisonics" to IMF Electronics, Westbourne St., High Wycombe, Bucks HP112 2PZ.

A product summary of available "Glennite" **piezoceramics** can be obtained from Gulton Europe Ltd., The Hyde, Brighton, Sussex. This covers the company's range of lead zirconate titanate and lead metaniobate piezoceramics, which are available as thin sheets, bender elements, shaped elements and strain gauges.

Catalogue from H. A. Wainwright and Co. gives details of the full range of Fenwal **temperature controls.** H. A. Wainwright and Co. Ltd., 95 Farncombe St., Farncombe, Godalming, Surrey, GU7 3BA.

A brochure from Ferranti discusses the selection and use of the **Uncommitted Logic Array (ULA).** This is a family of bipolar l.s.i. chips, each containing an unconnected final stage. The brochure explains how the interconnexion pattern can be arranged to convert the uncommitted chip into the required custom l.s.i. circuit. Ferranti Electronics Ltd., Fields New Rd., Chadderton, Oldham, OL9 8NP.

Illustrated catalogue of **professional audio equipment** from F.W.O. Bauch Ltd. Covers complete range of products under Studer, Revox, Neumann banners as well as many others. F.W.O. Bauch Ltd., 49 Theobald St., Borehamwood, Herts WD6 4RZ.

Latest technical information in the form of glossy brochures on the **product range** of Sony Broadcast, City Wall House, Basing View, Basingstoke, Hampshire RG21 2LA

Catalogue containing details of a **range of products** from abrasive paper to Zener diodes from Maplin Electronic Supplies Ltd., P.O. Box 3, Rayleigh, Essex. No price list supplied.

Shortform catalogue of **microcomputer hardware** plus list of books and software is available from New Bear Computing Store, 40 Bartholomew St., Newbury, Berks.

Information on **transmitter "happenings"** is contained in the IBA's "Engineering News" which covers activities in all UK regions. Engineering Information Service, Independent Broadcasting Authority, Crawley Court, Winchester, Hampshire SO21 2QA.

The Philips/Signetics data handbook, about 300 pages of technical information on **bipolar and m.o.s. memories** can be obtained from Mullard Ltd., Mullard House, Torrington Place, London, WC1E 7HD

NEWS OF THE MONTH

Anti-dumping talks in EEC

Mr John Nott, the Secretary of State for Industry, and Mr Cecil Parkinson, the Minister for Trade, visited Brussels on July 10 for talks with the EEC Commission on Community anti-dumping activities. At the meeting it was generally agreed that there was a need for streamlining the Community regulations and this would take place when they had implemented the changes recommended by the results of the recent world trade talks ** which included a modification of the General Agreement on Tariffs and Trade (GATT) dumping and subsidies code. The GATT anti-dumping code says that dumping occurs when a manufacturer sells goods at a lower price in an export market than in his home market.

Readers may remember that in the past the Japanese have been accused of dumping hi-fi and amateur radio equipment in UK markets (see p59, August 1977 issue — Amateur radio equipment survey) but this was apparently never proved — probably because of the problems encountered in obtaining the necessary facts and figures at the time (see p68, September 1977 issue). Today, however, the Department of Trade has its own expert anti-dumping unit which advises UK industries on the formulation of anti-dumping cases to present to the Commission.

A spokesman for the D. of T., when asked about the Japanese export question, said that the Japanese were generally not identified as a source of dumping. Because their products had been cheap compared with British products of the same kind they had frequently been suspected of dumping, but investigators had to determine whether the reduced prices were due to dumping or manufacturing and other efficiencies. On the odd occasion when the Japanese had been found to be dumping, the price difference due to dumping was very much less than that due to efficiency. The figures used t assess whether dumping is occurring are obtained by taking into account all the normal price differences due to shipment, import duty, product style changes etc, but even then there are variations due to such things as exchange rates and material cost fluctuations.

Dumping which does occur involves only relatively small amounts of money and this can be and is normally controlled by a policy of import restraints. Government (countervail) subsidies are allowed on regional policy and unemployment grounds, but if these are applied only to export and not generally to the manufacturing industry, then these too can contribute to dumping.

** The talks have been taking place over the last five years but general agreement was reached shortly before the general election this year.

America to get British viewdata

An agreement between the US giant General Telephone and Electronics Corporation (GTE), and Insac Data Systems, the government-owned UK company, is expected to result in the US getting British viewdata later this summer. Under the terms of the agreement, GTE will initially be offering a limited public service for business users only but this is to be extended to residential users later.

Although Insac, which has a sole licence from the British Post Office to exploit Prestel-type systems in America, developed its viewdata service specifically to suit the US market, the end result is similar in operation to Prestel and therefore helps to encourage world-wide acceptance of the BPO standards. Exclusive US and Canadian rights to the Insac system have been granted to GTE and the company has also been given a US sub-licence to Prestel under Insac's Post Office licence. Initially, the aim is to test the market in the US. Publishing, finance, news and entertainment companies have already expressed interest in the service. GTE will concentrate on business and domestic markets while Insac offers the service to corporate and closed-user organisations who may have special software needs.

This news follows the successes earlier in the year when it was announced that the Post Office had sold its viewdata expertise to Switzerland, West Germany, the Netherlands and Hong Kong.

Electronics vital in transglobe expedition

On September 2 this year an expedition, headed by Sir Ranulph Fiennes, sets sail from London to start the first longitudinal circumnavigation of the globe — via the North and South Poles. As is usual in present-day expeditions of this kind, electronics is to play a vital role in ensuring the safety and comfort of the expedition team. Some 330 companies have sponsored the expedition and about 80% of these are British. Burndept, Racal, Ferranti and Sinclair are just a few of the electronics firms who have provided equipment for the journey.

The expedition team will use the latest pioneering equipment, ranging from shoes for walking on water, cardboard huts and motorised sledges to highly accurate watches, underwater cameras and diesel generators. Burndept Electronics (E.R.) have provided miniature ground-to-air emergency beacons which will be used for aircraft and supply drops and for pinpointing team positions in ice floes. Wherever possible they intend to use solar power equipment provided by Ferranti Ltd and in white-out conditions (when vision is impaired by weather and surroundings) they will use solar sensors made by Hawker Siddeley Dynamics Ltd.

Muirhead Data Communications Ltd have provided facsimile machines which will be operated both on the ship and at the ice bases and it is hoped that they will enable photographs to be sent back to the ship. R. H. Minns (Baluns) Ltd are supplying radio monitoring equipment for indicating imperfections in the antennae systems which the team will be relying upon. No man can go anywhere without a calculator these days so Sinclair Equipment International Ltd has supplied the team with pocket calculators which are specially programmed for astro-navigation.

One of the most important aids that an exploration team can have is good communications and on this score the entire expedition will depend upon products produced by Racal. The group companies involved are Racal Communications Ltd, Racal Group Services Ltd, Racal Systems Ltd, and Racal Tacticom Ltd. They will provide communications equipment for use on land, with Land and Range Rovers, at sea, on the Benjamin Bowring, which is a polar research ship that will be used to transport the team, and in the air, from a De Havilland Twin Otter aircraft. Communications will also be provided on ice, between ice group members, and from ice bases back to a Royal Aircraft Establishment Cove. Most of this equipment will be expected to operate in temperatures as low as minus 80°F.

More home video machines at Berlin

Grundig will launch a new video cassette recording system at the Berlin Radio & Television Exhibition (24.8 to 2.9). Called video 2000, it has been jointly conceived with Philips as a European response to the recent Japanese video recorders, which now incidentally includes a new longitudinal machine from Toshiba.

Grundig say the cassettes, measuring 18.3×2.6×11cm, can be played both sides. They claim a substantial reduction in hourly tape cost and a total of eight hours playing time. Recording speed is 5.08 m/s with a tape speed of 2.44 cm/s.

The Toshiba system is a relative of the BASF longitudinal approach but whereas the original BASF proposal was to switch tape direction at the end of a longitudinal scan, the Toshiba machine uses an endless loop cartridge, the head stepping tracks after 100 metres of tape, travelling at 5.9 m/s. Toshiba say 200 tracks 40μm wide are contained on ½in wide tape, with a spacing of 10μm. The fixed-head approach of BASF, and now Toshiba, is expected to reduce mechanical complexity albeit with more complex though potentially cheaper signal processing circuitry.

The British exporter and the Japanese yen

As Britain joins the select group of petro-economies, spare a though for the British exporter shouldering the burden of an increase in sterling of 31 per cent against the Japanese yen and 10 per cent against the deutschmark since the beginning of the year, according to the trade weighted index. The trade figures for the first five months of the year are witness to these deadening export pressures, showing a £1 billion deficit on the current account. Following this trend of undiluted pessimism, a Department of Industry Survey of the top UK exporting companies predicts a slowdown in export growth for the whole of 1979.

Imports have been rising in inverse proportion to exports as the strength of sterling continues to restrict volume growth. There are many advocates of the swings and roundabouts theory, who emphasize the beneficial effects of a strong currency in curbing inflation and lowering the prices of imported raw materials for end products. The larger companies and multi-nationals always have the advantage in this and most other situations, keeping trading within the privileged confines of the group, not having to bear the full brunt of competitors with weaker currencies.

Announcing Plessey's results for the year ended March 31, 1979, chairman Sir John Clark reported that the fall in other currencies relative to sterling had cost the Group more than £2 million in profits, and yet he still favours a strong currency. Over the same period Racal reported that the upward movement in sterling had a £6 million impact on sales, but commenting on the military radio side of its operations a spokesman emphasized that though price was an important factor, it was by no means the only factor in determining sales. Asked about export expectations for the year, Pye of Cambridge stated that its first six months export turnover was up on the previous year but it was difficult to forecast the outcome of the second half with such variables as wages, fuel and currency fluctuations to consider. Centronics reported that exports were expected to stay at last year's level. Indications in the electronics industry are that export growth will be maintained over the year, though a decline is expected in many other industries.

Since 1977 Government has largely given up the attempt to give sterling some semblance of stability. In line with its ideal of a free market economy, the Conservative Government has stood behind or rather left alone the strong pound, quoting the example of other successful economies which have turned a strong currency to advantage. Indications are that the Government intends to follow through the relaxations in exchange control made in the budget. The dollar premium could go, freeing overseas investment, which might, though not necessarily, result in sterling declining against other currencies. Mrs Thatcher had also indicated a willingness to consider membership of the European Monetary System, though this would be particularly awkward at a time when sterling is at such an unnatural level.

Britain is not alone in the currency battle. In June the New York Federal Reserve Bank and the West German Bundesbank spent $2.5 billion to support the dollar against the deutschemark. Growth of the deutschemark has already severely distorted the European Monetary System particularly at the expense of the Belgian franc. Japan has been attempting to strengthen the yen, as inflation continues to bite into its growth rate. More recently the economy has been seeing a boom in domestic demand with the export benefits of a weaker currency taking time to filter through. The current level of advance orders from abroad indicates that there will be a sharp rise in exports over the remainder of the year, wiping out Japan's first quarter's current account deficit. This year has seen considerable pressure brought to bear on the Japanese to open up their markets to exporters. At the Tokyo Summit the right of UK telecommunications manufacturers to tender for Japanese contracts was due to be debated, since to date large contracts for corporations like the Nippon Telegraph and Telephone Corporation have only been open to Japanese manufacturers. The Inward Investment subgroup of the recent Japanese Import Promotion Mission are reported to have been impressed with the idea of manufacturing in the UK as a means of reducing exports without reducing the level of UK sales. The National Economic Development Council's report on the electronic consumer goods sector suggests that inward investment should be turned directly to the benefit of UK exporters by the formation of joint ventures, increasing the competiveness of UK goods.

The response of British industry to low-price competition from abroad has been defensive so far, often withdrawing manufacture of those products threatened. The appreciation of sterling has made the problem more acute, but competition is not only fought on the price front, and the anti-inflationary force of a strong currency can be used to increase export volume.

Solar energy used in Nepal expedition

A team of explorers who have just returned from a four-month hovercraft expedition to open up the Kali Gandaka River in the West Nepalese Himalayas used solar-energy, battery-charging units to charge their film cameras, communications radios, engine starting, lighting and other electronics equipment. The films recorded were shown on the BBC2's World About Us programme on July 1.

Traditionally, the sun is the explorer's worst enemy but this time the solar cell units, supplied by Lucas Industries Ltd, enabled some of it, at least, to be tamed. Using the sun to recharge their batteries helped the exploration team to conserve valuable fuel. The three Lucas panels shown in the picture, for example, are standard and supply a total of 13.6V at 650mA. Each panel contains 30 cells, each producing about 0.45V, and when connected in parallel their total current is almost 2 amps. In strong sunlight, such as exists in West Nepal, it takes about seven hours to completely recharge a typical car battery. Each panel weighs only about 2½kg and measures approximately 510 × 340 × 25mm.

The expedition's aim was to demonstrate that, using modern technology, a river route could open up to link remote communities with the medical facilities of the outside world.

Record firms not too worried about oil prices

Despite the fact that co-polymer, the petrochemical material used in the manufacture of records, has increased in price by about 400% over the last ten years, with large increases recently, record manufacturers do not appear to be too worried about the current increases in oil prices.

According to a spokesman at EMI, co-polymer cost £130 per ton in 1969, and at the end of June the same amount cost £500. Oil prices did have a direct effect on record production, he said, but manufacturers had to live with this. Mr Townsley, a director of Decca Records, held the same view but added that they had to be careful not to reduce the value of the product by making the record too thin. He did not know what the future held, as far as oil and record prices were concerned, but they were taking no special action at the present time. When asked whether record manufacturers would be looking for alternative materials for the product in the future, he said that this was "always on the books".

Houses discuss Post Office monopoly

The Post Office monopoly was the subject of discussion in both the House of Commons and the House of Lords recently.

In the House of Commons on June 25, the Industry Secretary, Sir Keith Joseph, said that he would not rule out the possibility of taking action to abolish the British Post Office's statutory monopoly, and during question time he joined MPs from both the Labour and Conservative parties in criticising PO efficiency. When Mr J. Bruce-Gardyne, Conservative MP for Knutsford, asked whether he would give his support in introducing a one-clause Bill to abolish the PO's statutory monopoly, Sir Keith said that he had "no plans for such initiative or response at the moment but would not like to rule it out".

At the House of Lords on May 23, Lord Torpichen raised a question relating to the Carter Report on the Post Office (see p51, September 1977 issue). His question was: "To ask Her Majesty's Government whether any review of the Post Office telecommunications monopoly has taken place since the publication of the Carter Report in July 1977, and whether they plan to implement the recommendation in paragraph 63 of that report to relax the monopoly". The Minister of State for the Department of Industry, Viscount Trenchard, said in reply to this that the government were studying the scope for increasing competition in some areas now served by monopoly-nationalised industries. He confirmed that this included the Post Office telecommunications monopoly and the matter contained in the Carter Report. Thanking the minister for his reply, Lord Torpichen asked him if he could give the House some indication of when this would happen. Viscount Trenchard was unable to answer this question but said that the government regarded some of the matters in the Carter Report as having been outstanding for a long while. They were unaware of the need, both for morale and for other reasons, to clarify the atmosphere on theser matters.

Lord Plant then asked the minister if he would bear in mind the urgent necessity to take into account the views of the workers in the telecommunications industry and the Post Office and to have consultations with them. Viscount Trenchard said that all concerned would be consulted.

Lord Wallace of Coslany, praising the Post Office's telecommunications system, suggested that it would be a most retrograde step to partially sell off such a prosperous organisation leaving "the not so remunerative parts to the postal services to stand at a loss with public expense involved and possibly higher charges". Despite interruption from several Lords, he then added, "It would be a damnable result for our British telecommunications system to be completely castrated, which is the policy of the Tory Party". To this Lord Trenchard said that the government was well aware of the dangers of taking parts away and leaving a part which was very difficult to run but he wished to assure Lord Wallace that because their object was efficiency this point would be taken into account. As the Carter Report had indicated, the Government believed that a little competition was able to be introduced.

When Lord Shinwell suggested that the transfer of Post Office liabilities should be considered as well as the transfer of assets, Lord Trenchard appeared to ignore the question at first and then added that he did not believe that efficiency was compatible with dogma. The Minister later agreed with Lord Orr-Ewing to bear in mind that a greater measure of competition amongst those who seek contracts from the Post Office would also be beneficial.

Returning to his original question, Lord Torpichen reminded the minister that the "so-called telephone interconnection industry is virtually denied to British firms by nature of the restrictions placed upon it by the British Post Office, and that quite a small liberalisation of this monopoly could possibly pay dividends both to Post Office workers and to British firms who would be able to export the products relating to the telephone system". The minister said that he would bear this in mind too.

US electronics sales up 15% in '78

American sales for electronic equipment, systems and components totalled $64.9 billion (about £32.5 thousand million) in 1978, representing an increase of nearly 15% over the previous year, according to the 1979 Electronic Market Data Book***, which was published recently by the Electronic Industries Association. Over one third of the sales were for industrial electronic equipment, which had grown by 18% in the same period, and the consumer electronics, electronic components and communicating equipment sales had grown by about 15%, 14% and 12% respectively.

About 20% of the total sales of electronic products were exported during 1978, according to the EIA, which gave a trade surplus in these products of $2.6 billion (about £1.3 thousand million) while the nation experienced an overall trade deficit of $34 billion (about £17 thousand million). America's largest customer was Canada, which imported $1.6 billion worth of electronic products, followed closely by the United Kingdom and West Germany who each imported $1.2 billion. These three countries accounted for more than 30% of the US's electronic exports.

Forty-four percent of America's electronic imports came from Japan who supplied the country with more than $4.6 billion worth of electronic products. The second and third largest exporters of electronics to the US were Taiwan, with $1.1 billion and Mexico, with almost $800 million worth of products. Together, these three countries accounted for more than 60% of the electronic products brought into America.

Employment growth rate in the electronic industries was 99% in 1978, almost twice the growth-rate in overall US employment. This brought the total number of US workers in that field to more than 1.3 million.

***The Electronic Market Data Book may be obtained from the EIA Marketing Services Department, 2001 Eye Street, NW, Washington, D.C. 20006.

Earth terminal brings Congress to American States

Earlier this year, the Cable Satellite Public Affairs Network (C-SPAN) in Georgia, inaugurated its first live television coverage of the US House of Representatives. A ten-metre diameter antenna, made by Scientific-Atlanta, at Fairfax, Virginia, has enabled television pictures and sound to be sent from the House chambers to 370 communities in 50 states. The signals are carried from the chambers to the earth terminal via a terrestrial microwave link and are then transmitted to the satellite for retransmission to the communities' cable tv systems.

New s.s. radar for Irish airspace

Eurocontrol, the European Organization for the Safety of Air Navigation, has placed an order with Thomson-CSF for a secondary surveillance radar (s.s.r.) system to be installed at Woodcock Hill (Shannon), in Ireland. The contract, worth almost £640,000, covers the first phase of a programme to replace the dual-head 'SECAR' s.s.r. system installed by Eurocontrol in 1968, which supplies upper airspace radar data to Shannon Upper Area Control Centre (see p70, October 1978 issue).

The new secondary surveillance radar, which is expected to be bought into service in early 1981, will be the first of its kind to be used in Europe. For reliability, it will have duplicated electronics so that if one set should fail, the other can take over. In addition, the system has been designed for future use in the monopulse mode. To minimise problems arising from ground reflections, a new antenna with a sharp lower cut-off is to be fitted. An option in the contract covers the installation of a second s.s.r. head in a new building near Woodcock Hill.

International trade exhibition in Paris

A new international exhibition and forum, called Expansion Co-operation 1980-1990, is to be held at the Centre National des Industries et des Techniques, Paris, from June 9 to 15, 1980. Its purpose is to develop closer trade links between Western Europe, the Arab countries of the Middle East and member nations of the Organization of African Unity by helping in the search for outlets for agricultural and industrial products, consumer goods, works and services and to provide the contacts necessary for arranging financial and technical agreements for the development of local industries. Developing nations will also have the opportunity to show off raw materials and other goods.

The exhibition is specificially Western European, and no exhibitors will be allowed from Eastern Europe or from Japan or the USA, though European branches of multinational companies will be permitted to exhibit. It is under the patronage of the French ministers of Foreign Affairs, Co-operation, Economy and External Commerce and of the presidents of the Federation of French Industries and the Paris Chamber of Commerce and Industry. IPC Business Press, publishers of *Wireless World*, will be ensuring a substantial British and German presence at the exhibition.

Fibre optic prices cut by almost 50%

Advances in cable manufacture and test techniques have resulted in Hewlett-Packard reducing the price of their 25 to 100m fibre optic connector and cable assemblies by as much as 47% on quantity orders. Even on small quantity orders, reductions range from 17 to 47%.

Hewlett Packard's components group manager, Ian Graham, pointed out that their new prices continue to include installed and tested connectors guaranteed to meet the standard performance specifications. Another spokesman from the company told *Wireless World* that the price cuts partly reflected increased usage but were mainly the result of the improved techniques. He believed that Hewlett-Packard was one of the first companies to introduce such a deal but he assumed that other companies would also be offering a similar package. Cuts of this magnitude are likely to increase the use of optical fibres still further in some fields.

False alarms anger firemen because they tie up costly men and machines at times when lives could be endangered by a real blaze. Racal Recorders Ltd has introduced an advanced cassette recorder which will help to guard against this. Callstore cassettes, as they are called, have been installed at the Oxfordshire fire service headquarters, Kidlington, and can quickly replay an incoming telephone call at the same speed, or faster or slower, to make identification of the caller's voice much easier. The divisional officer at the Kidlington HQ, which has three Callstores, says that they will also help the monitoring of genuine calls because people in a panic have a tendency to speak too fast. Our picture shows the Callstore recorders installed in one of the HQ's control consoles. A 19in rack houses the drive unit (below the desk) which can take up to four cassette drives. Although the digital remote-control units are shown at the console they can be used up to 100m away from the drive unit. Tape speed is nominally 1⅞ in/s but this can be varied —50% to +20%. A message search facility is also included in the unit — at the beginning of each message an audio tone is recorded and these can be sensed on rewind and selected by reference to a seven-segment message counter.

Israel solar heating for France

Miromit, an Israeli solar-heating equipment manufacturer, has been selected as "approved supplier" in France following a major international competition for the installation of sun-heating units in that country. The company was named as the only non-French firm among six, first prize winners in competition with 78 European solar equipment firms to supply solar energy for 3,000 residential units throughout France. Tests were conducted by the French Ministry of Environment with France's largest public building organization, L'Union Nationales des Federations De Organismes, H.L.M. Miromit will be awarded at least 500 of the solar installations. Users who purchase their collectors will receive subsidies from the French government, which is encouraging the use of solar energy for domestic hot water.

Radios protect wildlife from poachers

The Kenyan government's Ministry of Wildlife and Tourism, which is taking measures to stamp out poaching that is threatening some wildlife species with extinction, has placed a large order for v.h.f. communications equipment with Marconi Communication Systems Ltd.

The order, received through the Crown Agents for Oversea Governments and Administrations, is for sixteen base stations, fitted with RC730 transceivers, more than 350 outstations and mobiles, fitted with RC625 10-channel f.m. radiotelephones, and over 200 RC530 transportable lightweight radiotelephones. The portable transceivers will be used by foot patrols.

Marconi's contract is to completely re-equip and expand the country's present v.h.f. network to cover all their national parks and sanctuaries for both wildlife and fisheries.

NEWS IN BRIEF

Dr Thomas A. Mutch has been appointed (with effect from July 1, 1979) **NASA associate administrator for space science.** As professor of geological sciences at Brown University, Providence, R.I. he has been a major contributor to NASA science programs since 1969. Among other things he was a member of the Lunar Science Review Board from 1969 to 1973, leader of the lander imaging science team for the Viking project from 1969 to 1977, and is chairman of several NASA committees planning the post — Viking exploration of Mars.

Lionel Mudd, Head of the Engineering Support Department of the Research Division of Rediffusion Engineering Ltd, has been elected **President to the Society of Cable Television Engineers,** succeeding Chris Swires. Stanley Bell of the Radio Rentals' Relay Division is now Vice President. The society's Secretary is T. Hall, 10 Avenue Road, Dorridge, Solihull B93 8LD.

His Royal Highness, the Prince of Wales, has agreed to become **Vice-Patron of the Royal Institution.** There is a long tradition of Royal patronage going back to the foundation of the Institution in 1979, and past Princes of Wales have been Vice-Patrons since 1863.

CIRCUIT IDEAS

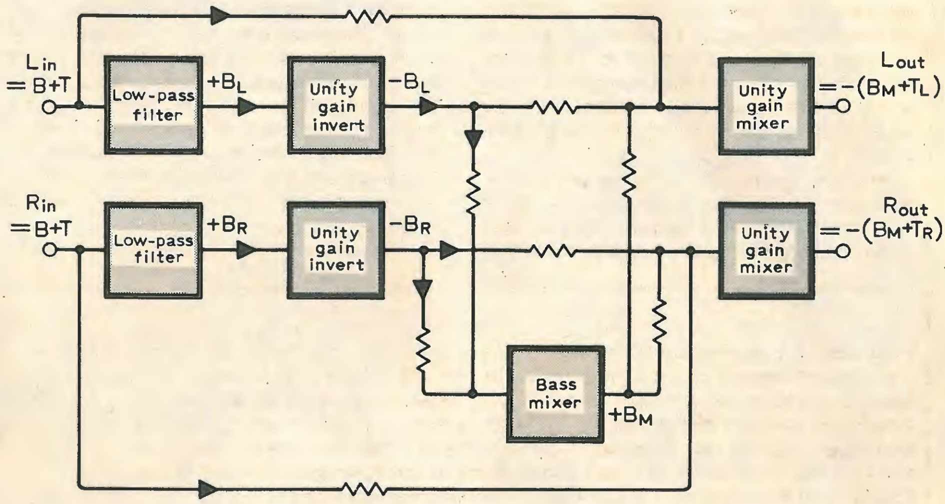
Differential rumble filter

A major problem with hi-fi reproduction from disc material is the large sub-audio signals known as rumble

A common solution to this problem is a steep cut filter below 50Hz, but unfortunately this also removes musical information.

Examination of the unwanted signals show that they are generated mainly by stylus movement in the vertical plane which produces stereo difference signals. Because purely vertical stylus signals will produce antiphase output voltages at the cartridge terminals, they can be removed by simply mixing the two channels. If the mixing is confined to frequencies below 100Hz, the mono bass output will have no effect on the stereo image.

The block diagram shows the basic system. The separate bass signals are simultaneously deducted from the treble components, T_L and T_R, and the mono bass is also added to the treble components in the unity gain mixers, the outputs of which provide a stereo signal with a mono bass.

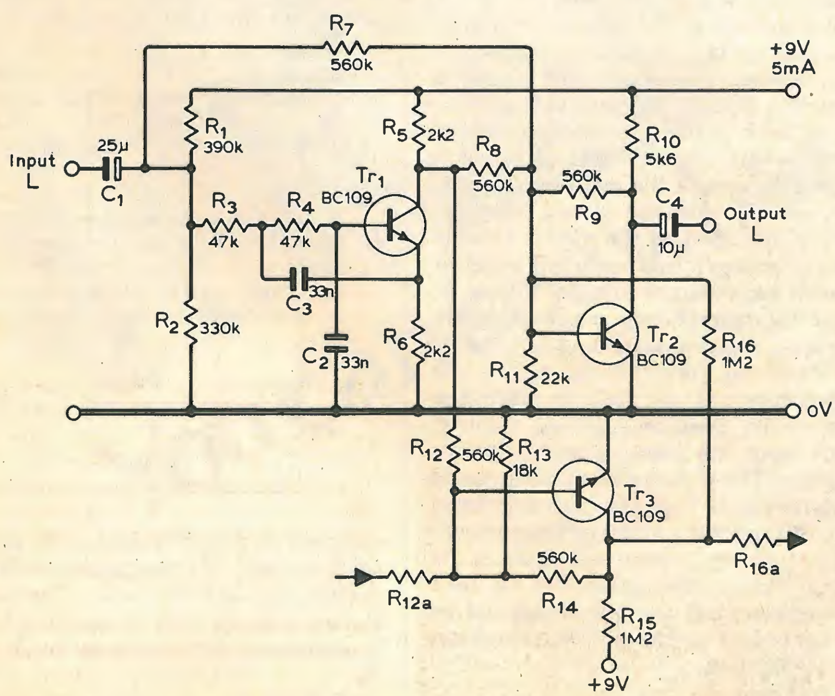


In the practical circuit the left channel, the filter and the inverter are in one stage around Tr_1. A Butterworth filter with a 12dB/octave roll off is used, and the common bass mixer is formed by Tr_3, R_{13}, R_{14} and R_{15}.

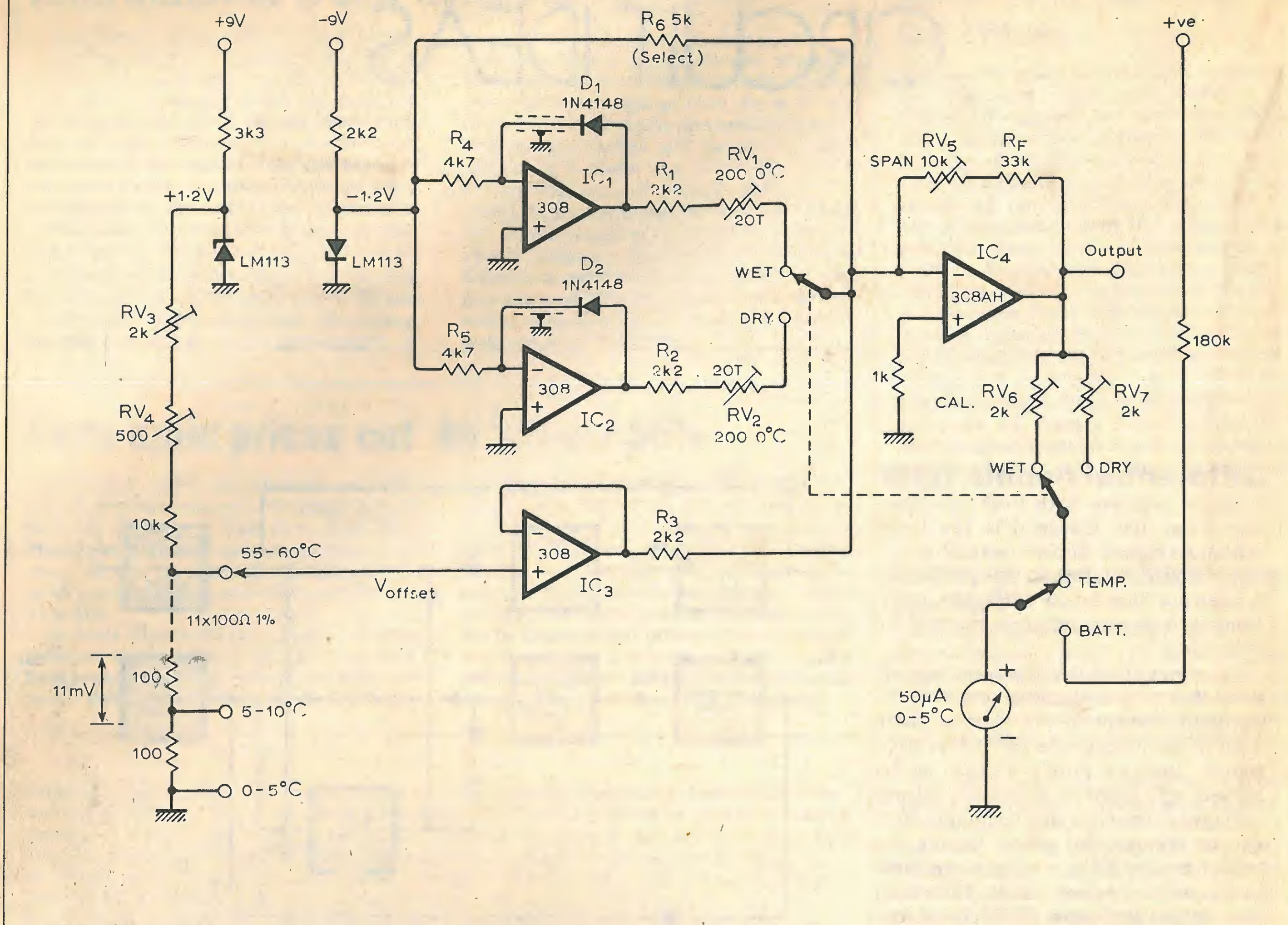
Transistor Tr_2 forms the unity gain mixer and operates in the virtual earth mode. To minimise phase shift and reduce the component count, direct coupling is used throughout.

The circuit should be inserted between the pre-amp and power-amp, and should be driven from an impedance of not more than 10kΩ.

My prototype significantly reduces spurious low frequency signals, and has no effect on the musical bass. No difference can be detected in the level of bass with or without the unit in circuit, and the measured frequency response of the prototype extends from 15Hz to 30kHz at the −1dB points. Distortion measures less than 0.1% for outputs of less than 1V r.m.s.



J. P. Macaulay
Crawley
W. Sussex



Portable wet and dry thermometer

By using two silicon diode sensors fed by a constant current source, this thermometer can make rapid temperature measurements from 0 to 60 deg C to within ± 0.1 deg C. With the values shown the diode current is $1.2\text{V}/R_4 = 250\mu\text{A}$. The output V is given by

$$-R_F\left[\frac{V_{OFFSET}}{R_3}+\frac{(V_{DO}-2.2T)}{R_1}-\frac{1200}{R_6}\right]\text{mV}$$

and after calibration this reduces to

$$V_{OUT}=\frac{R_F}{2k2}[2.2T-V_{OFFSET}]\text{mV}$$

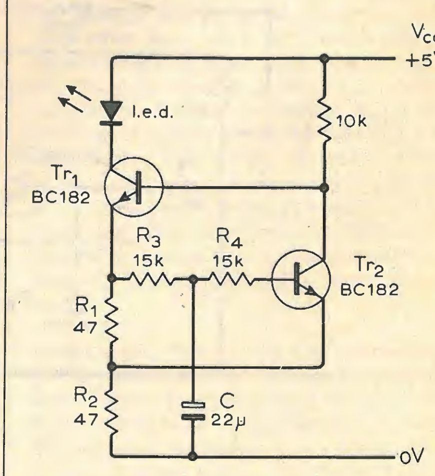
where R_F is the total feedback resistance in kΩ, T is the temperature in deg C, V_{DO} is the diode voltage at 0 deg C in mV and V_{OFFSET} is the temperature range offset voltage in mV.

Diode D_1 is housed in a wet wick and aspirated by a small fan. To calibrate the circuit disconnect the meter and set RV_1 and RV_2 about midway. Adjust RV_3 and RV_4 so that 11 mV is developed across each of the 100Ω 1% resistors. Then, with the temperature offset switch in the 0 to 15 deg C position, place both probes into an ice and water slurry. Connect a millivoltmeter to the output and adjust RV_1 and RV_2 for a null with the wet/dry selector switch in the appropriate position. If there is insufficient adjustment range replace R_6 with a slightly different value. Next, place both probes in an accurately known water temperature of about 4 deg C. Reconnect the meter and adjust RV_6 and RV_7 until the correct temperature is indicated on the meter. Finally, put the probes into a beaker of water of known temperature around 25 deg C, place the temperature range switch in the appropriate position and adjust RV_4 to obtain the correct reading. The last adjustment may be made in either the wet or dry position. Current drain is 4mA from the positive and negative supplies. The circuit maintains its stated accuracy if the batteries discharge from 9 to 6V, and if the ambient temperature rises to 45 deg C. High stability 1 or 2% metal oxide resistors should be used throughout and the circuit should be mounted in a case for protection against solar radiation.

K. D. Achleitner
Rondebosch
South Africa

L.e.d. flasher

If a flashing l.e.d. is required this circuit is simple and effective. A Schmitt trigger provides regenerative switching and R_1 gives the necessary charge/discharge bistable action as Tr_1 is



switched on and off. Resistors R_3 and R_4 set the on and off times respectively and the best ratio seems to be 2:1. The values shown achieve this at about 1.5 Hz. Brightness of the l.e.d. is set by R_1 and R_2.

W. C. Peaston
Gosta Green
Birmingham

WW—099 FOR FURTHER DETAILS

LETTERS TO THE EDITOR

ENGINEERS ARE VICTIMS OF THE MARKET

Mr C. E. H. Benson ("The Solicitor's Lot", May letters) contrasts the "bellyaching" engineer with the professional outlook of solicitors, yet is very reticent about their status.

The Law Society, as the professional body for solicitors, provides its members with guidance on the fees to charge for professional work. It prohibits advertising for clientele, thus limiting competition*. A law graduate who aspired to qualifying as a solicitor, but was in temporary employment, recently explained to me that practical training in law was difficult to obtain because the permitted number of training positions with firms of solicitors was limited. Thus competition was further limited. Overall, The Law Society has resort to the courts to protect its members from competition in legal work from outside the profession.

On the other hand, engineering is not a regulated profession. A qualified engineer has to have an aggregate of engineering education, training and responsible experience of not less than seven years to attain corporate membership of the Institution of Electrical Engineers, which has learned society status, and has to compete on the open market not only with other engineers but with many unqualified persons who trade and advertise as engineers. Because there is so much competition, skill and expertise cannot command economic rewards. Qualified engineers have to resort to the trade unions to prevent a continuing fall in living standards. Neither the engineer nor his institution can take action to prevent competition from unqualified persons.

The professional exercise of law differs from that of engineering. For example, last year The Law Society succeeded in obtaining a conviction (*The Guardian* 28 Jan. 1978) against Mr Barry Powell who runs a non-profit organisation called Assistance in Divorce. The complaint was that he had helped people prepare documents to get undefended divorces. The difference between the professional practice of engineering and law is that the former is subject to the caprices of market economics while the latter is the exercise of real power in the community.

R. E. George
Ilford
Essex

*But the Law Society itself advertises for the profession as a whole, pointing out, incidentally, that individual solicitors can be found in Yellow Pages. — Ed.

RELATIVITY AND TIME SIGNALS

Initially failing to grasp Dr Essen's point (October 1978 issue), I did not at the time give his article the attention it deserved. However, the "answers" to his problem which you have published, together with some inconsistencies in the recent BBC television programme "Einstein's Universe", have convinced me that it is high time we physicists awoke from our relativistic dreaming.

It is implied in the April issue that this correspondence is regarded as being closed by Professor Fremlin's letter in that issue, but I hope you will allow me space to pose the following extension to Professor Fremlin's scenario: consider a third party, "Observer", positioned along a line at right angles to that joining Sirius and Earth, far enough away that "Traveller" moves virtually at right angles to his line of sight. What is "Observer" to make of the proposed relativistic, or rather Lorentzian, caperings of "Traveller's" clock? Surely, he will see both "Traveller's" and "Stay at home's" clocks running always at the same rate.

A little more open-mindedness and a little less blind faith than has been revealed by this correspondence might reduce the present resemblance of physics to a moribund branch of theology.

W. T. Morris
Teddington
Middlesex

AUDIO KITS AND MODULES

I would most strongly like to endorse the comments of Ivor Abelson regarding reviews of kits and modules (May issue). Not one of the major electronics magazines even attempts to review such items, unless one absolutely pathetic attempt in April is to be counted (most of the samples never arrived so the magazine could not say very much).

The market in modules seems to be so cut-throat at present that unless the buyer wants something rather special which he is prepared to spend many hours building, it is pointless to build completely from scratch-designs and Veroboards etc. Hence anyone simply restoring disco units or building p.as (which I do for churches and halls etc.) naturally turns to the "module" or kit market. But although there are some excellent units, I've discovered, there are some very dodgy specimens as well ..... and specifications are often misleading – especially when the figures only apply when the unit is chassis mounted with an elaborate p.s.u. (not supplied!). To take an example, the Klifco 30+30 amplifier module, if ordered with a stabilised p.s.u. comes complete with both mounted on a solid chassis which acts as heat sink. The BiPak modules do not. This, in practice, is a major consideration and makes a great difference to installation.

In more esoteric fields, kits are often the answer to component buying problems. I tried to build a magazine project recently just buying the parts from their cheapest sources ...... and it took nearly 20 orders and cost a fortune in postage charges. I do, however, have the satisfaction of knowing that all the semiconductors are first grade, that the capacitors in the power supply are computer grade and of recent manufacture, that the output and input socketry is both of the type I want (Standard jacks rather than DIN-plugs) and that the cabinet-work is very rugged. Some of the socketry supplied with kits that I have bought is better thrown away. With these kits it is not the electronics that form the bulk of the expense but the hardware, the socketry and the transformers and smoothing capacitors .... and these can vary enormously in quality. In my opinion, there would be no greater service you could do for many of your non-professional readers, than reviewing and monitoring such items.

Hugh Bridge
Vauxhall
London SE11

OWNING CB SETS SHOULD BE AN OFFENCE

The mere mention of citizens' band radio in the technical press almost invariably precipitates heated correspondence. However, despite this, one fact seems to be generally overlooked — that certain people do use c.b. equipment within this country and as such are openly flouting the law of the land. Furthermore c.b. sets are both widely advertised and are readily available from several retailers, despite regulations which expressly forbid their importation. Unless action is taken soon it will be impossible to clear the 27MHz band if and when such a service is legally introduced on more suitable frequencies.

The activities of these c.b. pirate operators cannot possibly assist the efforts of many hardworking and responsible people who are at present campaigning for a recognised c.b. radio service within the United Kingdom. The apprehension of the 27MHz and other pirate operators is, however, seriously hampered by the present regulations, and I suggest that only by changing the law to make it an offence to possess radio transmitting equipment without the appropriate operating licences will the situation be readily brought under control.

J. Berry of Bristol (June letters) is mistaken in his belief that the "high and mighty" radio amateur is opposed to c.b. as such. The two services are fundamentally different and each has its part to play in a responsible society. The majority of radio amateurs do, however, take exception to the belief that c.b. should be introduced as an amateur band for unqualified operators, especially so since a radio amateur licence is readily available to any person who has sufficient interest to pass a simple examination.

W. B. Kendal G3GDU
Crawley
Sussex

RSGB TO CONTROL CB USERS?

I have no intention of entering into a discussion about the benefits that would result if we had a citizens' band in the UK; obviously very powerful financial interests are at work behind the scenes. But, as a member of the RSGB, I doubt the wisdom of compelling c.b. users to join this body as suggested by Mr

Berry in June letters. Although I feel that all radio amateurs should join the RSGB I would not dream of making it the law of the land that they should join.

And I do not follow Mr Berry's comment that if all c.b. users were members of the RSGB that body could ensure that they behaved properly on the air. The RSGB is not in my opinion the body to police either c.b. or the amateur bands. We have a government department charged with this task.

Of course the efficiency of the Home Office may fall soon as the Thatcher cuts take effect, but even then I would be loath to see the RSGB take over such jobs from the Government.

L. S. Chase
London SW2

ANOTHER CANADIAN ON C.B.

I felt it necessary to write in an effort to assure *Wireless World* readers that not all Canadians are cast in the same mould as Mr I. Switzer whose letter appeared under the heading "Ridiculous UK" in your May issue. Considering the rudeness of the opening paragraph one tends to suspect that the writer is at least to some extent lacking in manners and thus is hardly qualified to comment on what is sociably desirable or acceptable.

Mr Switzer implies that as there are millions of citizens' band sets operating in North America it therefore must be a good thing and the rest of the world must follow. This theory that high numbers make anything desirable and good is a very interesting one. In North America we have millions of people with cancer, VD and all kinds of things that in my ignorance I thought were nasty.

One problem of c.b. is the tendency of some people to prattle away with no thought to logic or common courtesy; but then sometimes we get the same thing in a much older form of communication.

C. Henry
Pte Clare
Quebec, Canada

HAVERSINE FOR ANTENNA AIMING

Mr A. M. Stephenson (June letters) is in good company. It seems that few of my colleagues know what a haversine is. The haversine formula. hav a = hav ($b \sim c$) + hav A sin b sin c; together with its various rearrangements, is very useful for solving spherical trangles. ($b \sim c$) means the difference between b and c.

The angles of such a triangle might be referred to as A. B. and C and the sides opposite them as a, b and c. The sides are arcs of great circles and are expressed as the angles subtended by each arc at the centre of the sphere. If the radius of the sphere be known the distances along the arcs may be calculated. Since the geographical mile corresponds to one minute of arc along the equator it is convenient to leave a, b and c in angular form.

It might be thought that the haversine formula requires the use of a special calculator button but this is not so. Hav $\theta = \sin^2\theta/2$ and so any scientific calculator will do. The haversine is used to avoid ambiguity. Sin 93° entered on a calculator will offer 87° when arc sin is pressed but sin 93°/2 squared and put through the reverse process returns one safely to 93°. The haversine is always positive because of this squaring process.

While considering the matter of haversines recently I realised that manipulation of $\sin^2\theta/2 = \frac{1}{2}(1 - \cos\theta)$ leads to an algorithm for finding square roots; that is, that $\sqrt{n} = \sin$ *arc cos* $(1 - 2n)$. This works well for values of $n < 1$. ${}^2\sqrt{375}$, say, is best considered as $100\sqrt{0.0375}$. Can anyone suggest a use for this amusing ornament?

Apropos of something quite different, I find that

$$\sqrt{n} = \frac{(n+1)}{2} \sin \text{arc} \cos \frac{(n-1)}{(n+1)}.$$

This, apart from being a good party trick, is equally useless.

Perhaps it would be as well to state that the three points of the antenna aiming triangle are the points of transmission and reception and the north or south pole; whichever is convenient.

P. Wadham
Carshalton
Surrey

"SIMPLIFIED DISTORTION MEASUREMENTS"

The late Mr Butler's article on distortion measurements (April issue) emphasizes the need for great care in the theory and practice, particularly when the distortion is small. As an oldie with experience in the design of wideband feedback amplifiers at r.f. and a.f., I learnt in the difficult days of valves and transformers the value of single-point earths to avoid spurious feedback due to mutual impedances and also to use local feedback loops sparingly. Thirty years ago such techniques made possible stable wideband amplifiers with over 60dB loop feedback over portions of the passband, but in those days we had the advantage of using pin-boards and not printed circuits but lacked the simplification due to transistors and transformer-less designs. Can anybody suggest a better method for seeking trouble due to improper earthing than to provide input and output sockets that are mounted close together on a sheet of metal? Mr Moir has drawn attention to similar bad practices. Mr Butler almost insists on the use of an isolating transformer as a cure but surely this only prevents troubles in one section of the system and problems due to poor earth techniques may well be causing troubles in other sections, necessitating the use of more transformers. No, the real answer is to 'clean up' the earth connections and only use transformers when such cleaning up is impractical or the other advantages of transformers are utilized.

On our tv feedback amplifiers we used, and rejected, the self-oscillating method described because the additional feedback loop could produce instability and changes in performance. Consider Mr Butler's typical amplifier shown in Fig. 5. The feedback network has a gain of about 1/40 at the fundamental frequency and an effective Q of about 6, but as the author says "worse is to come". Assuming that the gain of the original amplifier was $40\angle 0°$ at the second harmonic frequency, the addition of the network will change this gain to about 40 —j5. I think the amplifier designer would be justified in calling this a FB modification.

The RC parallel-T network is not strictly a three-terminal form of the Wien bridge since this bridge has two resistive arms. One can expect this T network to have a superior Q value — about twice — to the Wien bridge because in an equivalent bridge circuit all four arms contain RC combinations.

In the table associated with the bridged-T networks some of the information is wrong, as can be seen by applying Bartlett's Bisection Theorem to convert these networks to the lattice form. The sole reason for the presence of the resistance R is to compensate for the inductor loss resistance so that a complete null can be obtained. This is very important for low Q coils but the inclusion of these resistances alters the frequency of the null. In the case of the network using coupled coils the coefficient of inductive coupling is not unity and comes into the equation for the null frequency.

Thus from the foregoing and for other relevant reasons I think that it is more rewarding to spend effort on 'cleaning up' a driving oscillator than to use self-oscillating techniques. A useful network for nulling and the measurement of harmonics is as follows:

The use of a transformer can give a voltage gain which at low levels is always useful. The two halves of the centre-tapped winding are wound on together and high-permeability cores can be used. When $R = 5.6\omega_0 L_1$ the relative output voltages are optimum and for the 2nd, 3rd, and 10th harmonics are respectively 0.5, 0.77, and 0.9. For spot frequency working this can easily be equalized. In practice the oscillator frequency and the variable resistor are trimmed to give the desired null. It is much easier to set this null than with a bridged-T network.

F. G. Clifford
Wynberg
South Africa

I fear that the article "Simplified distortion measurements" by the late Mr F. Butler (April issue) dismisses the Wien oscillator too hastily. It has many advantages — uncritical setting up, range changing etc. — so it deserves a second look.

The author gives the correct transfer function (with $K = 1$) for the network as

$$\frac{e}{E} = \frac{1}{3 + j(n - (1/n))}$$

but the oscillator takes the form of the Wien bridge, and the transfer function now becomes

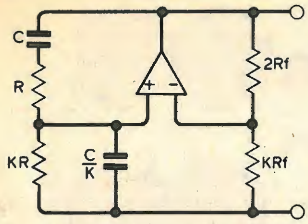
$$H(n) = \frac{K}{2 + K + j(n(1/n))} - \frac{K}{2+K}$$

$$= \frac{K}{2+K} \cdot \frac{1}{1 + j(2+K)\dfrac{n}{n_2 - 1}}$$

which is a notch filter with infinite attenuation at n = 1. Another form is

$$H_{(s)} = \frac{S^2 + \omega^2}{S^2 + (2+K)\omega S + \omega^2}$$

and the position of the poles depends on the value of K. By a judicious choice of K the circuit could be used at the designed gain of the amplifier, or to make life easier at a high gain (e.g. with $K = 0.01$) which would result in amplified distortion and so easier measurements.



On the subject of the low cost digital frequency meter by Messrs Tooley and Whitfield (January and February) there may be difficulties for some constructors in a well thought-out design.

There is no specification of frequency response for most c.m.o.s. devices, only typical performances being given, and quite the slowest device I have met is the 4049 inverter which could, in one case, just manage 180kHz. The binary dividers also are suspect here. NAND or NOR gates are much quicker. Perhaps the easiest solution would be to change over to a crystal at 250kHz. Another point is the input capacitance of the device, which varies significantly with the rail voltage at 5V. Around this figure it is easy to trim the frequency by small variations to the rail voltage, whereas at about 12V the frequency becomes much less voltage dependent.

For a frequency meter I would recommend a separate voltage regulator for the oscillator circuit.

Tim Hartigan
Dublin 4
Republic of Ireland

SMALLER TELETEXT RECEIVERS NEEDED?

I was interested to see the news item on the disappointing sales of teletext tv receivers in the July issue and the editorial comment on this subject in the August issue.

I wonder if this is due to the fact that the manufacturers treat teletext facilities as an exotic gimmick available only at the very top end of the market. I have enquired in several places about renting a set with teletext but in order to have the decoder I would also have to lumber myself with an obscenely large 26-inch colour tv receiver, ultrasonic controls and a king's ransom in rental fees.

If teletext were available on a compact tv set I would get one tomorrow and I'm sure a lot of other folk would too.

Charles G. Brewster
Brockley
London SE4

T.H.D. MEASUREMENT AND SOUND QUALITY

I was somewhat dismayed to see in your July issue, yet another article describing methods of measureing harmonic distortion of the order of 0.00001%. Mr Linsley Hood and the late Mr F. Butler (April issue) have produced two well thought-out methods of measuring t.h.d. but without questioning the validity and usefulness of the technique in the first place.

In the audio field percentages of distortion have very little relation to the purity of the perceived sound. Unless the figures are weighted in relation to the harmonic structure of the distortion, the results are misleading to say the least. An amplifier with a 'spikey' 1% crossover distortion will sound quite different from one with 1% second harmonic distortion. It is true that t.h.d.. measurements at high frequencies can indicate problems of slewing – induced distortion but the correlation is not straightforward.

The present popularity of valve amplifiers, with their distortions in the 1% region, indicate that harmonic distortion alone is hardly a reliable criterion on which to judge the sonic performance of an amplifier. There are many other parameters in my estimation worthy of such detailed attention as is currently given to t.h.d., among which in power amplifiers are: dynamic power supply rejection; intermodulation with power supply ripple; variation of output impedance with (a) frequency, (b) output voltage; and dynamic shifting of the working point (dynamic offset).

I hope in future to see some designs that have a wider understanding of the mechanism of hearing.

Brian E. Powell
Crimson Elektrik
Leicester

INTERFERENCE FROM ELECTRONIC IGNITION

Mr Whitehead does not describe the nature of the interference from which he suffers (May letters), but a note of my efforts may be of interest. My problem was both impulse noise from the discharging of the reservoir capacitor and whine from the inverter. My system is a home-built affair but is fairly representative in operation.

It is important to understand that the primary and secondary current in the ignition coil both pass through the wiring to the ignition switch and return to chassis through the battery (Fig. 1). Thus it is clear that a car radio will inevitably be connected to a noisy supply line. The actual route taken by the noise current may be quite complex and involve stray capacitances and inductances in the vehicle's wiring loom. Clearly, then, the interference must be suppressed at source.

The problem in my case was quite severe and the cure was complete. The lead to the coil primary was screened, this being earthed inside the box containing the electronics. All the other leads leaving the box were decoupled with 0.1μF capacitors. The 12V supply to the coil and to the electronics was passed through a filter as shown in Fig. 2; this filter was housed in a separate die-cast box and mounted close to the coil.

The performance of this arrangement is excellent. Only a trace of impulse noise remains at the high frequency end of the medium-wave band, and this disappears when the aerial is retracted. A just audible trace of inverter noise (a rapidly modulated whistle) is apparent on weak long-wave signals.

The car radio used here is of the "cheap and cheerful" kind and is plagued by images and other spurios responses. The cure for this has been a two-section L-R low-pass filter at the base of the aerial, with a cut-off frequency of 1.8MHz. This also gives some relief from noise from other vehicles and neon display lighting.

T. H. Woolner
Harpenden
Herts

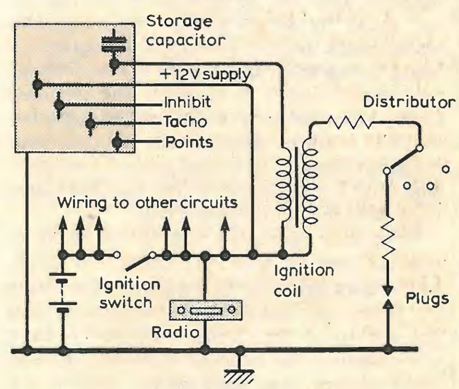


Fig. 1.

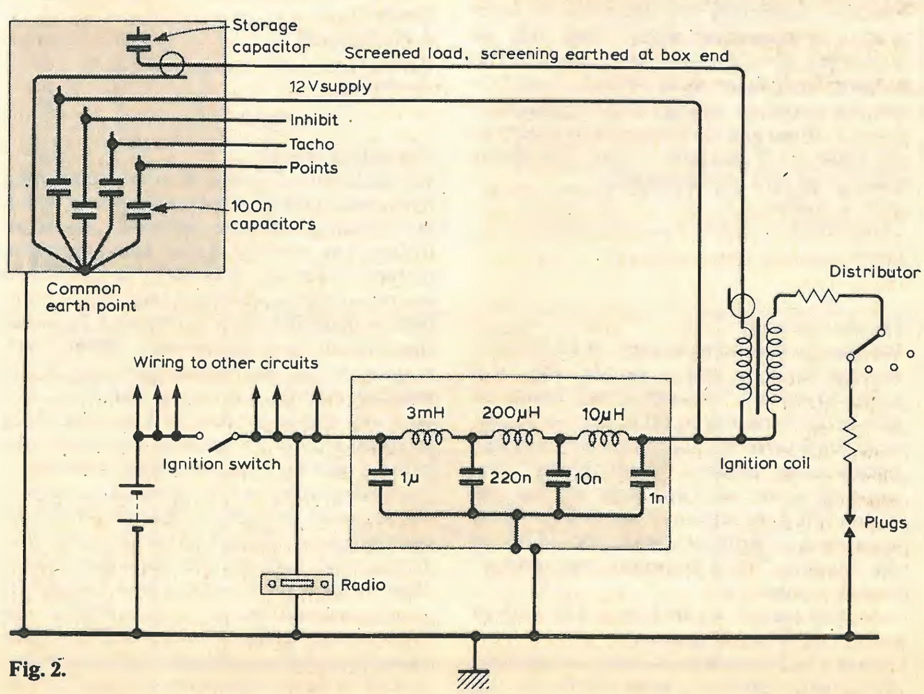


Fig. 2.

DISPLACEMENT CURRENT

Messrs Catt, Davidson and Walton are perhaps right to draw attention yet again to the importance the distributed nature of real capacitors can have in real circuits (December 1978 issue). Its significance in r.f. circuits is well-known and obviously it has some slightly unexpected subtleties in high-speed pulse circuits. But I cannot see how they can claim to have excised displacement current from Electromagnetic Theory – or in their case circuit theory – in any useful way.

To begin with, Kirchhoff's "Laws" apply to ideal circuits of zero physical extent described by simple mathematical relationships between their terminal voltages and currents. No assumptions are made about their physical nature, nor is the concept of "displacement current" necessary for the development of all the richness of modern circuit theory from these basic assumptions. Nor is there any doubt about the practical usefulness of the resulting theory, for example, in successfully designing high-performance filters.

If one must, for the sake of peace of mind, equate the terminal current of a capacitor with "... a mathematical manipulation of the electric field *E* between the capacitor plates" all well and good, and no harm will come provided the limits of the approximations necessary are always borne in mind; for example, that the dimensions of the capacitor must be small compared with the wavelength of the electrical disturbance being considered. But where is the conceptual improvement in equating the terminal current to what must in the end be a mathematical manipulation of the electric *and magnetic* fields associated with a transmission line? Especially when the manipulations involved are a lot more difficult.

If, as they claim, the concept of displacement current permits the retention of Kirchhoff's laws, does their "excision" of it throw out those too? And if so, what analytical tools are left to us for circuit analysis? If their transmission-line concept *replaces* displacement current, then how so? For there is *still* no closed path in which current can flow.

In short, are we to regard this article as a warning to beware of transmission-line effects in capacitors at frequencies (or pulse widths or risetimes) where they may be important, and can we therefore take the philosophical claims with a pinch of salt? Or are we asked to change the fundamental basis of circuit and electromagnetic theory as we know it? If the latter, I find the claims made to be very unconvincing.

John L. Haine,
Chelmsford,
Essex.

The authors reply:

We find the second paragraph of Dr Haine's letter ambiguous, and so cannot reply to it except to say that "modern circuit theory" is rich, in the same way as other tall stories are rich. High-performance filters are not designed using "modern circuit theory", because inductors and capacitors are not designed using theory; they are cobbled in a haphazard, experimental way. Try talking to the "experts" in a company "designing" chokes or capacitors.

As with para. 2, we find para. 3 is back to front, or at least ambiguous.

Para 4. The answer is, yes. Traditional analytical tools have been useful in the setting and passing of examinations, but not in practical engineering problems; emphatically not in the interconnection of high speed (lns) logic, where they have created havoc, leading to the abandonment of virtually all such projects.

Para. 5. You *are* asked to change the fundamental basis of circuit and electromagnetic theory as we know it. The need to successfully assemble high speed logic systems forces us to abandon the slovenly mess which has masqueraded as electromagnetic theory for fifty years, and build a sound theory from the ground up. The first casualty is displacement current, the bastard issue of a marriage between ignorance and nonsense. We must clear away the rubble before we begin to build.

"Our electrical theory has grown like a ramshackle farmhouse which has been added to, and improved, by the additions of successive tenants to satisfy their momentary needs, and with little regard for the future. We regard it with affection. We have grown used to the leaks in the roof. . . . But our haphazard house cannot survive for ever, and it must ultimately be replaced by a successor whose beauty is of structure rather than of sentiment." – Intermediate Electrical Theory, by H. W. Heckstall-Smith, Dent, 1932, page 283.

A lot more sludge has collected since 1935. We must dredge deep, through a century of sycophancy.

I. Catt. M. F. Davison, D. S. Walton.

DISAPPEARING MAGNET

May I take Epsilon's problem of the magnetic sphere (December 1978, page 69) a little further and ask what is the external field if the last plug is later removed? The answer is that the field remains zero! To see why, one simply considers the energy required to push the last plug into place. Since, after you have done this, there is no magnetic field inside or outside the sphere, the energy involved must be that required completely to demagnetize the whole structure. Consequently when it is disassembled, the pieces will no longer be magnets.

J. Middlehurst
Sydney
Australia

The author replies:

Mr Middlehurst poses a most interesting extension to the original problem, one which is difficult to discuss with any precision unless the coercivity of the magnetic material is known. (Coercivity is the H field in ampere turns per metre required to completely demagnetize a specimen.) To avoid this difficulty it is convenient to replace each magnet by an equivalent solenoid. If the original magnet were long and thin, this solenoid simply consists of a current sheet wrapped around the surface. The sphere can now be built up as in the original problem.

Starting with the first solenoid, as soon as the second is brought up against it there will be a repulsive force. Furthermore, the currents in the two sides that buck one another flow in opposite directions and completely cancel one another. This is illustrated in Fig. 1(a). As the sphere is assembled, it will be found that all the solenoids repel one another and all adjacent sides have opposite current flows. In fact, only the current at the extreme periphery causes an external magnetic field, and this is the situation illustrated in Fig. 1(b).

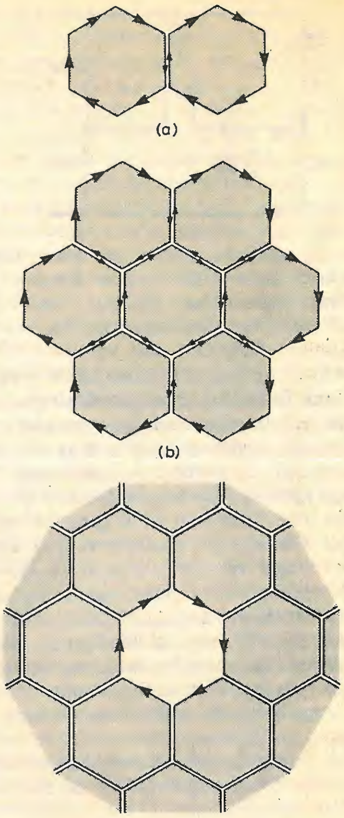


Fig. 1 *Stages in the assembly of the sphere, showing current cancellation.*

The situation when the last solenoid is about to be fitted in is shown in Fig 1(c); the currents cancel everywhere except round the small hole. The external field at this time is quite small, and insertion of the last solenoid will completely cancel the remaining currents shown in the diagram. The magnetic field is zero everywhere and the stored potential energy is distributed evenly over all the solenoids in the form of the strain in the clamps required to hold the whole structure together. Note that potential energy and magnetic energy are gradually interchanged as the sphere is built up.

What happens when the solenoids are replaced by permanent magnets is not quite the same. For all practical materials the coercivity is such that there would be a progressive demagnetization as the sphere is built up, the edges of the shell having the greatest magnetic intensity. Under such assumptions the completed sphere might have residual magnetism, and it is no longer possible to discuss Mr Middlehurst's interesting supposition.

TECHNICAL WORDS

F. L. Devereux (December 1978 letters) has raised a point which has been aired in some technical publications in this country, namely the use, spelling and pronunciation of words used by technologists. While "expertise" is not strictly a technological word (it does not describe an item or situation specifically related to a science or engineering) it is typical of the changes emer-

continued on page 86

Passive notch filters — 2

How to design high and low impedance null filters

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

Selecting the right type of filter for the particular job at hand from the literature is laborious and time consuming. And little information is provided about design procedure and hardware.

Three articles provide design procedure and simple formulae by way of examples as well as hardware details. To simplify description of the examples formulae and statements are given without theoretical proof; normally theoretical and mathematical development is treated separately in appendices.

THIS THREE-PART article concentrates mainly on null-type notch filters which are derived from a prototype lattice or Wheatstone bridge. At the notch frequency the arms of the bridge are made to resonate into four equal resistances which perform a null of the bridge and no output of the frequency appears at the filter output. At all other frequencies the filter acts as an all-pass network.

The lattice which possesses four resonant arms is a balanced type of network. In most practical applications an unbalanced or grounded form that employs only two resonant arms is preferred, achieved with a hybrid transformer.

There are number of unbalanced configurations, all of which use the same hybrid transformer and the choice depends on the particular application at hand. The notations of the formulae refer always to the prototype lattice; thus the same set of formulae serve all the variations. A detailed description summarising all the configurations is given in a section about the hybrid transformer in part three.

Examples 3 and 4 are high and low impedance null-type filters.

Example 3: High impedance null filter

A high impedance null type of filter provides a narrow notch in amplifier interstages where the impedances of the source and the load are comparatively high. The basic circuit is derived from Fig. 1-5 by the removal of the reactive components of arm 'b'. As with Fig. 1-5 it is possible to dispense with the hybrid transformer. The result is two possible configurations shown in Figs 3-1 and 3-2, derived from Figs 1-9 and 1-10 respectively.

To minimize insertion loss in the pass band, the null resistance $R_b/2$ should be as high as possible, consequently $2R_a$ which is $4 \times R_b/2$ should also be maximal. Hence, no real $2R_a$ resistor is employed; resistance $2R_a$ represents the dynamic impedance D of coil inductance $2L_a$. Thus

$$2R_a = D = Q_a \cdot \omega_o 2L_a$$

from equation 2-2 where Q_a is the Q value of coil $2L_a$.

The equivalent circuit at resonance is shown in Fig. 3-3. To have a null: $R_a = R_b$. Hence

$$R_b/2 = R_a/2 = 2R_a/4 = D/4 \qquad 3\text{-}1$$

i.e., $R_b/2$ is adjusted to be a quarter the value of the dynamic impedance.

From appendix C, equations C-10 to C-12,

$$\boxed{\omega_3 = \frac{(n+1)/n}{(C_a/2) \cdot 2R} \cdot M} \qquad 3\text{-}2$$

where n is the ratio of R_a to R,

$$n = R_a/R = D/2R \qquad 3\text{-}3$$

and

$$M = \frac{2(n+m)}{n + m(n+2)} \qquad 3\text{-}4$$

where m is the ratio of R_s to R,

$$m = R_s/R \qquad 3\text{-}5$$

When the source and load resistance are equal, $R_s = R$, then $m = 1$ which results in $M = 1$. Hence

$$\omega_3 = \frac{(n+1)/n}{(C_a/2) \cdot 2R},$$

when $m = R_s/R = 1$. 3-6

$$\text{Also } \omega_3 = \frac{1}{C_a/2}\left(\frac{1}{2R} + \frac{1}{D}\right). \qquad 3\text{-}7$$

When $D \gg 2R$ ω_3 approximates to

$$\boxed{\omega_3 = \frac{1}{(C_a/2) \cdot 2R}} \qquad 3\text{-}8$$

Notice that the larger the source, the load and dynamic impedances the narrower the notch becomes. In the example shown in Fig. 3-4, a notch is required at $f_0 = 24$MHz with bandwidth of about 10kHz at notch depth of -40dB, i.e., $f_{40} = 0.01$MHz. Hence

$$f_3 = 0.01 \times 100 = 1\text{MHz}.$$

Fig. 3-1

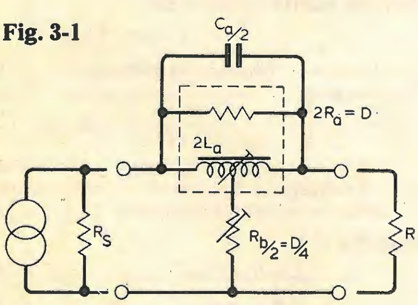
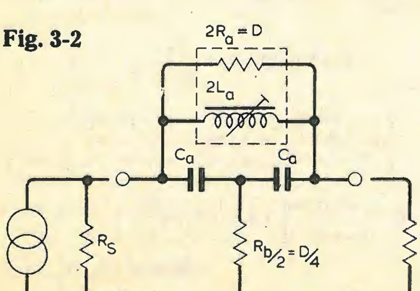


Fig. 3-2



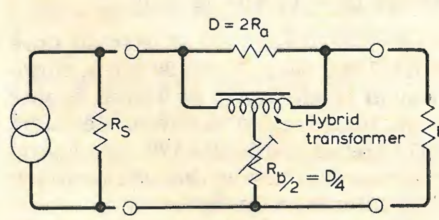


Fig. 3-3

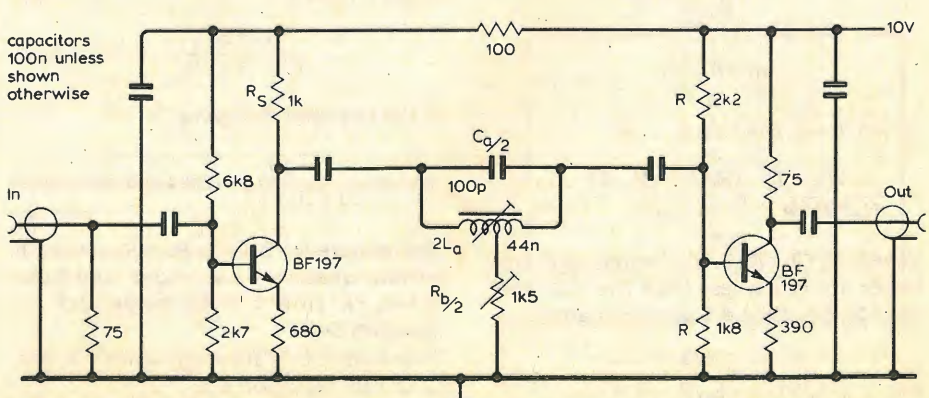


Fig. 3-4

$R_S = R = 1000$ ohm and $m=1$, $M=1$ (R is 2200Ω in parallel with 1800Ω is 1000Ω)
From equation 3-8

$$C_a/2 = \frac{1}{2\pi \,.\, f_3 \,.\, 2R} \approx 79.5\text{pF}$$

It is not possible to use equation 3-6 or 3-7 to compute $C_a/2$ more accurately because the dynamic impedance D of $2L_a$ is unknown. However if one assumes a Q value for the coil, it is possible to use the following equation (appendix C equation C-17)

$$\boxed{C_a/2 = \frac{1}{\omega_3 . 2R(1-q)}} \qquad 3\text{-}9$$

$$\text{where } q = \frac{Q}{Q_a} = \frac{f_o/f_3}{Q_a}, \qquad 3\text{-}10$$

and Q_a is the Q value of the coil.
Assuming $Q_a = 100$ then

$$q = \frac{24/1}{100} = 0.24 \text{ and}$$

$$C_a/2 = \frac{1}{2\pi \times 2000 \times (1-0.24)} = 104\text{pF}.$$

Thus a 100pF capacitor was used. The coil was made of 0.2mm-diameter bifilar copper wire, 3+3 turns wound on 4×0.5×10mm core, Neosid, grade 900. Q_a was measured to be 106 at 25MHz. The notch width at −40 dB was measured to be $f_{40} = 11$kHz. Maximum attenuation of the notch was −62 dB. Resistance $R_b/2$ was 1500 ohm, which means $D = 4 \times 1500 = 6000$ ohm. The introduction of $R_b/2 = 1500$ ohm gives an extra loss of 0.75 to the circuit. The general formula for extra insertion loss is

$$\frac{\dfrac{1}{R_S} + \dfrac{1}{R}}{\dfrac{1}{R_S} + \dfrac{1}{R} + \dfrac{1}{D/4}} \qquad 3\text{-}11$$

To compute $C_a/2$ when $R_S \neq R$; estimate Q_a as above and hence q (equation 3-10); then calculate n ($m = R_S/R$) from appendix C, equation C-15.
From n and m compute M of equation 3-4. Then compute $C_a/2$ from equation 3-2.

Correction. Equation 1.4 in example 1 (August) should read as equation E-7, page 86.

Appendix C. Lattice of high Z notch

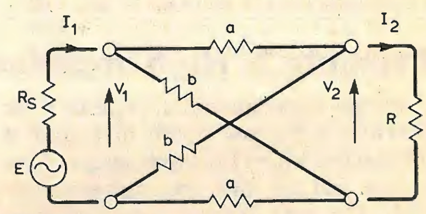


Fig. C-1

The lattice input impedance is not a constant at all frequencies, i.e. V_1 and I_1 are not constant, therefore the source resistance R_S has to be included in the calculation.
From the matrix equation B-5,

$$V_1 = \frac{1}{b-a} \,.\, [(b+a) \,.\, V_2 + 2baI_2] \qquad \text{C-1}$$

$$I_1 = \frac{1}{b-a} \,.\, [2V_2 + (b+a)I_2] \qquad \text{C-2}$$

From Fig. C-1

$$I_2 = V_2/R \text{ and} \qquad \text{C-3}$$

$$E = V_1 + R_S \,.\, I_1 \qquad \text{C-4}$$

Insert I_2 from equation C-3 in C-1 and C-2, and then insert C-1 and C-2 in C-4 which gives

$$E = V_1 + R_S \,.\, I_1 = \frac{V_2}{b-a}$$

$$\left[(b+a) + \frac{2ba}{R} + 2 \,.\, R_S + \frac{R_S \,.\, (b+a)}{R}\right]$$

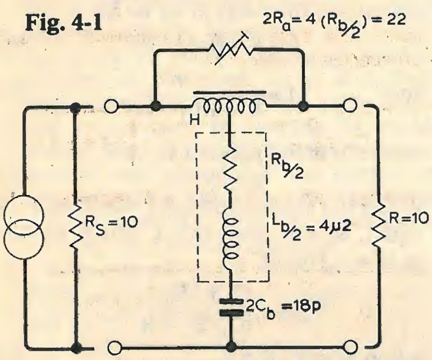
$$= E = \frac{V_2}{1-a/b}\left[(1+a/b)\left(1+\frac{R_S}{R}\right) + {} + 2a/R + 2R_S/b\right] \qquad \text{C-5}$$

Example 4: Low impedance null filter

The low impedance null filter suits networks where the source and load impedances are low. A common example of low impedance source is an emitter follower. The lower the impedances the narrower is the notch. The circuit is in a sense the inverse network of the high-Z notch of example 3.

The circuit is derived from Fig. 1-5 by the removal of the reactive components of arm 'a'. Unlike example 3, the hybrid transformer stays.

Fig. 4-1



To minimize insertion loss in the pass band $R_a = R_b$ should be minimal, i.e. high Q_b value for inductance $L_b/2$.

$$Q_b = \omega_o(L_b/2)/(R_b/2) \qquad 4\text{-}1$$

From appendix D, equations D-4 to D-7,

$$\boxed{\omega_3 = \frac{R/2}{L_b/2} \,.\, \frac{k+1}{k} \,.\, N} \qquad 4\text{-}2$$

where

$$\boxed{N = \frac{2(1+mk)}{2+k(1+m)}} \qquad 4\text{-}3$$

$$k = \frac{R/2}{R_b/2} \text{ and} \qquad 4\text{-}4$$

$$m = R_S/R.$$

When $m=1$, $N=1$ and

$$\omega_3 = \frac{R/2(k+1)}{(L_b/2) \,.\, k} = \frac{(R/2) + (R_b/2)}{L_b/2}.$$

When $R_b/2 \ll R/2$, i.e. when the coil losses are much less than the load resistance, equation 4-6 approximates to

$$\omega_3 = \frac{R/2}{L_b/2} \qquad 4\text{-}7$$

In an example where $R_S = R = 10$ ohms a notch is required at $f_o = 19$MHz with bandwidth of 4kHz at notch depth of −40dB, i.e. $f_{40} = 0.004$MHz, thus $f_3 = 0.4$MHz. From equation 4-7

$$L_b/2 = \frac{R/2}{\omega_3} = \frac{10/2}{2\pi \times 0.4} \approx 2\mu\text{H}$$

As the coil losses are not known it is not possible to use equation 4-6 for more accurate computation. However, one may assume a coil Q and compute (from appendix D, equation D-12)

$$\boxed{L_b/2 = \frac{R/2}{\omega_3} \,.\, \frac{1}{1-q} \text{ when } m=1} \qquad 4\text{-}8$$

$$\text{where } q = \frac{Q}{Q_b} = \frac{\omega_0/\omega_3}{Q_b} \qquad 4\text{-}9$$

Assume $Q_b = 90$ for coil $L_b/2$. Then

$$q = \frac{\omega_0/\omega_3}{Q_b} = \frac{19/0.4}{90} = 0.53$$

and from equation 4-8

$$L_b/2 = \frac{10/2}{2\pi \times 0.4} \,.\, \frac{1}{(1-0.53)} = 4.2\mu\text{H}$$

From equation 4-1

$$R_b/2 = \frac{\omega_0 \,.\, L_b/2}{Q_b} = \frac{(2\pi \times 19) \times 4.2}{90} = 5.5\text{ohm}$$

Hence $2R_a = 4 \times 5.5 = 22$ ohm.

Coil used was made of Neosid core CH1/7/900 wound with 20 turns, close-wound single layer, of 0.4mm copper wire, tinned nylon accetate. Measured Q of coil at 8MHz was 120. The hybrid coil was the same as that of example 1. Capacitor $2C_b$ was 18pF.

The extra insertion loss due to the notch circuit is

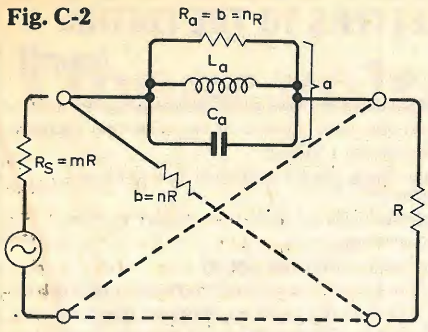
$$\frac{R_S + R}{R_S + R + 2R_a}. \qquad 4\text{-}10$$

In the example this gives

$$\frac{10+10}{10+10+22} = 0.48 \rightarrow 6.4 \text{ dB}$$

To compute $L_b/2$ when $R_S \neq R$; estimate q from equation 4-9 as above, and from $m = R_S/R$ find k from appendix D, equation D-10.
Then compute N from equation 4-3, and $L_b/2$ from equation 4-2.

Fig. C-2



In the high Z notch, Fig. C-2, arm b is a resistor, and R_a is made equal to b for a null at $\omega_0 = 1/L_aC_a$.

Make 'b' a multiple n of R, thus

$$b = nR \text{ or } R = b/n.$$

Also make $R_S = mR$, hence

$$E = \frac{V_2}{(1-a/b)} \times [(a/b)(1+m+2n)+(1+m+2m/n)]$$

and the voltage transfer is

$$\frac{V_2}{E} = \frac{(1-a/b)}{(a/b).(1+m+2n)+(1+m+2m/n)}$$

The voltage transfer in the pass bands V_{20}/E occurs when the impedance of arm 'a' is zero, i.e. $a=0$, thus

$$\frac{V_{20}}{E} = \frac{1}{(1+m+2m/n)}$$

which is the insertion loss in the pass bands. The voltage transfer function V_T is then the ratio of the transfer voltage to the insertion loss in the pass bands.

$$V_T = \frac{(V_2/E)}{(V_{20}/E)} = \frac{(1-a/b)}{(a/b).\frac{(1+m+2n)}{(1+m+2m/n)}+1} \qquad \text{C-6}$$

From Fig. C-2

$$\frac{1}{a} = 1/b + \frac{1}{pL_a} + pC_a = \frac{pL_a/b+1+p^2L_aC_a}{pL_a}$$

Hence $a/b = \dfrac{pL_a/b}{(pL_a/b+1+p^2L_aC_a)}$

Insert a/b in equation C-6

$$V_T = \frac{1+p^2L_aC_a}{(pL_a/b).\left[\frac{1+m+2n}{1+m+2m/n}+1\right]+1+p^2L_aC_a}$$

Multiply numerator and denominator by $\omega_0^2 = 1/L_aC_a$ and replace b by $nR = b$ then

$$V_T = \frac{\omega_0^2+p^2}{\frac{p}{C_a.nR}\left[\frac{2(n+1)(n+m)}{n+m(n+2)}\right]+\omega_0^2+p^2} \qquad \text{C-7}$$

From comparison with equation A-4, the coefficient of p is

$$\boxed{\omega_3 = \frac{(n+1)}{C_aR_n}.\frac{2(n+m)}{n+m(n+2)}} \qquad \text{C-8}$$

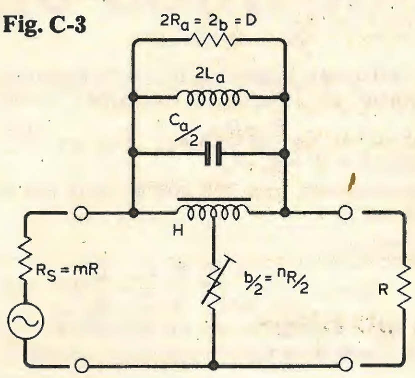
where R is the load, $m = R_S/R$ and $n = b/R$. When the source and the load resistance are equal, $m=1$ and equation C-8 reduces to

$$\boxed{\omega_3 = \frac{1}{C_a.R}.\frac{n+1}{n}} \qquad \text{C-9}$$

Unbalanced high-Z notch

The unbalanced form of Fig. C-2 is shown in Fig. C-3

Fig. C-3



Re-write equation C-8

$$\boxed{\omega_3 = \frac{1}{(C_a/2).2R}.\frac{n+1}{n}.M} \qquad \text{C-10}$$

where

$$\boxed{M = \frac{2(n+m)}{n+m(n+2)}} \qquad \text{C-11}$$

When $R_S = R$, $m=1$; hence $M=1$, and

$$\boxed{\omega_3 = \frac{(n+1)/n}{(C_a/2).2R}} \qquad \text{C-12}$$

To find $C_a/2$ in terms of Q_a of inductance $2L_a$

$$n = b/R = \frac{2b}{2R} = \frac{D}{2R} = \frac{Q_a.\omega 2L_a}{2R}$$

$$= \frac{Q_a}{2R}.\frac{1}{\omega_0.C_a/2} = \frac{Q_a}{2R\left(\frac{\omega_0}{\omega_3}\right)\omega_3.C_a/2} =$$

$$\boxed{n = \frac{1}{2Rq\omega_3C_a/2}} \qquad \text{C-13}$$

where

$$\frac{1}{q} = \frac{Q_a}{\omega_0/\omega_3} = \frac{Q_a}{Q}. \qquad \text{C-14}$$

From C-10: $2RC_a/2n\omega_3 = (n+1)M$
and from equation C-13: $n2R\omega_3C_a/2 = 1/q$.
Hence

$$\frac{1}{q} = [(n+1)M=] = (n+1).\frac{2(n+m)}{n+m(n+2)}$$

$$\therefore n^2.2q - n(1+m)(1-2q) - 2m(1-q) = 0.$$

The solution of n in terms of q and m; $n =$

$$\frac{(1+m)(1-2q)+\sqrt{(1+m)^2(1-2q)^2+16q(1-q)}}{4q} \qquad \text{C-15}$$

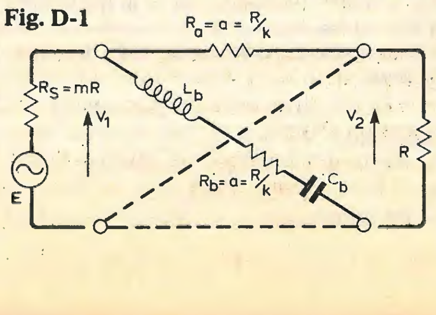
When $m=1$, $n = \dfrac{1-q}{q}$ C-16

and from equation C-12

$$C_a/2 = \frac{(n+1)/n}{\omega_3.2R} = \frac{1}{\omega_3.2R(1-q)} \qquad \text{C-17}$$

Appendix D. Lattice of low-Z notch

Fig. D-1



In a manner similar to appendix C arm 'a' is a resistor and R_b is made equal to a for a null at $\omega_0 = 1/(L_b.C_b)$. Make R a multiple k of 'a', i.e. $R = ka$. From equation C-5 where $R_s = mR$, $E =$

$$\frac{V_2}{(1-a/b)}\left[(1+a/b)(1+m)+\frac{2a}{ka}+2mk\,a/b\right]$$

$$= \frac{V_2}{(1-a/b)}[(a/b)(1+m+2mk)+(1+m+2/k)].$$

Hence

$$\frac{V_2}{E} = \frac{1-a/b}{(a/b).(1+m+2mk)+(1+m+2/k)}$$

When arm 'b' is open circuit, $b = \infty$ and

$$\frac{V_{20}}{E} = \frac{1}{1+m+2/k}$$

$$V_T = \frac{V_2/E}{V_{20}/E} = \frac{1-a/b}{(a/b)\frac{(1+m+2mk)}{(1+m+2/k)}+1} \qquad \text{D-1}$$

From Fig. D-1 (to simplify, use L and C instead of L_b, C_b)

$$b = a + pL + \frac{1}{pC} = \frac{pC.a+p^2LC+1}{pC}$$

Hence

$$a/b = \frac{pC.a}{pC.a+1+p^2LC}$$

Insert this expression in equation D-1 and proceed as in appendix C.

$$V_T = \frac{1+p^2LC}{pC.a\left[\frac{2(1+k).(1+mk)}{2+k(1+m)}\right]+1+p^2LC}$$

Multiply by $\omega_0^2 = 1/LC$ and replace 'a' by $a = R/k$

$$V_T = \frac{\omega_0^2+p^2}{p\frac{R}{kL}\left[\frac{2(1+k)(1+mk)}{2+k(1+m)}\right]+\omega_0^2+p^2}$$

Thus by comparison with A-4, the coefficient of p is

$$\boxed{\omega_3 = \frac{R(k+1)}{L_b.k}\left[\frac{2(1+mk)}{2+k(1+m)}\right]} \qquad \text{D-2}$$

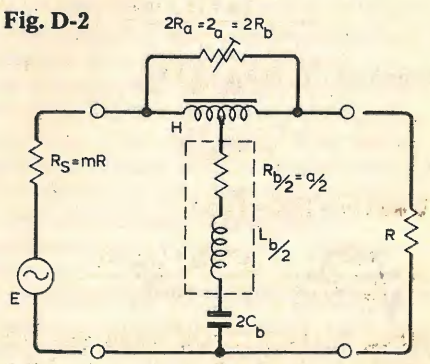
When $R_s = R$, $m = 1$

$$\boxed{\omega_3 = \frac{R}{L_b}.\frac{k+1}{k}} \qquad \text{D-3}$$

where $k = R/a$.

Unbalanced low-Z notch

Fig. D-2



Re-write equation D-2 to suit configuration of Fig. D-2

$$\boxed{\omega_3 = \frac{R/2}{L_b/2}.\frac{k+1}{k}.N} \qquad \text{D-4}$$

where $N=\frac{2(1+mk)}{2+k(1+m)}$ D-5

when $m=1$, $R_s=R$, $N=1$

$$\boxed{\omega_3=\frac{R/2}{L_b/2}\cdot\frac{k+1}{k}} \qquad \text{D-6}$$

and $k=\frac{R}{a}=\frac{R}{R_b}=\frac{R/2}{R_b/2}$. D-7

To find $L_b/2$ in terms of Q_b

where $Q_b=\frac{\omega_0 L_b/2}{R_b/2}$ or $\frac{1}{R_b/2}=\frac{Q_b}{\omega_0 L_b/2}$

$$k=\frac{R/2}{R_b}=\frac{R/2\,.\,Q_b}{\omega_0\,.\,L_b/2}=\frac{R/2\,.\,Q_b}{\omega_3\,.\,(L_b/2)\,.\,\omega_0/\omega_3}$$

$$=k=\frac{R/2}{\omega_3\,.\,(L_b/2)\,.\,q} \qquad \text{D-8}$$

where $\frac{1}{q}=\frac{Q_b}{Q}=\frac{Q_b}{\omega_0/\omega_3}$. D-9

From eq D-4 $\frac{k\,.\,(L_b/2)\,.\,\omega_3}{R/2}=(k+1)\,.\,N.$

From eq D-8 $\frac{k\,.\,(L_b/2)\,.\,\omega_3}{R/2}=1/q.$

Hence $\frac{1}{q}=(k+1)N=(k+1)\,.\,\frac{2(1+mk)}{1+k\,.\,(1+m)}$

$\therefore k^2\,.\,2mq-k(1+m)(1-2q)-2(1-q)=0$

and thus $k=$

$$\frac{(1+m)(1-2q)+\sqrt{[(1+m)(1-2q)]^2+16mq(1-q)}}{4mq} \qquad \text{D-10}$$

When $m=1$, $k=\frac{1-q}{q}$. D-11

From equation D-6

$$L_b/2=\frac{R/2}{\omega_3}\,.\,\frac{k+1}{k}=\frac{R/2}{\omega_3}\,.\,\frac{1}{(1-q)}. \qquad \text{D-12}$$

Appendix E

Derivations. Given: resonance (equation 1-1), constant resistance (equation B-4) and 3dB bandwidth (equation B-9).

E.1 Equation 1-5

From equation B-9

$$L_b/2=\frac{1}{\omega_3^2\,.\,C_a/2}=\frac{2}{\omega_3^2\,.\,C_a} \qquad \text{E-1}$$

From resonance equation 1-1

$$\frac{1}{C_a}=\omega_0^2\,.\,L_a$$

Substitute $1/C_a$ in equation E-1

$$L_b=\frac{2\omega_0^2\,.\,L_a}{\omega_3^2}$$

$$\frac{L_b}{L_a}=\frac{4\omega_0^2}{\omega_3^2}$$

or $\sqrt{\frac{L_b}{L_a}}=\frac{2\omega_0}{\omega_3}=$ (equal by definition to) $=2Q$ E-2

This confirms equation 1-5

E.2 Equation 2-3

Q factor of arm 'b' is

$$Q_b=\frac{\omega_0\,.\,L_b}{R_b}\ \therefore\ R_b=\frac{\omega_0 L_b}{Q_b} \qquad \text{E-3}$$

From resonance equation 1-1

$$\omega_0\,.\,L_b=\frac{1}{\omega_0\,.\,C_b}$$

thus $R_b=\frac{\omega_0\,.\,L_b}{Q_b}=\frac{1}{Q_b(\omega_0 C_b)}$ E-4

The dynamic impedance of arm 'a' equals R_a (where no resistor is employed), hence

$$R_a=Q_a\omega_o L_a \qquad \text{E-5}$$

From B-4 $R^2=R_a\,.\,R_b$

Substitute R_a from E-5 and R_b from E-4 in above.

$R^2=R_aR_b$

$$=(Q_a\omega_0 L_a)\frac{1}{Q_b\,.\,\omega_0 C_b}=\frac{Q_a}{Q_b}\frac{L_a}{C_b}=\frac{Q_a}{Q_b}R^2 \qquad \text{E-5}$$

as $\frac{L_a}{C_b}=R^2$ from B-4.

Hence $\frac{Q_a}{Q_b}=1$ or $Q_a=Q_b$ E-6

which completes equation 2-3.

E.3 equation 1-4

For $Q_{b(min)}$ where no extra coil resistor is employed in arm 'b', $R_b=R$. Similarly, for $Q_{a(min)}$, $R_a=R$. Thus

$$\frac{R_b}{R_a}=\frac{R}{R}=1$$

Substitute R_b from equation E-3 and R_a from equation E-5

$$1=\frac{R}{R}=\frac{R_b}{R_a}=\frac{\omega_0\,.\,L_b/Q_{b(min)}}{\omega_0\,.\,L_a/Q_{a(min)}}$$

$$=\frac{L_b}{L_a}\,.\,\frac{1}{Q_{a(min)}\,.\,Q_{b(min)}}$$

Substitute

$\frac{L_b}{L_a}=(2Q)^2$ from E-2, thus

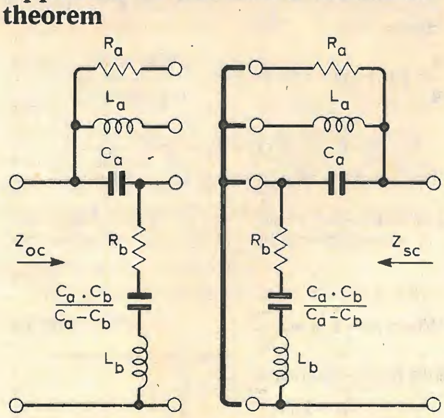
$$1=\frac{(2Q)^2}{Q_{a(min)}\,.\,Q_{b(min)}}$$

As $Q_{a(min)}=Q_{b(min)}$ from E-6

$$2Q=Q_{a(min)}=Q_{b(min)} \qquad \text{E-7}$$

which completes equation 1-4

Appendix F. Bartlett's bisection theorem



According to Bartlett's bisection theorem, if Fig. 1-10 is bisected the short-circuited half Z_{sc} forms one lattice arm and the open-circuit half Z_{oc} the other arm. Hence Z_{sc} becomes arm 'a' and Z_{oc} becomes arm 'b' in the lattice of Fig. 1-1 (see also ref. 2).

The two capacitors in series in Z_{oc} become C_b, thus

$$\frac{1}{\text{capacitance}}=\frac{1}{C_a}+\frac{1}{\frac{C_a\,.\,C_b}{C_a-C_b}}=\frac{1}{C_b}.$$

To be continued

LETTERS TO THE EDITOR (cont)

ging in the various English languages.

In the 1976 edition of the Concise Oxford Dictionary I found:

expertise n. Expert opinion or skill or knowledge.

expertize, -ise v.i. & t. Give expert opinion (concerning)

So I ask – why not use it?

The broad issue I wish to raise in this letter is who has the right to allow or disallow use of words. Obviously a dictionary compiler will not create a word and list it as in common use, so that it must be in use before it is listed. At this stage people with an academic interest in the language complain, forgetting that for most users of the language it is but a tool.

Specifically, technologists must have the right to create their own words not only as they do in naming a new invention, discovery or parameter (charmed quark), but where a minor descriptive category becomes of special importance. Brevity and phonetic ease with an attempt at spelling rationality are of prime importance. That this "jargon" is unintelligible outside the field is unimportant. Mathematical formulae, biological classifications, chemical nomenclature, astronomical designations are meant as *tools for people trained in their use* and these people resent being told that they may not coin new words for their use.

For it is not just the present with words such as expertise, program(me), hex(a)/(i)decimal, microprocessor/microcomputer which are in question but all technological names and descriptions which have been coined over the centuries. It will be impossible to produce any technical publication, such as *Wireless World,* when only non-specialised words and abbreviations are permitted.

My suggestion is that a society which desires literacy for all its people rather than as a privilege of the wealthy must actively expedite this policy. Acceptance of the nature of language (it is a tool) will precede the optimization and rationalization of usage, which includes acceptance of new words. Three types of dictionary could be collated:

Archaic – for words we may read but will never write.

Contemporary – for the words we see, hear, and use in everyday life.

Technical – a suitable criterion for inclusion would be frequency of occurrence in the media, as a measure of contemporaneity.

Our dynamic languages cannot be vitrified until our life styles do so. Countries which can alter currency and mensuration units can certainly regard their language with objectivity.

James Nolan
Sydney
Australia

MICROPROCESSOR USERS CLUB

It is proposed to set up a club in Britain for those people using the RCA 1802 microprocessor, Cosmac ELF, ELFII, Super Elf etc. The unofficial assistance of RCA and HL Audio has been promised. Would those interested please contact me at 7 Harrowden Court, Harrowden Road, Luton LU2 OSR. Please send a stamped addressed envelope.

James Cunningham
Luton

Linear voltage-controlled oscillator

LC circuit provides increased s/n ratio

by **J. L. Linsley Hood**

The author describes a technique for linearizing the characteristics of a varicap-tuned LC tuned circuit, which allows a frequency control of ±5%, with a linearity of better than 0.5% over the range.

A NUMBER of circuit arrangements exist for the generation of a.c. signals whose frequency is a linear function of some direct control voltage. Of these, the majority in current use employ some form of RC relaxation oscillator, which is usually an elaboration of the well-known cathode-coupled multivibrator.

There are three fundamental disadvantages in this type of circuit. These are that it is very difficult to make such circuits operate beyond some 20 or 30 MHz, because of the nature of the relaxation mechanism, and that the frequency stability is poor at this end of the operating range. Also, because of the way in which the circuit operates, the signal-to-noise ratio of the generated signal may be some 20-30 dB less good than that of a comparable LC oscillator.

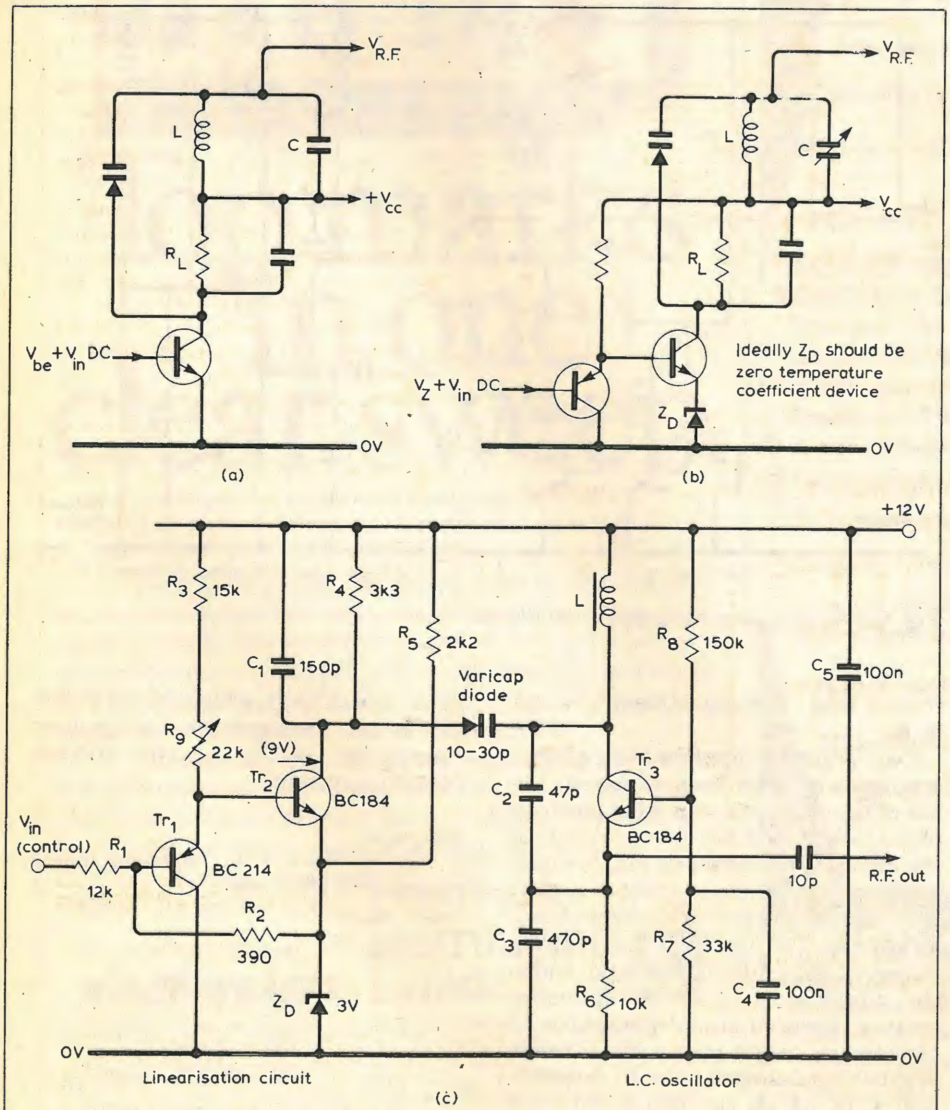


Fig. 1. *Voltage/capacitance characteristic of Varicap and base voltage/collector current curve of transistor follow similar law in circuit at (a). Modification at (b) removes effect of base-emitter voltage of transistor. Practical circuit is shown at (c).*

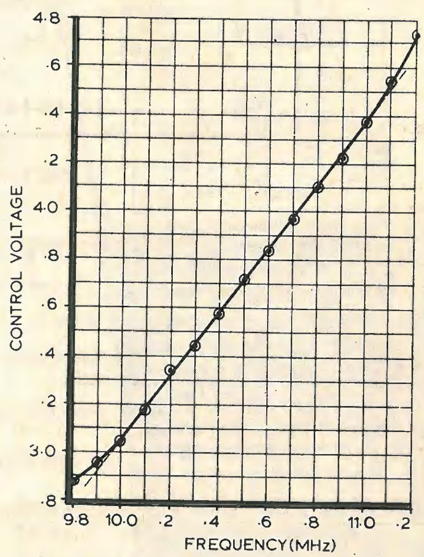


Fig. 2. *Characteristic of circuit in Fig. 1(c).*

For some applications, the less good s/n ratio of the multivibrator circuit is relatively unimportant. However, it will be appreciated that this expresses itself as a 'jitter' in the turn-on and turn-off timings, and that the noise is therefore of an f.m. nature.

By analogy with the way in which the noise accompanying the h.f. bias signal in a tape recorder will be superimposed on the recorded input, with a resultant degradation in the overall s/n ratio, it can be seen that any f.m. noise present on the output of the voltage-controlled oscillator in a phase-locked-loop, f.m. demodulator will be superimposed on the incoming f.m. signal during demodulation. This difficulty may be a significant reason for the almost complete absence of this type of demodulator in commercial f.m. receivers.

Alternative types of voltage-controlled oscillator based on the combination of an LC circuit and some form of voltage-controlled reactance, such as a Blumlein integrator or a voltage variable capacitor or Varicap diode, are seldom used except in expensive and specialized equipment because of the complexity of the circuitry normally employed to obtain a linear relationship

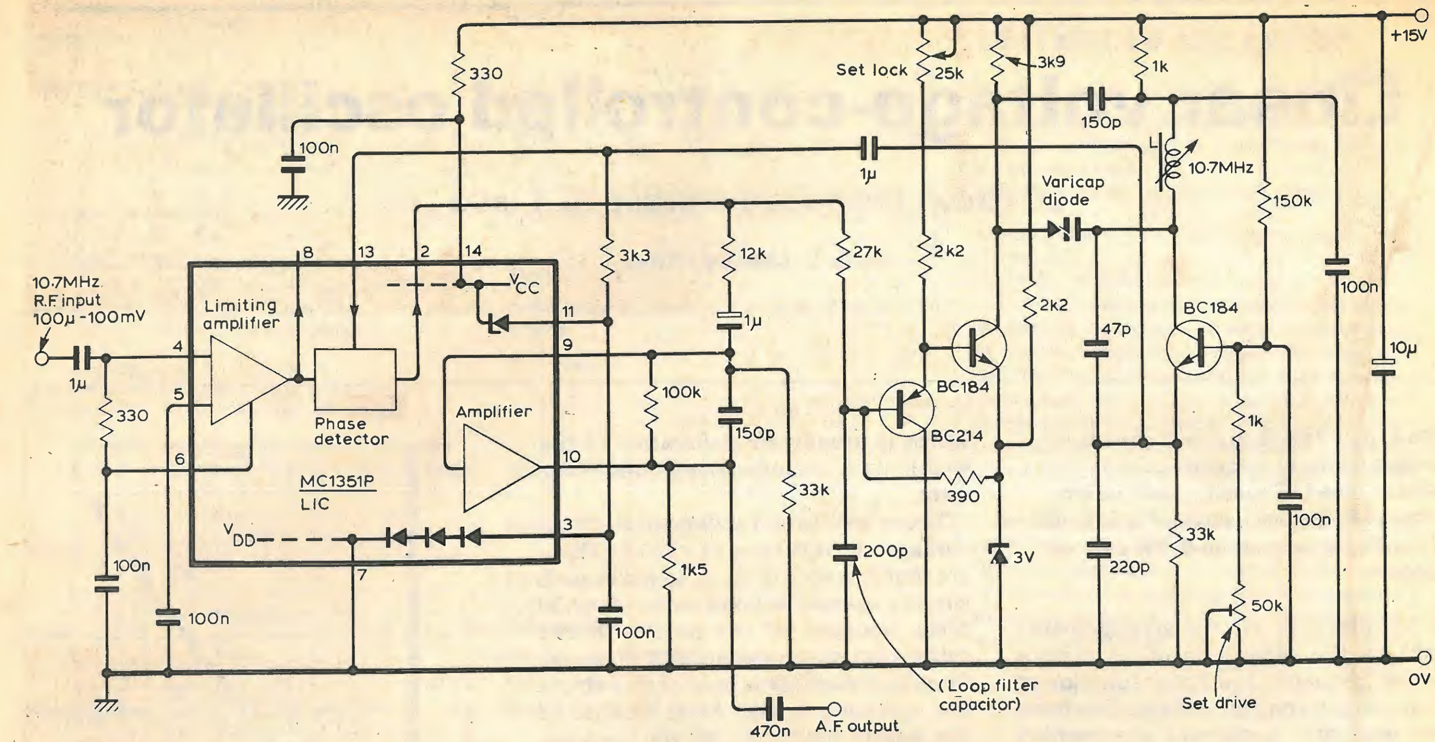


Fig. 3. *High-linearity, phase-locked-loop f.m. demodulator, providing improved s/n ratio.*

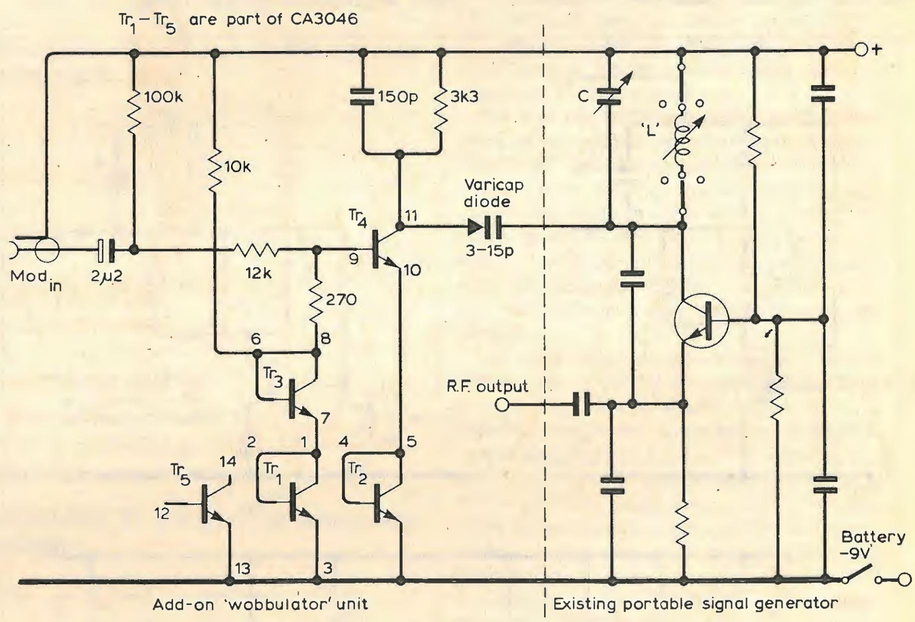


Fig. 4. *F.m. oscillator for use in wobbulator.*

between applied control voltage and output frequency. However, it is of interest, in this context, that there is a fairly close similarity between the exponential relationship in the applied voltage/capacitance characteristics of a Varicap diode and that of the base voltage/collector current characteristics of a normal junction transistor. Moreover, the temperature coefficients of these two characteristics appear to follow a similar law.

It is possible, therefore, to contrive a circuit in which the characteristics of these two components are complementary, and a simple arrangement which would achieve this result is shown in Fig. 1(a). In this circuit there would however, be an uncompensated d.c. component due to the forward base-emitter turn-on voltage of the transistor. This can be removed by the slight elaboration shown in Fig. 1(b), and a practical embodiment of this is shown in Fig. 1(c). The control voltage versus operating frequency characteristics of this circuit are shown in Fig. 2, based on a centre frequency of 10.5 MHz.

The measured linearity over the range 10-11 MHz is better than 0.5%/MHz, which would allow a linearity in a p.l.l. demodulator operating at 10.7 MHz of better than 0.1% over a ±75kHz modulation range. The actual centre frequency may, of course, be modified by adjustment to the L or C values of the tuned circuit. It was found in practice that a fair approximation to the optimum setting of the linear region of the v.c.o. is obtained when the circuit is adjusted so that there is some 3 volts d.c. across the Varicap diode – as reverse bias. This adjustment is made by R_9.

Two practical applications of this arrangement have been explored; the use of the v.c.o. in a very high linearity phase-locked-loop f.m. demodulator, of the circuit type shown in Fig. 3 which has a linearity as good as that of the RC v.c.o. used in the author's earlier phase-locked-loop f.m. receiver[1], but with an improved demodulator s/n ratio, and in the conversion of an inexpensive battery-powered signal generator of commercial origin into a multi-range 'wobbulator,' using the circuit shown in Fig. 4, in which the transistors are part of a CA 3046 i.c.

The range of input control voltages required for proper operation of the circuit shown in Fig. 1 depends on the ratio of the input resistance (R_1) to the value chosen for R_2 which should be low in relation to the dynamic base-emitter impedance of Tr_1 at the chosen operating current.

Reference

1. Linsley Hood, J. L., *Wireless World Annual*, 1975. p69 *et seq.* □

Video disc battle looms

Audio and video highlights from Chicago consumer electronics show

Introduced by Adrian Hope . . . . . . and continued by George Tillet

AMERICAN LETTER

Big news at this year's Consumer Electronic's Show in Chicago was the introduction of the long-awaited video discs and the Magnavision display created quite a sensation. So did the demonstration by Pioneer whose player also uses the Philips-MCA laser system. The MCA library now offers a choice of 200 disc titles ranging in price from $6 for 30 minutes playback to $16 for a two-hour movie.

PROBABLY THE MOST IMPRESSIVE demonstration was given by JVC with their VHD-AHD system, which superficially resembles the Philips/Magnavox video disc but is wholly incompatible with that system – and indeed every other video and digital audio system so far announced. Like the Philips disc, the JVC disc is of 30cm diameter, is pressed from vinyl plastics and has a spiral track pits on its smooth, ungroved surface. But whereas the Philips system reads the pits optically (the Philips disc surface is coated with reflective material) the JVC system reads the pits electrically. The JVC vinyl plastics pressing mix contains a carbon additive and the disc is tracked by a relatively large sapphire stylus which embraces a small electrode. This electrode follows the spiral of programme pits under servo control derived from signals coded in a sequence of guidance pits alongside the programme pits. The track pitch is 1.4μm and information is coded as variations in both length and depth of the pits. The relatively large stylus spreads its load over several turns of the spiral to offer a claimed stylus life of 2,000 hours and a claimed disc life of 50,000 plays. JVC cite the physical contact area as 30 times greater than that of a needle-in-groove system, such as Matsushita's Visc or the RCA grooved capacitance system. Tracking force is 40mg but the servo system enables a player to track a disc on an uneven surface. The grooveless surface also enables random access (as with the Philips system) and (also as with the Philips system) there are facilities for trick play, such as freeze frame, multiplication or division of speed by 2, 4, 8 or 16 times, and coded frame-by-frame identification. For NTSC countries the rotational speed is 900 rev/min which offers up to one hour playing time per side with two full picture frames, i.e. four fields, per revolution. Picture quality and stereo sound for the video disc appears every bit as good as that offered by the Philips laser system. Imperfections up to 10μm in size on the disc surface are simply sheared off and smoothed out by the tracking stylus and a drop-out compensator corrects for blemishes of up to 500μm on the disc surface. Main snag with this system appears to be susceptibility of the disc to surface containment. Any oil or grease from a human hand will upset tracking so discs must at all times be stored in protective caddies (similar to those used by RCA and Matsushita). The disc is automatically removed from the caddy when introduced into the player so the disc is never touched by hand.

The audic capability of the system using pulse code modulation was also demonstrated. JVC, unlike Philips, argue in favour of a single player to handle both video and p.c.m. discs. Philips of course argues in favour of one player for video discs and another tailored for digital audio. JVC use a 14-bit linear code with sampling at around 44kHz. This provides predictably impressive audio performance, e.g. signal-to-noise ratio of 90dB (presumably the extra 6dB is achieved with pre-emphasis). Unfortunately JVC's intention, at least as stated in Chicago, is to tie p.c.m. coding standards to TV frame standards, for instance by marketing a 900 rev/min video-audio player for NTSC countries and a different speed (e.g. 750 rev/min) player for Europe. Although the world is now accustomed to the impossibility of playing NTSC video recordings on European players and *vice-versa* it would seem an absurdly retrogressive step to impose the same strictures on p.c.m. discs. Such strictures are as unnecessary as they are undesirable. For instance by the adoption of constant tangential rather than constant rotational velocity tracking, Philips will make Compact Discs world-wide compatible. Hopefully JVC will think again before any commercial launch of the disc system (promised for the end of 1980) and by divorcing tv and p.c.m. standards ensure that JVC p.c.m. audio discs bought anywhere in the world will play on similar system players anywhere else in the world. Otherwise the system will surely never fly. But whatever route JVC takes over pulse encoding, the basic incompatability of the JVC capacitance and Philips laser systems seems assured. A potentially crippling battle between commercial giants with competitive systems of similar potential thus also seems assured.

Carver magnetic field amplifier claims an output of 400 watts at 94% efficiency.

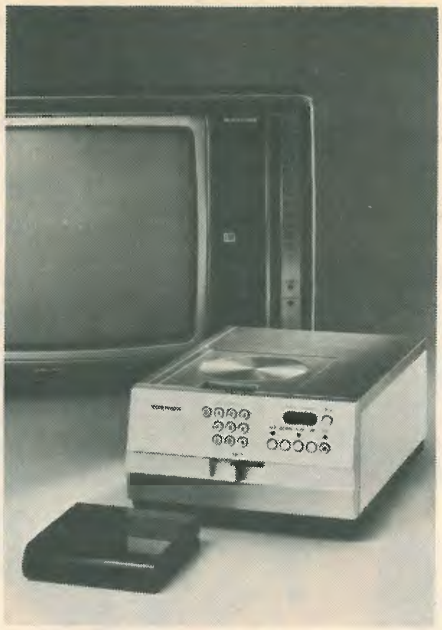
While the video world waits for BASF to show LVR, the linear or fixed head recording system at Berlin, Toshiba has already shown its own LVR system. According to the BASF technique a length of tape shuttles rapidly backwards and forwards past a fixed recording head. According to the Toshiba technique the tape is in a continuous loop, contained in a cartridge similar to an eight-track audio cartridge. The Toshiba cartridge contains a 100 metre continuous loop of 12.5mm tape which traverses the head at 6 metres per second. As the loop finishes a full pass every 17 seconds the head steps fractionally across the tape width. Each step takes 22 milliseconds, and 220 tracks are laid across the tape width. This provides an hour of continuous recording with generally imperceptible transitions. Rapid access to any point on the tape loop is achieved by fast-stepping the heads across the tape width. Longer playing time and smaller units than the prototype on show in Chicago are promised for 1980.

RCA are very much pre-occupied with their SelectaVision video tape recorders and now have quite a range. One model, the VDT 201 has a four-hour capacity and it comes complete with a digital clock timer that allows preset recording for seven days with a playing time of six hours.

Colour TV imports were down nearly 25% from last year's first quarter figures but black and white units were little affected at well over a million units. RCA are using a comb filter system with a memory to double process the picture, thus increasing the sharpness. The system is called a Dynamic Detail Processor and it involves a charge-coupled device that effectively increases the number of lines by about 25%. Sylvania, like several other manufacturers, have suddenly realized the importance of good TV sound and models use a two-way speaker system with tone controls — and a filter switch. Projection TV is slowly gaining in popularity and several new models were to be seen. Sony's one-piece models have 50- and 70-inch screens and the VIRS (vertical interval reference signal) is used for colour control. Advent also has a single-unit model and this one employs a five-foot diagonal) screen.

Now for a brief look at the audio scene: here the main interest centred on the new cassette decks which had provision for metal tapes. Some firms, like Pioneer and Akai had more than four models with "metal tape compability", as the copywriters put it. One of the most interesting decks was the Nakamichi 680 which can play at half-speed (15/16th in/s) as well as 1⅞ in/s. The upper −3dB at the slow speed was quoted at 15kHz while the response is extended to 20kHz at 1⅞in/s. The metal tape used at the demonstration was made by TDK but Nakamichi propose to market their own brand soon. The 680 has three motors, one for tape drive, one for hub control and the third for transport functions. It has a built-in calibration generator, azimuth head adjustment, monitoring capability, dual function (that is peak-average) fluorescent level indicators and provision for cable or wireless remote control. Many of the new decks are using bar-graph indicators of one kind or another instead of VU meters – some are LCD, others consist of a series of LEDs. Microprocessors are being used extensively now: for example one of the new BIC two-speed (1⅞ and 3¾ in/s) decks use one for program control with digital display while Phase Linear's Model 7000 employs a microprocessor for automatically setting the bias, equalisation and levels for nine operating parameters, including different kinds of tape.

Dolby Labs took Chicago in June as the opportunity to launch the new HX system which, as an addition to the basic Dolby B domestic noise reduction system, offers additional high frequency head room. This is achieved by varying the level of the record bias in dependence on the character of the pro-



Toshiba linear video recorder achieves tape speed of 6 m/s and a playing time of an hour with 220 tracks on continuous loop.

gramme being recorded. It is of course difficult, with even the most exotic cassette tapes and decks, to achieve accurate recordings of music which is particularly rich in high frequencies. The sound of percussion instruments, such as tambourines and cymbals, and synthesized music are particularly hard to record faithfully. This follows from the compromises necessary with a fixed bias system; the fixed level will often be too low for the optimal recording of mid and low frequencies and too high for optimally recording HF. The idea of varying the bias level according to signal content is not new but has so far foundered because bias variation also alters recorder sensitivity across the frequency spectrum and this produces a bumpy response. It was Dolby engineer Ken Gundry who recognized the need to vary the recorder sensitivity along with the bias. To achieve this a control signal is necessary and the new HX circuit derives this from the Dolby B circuitry which is already virtually standard in stereo cassette decks. Dolby is offering HX under free licence to all firms already licensed to use Dolby B. Headroom at 10kHz and over can be improved by around 10dB, regardless of tape type. This is of course in additon to the similar reduction of h.f. noise offered by the B system.

Tandberg's Dyneq system was also attracting a lot of attention and as used in the model TCD 440A it also reduces saturation effects and improves signal-to-noise. It works by automatically adjusting the record pre-emphasis to obtain the maximum high frequency response without distortion. The system is patented but the company is said to be willing to consider licensing agreements. DBX (who prefer to be known as dbx) now have an ambitious encoded disc program with the co-operation of many well-known recording companies. Recordings that meet stringent technical and/or musical standards are re-mastered to produce dbx encoded discs. A simple playback decoder is required for playback but this is relatively inexpensive. So far, 25 records have been issued (re-issued?) and I for one was most impressed with the increased dynamic range and silent background.

One of the sensations at the January Show in Las Vegas was the Carver "magnetic field" amplifier which is claimed to be 94% efficient. Precise details are not available but the circuit involves a voltage or rather energy storage "in a relatively small light-weight and low cost magnetic field coil, thereby eliminating the need for a power transformer and electrolytic capacitors". The unit measures less than a 7 inch cube and weighs only 8¾lb. Rated power output is 200 watts per channel and I can confirm that heat dissipation is insignificant. One of the most interesting features of the design is the constant impedance output so parallel loudspeaker connections cause no problems. Since the Las Vegas show, minor circuit changes have been made and the amplifier should be available later this year.

Amplifiers with "Class A" output stages are still popular with some audio enthusiasts although most of them are low powered models. An exception is the Threshold model 4000 which as a rated output of 200 watts per channel. The power supply uses a 1 kilowatt transformer and the 48 output transistors have a dissipation reserve of 6 kilowatts. A class A cascode circuit is used throughout and a matching cascode preamplifier is now available. The input stage is a little unusual as the open-loop curve is shaped to compliment the RIAA characteristic resulting in a constant amount of feedback over the audio range.

How to get bass from a small box is a problem that has long plagued loudspeaker designers and one method that has had a certain amount of success is the use of servo-feedback which involves a built-in amplifier. Now, KLH have come up with another variation – the use of a dynamic bass equalizer which is controlled by the signals present at the loudspeaker terminals. The unit is connected in the tape-in, tape-out circuit or between the preamp and power amplifier and low frequency lift is dynamically controlled so the maximum displacement of the speaker cone is not exceeded. The attack time of the processor is so fast, say KLH, that mechanical overload is most unlikely. There are three systems in the associated range of loudspeakers, the smallest measuring 12½ by 8½ by 6 inches and the −3dB point is at 40Hz.

Victorian microwaves

Millemetre transmissions before the Boer War

By K. L. Smith, Ph.D., University of Kent at Canterbury

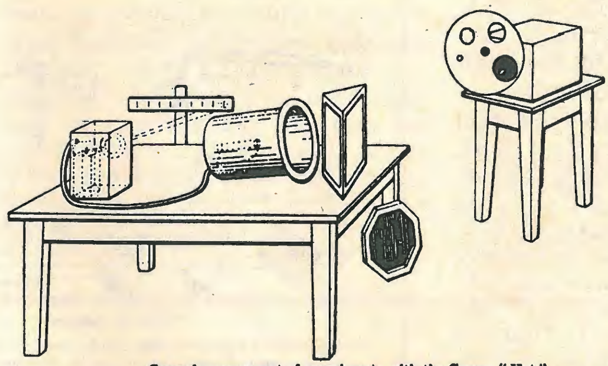
By 1900, the fundamentals of microwave transmission, and quasi-optical analogue results were firmly established. The theoretical solutions of waveguide transmission and modes of oscillation on spherical and other conductors were nearly all established; but the subject died completely.

MANY SCIENCE and engineering students in higher education still make believe how modern and up to the minute their advanced courses in microwaves are. Mainly because of the way modern mass-media approach such matters, they feel at one with all those dishes that sprout on Post Office towers and the microwave systems now used for satellite links around the the world. It seems to be symbolic of being right there and 'with it' in high technology.

It seems to come as a considerable shock to these students when it is pointed out that such technology was nearly all spelled out sufficiently early on for Queen Victoria to have had the possibility of seeing and inspecting the hardware. As the author of *Ecclesiastes* put it,[1] "There is nothing new under the Sun".

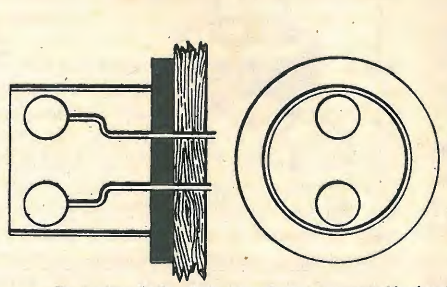
Microwave physics was bound to be realised soon after Clerk Maxwell's equations predicted the possibility of long electromagnetic waves. In 1883, F. G. FitzGerald was already suggesting that Leyden jar discharges should emit Maxwellian radiation.[2] Then in 1888[3], Heinrich Hertz at Karlsruhe conclusively demonstrated that such waves existed. The apparatus he devised to generate the shorter of his various wavelenghts was broadly resonant at 500MHz, and with it most of the properties of microwave optics were established. Hertz used a resonant dipole at the focal line of a cylindrical parabolic aerial, together with a short, parallel-wire transmission line to the detector from a similar dipole at the receiver. Working at the same time in Britain and very nearly establishing the space waves, Oliver Lodge was already well advanced in demonstrating powerful high-frequency waves on wires. Lodge, to quote a report of the time,[4] ". . . got quantitative evidence of nodes and loops in wires when working with Mr. Chattock in the session 1887-8 (the Bath meeting of the BA) . . . the wires themselves becoming momentarily luminous . . . except at the nodes, thus enabling the waves to be actually seen, having been made stationary by reflection. . . . The wires . . . were very long going five or six times round a large hall . . . ."

The reports published on all these spectacular preliminary observations soon resulted in the near-exponential

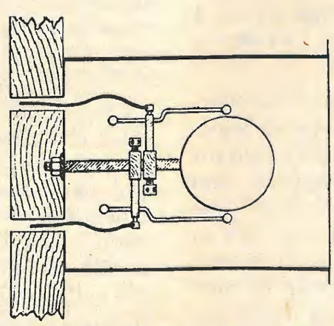


General arrangement of experiments with the Copper "Hat," showing Metal Box on a Stool, standing outside the Theatre. The Box is not exactly represented, but inside it the Radiators were fixed with a graduated series of apertures; the Copper Hat containing the Coherer is seen on the Table with the Metal Box on the left of the Table containing Battery and Galvanometer Coil connected to it by a compo pipe conveying the wires, as in Fig. 19c; the Lamp and Scale barely indicated at one side of the Table; a Paraffin Prism; and a Polarising Grid of copper wires stretched on a frame. [This figure is from a thumbnail sketch by Mr. A. P. Trotter, taken at the Lecture in 1894.]

Fig. 1. *Lodge's radiating cavity with irises is clearly seen in this picture, together with a flanged circular waveguide receiving aperture and detection system. (Lodge's caption in figure).*



Dr. Lodge's Hollow Cylindrical Radiator, arranged horizontally against the outside of a Metal-lined Box containing the Spark-producing Apparatus. Half natural size. Emitting 3in. waves.



Spherical Radiator for emitting a Horizontal Beam, arranged inside a Copper Hat, fixed against the outside of a metal-lined Box, which contains induction coil and battery and key. One-eighth natural size. The wires pass into the box through glass tubes not shown.

Fig. 2. *Pictured are two of Lodge's oscillators, which would have generated predominantly TE_{11} mode radiation.*

growth of experimental work and the publication of papers, so well described by Derek De Solla Price in his book "Big Science, Little Science".[5] Within five years, an identifiable "invisible college" existed on this subject – a socio-scientific phenomenon also described by Price. The members of this international group were described as "the Hertzians". Hertz died at this time, and leadership moved over more firmly to Lodge, A. Righi[6] in Italy, and to J. Chunder Bose from Calcutta,[7] whose milimetre wave experiments were quite remarkable. It was during Righi's public lectures that the young Marconi became acquainted with electromagnetic wave phenomena. Other workers included F. J. Trouton in Dublin, J. A. Fleming, Zehnder in Germany, and contributions from Lord Rayleigh strengthened the theoretical base.

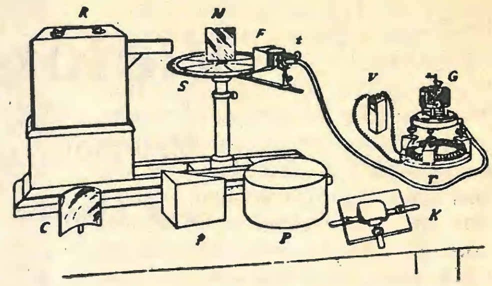
Oliver Lodge demonstrated radiation from circular waveguides on 1 June, 1894 at the Royal Institution in London. To this end, he invented the radiating iris, and in effect also resonant cavities. He called them 'copper hats', and clearly intended them as directive aperture radiators and to raise the "Q" of the oscillators, as in Figure 1. Figure 2 clearly shows that he was exciting the TE_{11} modes in the transmitting guide. By placing his coherer detector crossways in the receiving guide he detected this mode, but he also stated that, "Sometimes the (coherer) tube is put lengthwise in the hat instead of crossways, which makes it less sensitive, and also has the advantage of doing away with the polarising, or rather analysing, power of a crosswise tube." This position of his detector can be seen in figure 1.

Clearly Lodge understood he was using the circularly polarised TM_{01} mode in this instance. This mode has a null along the axis, and we find Lodge writing about the receiver as, ". . . a copper hat with its mouth turned well askew to the source . . ." thus receiving the TE_{11} mode radiation on one of the maxima to the side of the axis. Lodge's microwave demonstration operated at 4 GHz, his 7.5 cm waves were just above "S" band.

But it is to Bose we owe a considerable advancement in millimetre wave studies. He developed a semiconductor detector, rectangular waveguides and horn aerials (Figures 3 and 4). His microwave bench was put to use in measurements of refractive index, reflection from plane and curved surfaces and many experiments on polarisation.

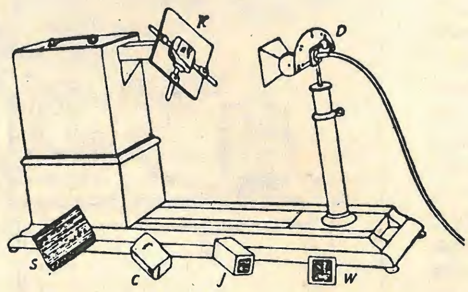
Bose generated 5mm wave radiation near "E" band. His resonator consisted of a conducting sphere set oscillating across a diameter. This was the common form of transmitter employed by virtually all the experimenters. Bose seems to have refined his spherical resonator by partially enclosing it in capacitive cups each side, as

Fig. 3. *This microwave bench enabled Bose to investigate polar diagrams, crystal lattice diffraction (or its analogue), total internal reflection, refractive indices and so on, all at 60 GHz. (Bose's caption in figure.)*



Arrangement of the Apparatus.

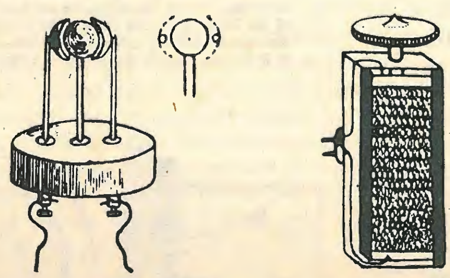
R, radiator; S, spectrometer-circle; M, plane mirror; C, cylindrical mirror; p, totally reflecting prism; P, semi-cylinders; K, crystal-holder; F, collecting funnel attached to the spiral spring receiver; t, tangent screw, by which the receiver is rotated; V, voltaic cell; r, circular rheostat; G, galvanometer.



Polarisation Apparatus.

K, crystal-holder; S, a piece of stratified rock; C, a crystal; J, jute polariser; W, wire-grating polariser; D, vertical graduated disc, by which the rotation is measured.

Fig. 4. *It is clear that Bose had all the requisite motions to establish polarisation angles. He must have understood the effect of wire gratings placed parallel, perpendicular and in practice at any angle, to the E-vector of the 60 GHz beam of radiation. (Bose's caption in figure.)*



The Radiator. The Spiral-spring Receiver.

Fig. 5. *Reproduced here are Bose's capacitively loaded spherical oscillator, and a curious two dimensional spring contact detector.*

seen in his drawing reproduced as Figure 5. This must have increased the charge stored, therefore the energy, by capacitive loading. Also, the radiation must have been reduced by the partial screening effect, thus raising the "Q" of the system, which yielded many more cycles of oscillation per discharge than must have been usual. (The bandwidth of the radiation must have been reduced.) It had been reported elsewhere by other members of the "Hertzians" that the damping of an open oscillator of this type was such that normally only one or two complete oscillations were obtained.

The ingenious detector evolved by Bose is also shown in Figure 5. It most likely consists of a space-irradiated multicontact semiconductor (using the natural oxide of the springs) plus some cohering action. But from Bose's reports this action, unlike most coherers, appeared to be self-decohering.

One of his experiments involved Bradshaw's Railway timetable, interleaved with sheets of tinfoil in the pages, as a cut off metal plate grating. Also, one of his millimetre aerials used a sulphur lens, shaped to the required curve by using the refractive index as measured on the bench at 60 GHz.

A most remarkable development carried out by Bose has already been mentioned. His use of microwave horn aerials occurred well before the turn of the century. No doubt he considered that the larger collecting area of a horn aperture would increase the energy incident on his detector – reasoning precisely in the same way as a microwave engineer now designing his receiving aerial for a communication, links or satellite ground station.

All these workers generated radio frequency powers of considerable magnitude, so they were not energy limited. Oliver Lodge estimated that one of the shock excited oscillators that were in popular use at the time developed a peak power of some 70 kW. He goes on to say that sparks could be drawn from all sorts of metal pipe wires and fittings, and that fuses were regularly blown by the received power that was picked up by the electrical system of the building, when the sending apparatus was operating.

In 1896, Lord Rayleigh[8] published a complete solution to Maxwell's equations yielding all the possible modes in rectangular and circular waveguides, complete with Bessel's functions and all. Thus the stage was set for point to point communications links with parabolic aerials, waveguide feeders, increasingly sensitive detectors – and even microwave Radio Astronomy of the Sun as Oliver Lodge proposed, and actually attempted.

Yet one of the most remarkable mysteries in science and technology is that none of this occurred. The subject faded rapidly from the scene. Hertz was dead, the others seemed to switch to new fields of work. Microwave electronics was before its time and had to wait half a century until just before the second world war for Southworth, Chu, Schelkunoff and others, to make the rediscovery and begin the applications.

Lodge, who was the outstanding British figure in this work, became increasingly involved in running a University, and took an increasing interest in the paranormal, becoming in fact President of the Society for Psychical Research. He continued to write many instructive articles on "wireless" in the journals such as the early editions of *Wireless World*, and was elected President of the Radio Society of Gt Britain for the year 1925.

Bose moved on to investigations of plant growth and the effects of e.m. radiation upon biological structures. All the other workers faded from view. Perhaps it was Gugielmo Marconi's great success in using extremely long Hertzian waves for telegraphy that swung all the young engineers away from microwaves. But whatever the historial cause of the moratorium in microwave science, nothing can detract from the lustre of these first pioneers of microwaves at the end of the 19th century.

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1. Ecclesiastes, ch. 1 and 2. (the 'Tao' of the Old Testament.)
2. See, Joseph Larmor, ed. "The Scientific Writings of the Late F. G. FitzGerald." Longmans Green (London) 1902. Page 100 contains the details of comments FitzGerald made at the 1883 British Association meeting in Dublin.
3. H. Hertz. "Electric Waves." Macmillan and Co. 1893. (Reprint by Dover available.)
4. O. J. Lodge. "Signalling Through Space Without Wires". 'The Electrician' Printing and Publishing Co. 1898.
5. Derek De Solla Price. "Big Science, Little Science". New York, Columbia University Press, 1963.
6. A. Righi. "L'Ottica delle Oscillazioni Elettriche".
7. J. C. Bose. "Collected Physical Papers". Longmans Green, NY. 1927.
8. Lord Rayleigh. "On the Passage of Electric Waves Through Tubes . . ." *Phil. Mag.* vol. 43, pp 125 to 132, February 1897.

Oliver Lodge had a paper on the history of his own contributions to early radio science in *"Wireless World,"* July 1st. 1922. He was President of the R.S.G.B. during the year 1925. □

Books Received

The latest offering in the Newnes Technical Books' "Master" series, in this case **Master Hi-Fi Loudspeakers and Enclosures,"** by Dave Berriman, offers some interesting and attractive material covering the essentials of each element of the loudspeaker, both as individual items and in concert with the box. However, those who are observant will notice a tendency to gloss over the hairy areas, such as the power output losses incurred by passive filter networks. Active networks are not even mentioned, but the nice paper and intermittent two-colour presentation (blue type-face for captions on illustrations and silky white paper throughout), added to the fairly wide spread given to the subject, makes the book a good buy at £2.95 in limp back. One nasty inconsistency is that represented by the cover illustration. A confused shopper stands in front of a pile of speakers with the slogan "Special Offer", but as Mr Berriman provides no information at all on the efficiency/price relationship in the book, it could prove frustrating for some: Butterworth and Co. (Publishers) Ltd., 88 Kingsway, London, WC2B 6AB.

"Starting and Running a Small Business", first published in 1977, must be one of those books which (ideally) should help to swell anyone's profits from business. The author, Alan Sproxton, outlines with admirable candour the main objection to the use of the book as an aid to money-making or the fractional reduction of the dole queue when he points out that he has so far managed to avoid making a fortune himself. Maybe fortunes aren't to be made in small business but it can't help circulation to act as your own devil's advocate. Nevertheless, the same general advice holds good in this up-dated version as did in the 1977 printing, though with more acid heaped upon Civil Service and government departments alike. A humorous and handy volume on the whole. Hardback at £3.95 from United Writers Publications, Trevail Mill, Zennor, St. Ives, Cornwall.

The IEE has recently (March) issued a new edition of its **"Symbols and Abbreviations for Electrical and Electronic Engineering"**, and there's not a great deal to say about this except that, as always, it provides the fundamental sign language of electronics as well as quantity symbols for mechanics, heat and illumination among other universal phenomena. It comprises a sixteen page booklet costing 75p from The Institution of Electrical Engineers, Marketing Dept., Station House, Hitchin, Hertfordshire SG5 1RJ.

"Digital Hardware Design", by the popular (for us!) team of Catt, Walton and Davidson, converts some of the contributions by Heaviside, S.P. Thompson and Hertz to solutions of digital problems. The ideas are well-explained, the maths fairly easy to handle and the drawings rather poor in places. Nevertheless, some half-forgotten ideas are given a fresh new treatment and appear at a high relevant moment, considering the development of high-speed digital techniques via ECL (emitter coupled logic) and Shottky t.t.l. £4.50 in limp-back from Macmillan Press, 4, Little Essex St., London WC2R 3LF.

"A Guide to Amateur Radio", by Pat Hawker, is a hard-back and up-dated version of the well-known booklet version of the 17th edition produced in 1978. This useful work contains two additional sections dealing with fundamentals of electronics and sample RAE examination questions. £5.40 from Butterworth and Co.

Yet another in the massive series of D.A.T.A. books has appeared. This deals with **memory integrated circuits** and covers 9118 types spread across 51 manufacturers. The technical sections deal with r.a.ms, r.o.ms, character generators, code converters, shift registers and special memory devices including oddities such as trigonometric r.o.m.s. — a.t.n, rhythm generators and transistor arrays. This is edition 16 and is, as usual, available from London Information (Rowse Muir) Ltd., Index House, Ascot, Berkshire SL5 7EU at a price of £32.65.

Thermistor stabilizers

continued from page 64

J. L. Linsley Hood's "Low Distortion Oscillator" (Wireless World, Oct. 1977 pp 69-70) can be examined. In this case $R_s = 220\Omega$, $R_f = 820\Omega$ and the thermistor is an STCR53. The quoted output is 1.5V and the calculated result is 1.60V. Calculated temperature coefficient is −22mV/°C, which is equivalent to −0.118dB/°C. With $R_s = 0$ and $R_f = 127\Omega$ the calculated voltage is 1.01V and the measured voltage 1.1V. The temperature coefficient is then −4.5mV/°C or −0.039dB/°C.

One way to reduce amplitude dependence upon temperature is to operate the thermistor at higher temperatures, but this is not profitable as the instantaneous temperature can rise above the steady-state level even when settling.

In principle it is possible to provide compensation over a temperature "band" by replacing R_f with a thermistor of dissipation factor which is much larger than the output sensing thermistor, or by means of a thermistor/resistor combination.

NEW PRODUCTS

Cassette with die-cast frame

Claiming that its MA-R die-cast (zinc) framed cassette provides improvements in tape-to-head relationships, resulting in reduced levels of wow and flutter etc., TDK points to greater rigidity as the prime source of the improvements. The new cassette features a new type of tape anchorage within "truly circular hubs" which ensures "even, regular spooling." In addition to the new frame and tape anchorage, the cassette contains (C60 size) "metal alloy" tape and a table is provided giving details of the electrical properties of the new tape. Sensitivity figures for the three frequencies of 333Hz, 10kHz and 16kHz are given as 5dB, —0.5dB and 2dB respectively. No information is provided concerning comparative wow and flutter measurements. The main advantage of the "metal alloy" (particle) tape is improved coercivity and remanence. This cassette will be available in the UK in September 1979 and the C60 will retail at about £6. TDK Tape Distributor (UK) Ltd., 11th Floor, Pembroke House, Wellesley Rod., Croydon CR0 9XW.

WW 301

WW 301

1W (max.) v.h.f. crystal oscillators

A range of fixed-frequency crystal oscillators covering the frequencies 5MHz to 300MHz, the CO-284W series, can deliver an output of up to 1W according to the distributors, Lyons Instruments. Those in the 300MHz to 500MHz range can deliver 0.5W, giving levels of 30dBm and 27dBm for the two range spreads respectively. Oscillators can be supplied as "standard stability" types at ±20 ppm at temperatures between 0 and 50°C with options of stability to ±3 ppm and operation over temperature extremes between —55°C to +125°C. Each oscillator is factory-set to within 10 ppm of the specified frequency but adjustment for setting within 1 ppm is available as an option and electronic tuning is available for phase-locking applications. Supply requirements are +15V d.c. at 300mA and the dimensions are 51×76×19mm. The oscillators are manufactured by Vectron Laboratories and the distributors point out that the pricing system is complicated by differences for "standard" and "high" stability units, variations for differing frequency coverage and savings obtained by "bulk" ordering. As an example, an item which costs between £285-£490 as a "one-off" could easily be brought down to the £120-£195 range when ordered as a "100-off". Lyons Instruments, Hoddesdon, Herts.

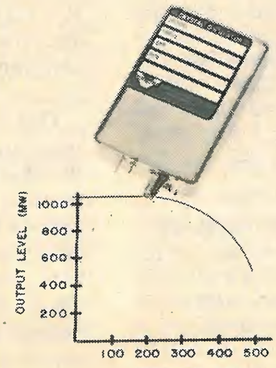
WW 302

Sub-miniature rotary switch

Full dust-proofing and operation over the temperature range —45°C to +85°C are features of the PS613 series of sub-miniature rotary wafer switches which the manufacturer, Radiatron, claims for its recently introduced range. The switches have been designed with miniaturized equipment in mind as well as long life. They may be specified with either silver or AuNi contacts and will switch loads at 110V d.c. or 125V a.c., both at 0.25A. Maximum load current is 1A and either 12 or 6 positions may be selected in both shorting and non-shorting configurations. Each wafer can have one or two poles and each switch can incorporate up to 4 wafers. The overall diameter of each switch is 12mm and a choice of p.c. board mounting or panel types is available. Radiatron Components Ltd, 76 Crown Rd., Twickenham, Middlesex.

WW 303

WW 302

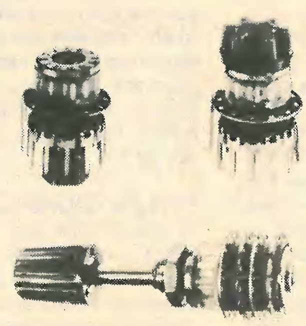


CW lasers

Two new injection c.w. lasers, offering a 5mW output with a typical beam divergence of 5 milliradians are now available from Laser Diode Laboratories, a subsidiary of the (American) Valtec Corporation. These devices, which are said to feature high c.w. power output and low beam divergence, are classified as the SCW-30 and SCW-31. Other significant characteristics include a threshold current of 85mA and a peak wavelength of 820 nm. Typical linewidth of the SCW-30 is 1nm and that of the SCW-31 is 0.1nm. Both lasers incorporate the SELFLOC lens and are housed in the LDL-9F package. A 10,000-hour warranty is offered for both items. Walmore Electronics Ltd., 9-15 Betterton St., Drury Lane, London WC2H 9BS.

WW 304

WW 303



Combined 5V regulator and bridge rectifier i.c.

A mains transformer, filter capacitor and an r.f. by-pass capacitor are all that is needed to turn a new i.c. from Fairchild (UK) into the central element of a self-contained 5V and 5A power supply. This is the SH1705 and contains the μA 78H05A regulator in combination with a diode bridge circuit. The usual features of short-circuit protection, thermal shut-down, low drop-out voltage and internal current limiting are included, and if desired the regulator section can be used separately from the bridge rectifier. Absolute maximum ratings are 23V r.m.s. input, 50W internal power dissipation (at a case temperature of 25°C) and a regulator section input/output differential voltage of 25V d.c. (max.). Regulator input is via a separate pin, making it suitable for use in more complex supplies, using other devices. The retail price of the i.c. is £9.71 before v.a.t. Fairchild (UK) Ltd., Potters Bar, Herts.

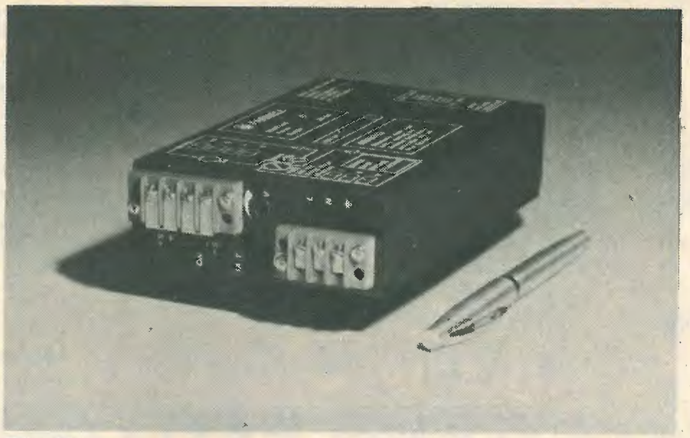
WW 305

30W opto-isolated switchers

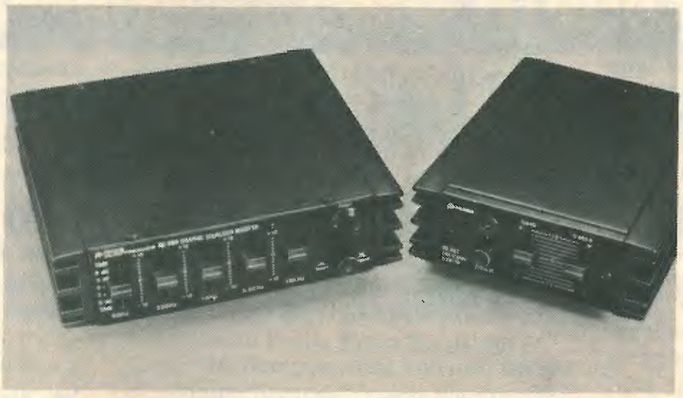
An efficiency level of 70% and remote sensing as a standard feature are two of the quoted points of interest relating to a new range of opto-isolated switchers recently introduced by

Farnell Instruments. These are an extension to the "G" range of switching power supplies and four current combinations can be employed, at 6, 12, 15 and 24V. A further claim is that they will tolerate wide variations in input voltage, i.e. in the range 176 to 264V (a.c.) or 92 to 132V (a.c.). The application of opto-isolation switching techniques has resulted in compact, lightweight power supplies housed in a case measuring 145×88×33mm and exhibiting an insulation tested breakdown point of 5.8kV d.c. input to output. That is, 2.9kV d.c. output to earth and 2.9kV input to earth. In keeping with the rest of the "G" range the unit output is designed to hold up for the duration of a missing mains cycle without the addition of external output capacitors. These switchers comply with the interference requirements of VDE 0875, curve N, CISPR (publication 2) curve N and BS800. Farnell Instruments Ltd., Sandbeck Way, Wetherby, LS22 4DH.

WW 306

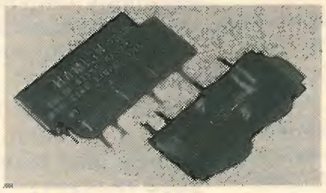


WW 306



WW 307

WW 308



WW 310

Car stereo booster and graphic equalizer

Compensation for high noise levels inside the car can be obtained by boosting the output power of a car stereo system and the RE-482 Car Stereo Booster, in combination with the RE-484 graphic equaliser, can supply this extra feature. The makers, Ross Electronics, say that each unit provides an output of 20W per channel and is fitted with by-pass switches to re-connect the car stereo unit to the speakers direct. Each unit operates only with 12V negative earth systems and output impedance is 4 to 8-. The RE-482 is fitted with bass and treble controls providing, according to the makers, frequency control which can provide a response equivalent to home hi-fi systems. The graphic equalizer offers the same basic tonal variations but the five controls cover centre frequencies of 60Hz, 250Hz, 1kHz, 3.5kHz and 10kHz. The dimensions of the RE-482 are 115×40×150mm, the unit being priced at £27.90 plus v.a.t. while those for the RE-484 are 160×40×150mm, the price of this item being £50.40 plus v.a.t. Ross Electronics, 32 Rathbone Place, London W1P 1AD.

WW 307

Digital thermometer

Covering the range 0 to 400°C, a new digital thermometer offers more durable features than many previous items of a similar nature, according to the makers, DMS Electronics. For example, the probe is permanently wired to minimize errors and is fed with "armoured" coaxial cable for hard wear. Error is ±1 digit over the entire temperature range with a claimed fast response in changes of temperature. The display is l.c.d. (0.5in) and the low power consumption permits up to 100 hours continuous use from the self-contained rechargeable battery. The instrument is housed in a lightweight ABS case with a protective hinged lid. A carrying wallet is also supplied with the thermometer. DMS Electronics, Unit 10 Willow Close, South Anston, Sheffield S31 7GX.

WW 308

Suppression chokes

Radio frequency interference suppression chokes in a heavy-duty form are being made and marketed by Ashcroft Electronics. Intended for use in vehicles, aircraft and ships, these chokes operate within the range 150kHz to 200MHz (approx.) and are constructed from enamelled wire wound on a ferrite former and connexions are taken to axial lead-outs. A tough plastic outer sheath gives protection against vibration and moisture. Inductance range is 5.5 H to 70 H, tolerance is ±20% and the normal operating temperature range is −40°C to +85°C. Ashcroft Electronics, Cirencester, Gloucestershire.

WW 309

Thick-film relays and drivers

Combination of several modern constructional techniques has given rise to a new range of solid state a.c. relays and thyristor drivers from Hamlin Electronics. Designated the 7580 series, the relays are constructed using thick-film technology and optical isolation methods and are formed as a compact single-in-line package occupying less than half a square inch (300mm^2) of mounting area. Input/output isolation voltage (max.) is 1,500V. r.m.s. and the device features polarity-protected inputs, zero voltage switching and compatibility with i.c. logic. Load current rating is 2A r.m.s. at a control voltage of 3V d.c. and 1.75A r.m.s. at 32V d.c. Non-repetitive single-cycle surge current is 70A peak, and 1 second overload current is 35A peak. The driver units in this series are intended to interface with logic control circuits and power thyristors operating on the a.c. line. Output current to the thyristor is 50mA r.m.s. (max.) or 150mA pulse current. Both relays and drivers are mounted in a package measuring 40x22x9mm and each weighs 7g. Hamlin Electronics Europe Ltd., Diss, Norfolk.

WW 310

Quick index machine

Rapid access to index details and a capacity of about 1,000 entries are features of an electrically-operated records index, the "Datax," which is available from Hadley Sales Services. Index cards slide in and out of plastic trays and the relevant details are quickly displayed behind a transparent plastic screen in response to the pressing of a button. The information stored could be telephone numbers, part numbers, prices, inventories, customer accounts, etc, and a 30 button keyboard (full alphabetical range) allows flexibility for combinations of letters and numerals. Each unit includes a supply of pre-cut index cards and keyboard tables. The "Datax" is portable and operates either from two HP2 cells or an a.c. mains adaptor. The price is £40 (plus 15% v.a.t.) for the TBX-30 and a smaller version, the TB-15, with a capacity of 360 entries, costs £18 plus 15% v.a.t. Hadley Sales Services, 112 Gilbert Rd., Smethwick, Warley, West Midlands B66 4PZ.

WW 311

Quad v.m.o.s. power f.e.t.

Four independently accessible v.m.o.s. power f.e.t.s. contained in a single 14 pin d.i.l. package and specified as the VQ1000 constitute one of the latest products from Siliconix. The manufacturer claims for this device advantages such as reduced component count, high switching densities and lower than usual assembly costs. Each individual f.e.t. within the package has a maximum switching capability of 60V and a continuous current rating of 0.5A or 1A in pulse applications. In higher power applications each f.e.t. can be connected in parallel externally to take advantage of the load-sharing capabilities of v.m.o.s. devices and typical switching times are as low as 5ns. Applications are various and include t.t.l./c.m.o.s. logic to high power interfacing, l.e.d. digit strobe drivers, high speed line drivers, stepping motor drivers and peripheral control driving circuits. Overall package power dissipation is 1.75W max. at 25°C and each VQ1000 will be available in either plastic or ceramic packages complete with Zener protection. Siliconix Ltd, Morriston, Swansea SA6 6NE.

WW 312

SIDEBANDS by Mixer

Softly, softly . . .

I would like all manufacturers of domestic audio equipment to pay attention for a moment. It's high time for some plain speaking, so just stop trying to decide which bit of planned obsolescence to build in next and listen to me.

Well, that's it, really. Built-in obsolescence. It never used to be like this. When my father bought us a gramophone, he was reasonably confident that he would have time to get it out of the box before we were made to feel under-privileged by "new technology." At the current frantic rate of innovation, it would barely be fully wound up for the first Gracie Fields record before a new model with oil-fired winding and a cast-iron needle was introduced.

Even motor cars seem to last for a year or two before petrol-pump attendants start sneering at them, and in the other gadget-conscious brotherhood of photography, it is positively not done to have shiny new equipment — not according to glossy ads. for Olympus, at any rate.

What I feel is that it would be rather nice to have time to get the 13A plug on my new cassette deck before the next one is launched (amphibious, are they?). Because that is what this is all about. I want to buy a cassette deck, but by the time these devices have been on the market long enough for the intelligentsia to tell me whether they are any good or not, they can't be found in the shops, having been replaced by new designs with slight and probably unimportant differences. One can't keep up the pace. So, look, chaps, can you hold it for a couple of months, please. I'd quite like to be up there with the cognoscenti for the first time in my life, even if it is only for a week or two.

Paper tigers

When television was young, and keeping up with the Joneses entailed knowing someone who'd been to Torquay instead of Blackpool for the annual fortnight, it was not unknown for the H aerial on a chimney to feed nothing but its own downlead. If the neighbours *thought* you had a television set, that was the main consideration.

That sort of ploy was understandable I suppose, from impecunious high livers, but to transfer the philosophy to the camera end takes a devious mind — the kind which impels people to put notices on the front gate implying that the Hound of the Baskervilles is in residence and praying for a chance to sink its teeth into the juicy bits.

Nevertheless, I do feel a little less threatened than I used to when doing the weekend shopping in the supermarket, because a note came from a firm which makes it its business to keep all us potential shoplifters in line to tell me that the latest line in c.c.t.v. cameras aren't what they seem. Those devices that follow your every move aren't cameras at all. A new fitting lately on the scene consists of four dummy lenses, mounted on a sort of pudding basin affair and fixed to the ceiling. Red lights flash to make you think that the manager has his little button eyes on you and a sign says "c.c.t.v. pictures relayed to central monitors." The missing articles and verb avoid the accusation of a downright lie, but the message is certainly there.

This isn't the only one of its kind. The same firm do a wall-mounted one which darts quick glances about the shop in an apparently purposeful way. It doesn't have anything behind the "lens," either.

I don't know how long this has been going on, but it's made me feel a bit foolish. It means that all those funny faces I've been pulling at c.c.t.v. cameras have been wasted. I would also have thought that to tell everyone about it would rather tend to reduce the effectiveness of the operation.

Information gap

I'm pretty sure that the most certain way of indicating which gaps in one's education yawn wider than average is to look at the front covers of the IEEE Transactions on various subjects. The front cover is about as far as I usually get because, since the contents list is printed thereon, it is made painfully clear to me that I can't even understand the titles, much less the articles themselves. Faced with a title such as "Recursive implementation of a two-step non-parametric decision rule," I cannot claim that my hearbeat reacts at all dramatically. The effect of "An intrinsic dimensionality estimator from near neighbour information" on my pulse rate can best be described as unspectacular.

It is all very depressing and I was considerably cheered to see, on the first issue of a new Trans., the article "A family of similarity measures between two strings." Well, like most people, I had previously supposed that when you'd seen one piece of string, you'd seen the lot, but I was pleased that there was at least one word in the title that meant something to me. So I took the not inconsiderable step of opening the journal to read this account, and found that the strings in question were strings of symbols which were either identical (S = 1) or not like each other one little bit (S = 0), with shades of similarity in between. Well, that's fine, as far as it goes, but it's the kind of article that does tend to leave me wondering if I've missed the punch line.

What I mean to say is, it's so difficult to obtain even a smattering of the whole field of electronic study. When I was a lad, just after the Flood, a well-rounded engineer was expected to work effectively in any branch of the discipline — from directly-coupled amplifiers to microwaves, from record players to guided weapons, from stabilised power supplies to stabilised platforms. The amount of information released in the last twenty years means that no one, or no one I know anyway, can even comprehend the whole field of interest.

It doesn't half make you feel old.

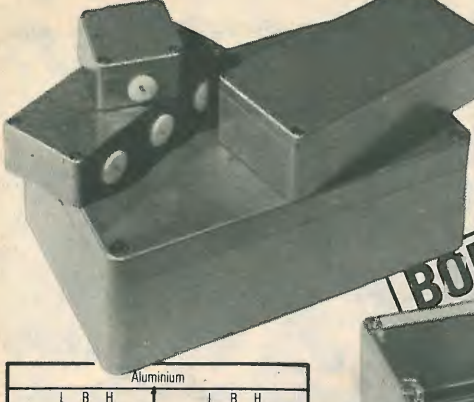
Les Miserables

As all good chess players know, the only thing to do when your king is pinned down and your queen is about to be abducted is to bend down to stroke the cat and accidentally knock the board on the way up again. In the ensuing argument, you can then maintain that the brilliant coup you were about to pull off would have enabled you not only to escape check, but to mate in the next four moves. When challenged to prove it, you can't, of course, quite remember where the pieces were.

Chess, so I'm told, is popular in France, which possibly explains the unreliability of their telephone system. You don't get the connexion? Well, no — neither did the Post Office Prestel exhibit at the Tele-informatics exhibition in Paris a few weeks ago. It seems that Prestel and Didon, a French viewdata system somewhat similar to Prestel, were on neighbouring stands. Comparison was thereby invited — at least, it would have been but for the fact that Didon wouldn't work. Prestel pressed on regardless, the Post Office people no doubt feeling distinctly chuffed by their unforeseen edge over Didon, until just after the relevant French Minister did his walkabout of the show, whereupon the Prestel decoder was left talking to itself. The telephone line had been cut off.

Urgent representations were naturally made, but in spite of the location of the exhibition — the French post office headquarters — the phone stayed dead. A token French engineer came round, said he'd have to get his screwdriver or something, and promptly disappeared into the hinterland. No one is saying anything. Not even why, out of all the telephone lines in use, only the three on the Prestel stand were out.

Still, these accidents will happen. Sometimes, it's the only way.

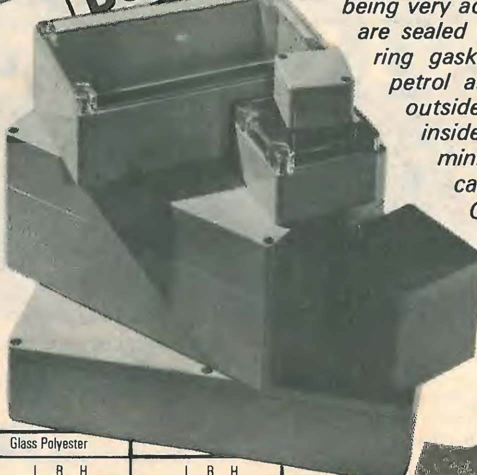


WH WEST HYDE

Best Selling BOPLA range

BOPAL

BOCON



All the Bopla range, with the exception of BOCON are to IP65 standard, being very accurately made. Their lids are sealed by a recessed continuous ring gasket, which will also resist petrol and oil. Fixing screws are outside the sealed chamber, but inside the case. Bopal are aluminium and Boplast either polycarbonate or glass polyester. Certain sizes can have clear covers.

The Bocon is a two-toned high impact polystyrene case to IP44. In dark/light grey, red/black, or clear covers (see cat.).

	L	B	H	
BOC 410	100	50	25	2.06
BOC 420	100	50	40	2.20
BOC 430	120	65	40	2.38
BOC 440	150	80	55	2.68
BOC 445	150	80	80	3.42
BOC 450	188	110	70	3.53
BOC 460	188	110	100	4.02

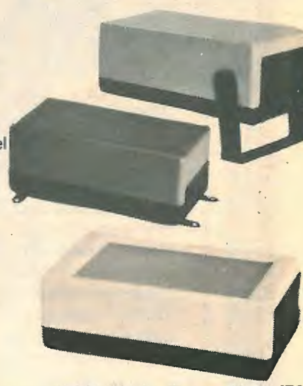
Aluminium

	L	B	H			L	B	H	
A100	50	45	30	**2.80**	A124	360	120	80	**20.81**
A101	58	64	34	**4.01**	A125	160	160	90	**17.68**
A102	98	64	34	**4.71**	A130	260	160	90	**22.06**
A103	150	64	34	**6.39**	A135	360	160	90	**27.52**
A105	75	80	57	**5.87**	A138	560	160	90	**42.24**
A110	125	80	57	**7.67**	A140	200	230	110	**37.84**
A115	175	80	52	**8.74**	A160	330	230	110	**49.98**
A117	250	80	52	**12.31**	A165	330	230	180	**70.78**
A120	122	120	90	**13.36**	A168	400	230	110	**64.83**
A123	220	120	90	**16.18**	A195	420	240	210	**61.30**

Polycarbonate

M205	52	50	35	**2.31**	M235	160	80	90	**6.32**
M206	65	50	35	**3.22**	M240	250	160	90	**11.60**
M210	82	80	55	**4.25**	M2401	240	160	90	**11.60**
M215	120	80	55	**4.84**	M241	250	160	120	**15.57**
M217	122	120	65	**6.44**	M242	240	120	100	**10.21**
M220	160	80	65	**5.67**	M243	240	160	120	**15.53**
M221	200	120	75	**9.61**	M244	340	150	100	**17.51**
M223	200	150	75	**10.21**	M245	340	150	120	**19.45**
M225	82	80	85	**4.84**	M250	250	160	150	**15.53**
M226	120	80	85	**5.67**	M252	300	230	65	**16.98**
M227	122	120	85	**7.33**	M253	300	230	85	**19.50**
M228	122	120	110	**8.78**	M254	300	230	110	**22.41**
M230	120	80	90	**5.67**	M255	360	200	150	**28.23**
M231	160	80	95	**6.32**					

BOPLAST



Bocon handles, mounting brackets and aluminium panel versions are also available.

Glass Polyester

	L	B	H			L	B	H	
P305	80	75	50	**7.21**	P326	80	75	75	**7.90**
P311	110	75	50	**7.88**	P327	230	75	75	**12.59**
P316	160	75	50	**8.98**	P328	190	100	90	**16.50**
P319	190	75	50	**9.82**	P330	160	160	90	**21.23**
P322	230	75	50	**10.65**	P333	260	169	90	**26.28**
P323	55	55	58	**6.31**	P334	360	160	90	**32.76**
P324	110	75	75	**8.86**	P355	400	250	120	**61.11**
P325	160	75	75	**9.65**					

Prices are one off and include P & P but not VAT. Discounts on quantity.

NOTE NEW PHONE NO. **WEST HYDE DEVELOPMENTS LIMITED, Unit 9, Park Street Industrial Estate, AYLESBURY, BUCKS. HP20 1ET. Phone: Aylesbury (0296) 20441. Telex: 83570**

WW—065 FOR FURTHER DETAILS

TRANSISTORISED DC TO AC INVERTERS

12v-24v-48v dc input models
110v or 240v AC off load output models
Square-wave output or optional filtered models
Frequency 50Hz or 60Hz models (± 5% typical)

All silicon power transistors
Separate driver and output transformers
Designed for cool continuous operation
Aluminium ventilated cased units
DC input fused

12v dc inputs/110v or 240v outputs
50Hz or 60Hz

N12/A—8"x6"x6" 40 watts	**£18.00**
N12/B—8"x6"x6" 60 watts	**£23.20**
N12/C—8"x6"x6" 100 watts	**£28.10**
N12/D—8"x6"x6" 150 watts	**£34.50**
N12/E—8"x6"x6" 200 watts	**£42.00**
N12/F—8"x6"x6" 250 watts	**£50.60**
N12/G—8"x6"x6" 300 watts	**£58.00**
N12/H—10"x8"x6" 400 watts	**£69.80**

Filtered waveform models available at 15% extra.

24v dc inputs/110v or 240v outputs
50Hz or 60Hz

N24/A—8"x6"x6" 40 watts	**£19.20**
N24/B—8"x6"x6" 100 watts	**£29.80**
N24/C—8"x6"x6" 150 watts	**£36.00**
N24/D—8"x6"x6" 200 watts	**£44.00**
N24/E—8"x6"x6" 250 watts	**£52.50**
N24/F—8"x6"x6" 300 watts	**£60.00**
N24/G—10"x8"x6" 400 watts	**£71.40**
N24/H—10"x8"x6" 500 watts	**£83.00**
N24/I—12"x8"x8" 700 watts	**£101.00**
N24/J—12"x8"x8" 1000 watts	**£150.00**

Filtered waveform models available at 15% extra.

48v dc inputs/110v or 240v outputs
50Hz or 60Hz

N48/A—8"x6"x6" 50 watts	**£20.00**
N48/B—8"x6"x6" 100 watts	**£31.60**
N48/C—8"x6"x6" 150 watts	**£37.00**
N48/D—8"x6"x6" 200 watts	**£45.00**
N48/E—8"x6"x6" 250 watts	**£54.00**
N48/F—8"x6"x6" 300 watts	**£62.00**
N48/G—10"x8"x6" 400 watts	**£73.00**
N48/H—10"x8"x8" 500 watts	**£86.00**
N48/I—12"x10"x8" 700 watts	**£112.00**
N48/J—12"x10"x8" 1000 watts	**£160.00**
N48/K—12"x10"x10" 1500 watts	**£210.00**

Filtered waveform models available at 15% extra.

Please add £5.00 carriage per unit U.K. overseas at cost
Delivery 10 to 21 days subject to availability — Cased sizes subject to variations
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ELECTROVANCE P.O. BOX 191, LONDON SW6 2LS

WW — 085 FOR FURTHER DETAILS

LANGREX SUPPLIES LTD

Climax House, Fallsbrook Rd., Streatham, London SW16 6ED

RST Tel: 01-677 2424 Telex: 946708 RST

SEMICONDUCTORS

AA119	0.12
AAY30	0.31
AAY32	0.48
AAZ13	0.21
AAZ15	0.39
AAZ17	0.31
AC107	0.69
AC125	0.23
AC126	0.23
AC127	0.23
AC128	0.23
AC141	0.29
AC141K	0.40
AC142	0.23
AC142K	0.35
AC176	0.23
AC187	0.23
AC188	0.23
ACY17	0.98
ACY18	0.92
ACY19	0.86
ACY20	0.80
ACY21	0.86
ACY39	1.72
AD149	0.80
AD161	0.52
AD162	0.52
AF106	0.52
AF114	0.86
AF115	0.86
AF116	0.86
AF117	0.86
AF139	0.46
AF186	1.38
AF239	0.52
AFZ11	3.16
AFZ12	3.16
ASY26	0.46
ASY27	0.46

ASZ15	1.44
ASZ16	1.44
ASZ17	1.44
ASZ20	1.72
ASZ21	2.30
AU113	1.96
AUY10	2.30
AU110	1.96
BA145	0.15
BA148	0.15
BA154	0.10
BA155	0.12
BA156	0.10
BAW62	0.06
BAX13	0.07
BAX16	0.10
BC107	0.14
BC108	0.14
BC109	0.15
BC113	0.14
BC114	0.15
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BC116	0.17
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BC126	0.23
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BC137	0.17
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BC148	0.09
BC149	0.10
BC157	0.10
BC158	0.09
BC159	0.12
BC167	0.14
BC170	0.13
BC171	0.12

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BC184	0.13
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BC214	0.17
BC237	0.10
BC238	0.14
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BC303	0.28
BC307	0.12
BC308	0.12
BC327	0.23
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BC337	0.21
BC338	0.20
BCY30	1.15
BCY31	1.15
BCY32	1.15
BCY33	1.04
BCY34	1.04
BCY39	3.45
BCY40	1.15
BCY42	0.29
BCY43	0.29
BCY58	0.18
BCY70	0.17
BCY71	0.20
BCY72	0.15
BCZ11	1.72
BD115	0.52
BD121	1.38
BD123	1.38
BD124	1.50

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BD136	0.39
BD137	0.40
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BD140	0.51
BD144	2.30
BD181	1.26
BD182	1.36
BD237	0.46
BD238	0.63
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BDX32	2.30
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BDY60	1.72
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BF152	0.21
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BF159	0.26
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BF167	0.23
BF173	0.23
BF177	0.28
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BF336	0.35
BF337	0.35
BF338	0.36
BFS21	4.55
BFS28	2.56
BFS61	0.23
BFS98	0.23
BFW10	0.74
BFW11	0.74
BFX84	0.25
BFX85	0.26
BFX87	0.24
BFX88	0.24
BFY50	0.30
BFY51	0.30
BFY52	0.30
BFY64	0.30
BFY90	1.44
BSX19	0.24
BSX20	0.23
BSX21	0.23
BT106	1.44
BTY79/400R	3.67
BU205	2.02
BU206	2.59
BU208	2.30
BY100	0.52
BY126	0.16
BY127	0.17
BZX61 Series	0.21
BZY88 Series	0.15
CRS1/40	0.69
CRS3/06	0.52
CRS3/40	0.86

CRS3/60	1.04
GEX66	1.73
GEX541	2.02
GJ3M	0.86
GM0378A	2.02
KS100A	0.52
MJE340	0.92
MJE370	1.35
MJE371	0.71
MJE520	0.60
MJE521	0.63
MJE2955	1.44
MJE3055	0.86
MPF102	0.35
MPF103	0.35
MPF104	0.35
MPF105	0.35
MPSA06	0.28
MPSA56	0.30
MPSU01	0.41
MPSU06	0.53
MPSU56	0.56
NE555	0.52
NKT401	2.30
NKT403	1.99
NKT404	1.99
OA5	1.09
OA7	0.63
OA10	0.74
OA47	0.16
OA70	0.35
OA79	0.35
OA81	0.35
OA85	0.35
OA90	0.09
OA91	0.09
OA95	0.09
OA200	0.10
OA202	0.10
OA211	1.15
OAZ200	1.15

OAZ201	1.15
OAZ206	1.15
OAZ207	1.15
OC16	2.30
OC20	2.88
OC22	2.88
OC23	3.16
OC24	3.45
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OC26	1.04
OC28	2.30
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OC36	1.73
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OC81	0.74
OC81Z	1.38
OC82	0.74
OC83	0.74
OC84	0.74
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OC123	2.02
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OC140	3.16
OC141	3.74
OC170	1.15
OC171	1.15
OC200	1.73
OC201	2.02
OC202	2.02

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OC206	2.88
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ORP12	1.15
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R2010B	2.02
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T1C226D	1.38
TIL209	0.23
T1P29A	0.47
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T1P33A	0.79
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ZS271	0.26
ZS278	0.65
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ZTX300	0.14
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1S920	0.08
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2G301	1.15
2G302	1.15
2G306	1.27
2N404	1.15
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2N698	0.35
2N705	1.38
2N706	0.17
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2N3773	3.45
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2N3823	0.63
2N3866	0.83
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2S019	7.48
2S026	13.80
2S103	1.73
2S302	0.86
2S303	0.86
2S322	0.92
2S324	1.44
2S701	1.73
2S745A	0.40
2S746A	0.40

VALVES

A1834	10.35
A2087	13.58
A2134	10.06
A2293	8.62
A2426	13.50
A2521	11.62
A2900	10.98
A3343	25.56
AZ31	1.26
AZ41	1.32
BK448	88.43
BK484	119.54
BS90	31.33
BS810	35.24
BT5	43.47
BT17	79.29
BT19	27.08
BT29	242.93
BT69	247.30
BT75	102.46
BT95	95.16
CBL31	2.30
CL33	2.30
CY31	1.15
C1K	11.50
C3A	11.50
C3JA	23.23
DA41	21.50
DA42	12.30
DA100	52.90
DAF91	0.46
DAF96	1.15
DET22	24.15
DET24	52.90
DF91	0.46
DF96	1.15
DK91	1.21
DK92	1.44
DK96	1.26
DL92	1.26
DL94	1.38
DL96	1.26
DLS10	9.48
DLS15	12.37
DLS16	12.37
DLS19	12.37
DM70	1.44
DM71	1.44
DM160	3.96
DY86/7	0.73
DY802	0.96
E55L	25.17
E80CC	9.27
E80CF	11.96
E80F	9.75
E80L	9.51
E81CC	6.62
E81L	10.28
E82CC	7.03
E83CC	7.16
E86C	12.48
E88C	6.71
E88CC	3.86
E90CC	9.34
E90F	9.71
E91H	5.34
E92CC	8.86
E99F	9.39

E130L	19.39
E180CC	8.86
E180F	7.83
E182CC	9.34
E186F	11.62
E188CC	7.36
E280F	25.88
E283CC	9.02
E288CC	17.25
EA52	19.43
EA76	2.02
EABC80	1.38
EAC91	0.92
EAF42	1.44
EAF801	2.02
EB41	2.30
EB91	1.01
EBC33	2.02
EBC41	1.44
E rC81	1.26
EBC90	0.97
EBF80	0.58
EBF83	1.44
EBF89	0.97
EBL31	2.88
EC90	1.28
EC91	7.87
EC92	1.44
EC157	276.92
ECC33	4.02
ECC35	4.02
ECC40	1.44
ECC81	1.01
ECC82	0.82
ECC83	1.01
ECC84	1.36
ECC85	1.38
ECC86	2.30
ECC88	2.07
ECC89	1.88
ECC91	8.72
ECC189	1.90
ECC807	2.02
ECC808	2.59
ECF80	1.24
ECF82	1.38
ECF86	1.73
ECH35	2.30
ECH42	1.32
ECH81	1.38
ECH83	1.44
ECH84	1.47
ECL80	1.15
ECL81	1.73
ECL82	1.15
ECL83	1.73
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ECL86	1.38
EF37A	4.02
EF39	3.16
EF40	1.32
EF41	1.38
EF42	2.30
EF50	1.73
EF54	5.75
EF55	2.88
EF80	0.92
EF83	2.02
EF85	0.92

EF86	1.74
EF89	1.84
EF91	2.07
EF92	6.03
EF93	1.15
EF94	1.24
EF95	5.25
EF98	1.44
EF183	0.92
EF184	0.96
EF804S	7.47
EF805S	8.05
EH90	1.61
EK90	1.24
EL32	1.73
EL33	4.02
EL34TH	2.53
EL34M	2.57
EL36	1.84
EL41	1.44
EL42	2.02
EL81	1.26
EL83	1.44
EL84	1.15
EL86	2.48
EL90	1.10
EL91	7.44
EL95	1.51
EL156	18.68
EL360	6.32
EL500/504	2.16
EL509	3.63
EL821	11.06
EL822	11.38
EM80	1.26
EM81	1.15
EM84	1.15
EM85	1.44
EM87	1.73
EN32	14.80
EN91	2.94
EN92	5.61
EY51	2.02
EY81	1.89
EY83	2.02
EY84	9.75
EY86	0.96
EY88	2.02
EY500A	2.23
EY802	94
EZ35	97
EZ40	1.44
EZ41	1.44
EZ80	0.96
EZ81	0.96
EZ90	1.38
FW4-500	2.88
FW4-800	2.88
G1.371K	23.23
G551K	12.65
G180.2M	18.42
G240.2D	12.85
G400.1K	19.28
GN4	8.62
GN4A	8.62
GS16	10.35
GT1C	10.61
GU50	14.31
GU51	13.62
GXU1	16.10

GXU2	28.43
GXU3	30.49
GXU4	32.77
GXU50	12.80
GY501	2.95
GZ32	1.44
GZ33	4.60
GZ34	2.18
GZ37	4.60
KT61	4.02
KT66	7.18
KT88	9.20
KTW61	2.02
KTW62	2.02
KTW63	2.02
M8079	11.59
M8080	7.68
M8081	9.95
M8082	6.41
M8083	7.59
M8091	10.85
M8096	4.31
M8097	4.09
M8098	4.37
M8099	5.98
M8100	8.23
M8136	8.46
M8137	8.72
M8140	5.17
M8141	5.52
M8142	6.15
M8144	4.31
M8149	5.86
M8161	7.87
M8162	7.59
M8163	5.17
M8190	5.29
M8195	4.25
M8196	7.47
M8204	6.57
M8212	11.76
M8223	3.16
M8224	3.85
M8225	2.99
M8248	11.55
MU14	1.73
MX119	53.82
MX123	63.25
MX145	50.40
MX151	15.18
MX152	115.00
MX161	129.72
MX163	19.55
MX164	21.14
MX166	126.50
MX168	40.25
N78	10.35
OA2	1.78
OA3	5.93
OA4	4.02
OB2	1.44
OB3	2.20
OC2	3.04
OC3	2.20
OD3	2.20
OZ4	1.84
PC86	1.61
PC88	1.61
PC95	1.49
PC97	1.38

PC900	1.38
PCC84	1.15
PCC85	1.38
PCC88	1.38
PCC89	1.56
PCC189	1.61
PCC805	1.51
PCC806	2.07
PCE82	2.07
PCF80	1.15
PCF82	1.15
PCF86	1.84
PCF87	1.84
PCF200	2.82
PCF201	2.45
PCF801	1.84
PCF802	1.82
PCF805	1.84
PCF806	1.84
PCF808	1.84
PCL82	1.15
PCL83	1.82
PCL84	1.15
PCL85	1.24
PCL86	1.24
PCL805/85	1.24
PD500	4.14
PE06-40N	31.40
PFL200	2.07
PL36	1.38
PL81	1.38
PL81A	1.38
PL82	1.38
PL83	2.55
PL84	1.24
PL504/5	1.61
PL508	2.07
PL509	3.45
PL519	3.73
PL801	1.27
PL802	3.40
PY33	1.27
PY81	0.97
PY82	0.92
PY83	0.81
PY88	1.01
PY5000A	2.07
PY800	0.97
PY801	0.97
QQV02-6	13.16
QQV03-6	5.44
QQV03-20A	20.13
QQV06-40A	40.25
QQV07-50	50.14
QQZ03-20A	31.63
QQZ06-40A	55.10
QU37	14.38
QV03-12	4.31
QV04-7	2.88
QV08-100	118.45
QY3-65	53.74
QY3-125	56.78
QY4-250	65.93
QY4-400	75.67
QY5-500	59.39

QY5-3000A	82.56
QZ06-20	27.72
R10	5.75
R17	1.89
R18	4.89
R19	1.38
R20	1.66
RG3-250	32.49
RG3-250A	34.09
RG3-1250	29.56
RG4-1250	13.13
RG4-3000	75.44
RR3-250	48.68
RR3-1250	86.20
S11E12	30.48
S130	2.30
S130P	2.88
STV280-40	11.50
STV280-80	24.15
SU41	2.88
SU42	10.35
TD03-10	24.73
TD03-10E	26.16
TD03-10F	27.60
TT15	34.50
TT21	14.16
TT22	14.16
TT100	59.51
TY2-125	65.33
TW4-400	71.61
TY4-500	95.40
TY5-500	147.20
TY6-800	165.70
TY6-5000A	263.05
TY6-5000B	236.90
TY6-5000W	236.44
TY7-6000A	286.93
TY7-6000W	232.47
TZ40	17.25
U18-20	2.88
U19	10.33
U25	1.33
U26	1.66
U37	10.35
UABC80	1.44
UAF42	1.44
UB41	1.44
UBC41	1.73
UBF89	1.38
UCC84	1.26
UCC85	1.38
UCF80	1.32
UCH42	1.38
UCH81	2.67
UCL82	1.20
UCL83	1.66
UF41	1.15
UF42	1.44
UF80	1.66
UF85	1.66
UF89	1.66
UL41	1.84
UL84	1.38

UM80	1.15
UY41	1.44
UY85	1.20
VLS631	15.24
XG1-2500	32.37
XG2-6400	92.98
XG5-500	19.32
XGQ2-6400	106.15
XR1-1600A	27.54
XR1-3200	76.94
XR1-3200A	76.94
XR1-6400	84.24
XR1-6400A	149.30
YD1120	226.60
YD1240	241.50
Z759	11.04
ZM1000	6.03
ZM1001	6.19
ZM1020	10.83
ZM1021	10.17
ZM1022	10.60
ZM1023	8.81
ZM1040	22.26
ZM1041	19.16
ZM1042	20.44
ZM1051	100.05
1B3GT	2.58
1B24	11.50
1B35A	28.75
1B63	57.50
1R5	1.21
1S5	0.46
1T4	0.46
2AS15	11.50
2C39A	21.85
2C43	20.70
2D21	2.94
2E26	7.82
2J42	89.70
2J55	201.25
2J70A	270.25
2J70B	287.50
2K25	40.25
3-400Z	51.75
3-500Z	51.75
3A5	1.55
3B24	9.20
3B28	5.18
3B29	11.50
3B240M	17.25
3B241M	17.25
3C23	13.89
3C45	22.77
3CX100A5	23.00
3E29	29.67
3S4	1.26
3V4	1.38
465A	29.15
4-125A	41.99
4-250A	41.99
4-400A	52.05
4B32	29.16
4C35	46.00
4CX250B	28.53
4CX350A	36.05

4X150A	24.41
4X150D	28.75
5B254M	23.12
5B255M	23.12
5C22	46.00
5J180E	851.00
5R7GY	2.30
5U4G	4.35
5U4GB	2.60
5V4G	1.75
5Y3GT	0.98
5Z3	1.73
5Z4G	1.75
5Z4G7	1.75
6-30L2	1.79
6AB4	1.44
6AB7	1.73
6AC7	1.61
6AF4A	1.84
6AG7	2.30
6AH6	5.52
6AK5	3.98
6AK6	2.81
6AL5	1.01
6AM4	2.65
6AM5	4.43
6AM6	2.07
6AN5	6.12
6AN8A	3.80
6AQ5	1.10
6AR5	1.84
6A56	6.42
6A57G	7.76
6AT6	0.98
6AU5GT	4.81
6AU6	1.24
6AV5GT	4.36
6AV6	0.98
6AX5GT	3.57
6B7	1.73
6B8	2.02
6BA6	1.15
6BA7	5.89
6BA8A	4.31
6BC4	4.27
6BE6	1.24
6BH6	1.75
6BJ6	1.24
6BK4	4.84
6BL6	97.75
6BL7GT	4.44
6BM6	97.75
6BN6	1.89
6BQ7A	4.14
6BR7	4.60
6BR8	2.02
6BS7	4.60
6BW6	4.60
6BW7	1.75
6BX7GT	5.70
6BZ6	2.62
6C4	1.01
6CB6A	2.76
6CD6GA	5.64
6CG7	2.55
6CH6	7.48
6CL6	4.12
6CW4	8.33
6D2	1.01

6DK6	2.59
6DQ6B	4.49
6EA8	3.31
6EB8	2.44
6EW6	1.73
6F6	2.02
6F23	1.84
6F28	1.33
6F33	22.08
6H1	14.38
6H2N	1.21
6H3N	1.21
6H6	1.73
6J4	6.10
6J6	6.21
6J7	9.04
6K4N	1.44
6K6GT	1.50
6K7	1.73
6K8	2.02
6KD6	1.08
6L6G	2.88
6L6GA	1.73
6L6GT	2.24
6L6GC	2.24
6L7	2.30
6N2P	1.21
6N3P	1.21
6N7	1.73
6P25	4.14
6Q7	2.53
6R7	2.07
6SA7	1.67
6SC7	1.73
6SF7	1.84
6SH7	1.73
6SJ7	1.84
6SK7	1.50
6SK7GT	3.08
6SN7GT	1.84
6SQ7	1.50
6SR7	1.73
6SS7	2.07
6U5G	2.30
6U8	0.92
6U8A	3.24
6V6GT	1.84
6X4	1.38
6X5GT	0.97
7B7	1.96
7C5	2.02
7C6	1.44
7H7	2.30
7R7	1.73
7S7	2.59
7Y4	1.84
7Z4	2.13
11E3	60.82
12AT6	1.38
12AT7	1.01
12AU6	2.83
12AU7	0.83
12AV6	2.30
12AV7	3.98
12AX7	1.01
12AY7	5.24
12B4A	3.50
12BA6	2.42
12BE6	2.55

12BH7	1.29
12BY7	3.01
12E1	8.17
12E11TT	19.26
12E14	34.50
13E1	62.20
19H4	28.75
19H5	40.25
24B9	43.87
30C15	1.84
30C17	1.84
30C18	1.84
30F5	1.93
30FL1/2	1.28
30FL12	2.07
30FL14	1.84
30L1	1.15
30L15	2.07
30L17	2.07
30P4	1.06
30P19	1.38
30PL1	1.52
30PL13	2.07
30PL14	1.93
30PL15	2.07
35W4	0.69
50C5	0.81
75B1	4.26
75C1	2.24
85A1	8.63
85A2	2.19
90AG	9.15
90AV	9.15
90C1	2.24
90CG	15.73
90CV	15.30
92AG	9.15
92AV	9.15
95A1	5.98
150B2	2.76
150B3	5.06
150C2	1.73
150C4	2.19
211	6.90
723AB	40.25
803	11.50
805	23.00
807	2.30
811A	9.78
812A	9.60
813	36.80
833A	86.25
866A	6.61
872A	15.81
922	5.01
931A	14.08
1624	2.59
1625	1.96
2050	8.00
4212E	169.90
4212H	207.00
5544	62.10
5545	67.85
5551A	88.44
5552A	119.54
5553A	259.10
5642	6.05
5654	4.05
5651	2.07

5670	5.29
5675	14.03
5687	7.08
5696	4.53
5718	7.36
5725	6.28
5726	4.05
5727	5.52
5749	5.73
5751	5.36
5763	4.14
5814A	4.81
5840	5.06
5842	15.59
5876A	13.06
5879	5.57
5886	12.08
5963	3.45
5965	4.07
6005	6.33
6021	5.13
6057	4.02
6058	10.40
6059	4.60
6061	4.89
6062	4.31
6063	4.20
6064	6.50
6067	4.02
6072	6.53
6080	7.88
6097A×B×C	46.00
6146A	5.89
6146B	6.42
6159	9.18
6189	9.25
6201	5.93
6442	17.25
6883B	6.81
6973	4.05
7025	2.62
7551	6.83
7586	13.09
7587	22.54
7609	36.57
7868	4.53
7895	14.84
8005	34.50
8068	6.33
6122	48.30
8136	2.81
8417	6.14
18042	6.92
18045	10.66

Tested Ex-Equipment

4CX250B	5.75

BASES

B7G unskirted	0.17
B7G skirted	0.35
B9A unskirted	0.17
B9A skirted	0.35
Int Octal	0.29
Loctal	0.63
Nuvistor base	0.86
8 pin DIL	0.17
14 pin DIL	0.17
16 pin DIL	0.20
Valve screening cans all sizes	0.35

CRTs

2AP1	9.78
2BP1	10.35
3BP1	9.20
3DP1	5.75
3EG1	8.05
3FP7	6.90
3GP1	6.90
3JP1	9.20
3JP2	9.20
3JP7	11.50
3KP1	17.25
3RP1	40.25
3WP1	23.00

5ADP1	40.25
5BP1	11.50
5CP1	11.50
5CP1A	46.00
5FP15A	17.25
5UP7	16.10
DG7-5	28.75
DG7-32	41.40
DH3-91	35.65
DH7-11	78.20
VCR97	13.80
VCR138	11.50

VCR138A	14.38
VCR139A	9.20
VCR517A	11.50
VCR517B	11.50
VCR517C	11.50
Tube Bases	0.86

INTEGRATED CIRCUITS

7400	0.18
7401	0.18
7402	0.18
7403	0.18
7404	0.20
7405	0.18
7406	0.46
7407	0.46
7408	0.23
7409	0.23
7410	0.18
7412	0.30
7413	0.37
7416	0.37
7417	0.37
7420	0.20
7422	0.23

7423	0.37
7425	0.35
7427	0.35
7428	0.49
7430	0.20
7432	0.35
7433	0.41
7437	0.37
7438	0.37
7440	0.21
7441	0.97
7442	0.83
7447AN	1.04
7450	0.21
7451	0.21
7453	0.21
7454	0.21

7460	0.21
7470	0.40
7472	0.38
7473	0.41
7474	0.46
7475	0.62
7476	0.46
7480	0.63
7482	0.86
7483	1.04
7484	1.15
7486	0.40
7490	0.60
7491	0.92
7492	0.69
7493	0.69
7494	0.92

7495	0.83
7496	0.92
7497	3.45
74100	1.73
74107	0.52
74109	0.81
74110	0.58
74111	0.81
74116	2.02
74118	1.15
74119	1.73
74120	0.95
74121	0.46
74122	0.69
74123	1.15
74125	0.63
74126	0.63
74128	0.69

74132	0.81
74136	0.63
74141	0.92
74142	2.65
74143	2.88
74144	2.88
74145	1.04
74147	2.30
74148	2.02
74150	1.84
74151	0.97
74154	2.02
74155	0.97
74156	0.97
74157	0.86
74159	2.42
74170	2.65
74172	5.06

74173	1.61
74174	1.73
74175	1.04
74176	1.26
74178	1.44
74179	1.44
74180	1.32
74190	1.73
74191	1.73
74192	1.55
74193	1.55
74194	1.44
74195	1.15
74196	1.38
74197	1.26
74198	2.59
74199	2.59
76013N	2.02

TAA570	2.65
TAA630S	4.02
TAA700	4.50
TBA480Q	2.12
TBA520Q	2.65
TBA530	2.28
TBA540Q	2.65
TBA550Q	3.70
TBA560CQ	3.70
TBA673	2.52
TBA700	1.75
TBA720Q	2.65
TBA750Q	2.38
TBA800	1.38
TBA920	3.34
TBA920Q	3.34
TBA990Q	3.34
TCA270Q	3.34
TCA760A	1.59

Terms of business: CWO. Postage and packing valves and semiconductors 30p per order. CRTs £1. All prices include VAT. Price ruling at time of despatch.
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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

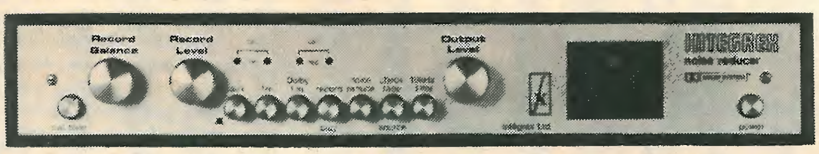
NEW S5050A STEREO AMP

50 watts rms-channel. 0.015% THD. S/N 90 dB, Mags/n 80 dB.

Tone cancel switch. 2 tape monitor switches.
Complete kit only **£63.90 + VAT.**

Wireless World Dolby(TM) 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(TM) PROCESSOR BOARDS (92 x 87mm) with gold plated contacts are available with all components .... **Price £9.00** + VAT

Single channel board with selected fet .... **Price £2.75** + VAT*

Gold Plated edge connector .... **Price £1.75**+VAT

Selected FETs **65p** each + VAT, **110p** + VAT for two, **£2.10** + VAT for four.

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?

Buy it with Access — BARCLAYCARD — EUROCARD — master charge

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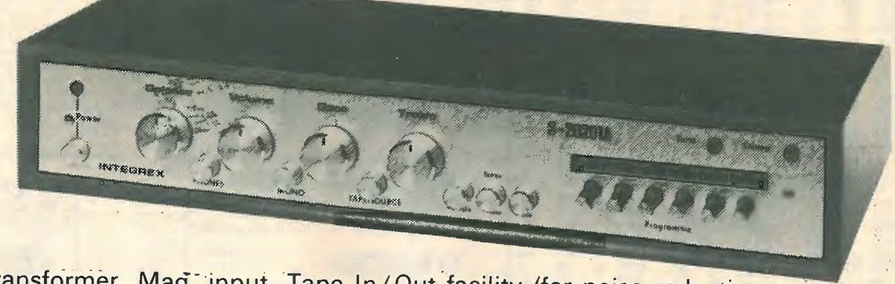
INTEGREX

S-2020TA STEREO TUNER/AMPLIFIER KIT

SOLID MAHOGANY CABINET



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

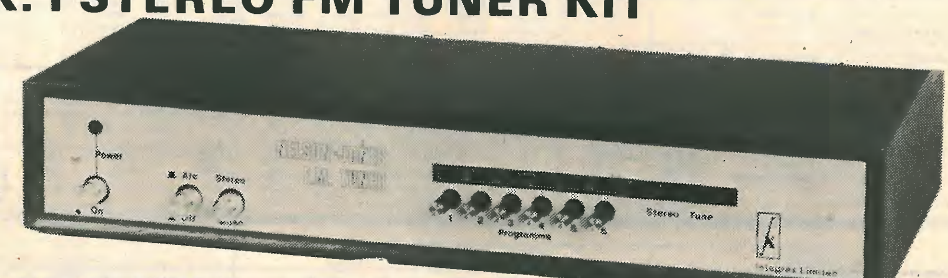
Brief Spec. Amplifier Low field Toroidal transformer, Mag. input, Tape In/Out facility (for noise reduction unit, etc.), THD less than 0.1% at 20W into 8 ohms. Power on/off FET transient protection. All sockets, fuses, etc., are PC mounted for ease of assembly. Tuner section uses 3302 FET module requiring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

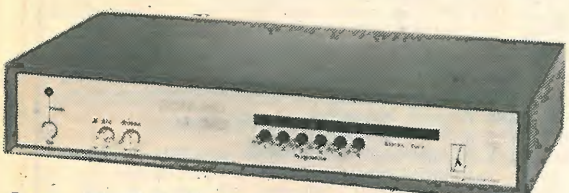


A very high performance tuner with dual gate MOSFET RF and Mixer front end, triple gang varicap tuning, and dual ceramic filter/dual IC IF amp.

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
With Portus-Haywood Decoder £44.20 + VAT



STEREO MODULE TUNER KIT

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

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

PRICE: Stereo £33.95 + VAT

S-2020A AMPLIFIER KIT

Developed in our laboratories from the highly successful "TEXAN" design. PC mounting potentiometers, switches, sockets and fuses are used for ease of assembly and to minimize wiring Power 'on/off' FET transient protection.

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

PRICE: £35.95 + VAT

BASIC NELSON-JONES TUNER KIT £15.70 + VAT
BASIC MODULE TUNER KIT (stereo) £18.50 + VAT
PHASE-LOCKED IC DECODER KIT . . . £4.47+VAT
PUSH-BUTTON UNIT . . . . £6.00 + VAT
PORTUS-HAYWOOD PHASE-LOCKED STEREO DECODER KIT . . . . £8.80 + VAT

WW — 033 FOR FURTHER DETAILS

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 previous lines.

2kW HIGH VOLTS TRANSFORMER
For metal erosion by the electro-spark principle and for high voltage applications generally. This is a big transformer, size approx. 7in. cube, weight around 60lb, beautifully made. Would probably cost at least £100 from its manufacturer if ordered currently. The voltage is 2400 off load, we are not certain of the current rating but we estimate this at 1 amp. Price **£32.40** carriage **£5** mainland only.

IC SOCKETS (do-it-yourself type)
These are silver-plated pin sockets sometimes called solder-cons. You push them through vero board, solder and then detach the top section. The result is a low profile IC socket of the right type just where you want it. 8 pin **17p,** 16 pin **27p,** 18 pin **38p** or quantity of 100 soldercons for **£1.30.**

WAFER SWITCH BARGAINS
2 pole 4-way silver plated 5 amp contacts with good length ¼in. spindle. Price **34p + 4p.** Plenty of others, state your wants.

INTER VALVE SPEAKER TRANSFORMER
For valve type circuits standard matching to ¾ ohms. Price **56p.**

WIRE ENDS
Ring type for fixings on terminals and screws, and push on to spade types. Both for crimping on the ends of wires. 10 for **20p + 2p,** or 1,000 for **£10 + 80p.** Boots for the spade type, **£2 + 16p** per 100.

PLASTIC SADDLES
White for ⅜in. circular flex etc. 10 for **22p.**

ARROW ROCKER SWITCH
Miniature type reference No.16045 — this is an all white 250v 10amp changeover switch with centre off position, offer at bargain price **22p.**

MINIATURE FAN
Motor and four bladee fan built into a tube approx. 2in. dia. and 3in. long, will work off 6/12v battery or from a car socket. Price **£3.06.**

MAKING A BLOWER HEATER?
Element assembly made of 3 x 1kw spirals with leads and Bank rocker switch which will give off, 1kw spirals with leads and Bank rocker switch which will give off, 1kw, 2kw or 3kw. Price **£1.62** per pair with diagram.

¼ HORSE POWER DOUBLE ENDED MOTOR
22/230v single phase best American make 1,500rpm thermal protection, base mounting plate, good length of ⅝in. shaft. Price **£15.66,** carriage **£4** (mainland only).

PROCESS TIMER
Chambalain and Hookham Ltd. Their type no. P. We have two models in stock, 0.30 seconds and 0.3 mins. Both are for mains operations and are impressive panel mounting instruments. Price **£15.12.**

MANUFACTURERS
Using wires with spade or tag ends might be able to save themselves time and money. Send us a sample of the lead you use, if we have one the same or near enough we will supply at **5p** per lead for wires fitted with one or two tags and **2½p** per tag for multiple leads.

MAINS SOLENOIDS
With slugs for pulling when a mains voltage is applied, made by Westool, these are replacements in many washing machines, food dispensers etc. Also useful as a magnetic lock. We have 4 models in stock. TT2 size 1½in. x 1½in. x 1¼in., has a powerful 1in. pull. Price **£2.16.**
TT4 size 1¾in. x 2½in. x 2in. Price **£2.95.**
TT6 size 2½in. x 2½in. x 2in. Price **£3.50.**
TT10 size 3in. x 2½in. x 2in. has 1½in pull. Price **£4.86.**

MODEL PP1
An even more powerful model by Magnetic Devices Ltd. Has the normal pull plunger but this is extended through to give a big push as well as a 10lb pull, approximate length of travel is 1½in. Price **£8.02.**

HIGH VOLTAGE ISOLATION AND STEPDOWN TRANSFORMER
This gives 230/40v from a 400v/440v supply and is suitable for 100w load. Other uses for this are as a normal stepdown 230v to 15v with isolation, or as a step up 400 from 230v with isolation. Price **£8.50.**

DOOR MOVING MOTOR
Framco reversible single phase 240v AC motor with gear box giving final speed 56rpm. Motor rated at 50lb to the inch, shaft length is approx. weight approx. 13lb. Price **£15,** carriage **£3** mainland only.

10 KVA 3 PHASE AUTO TRANSFORMER
Beautifully made and enclosed in a solid sheet steel case with a removable lid for easy access to terminals. Voltages available are 440, 400, 380 and 240. There is also a neutral tappiNg point, this transformer weighs approximately 50 kilos. 2 only in stock. Price **£54,** carriage **£7.50** mainland only.

MULTI CORE POWER CABLE
36 colour coded conductors each rated at 5 amps for longish runs, and 8-10 amps for short runs. Screened then covered overall with high grade PVC. The diameter of the finished cable is ¾in. approximately. Good quantity available, cut to your required length. Price **81p** per metre. Post and packing **25p** per metre.

ARE YOU USING AMERICAN TOOLS SAFELY?
American tools which are made for 115v working will not have the same quality of insulation as 230v tools, therefore to use these with an auto transformer especially in damp conditions could be asking for trouble. You should use an isolation step down transformer. We have some of these to offer at bargain price this month made for computers but little used. They come in metal cases with inputs and outputs for leads. Rated at 500w regular price **£35,** our price **£16.25** each, post etc **£2.**

MAGNETIC CLUTCH
Xerox 1215494 — j/n — 10 — 110 PN866-10. Have no information sheet on this but it appears that one section fits to the spindle of the machine and the other to a stationary part. It appears also that the clutch can be used as a partial brake by putting reduced voltage into it, as a normal brake with normal voltage, or as emergency stop by putting increased voltage into it. American ad very well made. Price **£4.32.**

MULTI SECONDARY TRANSFORMER
'C' Core type T522. Manufactured by E.R.G. Primary 10 — 0 — 10 — 115 — 210 — 240v, 50cps.

Sec. 1	240v at 75mA
Sec 2	10v at 20mA
Sec. 3	0—2—6—12v at 100mA
Sec. 4	Ditto
Sec. 5	Ditto
Sec. 6	9v at 1A
Sec. 7	6.3v at 2A with centre tap.

Price. **£10.42.**

MULTI SECONDARY TRANSFORMER
'C' Core type T567 made by E.R.G.
Primary 10—0—10—115—210—240v, 50cps.

Sec. 1	240v at 75mA
Sec. 2	10v at 20mA
Sec. 3	0—2—6—12v at 100mA
Sec. 4	0—2—6—12v at 100mA
Sec. 5	0—12v at 100mA
Sec. 6	9v at 1A
Sec. 7	6.3v CT at 2A
Sec. 8	30v at 30mA. Price. **£11.06**

OFF ON HOLIDAY?
Don't forget your quick cuppa, mini immersion heater. 250 watts makes a cup of tea in 2 or 3 minutes, off 230v mains and 7 or 8. Price **£2.95 + 37p.**
Camping model works off a 12v car battery. **£3.50 + 48p.**

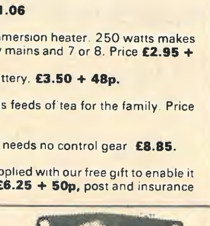
JUG HEATER
900 watts immersion heater, for baby's feeds of tea for the family. Price **£6.05.**

U.V. DISCO LAMP
175 watts, plugs into any light socket, needs no control gear **£8.85.**

MINI MULTI TESTER
New model with 2 ohms ranges and supplied with our free gift to enable it to measure up to 10 amps D.C. Price **£6.25 + 50p,** post and insurance **50p.**

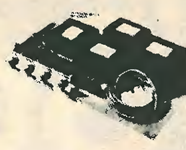
EXTRACTOR FAN

Ex-computers — made by Woods of Colchester. Ideal for fixing through panel — reasonably quiet running — very powerful 2,500 r.p.m. Choice of two sizes 5in or 6¼in. **£5, £6.**



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.



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.

DELAY SWITCH

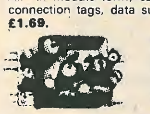
Mains operated — delay can be accurately set with pointers knob for periods of up to 2½ hrs, 2 contacts suitable to switch 10 amps — second contact opens few minutes after 1st contact **£1.50.**

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.**

MULLARD AUDIO AMPLIFIERS

All in module form, each ready built complete with heat sinks and connection tags, data supplied Model 1153 500mW, power, output **£1.69.**



Model 1175 — 10 watts power output **£3.94**
Model 1172 1W, power output **£2.25**
Model EP9000 4 watt power output **£2.90.**
EP 9001 twin channel or stereo pre-amp **£2.90.**

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**

MAINS BLOWER

The Torrin — quiet but powerful outlet size 2½ x 1¾ for cooling equipment, etc. will extract if outlet is blowing outwards price **£5.50.**
Other models from £2.00.

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 stack **£3.25.**

BURGLAR ALARM ITEMS

(Circuit free on application)

Trigger mats 24in × 18in	**£2.45**
13in × 10in	**£1.95**
Relay 24 volt	**95p**
9-12 volt	**95p**
Alarm Bell 24 volt	**£7.50**
9-12 volt	**£2.25**
Mains	on application
Reset, Switch, ordinary	**45p**
Secret type with key	**95p**
Wire — 100 metres	**£1.50**
24V Power unit mains operated	**£5.35**

MINI-MULTI TESTER

Amazing, deluxe pocket size precision moving coil instrument jewelled bearings — 1000 opv — mirrored scale.
11 Instant ranges measure —
DC volts 10, 50, 250, 1000
AC volts 10, 50, 250, 1000
DC amps 0-1 mA and 0-100 mA
Continuity and resistance 0-150K ohms.
Complete with insulated probes, leads, battery, circuit diagram and instructions.

Unbelievable value only **£6.50 + 50p** post and insurance.
FREE Amps ranges kit enable you to read DC current from 0-10 amps, directly on the 0-10 scale. It's free if you purchase quickly but if you already own a mini-tester and would like one send **£1.50.**

TERMS: Cash with order — but orders under **£6** must add **50p** to offset packing, etc.

BULK ENQUIRIES INVITED. PHONE 01-688 1833.
ACCESS & BARCLAYCARD ACCEPTED

J. BULL (ELECTRICAL) LTD

**(Dept. WW), 103 TAMWORTH RD.
CROYDON CR9 1SG**

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 previous lines.

EX GPO TELEPHONES
Normal black desk instrument with dial and internal bell, latest type £8.85 each, preceding type £4.05 each.

TELEPHONE SWITCHES
Desk mounting. These are the older, winking eye type almost becoming museum pieces. Prices depend on condition starting at £15 + £1.20 plus carriage at cost.

BLOWER BARGAIN
Smith's Industries — mains operated blower/fan — a real air mover that takes up very little space as it's balanced four-pole motor is let into the air turbulator — overall size approx 7in diameter by 2¼in thick. Suitable for drying — blowing extraction, air circulating etc etc only £4.

THREE MORE TRANSFORMERS are added to our list this month. TM54: This is an upright mounting — varnish impregnated, it has a main secondary of 200v 500mA and another of 6.3v 1 amp price £4.50 + 34p £1.
TM55: Again upright mounting and impregnated, this one has two secondary windings both 12v 5 amp so it can be used as 12v 10 amp — 24v 5 amp or 12 — 0 — 12 @ 5 amp, price £4.95 + 40p post £1.25.
TM56: One secondary of 4v 2½ amp = this is quite a small transformer and could also be used as a 60-1 matching transformer for microphone etc. price £1.50 + 12p.

TANGENTIAL BLOWER
Metal bladed Smith's made super silent unit with dozens of applications, cooker hoods — fume extractor — blower heater — fresh air impeller etc. Air outlet is rectangular size approx 10½in x 2¼in £3.95.

WANT LOW VOLTAGE MAINS AND ISOLATION
A 10 watt £2.10, 36 watt at £4. Larger sizes on request.

MODEL MOTORS
We have at least 150,000 small battery operated motors in stock, mostly Japanese made and good quality, all will work on 3 volts upwards, some will work from single 1½ volts cell, some are very small and the smallest requires no on/off switch as it won't start until it is spun and when it stops it will get into a current position if possible. The largest is powerful enough to operate a hand drill. We have a leaflet which briefly describes these but if you're contemplating making a toy or a novelty needing a motor then send £2.50 for our assortment of 8 motors — find the right one for your project — we will supply this at a special quantity discount.

NOW SOME BIGGER 12 VOLT MOTORS
12v MOTOR BY CROUZET — a powerful motor virtually impossible to stop by hand, size approx 2¼in long and 2½in dia, this is a permanent magnet field type so is reversible simply by changing polarity and has a relatively constant speed with or without load. Fitted with a splined shaft which could directly engage a toothed gear wheel or to which a pulley could be attached. Ideal for large models, or small machines etc. Price £4.25.

12 VOLT MOTOR BY SMITHS INDUSTRIAL
Made for use in cars these are series wound and become more powerful as load increases — they will in fact burn themselves out if overloaded to stopping point — reversible by rewiring. Being series wound they will also work off a.c. mains through a step down transformer and if you use a variable voltage type then the motor speed can be varied by the voltage.
Size approx 3½in long by 3in dia, these have a good length of ¼in dia spindle — price £3 + 24p. Ditto but double ended £3.95.

MAINS OPERATED LOW SPEED MOTORS
Type as fitted into time switches etc — we have a good selection and can offer the following final speeds: 1 r 24 hrs — 1 r 8 hrs — 1 r 4 h — 1 rh — 2 rh — erh — 4 rh — 12 rh — 20 rh — 30 rh — 1 r min — 2 rm — 4 rm — 8 rm — 15 rm — 25 rm — 30 rm 200 rm, all at £2.85 each.

SPIT MOTORS
These are powerful mains operated induction motors with gear box attached. Shaft is a ½in rod with square hole, final speed is approx 5 revs per min, price £5.25 — similar motor but with final speed 110 rpm £5.15 80 rpm same price.

SUB MINI MICROPHONE
Size only ½in x ⅜in x 3/16in so small enough for a buggind device ex-hearing aids but guaranteed. Price £1.50.

SUB MINI MICRO SWITCH
American make size approx ¾in x ⅜in x 3/16in changeover contacts — three types in stock, button operated 35p lever 40p + 3p.

MEDIUM AND LARGE MICRO SWITCHES
We have over 100,000 of them in stock at prices from 10p each — may we have your enquiries please with a sample if possible.

DP DT TOGGLE SWITCH
Normal size, normal fixing bright plated toggle and fixing nuts — by NSF. 3 amp 250v price 49p each. £35 + £2.40 per hundred.

SP DT TOGGLE SWITCH
13 amp at 250v — bakelite body flat toggle — bright plated fixing nut 33p £22 per hundred.

WAVE CHANGE SWITCHES
We have mini types @ 40p + 5p available in the following combinations: 4-pole 3-way, 3-pole 4-way, 2-pole 6-way and 1-pole 12-way.

STANDARD TYPES
1½in wafer made to your specification at £1 + 12p per wafer plus 50p + 6p for clicker mechanism and spindle. Wafers stock are 1-pole 12-way, 1-pole 10-way, 2-pole 9-way, 2-pole 8-way, 2-pole 6-way, 3-pole 5-way, 4-pole 4-way, 6-pole 3-way, and 8-pole 2-way. We can stack up to 10 wafers so could make say 10-pole 12-way or 80-pole.

INSTRUMENT SWITCHES
These use a smaller moulded wafer size approx ¾in dia — available in some combinations as standard switches price £1.50 + 19p for each wafer and 75p + 5p for clicker and spindle.

WALL MOUNTING THERMOSTAT
By Danfoss in a really pretty two-tone grey case with scale and dial. Setting temperature from 0-30c — 13 amp 250v contacts. Price £4.32.

UP TO 5 MINUTE TIMER
Mains motorised, the dial of this is calibrated in 1/10th of a minute up to 5 minutes — slipping clutch motor takes preset time to travel to its stop, then it slips until switched off. Fitted micro switch operates at the stop. Micro switch could be used to make the timer repeat, switch off etc. American made — ex equipment — believed unused. Price £3.25.

MAINS STEPPER
IS A 24-way stud switch controlled by two solenoids. One ratchets the switch arm around one stud per impulse — the second solenoid returns the switch arm on a metal chassis size approx 4½in x 3in. £4.86.

MINIATURE MAGNETIC CIRCUIT BREAKERS
Will trip faster than a fuse can blow, use to control your service bench etc, will save you the trouble of renewing fuses, or replace your fuse box with a line of these. Available as follows: 1 amp — 2 amp — 5 amp — 10 amp — 15 amp — 25 amp. All same price £2.25 each.

CASSETTE MECHANISMS
With record and playback heads. All electronics, switches and speakers. Price £9.95 (Surely this must be the bargain of the year). Stereo with heads but not electronics £14.95.

BUS BARS FOR PUSH ON TAGS Type 1
As used in cookers etc is a panel approx 3in x 2in with two hefty cable trap terminals, marked N & L and bus bars will take 12 push on tags each — useful on work bench or would help in construction of most electrical heaters etc. Price 44p. Type 2.

JUNCTION BOXES. Ideal for ring main or lighting installations. Brown bakelite base and cover. 25p each or box of 12 for £2.

CONNECTOR STRIPS. Normal 12 screw down in polythene base. 3-5 amp 10 for £2. 15 amp 10 for £3. 25 amp. 10 for £4.

NUMBERED CONNECTION STRIP. For 25 amp cables this is very compact only 3½in long. ⅞in wide. The body is not polythene but a harder material probably nylon. The contacts are numbered 1-12, useful for intercom, and similar installations. Price 10 for £4.50.

PLUG-IN-ABLE CONNECTOR STRIP. Female usual screw downs on one side, but sprung holes on other. Male has screw down one side and plugs on the other. The plugs are tightly gripped by the sprung holes. Female portion is available in strips of 3 connectors 16p or 12 connectors 50p. Male portion only in strips of 3 connectors price 25p.

600 OHM WIRE WOUND RESISTOR 15 watt type, 10 for £1.

SPRING FIXING FOR 15 WATT RESISTORS. Specially shaped sprung clip pushes into resistor. 20 for £1.

FUSE HOLDERS. For 20mm fuse. Chassis mounting, polythene base with hole for fixing, strips of 10. Price 54p.

THYRISTOR TRIGGER MODULE by Mullard their ref MY5001, brand new in maker's sealed packing. Price £6.50.

NOVEL 50hz FREQUENCY CHECKER for checking frequency of inverters etc. this is a frequency controlled motor with reduction gearbox — simply fit a cardboard disc to spindle, connect direct to the unknown supply — if 200-250v if not use a transformer — if the disc revolves at 16 rpm then supply is correct frequency if less than 16 rpm it is slow, if more then it is fast. Price £1.50 + 12p.

SERVICEMAN'S LEAD ASSORTMENT more and more appliances. We have tags and to quickly hook those up you need female ended leads: we offer an assortment of 20 leads ending with push on connectors, all for £1.08, will save their cost in no time.

KETTLE LEAD AND PLUG fits all normal kettles: a robust plug with a good length of heavy duty three-core lead. Price 85p, 10 for £8.

HEAVY DUTY RELAY with twin 20 amp changeover contacts, coil voltage is 24 volts D.C. or 50 volts A.C. Four of these with coils in series could be used to switch mains lighting etc. Price 88p.

MAINS OPERATED CONTACTOR. Beautifully made in West Germany, this has 3 poles switching on, and a fourth pole with changeover, all contacts look big enough for 10-15 amps and the closing coil is mains operated. Normal bakelite upright mounting, size approx 3in x 2½in x 3¾in high. Price £4.50.

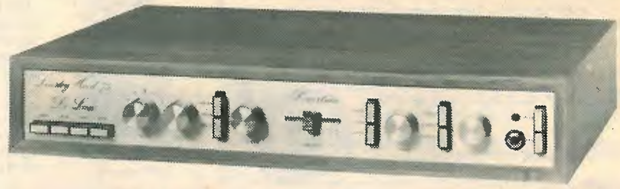
6 VOLT RELAY. Standard open single screw fixing with 3 pairs 10 amp C/O contacts. Price £1.08.

MAINS SOLENOID WATER VALVES. Made by Asco. Two models available both suitable for water and non-corrosive liquids, both for normal mains operation. Ref V1 for ½in pipes and low pressure operation, V2 is for ½in pipe and high pressure operation, only £4.32 either type.

ELECTRONIC KITS OF DISTINCTION FROM POWERTRAN

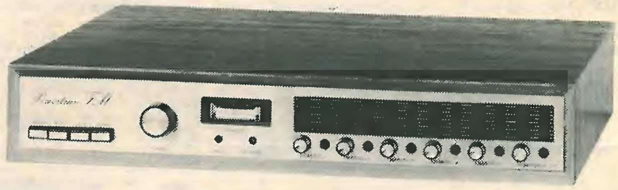
DE LUXE EASY TO BUILD LINSLEY-HOOD 75W STEREO AMPLIFIER £99.30 + VAT

This easy to build version of our world-wide acclaimed 75W amplifier kit based upon circuit boards interconnected with gold plated contacts resulting in minimal wiring and construction delightfully straightforward. The design was published in Hi-Fi News and Record Review and features include rumble filter, variable scratch filter, versatile tone controls and tape monitoring whilst distortion is less than 0.01%.



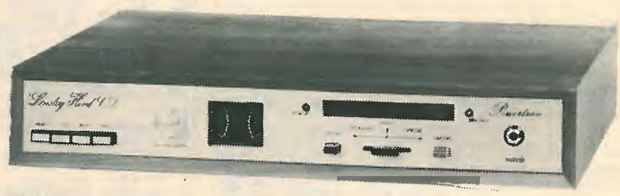
WIRELESS WORLD FM TUNER £70.20 + VAT

A pre-aligned front-end module makes this Wireless World published design very simple to construct and adjust without special instruments. Features include an excellent a.m. rejection push-button station selection as well as infinitely variable tuning and a phase locked loop stereo decoder, incorporating active filters for "birdy" suppression.



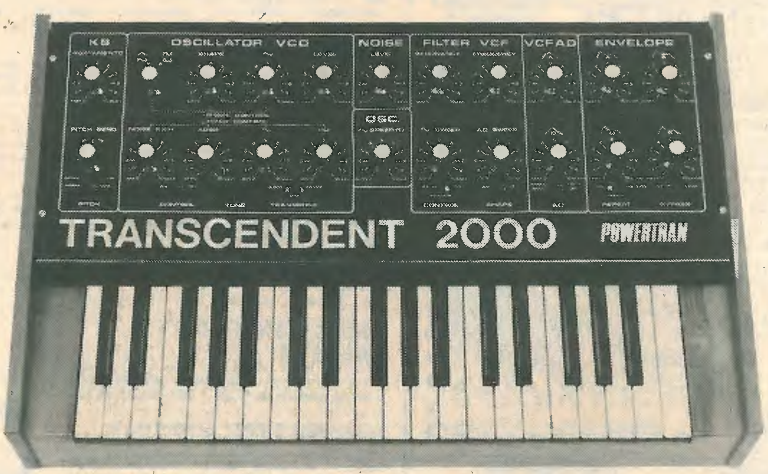
LINSLEY-HOOD CASSETTE DECK £79.60 + VAT

This design, published in Wireless World, although straightforward and relatively low cost provides a very high standard of performance. There are separate record and replay amplifiers and switchable equalisation together with a choice of bias levels are also provided. The mechanism is the Goldring-Lenco CRV with electronic speed control.



TRANSCENDENT 2000 SINGLE BOARD SYNTHESIZER

As featured in Electronics Today International



Cabinet size 24.6"x15.7"x4.8" (rear) 3.4" (front)

The kit includes fully finished metalwork, fully assembled solid teak cabinet, filter sweep pedal, professional quality components (all resistors either 2% metal oxide or ½% metal film!) and it really is complete — right down to the last nut and bolt and last piece of wire! There is even a 13A plug in the kit — you need buy absolutely no more parts before plugging in and making great music! Virtually all the components are on the one professional quality fibre glass PCB printed with component locations. All the controls mount directly on the main board, all connections to the board are made with connector plugs and construction is so simple it can be built easily in a few evenings by almost anyone capable of neat soldering! When finished you will possess a synthesizer comparable in performance and quality with ready built units selling for between £500 and £700!

COMPLETE KIT ONLY £172.00 + VAT!

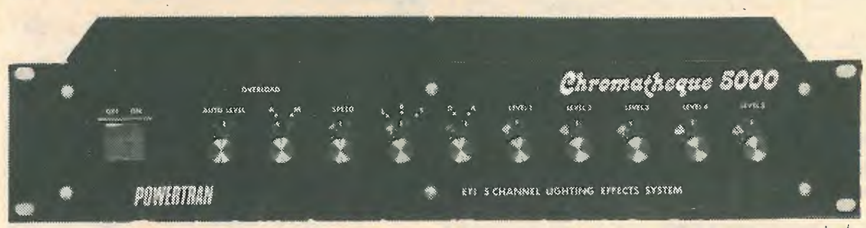
Comprehensive handbook supplied with all complete kits! This fully describes construction and tells you how to set up your synthesizer with nothing more than a multi-meter and a pair of ears!

CHROMATHEQUE 5000 5-CHANNEL LIGHTING EFFECTS SYSTEM

This versatile system featured as a constructional article in ELECTRONICS TODAY INTERNATIONAL has 5 frequency channels with individual level controls on each channel. Control of the lights is comprehensive to say the least. You can run the unit as a straightforward sound-to-light or have it strobe all the lights at a speed dependent upon music level or front panel control setting or use the internal digital circuitry which produces some superb random and sequencing effects. Each channel handles up to 500W and as the kit is a single board design wiring is minimal and construction very straightforward.

Kit includes fully finished metalwork, fibreglass PCB, controls, wire, etc. — Complete right down to the last nut and bolt!

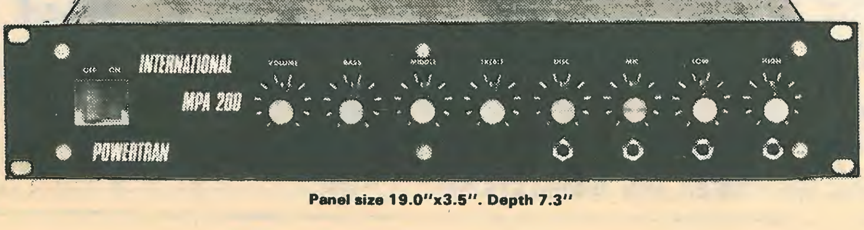
COMPLETE KIT ONLY £49.50 + VAT



Panel size 19.0"x3.5". Depth 7.3"

MPA200 100W MIXER/AMPLIFIER

Featured as a constructional article in Electronics Today International the MPA 200 is an exceptionally low-priced but professionally finished general purpose, rugged, high-power amplifier which has an adaptable range of inputs such as disc, microphone, guitar, etc. There are 3 wide range tone controls and a master volume control. Mechanically the design is simplicity in the extreme with minimal wiring making construction very straightforward. Kit includes fully finished metalwork, fibreglass PCB's, controls, wire, etc. — Complete right down to the last nut and bolt!



Panel size 19.0"x3.5". Depth 7.3"

COMPLETE KIT ONLY £49.90 + VAT

All kits also available as separate packs (e.g. P.C.B. component sets, hardware sets, etc.). Prices in FREE CATALOGUE.

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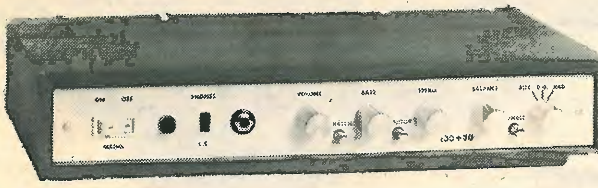
T20+20 AND T30+30 20W, 30W AMPLIFIERS



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

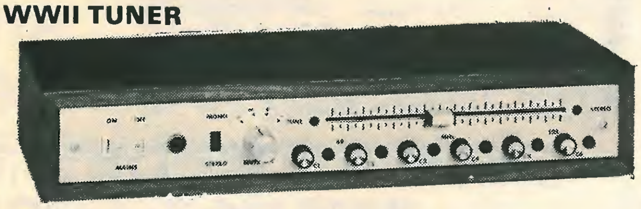
SPECIAL PRICES FOR COMPLETE KITS

T20+20 KIT PRICE £33.10 + VAT

T30+30 KIT PRICE £38.40 + VAT

AVAILABLE AS SEPARATE PACKS — PRICES IN OUR FREE CATALOGUE

WWII TUNER



SPECIAL PRICE FOR COMPLETE KIT £47.70 + VAT

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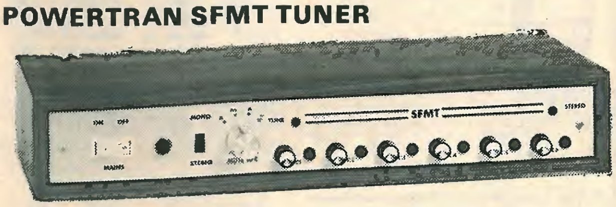
Following the success of our **Wireless World FM Tuner Kit** this cost reduced model was designed to complement the **T20+20** and **T30+30** amplifiers and the cabinet size, front panel format and electrical characteristics make this tuner compatible with either.

POWERTRAN SFMT TUNER



PRICE FOR COMPLETE KIT £35.90 + VAT

AVAILABLE AS COMPLETE KIT ONLY

This is a simple, low cost design which can be constructed easily without special alignment equipment but which still gives a first-class output suitable for feeding any of our very popular amplifiers or any other high quality audio equipment. A phase-locked-loop is used for stereo decoding and controls include switchable afc, switchable muting and push-button channel selection (adjustable by controls on the front panel). This unit matches well with the **T20+20** and **T30+30** amplifiers.

NEW!

Another superb design by synthesizer expert Tim Orr!

TRANSCENDENT DPX

As featured in Electronics Today International August, September October, 1977 issues

DIGITALLY CONTROLLED, TOUCH SENSITIVE, POLYPHONIC, MULTI-VOICE SYNTHESIZER

The Transcendent PDX is a really versatile new 5 octave keyboard instrument. There are two audio outputs which can be used simultaneously. On the first there is a beautiful harpsichord or reed sound — fully polyphonic i.e. you can play chords with as many notes as you like. On the second output there is a wide range of different voices, still fully polyphonic. It can be a straightforward piano or a honky tonk piano or even a mixture of the two! Alternatively you can play strings over the whole range of the keyboard or brass over the whole range of the keyboard or should you prefer — strings on the top of the keyboard and brass at the lower end (the keyboard is electronically split after the first two octaves) or vice versa or even a combination of strings and brass sounds simultaneously. And on all voices you can switch in circuitry to make the keyboard touch sensitive? The harder you press down a key the louder it sounds — just like an acoustic piano. The digitally controlled multiplexed system makes practical sensitivity with the complex dynamics law necessary for a high degree of realism. There is a master volume and tone control, a separate control for the brass sounds and also a vibrato circuit with variable depth control together with a variable delay control so that the vibrato comes in only after waiting a short time after the note is struck for even more realistic string sounds.

Cabinet size 36.3"x15.0"x5.0" (rear) 3.3" (front)
Also available as separate packs — prices in free catalgoue

COMPLETE KIT ONLY £365.00 + VAT!

To add interest to the sounds and make them more natural there is a chorus/ensemble unit which is a complex phasing system using CCD (charge coupled device) analogue delay lines. The overall effect of this is similar to that of several acoustic instruments playing the same piece of music. The ensemble circuitry can be switched in with either strong or mild effects.
As the system is based on digital circuitry data can be easily taken to and from a computer (for storing and playing back accompaniment with or without pitch or key change, computer composing etc., etc.) and an interface socket (25 way D type) is provided for this purpose.
Although the DPX is an advanced design using a very large amount of circuitry, much of it very sophisticated, the kit is mechanically extremely simple with excellent access to all the circuit boards which interconnect with multiway connectors, just four of which are removed to separate the keyboard circuitry and the panel circuitry from the main circuitry in the cabinet.
The kit includes fully finished metalwork, solid teak cabinet, professional quality components (all resistors 2% metal oxide), nuts, bolts, etc., even a 13A plug — you need buy absolutely no more parts before plugging in and making great music! When finished you will possess an instrument comparable in performance and quality with ready-built units selling for over £1200!

EXPORT A SPECIALITY!

Our Export Department can readily despatch orders of any size to any country in the world. Some of the countries to which we sent kits last year are shown in this advertisement. To assist in estimating postal costs our catalogue gives the weights of all packs and kits. This will be sent free on request, by airmail, together with our "Export Postal Guide" which gives current postage prices. There is no minimum order charge. Prices same as for U.K. customers but no Value Added Tax charged. Postage charged at actual cost plus 50p documentaton and handling. Please send payment with order by Bank Draft, Postal Order, International Money Order or cheque drawn on an account in the U.K. Alternatively for orders over £500 we will accept Irrevocable Letter of Credit payable at sight in London.

Value Added Tax not included in prices
UK Carriage FREE

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SECURICOR DELIVERY: For this optional service (U.K. mainland only) add £2.50 (VAT inclusive) per kit.
SALES COUNTER: If you prefer to collect your kit from the factory, call at Sales Counter. Open 9 a.m.-4.30 p.m. Monday-Thursday.

QUALITY: All components are brand new first grade full specification guaranteed devices. All resistors (except where stated as metal oxide) are low noise carbon film types. All printed circuit boards are fibreglass, drilled roller tinned.

FOR FURTHER INFORMATION PLEASE WRITE OR TELEPHONE FOR OUR FREE CATALOGUE

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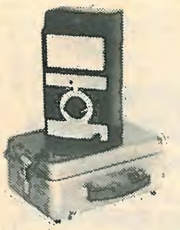
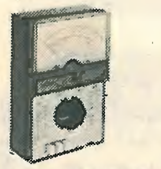
SPECIAL OFFER OF BRAND NEW USSR MADE MULTIMETERS



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**

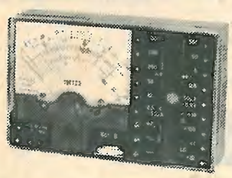
TYPE U4324



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

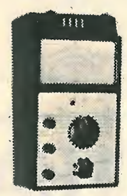
TYPE U4323
COMBINED WITH SPOT FREQUENCY OSCILLATOR



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**
Packing and Postage £1.50

THIS OFFER IS VALID ONLY FOR ORDERS ACCOMPANIED BY REMITTANCE WHICH SHOULD INCLUDE DELIVERY CHARGES AS INDICATED AND 15% V.A.T. ON THE TOTAL

OUR 1978 CATALOGUE/PRICE LIST OF VALVES, SEMICONDUCTORS, PASSIVE COMPONENTS AND TEST EQUIPMENT IS AVAILABLE. PLEASE SEND P.O. for £0.30 FOR YOUR COPY

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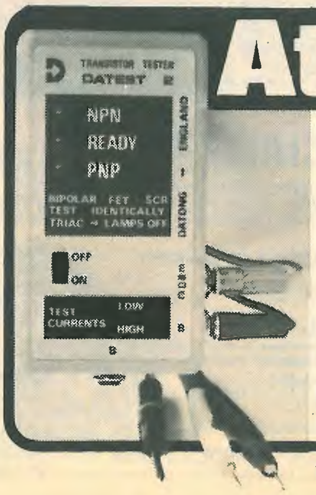

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A REALLY RELIABLE IN CIRCUIT TRANSISTOR TESTER THAT WORKS!

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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7409	19p
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7412	20p
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7414	50p
74C14	90p
7416	27p
7417	27p
7420	17p
7421	40p
7422	22p
7423	34p
7425	30p
7426	40p
7427	34p
7428	36p
7430	17p
7432	30p
7433	40p
7437	35p
7438	35p
7440	17p
7441	70p
7442A	60p
7443	112p
7444	112p
7445	100p
7446A	93p
7447A	60p
7448	80p
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7473	34p
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7474	30p
7475	30p
7476	35p
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7482	84p
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7484	100p
7485	110p
7486	34p
7489	175p
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74145	90p
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74LS279	90p
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74LS324	200p
74LS348	200p
74LS365	100p
74LS367	100p
74LS368	100p
74LS373	180p
74LS374	195p
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74LS390	160p
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4014	84p
4015	84p
4016	45p
4017	80p
4018	89p
4019	45p
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4023	22p
4024	50p
4025	20p
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4033	180p
4034	200p
4035	110p
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4047	100p
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4052	80p
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4538	120p
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4553	450p
4560	250p
4569	250p
4572	40p
4583	90p
4584	90p
4724	250p
40014	90p
40085	200p
40097	90p
14411	1100p
14412	1100p
14433	1100p
14500	700p
14599	290p
CD22100	350p
CD22101	700p
CD22102	700p

INTERFACE ICs

MC1488	100p
MC1489	100p
75107	160p
75150	175p
75154	175p
75182	230p
75322	300p
75324	375p
75325	375p
75361	300p
75363	400p
T5365	250p
75451	72p
75491/2	96p
8T26	250p
8T28	300p
8T95	200p
8T97	200p
81LS95	140p
81LS96	140p
81LS97	140p
81LS98	140p
9601	110p
9602	220p
9603	160p

93 SERIES

9301	160p
9302	175p
9308	316p
9310	275p
9311	275p
9312	160p
9314	165p
9316	225p
9321	225p
9322	150p
9334	225p
9368	200p
9370	200p
9374	200p

VEROBOARDS

	0.1	0.15 (copper clad)
2.5×3.75"	48p	43p
2.5×5"	57p	51p
3.75×3.75"	57p	—
3.75×5"	64p	64p
3.75×17"	222p	194p
4.75×17.9"	290p	—
Pkt of 100 pins		50p
Spot face cutter		86p
Pin insertion tool		118p
Vero Wiring Pen+ 2 wire spools + combs		370p
Coxs		7p

LINEAR I.Cs

AY1-0212	600p
AY1-1313	668p
AY1-1320	320p
AY1-5050	211p
AY5-1224A	240p
AY5-1315	600p
AY5-1317A	775p
CA3019	80p
CA3046	70p
CA3048	225p
CA3080E	72p
CA3086	48p
CA3089E	225p
CA3090AQ	375p
CA3130E	100p
CA3140E	70p
CA3160E	100p
CA3161E	140p
CA3162E	450p
CA3189E	400p
FX209	750p
ICL7106	850p
ICL8038	340p
LF356P	95p
LF358P	75p
LM10C	450p
LM301A	30p
LM311	120p
LM318	200p
LM319	225p
LM324	70p
LM339	75p
LM348	95p
LM377	175p
LM380	75p
LM381AN	160p
LM389N	140p
LM709	36p
LM710	50p
LM725	350p
LM733	100p
LM741	20p
LM747	70p
LM748	35p
LM2917	250p
LM3900	70p
LM3911	130p
LM3914	250p
LM4136	120p
MC1310P	150p
MC1458	55p
MC1495L	350p
MC1496	100p
MC3340P	120p
MC3360P	120p
MK50398	750p
MM57160	620p
NE531	110p
NE543K	225p
NE555	25p
NE556	70p
NE561B	425p
NE562B	425p
NE565	130p
NE566	155p
NE567	175p
NE571	425p
NE585-6N	300p
RC4151	400p
SAD1024	1250p
SFF96364	1150p
SN76003N	175p
SN76013N	140p
SN76013ND	120p
SN76023N	140p
SN76023ND	120p
SN76477	250p
SP8515	750p
TAA621	275p
TBA641B11	225p
TBA651	200p
TBA800	100p
TBA810	100p
TBA820	90p
TCA940	175p
TDA1004	300p
TDA1008	320p
TDA1010	225p
TDA1022	600p
TDA1024	120p
TDA1034B	250p
TDA1170	250p
TDA2002V	325p
TDA2020	320p
TL072	95p
TL074	150p
TL084	130p
TL170	50p
UDN6118	320p
UDN6184	320p
ULN2003	100p
XR2206	400p
XR2207	400p
XR2211	600p
XR2216	675p
XR2240	400p
ZN414	90p
ZN424E	135p
ZN425E	400p
ZN1034E	200p
95H90	800p
11C90	1400p

VOLTAGE REGULATORS

Fixed Plastic TO-220

1A	+ve		−ve	
5V	7805	70p	7905	90p
12V	7812	70p	7912	90p
15V	7815	70p	7915	90p
18V	7818	70p	7918	100p
24V	7824	70p	7924	100p

100mA	TO-92			
5V	78L05	30p	79L05	80p
12V	78L12	30p	79L12	80p
15V	78L15	30p	79L15	80p

OTHER REGULATORS

LM309K	135p	TBA625B	120p
LM317T	200p	78HGKC	725p
LM323K	550p	78H05KC	625p
LM723	37p	78MGT2C	135p
		78P05	900p

OPTO-ELECTRONICS

2N5777	45p	ORP60	90p
OCP71	130p	ORP61	90p
ORP12	90p	TIL78	70p

OPTO-ISOLATORS

ILD74	130p	TIL111	90p
MCT26	100p	TIL112	90p
MCS2400	190p	TIL116	90p

LEDS

0.125"		0.2"	
TIL32	75p	TIL220 Red	16p
TIL209 Red	13p	TIL222 Gr	18p
TIL211 Gr	20p	TIL228 Red	22p
TIL212 Ye	25p	MV5491 TS	120p
TIL216 Red	18p	Clips	3p

DISPLAYS

3015F	200p	NSB5881	570p
DL704	140p	TIL311	600p
DL707 Red	140p	TIL312/3	110p
707 Gr	140p	TIL321/2	130p
DL747 Red	225p	TIL330	140p
747 Gr	225p	7750/60	200p
FND357	120p	9638	200p
FND500	120p	9370	200p
FND507	120p	UDN6118	320p
MAN3640	175p	UDN6184	320p
MAN4640	250p		

TRANSISTORS

AC126	25p
AC127/8	20p
AC176	25p
AC187/8	25p
AF116/7	30p
AD149	70p
AD161/2	45p
AU107	200p
BC107/8	11p
BC109	11p
BC117	20p
BC147/8	9p
BC149	10p
BC157/8	10p
BC159	11p
BC169C	12p
BC172	12p
BC177/8	17p
BC179	18p
BC182/3	10p
BC184	11p
BC187	30p
BC212/3	11p
BC214	12p
BC237	15p
BC327	16p
BC338	16p
BC461	36p
BC477/8	30p
BC516/7	50p
BC547B	16p
BC548C	9p
BC549C	18p
BC557B	16p
BC559C	18p
BCY70	18p
BCY71/2	22p
BD131/2	50p
BD135/6	54p
BD139	56p
BD140	80p
BD189	60p
BD232	95p
BD233	75p
BD235	85p
BD241	70p
BD242	70p
BDX53B	150p
BDY56	200p
BF200	32p
BF244B	35p
BF256B	70p
BF257/8	32p
BF259	36p
BFR39	25p
BFR40	25p
BFR41	25p
BFR79	25p
BFR80	25p
BFR81	25p
BFX29	30p
BFX30	34p
BFX84/5	30p
BFX86/7	30p
BFX88	30p
BFW10	90p
BFY50	22p
BFY51/2	22p
BFY56	33p
BFY90	90p
BRY39	45p
BSX19/20	20p
BU104	225p
BU105	190p
BU108	250p
BU109	225p
BU205	200p
BU208	200p
BU406	145p
E300	50p
E308	50p
E310	50p
MJ2501	225p
MJ2955	100p
MJ3001	225p
MJE340	65p
MJE2955	100p
MJE3055	70p
MPF102	45p
MPF103/4	40p
MPF105/6	40p
MPSA06	30p
MPSA12	50p
MPSA13	50p
MPSA20	50p
MPSA43	50p
MPSA56	32p
MPSA70	50p
MPSU06	63p
MPSU07	90p
MPSU45	90p
MPSU65	78p
OC28	130p
OC35	130p
R2008B	200p
R2010B	200p
TIP29A	40p
TIP29C	55p
TIP30A	48p
TIP30C	60p
TIP31A	58p
TIP31C	62p
TIP32A	68p
TIP32C	82p
TIP33A	90p
TIP33C	114p
TIP34A	115p
TIP34C	160p
TIP35A	225p
TIP35C	290p
TIP36A	270p
TIP36C	340p
TIP41A	65p
TIP41C	78p
TIP42A	70p
TIP42C	82p
TIP2955	78p
TIP4055	70p
TIS43	34p
TIS93	30p
ZTX108	12p
ZTX300	13p
ZTX500	15p
ZTX502	18p
ZTX504	30p
2N457A	250p
2N696	35p
2N697	25p
2N698	45p
2N706A	20p
2N708A	20p
2N918	45p
2N930	18p
2N1131/2	20p
2N1613	25p
2N1711	25p
2N2102	60p
2N2160	350p
2N2219A	22p
2N2222A	22p
2N2369A	16p
2N2484	30p
2N2646	50p
2N2904/5	25p
2N2906A	24p
2N2907A	30p
2N2926	9p
2N3053	22p
2N3054	65p
2N3055	48p
2N3442	140p
2N3553	240p
2N3565	30p
2N3643/4	48p
2N3702/3	12p
2N3704/5	12p
2N3706/7	14p
2N3708/9	12p
2N3773	300p
2N3819	25p
2N3820	50p
2N3823	70p
2N3866	90p
2N3902	700p
2N3903/4	18p
2N3905/6	20p
2N4037	65p
2N4058/9	12p
2N4060	12p
2N4061/2	18p
2N4123/4	27p
2N4125/6	27p
2N4289	20p
2N4401/3	27p
2N4427	90p
2N4871	60p
2N5087	27p
2N5089	27p
2N5172	27p
2N5179	90p
2N5191	83p
2N5194	90p
2N5245	40p
2N5296	55p
2N5401	50p
2N5457/8	40p
2N5459	40p
2N5460	60p
2N5485	44p
2N6027	48p
2N6247	190p
2N6254	130p
2N6290	65p
2N6292	65p
3N128	120p
3N140	100p
3N141	110p
3N201	110p
3N204	100p
40290	250p
40360	40p
40361/2	45p
40364	120p
40408	70p
40409	85p
40410	85p
40411	300p
40594	97p
40595	105p
40673	75p
40841	90p
40871/2	90p

DIODES

BY127	12p
BYX36-300	20p
OA47	9p
OA81	15p
OA85	15p
OA90	9p
OA91	9p
OA95	9p
OA200	9p
OA202	10p
1N914	4p
1N916	7p
1N4148	4p
1N4001/2	5p
1N4003/4	6p
1N4005	6p
1N4006/7	7p
1N5401/3	14p
1N5404/7	19p
IS920	9p

HEAT SINKS

For TO220 Voltage Regs. and Transistors	22p
For TO5	12p

BRIDGE RECTIFIERS

1A	50V	21p
1A	100V	22p
1A	400V	30p
1A	600V	35p
2A	50V	30p
2A	100V	35p
2A	400V	45p
3A	200V	60p
3A	600V	72p
4A	100V	95p
4A	400V	100p
6A	50V	90p
6A	100V	100p
6A	400V	120p
10A	400V	200p
25A	400V	400p

ZENERS

2.7V-33V 400mW	9p
1W	15p

TRIACS PLASTIC

3A	400V	60p
3A	500V	65p
6A	400V	70p
6A	500V	88p
8A	400V	75p
8A	500V	95p
12A	400V	85p
12A	500V	105p
16A	400V	110p
16A	500V	130p
T2800D		130p

THYRISTORS

1A	50V	40p
1A	400V	65p
3A	400V	90p
8A	600V	140p
12A	400V	160p
16A	100V	160p
16A	400V	180p
16A	600V	220p
BT106		110p
C106D		45p
MCR101		36p
2N3525		120p
2N4444		140p
2N5060		34p
2N5064		40p

LOUDSPEAKERS

Size		
2½"	64R	70p
2½"	8R	70p
2"	8R	80p
1½"	8R	80p

MEMORIES

2102-2L	120p
2107B	500p
2111-2	225p
2112-2	300p
2114	525p
4027	375p
4116	£11
5101	510p
6810	350p
74S201	325p
82516	325p

ROM/PROMs

71301	700p
74S188	225p
74S287	350p
74S387	350p
74S470	650p
74S471	650p
74S571	1100p
93427	400p
93436	650p
93446	650p
93448	1000p

CPUs

1600	£12
6502	£10
6800	900p
6802	1250p
8080A	550p
Z80	1150p

EPROMS

1702A	500p
2516	3200p
2708	900p
2716	£32

SUPPORT DEVICES

3245	400p
4002	
6820	500p
6821	500p
6850	500p
8205	320p
8212	225p
8216	225p
8224	400p
8228	525p
8251	700p
8253	1200p
8255	550p
8257	1100p
8259	1400p
Z80P10	650p
Z80CTC	650p
MC14411	1100p
MC14412	1100p

UART

AY-3-1015P	500p
AY-5-1013P	400p
IM6402	500p
TMS6011NC	400p

CHARACTER GENERATORS

3257ADC	990p
MCM6576	£10
RO-3-2513 U.C.	600p
RO-3-2513 L.C.	600p
SN74S262AN	1350p

KEYBOARD ENCODER

AY-5-2376	£10

TRANSFORMERS

(prim 220/240V)

6-0-6	100mA	88p
9-0-9	75mA	92p
12-0-12	100mA	95p
0-120	12500mA	280p
0-25V (5VA)		250p
9-0-9 1A		270p*
12V 2A		360p*
0-12-15		
20-24-30 1A		340p*
15-0-15 1A		265p*

(Please add 50p p&p charge to all marked * above our normal p&p charge).

RESISTORS High Stab 5% E12 Carbon Film

¼W 10R-1M one value	7p/5pcs
½W 10R-10M one value	5p/3pcs
Miniature Presets Hor/Vert 100R-1M	12p
Carbon Track Pots 5K-1M Log or Lin	
Single	30p
Single with Switch	60p
Dual	72p

LOW PROFILE DIL SOCKETS BY TEXAS

8 pin	10p	18 pin	22p	24 pin	30p
14 pin	11p	20 pin	25p	28 pin	38p
16 pin	12p	22 pin	28p	40 pin	48p

WIRE WRAP SOCKETS BY TEXAS

8 pin	30p	18 pin	70p	24 pin	90p
14 pin	40p	20 pin	75p	28 pin	110p
16 pin	55p	22 pin	80p	40 pin	140p

SUBMINIATURE SWITCHES

Toggle	
SPST	60p
SPDT	65p
DPDT	70p
DPDT (centre off)	85p
Push to make	15p
break	25p
SLIDE DPDT	18p
ROCKER SPST	28p

WAFER

1P/12W	45p
3P/4W	45p
4P/3W	45p
2P/6W	45p

CRYSTALS

100KHz	300p
1MHz	370p
1.008MHz	370p
3.2768MHz	350p
3.579545MHz	200p
4MHz	350p
8.867237MHz	400p
10.7MHz	350p
18MHz	300p
26.690MHz	210p
27.145MHz	210p

ANTEX SOLDERING IRONS

C-15W	360p
CX-17W	380p
CCN-15W	380p
X25	380p

SPARE BITS

C/CX/CCN	46p
X25	50p

SPARE ELEMENTS

C/CX/X25	180p
CCN	200p

ADCOLA IRONS

K1000	550p
K2000	550p

VEROBOARDS

DIP Breadboard 4.15 × 6.15 (Suitable for 20 × 14 pin or 16 × 16 pin DIL ICs)	270p
DIP Breadboard as above with tracks for 31 way connector	340p
V-Q Boards for ICs (No track cutting)	105p

CONNECTOR PLUGS

31 way Plug	110p
31 way Socket	110p
S-100 Busboard	£12

EDGEBOARD CONNECTORS 0.156" PITCH

2 x 10 way	85p	2 x 22 way	135p
2 x 15 way	100p	2 x 25 way	160p
2 x 18 way	120p		

COUNTERS

74C925	475p	ZN1040E	700p
ICM7217A	850p	ICM7216B	1950p

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 2.1" (Uto 6 x 14 pin ICs)	£5.75
EXP600 6" x 2.4" (Up to 1 x 40 pin DCs)	£6.30

PROTOBOARD (R) SOLDERLESS BREADBOARDS

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	£18.00
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).

IC TEST CLIPS

14 pin	£2.60	24 pin	£2.90
16 pin	£2.75	40 pin	£7.90

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.

PLEASE SEND SAE FOR LIST.

VAT: Please add 15% to total order.

Please add 30p p&p

Government, Colleges, etc. Orders accepted

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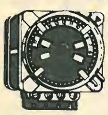
SOUTHEAST ENGLAND'S ELECTRONICS CENTRE

In stock now test equipment, microprocessors, teletypes, transformers, power supplies, scopes, sig. gen's, motors, peripheral equipment, I.C.'s, tools, components, variacs, keyboards, transistors, microswitches, V.D.U's sub-assemblies + thousands of other stock lines. Just a mere fraction of our vast range, is displayed below: 100's of bargains for callers.

MINIATURE 24 HR TIME SWITCH



- ★ Only 2" square
- ★ Up to 32 on-offs
- ★ 16 amp contacts
- ★ Plug-in carrier

This amazing time switch enables the programming of up to 32 on-offs in a 24 hour period. This is achieved by inserting triggers into the dial in the appropriate time positions. Plug in carrier for easy time setting and 16 amp contacts make it suitable for most switching applications. Supplied brand new with fixing screws and 3 sets on-off triggers.

£8.50

OPTO SMASH!

TIL 302/MAN 7 7 segment LED readout common anode direct drive (via resistors) from 7447 £1-10 each
TIL 119/OC72 Darlington opto isolator 3 for £1-00.
SAVE THAT SPACE! THICK FILM RESISTOR NETWORK 7x100Ω resistor in DIL pack. Ideal for use with 7 seg. displays etc. 4 for £1-00.
TIL305 0.3" 7 x 5 matrix LED alphanumeric readouts £3.75 each.
PHOTO TRANSISTOR Fairchild FPT-100 NPN silicon 30v, 25ma. 4 for £1.00

4k x 12 RAM static Memory card

Complete 4K x 12 bit memory system on one PCB. This ex computer memory card contains all relevant decoding, read write and control logic for coupling to your M.P.U. or mini computer system. TTL in and out make interfacing a "cinch". We understand that by reading the outputs correctly, the memory can be organised as a 6K x 8! Features include fast 250ns max. access time. Standard +12v, −12v+5v power rails compact construction, non-volatile memory, data remains even when power switched off! Original cost over £800 each, supplied complete with full data and circuit manual, at an unbelievable price of **£39.95** P.P. £1.75
Note: Memories are removed from working equipment but supplied untested, unguaranteed.

HOW TO GET HERE

Victoria, London Bridge or Holborn Viaduct to Thornton Heath. 1 minute from Thornton Heath Station.

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!!

DISPLAY I.C. AND TRANSISTOR BARGAINS NEVER CHEAPER

All I.C.'s and Transistors by well known manufacturers and fully guaranteed. No fall outs. Comprehensive data on I.C.'s 15p per type.
2N4351 N channel MOS FET.
2N4352 P channel MOS FET.
60p each £1.00 per pair.
HIGH VOLTAGE NPN POWER SWITCHING transistors BVcbo 600v BVceo 500v BVebo 15v 1c 5 amps Pc 125 watts HFE 60 typ ft 2.5 mhz ideal invertors, etc. TO3 £1.60 each 4 for £5.40.
BF258 NPN 250v @ 200ma 45p each 3 for £1.08.
I.R. BSB01 2.5 amp 100v bridge rec. P.C. mount long leads 35p each 4 for £1.08.
IN4998 4 amp 100v P.C. mount diodes long leads 14p each 10 for £1.10.
LM309K +5v 1.2 amp regulator £1.10 each 6 for £5.35.
2N1671B unjunction 450mw 30v 48p each 3 for £1.00.
IN4004 SD4 1 amp 400v diodes 7p each 18 for £1.00.
I.R. 12 amp BRIDGE RECS. 400 volt £1.25 each.

POWER DARLINGTON SCOOP!
MJ1000 NPN 60v 90w 8 amps TO3 95p each
2N6385 PNP 80v 100w 10 amps TO3 £1.25 each
MJ4030 NPN 60v 150w 16 amps TO3 £2.25 each

S.C.R.'s
2N3001 30v 350 ma TO18 22p each 6 for £1.00
2N4441 50v 8 amps TO220 45p each 10 for £4.00
C106D1 400v 5 amps TO202 55p each 10 for £5.00

TRIACS
G.E. 12 amp 600v TO220AB 95p each 10 for £8.75
E.C.C. 1.6 amp 400v TO5 38p each 3 for £1.00
A.E.I. 10 amp 400v ready mounted on 2½" x 2½" heatsink £1.00 each 4 for £3.75

LOW PROFILE I.C. SOCKETS
14 D.I.L. 14p each 8 for £1.00
16 D.I.L. Gold Plated mil. grade 22p each 6 for £1.00
22 D.I.L. 27p each 5 for £1.00

OTHER GOODIES
AF279 low noise P.N.P. germanium up to 780MHZ 32p each 4 for £1.10
2N4304.WN720 F.E.T. transistor 37p each 3 for £1.00
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 TO99 case 65p each 2 for £1.00
TMS3114 DUAL MOS 128 bit static shift reg. DC. 2.5 MHZ £1.50 each 4 for £4.25
NE555 10 for £2.55
GE424 zero voltage switch, triac SCR relay driver TO5 can £1.10 each 7 for £6.50
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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 an even bigger purchase we are now able to pass our bulk buy savings direct to you!

960 characters 12 x 80, 55 key TTY keyboard, RS232 interface, scroll up, adjustable baud rate 75-9600 upgradable to 1920 (24 x 80) characters, lower case option, plus many other features.

Brand New and Boxed — at only **£250** + VAT. Carriage

FULL TECHNICAL MANUAL **£10.00**

HY GRADE SMOOTHING CAPS
MULLARD - PLESSEY - MALLORY - SPRAGUE

1500mf	100v 60p*	3300mf	40v 50p
3300mf	63v 70p*	4500mf	25v 70p
10,000mf	15v £1†	22,000mf	16v £1.10†
87,000mf	7v £1†	2100mf	200v £2.50†

*Ex equipment tested †P.P. 40p

SEMICONDUCTOR 'GRAB BAGS'

Amazing value mixed semiconductors, include transistors, digital, linear I.C.'s, triacs, diodes, bridge recs. etc. etc. All devices guaranteed brand new, full spec. with manufacturers markings, fully guaranteed.
50 + BAG £2.95 100 + BAGS £5.15

MUFFIN FANS

☆ ideal equipment cooling etc. tested, ex-equipment. ☆
240v 50-60 HZ **£6.15** + p.p. 45p
110v 50-60 HZ **£5.05** + p.p. 45p

ELECTRONIC COMPONENTS & EQUIPMENT 66% DISCOUNT

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

7lb £ 5.25 **14lb £ 7.95**
28lb £13.75 **56lb £22.00**
PLEASE ADD P + P £1.25

ISOLATED 240v 4 AMP & 10 AMP SOLID STATE RELAYS

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. Dimensions: 4 amp, 1½" x 1" x ¾". 10 amp, 1¾" x 1½" x 1". 4 amp £1.45 10 amp £2.10 complete with circuit

PLESSEY EDGE STACKABLE DECADE THUMBWHEEL SWITCHES. Gold plated contacts dimensions 2" x 2" x ⅜" 85p each 8 for £5.35.
AMPHENOL 50Ω BNC chassis socket single hole fixing 50p each.
AMPHENOL 50Ω BNC plug 50p. **50Ω BNC** plug right angled 60p.
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Bulbs 24v 14 watt white frosted S.B.C. 8 for £1.00.
Bulbs 12v 100 watt clear, base similar S.B.C. 45p each.
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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1 ONLY DEC PDP8M

16k memory, auto restart, vk8 video set, serial/parallel, printer interface etc. Perfect order. **£850.00** + VAT + carriage.

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FREQUENCY	CASE	PRICE
100 KHZ	B7G	£2.35
250 KHZ	B7G	£2.35
1.00 MHZ	HC6/U	£2.75
2.00 MHZ	HC6/U	£2.35
2.50 MHZ	B7G	£2.35
5.00 MHZ	HC18/U	£2.25
8.00 MHZ	HC18/U	£2.25
10.25 MHZ	HC18/U	£2.25
11.20 MHZ	HC18/U	£2.25
33.339 MHZ	HC18/U	£1.75
UART Xtal 38.40 KHZ*		£2.80

SAE for latest XTAL stock list.

IMPORTANT

We have now moved to larger premises and whilst we are recovering! callers are welcome on Fridays and Saturdays between 9.30am and 5.30pm, and by appointment on other days.

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

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A special bulk purchase enables us to offer the above Keyboard at a lowest ever price. 49 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

UNIVERSAL TOROID TRANSFORMER

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 2⅞" x 1⅜" and negligible hum field make it a snip at only **£4.25** + pp 60p.

HIGH EFFICIENCY SMITHS RADIAL BLOWERS

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 2½" x 3". Ideal linears etc. Please state 240v or 110v operation. 50hz only.

BRAND NEW **£4.25** P.P. £1-10

DISPLAY ELECTRONICS

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Unless otherwise stated all prices inclusive of VAT. Cash with order. Minimum order value £2.00. Prices and Postage quoted for UK only. Where post and packing not indicated please add 30p per order. Bona Fide account orders minimum £10.00. Export and trade enquiries welcome. Orders despatched same day where possible. Access and Barclaycard welcome.

Electronic Brokers

49/53 Pancras Road London NW1 2QB Tel: 01-837 7781. Telex 29869

Our background

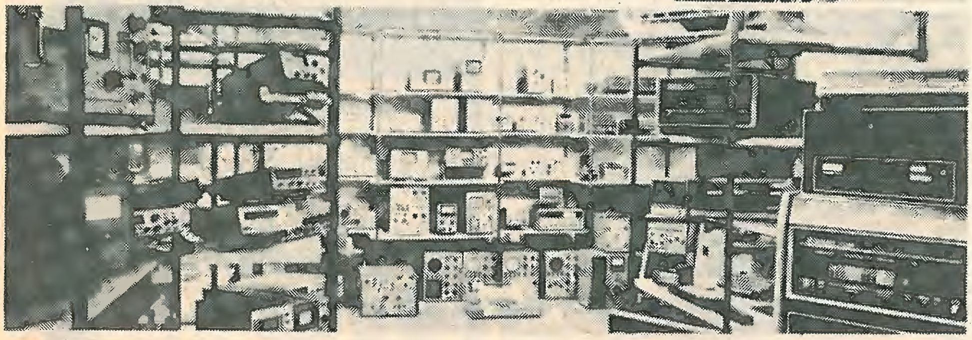
Electronic Brokers is Europe's largest specialist in quality, second user test equipment, mini-computers and associated peripherals. Established 11 years ago, we have pioneered the second user concept in Britain, and many overseas territories.

One reason for our success is the company's policy of continually updating the type of equipment we sell. So from selling to private users, the business has rapidly developed, and today, our customer list includes leading international companies, research establishments, universities, colleges and government institutions throughout the world.

SEND FOR AUTUMN '79 CATALOGUE

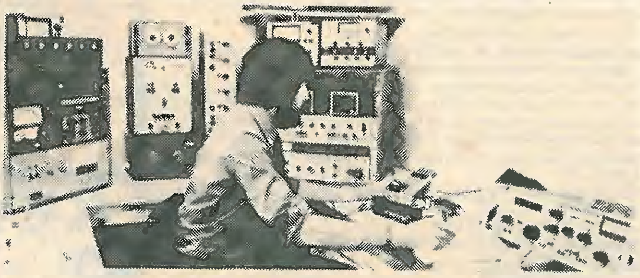
Containing latest information on our stocks of Test Equipment, Minicomputers, Peripherals, Stroboscopes, Tachometers, etc. Airmail to overseas addresses £2.00.

SEE US AT E.M.I.X. '79 OCT. 9, 10 and 1 BLOOMSBURY CENTRE LONDON



Back up

To support our growth we have a skilled team. This includes trained sales staff, whose role is not only to sell, but provide a helpful information service to our many customers. Backing this team is our own service laboratory where technicians monitor each item of equipment we sell. Our maxim is *service*, and those who have dealt with us will know that we endeavour to always live up to our reputation. Equipment can be configured to customer's exact requirement, and a number of options can be made available — almost like custom-tailoring.



Refurbishing

Our own service laboratory checks each item that arrives at our Pancras Road headquarters. Electronic test equipment is then thoroughly cleaned and a schedule prepared for any work which needs to be carried out to meet customer's requirements. Whether it is new test equipment or used, all items pass through the service laboratory where they are given final tests to ensure they meet manufacturers' specifications, before delivery to the customer.

Unless otherwise stated all equipment offered in the Electronic Brokers 4 page advertisement is refurbished and in the case of Test Equipment also calibrated. Test equipment is guaranteed for 12 months; computer peripherals for 3 months.

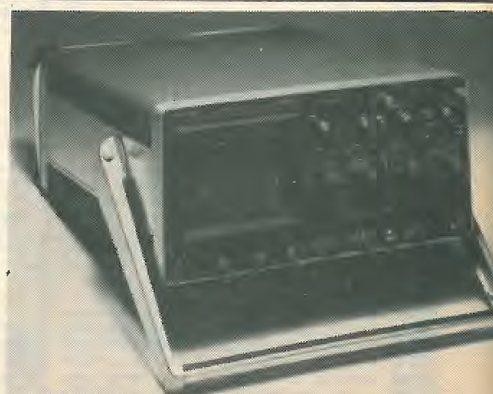
Add 15% VAT to ALL PRICES

Carriage and Packing charge extra on all items unless otherwise stated.

Hours of Business: 9 a.m. - 5 p.m., Mon.-Fri. Closed lunch 1-2 p.m.

A copy of our trading conditions is available on request.

WW — 114 FOR FURTHER DETAILS



PHILIPS

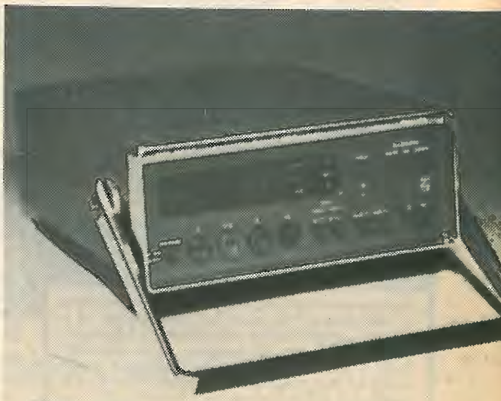
PM3261 Dual Trace Portable Oscilloscope.
DC — 120MHz. 5mV — 2/div
5nS — 1S/div Full delayed sweep.
5 digit LED event display
Auto. TTL triggering

£1250.00
current new price £1990.00

WAYNE KERR

Wayne Kerr B602 VHF Admittance Bridge c/w SR268 source and Detector
Frequency Range 100kHz—100MHz.
Ranges. 1fF—1mF, 100μΩ—100MΩ
1pH — 10H, 10n mhos — 10k mhos
Accuracy typically 1%

£1900.00



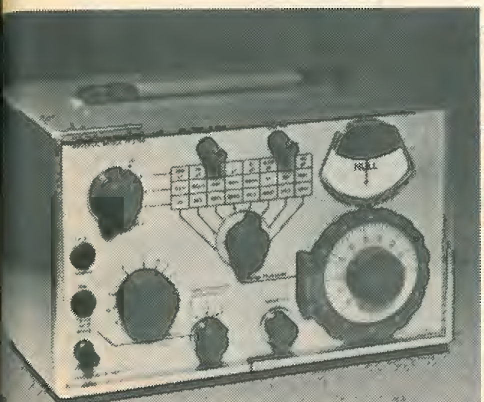
PHILIPS

PM2524. 4½ Digit D.M.M.
AC/DC voltage and current and resistance
Full autoranging.

£299.00
Current new price £435.00

No.1 in Second User Test Equipment

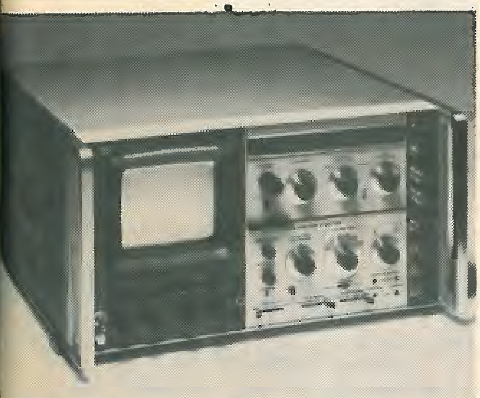
Add 15% VAT to all prices



MARCONI INSTRUMENTS

TF2700 RCL Bridge
Ranges: 0.2μH—110H,
0.5pF—1100μF.
0.01Ω — 11MΩ. Accuracy typically 1%
Battery operated

£210.00



HEWLETT PACKARD

141T-8552A-8553B Spectrum Analyser.
1kHz-110MHz. Variable persistance display. Sensitivity — 140dBm
THE MOST POPULAR ANALYSER OF ALL TIME.

£5100.00

STOP PRESS!

Exclusive purchases of outstanding Test Equipment now arriving . . . Save on the best at Electronic Brokers!

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PR 2200 FM/DR Tape Recorder **£6500**

BIOMATION
1650 16 Channel Logic Analyser **£4100**

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DATA LABS
DL 905 Transient Recorder **£875**
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DATRON
1051 5½ Digit D.M.M. **£995**

DYMAR
1771 L.F. Wave Analyser **£375**
1785 AM/FM Mod. Meter **£300**
1765 L.F. Distortion Meter **£250**

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HEWLETT PACKARD
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1600A 16 Channel Logic Analyser **£2050**
8640A AM/FM Signal Generator **£1800**

MARCONI INSTS.
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TF 2950/8 Mobile Radio Test Set **£1500**
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TF 2012 U.H.F. Sig. Gen. **£900**
TF 2606 Diff Voltmeter ....
TF 2331 Distortion Factor Meter **£475**
TF 2330A Wave Analyser **£725**
TF 2300B Mod. Meter **£950**

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F 10-650 6 Channel U/V Recorder **£725**

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6250 8 Digit 50MHz Counter Timer **£175**
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7055 Microprocessor Controlled D.M.M.
Without Processor Option **£975**
With Processor Option **£1300**
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Without Processor Option **£1150**
With Processor Option **£1450**

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5403 Scope (with 5A48 + 5B42) **£975**
434 25MHz Split Screen Storage Scope **£1600**
434 (option 01) Storage Scope **£1700**
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WAYNE KERR
B 642 Autobalance Univ. Bridge **£695**

WATANABE
MC 641 6 Channel Chart Recorder **£2250**

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131 Function Generator **£225**
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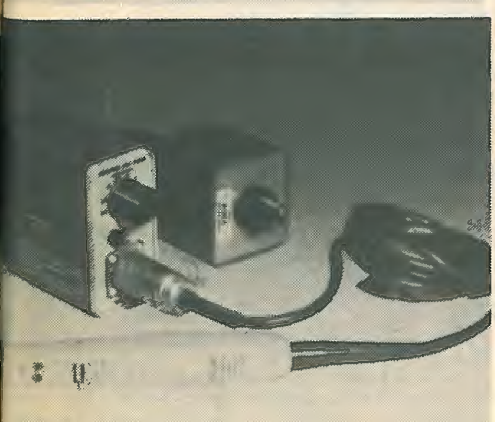
1801A R.F. Sweep Gen. **£435**
2001 R.F. Sweep Gen. **£650**

REMEMBER!!
All equipment has a 12 month Warranty, full specifications are available on request.



TEKTRONIX

P6046 Differential Probe
DC-100MHz
1mV-300mV/div
complete with power supply.

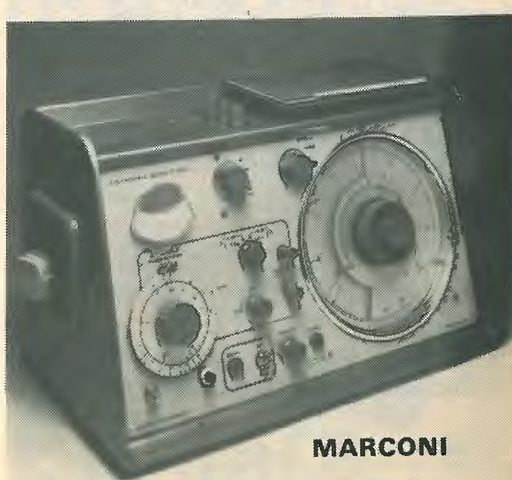
£350.00

HEWLETT PACKARD

5½ DIGIT D.M.M. 3490A
AC-DC volts
and resistance
Self check facility

only £550.00

Current new price £1,679.00



MARCONI

TF1313A Universal Bridge
L.C.R. 0.1% accuracy

£790
Current new price **£995.00**

Electronic Brokers

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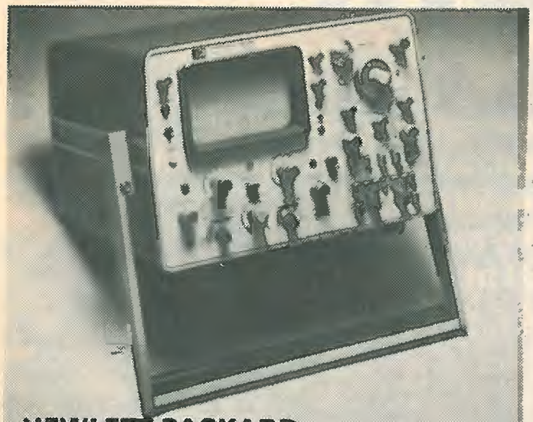
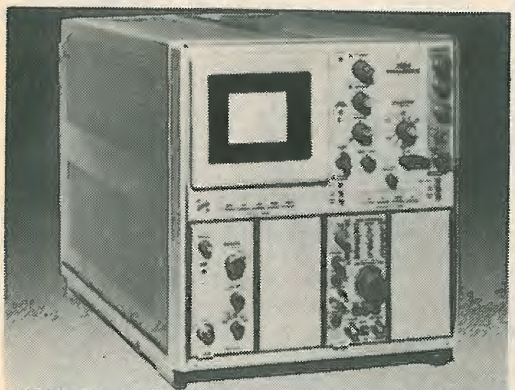
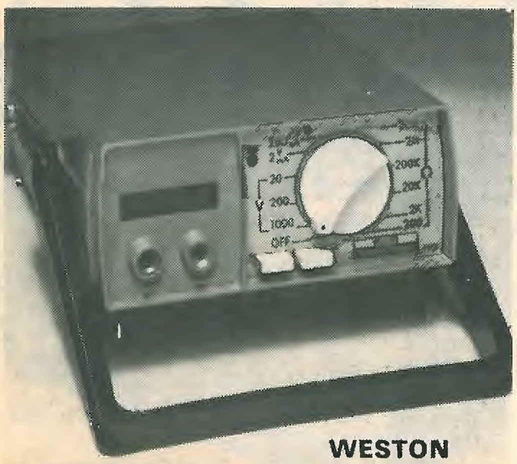


HEWLETT PACKARD
DUAL TRACE PORTABLE OSCILLOSCOPE 1707B
DC-75MHz. 10mV-10V sensitivity.
Delayed Sweep. Very High Quality
£925.00



TEKTRONIX
7904 Oscilloscope Main Frame with 7A26 — 7A19 — 7A21 — 7B92
Bandwidth: 350MHz with 7A26
500MHz with 7A19
1GHz with 7A21
Sweep speeds 0.5nS—0.2S/div.
Full delayed sweep.
SUPERB/QUALITY AT VERY SENSIBLE PRICE **£6350**



WESTON
4449 3½ Digit D M M
AC-DC Voltage and current and resistance.
SUPERB VALUE AT ONLY
QUANTITIES AVAILABLE
£59.00

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GENERAL RADIO
Immitance Bridge 1607A **£750**
1608A LCR Bridge. Accuracy typically .05% ... **£1450**
MARCONI INSTS.
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DC Voltage Source & AC/DC Diff. Voltmeter 741B **£975**
FLUKE
883AB AC/DC Differential Voltmeter ... **£975**
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3½ digit D.M.M. PM2513 **£90**
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HEWLETT PACKARD
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ELECTRONIC BROKERS (NEW)
X1 Probe Kit EB90 ... **£9**
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MARCONI INSTS.
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AM/FM Sig. Gen. TF995A/5 ... **£38**
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R.C. Oscillator TF1101 **£12**
A.F. Oscillator TF2100 **£15**
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Function Generator PM 5167 ... **£795**
SIGN/ROGERS
Low Distortion Oscillator S324 ... **£90**

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AVO/BPL
Component Comparato CZ457/6 ... **£235**
Electronic Multimeter EA 113 ... **£85**
BRADLEY
D.C. Voltage Calibrator 126B ... **£275**
E.N.I.
R.F. Power Amplifier 500L ... **£315**
GERTSCH
Complex Ratio Bridge CR1B ... **£600**
GENERAL RADIO
Vibration Analyser 1911A ... **£2100**
HEWLETT PACKARD
310A Wave Analyser 1kHz-1.5MHz ... **£1200**
True R.M.S. Voltmeter 3400A ... **£505**
Microwave Freq. Converter 2590B ... **£595**
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M.F. Transmission Test Set TF2333 ... **£600**
Quantization Distortion Tester TF2343 ... **£400**
Deviation Meter TF791D **£195**
Electronic Voltmeters TF2604 ... **£250**
Attenuator TF2162 ... **£135**
Sine Sq. Pulse & Bar Generator TF2905 ... **£450**
Grey Scale Generator TF2909 ... **£600**
PHILIPS
Pulse Generator PM5712 **£525**
Pulse Generator PM5715 **£575**
Pulse Generator PM5775 **£600**
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Pattern Generator PM5501 ... **£180**
Wow & Flutter PM6307 **£275**

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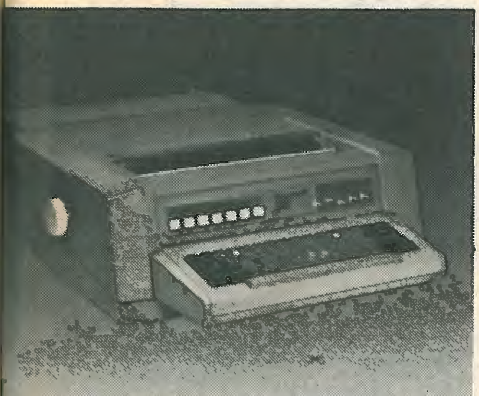

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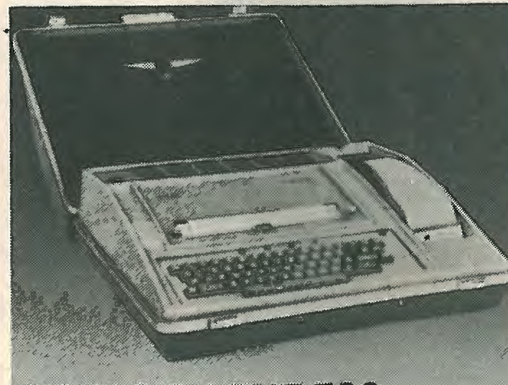

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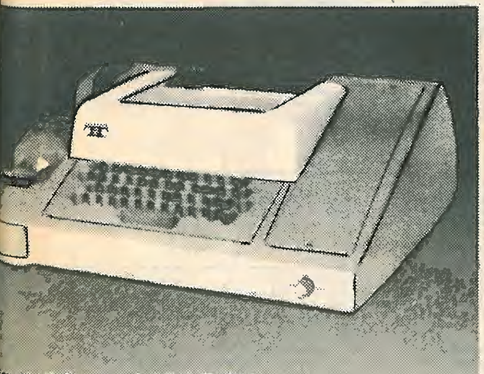

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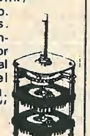

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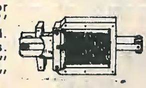

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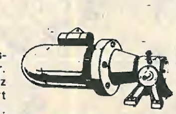

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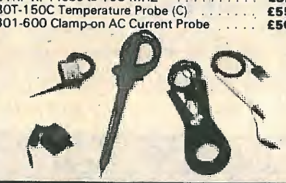

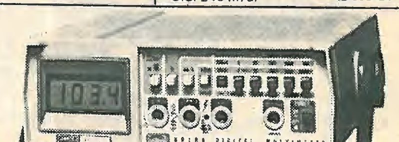

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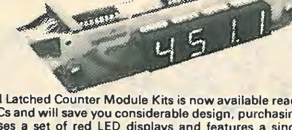

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EABC80	0.60	GZ32	0.75	U301	0.60	6AX4GT	0.90	9D6	0.85	75	0.90
EB91	0.45	GZ33	3.95	U600	5.10	6AX5GT	1.16	10C2	0.70	75C1	1.15
EBC33	1.15	GZ34	2.25	U801	0.90	6B7	0.85	10F18	0.70	76	0.90
EBF80	0.60	GZ37	2.80	UABC80	0.70	6BA6	0.45	10P13	0.70	78	0.90
EBF83	0.60	KT66	5.75	UAF42	0.85	6BE6	0.60	11E2	12.40	80	0.85
EBF89	0.60	KT88	7.20	UBF80	0.65	6BG6G	1.15	12A6	0.70	85A2	0.85
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ECC83	0.65	OA2	0.65	UCC84	0.70	6BW6	3.10	12AV6	0.80	807	20.25
ECC84	0.50	OB2	0.70	UCC85	0.75	6BW7	1.15	12AX7	0.60	813	1.15
ECC85	0.60	PABC80	0.60	UCF80	0.90	6C4	0.70	12BA6	0.60	829B	11.85
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ECF80	0.60	PC900	1.40	UF80	0.55	6CY5	1.00	12E1	4.80	954	6.75
ECF82	0.55	PCC84	0.75	UF85	0.60	6D6	0.85	12K5GT	0.50	955	0.60
ECF801	0.90	PCC89	0.65	UL41	0.85	6EA8	0.90	12K7GT	0.70	956	0.65
ECH34	1.15	PCC189	0.75	UL84	0.85	6F6GB	0.85	12K8GT	0.80	957	0.60
ECH35	1.70	PCF80	0.90	UM80	0.70	6F8G	0.75	12Q7GT	0.60	1625	1.00
ECH42	0.95	PCF82	0.45	UM84	0.70	6F12	0.90	12SC7	0.65	1629	1.15
ECH81	0.55	PCF84	0.75	UY82	0.65	6F14	0.95	12SH7	0.80	2051	0.80
ECH84	1.15	PCF86	0.75	UY85	0.60	6F15	1.15	12SJ7	0.65	5763	1.15
ECL80	0.70	PCF200	1.05	VR105/30	2.05	6F17	1.15	12SQ7	0.65	5842	2.25
ECL82	0.65	PCF201	1.05	VR150/30	1.40	6F24	1.00	12Y4	0.45	5933	7.30
ECL83	1.40	PCF801	1.15	Z66	1.05	6F33	4.75	13D6	0.70	6057	3.45
ECL85	0.75	PCF802	0.75	X61M	1.70	6H6	1.05	14S7	1.15	6060	0.95
ECL86	0.65	PCF805	2.05	Z800U	3.40	6J4WA	2.00	19AQ5	0.85	6064	0.95
EF37A	1.80	PCF806	0.95	Z801U	3.90	6J4	1.35	19G3	11.25	6065	0.95
EF39	3.30	PCF808	2.05	Z900T	2.50	6J5GT	0.85	19G6	6.75	6067	1.35
EF40	0.80	PCH200	0.90	1A3	0.70	6J6	0.60	19H5	19.15	6080	4.80
EF41	0.85	PCL81	0.70	1L4	0.50	6J7	0.85	20D1	0.70	6146	4.95
EF80	0.45	PCL82	0.75	1R5	0.65	6J7G	0.60	20F2	0.70	6146B	5.10
EF83	1.70	PCL84	0.80	1S4	0.45	6K7	0.80	20L1	1.15	6360	2.25
EF85	0.45	PCL86	0.80	1S5	0.45	6K7G	0.45	20P1	0.45		
EF86	0.55	PCL805/85		1T4	0.45	6K8GT	0.65	20P3	0.60		
EF91	0.65		0.85	1U4	0.80	6L6M	2.15	20P4	1.25		
EF92	0.75	PD500	3.65	1X28	1.25						
EF95	0.85	PFL200	2.80	2D21	0.65						
EF183	0.65	PL36	0.90	2K25	12.95						
EF184	1.80	PL81	0.85	2X2	0.90						
EF804	2.25	PL82	0.60	3A4	0.70						
EFL200	0.85	PL83	0.60	3D6	0.50						
EH90	0.70	PL84	0.75	3D21	23.00						
EL32	1.00	PL504	1.60	3S4	0.60						
EL34	2.95	PL508	1.50	3V4	0.95						
EL37	3.40	PL509	3.65	5B/254M	8.45						
EL38	4.50	PL802	3.15	5B/255M	8.45						
EL41	0.90	PLL80	3.40	5B/258M	8.45						
EL81	1.20	PY33	0.70	5R4GY	1.25						

POSTAGE: £1-£2 20p; £2-£3 30p; £3-£5 40p; £5-£10 60p; over £10 free.

VIDECON TUBE TYPE P863B
English Electric — £20

SPECIAL VALVES
4CX 1000A YL 1420
4CX 5000A YL 1430
BM 25L YL 1440

VALVES AND TRANSISTORS
Telephone enquiries for valves, transistors, etc.; retail 749 3934; trade and export 743 0899.

WE CAN ACT AS YOUR CONSULTANTS for MICRO COMPUTERS & TEST EQUIPMENT

TELUROMETER MRA3 DISTANCE MEASURERS
LOW RESISTANCE HEADPHONES TYPE CLB £1.50. 40p postage. VAT 12½%.

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Phone for our exceptionally high offer.

36' AERIAL MASTS consisting of 6 sections 6' 8'' × 2¼'' dia. Complete with all accessories to erect and instal.

FOR EXPORT ONLY
Mullard C11. High power installation, 1000W. Technical details and prices available on request.

HIGH VACUUM VARIABLE CAPACITORS — ceramic envelopes — UC 1000A/20/150=VMMHC 1000 60-1000µF, 20kv-150A RF max≐27MHz.
TEST SET FT2 for testing Transceivers A40, A41, A42 and CPRC26.
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THYRATRONS GLASS ENVELOPE. MIL 5948/1754. Us 25KV. TA 1.25A. P-12.5M.
IGNITION BK 484/5552A. Max. 1200 KVA. Anode Current 140A.

COLOMOR
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170 Goldhawk Rd., London W.12
Tel. 01-743 0899
Open Monday to Friday
9-12.30, 1.30-5.30 p.m.

BRITISH MOTOROLA 6800-6809 COMPUTER SYSTEMS

6800S, the world's most powerful 6800/6809 computer kit. Basic kit has 16K ram, Mikbug type monitor, cuts + high-speed tape interface, power supply, full Querty keyboard, mem. mapped VDU with u/l case, graphics, scrolling, spare ACIA and PIA. Addon 16K ram kit, disc available. All on a single board. From **£275.00.**

Mini 6800 System. A very versatile system based on several 100mm x 275mm PCBs. The basic kit contains the CPU + cuts card and VDU card and costs **£127.50.** Add to this: 8K RAM + 5EPROM card + calculator (MM57109) card + Errom programmer card + multifunction input-output card and you have a do anything system. Microcase: our own big ABS case to house a 6800S or Mini. **£29.00.**

All prices exclude VAT and postage. Send stamped addressed envelope, please, for leaflets.

HEWART MICROELECTRONICS
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WW — 100 FOR FURTHER DETAILS

FOTOLAK

POSITIVE LIGHT SENSITIVE AEROSOL LACQUER

Enables YOU to produce perfect printed circuits in minutes!
Method: Spray cleaned board with lacquer. When dry, place positive master of required cirouit on now sensitized surface. Expose to daylight, develop and etch.. Any number of exact copies can of course be made from one master. Widely used in industry for prototype work.

FOTOLAK	£1.50
Developer	30p
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Pre-coated 1/16'' Fibre-glass board	
204mm x 114mm	£1.50
204mm x 228mm	£3.00
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467mm x 305mm	£9.00

Plain Copper-clad Fibre-glass.	Single-sided	Double-sided
Approx. 3.18mm thick sq. ft.	£1.25	£1.50
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Clear Acetate Sheet for making master, 260mm x 260mm		12p

Postage and packing 65p per order. VAT 15% on total

G. F. MILWARD ELECTRONIC COMPONENTS LIMITED
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FOR TESTING AMPLIFIER QUALITY
YOU NEED A SIGNAL WITHOUT DISTORTION

We do not claim our Model A0146 Signal Generator is distortionless.
However it is so low (.0015%) that only the most sophisticated Analyser can detect it.

Spec. Sine wave distortion below .0015% output lv rms. Freq. coverage 10hz-100kHz Coarse and fine attenuation into 600 ohms. Square wave alternative.

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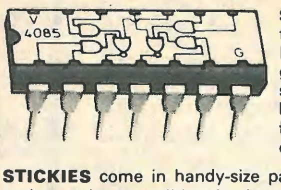
PPM2: PEAK PROGRAMME METERS

- ★ Approved by broadcasting authorities in the U.K. and overseas for critical programme monitoring.
- ★ Reviewed *Studio Sound* September, 1976. Meets IEC268-10A, draft BS5428-9.
- ★ Accurate law at and between all PPM marks with minimal preset adjustment. Marginal adjustment is retained to allow compensation for the tolerance in scale markings between meter manufacturers and different meters from the same maker.
- ★ Decay matching of all boards allows use with twin movements without pairing.
- ★ Flat frequency response at all PPM marks and also below minimum calibration point.
- ★ Gold plated connector and floating input protected against mains or static voltages on the signal lines. Supply input protected against reverse polarity.
- ★ Close tolerance components with excellent temperature and ageing characteristics used throughout.
- ★ Soak tested bards. *Ernest Turner* meter movements 642, 643 and TWIN flush mounting adaptors and illumination kits from stock. Scalings available 11.7, IEC268 10A Type 11a; —12T/TEST/+12 Type 11b used by EBU and conforming to CCITT recommendation N15 (1972) but not recommended by us except for EBU and measuring instruments.

Stereo Disc Amplifier 2 ★ 10 Outlet Distribution Amplifier 2 ★ Stabilizer ★ Peak Deviation Meter ★ Chart Recorders.

SURREY ELECTRONICS
The Forge, Lucks Green, Cranleigh, Surrey GU6 7BG. Tel: (04866) 5887

SIGHT for sore eyes



STICKIES are printed self-adhesive labels that stick to the top of ICs. They turn a board-full of ICs into a working circuit diagram! See at a glance where to place your soldering iron or test probe. Use STICKIES for building and de-bugging prototypes, fault-finding, experimenting, teaching — even designing PCB layouts.

STICKIES come in handy-size packs for 7400- or 4000-series ICs. Each pack contains a sensible mix of more than 60 different IC types.
120-label packs **80p.**
480-label packs **£2.80,** 2-10 packs **£2.50** each, 11+ **£2.20** each.
Prices include 15% VAT and first-class postage.
Please state whether TTL or CMOS required.
Official orders welcome.
Let others suffer the sore eyes—try a pack of STICKIES and *see* the difference.

For your STICKIES by return of post, contact **CONCEPT ELECTRONICS, 8 Bayham Road, Sevenoaks, Kent, TN13 3XA (0293 514110).**

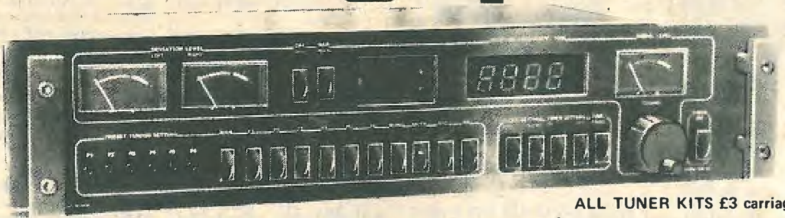
WW—051 FOR FURTHER DETAILS

Tecknowledgey for sale.

The Mark III FM Tuner

DIY Hi-Fi will never seem the same again. Ambit's Mark III tuner system is electrically & visually superior to all others. Some options available, but the illustrated version with reference series modules: £149.00 + £18.62 VAT

With Hyperfi Series modules £185.00 + £23.12



Features of the system:

- * Precision construction & design of all parts
- * Time/frequency display
- * State of the art performance with facilities for updates, using modular plug in systems.
- * Deviation level calibrator for recording
- * All usual tuner features

ALL TUNER KITS £3 carriage

PW SANDBANKS PI METAL LOCATOR

Maintaining our professional approach to home constructor kits, we offer the pulse induction 'Sandbanks'. Now with injection molded casing for greatly improved enviromental sealing. £37.00+£5.55vat

VHF MONITOR RX WITH PLESSEY IC

4/9 channel version of the PW design - but **using standard (fundx9) crystals**, and **TOYO 8 pole crystal filter** with matching transformers. Coil sets from our standard range to cover bands from 40 to 200MHz. **Complete module kit £31.25 +£3.90vat .**

MICROMARKET OSTS overflow:

6800P	650p	8212	230p	2102	170p
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6852	365p	8251	625p	2114	1000p
8080	630p	8255	540p	+15% VAT	

RADIO and AUDIO MODULES : Consistently the most advanced

FOR FM

EF5801-3-4 series: 6 stage varicap tuning, all with oscillator output

5801	Dual gate MOSFET RF stages, bipolar mixer	£17.45 + 2.61VAT.
5803	Dual gate RF/mixer stages, amplified LO out	£19.75 + 2.96VAT
5804	'Hyperfi' series, with internal PIN diode agc, and ultra wide range tuning system	£24.95 + 3.74VAT
EF5402	4 stage varicap tuner with TDA1062 and LO output. Uses FET/IC input. PIN agc	£10.75 + 1.61VAT

FOR 30-200MHz

The EF series are available on special order to cover bands (usually approx 20% of the centre frequency) in the range described. Details in our price list.

FOR FM IFs at 10.7MHz

7030	single 6 pole linear phase filter IF with HA1137	£10.95 + 1.64VAT
7130	two 6 pole linear phase filter IF with CA3189E	£16.25 + 2.44VAT
7230	Hyperfi IF, switched bandwidth, AGC IF preamp, linear phase ceramic filters with diode switched narrow filter	£24.95 +3.74VAT

DECODERS for MPX (STEREO)

Various types, guaranteed the world's biggest and best ranges

LARSHOLT FM TUNERSETS

7252	MOSFET front end combined with CA3089 IF	£26.50 +3.97VAT
7252	JFET front end, combined with IF and decoder	£26.50 +3.97VAT

FM/AM tuning synthesiser, see details elsewhere in th is advertisement

COMPONENTS FOR RADIO/COMMUNICATIONS/AUDIO/TV etc.

As usual, Ambit brings you the latest and best, a small selection of which is shown in this advertisement. The Ambit catalogues contain information on most of the devices mentioned here - and an order for the new part three will ensure you stay up with latest developments. Data photocopying service described in pricelist info.

RADIO ICs for FM		vat
CA3089E	1.94	29
CA3189E	2.45	37
HA1137W	2.20	33
HA11225	2.20	33
SN76660N	0,75	11
RADIO ICs for AM/FM		
TDA1090	3.35	50
TDA1083	1.95	29
TDA1220	1.40	21
IF AMPLIFIERS		
KB4406	0.50	07
MC1350	1.20	18
see comms ics also		
COMMUNICATIONS		
KB4412	2.55	38
KB4413	2.75	41
SD6000	3.75	56

SL1600 series		
SL1610	1.60	24
SL1611	1.60	24
SL1612	1.60	24
SL1613	1.89	28
SL1620	2.17	33
SL1621	2.17	33
SL1623	2.44	37
SL 624	3.28	49
SL1625	2.17	33
SL1626	2.44	37
SL1630	1.62	24
SL1640	1.89	28
SL1641	1.89	28
SL6640	2.75	41
SL6690	3.20	48
MC3357	3.12	47
MC1496	1.25	19
NE544	1.70	25

Audio preamps		vat
LM381N	1.81	27
LM382N	1.65	25
KB4436	2.53	38
KB4438	2.22	33
TDA1028	3.50	53
TDA1029	3.50	53
TDA1074	3.75	56
Audio power		
TBA820M	0.75	11
TBA810AS	1.09	16
LM380N	1.00	15
ULN2283	1.00	15
TDA2002	1.95	29
HA1370	2.99	45
TDA2020	2.99	45

FETs, MOSFETs, bipolars. and various others: see PL

2SJ133/2SJ48 £10.00 + £1.50 pr. various high voltage drivers etc. from correctly matched Hitachi series transistors. (All 120v types)

Current news: A PCB for the Mullard DC tone and volume control system is now available £3 + 0.45 VAT. HMOS PA modules for 60-100W - kit £14 +£2.10VAT, heatsink £4.10+0.61. FM radio control system crystals £3.75 pair inc VAT (Sept. on). MK50366N: static drive clock/timer IC £3.78 + 0.57 VAT. 12½kHz channel spacing 8 pole 10.7MHz XTAL filter by TOYO type H4402 £15.50 + £2.32VAT. A further updated pricelist is now available, and we would like to remind you that enquiries can only be answered if accompanied either by an official business letterhead, or an SAE. STOP PRESS: TOKO's new split-apart triple AM tuning diodes are in stock £2.45 + 37p VAT, (KV1215). S BL1 diode DBM 1-500MHz - £4.25+0.64p.

Terms: CWO please. Account facilities for commercial customers OA. Postage 25p per order. Minimum credit invoice for account customers £10.00. Please follow instructions on VAT, which is usually shown as a separate amount. Overseas customers welcome - please allow for postage etc according to desired shipping method. Access facilities for credit purchases.

Catalogues: Ambit. Part 1 45p. Part 2 50p 90p pair. TOKO Euro shortform 20p. Micrometals toroid cores 40p. All inc PP etc. Full data service described in pricelist supplements.

Hours/phone: We are open from 9am -7pm for phone calls. Callers from 10am to 7pm. Administrative enquiries 9am to 4.30pm please (not Saturdays). Saturday service 10am to 6pm.

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WW — 110 FOR FURTHER DETAILS

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BUY A minicomputer for less than some TV games

only £79·95 + VAT

ELF 11 BOARD WITH VIDEO OUTPUT

STOP reading about computer and get your "hands on" an, ELF 11 and Tom Pitman's short course. ELF 11 demonstrates all the 91 commands which an RCA 1802 can execute, and the short course speedily instructs you how to use them.

ELF 11's VIDEO OUTPUT makes it unique among computers selling at such a modest price. The expanded ELF 11 is perfect for engineers, business, industry, scientific and educational purposes.

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SAVE 10% AND BUY ALL THREE TOGETHER

All units can be supplied wired and tested

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Add 15% VAT to all prices shown. Pus £2 P&P Over £20

SPECIFICATION

***RCA 1802 8-bit microprocessor with 256 byte RAM — expandable to 64K bytes**

***RCA 1861 video IC to display program on TV screen via the RF Modulator**

Single Board with:

Professional hex keyboard — fully decoded to eliminate the waste of memory for keyboard decoding circuits

Load, run and memory protect switches

16 Registers

Interrupt, DMA and ALU

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Built-in power regulator

5 slot plug in expansion bus (less connectors)

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of H. L. Audio Ltd.
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WW- 101 FOR FURTHER DETAILS

YOU ARE INVITED TO THE WORLD'S FIRST PERMANENT ELECTRONICS EXHIBITION.

OPENING TUESDAY 25th SEPTEMBER 1979
Open thereafter each week-day, 10.00 a.m. until 4.00 p.m. with the permanent exhibition.
First 'mini' exhibition:
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September 25th to 27th.
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All enquiries to 'The Centre,'
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AND ADMISSION IS FREE.

On September the 25th the doors of the National Microprocessor and Electronics Centre will be opened to the public.

We know it will surprise you. And admission is free to all.

Beneath the historic walls of The Tower of London we have established a unique facility for engineers and buyers to examine the latest products – without any salesmen breathing down their necks!

Over the coming year we shall create comprehensive displays augmented by a regular series of single technology displays.

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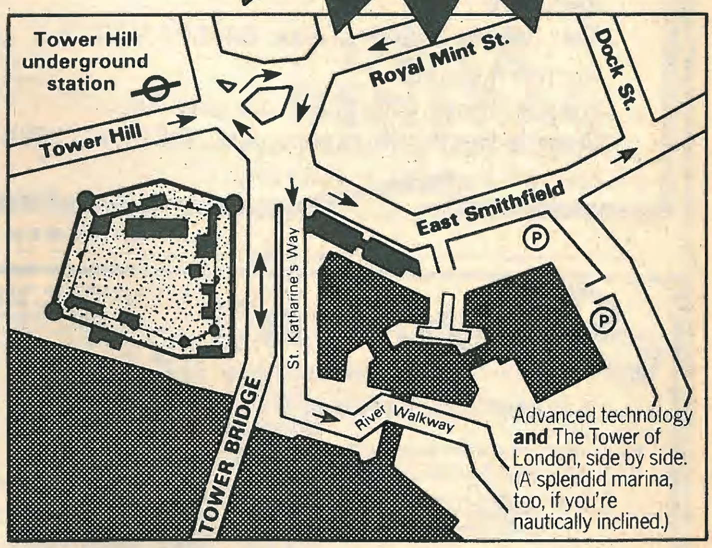
It is our intention that each product area shall be **totally** reviewed. So that you can try out all those you are likely to consider in a single visit to a single location. (And, obviously, make comparisons on the spot.)

The World Trade Centre, which houses our own Centre, is easy to get to by train, car – or by boat (just moor at Tower Bridge!).

But we'd prefer that you completed the coupon or used our enquiry number so that we can send you full instructions, our programme for the first months of operation, and some more news about this unique service that is freely available.

Please make contact. Or else we'll have to put you next door...



Advanced technology **and** The Tower of London, side by side. (A splendid marina, too, if you're nautically inclined.)

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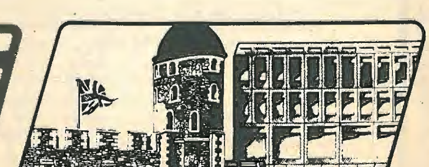

10268

C.T.ELECTRONICS (ACTON) LTD.

9.30am-6.00pm
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CONTINUOUS

Registered in England 1179820

267 & 270 ACTON LANE, LONDON W4 5DG. Telephone: 01-994 6275

This advertisement represents a fraction of our stock. Please phone your requirements. Minimum mail order £5 plus carriage and packing charge. Add VAT at 15% to all prices. Government, colleges, trade and export welcome.

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We have three complete systems left, each consisting of:
NOVA 820 main frame (including 240V 50Hz power supply)
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CPU 1 (8206) with power monitor and restart (16 bit)
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32K core memory. Disk pack controller (4046)
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Diablo series 30 (type 4047A) moving head 2.5M byte disk drive.
240V 50Hz power supply for above, with adaptor and logic board (4047)
Computer control panel. Cabinet, including fans and mains filter.

OFFERS AROUND £5,000

We have large stocks of spare parts for the Nova 820 series computers, eg, Memory boards, I/O interface boards, Disk pack controller boards, disk drive power supplies, etc. Many surplus bargains in our retail shop for callers only. Much of our stock is constantly changing and hence not practical to list. Please phone your requirements.

3 Centaur Fans 110/120V 12W (119/119/38mm). In 19 inch Vero case. **£12** + VAT.

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We have two machines each consisting of: Heavy duty typewriter, photoelectric paper tape reader, paper tape punch and solid state logic control. The units together provide an automatic data processing system. **£750** + VAT.

DATA DYNAMICS 390 ASR TELETYPE

Refurbished, full working condition. **£300** + VAT.

Diablo series 30 DISK DRIVES: Type 4047A, 2.5M byte with psu. **£400** + VAT.

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TEXAS 4030JL DYNAMIC RAM (Eq. Intel 2107). **£3** + VAT.

NEW SURPLUS OFFER HIGH SPEED 15MHz 8-BIT DIGITAL TO ANALOGUE CONVERTERS

by Micro-Consultants Ltd. 50ohm Cable-drive output. Linearity: 0.25% max; 0.125% typ. Settling time: 2volt step 70nS typ; 2mV step 50nS.
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TYPES RAD 802 AND MC2208/8
UNUSED, EX-MAKER'S PACK

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SPECIAL OFFER PRICE NOW £50 + VAT

Berk Tek BTK-30-3CL 30 AWG 5mil wall Kynar cable (for computer back panel wiring) style 1423 105°C, red or white. Approx. ½ list price at £20 per 10,000 ft. reel.
Blues Macs RIBBON CABLE £20 + V.A.T. 25-way (150V, 105°C). 100ft. Reels per reel.
Thermosetting Silver Compound £20 + V.A.T. per 50g Tube.
Special offer Filmet SC 65 1MΩ 0.1% M. Film Resistors 20p each.
REED RELAYS OSMOR CD3182 6V 2PCO PCB MOUNTING (60 x 18 x 13mm), £1.00 + V.A.T.

7400	0.12	7451	0.20	74141	0.75
7401	0.12	7453	0.20	74150	1.00
7402	0.12	7454	0.20	74151	0.70
7403	0.12	7460	0.20	74153	0.70
7404	0.12	7470	0.35	74154	1.00
7405	0.18	7472	0.30	74155	0.70
7406	0.32	7473	0.30	74156	0.85
7407	0.32	7474	0.30	74157	0.70
7408	0.20	7475	0.45	74160	0.95
7409	0.20	7476	0.35	74161	0.50
7412	0.20	7480	0.60	74162	1.00
7413	0.30	7481	1.00	74163	1.00
7414	0.70	7482	0.90	74164	1.00
7415	0.30	7483	0.80	74165	1.00
7417	0.30	7484	1.10	74166	1.00
7419	0.50	7485	0.90	74167	2.50
7420	0.18	7486	0.30	74170	2.00
7421	0.20	7489	1.60	74174	0.95
7422	0.35	7490	0.35	74175	0.80
7423	0.32	7491	0.50	74176	0.80
7425	0.30	7492	0.45	74177	0.80
7426	0.30	7493	0.40	74180	0.80
7427	0.30	7494	0.90	74181	1.85
7428	0.40	7495	0.65	74182	0.95
7430	0.18	7496	0.65	74184	1.50
7432	0.26	7497	1.90	74185	1.50
7433	0.50	74100	1.40	74188	2.50
7437	0.30	74104	0.70	74190	1.00
7438	0.30	74105	1.70	74191	1.00
7440	0.18	74107	0.30	74192	1.00
7441	0.70	74109	0.55	74193	1.00
7442	0.50	74110	0.55	74194	1.00
7443	1.30	74118	0.95	74195	0.95
7445	1.00	74119	1.30	74196	0.95
7446	1.00	74121	0.28	74197	0.80
7447	0.75	74122	0.55	74198	1.60
7448	0.75	74123	0.55	74100	1.60
7449	1.00	74125	0.50		
7450	0.20	74132	0.70		

4000UB	0.17	4027B	0.44	4075B	0.20
4001UB/B	0.17	4028B	0.77	4076B	1.17
4002UB/B	0.17	4029B	1.03	4077B	0.39
4006B	1.04	4032B	0.89	4078B	0.20
4007UB	0.18	4034B	1.71	4081B	0.20
4008B	0.87	4040B	0.97	4082B	0.20
4011UB/B	0.18	4043B	0.88	4093B	0.80
4012UB/B	0.20	4044B	0.84	40160B	1.19
4013B	0.43	4049UB	0.50	40161B	1.19
4014B	0.83	4050B	0.43	40162B	1.19
4015B	0.83	4051B	0.82	40163B	1.19
4016B	0.48	4052B	0.82	40174B	0.85
4017B	0.79	4053B	0.82	40175B	0.86
4018B	0.83	4066B	0.55	40194B	1.19
4020B	1.11	4068B	0.20	4510B	1.01
4021B	0.90	4069UB	0.20	4511B	1.25
4022B	0.82	4070B	0.46	4512B	0.91
4023UB/B	0.18	4071B	0.20	4516B	1.01
4024B	0.70	4072B	0.20	4518B	0.97
4025UB/B	0.20	4073B	0.20	4528B	0.80

EDGE CONNECTORS
Single sided 0.1 pitch:
24-way (fixing holes 73mm)—UCL **£0.70**
40-way (fixing holes 118mm)—RS **£1.20**
78-way (length 204mm)—UECL **£1.50**
Single sided 0.15 pitch:
15-way (fixing holes 73mm). Gold plated EB **£0.60**
18-way (fixing holes 85mm) inc. locating pin **£0.75**
32-way (fixing holes 136mm). Gold plated, EB **£1.50**
27-way (fixing holes 122mm) **£1.30**
Double sided-0.1 pitch:
2×40-way (fixing holes 117mm). Gold plated **£2.00**
Double sided 0.15 pitch:
2×40-way (fixing holes 165mm), Gold plated **£2.00**

LEVER SWITCHES GPO BP1000 Type
4PCO, 8PCO with knobs **£0.60**

PUSHBUTTON SWITCHES by A. B. Electronics
4-way 2PCO **£0.50,** 7w, 5×2PCO, 2×4PCO **£0.80.**

TRANSFORMERS, all 240V primary

6-0-6 500mA (63×35×48)	£1.40
0-11, 2A; 0-22, 1A (76×64×60)	£2.40
12V 130mA (36×45×40)	£0.75
17V 300mA (44×47×74)	£1.50
18V 2A (80×55×70)	£2.80
18V 2.5A (115×65×62)	£2.50
28V 200mA (53×45×37)	£1.00
32V 250mA (46×37×31)	£1.20
0-2-4-6-8-10-12, 0-1-1, 5A	£6.00

ALUMINIUM BOXES

	ins L	W	H	Retail price + VAT
AB7	5¼	2½	1½	0.70
AB8	4	4	1½	0.70
AB9	4	2¼	1½	0.70
AB10	4	5¼	1½	0.70
AB11	4	2½	2	0.85
AB12	3	2	1	0.70
AB13	6	4	2	1.00
AB14	7	5	2½	1.20
AB15	8	6	3	1.55
AB16	10	7	3	1.75
AB17	10	4½	3	1.45
AB18	12	5	3	1.75
AB19	12	8	3	2.40

BLUE REXINE COVERED

RB1	6	4½	2½	1.45
RB2	8	5	3	1.70
RB3	9	5	3½	1.00
RB4	11	6	4	2.30
RB5	11	7½	4½	2.70

DATA GENERAL
PHOTO PAPER TAPE READERS
400 I.P.S. 8 BIT Part No. 6013-2
SPECIAL OFFER PRICE £150 + VAT

MAINS FILTERS
Potter 30A, 125V (184×51×70). Sealed **£3.00**
Erio 8A, 250V (61 × 120 × 47). Diecast box **£5.00**

BRIMAR CRT M17/15GV, with scan coils and Wallis power supply. Rectangular screen (96 × 130) **£20.00**

LARGE PANEL METERS (Clear view)
SIFAM 140-0-140microAmp (107×145), Calibrated 0-14 and 7-0-7. Boxed **£5.00**
ANDERS 1mA f.s.d. (145×115), Calibrated 0.15KV boxed. **£5.00**

KEYSWITCHES — HEAVY DUTY by Kraus & Naimer
2P (1PM-1PB) 12A 600VAC **£1.50** 49mm square
10P (4PM-6PB) 12A 600VAC **£3.00** fascia
By Baco:
8P (4PM-4PB) 10A 380VAC. By Baco **£3.00**

ILLUMINATED SWITCHES by Licon
Rectangular snap in (01-800 series). 10A contacts.
Min. flange bulb holders
SPCO Momentary **£1.00**
2PCO Momentary **£1.50** Indicator only **£0.50**
Price includes lenses but not bulbs.
Red, yellow, blue, green and white lenses available.

VEROBOARDS

0.1" Pitch Copper Clad		0.15" Pitch Copper Clad	
2.5"×5"	0.59	2.5"×5"	0.53
2.5"×3.75"	0.50	2.5"×3.75"	0.44
2.5"×17"	1.77	3.75"×17"	1.98
3.75"×5"	0.66	3.75"×5"	0.74
3.75"×3.75"	0.59	0.15" Pitch Plain Board	
3.75"×17"	2.28	5"×3.75"	0.47
4.7"×17.9"	2.99	2.5"×5"	0.30
2.5"×1" (Sold in 5s)	0.70	New V-Q DIP Board	1.11
0.1" Pitch Plain Board			
3.75"×17.9"	1.49		
3.75"×2.5"	0.36		
3.75"×5"	0.56		

SPECIAL OFFER
741 8 pin DIL **15p**

Cassette Erase Tape Heads ¼" **£1.00 each*.**
Cassette Monotape Heads ¼" **£2.00 each*.** Brand new.
Miniature Moulded Track Presets by Plessey. Screwdriver operation, 0.25W dissipation. PCB fixing, **15p each.**
Open Cermet Presets. Most values in stock. **15p** each.
ROTARY SWITCHES available in 30 different types, prices range from **45p-£1.20**
PREH Television Push-button Tuner Units, 4 and 6 button, brand new in original boxes **75p each.** Large quantity available.

Appointments

Advertisements accepted up to 12 noon Friday, August 31st for October issue, subject to space being available.

DISPLAYED APPOINTMENTS VACANT: £10.00 per single col. centimetre (min. 3cm).
LINE advertisements (run on): £1.50 per line, minimum three lines.
BOX NUMBERS: 70p extra. (Replies should be addressed to the Box Number in the advertisement, c/o Wireless World, Dorset House, Stamford Street, London SE1 9LU.)
PHONE: Neil McDonnell on 01-261 8508
Classified Advertisement Rates are currently zero rated for the purpose of V.A.T.

RADIO TECHNICIANS

At the Government Communications Headquarters we carry out research and development in radio communications and their security, including related computer applications. Practically every type of system is under investigation, including long-range radio, satellite, microwave and telephony.

Your job as a Radio Technician will concern you in developing, constructing, installing, commissioning, testing, and maintaining our equipment. In performing these tasks you will become familiar with a wide range of processing equipment in the audio to microwave range, involving modern logic techniques, microprocessors, and computer systems. Such work will take you to the frontiers of technology on a broad front and widen your area of expertise — positive career assets whatever the future brings.

Training is comprehensive: special courses, both in-house and with manufacturers, will develop particular aspects of your knowledge and you will be encouraged to take advantage of appropriate day release facilities.

You could travel — we are based in Cheltenham but we have other centres in the UK, most of which, like Cheltenham are situated in environmentally attractive locations. All our centres require resident Radio Technicians and can call for others to make working visits. There will also be some opportunities for short trips abroad, or for longer periods of service overseas.

GCHQ

You should be at least 19 years of age, hold or expect to obtain shortly the City and Guilds Telecommunications Technician Certificate Part I, (Intermediate), or its equivalent, and have a sound knowledge of the principles of telecommunications and radio, together with experience of maintenance and the use of test equipment. If you are or have been in HM Forces your Service trade may allow us to dispense with the need for formal qualifications.

WORK IN COMMUNICATIONS R&D AND ADD TO YOUR SKILLS

You start at £3900 rising to £5530, and promotion will put you on the road to posts carrying substantially more. There are also opportunities for overtime and on call work paying good rate.

Get full details from our Recruitment Officer, Robby Robinson, on Cheltenham (0242) 21491, Ext. 2269, or write to him at GCHQ, Oakley, Priors Road, Cheltenham, Glos. GL52 5AJ. If you seem suitable we'll invite you to interview in Cheltenham — at our expense, of course.

(9106)

UNIVERSITY OF KEELE

ELECTRONICS TECHNICIAN

in the

DEPARTMENT OF COMMUNICATION AND NEUROSCIENCE

Vacancies exist for an Electronics Technician or Trainee to work on laboratory instrumentation, including computers and peripherals, in a Department engaged in research into communication mechanisms of the brain. Experience in electronics and/or computer maintenance desirable. A suitably qualified and experienced applicant can be appointed in Grade V (salary range at present £3474-£4056 p.a.); but applications will be considered from less qualified persons willing to undergo training, with an initial appointment in a lower grade (salary range £1722-£3336 p.a.) Application forms and further particulars obtainable from the Registrar, The University, Keele, Staffs ST5 5BG. Forms should be returned by 20th August 1979. (9614)

NATIONAL VEGETABLE RESEARCH STATION

Instrumentation and Electronics Engineer

An Instrumentation and Electronics Engineer is required to provide a service for design, development and fabrication of electronic, electro-mechanical and mechanical apparatus and equipment.

Degree in electrical/electronic engineering or Council of Engineering Institutions Part II examination in an appropriate subject, or equivalent or higher qualification, with an aggregate of at least five years' recognised study, professional training or experience.

Salary scale: Professional and Technology grade P & TO II £4869 rising by 5 increments to £5739. (Salary under review from 1 April 1979).

Further particulars and application forms from Secretary, National Vegetable Research Station, Wellesbourne, Warwick CV35 9EF.

(9646)

UNIVERSITY OF LIVERPOOL

EXPERIMENTAL OFFICER

(TWO POSTS)

(a) DEPARTMENT OF ELECTRICAL ENGINEERING & ELECTRONICS

(b) DEPARTMENTS OF MECHANICAL & CIVIL ENGINEERING

Post (a) involves assistance in the development and application of microprocesses and other digital systems to a wide range of undergraduate, postgraduate and industrial activities.
Post (b) involves responsibility for interfacing microcomputers with a wide variety of laboratory sensors and transucers used by these Departments in both teaching and research.
Expert advice on hardware and software is available.
Candidates must possess a degree or equivalent qualification.
Salary within range up to £5604 p.a.

Application forms available from: The Registrar, The University, P.O. Box 147, Liverpool L69 3BX. Quote Ref: RV/709/WW.

(9607)

Good Radio Systems Engineers are few and far between

So are opportunities like this

£5,500–£7,500

Yet again we are adding personnel to our Systems Planning Team. We need male or female Engineers to take on the responsibility of designing and planning systems ranging from single channel HF to Broadband microwave links. Detailing performance estimates, writing specs and systems descriptions are all part of the job. Naturally technical expertise and experience are paramount in our developing world. We need experience in the latest state of the art as well as traditional technology.

In return for your services we offer a variety of tasks and early responsibility in a highly motivated team. Please do not waste your time or ours unless you are prepared to travel overseas from time to time and to put in that little extra that IAL expects as the norm.

As well as paying the salary noted above we have an excellent pension scheme – the usual company social club who will do their best to organise your off time – good holiday travel benefits are available and our staff catering facilities are second to none. If you have to relocate to join IAL we will pay you reasonable relocation expenses and provide accommodation for the employee during the first few weeks of employment.

Our offices are close to Heathrow which puts the residential areas of Wokingham, Reading, the Chalfonts and Harrow in easy commuting reach.

Write or 'phone quoting ref. 259/K to The Senior Recruitment Officer, IAL, Aeradio House, Hayes Road, Southall, Middlesex. 01-574 5134.

(9503)

IAL Aviation and Communications Systems and Services–worldwide 1978

ROYAL NORTHERN COLLEGE OF MUSIC

Applications are invited for the post of

SENIOR TECHNICIAN
(SPECIAL PROJECTS)

Salary £3,732-£4,161 (under review)

Duties will include investigation into acoustic modifications, new recording techniques (quadrophonic and digital systems), design of equipment for electronic synthesis. Assistance will also have to be given to Academic Staff in respect of Aural Training and to the Recording Manager in the running of his Department. Qualifications should include HNC or HND in Electrical Engineering, appropriate degree or Corporate Membership of the IEETE. This should be combined with an exceptional understanding of electro-acoustics (theoretical and practical), of acoustic problems and design and an interest in music and experience in video / sound recording. Application forms and further details may be obtained from Administrative Registrar, Royal Northern College of Music, 124 Oxford Road, Manchester M13 9RD. Tel: 061-273 6283, Ext. 46. Closing date for return of application form 10 September, 1979.

(9496)

UNIVERSITY OF LONDON GOLDSMITHS' COLLEGE New Cross, London SE14 6NW

Psychology Department

The Psychology Department has two senior vacancies for technical staff to start as soon as possible.

(1) **TECHNICIAN**
(Grade 6) to work on the Department's extensive range of electronic and video equipment. Normal qualifications for this post will be HNC/HND.
Salary on the following scale:
£3,984 - £4,104 - £4,236 - £4,365 - £4,497 - £4,626 - £4,758 plus £525 London Weighting Allowance.

(2) **TECHNICIAN**
(Grade 5) to work in the field of computer and microprocessor applications in psychological research. Normally technical qualifications/experience would be required for this post but applications for graduates in relevant fields will be welcome.
Salary on the following scale:
£3,474 - £3,582 - £3,699 - £3,816 - £3,933 - £4,056 plus £525 London Weighting Allowance.

Write for further details to the Personnel Officer to whom applications should be sent by **31st August, 1979.**

(9603)

THE CITY UNIVERSITY DEPARTMENT OF COMPUTER SCIENCE

SRC RESEARCH STUDENTSHIP

Applications are invited for an SRC Research Studentship to investigate braille translation. This project, in collaboration with the Royal National Institute for the Blind, aims to produce a low-cost office machine capable of accepting typewriter input, and forming braille on a refreshable braille display.

Candidates would normally be required to have a good Honours Degree in computer science or electronics.

Applications, together with the names of two referees should be submitted as soon as possible to Dr. G. R. Dowling, Department of Computer Science, The City University, Northampton Square, London EC1V 0HB, from whom further particulars may be obtained.

(9631)

Radio Communications
Electronics Engineers and Software Designers

Mid-Sussex – S.W. London **Salaries up to £7,000**

To join our expanding R&D Laboratories covering a wide range of R.F. spectrum, from L.F. to V.H.F. Equipments include transmitters and receivers for marine and land based use, radio navaids and radio monitoring remote computer controlled systems.
Electronics Engineers should have experience in transmitter or receiver design, analogue or digital circuit design, microprocessor applications. Software Designers should be experienced Programmers with an interest in control, signal processing or navigational software.

Attractive salaries are complemented by excellent prospects and generous benefits.

Contact: **The Personnel Manager, Redifon Telecommunications Limited, Broomhill Road, Wandsworth, London S.W.18. Phone: 01-874 7281** (reverse charges).

(9033)

Inner London Education Authority

HACKNEY COLLEGE

LECTURER I

Suitably qualified person required to teach theory and craft processes to **ELECTRICAL AND ELECTRONIC ENGINEERING CRAFT AND TECHNICIAN APPRENTICES.**

Applicants should hold a City and Guilds of London Institute Advanced Craft or Full Technological Certificate and have suitable industrial experience.

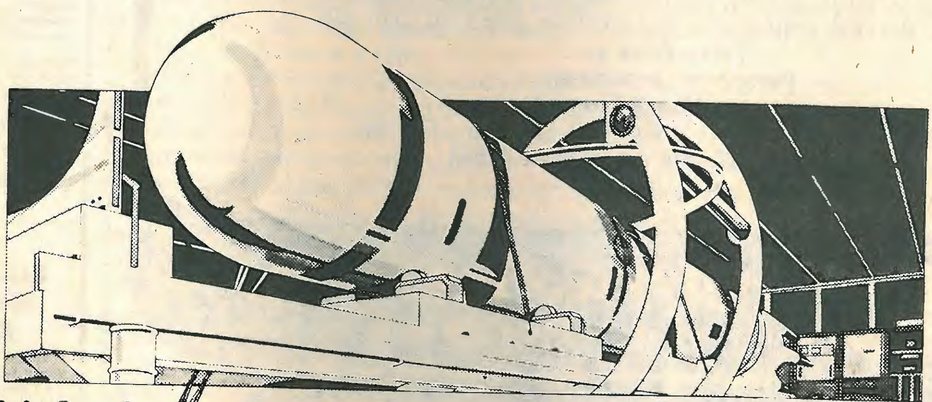
Salary on an incremental scale within the range £3,192-£5,334 (under review) plus £474 Inner London Allowance. Starting point will depend on qualifications and experience.

Applications obtainable from / returnable to Senior Administrative Officer, Hackney College, Dalston Lane E8 1LJ, Ext. 212 (01-985 8484).

Closing date 31 August, 1979.

(9604)

Electronics Engineers



Can you think of a more testing environment for your test experience?

There can be few areas that present greater technical challenge than the project we have started. It involves the creation of entirely new torpedo-based defence systems flexible enough to counter threats as yet unknown and incorporating the latest advances in microprocessing control and guidance technologies.

We need hardly underline the importance of an accurate, flexible and, above all, reliable test and maintenance system for the torpedo's success. What we're offering you is the chance to make your own direct contribution – right from the start of the project.

As a vital member of a tightly-knit engineering team, developing the sophisticated ATE the system requires, you can expect full involvement. The scope of our work includes systems design, detail design and software applications of both manual and automatic test systems – integrating maintainability aspects of test logistics.

The men and women we're looking for are self-motivated Electronic Engineers, unafraid of applying innovative thought to ATE systems and design.

If you fit one of the following, we want to hear from you.

An ATE Manager

Concerned with the design and development of an Automatic Test System, you will supervise both in-house design and sub-contract control following the generation of the initial requirement specification.

A Section Leader

You will be responsible for the design of special to type test equipment, to support the development, production and in-service use of the weapon system. This will involve generation of the initial requirement specification – as well as the subsequent design and development.

Engineers-Test System Studies

Possible areas of involvement include depth of test calculations, tolerance tiering philosophy, diagnostic procedures and maintenance logistics. Some previous experience of servicing complete weapon systems, while not essential, would be an advantage.

Engineers-Detailed Design

You will be working on special to type test equipment, both manual and computer controlled. Your involvement will extend to the weapon system's commissioning and development trials.

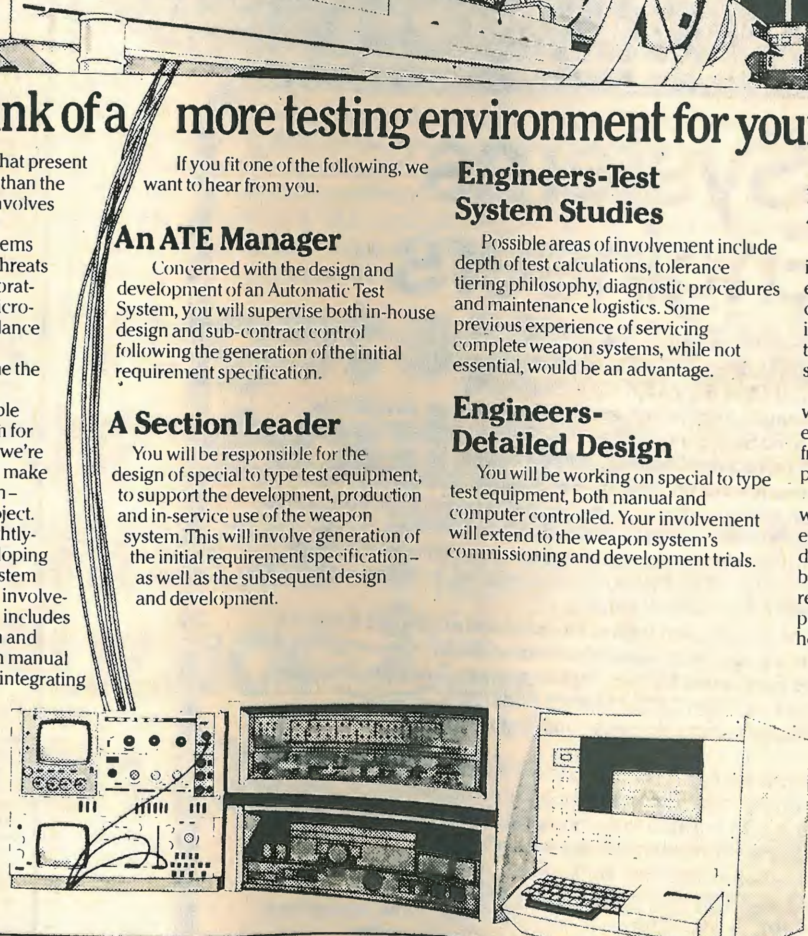
ATE Software Manager

You will lead a group concerned with i) the programs associated with executive control of a computer controlled ATE. and ii) generating, in conjunction with Design Engineers, the test specifications for the weapon system.

If you can't see your precise area of work here, but have an interest in test equipment, we would still like to hear from you – as we have a number of projects under way.

Apart from the excitement of the work itself, we offer realistic salaries, excellent opportunities for career development and a range of fringe benefits – including financial help with relocating you and your family to our pleasant South Coast setting, where housing is readily available.

For full details of career opportunities in our testing environment, complete the attached coupon. And get ready for your career to grow.



Name ____________________

Address ____________________

____

Area of interest ____________________

Jack Burnie, Applied Electronics Laboratory, Marconi Space & Defence Systems Ltd., Browns Lane, The Airport, Portsmouth. Telephone: Portsmouth 699 111 (Ref. 9610)

Marconi Space & Defence Systems (Portsmouth)

A GEC Marconi Electronics Company

Closed Circuit Television Manager

The name of "Chubb" is synonymous with progress and expansion in the field of integrated security systems. Recently we have relocated part of our diverse operation to Woking, Surrey. It is here that we wish to appoint a high calibre Closed Circuit T.V. Manager. The person we are looking for will be a self-starter with both engineering and commercial experience plus a sound and up to date knowledge of CCTV systems and techniques.

Sales project management and support to our busy field force both at home and abroad are two of the main responsibilities of this demanding position. The successful applicant (male/female) can expect an attractive remunerative package with salary in the range of £6,500 to £8,500 per annum, Company car and a wide range of Company benefits. If you feel that you can meet the above requirements and would like to develop your career in a positive direction then call:

Terry Ainsley
Personnel Department
Chubb Alarms Limited
42/50 Hersham Road · Walton-on-Thames · Surrey
Telephone: Walton-on-Thames 43851

Relocation expenses will be paid where appropriate.

(9623)

Chubb Alarms
a member of The Chubb Electronics Group.

Systems Engineers

Collins Radio, a division of Rockwell International, are acknowledged leaders in the field of communication systems. As a result of recent contract awards our Operations Group is expanding.

Qualified Engineers, at all levels, are required to work as systems Engineers in our Ship Systems and Ground/Transportable Systems Groups. They will be required to evaluate and systemise complex communication requirements utilising HF/SSB, MF, VHF, UHF, microwave and data transmission techniques. Systems projects, in addition to radio equipment, typically include antennas, power sources, RTTY, voice/data scramblers, remote control/supervisory, radio telephone patch, selective calling, audio distribution/switching, antenna matrix and customised terminal/control equipment.

These positions would be of interest to qualified engineers currently employed as Radio Engineers, Radio Communication Engineers, Communications Engineers, System Test Engineers, Systems Engineers, Systems Designers, System Circuit Design Engineers, Electronic Engineers, Project Engineers, Applications Engineers, and Planning Engineers.

Ideally applicants should have a broad theoretical and/or practical background in communication methods, but training would be given to suitable engineers who are able to demonstrate an ability or willingness to undertake projects from inception to final system implementation. The positions will be based in Reading, Berkshire, and will involve some overseas travel.

We offer an attractive starting salary which is negotiable, assistance with relocation expenses and considerable Company benefits.

Please telephone Reading (0734) 61111 or write for application forms to:– Personnel Manager, Rockwell-Collins (U.K.) Ltd., Suttons Industrial Park, London Road, Earley, Reading RG6 1AZ.

Rockwell International

(9506)

INNER LONDON EDUCATION AUTHORITY
London College of Printing, Elephant and Castle, London SE1 6SB
DEPARTMENT OF PHOTOGRAPHY, FILM AND TELEVISION

TELEVISION TECHNICIAN/ ENGINEER (ST1/2)

Applications are invited for the above post in the School of Film and Television, Department of Photography, Film and Television. Candidates should be conversant with ½", ¾" and 1" black and white and colour equipment and be capable of electronic maintenance. Experience in professional broadcasting would be an advantage, as well as an interest in experimental video work. The successful applicant will be expected to assist in running studio productions, and video tape editing.

Salary within the scale £3688.44-£5401.44 inclusive. Progression up the scale to £4867.44 is by annual increments subject to satisfactory performance. Progression beyond that point is dependent on a positive assessment.

Application form, returnable within 14 days, obtainable from the Senior Administrative Officer at the College. Tel: No. 735 8484 ext 227. (9624)

LONDON BOROUGH OF HARINGEY
— Education Service

PART-TIME ASSISTANT HEARING AND VISUAL AIDS TECHNICIAN

required at Blanche Nevile Special School, Philip Lane, N15, to work 15 hours per week x 52 weeks per annum to assist in the repair and maintenance of hearing and visual aids equipment.

Grade/Salary: Pro-rata to N.J.C. Technical Grade 2 — £3600 per annum rising to £3972 per annum inclusive, which equals £1542 per annum rising to £1704 per annum inclusive (under review).

Applicants should preferably have experience in maintaining electronic equipment and should hold one of the following qualifications.

Final City and Guilds Certificate for Electrical Technicians/Marine Shop Engineering/Mechanical Engineering, or other equivalent qualification.

OR a minimum of ten years' suitable experience in a school or industry.

Hours of duty. 9.30 a.m. to 12.30 p.m.

Candidates will be welcome to contact Mr. J. H. Stanway, Headmaster (01-808 5744).

Application forms obtainable from.
Chief Education Officer
Education Offices
Somerset Road, N17
Forms returnable by: September 7, 1979.
(9641)

UNIVERSITY OF EDINBURGH

DEPARTMENT OF CHEMISTRY

ELECTRONICS SPECIALIST

£3,689 to £7,145 (Grade 1A/1B)

Electronic Engineers! You are invited to apply for this post of electronics specialist. It is a staff position, academically related and benefits include six weeks' holidays per annum. Applicants should have a broad spectrum of analogue and digital expertise which they will exercise on the very broad range of analytical instrumentation used for teaching and research. The successful applicant will be responsible to the Head of Electronic Services for the design and construction of new equipment and the maintenance of existing equipment which includes N.M.R., E.S.R., Mass Spectrometers, real time computer systems and peripheral devices, ultra high speed RF and digital equipment. Experience in RF and microprocessor techniques would be advantageous.

The appointment will be within the scale as shown commensurate with experience/qualifications.

Applications giving career history and the names of two referees should be made to: The Secretary, University of Edinburgh, Old College, South Bridge, Edinburgh.

Closing date for application 3rd September, 1979. Please quote reference 5034. (9489)

Overseas Installations and Commissioning Staff

Vacancies exist for all levels of technical staff to work world-wide on strategic HF radio installations. All posts are permanent and are based in Bracknell, Berkshire.

Extensive overseas travel is necessary on unaccompanied tours of up to 90 days. Generous leave breaks apply, plus the opportunity for UK-based familiarisation and refresher training.

Installation/Commissioning Engineer vacancies up to **Principal Engineer** status.

All positions will require relevant academic qualifications, plus considerable field experience for the senior positions. A knowledge of modern circuit technology and HF/VHF experience is required.

Antenna Installation Supervisor

Previous rigging and mast experience is a necessity for this post, together with an ability to supervise field crews. Candidates should have extensive experience in modern HF antenna systems. (eg Log Periodic Antennas).

Customer Liaison/Commissioning Engineers

In addition to the requirements outlined above, candidates will also need the ability to liaise with customers and represent the Company at a high level.

These posts require previous experience, ideally in a similar capacity, and a confident ability to work on one's own.

Installations Technicians

A craft apprenticeship or Forces experience would provide the ideal background. Good craft ability in prototype wiring and assembly of electronic equipments is required, together with the ability to use tools and work to high standards of modern installation practice.

All the above positions carry an excellent salary and benefits package, including overseas allowances and free overseas accommodation. Full medical insurance is also provided.

Please apply in writing, with brief career details to date, to:
Personnel Manager,
Racal Communications Limited, Western Road,
BRACKNELL, Berkshire.
or
Telephone for an application form to:
BRACKNELL (0344) 3244 Ext. 149.

Britain's fastest growing electronics group RACAL

AUDIO + VIDEO LTD.

VTR ENGINEER

We require a VTR Engineer, 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.

Other in-house facilities include Marconi DICE Standards Converter, TBCs and a multitude of helical scan machines, and so the work can often be varied.

Please ring Mr. C. J. Carroll and have an informal chat about the work, salary and holidays, etc.

(9605)

ELECTRONICS PRODUCTION

ENGINEERS AND TECHNICIANS

Dolby Laboratories, the successful and progressive London manufacturers of professional audio noise reduction equipment, require production engineering staff. Duties will include the design and fabrication of test and assembly equipment, method study and application of techniques to maximise production from a limited area.

Qualifications: Several years' experience in electronics manufacture, appropriate academic qualifications and the ability to work projects through to successful conclusions without close supervision.

Competitive salaries and excellent employment conditions are offered.

For application form, contact:

Dolby

Paul Garrard
DOLBY LABORATORIES, INC.
346 Clapham Road, London, S.W.9
01-720 1111

(9329)

3M

MINNESOTA 3M RESEARCH LIMITED

CREATIVE ELECTRONIC EQUIPMENT DESIGNER

We have a vacancy in our Physics and Systems Research Group for a person with an interest in applying the latest electronic techniques in the design and construction of novel instrumentation for a wide variety of research projects. Current programmes include dielectric measurements, electrolytic processes, particle size measurement and methods of process control. The broad interests of this Laboratory require that the successful candidate show initiative and genuine creativity in developing the specialized equipment required. Some knowledge of and interest in Physics or Chemistry would be an advantage.

The attractive salary offered will reflect experience and academic qualifications. The Company operates generous pension, life assurance and sickness benefit schemes, and above all, offers good future prospects.

The 3M Company world-wide invests millions of pounds in research programmes each year. This has been, and will continue to be, a major factor in the Company's success.

Please apply in writing, giving brief details of qualifications and experience to:

Administrative Manager
MINNESOTA 3M RESEARCH LIMITED
The Pinnacles, Harlow, Essex CM17 OHL

(9638)

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

ELECTRONICS TECHNICIAN Grade 5

DEPARTMENT OF PHYSICS

A vacancy exists in the Electronics Workshop of the above Department. The Workshop is responsible for the development, construction, repair and calibration of analogue and digital equipment used for both research and teaching. Whilst qualification to HHNC or final year City and Guilds will be required, emphasis will be placed on a broad background experience. The post will offer an opportunity to help develop microprocessor systems. Further particulars and application form may be obtained from the Staff Officer, University of Surrey, Guildford, Surrey GU2 5XH, or telephone Guildford 71281 ext. 452. (9615)

CHELSEA COLLEGE
University of London
Electronics Workshop

DEPUTY SUPERVISOR

(Grade 6)

ELECTRONICS TECHNICIAN/ENGINEER (Grade 5) and ELECTRONICS TECHNICIAN (Grade 3) 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. Day release for approved further study can be arranged at Grade 3. Inclusive salaries (under review).

Grade 6 £4508 to £5282 p.a.
Grade 5 £3998 to £4580 p.a.
Grade 3 £3455 to £3860 p.a.

Further details and application forms from. Mr. M. E. Cane (E.W.), Chelsea College, Pulton Place, London SW6 5PR. (9642)

Royal Holloway College
(University of London)
Egham Hill, Egham, Surrey

TECHNICIAN

required by the departments of Computer Science and Computer Services. The technician will be in his early to mid-twenties with O.N.C. standard electronics or any similar training or experience and will undergo further in-house and day-release training, particularly in computer programming. The appointment will be on the University Technician Grade 4 or 5 depending on age and experience, that is £3500-£4300 including London weighting. Further details can be obtained from the Personnel Officer (WW). (9497)

BRIGHTON POLYTECHNIC

LEARNING RESOURCES

VTR ENGINEER

£4245-£5073 per annum
(plus 1979 salary award)

Unique opportunity to work in the forefront of helical vtr developments; using new 1" high band, broadcast ¾" and all consumer formats; requiring a qualified engineer to work to broadcast standards but interested in working with all vtr formats.

Further details and application forms from **Personnel Officer, Brighton Polytechnic, Moulsecoomb, Brighton. BN2 4GJ. Tel: Brighton 693655 ext 2536.**
To be returned as soon as possible.

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.

ICAO Seeks Aviation Specialists

THE CHALLENGE

Over the next six months we will be hiring more than 170 aviation specialists for short and medium-term assignments in Africa, Asia, Latin America and the Middle East.

We are looking for very expert, very experienced technical specialists who have good academic degrees or equivalent high professional qualifications, together with a minimum of ten years' practical aviation experience, at least half of it in the specific area of specialisation. Obviously with this experience requirement we don't expect applicants to be much below the age of 35. There is no upper limit as long as you are young in spirit and in good health.

THE ORGANISATION

We are the International Civil Aviation Organisation (ICAO), and we administer a technical assistance operation funded in main part by the United Nations Development Programme. Our expenditures this year will be close to (U.S.) $50 million, and we shall be helping more than 75 developing countries.

THE JOBS

We are looking particularly for **electronics engineers** and **electronics technicians** (technical officers) who are highly qualified in one or more of the following fields:

- **Aeronautical Communications**
- **Aeronautical Radar**
- **Aeronautical Navigation Aids**

THE TERMS

We pay good salaries, ranging from (U.S.) $28,000 to $44,000 before taxes, depending upon the job. The cost-of-living allowance depends on the duty station. For example, currently for an expert with dependants: $12,940 to $17,730 in Jordan and Venezuela, $7,470 to $10,240 in Nigeria, $6,370 to $8,740 in Malaysia. Plus: Installation grants, travel for dependants, education grants and six weeks' leave per year with home leave after two years.

If you have the necessary experience and ability, and if you or your employer would like to help a country develop its citizens and resources—while you accumulate valuable international experience — send you résumé to:

Technical Assistance Recruitment
International Civil Aviation Organisation
1000 Sherbrooke Street West
Montreal, Quebec, Canada H3A 2R2

ICAO·OACI·ИКАО

(9494)

Service Engineers

Greenford, Middlesex

Sansui manufacture some of the most sophisticated equipment, and are rapidly making inroads into the U.K. market. To keep in line with current expansion, they now need two Service Engineers for their new service department in Greenford.

You will be involved in the repair and maintenance of our product range which includes speakers, turntables, amplifiers etc. If you're qualified to City & Guilds or possess a similar qualification, so much the better. But experience will be considered as important.

Salary will very much be dependant on age and experience but will reflect the importance of the job. To find out more, telephone or write to:–

Peter Gibson, Sansui Audio Europe N.V.,
Unit 10A,
Lyon Industrial Estate,
Rockware Avenue,
Greenford, Middlesex,
UB6 0AA.

Sansui
Only Hi-Fi, everything Hi-Fi.

(9602)

ELECTRONIC ENGINEERS

The BBC requires experienced electronic engineers to maintain Videotape equipment in its West London premises. These staff work a 7-day fortnight shift pattern.

In addition to possessing a degree in Electrical Engineering, Electronics or Applied Physics, HNC/HND (Electrical) or City & Guilds full Technological certificate in Telecomms., applicants, male or female, must have a thorough understanding of Television Broadcast Systems and be experienced in the maintenance of Videotape equipment.

Starting salary is between £6,350 and £6,913 (including shift allowance).

For further details and application forms, please ring **Ray Bell 01-743 8000 extension 2308.**

BBC tv

(9495)

ENGINEER

The BBC requires an Engineer in the Semiconductor Unit of its Valve Section, Motspur Park, Surrey. The Engineer deals with technical enquiries and is involved in all aspects of the acquisition from manufacturers and the distribution throughout the Corporation of a wide range of solid state devices. Candidates, male or female, should have a Degree or H.N.C. and be experienced in the use of transistors, integrated circuits, etc. and/or be able to demonstrate an in depth knowledge of modern devices.

The salary will be in the range of £6955/£8405 per annum depending on experience. Other benefits include modern pension scheme, 23 days' annual leave, luncheon vouchers and assistance with removal expenses where appropriate.

Requests for application forms to the **Engineering Recruitment Officer BBC, Broadcasting House, London W1A 1AA,** quoting Reference Number 79.E. 2314/WW.

BBC

(9629)

CATV CHIEF ENGINEER

Canada's most advanced CATV manufacturer requires a chief engineer with a solid background in RF and CATV design or related electronic experience. An exciting career opportunity for a highly technical innovative person eager and willing to learn and adapt to new technology in an expanding and stimulating field. Related RF, Passive, Digital, Microwave experience would be valuable to us.

This is a senior position with commensurate salary and a wide range of company benefits.

Situated in Ontario we have beautiful mountains, excellent housing and schooling and superb recreational facilities. An ideal place to bring up the family in an unspoilt area of Canada.

Please forward resumé with salary history and expectations in confidence to:

Mr. Thomas
LINDSAY SPECIALITY PRODUCTS
50 Mary Street West
Lindsay, Ontario, Canada K9V4S7
Tel. Area Code 705 324 2196

(9648)

THE POLYTECHNIC, HUDDERSFIELD
COMPUTING AND AUDIO VISUAL SERVICES DIVISION

TECHNICAL OFFICER

(Audio Visual)
T3 £3732-£4146 Ref NT417 B/WW

A Technical Officer is required to take responsibility for all radio and TV work within the audio visual services. He/she will lead a small team of Technicians, involved in a variety of audio visual work.

Experience of colour TV equipment, including vtr's and cameras is essential, as is C&G 101 or equivalent qualifications. Experience of TV studio and production work is also desirable.

Application forms, obtainable from The Personnel Office, The Polytechnic, Queensgate, Huddersfield HD1 3DH. Telephone Huddersfield 22288, ext. 2223, should be returned by 29th August, 1979.

(9488)

COME TO THE SUNNY SOUTH COAST

We require the following personnel in the areas: Hampshire, Dorset, Sussex, Somerset, Wiltshire and Berkshire.

- **ATE Engineers**
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- **Electronic Design Engineers**
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- **Microprocessor Engineers**
- **Sales Engineers**
- **Software Specialists**
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- **Test Engineers**
- **Buyers**
- **Electro Mechanical/ PCB Draughtsmen**
- **Instrumentation Engineers**
- **Physicists**
- **Microwave Engineers**
- **Service Engineers**
- **Software Programmers**
- **Technical Authors**
- **Q.A. Engineers**

All these positions offer excellent salaries and in most cases relocation expenses.

Please write or ring: **CBS Appointments, 224 Old Christchurch Road, Bournemouth, Bournemouth 292155.** (24-hour Ansaphone Service—Agy.).

(9416)

AMPEX

Ampex Corporation, a world leader in analogue and digital data recording technology, has been designated the official supplier of video recording and magnetic tape products to the 1980 Moscow Olympics. The Group's UK companies now seek:

... ENGINEERS

with broadcast television equipment experience, for their International Systems department which prepares proposals, designs and produces outside broadcast vans and television systems. Interest and challenge for dedicated engineers with possibility of travel overseas.

... CUSTOMER SUPPORT ENGINEERS

to maintain digital or analogue recording equipment throughout the United Kingdom.

These positions are based in Reading. The usual International Company benefits apply including Pension Plan and Life Assurance. Please contact **Joan Feaver, Ampex Great Britain Limited, Acre Road, Reading, Berks. Telephone 0734-85200.**

(9622)

LEEDS CITY COUNCIL
Department of Education
Leeds Polytechnic
Educational Unit

SENIOR TECHNICIAN

(ELECTRONICS)

Ref. 188/10 T 3/4 £3732-£4632 + Technicians qualification allowance. Required to service and maintain high grade electronics equipment used in the various schools of the Polytechnic in their teaching work to a wide range of courses. Knowledge of micro-electronics technology would be an advantage.

Applciation forms quoting reference number from the Administrative Services Officer, Leeds Polytechnic, Calverley Street, Leeds LS1 3HE. Closing date 14 days' after appearance of advert.

(9644)

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29, Windmill St. London. W.1.

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CURRENT VACANCIES INCLUDE

Design development engineers to join a new products group — a "thorn in the flesh" to an industrial giant working on the latest intelligent terminals for TV applications. Very sophisticated audio telephone techniques and a wide range of microprocessors (4 bit - 16 bit) in use. Salary to £9,000 area. Ring and find out.

Commercial-aware Boffin to research futuristic data channels, application of CAD techniques to real design, circuit synthesis, digital coding and researching into high density recording. Intellectual dexterity in physical sciences essential. Area: Middlesex. Salary: "Wot 'e's werf."

Technological Think Tank Boffs, i.e. pretty authoritative engineers to augment a team who have produced some of the most advanced satellite communications and radar systems of the century. To £10,000 for expertise in either computer controlled message switching, servo systems, Microwave systems or VHF/UHF equipment, Berks.

Young graduate to join a high powered firm of telecommunication consultants involved in: research, planning and information retrieval for public and private sector of industry. Intellectual dexterity essential. London. Excellent salary.

ALWAYS IN DEMAND

Electronic engineers for design, development, post design, production control, quality assurance, field trials, systems test, computer field service, test installation and commissioning. Note our success rate is between 70 and 80% of engineers placed.

For further details, please contact:

Charles Airey Associates

"PROBABLY THE BEST KNOWN SUPPLIER OF ELECTRONICS ENGINEERS IN THE COUNTRY"
FINANCIAL TIMES

155 KNIGHTSBRIDGE, LONDON, SW1. TEL: 01-581 0286

(9643)

TEST/QUALITY ASSURANCE ENGINEERS

Test/quality assurance engineers at senior and intermediate level wanted to work on our range of advanced broadcast television studio products including colour and monochrome television studio cameras.

Applicants should have an up to date knowledge of digital and linear circuit techniques gained from experience working on television studio equipment, radar equipment or similar sophisticated products, and qualified to HND, HNC or equivalent level.

Employment benefits include excellent salary, generous holidays, free life and health insurance, pension scheme, staff restaurant and relocation expenses.

Please apply for further details and application forms to Jean Smith at the address given below.

Advanced Broadcasting Equipment

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Telephone: (0264) 61345

(9601)

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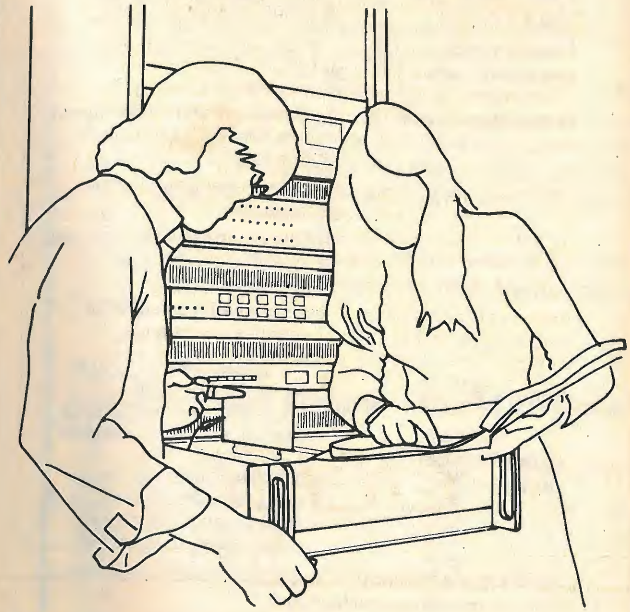

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At Marconi Instruments we ensure that the very best of innovative design is used on our range of communications test instruments and A.T.E. We have a number of interesting opportunities in our Design, Production and Service Departments and we can offer 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 ______________________________

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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 ☐
Qualifications	None ☐	C & G ☐	HNC ☐	Degree ☐

Present job ______________________________

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Return this coupon to John Prodger, Marconi Instruments Limited, FREEPOST, St. Albans, Herts, AL4 0BR. Tel: St Albans 59292

Marconi Instruments

A GEC MARCONI ELECTRONICS COMPANY

(9200)

Imperial War Museum

LONDON

Audio Technician

The Museum illustrates and records all aspects of the two world wars and all other military operations involving Britain and the Commonwealth since 1914. This post is in the Department of Sound Records, where the technical operations are based on a Sound Suite incorporating Leevers-Rich E200 and Revox tape machines, disc reproducers, a Neve BCM 10/2 mixing desk and ancillary facilities.

The technician appointed will be responsible for the control of studio recording, transfer operations, routine servicing and maintenance of all the audio equipment, some location recording, control of public listening facilities in the Museum and the provision and maintenance of certain archival lists and procedural records. In addition the successful candidate will work from old recordings and those produced on domestic equipment, and assist in the production of programme material for use in the Museum's public and educational services.

This post has been exempted from the Government's ban on recruitment.

Candidates must have an ONC in engineering TEC/SCOTEC Cert **or** C & G Pt II in a relevant subject **or** an equivalent or higher qualification, and an aggregate of at least 8 years' training (eg apprenticeships and/or full-time study) and experience. Practical experience of operating and maintaining audio equipment and a theoretical knowledge of sound recording essential.

Salary, starting at £4850 rises to £5390. **Salaries under review.** Non-contributory pension scheme.

For further details and an application form (to be returned by 5 September 1979) write to Civil Service Commission, Alencon Link, Basingstoke, Hants RG21 1JB, or telephone Basingstoke (0256) 68551 (answering service operates outside office hours). **Please quote ref: T/5127.**

(9498)

TELECOMMS TECHNICIANS/ENGINEERS

ABU DHABI

Al-Mariah United Company a fast growing telecommunications company has regular requirements for qualified and experienced personnel ranging from City and Guilds to Degree Level. Present requirements are for Telemetry Systems and VHF/UHF Radio Links CGLI Final and for a Senior Telecoms Engineer (married, accompanied or bachelors) of degree level.

Applications to Mr. George Fee, General Manager, 16 Hallview Grove, Darlington during August with copy to P.O. Box 206, Abu Dhabi with telephone contact. Full C.V. and if bachelor status interest. Usual expatriate terms and conditions.

(9636)

KINGSTON POLYTECHNIC

TECHNICIAN

School of Electronic Engineering and Computer Science

The technician is required to support the work of the digital electronics laboratory. Duties include the servicing of electronic instruments and peripherals, and the development of digital sub-assemblies microprocessors experiments and digital experimentation.

Wide variety of interesting work in the forefront of digital techniques in both development and research. Applicants should have some knowledge of digital integrated circuits and preferably of logical techniques.
T2 grade £3600-£3972 inclusive (award pending).

Application forms from Assistant Registrar (Personnel), Kingston Polytechnic, Penrhyn Road, Kingston upon Thames KT1 2EE, 01-549 1366.

(9637)

Radio Officers

If you trade or training involves radio operating and you are no more than 35 years of age, you qualify to be considered for a Radio Officer post with the Composite Signals Organisation.

A number of vacancies will be available in 1979/80/81 for suitably qualified candidates to be appointed as Trainee Radio Officers. Candidates must have had at least 2 years radio operating experience or hold a PMG, MPT or MRGC certificate.

On successful completion of 40 weeks specialist training, appointees move to the Radio Officer Grade.

Salary Scales

Trainee Radio Officer

Age	
19	£3271
20	£3382
21	£3485
22	£3611
23	£3685
24	£3767
25+	£3856

Radio Officer

Age	
20	£4107
21	£4243
22	£4359
23	£4571
24	£4854
25+	£5166

then by 5 annual increments to £6981 inclusive of shift working and Saturday, Sunday elements

for further details telephone Cheltenham 21491 ext 2269 or write to the address below

(9493)

GCHQ

Recruitment Office

Government Communications Headquarters

Oakley, Priors Road, Cheltenham GL52 5AJ

NATIONAL FILM SCHOOL

ELECTRONICS TECHNICIAN

FOR VIDEO STUDIOS

Experienced in prototype construction, versed in analogue, digital and RF design, to assist video engineer in the establishment and operation of the new video production facility.

Knowledge of video an advantage but not essential.

Apply to Studio Manager for application form, Beaconsfield Studios, Station Road, Beaconsfield, Bucks.

TEL: BEACONSFIELD 71234 ext. 22

(9645)

SITUATIONS VACANT

Test Gear Engineer

Consumer Electronics

We have a vacancy for someone of HND/C (or equivalent) qualification in electronics, with a bias towards television and digital techniques, to join a team engaged in the design and construction of test gear for use in a manufacturing environment.

As well as a good theoretical and practical knowledge, the post demands the ability to apply the elements of circuit design and component technology to the production of test equipment to technical and commercial specification.

It is unlikely that we shall find someone with the necessary experience and creative flair outside the ranks of those already working in the field. Both men and women may apply.

The salary will reflect the job requirements and the calibre of person likely to fill it effectively. In addition, the situation affords a valuable opportunity to join a forward-looking company offering attractive conditions, including generous holiday entitlement, contracted-out pension arrangements, and the satisfaction of doing a technically interesting job located in a very pleasant part of the South Coast. (We will provide help to move here, where this is appropriate.)

Write, phone or call for application form: George Greaves, Senior Personnel Officer, ITT Consumer Products (UK) Ltd., Theaklen Drive, Hastings, Sussex. Tel: (0424) 437061.

ITT

World-wide Technology

The Royal Fleet Auxiliary requires

Junior Radio Officers

Applications are invited for Junior Radio Officer vacancies which will be arising in the near future.
Applicants should possess MRGC and Radar Maintenance Certificate.
For further details and application form contact: The Careers Office, Royal Fleet Auxiliary DST (FMV) 74a, Room 705 Empress State Building, London SW6 1TR. Tel: 01-385 1244 ext 2192
Closing date for receipt of completed applications 5th September.

ROYAL FLEET AUXILIARY **RFA**

(9619)

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(9357)

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(9063)

ARTICLES FOR SALE

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The kit as supplied interfaces to an unmodified Nascom I.

Functions available include +, —, ×, /, sine, arcsine, logarithms and exponents. The design of the unit ensures that only a minimum amount of memory is required to perform complex calculations.

Complete Kit (inc. VAT) £38.75 + £1.25 p&p.

From:

Control and Electronic Developments, 719 Pinebank, Craigavon, Co. Armagh, N. Ireland.

(9375)

FOR SALE: 24 band receiver RF8000 Super National Panasonic, unused, shop soiled only, value £2,000, will let go for £1,200. V.C.R. N.1700. Used, new cost £760, will let go for £350. Reusable 1 hour tapes available at £5 each. — Contact Morris 66455 (0223) office hours, 46274 after office hours. (9464

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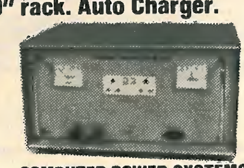

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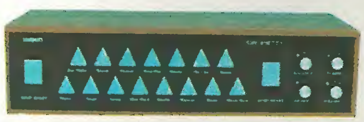

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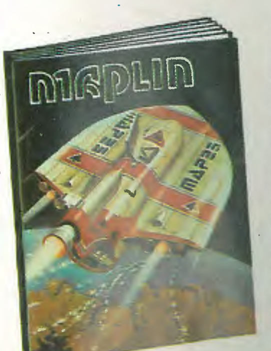

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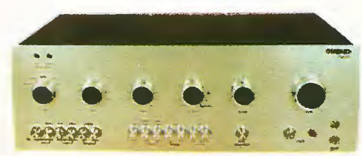

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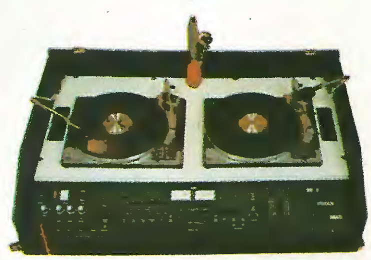

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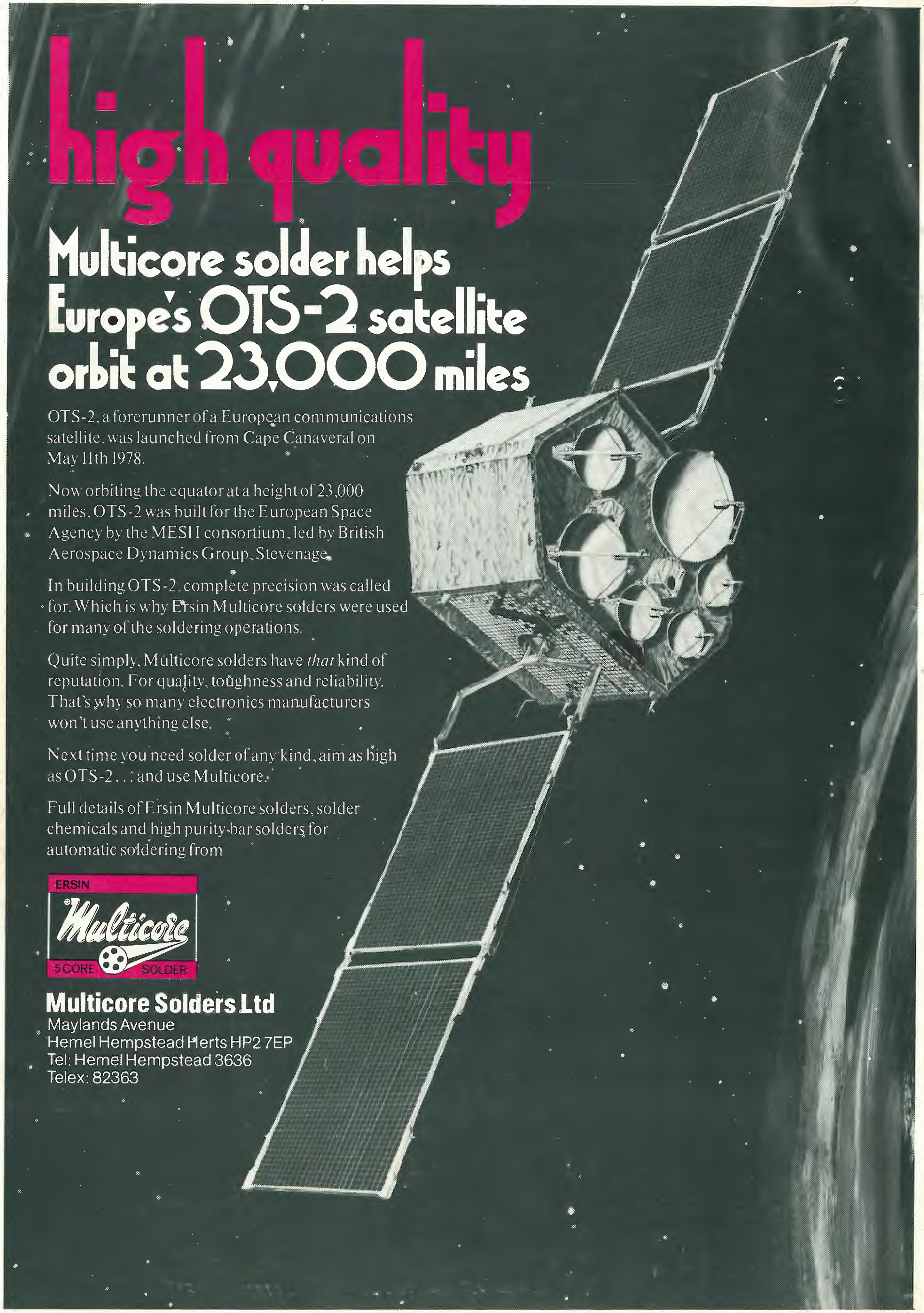
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