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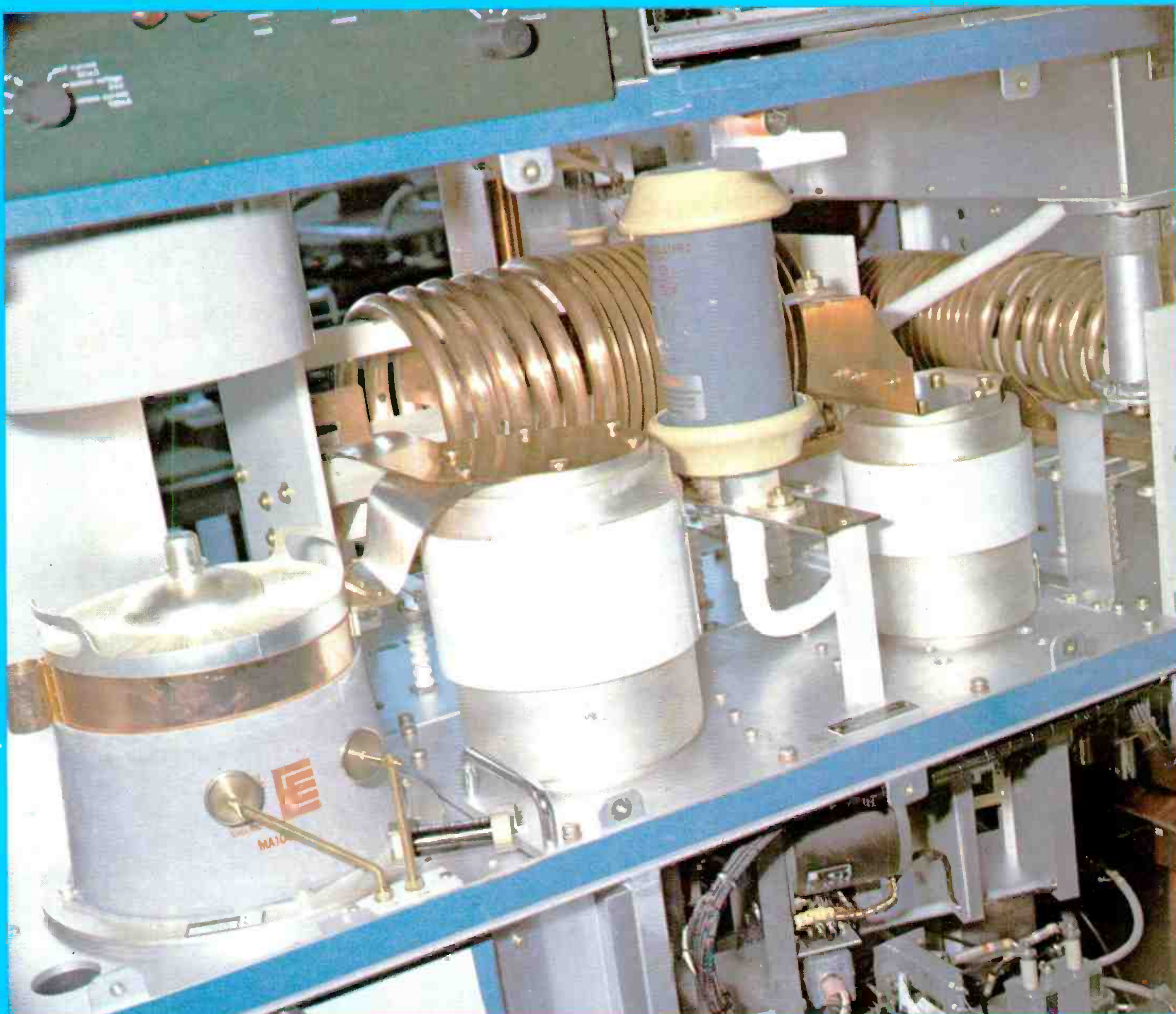

Digital capacitance meter
New Wien oscillator
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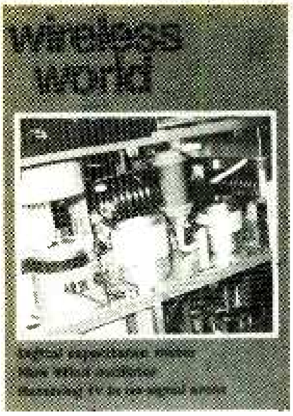

Front cover shows power output stage of 10kW linear h.f. amplifier by Marconi, photographed by Paul Brierley.

IN OUR NEXT ISSUE

***Morse code lock* is operated by keying in up to sixteen characters, which are compared with code in memory.**

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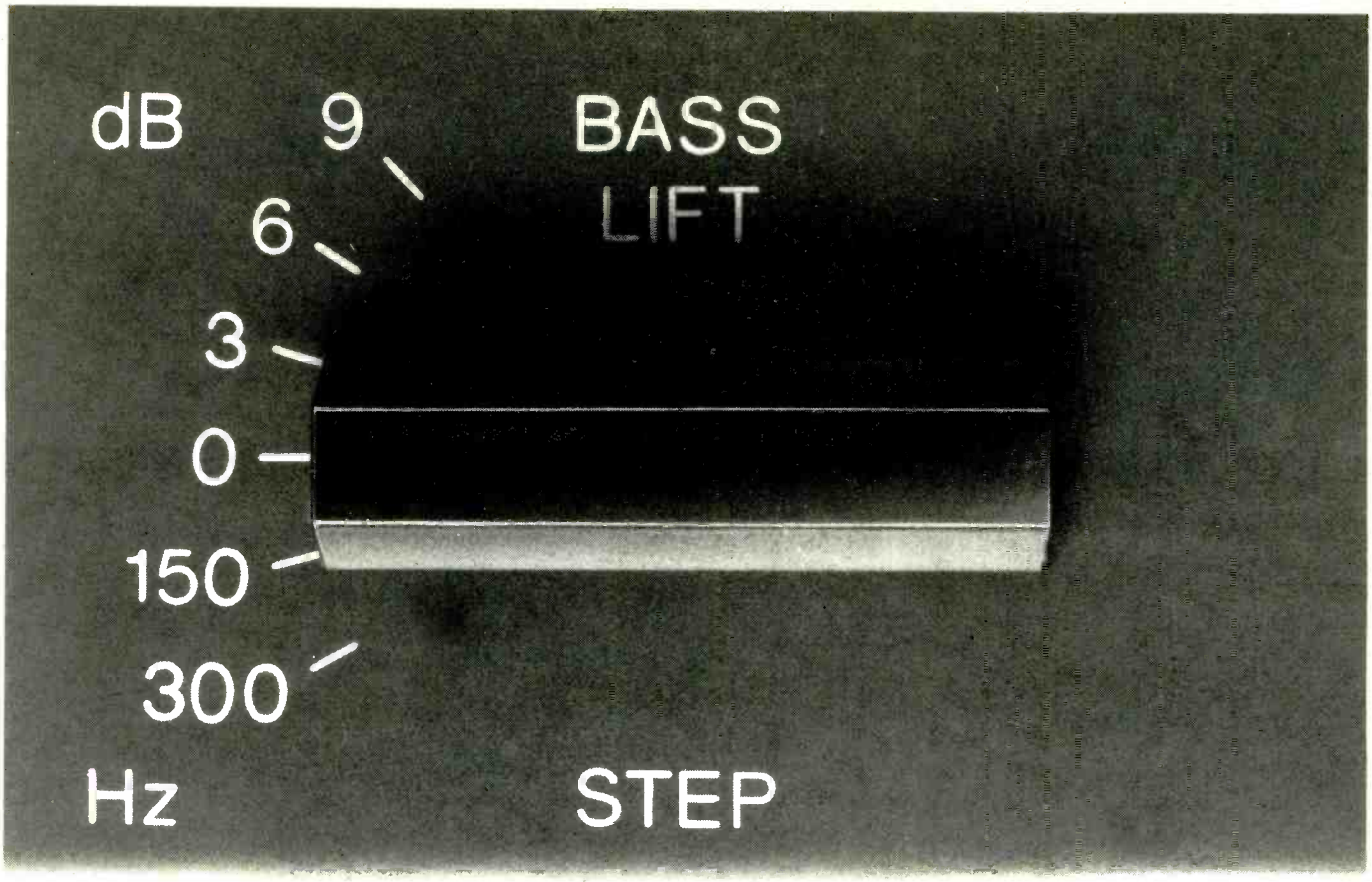
ELECTRONICS / TELEVISION / RADIO / AUDIO

MAY 1981 Vol 87 No 1544



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It is rarely necessary to have to boost the bass response of a top quality high fidelity system, (although the Quad 44 tilt control does enable subtle changes to be made to the overall balance of the programme), but there are a number of high quality loudspeakers on the market, which because of their Lilliputian dimensions, necessarily have attenuated low frequency response and the Quad 44 is fitted with a bass control which in the lift position provides optimum equalisation.

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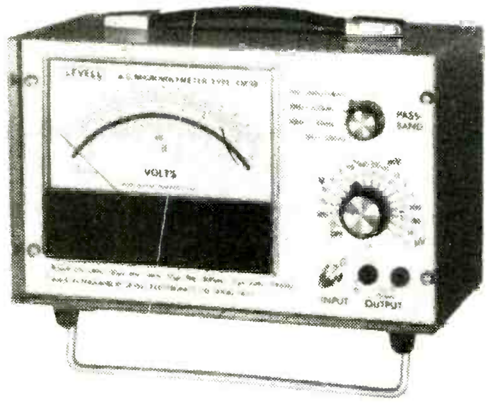
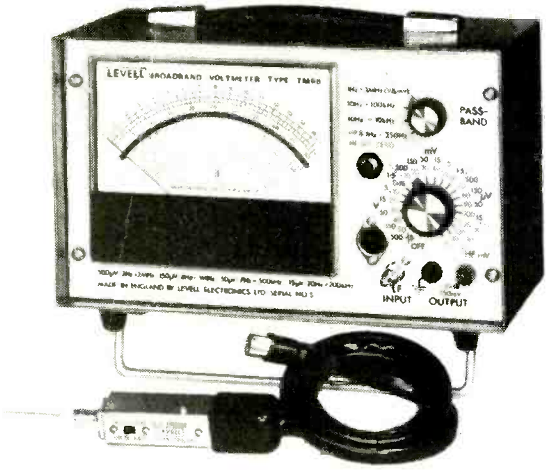


A.C. MICROVOLTMETERS

VOLTAGE & dB RANGES	15μV, 50μV, 150μV . . . 500V fsd. Acc. ± 1% ± 1% fsd ± 1μV at 1kHz. — 100, —90 . . . + 50dB. Scale —20dB/ + 6dB ref. 1mW/600Ω.
RESPONSE	± 3dB from 1 Hz to 3MHz, ± 0.3dB from 4 Hz to 1MHz above 500μV. TM3B filter switch: LF cut 10Hz, HF cut 100KHz, 10KHz or 350Hz.
INPUT IMPEDANCE	Above 50mV: 10MΩ <20pF. On 50μV to 50mV: >5MΩ <50pf.
AMPLIFIER OUTPUT	150mV at fsd.

type TM3A £130 **type TM3B £145**



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H.F. VOLTAGE & dB RANGES	1mV, 3mV, 10mV . . . 3V fsd. Acc. ± 4%± 1% fsd at 30MHz. —50, —40 . . . +20dB. Scale — 10dB/ + 3dB ref. 1mW/50Ω.
H.F. RESPONSE	± 3dB from 300kHz to 400MHz. ± 0.7dB from 1MHz to 50MHz.
L.F. RANGES	As TM3.
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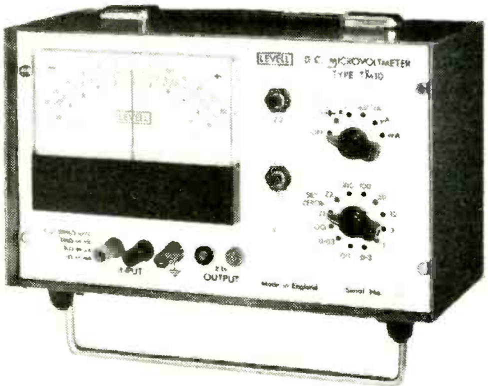
type TM6A £199 **type TM6B £215**



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VOLTAGE RANGES	30μV, 100μV, 300μV . . . 300V. Acc. ± 1% ± 2% fsd ± 1μV. CZ scale.
CURRENT RANGES	30pA, 100pA, 300pA . . . 300mA. Acc. ± 2% ± 2% fsd ± 2pA. CZ scale.
LOG. RANGE	± 5μV at± 10% fsd, ± 5mV at ±. 50% fsd, ± 500m V at fsd.
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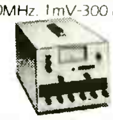

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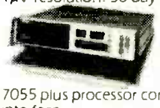

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Hewlett Packard.
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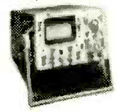

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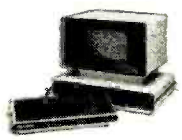

Modular One. Now with upper/lower case, XY cursor addressing, 24 x 80 line display, dual intensity detachable keyboard, choice of 8 transmission rates up to 9600 baud **£399.00**

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15in. diagonal green phosphor tube, integral power supply. Requires separate horizontal and vertical video input. BRAND NEW SURPLUS **£75.00**

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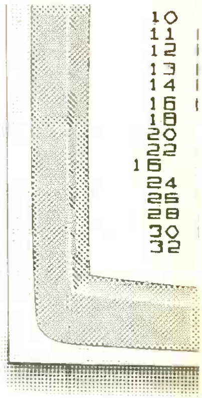


New! Sinclair ZX81 Personal Computer.

Kit: £49.95 complete

Built: £69.95 complete

Reach advanced computer comprehension in a few absorbing hours

1980 saw a genuine breakthrough – the Sinclair ZX80, world's first complete personal computer for under £100. At £99.95, the ZX80 offered a specification unchallenged at the price.

Over 50,000 were sold, and the ZX80 won virtually universal praise from computer professionals.

Now the Sinclair lead is increased: for just £69.95, the new Sinclair ZX81 offers even more advanced computer facilities at an even lower price. And the ZX81 kit means an even bigger saving. At £49.95 it costs almost 40% less than the ZX80 kit!

Lower price: higher capability
With the ZX81, it's just as simple to teach yourself computing, but the ZX81 packs even greater working capability than the ZX80.

It uses the same micro-processor, but incorporates a new, more powerful 8K BASIC ROM – the 'trained intelligence' of the computer. This chip works in decimals, handles logs and trig, allows you to plot graphs, and builds up animated displays.

And the ZX81 incorporates other operation refinements – the facility to load and save named programs on cassette, for example, or to select a program off a cassette through the keyboard.

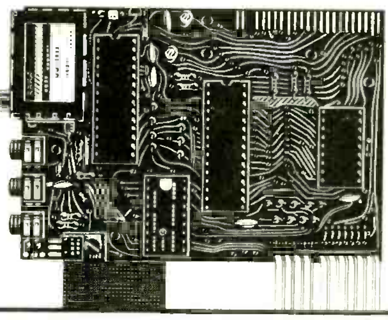
Higher specification, lower price – how's it done?
Quite simply, by design. The ZX80 reduced the chips in a working computer from 40 or so, to 21. The ZX81 reduces the 21 to 4!

The secret lies in a totally new master chip. Designed by Sinclair and custom-built in Britain, this unique chip replaces 18 chips from the ZX80!

Kit or built – it's up to you!

The picture shows dramatically how easy the ZX81 kit is to build: just four chips to assemble (plus, of course the other discrete components) – a few hours' work with a fine-tipped soldering iron. And you may already have a suitable mains adaptor – 600 mA at 9 V DC nominal unregulated (supplied with built version).

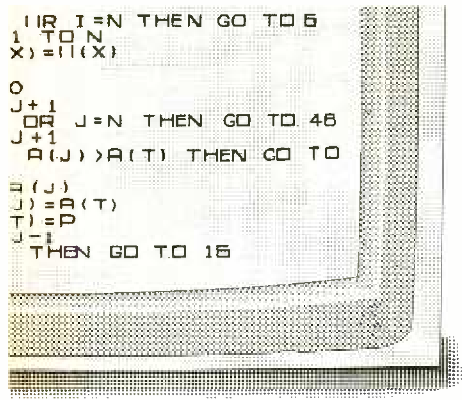
Kit and built versions come complete with all leads to connect to your TV (colour or black and white) and cassette recorder.



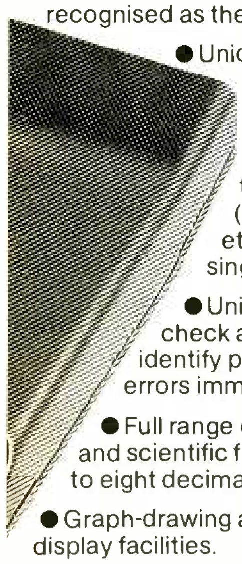
Proven micro-processor, new 8K BASIC ROM, RAM – and unique new master chip.

New Sinclair teach-yourself BASIC manual

Every ZX81 comes with a comprehensive, specially-written manual – a complete course in BASIC programming, from first principles to complex programs. You need no prior knowledge – children from 12 upwards soon become familiar with computer operation.



ew, improved specification
Z80A micro-processor – new faster ersion of the famous Z80 chip, widely recognised as the best ever made.



- Unique 'one-touch' key word entry: the ZX81 eliminates a great deal of tiresome typing. Key words (RUN, LIST, PRINT, etc.) have their own single-key entry.
- Unique syntax-check and report codes identify programming errors immediately.
- Full range of mathematical and scientific functions accurate to eight decimal places.
- Graph-drawing and animated-display facilities.
- Multi-dimensional string and umerical arrays.
- Up to 26 FOR/NEXT loops.
- Randomise function – useful for games s well as serious applications.
- Cassette LOAD and SAVE with amed programs.
- 1K-byte RAM expandable to 16K ytes with Sinclair RAM pack.
- Able to drive the new Sinclair printer ot available yet – but coming soon!)
- Advanced 4-chip design: micro-rocessor, ROM, RAM, plus master chip unique, custom-built chip replacing 3 ZX80 chips.

sinclair ZX81

Sinclair Research Ltd,
Kings Parade, Cambridge, Cambs., CB2 1SN. Tel: 0276 66104.
Reg. no: 214 4630 00

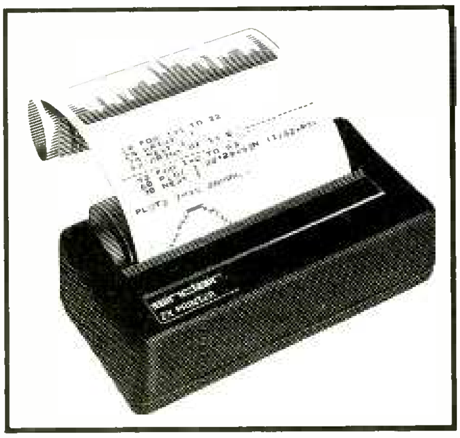
If you own a Sinclair ZX80...

The new 8K BASIC ROM used in the Sinclair ZX81 is available to ZX80 owners as a drop-in replacement chip. (Complete with new keyboard template and operating manual.)

With the exception of animated graphics, all the advanced features of the ZX81 are now available on your ZX80 – including the ability to drive the Sinclair ZX Printer.

Coming soon-the ZX Printer.

Designed exclusively for use with the ZX81 (and ZX80 with 8K BASIC ROM), the printer offers full alphanumerics across 32 columns, *and* highly sophisticated graphics. Special features include COPY, which prints out exactly what is on the whole TV screen without the need for further instructions. The ZX Printer will be available in Summer 1981, at around £50 – watch this space!



16K-BYTE RAM pack for massive add-on memory.

Designed as a complete module to fit your Sinclair ZX80 or ZX81, the RAM pack simply plugs into the existing expansion port at the rear of the computer to multiply your data/program storage by 16!

Use it for long and complex programs or as a personal database. Yet it costs as little as half the price of competitive additional memory.

How to order your ZX81
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BY FREEPOST – use the no-stamp-needed coupon below. You can pay by cheque, postal order, Access or Barclaycard.
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2

To: Sinclair Research Ltd, FREEPOST 7, Cambridge, CB2 1YY. **Order**

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3X017	30+30	1.33
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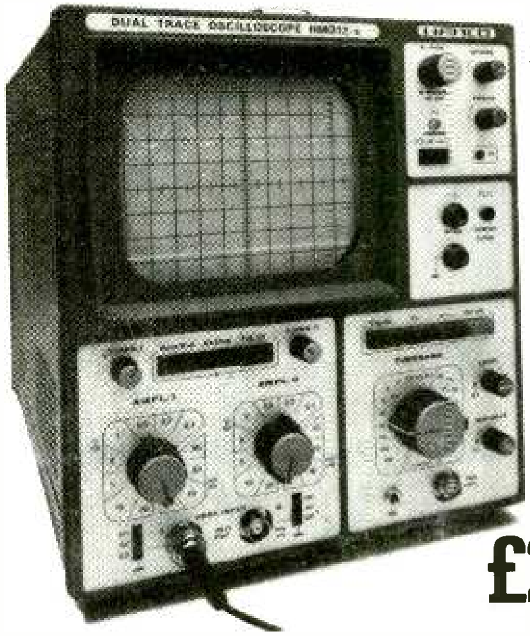

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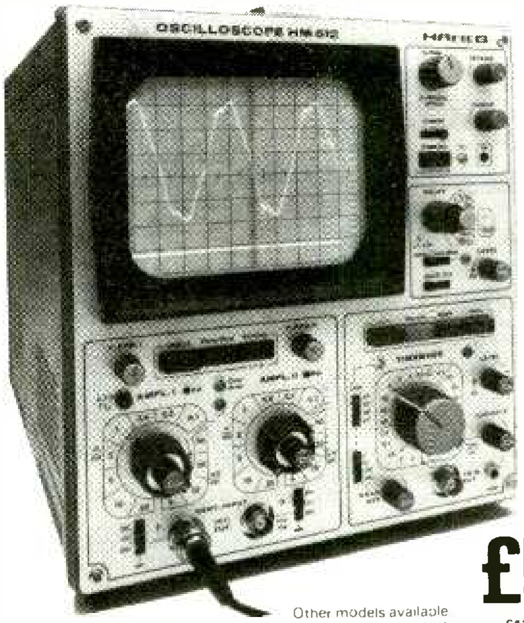

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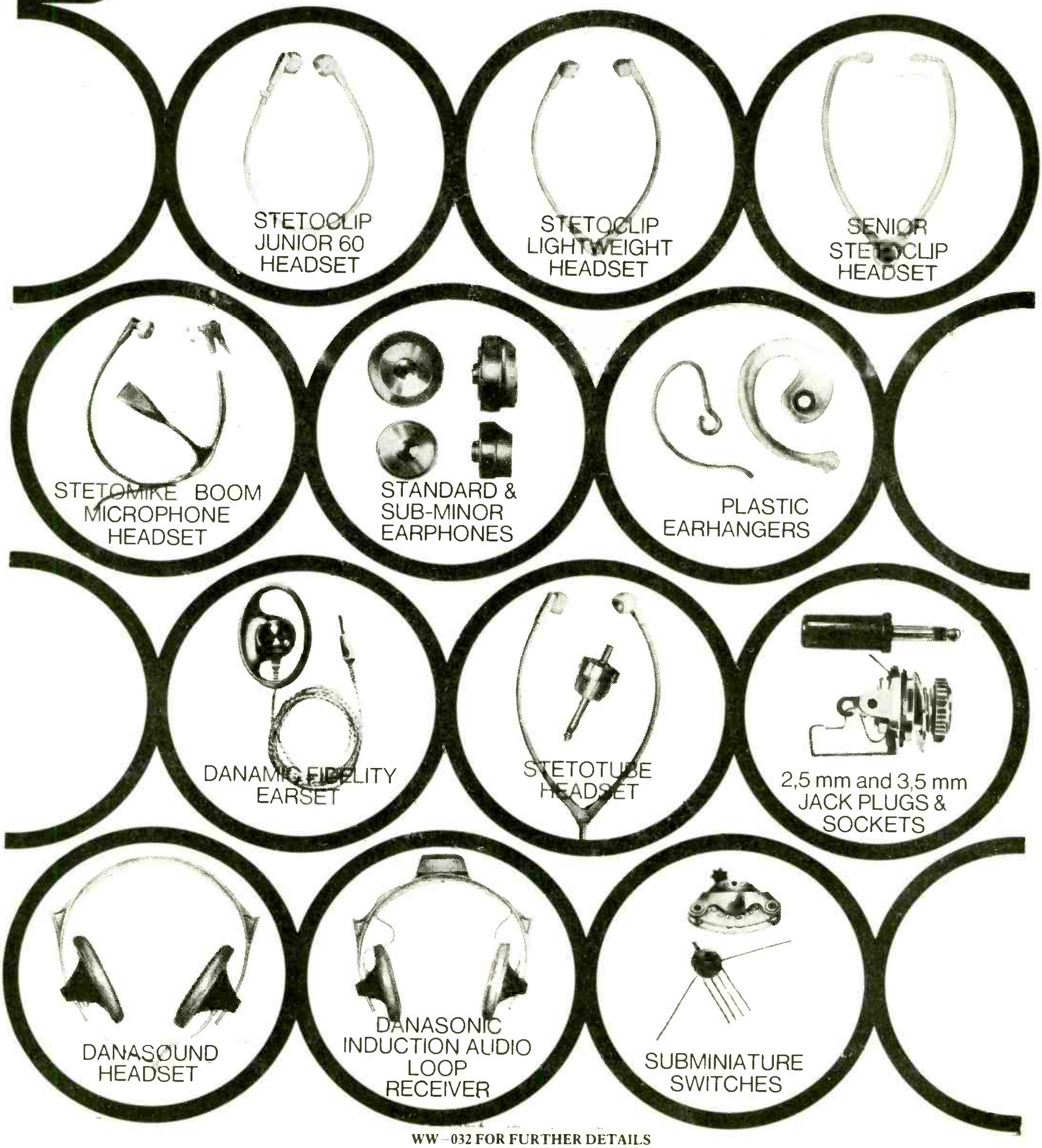

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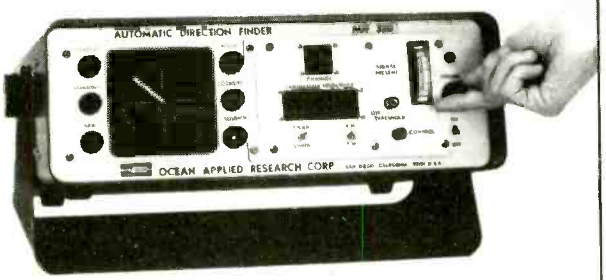

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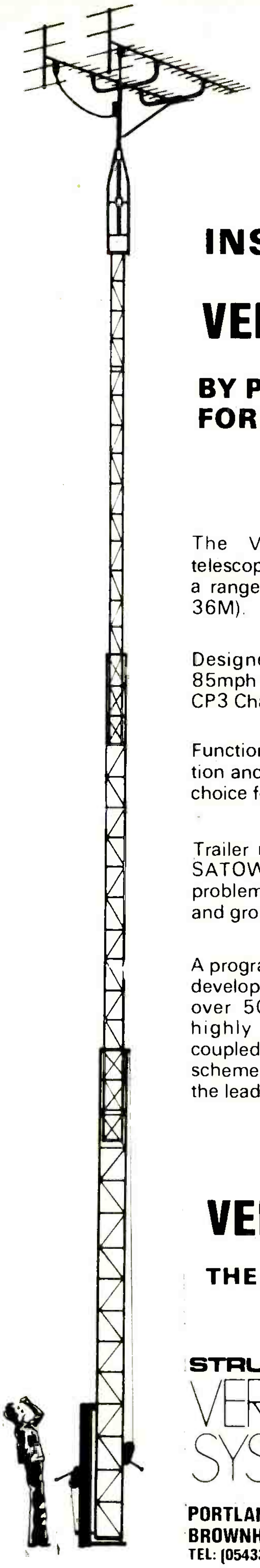

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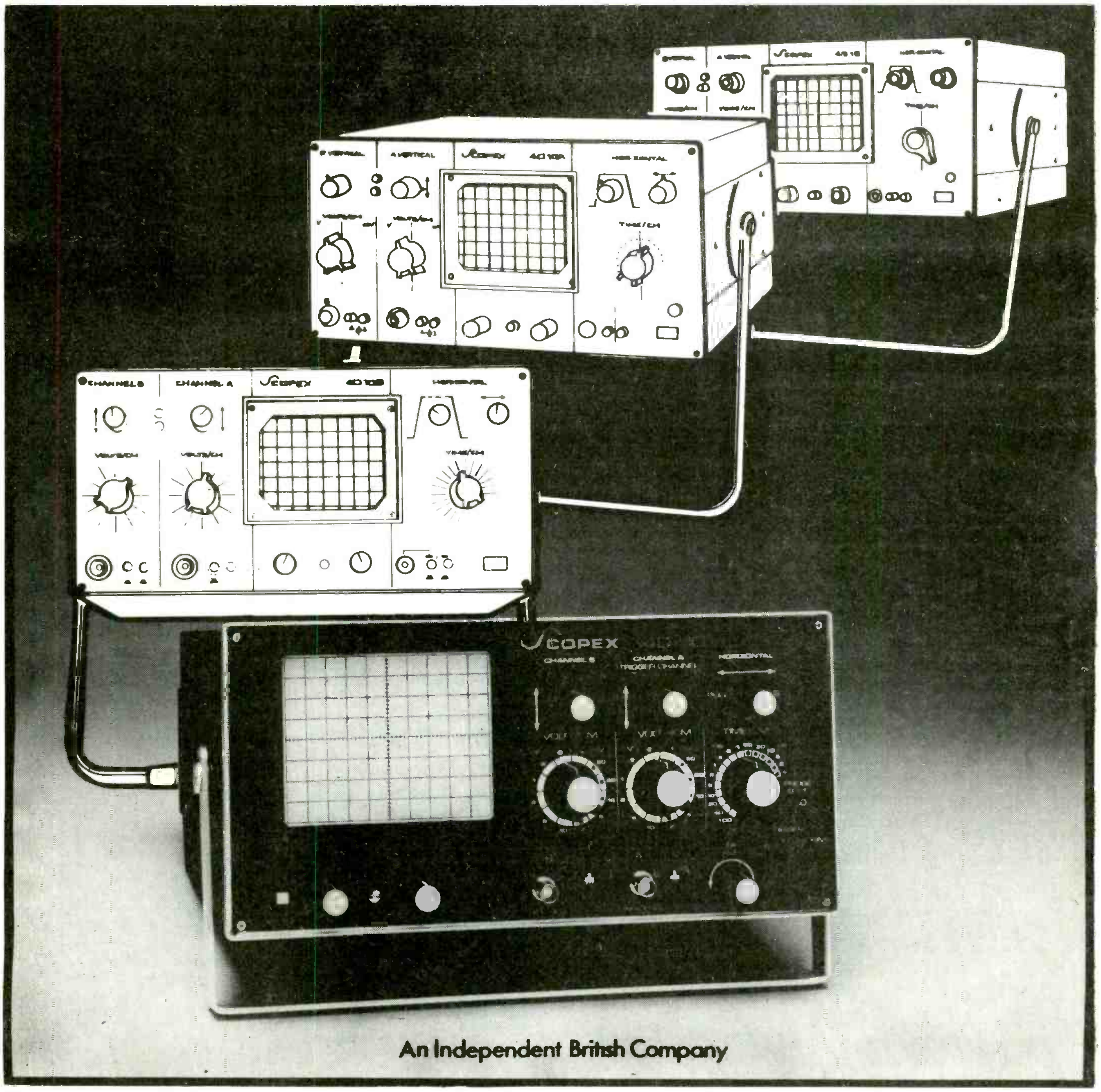

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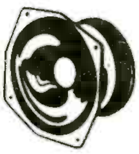

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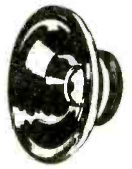

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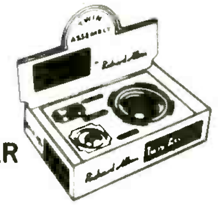

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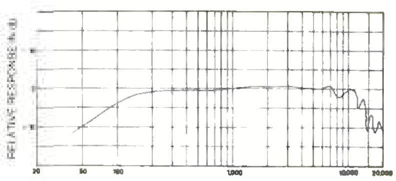

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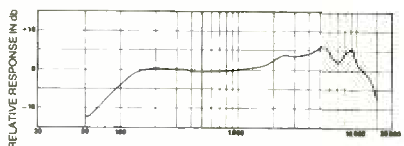

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Deputy Editor:
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Technical Editor:
GEOFF SHORTER, B.Sc.
01-661 3500 X3590

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Communications Editor:
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News Editor:
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01-3500 3587

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01-661 3130

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Most readers will be aware that the Home Secretary has given his assent to the use of personal radio (c.b.) equipment in the UK. The bands to be allotted in the Autumn are around 27MHz and 930MHz, frequency modulation to be used in both.

We congratulate all those concerned with this decision for recognizing that the public has a right to the private use of radio communication, and for choosing a specification that will afford users a tractable frequency (27MHz) while keeping potential interference to a minimum by the use of f.m. It is probably the best that could be hoped for by any thinking person: while 930MHz transceivers would probably be even better from the interference point of view, there has been enough adverse comment on this suggested band to reduce its chances of large-scale adoption. Its possible dangers to health, despondent guesses at the short range to be expected and some wild estimates of high prices may be exaggerated, but some of the mud will doubtless stick, at least until the rest of the world adopts this u.h.f. band, as is possible.

The choice of modulation is a blow in the face for the very large number of users of illicit 27MHz, amplitude-modulated sets in the UK. These people have operated their 'rigs' for several years now, and have conducted a campaign to have an a.m., 27MHz band legalized. They have shown themselves to be not in the least concerned with the effects of their activities on the community and will probably continue to use their illegal equipment: the cachet of respectability and social responsibility is unlikely to be worth the cost of a new transceiver and a licence to operate.

Sooner or later they will begin to change to f.m. sets, and as soon as this happens, the rest will have to conform or face the danger of being left high and dry, talking to themselves. The Home Office choice of f.m. is a good one: not only will it lead to much less interference than a.m., but it is a rap across the knuckles for the pirates. They have deliberately broken the law and cannot grumble when they are put to some expense and inconvenience.

Amateur radio could well find itself the slightly surprised beneficiary of any surge of enthusiasm for c.b. radio. Throughout the campaign for c.b., amateurs have presented a fairly equable face to the c.b. fraternity: relatively few condemnatory remarks have been published – fewer than might have been expected. It may be that, attracted by the temperate attitude of the amateurs and limited by the inflexibility of c.b. equipment, c.b. enthusiasts will 'graduate' to full amateur status and worldwide, rather than local communication.

The protracted lobbying for a personal radio band ought to have its effect on the Home Office, too. Its job is to ensure that the radio spectrum is properly used, not to assume ownership. This decision could have been taken many months ago, long before the number of a.m. sets constituted a problem. There was no constitutional reason not to take it: nothing has changed – if 27MHz f.m. is available now, it could also have been made available then. If it was considered that such an allocation would cause interference then, it will do so now, and the public interest is being compromised.

If a similar demand for an allocation occurs in the future, let us have a little more open discussion and less concealment or exaggeration of selected facts, on both sides.

Digital capacitance meter

A four-digit meter with input circuit protection for measuring values from 1pF to 1000μF

by **I. H. Ibrahim,** Ph. D., Cairo University

Input protection circuits on wide-range, low-cost, capacitance meters are often a source of non-linearity errors. This article describes the theory of operation and construction of a four-digit capacitance meter which can be used to measure capacitors from 1pF to 1000μF in six ranges. Emphasis has been placed on the design of the input protection circuit and other parts of the circuit where errors could possibly be introduced. A null adjustor allows compensation for stray capacitance, and a polarizing voltage can be used for electrolytics.

The different techniques used for measuring the value of a capacitor at low frequencies can be divided into three general groups: reactance compensation, impedance comparison and charge injection. When low frequncies are used, the effects of lead inductance and high-frequency dielectric losses may be neglected. In the first technique, reactance compensation, the capacitor to be measured is connected to the input of the meter and the impedance of the input adjusted until its reactance at the fixed operating frequency is equal to that of the capacitor, but with opposite sign. The capacitor and the impedance of the input form a resonant network and the value of the capacitor can be obtained from the impedance value of the input at the point at which the peak voltage or current is obtained. This method, although accurate, is difficult to apply when high-value and electrolytic capacitors are to be measured.

In the second method, impedance comparison, the capacitor under test is connected as part of a bridge circuit. When balance conditions are obtained the value of the capacitor can be calculated from the known values of the other components of the bridge and the operating frequency. This method is suitable for high-accuracy measurements, but it has the disadvantage that the balancing procedure in manually balanced bridges is tedious. On the other hand, automatic and self-balancing bridges are very expensive.

The third technique is the charge-injection method in which an electrical charge of Q coulombs is injected into the capacitor during a charging period of T seconds. This will cause a change of V volts in the capacitor voltage. The value of the capacitor is then obtained as the ratio Q/V farads. In some meter circuits Q is a constant value while V is inversely proportional to the value of the capacitor. In other meter circuits the change in voltage over the capacitor is constant, while Q is directly proportional to the value of the capacitor. But as the charge Q is the integration of current with time it is possible to design meter circuits so that the charging period T is directly proportional to the measured capacitor. The latter method is used in this design and is the most convenient for digital capacitance meters, in which the charging period is measured by counting the number of clock pulses that occur during that period. These clock pulses are usually obtained from a stable crystal oscillator.

Input protection

Most low-cost meter circuits do not include a means of protecting the meter against any initial charge stored in the capacitor under test. The need for protection becomes greater when the meter is designed for measuring large and electrolytic capacitors, which are capable of storing large electrical charges over long periods. In this case, it is vital to insert a suitable protection network between the capacitor under test and the input port of the meter. The insertion of such a network usually causes a non-linear relation between the value of the capacitance and the charging period T and this in turn causes non-linearity errors in the readings. Fortunately, with optimum design of the protection network, it is possible to reduce these errors to negligible proportions – much smaller than the errors caused by the tolerances of the values of the circuit components. The various sources of error will be discussed in more detail later in this article.

Charge-injection technique

Although this technique is well known, a quick review will help to show the effect of inserting the protection network. Figure 1 shows the basic idea of the charge-injection method. The capacitor C_x is charged from

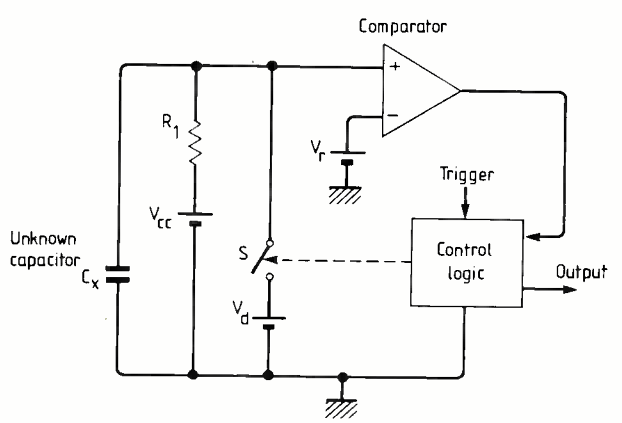

Fig. 1. Simplified diagram of the charge-injection technique used to measure capacitors.

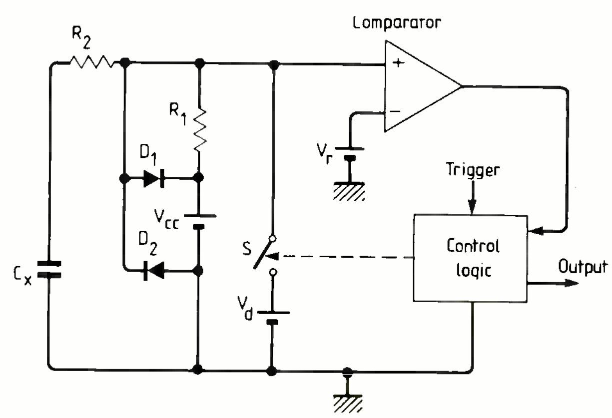

Fig. 2. The simplified charge-injection circuit with input circuit protection consisting of R_2, D_1 and D_2. An initial charge in C_x is discharged through R_2 and the switch S.

V_{cc} through R_1 until the voltage across it reaches the value of the reference voltage V_r. The output voltage from the comparator will then go positive. This will be sensed by the logic-control circuit, which will then close the switch S, discharging the capacitor to a voltage V_d, which is less than V_r.

In digital capacitance meters, the data is updated every T_o seconds by triggering of the control-logic circuit, which opens switch S and starts the capacitor charging. During the charging period T, the voltage across the capacitor will rise from V_d to V_r in a time T, given by:

$$T=R_1C_x\log_e\frac{V_{cc}-V_d}{V_{cc}-V_r} \qquad (1)$$

and is directly proportional to C_x. The period during which the capacitor is being discharged (switch S closed) will be termed the relaxation period, and is equal to T_o-T. In Fig 1, the relaxation period has no effect on the charging period, assuming that switch S is ideal.

A similar situation will arise if V_{cc} and R_1 are replaced by a current source I. The charging period then becomes:

$$T=C_x.\ (V_r-V_d)/I \qquad (2)$$

and is still directly proportional to C_x.

The circuit of Fig 2 is similar to that of Fig. 1, apart from the addition of the protection circuit R_2, D_1 and D_2. When a capacitor with an initial charge voltage greater than V_r is connected as shown in Fig. 2, it will be discharged through R_2 and the closed switch S. When the voltage across the series combination of C_x and R_2 is less than the reference voltage V_r, the logic circuit will trigger, open the switch, and start the capacitor charging up again. The two diodes are used to keep the input voltage of the comparator between -V_{D2} and+ (V_{D1}+V_{cc}), where D is the forward voltage-drop of the diode used.

The following formula shows that for steady-state conditions, the period I can be obtained:

$$V_{cc}-V_d+\left(V_{cc}\frac{R_2}{R_1}-V_r(1+\frac{R_2}{R_1})\right).\ \exp\left(\frac{-(T_o-T)}{R_2C_x}\right)=\left(1+\frac{R_2}{R_1}\right).(V_{cc}-V_r).\ \exp\left(\frac{T}{C_x(R_1+R_2)}\right) \qquad (3)$$

The solution of this formula is a non-linear relation between the value of the capacitor and the charging period. Before considering this relationship, take the limiting case where the updating period T_o and the relaxation period T_o-T, are very long compared with the time constant R_2C_x. Equation 3 can then be simplified and the following expression applied:

$$T_1=\ (R_1+R_2)C_x\log_e\left(\frac{R_1(V_{cc}-V_d)}{(R_1+R_2)(V_{cc}-V_r)}\right) \qquad (4)$$

Note that T has been changed to T_1 in

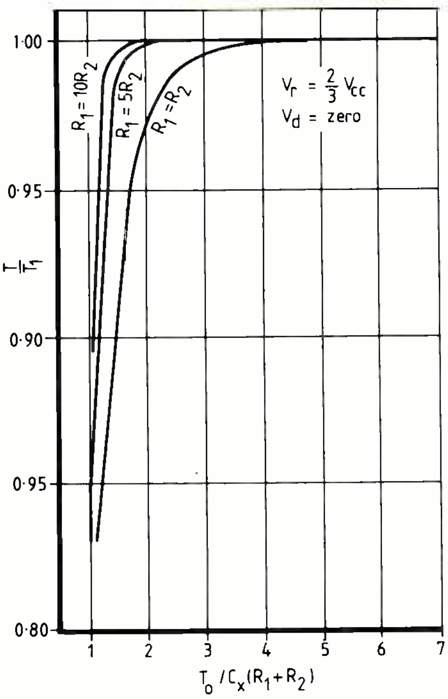

Fig. 3. The error in the charging period T caused by the protection network.

equation 4. Ideally, the charging period T needs to be directly proportional to C_x so we investigated practical circuit modification which would make T of equation 3 approach the limiting solution given in equation 4.

Because the analytical solution of equation 3 is difficult to obtain we solved it numerically for a specific case where we assumed that V_d=0 and V_r= $2V_{cc}/3$. These figures were chosen so that the results can be directly applied to circuits using the 555 timer. The results are shown in Fig. 3 where T/T_1 is plotted againt $T_o/C_x(R_1+R_2)$ with R_1/R_2 as a parameter. T is obtained from equation 3 and T_1 is as given by equation 4. The results show that T becomes very close to T_1 if T_o is a few times greater than C_x (R_1+R_2), if R_1 is much greater than R_2 or if both conditions apply. Calculations have shown that if R_1 is greater than 0.6 R_2 and if T_o is greater than 6C_x(R_1+R_2), the difference between T and T_1 is less than 0.01%.

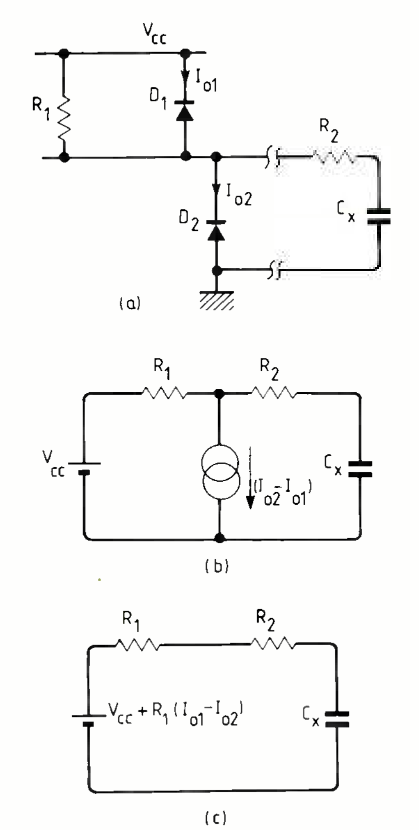

Fig. 4. Charging circuit of the capacitor under test. The practical circuit is shown in a, an equivalent linear circuit in b, and an equivalent Thévenin circuit in c.

Other sources of error

When the circuit of Fig. 2 is designed so that the above requirements are satisfied, the charging period will be given by equation 4 only if the two diodes are identical and if the input impedance of the comparator is equal to infinity. From a practical point of view those additional requirements are impossible, so it is worth while investigating their influence on the meter accuracy.

Let us first consider the effect of the protection diodes D_1 and D_2, assuming that they carry the reverse saturation currents I_{o1} and I_{o2} respectively. The two diodes, together with R_1 and V_{cc}, are replaced by an equivalent Thévenin circuit with an output resistance of R_1 and an open-circuit voltage of V_{cc}+(I_{o1}−I_{o2})R_1 as shown in Fig. 4. The charging period given by equation 4 should then be modified to:

$$T=C_x(R_1+R_2)\times\log_e\frac{R_1(V_{cc}-V_d+(I_{01}-I_{o2})R_1)}{(R_1+R_2)(V_{cc}-V_r+(I_{o1}-I_{o2})R_1)} \qquad (5)$$

Equation 5 indicates that T is still proportional to C_x, but now a new problem arises, due to the dependence of the proportionality constant on the reverse saturation currents, which are temperature dependent. If the two diodes are identical, the effect of the reverse saturation currents will be cancelled out. It is advisable to select the diodes so that the error in T caused by the drift in the circuit components is compensated for by the effect of the drift in I_{o1} and I_{o2}. The second source of error that should be investigated is the input capacitance of the comparator. Its effect is considered in the following section.

Input capacitance effects

In the circuit of Fig. 1, the comparator input capacitance C_{in} is in parallel with the capacitor C_x and the charging period is given by:

$$T=(C_x+C_{in}).\log_e\frac{V_{cc}-V_d}{V_{cc}-V_r} \qquad (6)$$

For the circuit of Fig. 2, it is difficult to find an exact expression for the charging period, so an approximate expression is given.

For sake of simplicity the analysis begins with the assumption that T_o is greater than 6(C_x+C_{in}). (R_1+R_2), and V_d=0. The Laplace transform of the voltage input to the comparator during the charging period will be equal to:

$$V_{in}(s)=\frac{V_{cc}}{s}\times\frac{1+R_2C_xs}{s^2R_1R_2C_xC_{in}+s(R_1C_{in}+R_1C_x+R_2C_x)+1} \qquad (7)$$

where s is the complex frequency. The frequency domain expression for $V_{in}(s)$ has two real poles, and a third pole located at the origin of the complex frequency-plane. The locations of the two poles can be obtained from equation 7.

It is interesting to consider the relationships between the values of the components R_1, R_2, C_x, and C_{in} of a practical meter circuit under these three conditions:

(a) When the meter is set to measure small capacitances. In this case the resistance R_1, which is the range setting resistor, will have a very large value compared with R_2.

(b) When the meter is used to measure medium value capacitors, usually where $R_1C_x >> R_2C_{in}$.

(c) When the capacitor to be measured, $C_x >> C_{in}$.

In any of the above cases it could easily be shown that the two real poles of equation 7 are located near s_1 and s_2 by:

$$s_1=-\left(\frac{1}{R_1C_{in}}+\frac{1}{R_2C_{in}}+\frac{1}{R_2C_x}\right)$$

$$s_2=\frac{-1}{R_1(C_{in}+C_x)+R_2C_x} \qquad (8)$$

Under the conditions stated in (a), (b) and (c) above we find the pole at s_1 is located much further to the left of the pole at s_2 in the complex frequency plane. This means that in the time-domain, the first pole will produce rapidly decaying exponential components that will decay down to a negligible value before the charging period is reached. To a good degree of approximation, the time-domain expression for V_{in} will be:

$$V_{in}(t) = V_a + V_b \exp(s_2t)$$

The charging period after which the voltage V_{in} reaches the reference voltage V_r will then be inversely proportional to s_2 as is shown by:

$$T=((R_1+R_2)C_x+R_1C_{in})\times \log_e\frac{R_1(V_{cc})}{(R_1+R_2)(V_{cc}-V_r)} \qquad (9)$$

This shows that the indicated value for the capacitance will be greater than the true value by an amount proportional to C_{in}. That error can be easily compensated for by inhibiting the clock pulses to the counter for a short period.

The meter was built around a four-digit counter and an NE555 timer operating in the monostable mode so that the duration of the output pulse is a linear function of the measured capacitance. The design was optimized according to the above theoretical analyses, so that the accuracy of the meter is maintained throughout all the ranges.

Figure 5 shows the monostable configuration and the protection circuit. To start with, a reasonable value for the current-limiting resistor R_2 must be found, so that the discharge current through pin seven of the ic does not exceed 200mA. We chose R_2 as 1kΩ, to allow measurement of capacitors that are initially charged up to 200 volts without causing damage to the NE555.

The second step is calculating the value of the charging-up resistor, R_1 (one of the range selection resistors R_{1a} to R_{1d}), using equation 4 with $V_d=0$, $V_r=⅔V_{cc}$, and the charging period T (which is arbitrary) chosen from Table 1.

Table 1

Range	1	2	3	4	5	6
C_x (minimum)	1 pf	10 pf	100 pf	1 nf	10 nf	0.1 µf
C_x (maximum)	10 nf	0.1 µf	1 µf	10 µf	100 µf	1000 µf
T_{max} (seconds)	0.01	0.1				1.0
Clock frequency	1MHz	100 kHz				10 kHz
R_1 (ohms)	910149	910149	90939	9061.1	1137.5	1137.5
$\frac{R_1.C_x\ (\text{min.})}{R_2.C_{in}}$	20.22	202.2				2527
T_0 (seconds)	0.1	1.0				10.0

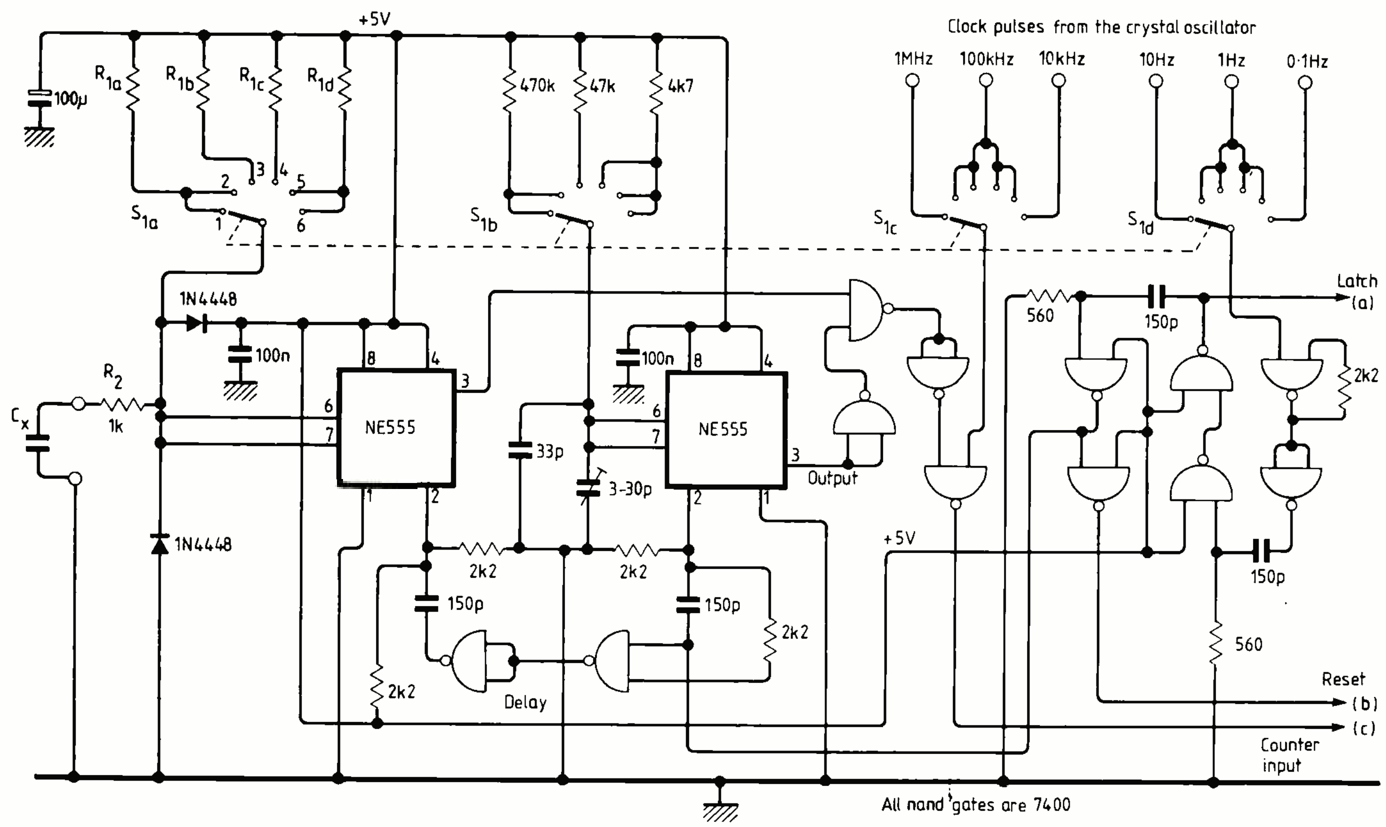

Fig. 5. Circuit diagram of the charge-injector, input protection, null adjustment, range-selectors and counter-drive sections.

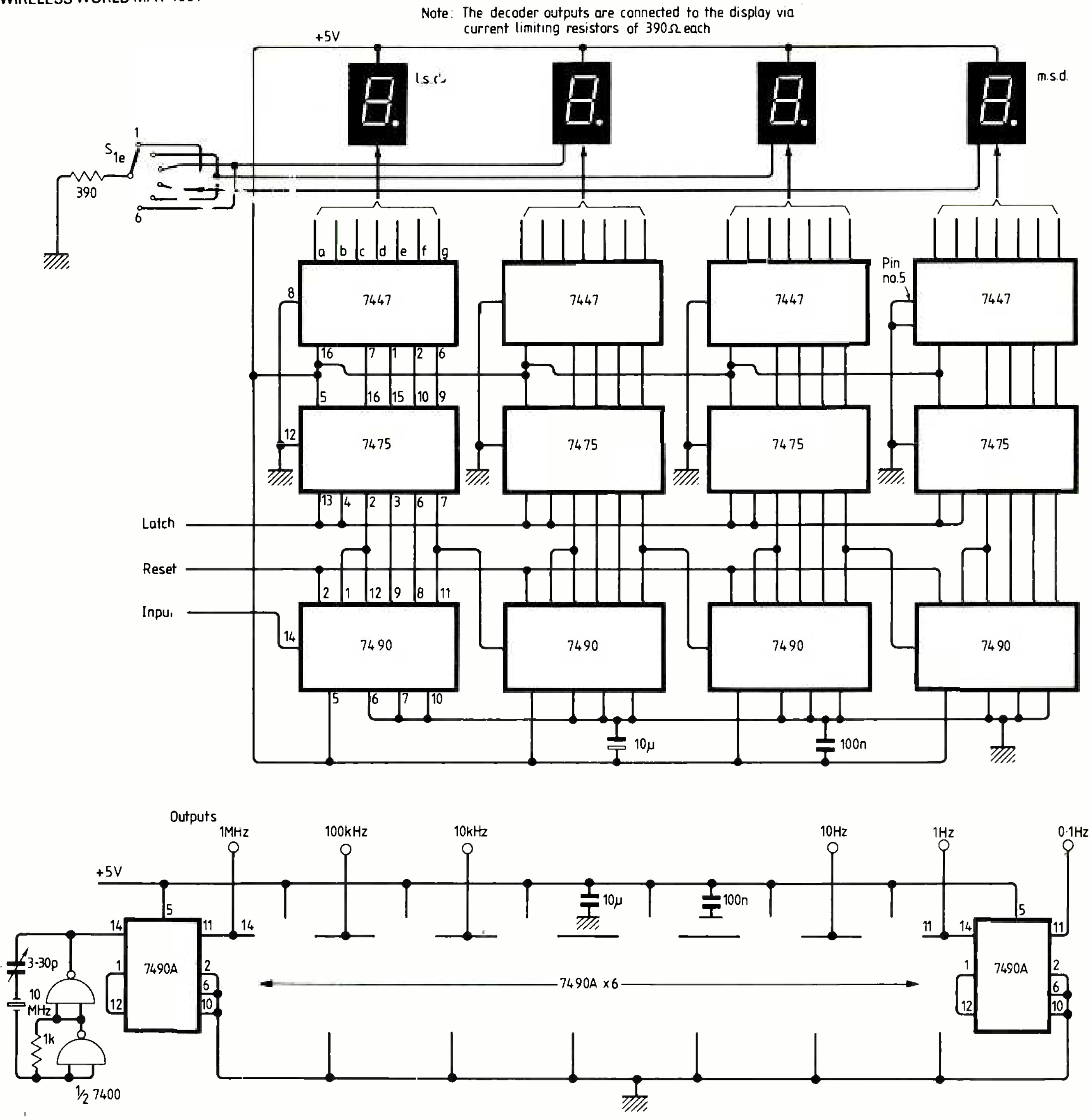

Fig. 6. Counter circuit (above) with crystal-oscillator and frequency-divider circuits (below)

The third step is to calculate the data-updating period T_o to be greater than or equal to $6(R_1+R_2)$. $C_x(max)$ for each range. Table 1 shows that T_o was chosen slightly greater than $10(R_1+R_2)C_x(max)$ and therefore the error caused by the protection network will always be less than 0.01% of the indicated value.

If a polarizing voltage is required, the circuit of Fig. 5 can be easily modified. The negative terminal of C_x could be connected to an adjustable negative voltage-source of voltage V_p. The polarizing voltage applied to the capacitor is then equal to $V_p+\frac{1}{2}V_{cc}$ and can be adjusted to the desired value. The timer is protected against the polarizing voltage and the operation of the circuit remains unchanged.

A second timer circuit, also operating in the monostable mode, provides the null adjustment circuit, as shown in Fig. 5. On the application of the trigger pulse to both monostable circuits, the voltages of the two outputs will rise to V_{cc} shortly after the application of the trigger pulse. The output voltage of the second monostable will fall after a time T_z which depends on the value of the trimmer capacitor, but the output of the first monostable circuit will fall to zero after a time T, as given by equation 4. The four NAND gates will then allow the clock pulses to pass to the counter during a time period $T-T_z$. The value of the trimmer capacitor can then be adjusted until the effect of the input capacitance C_{in} is compensated for and $T-T_z$ becomes directly proportional to the measured capacitor C_x. Setting up is achieved by setting the meter to range 1, removing C_x, and adjusting the trimmer capacitor until the meter reading is zero.

Figure 6 shows the circuit of the four-digit counter and the clock circuit.

The use of an l.s.i. chip for the counter circuit of Figure 6 will save space, power and could, especially if i.c. sockets are to be used, save money. (Ed.)

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Data store by running average

Processor-based measuring system for long term readings

by J. L. Gordon

In monitoring systems which measure variables, periodic readings over many days are often required for a data base. For some applications, such as recording the light level during a season, an average reading is needed rather than individual items of data.

This system can be used in applications where individual readings are not required and the variable changes value at a rate which allows processing between readings.

In digital systems, data is sampled at regular intervals with a sampling frequency greater than twice the highest frequency of the variable being monitored. For the example above, the period of change may be minutes rather than seconds, so sampling at five-second intervals is more than adequate. However, sampling every five seconds requires a considerable number of readings over a year if the data is held as individual totals. An alternative scheme, which gives a running average of the sampled data, can often provide all of the necessary information. Data available in this form is accessible immediately as an average of the individual samples taken and, by multiplying this average by the number of readings, a figure representing the total units read can be obtained. Furthermore, predictions for the completed total can be made if the running average is multiplied by a constant which represents a period of time.

An instrument for producing a running average has been conveniently constructed using a 6502 based Acorn microcomputer.

Table 1. Monitor

Main program

0200	A9	7C		
0202	8d	23	09	
0205	A9	00		
0207	8d	22	09	
020A	A2	80		clear part zero page
020C	95	1F		
020E	CA			
02DF	d0	Fb		
0211	85	0E		
0213	A9	02		N.M.I. address
0215	85	1d		
0217	A9	7b		
0219	85	1C		
021b	A2	07		clear display
021d	A9	00		
021F	95	10		
0221	CA			
0222	10	Fb		
0224	A9	77		write AVE = on display
0226	85	10		
0228	A9	1C		
022A	85	11		
022C	A9	79		
022E	85	12		
0230	A9	48		
0232	85	13		
0234	A9	00		display decimal running average
0236	85	0E		
0238	A0	06		
023A	A2	20		
023C	20	66	FE	
023F	20	0C	FE	
0242	4C	24	02	

NMI

027b	48			save A x y
027c	8A			
027d	48			
027E	98			
027F	48			
0280	A9	40		reset counter blank display
0282	8d	21	09	
0285	A9	00		
0287	8d	21	0E	
028A	A9	20		take in count
028C	8d	21	09	
028F	A2	80		
0291	20	cd	FE	
0294	CA			
0295	10	FA		
0297	EA			
0298	EA			
0299	EA			
029A	A9	00		
029C	8d	21	09	
029F	Ad	20	09	store new data
02A2	85	22		
02A4	Ad	21	09	
02A7	85	23		
02A9	A9	03		
02Ab	25	23		
02Ad	85	23		
02AF	EA			
02b0	EA			
02b1	EA			
02b2	EA			
02b3	20	80	03	multiply old av. by number of reading clear 0050 005F
02b6	A2	0F		
02b8	A9	00		
02bA	95	50		
02bc	CA			
02bd	10	Fb		
02bF	A5	22		add new data
02C1	85	58		
02C3	A5	23		
02C5	85	59		
02C7	20	d3	03	
02CA	E6	28		
02CC	d0	0b		increment number of readings
02CE	E6	29		
02d0	d0	07		
02d2	E6	2A		
02d4	d0	03		
02d6	20	b8	00	alarm
02d9	A2	20		clear for divide
02db	A9	00		
02dd	95	70		
02dF	CA			
02E0	10	Fb		
02E2	A2	02		transfer number of readings to 74 75 76
02E4	65	28		
02E6	95	74		
02E8	CA			
02E9	10	F9		
02Eb	A2	0F		total from multiply to 0060-006F
02Ed	b5	40		
02EF	95	60		
02F1	CA			
02F2	10	F9		
02F4	A2	80		load divide time
02F6	86	26		
02F8	A2	EC		
02FA	18			shift m.s.b. of data into 70-73
02Fb	36	74		
02Fd	E8			
02FE	d0	Fb		
0300	38			
0301	d8			subtract number of readings from 70-73
0302	A2	FC		
0304	b5	74		
0306	F5	78		
0308	95	7C		
030A	E8			
030b	d0	F7		
030d	90	1d		
030F	A2	03		branch if result negative transfer remainder back to 70·73
0311	b5	78		
0313	95	70		
0315	CA			
0316	10	F9		
0318	A2	F0		shift 1 into answer
031A	38			
031b	36	90		
031d	E8			
031E	d0	Fb		
0320	90	03		
0322	20	b8	00	alarm
0325	C6	26		back if not complete
0327	d0	CF		
0329	18			
032A	90	0C		jump on to end divide
032C	18			
032d	A2	F0		Shift 0 into answer
032F	36	90		
0331	E8			
0332	d0	Fb		
0334	C6	26		jump back if not complete
0336	d0	C0		
0338	A2	0F		put new average back in 30-3F
033A	b5	80		
033C	95	30		
033E	CA			
033F	10	F9		
0341	A5	38		
0343	85	90		
0345	A5	39		
0347	85	91		
0349	EA			
034A	EA			
034b	A0	00		
034d	EA			
034E	EA			
034F	F8			
0350	A2	00		
0352	86	92		
0354	A5	90		
0356	d0	06		
0358	A5	91		
035A	F0	13		

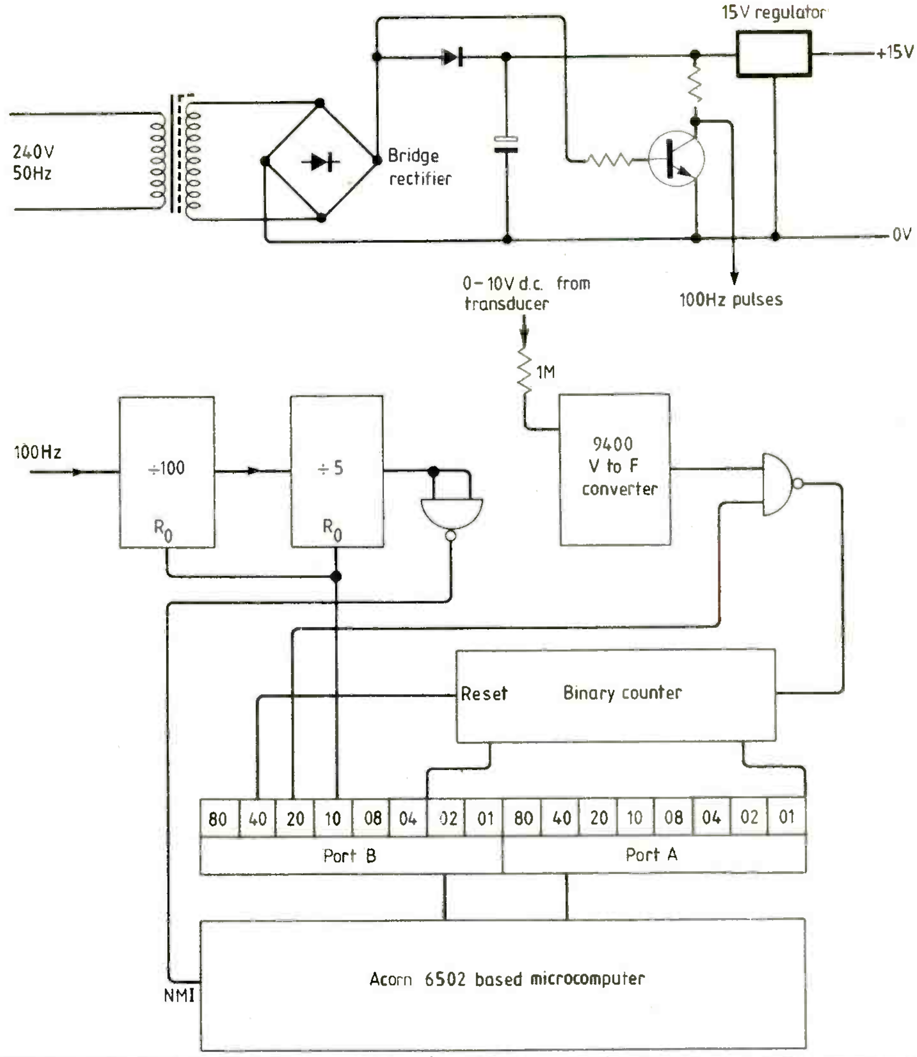


Fig. 1. Simplified block diagram of the prototype instrument.

This prototype samples data every five seconds and reads it in via a 10-bit bus. Data is presented as d.c. levels from 0 to 10V, and the system can take continuous readings for 2.66 years without loss of accuracy. An additional 8154 i.c. is provided in a spare socket on the Acorn controller board to interface between the microprocessor and external circuits. This device provides two 8-bit i/o ports which can be used as separate lines. Normally, port A and two bits of port B are used to read data from a binary counter, but two additional bits can be used for greater accuracy. Three lines of port B are used to control the sampling circuit and the remaining line is available for expansion as shown in Fig. 1.

The five-second interrupts are initialized by the program so that the necessary conditions can be set by the processor before an interrupt is received. When an interrupt signal arrives, the measuring circuit is controlled by the program. Analogue-to-digital conversion is achieved by a 9400 voltage-to-frequency converter, and the optimum digital value for an analogue input can be adjusted by modifying the program listing, i.e., the time that the count takes.

The main program displays the data present in two bytes of memory. When an interrupt command is received by the NMI, new data is read. Initially the 6502 registers and accumulator are saved and then the binary counter is reset to zero to

```
035C   C6   91          38 39
035E   C6   90          from new
0360   18               average
0361   98               Hex to Dec
0362   69   01          conversion
0364   A8               then
0365   8A               dump for
0366   69   00          display
0368   AA
0369   90   E9
036b   E6   92
036d   b0   F5
036F   84   20
0371   86   21
0373   68
0374   A8               retrieve
0375   68               A, x, y,
0376   AA
0377   68
0378   40               return
```

Sub routines

Multiply

```
0380   A2   02
0382   B5   28
0384   95   70
0386   CA
0387   10   F9
0389   A2   0F
038b   A9   00
038d   95   40
038F   CA
0390   10   Fb
0392   18
0393   66   72
0395   66   71
0397   66   70
0399   90   06
039b   20   E5   03     transfer
039E   20   D3   03     add
03A1   A2   16
03A3   A0   01
03A5   84   27
03A7   18
03A8   66   72
03AA   66   71
03AC   66   70
03AE   90   03
03B0   20   Co   03     process
03B3   C8
03B4   CA
03B5   10   EE
03B7   60
```

Process

```
03C0   86   26
03C2   20   E5   03     transfer
03C5   A6   27
03C7   20   A0   00     shift
03CA   CA
03Cb   D0   FA
03cd   20   d3   03     add
03D0   86   26
03D2   60
```

Add

```
03D3   86   2F
03D5   18
03D6   D8
03D7   A2   F0
03D9   B5   60
03Db   75   50
03DD   95   50
03DF   E8
03E0   D0   F7
03E2   A6   2F
03E4   60
```

Transfer

```
03E5   86   2F
03E7   A2   0F
03E9   A9   00
03Eb   95   50
03Ed   CA
03EE   10   Fb
03F0   A2   0F
03F2   B5   30
03F4   95   50
03F6   CA
03F7   10   F9
03F9   A6   2F
03FB   60
```

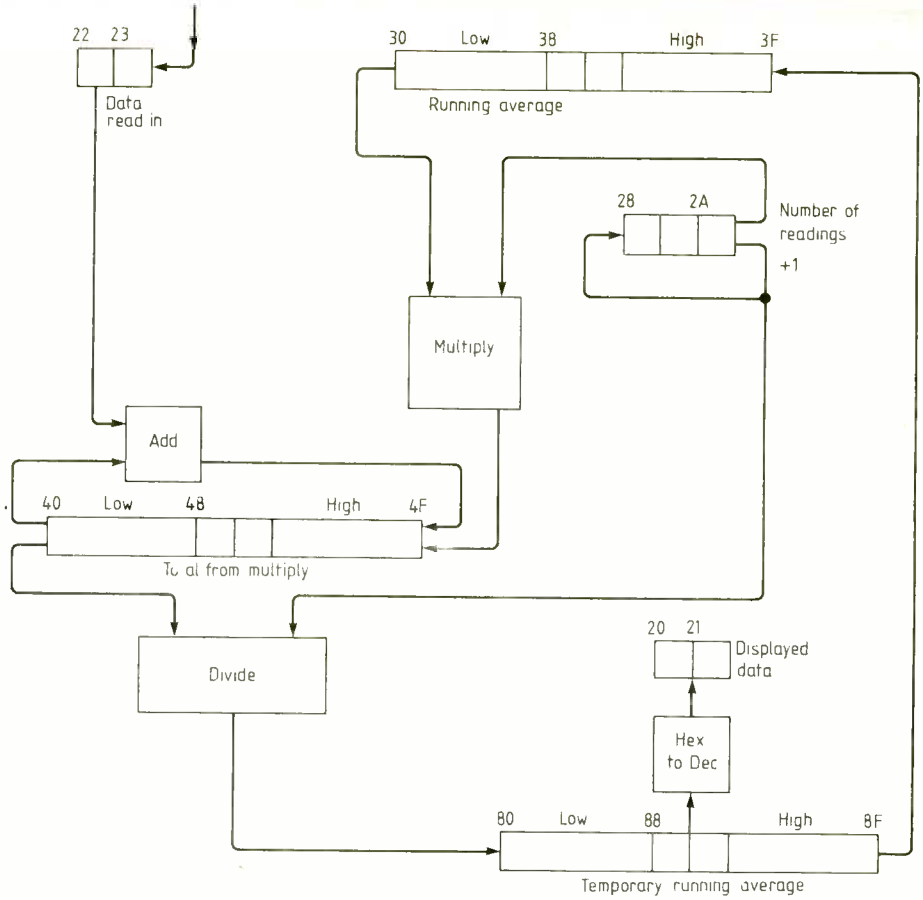
Shift

```
00A0   86   2F
00A2   18
00A3   A2   F0
00A5   36   60
00A7   E8
00A8   D0   FB
00AA   90   03
00AC   20   b8   00
00AF   A6   2F
00b1   60
```

Alarm

```
00b8   86   2E
00bA   A2   07
00bc   A9   49
00bE   95   10
00C0   CA
00C1   10   F9
00C3   A2   80
00C5   20   0C   FE
00C8   A0   18
00CA   20   cd   FE
00cd   88
00CE   d0   FA
00d0   CA
00d1   D0   F2
00d3   A2   07
00d5   A9   00
00d7   95   10
00d9   CA
00dA   10   Fb
00dC   A6   2E
00dE   60
```

Fig. 2. Data flow within memory during executing program. The numbers refer to zero page locations.



clear the previous reading. The counter gate is then opened for a specific period which is controlled by a delay subroutine in the Acorn monitor. The gate is then closed and new data is read into two bytes in zero page memory. When this operation is complete, the existing running average from a 16-byte register in zero page is multiplied by the number of readings taken, which is contained in three bytes of zero page. New data is then added to this total and the number-of-readings register is incremented. To complete the averaging procedure, the total from the multiplication plus the new data is divided by the incremented number of readings and then returned as a new figure to the 16-byte register reserved for the running average. The new data is added to the multiplication so that it has 64 trailing zeros, which provides a fixed decimal point for division. The two least significant bytes, which form whole numbers, from the running average are converted to decimal for display by the main program. These bytes correspond in significance with the data read in, so the running average total will never exceed the two bytes which are displayed. The events that take place during the processing of new data are shown in Fig. 2.

As the 3-byte register containing the numberof readings can cater for 2^{24} events before overflow, a reading every 5s can be stored for over 2.5 years before data is lost. Because the register containing the running average has, in effect, 2^{64} decimal places, after 2.5 years new data can still significantly alter the running average. If only two bytes of data are displayed, small variations in totals will not be seen immediately although the information will be stored in memory.

A sample program listing used with the prototype instrument is shown in Table 1. However, both the hardware and software can be modified to suit specialized applications.

One practical use for a modified instrument is the calculation of a domestic electricity bill. A current transformer with an accurate resistor across it can be used as a transducer to provide a voltage proportional to the current. This output is rectified by a single germanium diode so that the voltage drop across the device is small. Peak voltage can be measured by choosing a suitable smoothing capacitor and using the correct frequency of readings for the time constant of the circuit. The data can be multiplied by a constant which includes an adjustment to give the r.m.s. values and a conversion to kW. With this arrangement the maximum desired bill can be selected and, if the running average is such that the bill will be drastically exceeded, an alarm can be triggered or non-essential equipment can be disconnected until the average is reduced.

If faster operation is needed, the program can be speeded up by changing from hex-to-decimal conversion to a different type, and increasing the frequency of the v-to-f converter so that the counter gate-time can be reduced.

IN OUR NEXT ISSUE

Audio millivoltmeter
A simple instrument which uses 20 l.e.ds to give a fast-response, peak reading indication. It can be used for audio frequencies and d.c. and is battery-powered. The meter offers many of the advantages of a pointer meter without the inertia of the movement.

Morse code lock
An 8748 microcomputer recognizes sixteen morse characters, keyed-in by the user, and operates an electric lock when the input code corresponds with that held in memory. The lock uses only two integrated circuits, and the standby current is around 1 microamp.

Remote keyboard
Using an RS232 serial link, this design allows a remote keyboard to be connected to a computer and used simultaneously with the existing keyboard, without complex software. The circuit can easily be adapted to suit individual circumstances.

On sale 20 May

Measuring transient intermodulation in audio amplifiers

The 'inverting-sawtooth' method for low t.i.d. measurements

by **P. Antoniazzi, C. Buongiovanni and S. Tintori**, SGS-Ates, Milan.

Over the last ten years transient intermodulation distortion (t.i.d.) has attracted considerable interest in audio engineering circles, as a glance at the bibliography shows. Among the many published papers on the subject a number deal with the measurement of t.i.d.

The best known method consists of feeding sine waves, superimposed onto square waves, into the amplifier under test. The output spectrum is then examined using a spectrum analyser and compared to the input. This method suffers from serious disadvantages: the accuracy is limited, the measurement is a rather delicate operation and an expensive spectrum analyser is essential.

Recently, a new approach has been described by S. Takahashi and S. Tanaka which is, in their own words, simple yet precise. This method, which we will refer to as the "inverting sawtooth" method, is also fast, cheap – it requires nothing more sophisticated than an oscilloscope – and sensitive – and it can be used down to t.i.d. values as low as 0.002% in high power amplifiers.

Transient intermodulation distortion is an unfortunate phenomenon associated with negative-feedback amplifiers. When a feedback amplifier receives an input signal which rises very steeply, i.e., it contains high-frequency components, the feedback can arrive too late so that the amplifier overloads and a burst of intermodulation distortion will be produced, as in Fig. 1.

Since transients occur frequently in music this is obviously a problem for the designers of audio amplifiers. Unfortunately, heavy negative feedback is frequently used to reduce the t.h.d. (total harmonic distortion) of an amplifier, which tends to aggravate the transient intermodulation (t.i.m.) situation.

Method of measurement

The 'inverting-sawtooth' method of measurement is based on the response of an amplifier to a sawtooth waveform. The amplifier has no difficulty following the slow ramp but it cannot follow the fast edge. The output will follow the upper line in Fig. 2, cutting off the shaded area and thus increasing the mean level. If this output signal is filtered to remove the sawtooth, a direct voltage remains which indicates the amount of t.i.m. distortion, although it is difficult to measure because it is indistinguishable from the d.c. offset of the amplifier. This problem is neatly avoided in the i.s.-t.i.m. method by periodically inverting the sawtooth waveform at a low audio frequency as shown in Fig. 3. In the case of the sawtooth in Fig. 2, the mean level was increased by the t.i.m. distortion; for a sawtooth in the other direction the opposite is true.

The result is an a.c. signal at the output whose peak-to-peak value is the t.i.m. voltage, which can be measured easily with an oscilloscope.

Practical measurements

The equipment needed for i.s.-t.i.m. measurement is shown in Fig.4. A 20kHz sawtooth generator, its output inverted every 256 cycles, is followed by a high pass filter which attenuates the 78 Hz switching component by more than 100dB. A suitable circuit, shown in Fig. 5, is a straightforward, 36 dB/oct. Butterworth filter, with a cutoff at around 1 kHz. The circuit contains a simple RC network to limit the maximum signal slope to a reasonable value. It can be switched to supply signals of varying severity to the test amplifier: for most purposes the f_c = 30kHz position gives realistic results but for "super-fi" amplifiers the 100 kHz position can be used. An intermediate position, not normally used, is provided.

After leaving the amplifier under test, the 20 kHz sawtooth must be filtered out so that the t.i.m.-induced voltage can be measured. The passive low-pass network in Fig. 6 gives the desired response.

Finally, the filtered output signal is displayed on an ordinary oscilloscope. If the peak-to-peak value of this signal and the peak-to-peak value of the inverting sawtooth are measured, the t.i.d. can be found very simply from:

$$\text{t.i.m.} = \frac{V_{\text{out}}}{V_{\text{sawtooth}}} \times 100$$

The two oscilloscope photographs show the waveforms actually observed. The top one shows part of the 20kHz inverting-

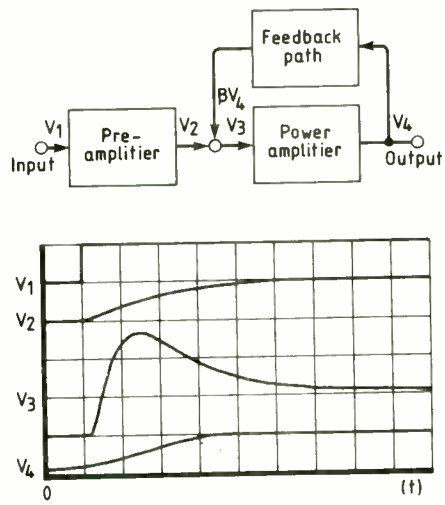


Fig. 1. Response of negative-feedback amplifier to very steep input slope

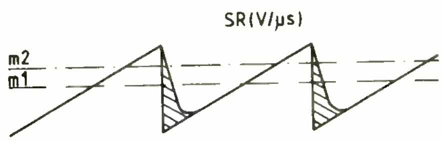


Fig. 2. Input sawtooth and response of amplifier

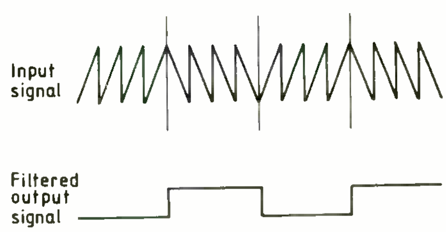
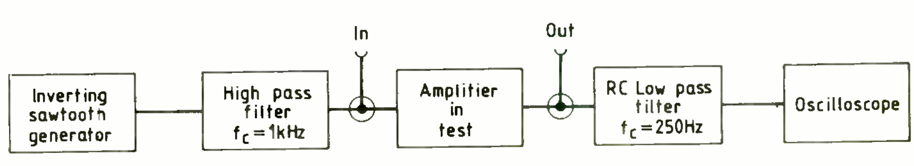


Fig. 3. Inverting sawtooth and filtered output of amplifier under test

Fig. 4. Block diagram of measurement setup



sawtooth waveform at the output of the generator, while the second shows a typical filtered output waveform (20kHz/256 = 78Hz) which is used to measure the peak-to-peak amplitude of the t.i.m.-induced voltage.

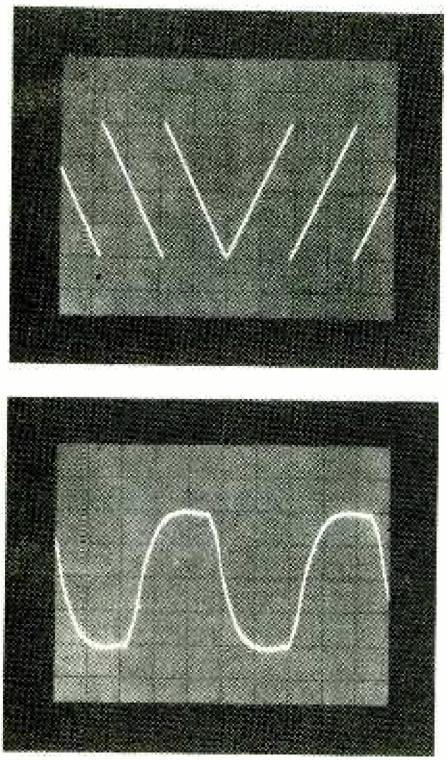
Inverting sawtooth generator

To generate the special inverting-sawtooth waveform we designed the simple circuit shown in Fig. 7. An ordinary sawtooth signal is generated by a relaxation oscillator consisting of the constant current generator Tr_1, a capacitor C1, inverting triggers IC_{1a} and IC_{1b} and an analogue switch, I_{2a}. Capacitor C_1 is charged by the constant current generator until the voltage across it reaches the upper threshold of the trigger IC_{1b}, which is about 6.5V. This closes the analogue switch and discharges C_1. Discharging continues until the voltage across C_1 falls to the lower threshold of the trigger, about 3V, when the analogue switch opens and C_1 charges again. The frequency of the resulting sawtooth waveform is adjusted to 20kHz by the trimmer in Tr_1 emitter.

The buffer, Tr_2, minimizes the loading on C_1 and attenuates the signal to avoid saturating the phase-splitter that follows. The phase-splitter, Tr_3, provides two out-of-phase sawtooth waveforms, the trimmer in the collector of Tr_3 adjusting the symmetry of these waveforms. Another trimmer in the inverted signal decoupling network, adjusts the relative offset of the two waveforms.

The analogue switches IC_{2b} and IC_{2c} select either the direct or the inverted sawtooth under control of the counter, which divides the discharge pulses from the relaxation oscillator by 256, so that the output sawtooth signal changes phase every 256 cycles. The inverting sawtooth is buffered by Tr_4.

The output of the counter also serves to synchronize the oscilloscope used in the measurements. Without this sync., it would be virtually impossible to observe the inverting sawtooth waveform.



Inverting sawtooth is shown in top trace; bottom picture is t.i.m.-induced voltage after filter.

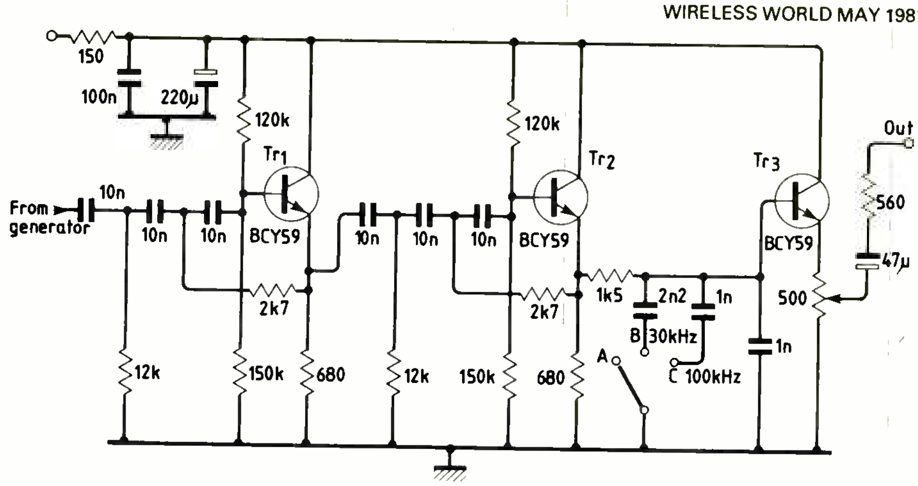


Fig. 5. High-pass filter and signal slope limiting network

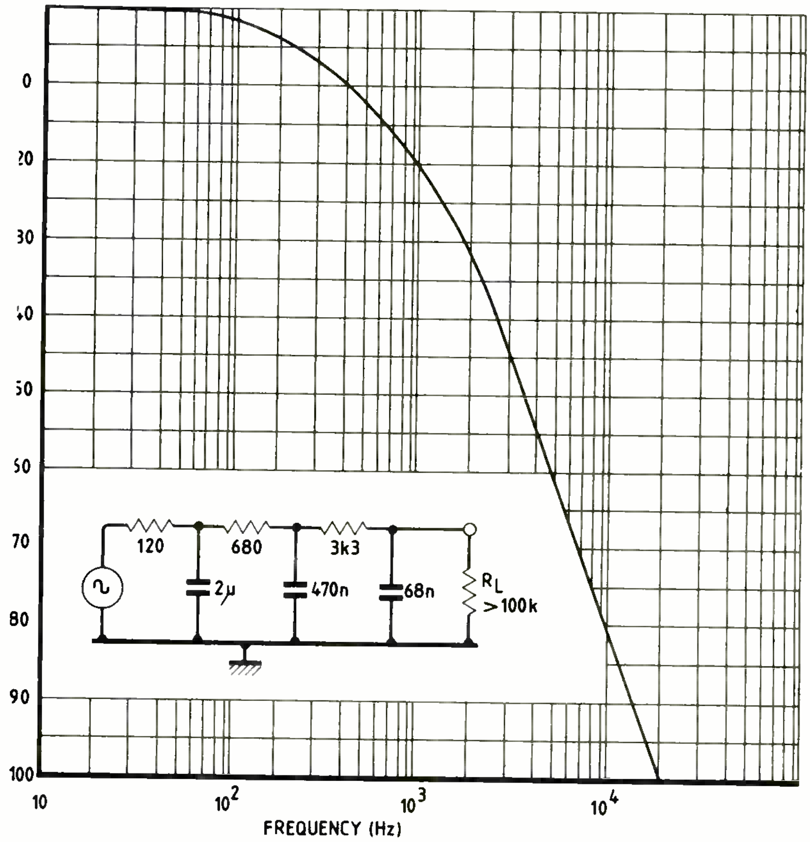


Fig. 6. Low-pass filter characteristic

Some results

TO see how the inverting sawtooth method works in practice, we have tested a variety of audio integrated circuits – standard operational amplifiers, monolithic power amplifiers and an RIAA preamplifier based on a new high-quality preamplifier i.c. For the t.i.d. measurements on the operational amplifier, a unity-gain buffer, shown in Fig. 8, was used to match the low impedance filter to the op-amp. input. Figure. 9 shows the results obtained from an LS148 op-amp. with three different values of compensation capacitors.

These results show t.i.d. values higher than those obtained using other methods – a result of the greater sensitivity of the i.s.-t.i.m. technique. Extensive comparison of t.i.d. measurements using various methods have been published elsewhere and confirm the validity of the inverting-sawtooth method. Although it is possible to measure t.i.d. as low as 0.002% this only applies to high-power amplifiers when the t.i.m. voltage can be measured more easily.

Figure 10 shows typical t.i.d. values for a 15W monolithic amplifier, the TDA 2030, in the test circuit, Fig 11. As in the case of the operational amplifier the measurements were carried out at the three different settings of the signal slope

continued on page 53

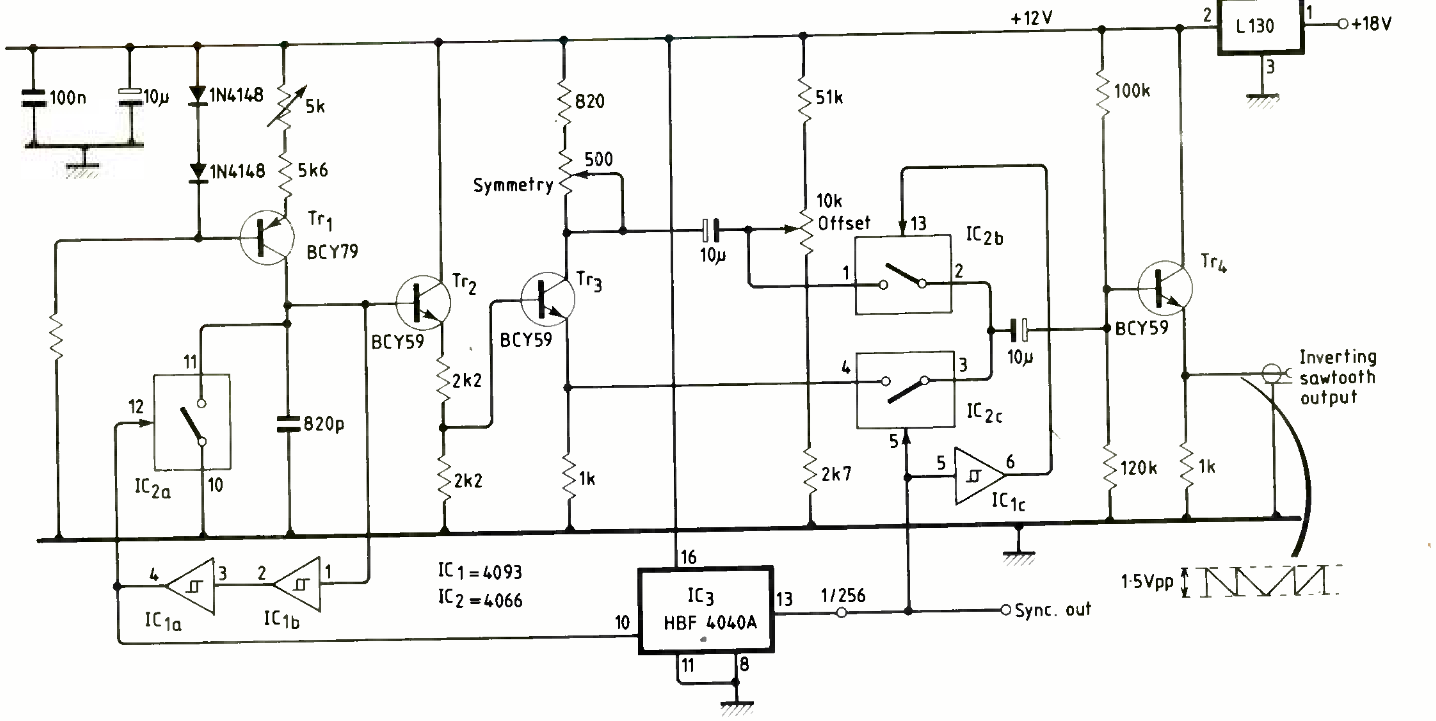


Fig. 7. Inverting sawtooth generator

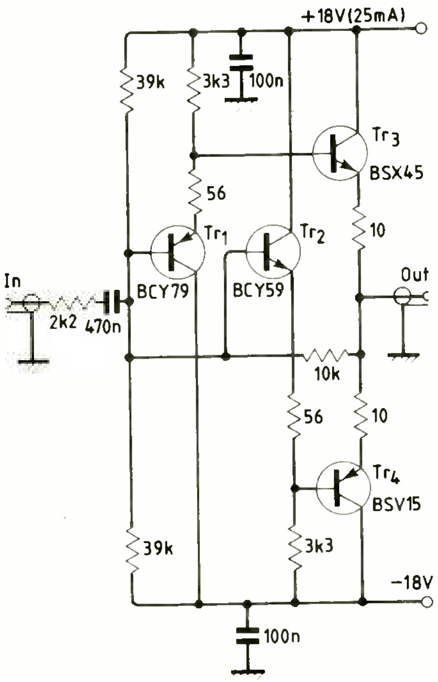


Fig. 8. Unity-gain buffer

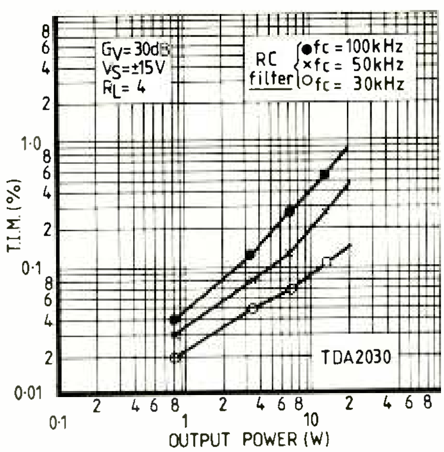


Fig. 10. T.i.d. measurements on TDA2030 audio power amplifier

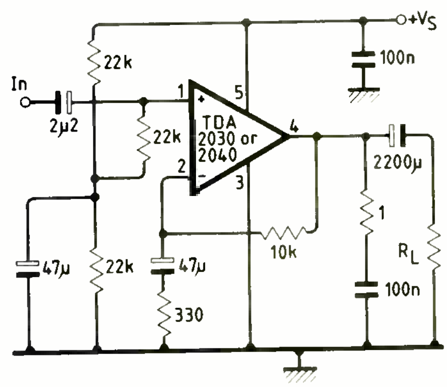


Fig. 11. Test circuit used for TDA2030/TDA2040

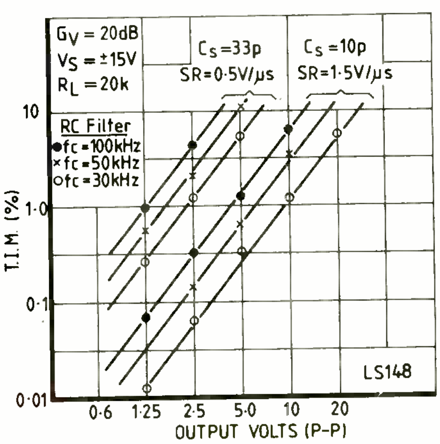


Fig. 9. T.i.d. measurements on LS148 op.-amp.

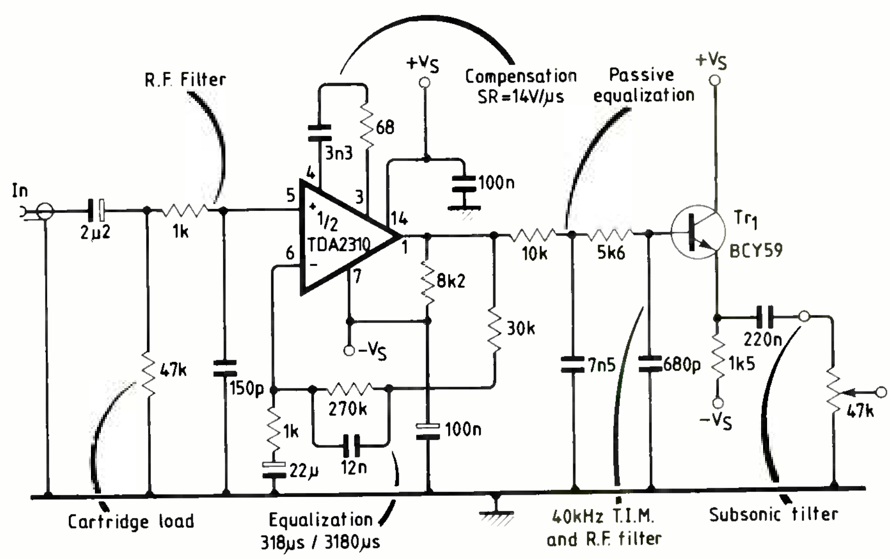


Fig. 12. R.I.A.A. preamp. based on TDA2310 (one channel)

Television for no-signal areas

An "active deflector" for re-directing broadcast signals

by J. M. Osborne, G3HMO

In the last decade u.h.f. colour television broadcasting has, for all practical purposes, replaced black-and-white at v.h.f. The use of the higher frequencies sharpens the "no-go" areas where no signal or no usable signal exists; rectilinear propagation rules. However many relay stations are erected, inevitably there will be isolated sites for which this solution must be uneconomic. From many of these isolated sites, perhaps for most, it is possible to see a point on local high ground from which in turn a television broadcast mast is visible; visible in theory, that is, or with a telescope on a clear day. An active deflector becomes a plausible possibility.

If the signal at the top of the hill is received in the conventional way and redirected towards the 'no-signal' site, normal reception there can be achieved. The description that follows is a case history of how a single installation provided six households in three neighbouring 'no-signal' sites with normal signals. Conventional aerials with and without masthead amplifiers at these sites give performance not significantly different from that received by those at the top.

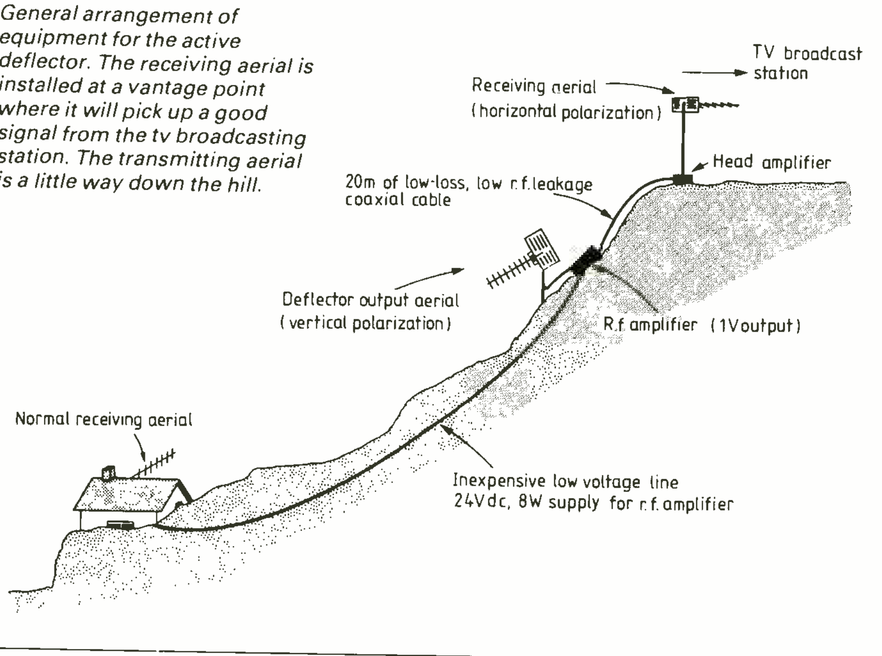
The situation is a classic one; the houses are on the coast with high ground inland. The problem: all broadcast tv stations, high power and relay, within range are screened by this high ground. The solution: a signal (of a few millivolts) received up top, amplified as necessary, is redirected to give a comparable signal down below perhaps 500 to 1000m away.

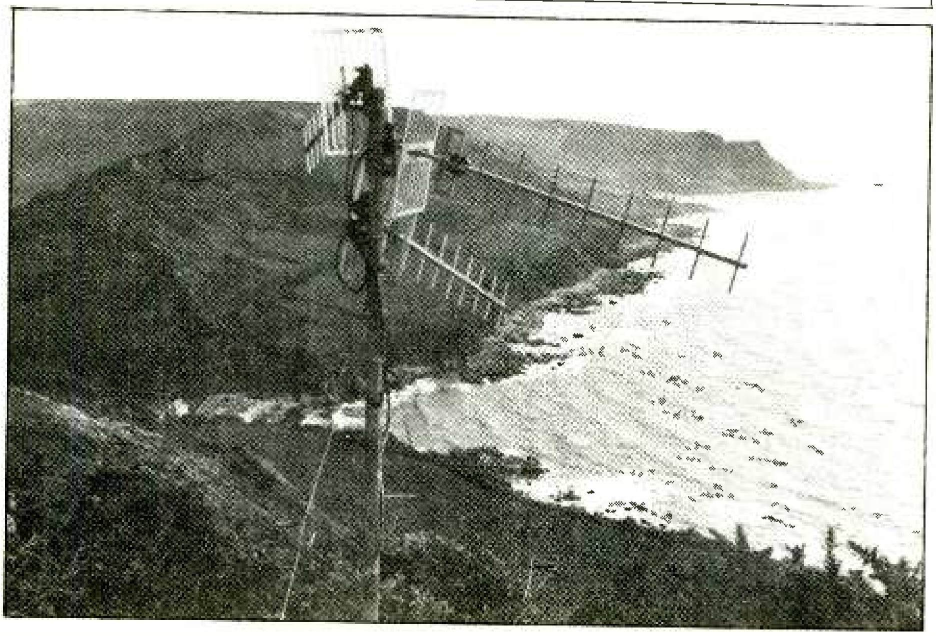
The hardware is basically very simple. The main aerial, about 3m high, is connected to a head amplifier and then by 20m or so of low-loss, low-leakage coaxial cable to another r.f. amplifier. This wideband amplifier is crucial to the project and its specification is quoted later. The output is connected via a further short length of low-leakage coax to three aerials on an adjacent mast about 2m high. A specially made harness using quarter wave 50-ohm sections matches the amplifier (75 ohms) to the aerials (each also 75 ohms). These aerials, pointing at the respective sites, are vertically polarised to minimise the possibility of oscillation or instability through coupling to the main horizontally polarised aerial.

Coax with low r.f. leakage is used throughout to avoid feedback problems. These cables also run at ground level except where running vertically up the earthed aluminium masts, for the same reason. It is comforting that at no time has r.f. feedback occurred with these simple precautions. How far these precautions can be relaxed before running into trouble has not been investigated.

At the three receiving sites, normal tv aerials (vertically polarised and pointing up the hill) with and without head amplifiers result in good quality colour pictures on all three channels. In fact, the aerials need only have a clear line of sight to the top of the hill and need not, in general, be above the roof. Fixing to a wall makes a cheap, tidy installation. On one site a black-and-white portable gives a usable (though admittedly slightly noisy) picture

General arrangement of equipment for the active deflector. The receiving aerial is installed at a vantage point where it will pick up a good signal from the tv broadcasting station. The transmitting aerial is a little way down the hill.





Nature of the terrain can be seen from this view with the three transmitting aerials in the foreground.

Main items of equipment

Main amplifier:
Amethyst (u.h.f. only). Wolsey Electronics, Cymmer Road, Porth, Mid Glamorgan CF39 9BT. (Trade price £77.48 plus VAT.)

Aerials:
Antiference TC18 (one) and TC10 (three).

Masthead amplifier:
CM7025/CD. Labgear Ltd, Abbey Walk, Cambridge CB1 2RQ.

using its built-in halo aerial, if the set is placed in the window on the right side of the house.

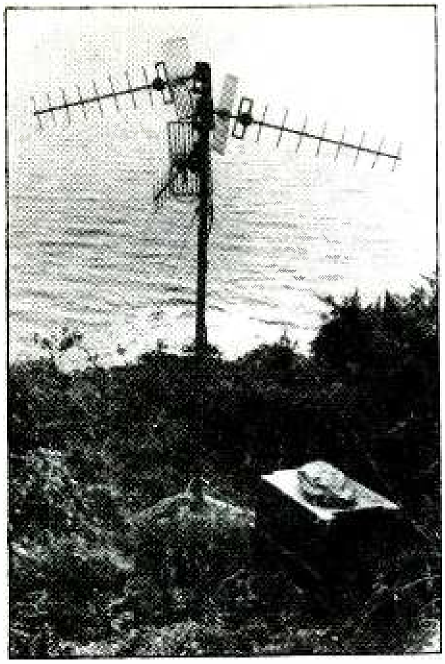
The amplifier that made this project possible is the Amethyst supplied by Wolsey Electronics. The u.h.f. version cost less than £100, including the mains power supply. This unit is designed as a distribution amplifier, e.g. providing a large number of outlets in blocks of flats from a communal aerial on the roof. It is ideal for the present application: broad band, ultra linear, 75-ohm coax input and output, up to 1V r.f. output and an integral d.c. supply up the input coax for the head amplifier.

A mains supply up the hill is out of the question. The power unit was therefore removed from the Amethyst. The amplifier draws an economical 240mA at 24V. This is supplied by a pair of p.v.c. 24-s.w.g. wires run up the hill for the most part through the uncultivated undergrowth under an old dry wall. It is fairly unlikely to be disturbed. At the lower end this pair of wires is run into an outhouse along the posts of a chicken run. At the top, where it connects to the amplifier, a series diode provides polarity protection. The resistance of the wire (25 ohm) at 240mA and the diode drop requires that a 30V supply be provided. This is left on permanently in the outhouse.

The weather protection of the amplifier is taken care of by standing it clear of the ground on an inverted tray as used for market garden produce. It is covered with plastic sheets (ventilated, not sealed). Over the whole is placed a large heavy-gauge plastic box, upside down to keep out the wind and rain.

The aerials are standard yagis made by Antiference Ltd. Their disposition is clear from the photographs. The excellent directional and gain properties make them a good choice in this application. Their ability to take the weather, including gales and storms, is implicit. The head amplifier, replacing the first one of Continental origin which proved to have inadequate gain, was a Labgear CM7025 compatible with the Amethyst coax supply. Its ability to stand the weather is likewise implicit.

The masts have to be guyed to withstand gale and storm on such an exposed site. They are guyed with stainless steel stranded wire to heavy iron staves driven deep into the ground with a sledge hammer. The staves are made from fencing angle iron, cut and sharpened. The



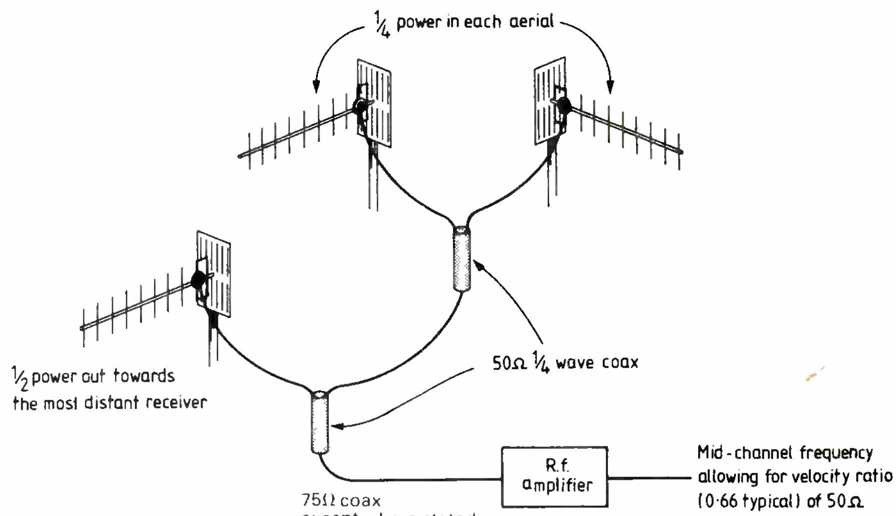
The three transmitting aerials mounted on a mast a little way down the hill. In the foreground is the r.f. amplifier box (with rock on top of it!)

base of each mast has been set in concrete.

Now that the project has been brought to a successful conclusion – for the time being anyhow, since nothing lasts forever – it is interesting to reflect on the variety of problems and solutions engendered by it.

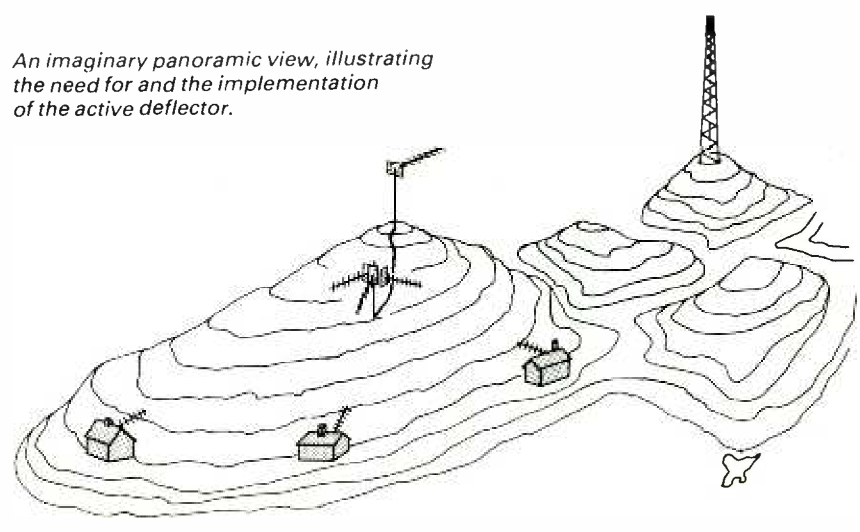
The only instruments used were an Avo multimeter and a Ferguson black-and-white portable which would operate for a short time for test purposes on 12V from heavy duty dry cells. As one was unwilling to lay out cash on an unproved project, the proving of the signal up top was done with redundant aerials. (These became redundant when a local relay was established elsewhere in the West country.) The coax was salvaged from a previous highly satisfactory project – an amateur radio telescope of 1959 – being low-loss cable supplied by J. Beam Ltd to connect the arms of an interferometer made with J. Beam skeleton slot 1.5m aerials.

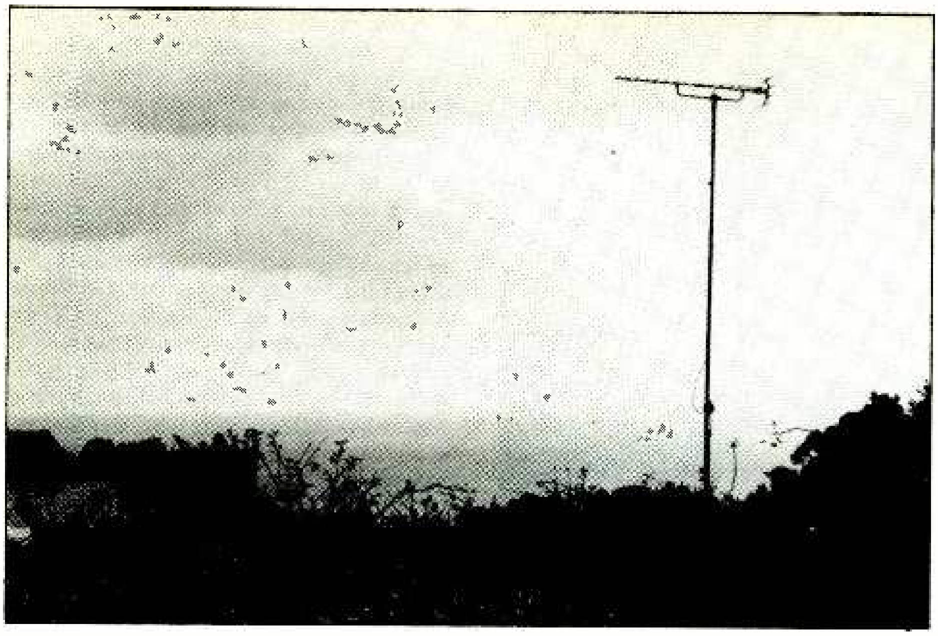
Before any stage of this project was implemented it was proved. Everything up top was carried up a tortuous path 350ft a.s.l. taking 25 minutes by the easiest route (and 15 minutes down). Weather was relevant to what could be done and how



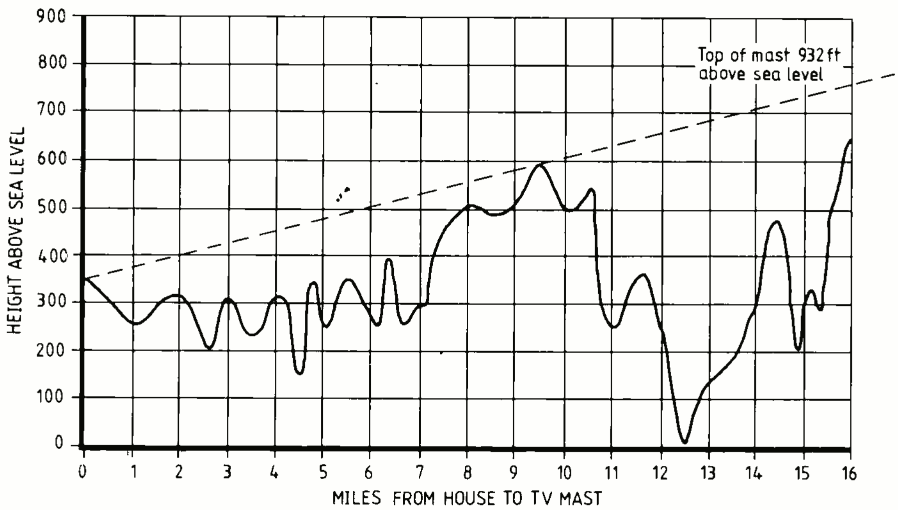
Method of matching three transmitting aerials (each 75 ohm) to the coaxial cable from the r.f. amplifier. 75-ohm inners and outers connect to respective 50-ohm inner and outer

An imaginary panoramic view, illustrating the need for and the implementation of the active deflector.





Main receiving aerial, installed on high ground, with sea in the background.



A plot of contour heights along the path from the broadcast transmitting aerial. Height of the aerial and grid reference are obtained from the BBC Engineering Information Department. The contours are from the Ordnance Survey.

long it took. To test the effect of a single change (2 minutes in a lab) might take half the morning. The justification of the work and the expense of the amplifier was confirmed when good pictures were received down below on a battery operated amplifier (four EverReady 6V type PJ996 batteries ran for two days, the voltage falling to 16V before signals became significantly weak). The laying of the 24V line followed. This involved cutting through undergrowth which must compare with the Burmese jungle. Certainly I wore top boots in view of frequent sightings of adders!

A paradoxical situation arose as a result of the installation of the Labgear head amplifier. That, together with the 18-element Antiference yagi, overloaded the amplifier, causing cross-modulation. A faint interference band across the screen moved slowly up or down. Blank parts of the screen when the set was tuned to one channel revealed faint ghosting from another. All that was needed was to turn the attenuator on the input of the amplifier – but by how much? A system of flag signalling was devised using red (up) blue (down) and white (OK) items of clothing. This, together with executive signals from the top, enabled a good setting of the attenuator to be found. (Citizens' band walkie-talkies will come in handy for this kind of work.)

A non-problem was permission from a neighbouring landowner to park an aerial on his territory. No loss to him but equally no gain – and it's always easier to say no. The greatest reward is the pleasure brought to neighbours by television in dark winter evenings. Cynics may dispute the programme value even in such isolated surroundings. Is a good book a better option, once the novelty wears off? I think not. We shall soon have four channels to choose from. They surely cannot always be simultaneously an American detective/police/car chase or world news or home political broadcast.

I very much hope the active deflector will keep us going for a decade, by which time a dustbin lid on the roof will provide a plethora of satellite relayed programmes.

Footnote on interference

An active deflector of this kind, if set up in a populated area, could cause interference. Television receivers already getting a signal direct and in line of fire of a deflected signal would suffer interference from this delayed signal. It is therefore necessary to consider this possibility where there are dwellings already receiving tv in sight of the proposed deflector. If the distance from the deflector is large, the direct signal strong and the directivity of the receiving aerial adequate, no problem need arise. If the direct signal is weak and interference is shown to arise, using the signal from the deflector, picked up by an aerial blind to the direct signal, may prove to be the solution. Television engineers and their aerial fitters, using knowhow and tact, might well extend the number of dwellings getting good colour using this technique. As 405-line tv comes up to retirement it might be the only solution in some places.

Licences

To operate an active deflector of this kind you are legally required to obtain a licence (£100 valid for 5 years). To obtain a licence you must first have your scheme technically approved by the broadcasting authorities (Home Office and either BBC or IBA). Procedure is as follows:

Contact the Home Office, BBC or IBA requesting a licence to operate a "self-help" scheme. Either the BBC or the IBA, depending on your area, will send you an enquiry form and an explanatory booklet "Self-help television reception". On receiving your completed form the broadcaster will plan the scheme for aerial radiation pattern, power and coverage to ensure that the active deflector will not cause interference to existing viewers or other services. When details have been agreed at a joint BBC/IBA Home Office television planning group you will be given permission by provisional licence to install the equipment. When the installation is working, inform the broadcaster concerned, who will check it for interference. If then it is approved, the Home Office will issue the full licence.

It is your own responsibility to procure the site and obtain planning permission. Nor do the broadcasters take responsibility for the picture quality obtained.

Addresses: Home Office, Broadcasting Department (Room 668), 50 Queen Anne's Gate, London SW1H 9AT. BBC, Engineering Information Department, Broadcasting House, London W1A 1AA. IBA, Engineering Information Service, Crawley Court, Winchester, Hants SO21 2QA.

Wien-bridge oscillator with low harmonic distortion

New way of using Wien network to give 0.001% t.h.d.

by J. L. Linsley Hood, Robins (Electronics)

The Wien-bridge network can be connected in a different way in an oscillator circuit to give a sine wave with very low total harmonic distortion. An l.e.d/photocell amplitude control is external to the circuit.

The Wien-bridge network remains the most popular method of construction of variable-frequency sine-wave oscillators, since the basic circuit can be very simple in form. It is a fairly straightforward matter to design oscillators of this type in which the harmonic distortion is only of the order of 0.01-0.02%, and which allow frequency control by means of a simple 2-gang potentiometer.

The basic circuit for an oscillator of this form, using a single operational amplifier as the gain block, is shown in Fig. 1, and the author has shown a practical design of oscillator, based on this, for a use as a simple, general-purpose workshop tool.[1] However, in the form shown in Fig. 1, a significant problem exists in that the transmission of a normal Wien network, at the operating frequency, is only 1/3, which means that an inconveniently large proportion of the output signal voltage appears at the inputs of the amplifier, and will lead to non-linearities in the transfer characteristics of the amplifier due to 'common mode' defects. An oscillator design, which employed an input device operated in a cascode configuration with a junction f.e.t. to minimize this type of defect, was shown by the author in 1977,[6] and allowed a t.h.d. at 1kHz of some 0.003%, which tended to increase with frequency above this point, as the effectiveness of the common-mode isolation deteriorated.

However, it is not implicit, in the use of a Wien network as the frequency-control method, that the configuration shown in Fig. 1, in which the output of the network is taken to the non-inverting input of the amplifier and the amplitude controlling negative-feedback signal is taken to the other, is the only circuit configuration which can be employed. In particular, consideration of the phase and transmission characteristics of such a network, shown in Table 1 and Fig. 2 for equal values of C

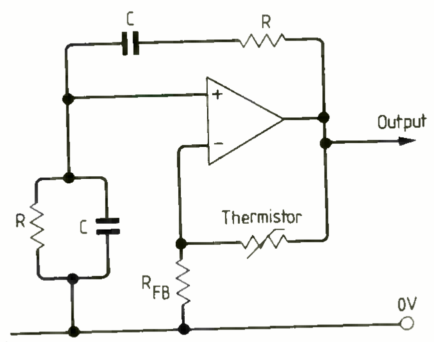
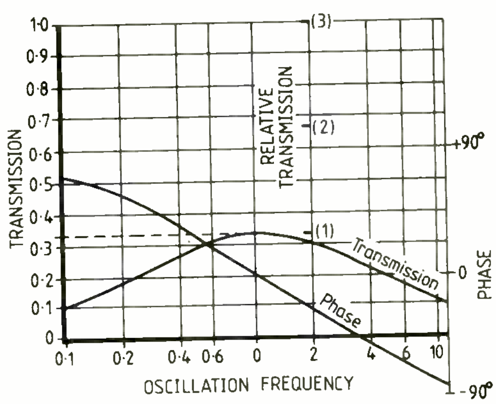


Fig. 1. Basic Wien-bridge oscillator circuit

Fig. 2. Gain and phase characteristics of Wien network



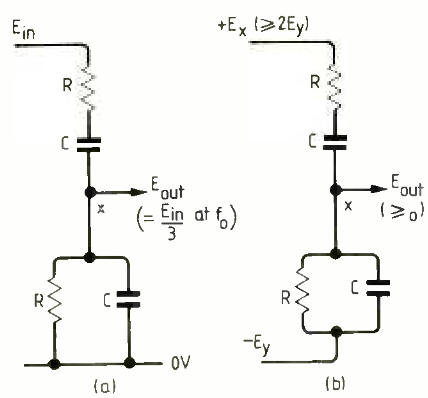
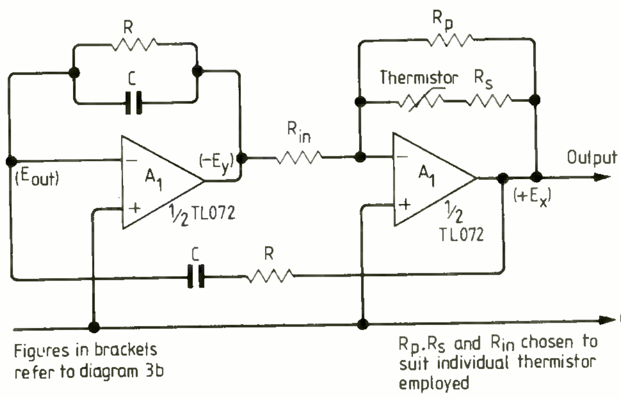


Fig. 3. Rearrangement of Wien network between signal sources gives small in-phase signal at point X

Fig. 4. Use of arrangement of Fig. 3 in oscillator circuit

TABLE 1. *Phase and transmission characteristics of simple Wien network.*

F/F_0	phase	transmission
0.1	73.14°	0.10
0.2	57.99°	0.18
0.3	45.32°	0.23
0.4	34.99°	0.27
0.5	26.57°	0.30
0.6	19.57°	0.31
0.7	13.65°	0.32
0.8	8.53°	0.33
0.9	4.03°	0.33
1.0	0°	0.33
1.2	−6.97°	0.33
1.5	−15.52°	0.32
2	−26.57°	0.30
3	−41.63°	0.25
5	−57.99°	0.18
8	−69.15°	0.12
10.	−73.14°	0.10



and R, implies that if, instead of the network of Fig. 3(a) being connected between a signal source E_{in} and the 0V line, it was connected between two signal sources $+E_x$ and $-E_y$, where these are sinusoidal and identical in frequency and the negative sign implies phase opposition, as shown in Fig. 3(b), then a small, in-phase signal would exist at the point 'X', at the frequency of maximum transmission, (f_o), if $+E_x$ was slightly greater than $-2E_y$.

This could then be used as a positive-feedback signal in a circuit such as that shown in Fig. 4, to sustain oscillation at the frequency f_o. Indeed, such a circuit will work quite well, and will sustain a constant output magnitude of oscillation if a thermistor is employed, as shown, to make the gain of the second, inverting, amplifier stage dependent on the amplitude of the input signal. However, there is, in practice, a small snag with such an arrangement, and that is that the inverted negative-feedback signal applied to the input of A_1 will suffer an additional phase error due to the internal time lag within A_2, and this will cause unwanted h.f. instability if '3rd generation' high speed op.-amps. such as the CA 3140, or the 1741 S, are used in the realisation of this circuit.

It is, fortunately, an easy matter to resolve this difficulty if the circuit is recast in the form shown in Fig. 5, in which the negative-feedback signal, equivalent to $-E_y$ in Fig. 3(b), is derived from the amplifier A_1, and the positive-feedback signal is obtained from the output of the second inverting amplifier A_2.

This configuration offers several significant advantages.

• The input signal to A_1 is extremely small, since it is only required to be $E_{out}/2M$, where M is the open-loop gain of A_1 – typically 100dB for a good modern op.amp. i.c. – and, as pointed out by the author in an earlier article[2], with semiconductor amplifiers the non-linearity of such devices is essentially an input characteristic, dependent on the magnitude of the input signal.

• The second-stage amplifier is operated as a shunt-feedback element, and the non-linearities of such a stage can be shown to be significantly lower, because of the very small input-signal amplitude and the absence of any internal transfer errors between the inverting and non-inverting inputs, than is the case for an identical amplifying element in a series-feedback configuration.[3,4]

• The time-delay errors in the second amplifying stage (A_2) no longer contribute to loss of stability in the system, but only to a very small compensatory shift in the operating frequency of the oscillator. Fast response-speed, high h.f. gain op.-amps. can therefore be used without problems.

For these reasons, it can be expected that the residual harmonic distortion of this oscillator design will be exceedingly small, and measurements on two prototypes have indeed shown this to be the case. So far as can be determined, the residual distortion – almost exclusively

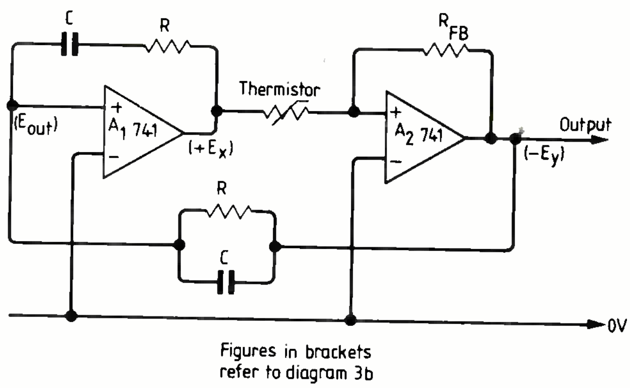


Fig. 5. Final form of new configuration in low-distortion oscillator

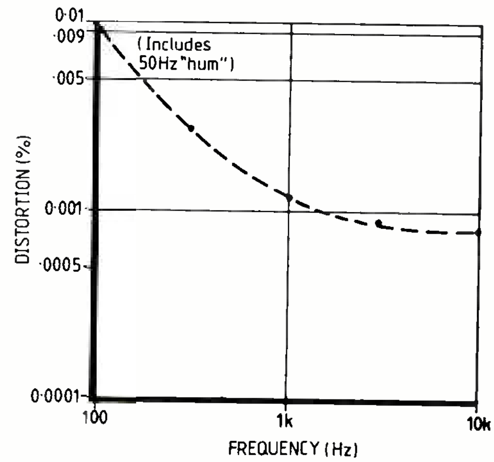
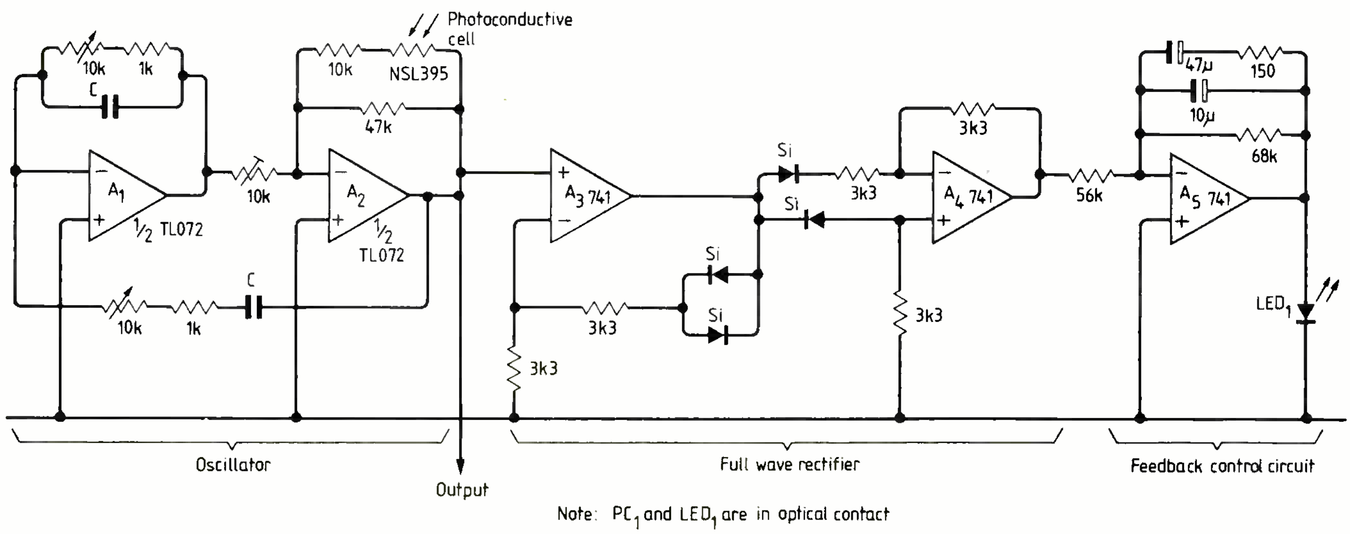


Fig. 6. Measured total harmonic distortion of improved oscillator of Fig. 5

Fig. 7. New oscillator with external optoelectronic amplitude-control circuit. Silonex (formerly National Semiconductors) cell, Type NSL395, is obtainable from Cheston Electronics Ltd., Vanguard House, 56 Oughton Street, Ormskirk, Lancs. Tel: 0695 72456



third harmonic – is that due to the dependence of the resistance of the thermistors used to control the amplitude of the oscillation on the instantaneous value of the signal potential applied to them. This characteristic of oscillators with averaging control systems has been analysed by Robinson[5] who suggests that the distortion of such a system, which is shown to be mainly third harmonic, will be

$$\frac{x_3}{x_1} \simeq \frac{1}{8\eta} \cdot \frac{A_0-\eta}{\eta} \cdot \frac{1}{2\pi fT}$$

where $(A_0-\eta)/\eta$ is the fraction by which the low-level loop gain exceeds the gain required to initiate oscillation, and T is the time constant of the control system (thermistor or similar). In the case of a Wien-bridge oscillator, $\eta=3$.

This equation indicates that if the feedback amplitude is very little above that required to sustain oscillation – which is implicit in the design – the residual distortion will be dependent on the time constant of the control mechanism. By the use of series and parallel resistors of appropriate values with the thermistor, this can be made to control the amplitude of the oscillation at a resistance value which is only a little less than its room-temperature value. Under these circumstances, the settling time of the amplitude is long – perhaps 3-4 seconds at 1kHz, but the t.h.d. will be very low. The penalty incurred in this type of adjustment, apart from the obvious inconvenience of a relatively long settling time following any disturbance, is that the two gangs of the potentiometer used to control the operating frequency of the oscillator must be reasonably well matched in resistance value across the adjustment range, and also, if switched capacitors are used to provide step changes in frequency sweep, the ratios of their values must remain the same.

However, this is merely a statement of the obvious, that it is a pointless exercise to try to design high-performance equipment using low-performance components. Nevertheless, within the limitations imposed by the use of a thermistor as the stabilizing element, the performance of a very simple oscillator, built around a dual operational amplifier (a Texas Instruments TL072), is very good, as is shown in Fig. 6. The total harmonic distortion from this arrangment, in which the resistors associated with the thermistor were adjusted to give a settling time of 5 seconds at 1 kHz, and an output voltage of 2 volts r.m.s., is lower than that obtainable from any other simple Wien-bridge oscillator (that is to say with the exception of systems with low-pass output filtering) known to the author. This distortion is almost exclusively third harmonic – decreasing with frequency – which implies that the source of this waveform distortion is the instantaneous change in gain of the system, during the excursion of each half sinusoid, due to the limited thermal inertia of the thermistor.

The very high performance obtainable from such a circuit encourages the consideration of alternative methods of amplitude control such as that employing a photo-conductive cell and the light-emitting diode combination shown in Fig. 7, in which the time constant and other dynamic characteristics of the control circuit can be optimized by a suitable combination of proportional, integral and differential (p.i.d.) adjustment to the gain of the control circuit (A_2). Needless to say, the photoresistive element should be chosen to have a very low voltage coefficient of resistance and an adequate response speed to avoid the introduction of a further significant time delay into the control loop.

Leaving aside the question of the means employed to control the amplitude of the output signal (which imposes limitations of an identical kind on any oscillator system, in terms of the settling time, and the influence of the control time constant on the harmonic distortion at any given frequency) the improvement in performance given by the circuit design shown in Fig. 5 over that obtainable from the more conventional arrangement shown in Fig. 1, suggests that it would be sensible to regard the improved circuit as a general replacement for the earlier system in all future designs.

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3. Linsley Hood, J. L., *Wireless World*, Jan. 1973, pp 11-12.
4. Taylor, E. F., *Wireless World*, April 1973, p 194.
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6. Linsley Hood, J. L., *Wireless World*, Sept. 1977, pp 40-42 □

The impact of new technology at work

More than £90,000 is being made available over three years by two research councils for studies into the shop-floor impact of the introduction of new technology.

Three studies are planned: on telephone exchange modernisation; on the adoption of a computer-based freight information system in British Rail; and on the introduction of electronic news gathering (ENG) equipment in television.

The Science and Social Science Research Councils are sponsoring the work which will be carried out by the New Technology Research Group of Southampton University. The Group has been formed by engineers and social scientists committed to interdisciplinary research "on the introduction of new electronic and computer technologies at the level of the individual workplace".

The two main objectives of the work will be to explore the process of technological change and to develop interdisciplinary research methods for the problems that arise. The team will be investigating the nature of technological innovation and engineering decision-making in the economic and social context of business organisations; the bearing of organisational structures on the capacity of managers to generate methods and mechanisms for the introduction and control of new technology; the development of union strategies towards new technology; the consequences of technological change for the nature of work and occupations; and the effectiveness of industrial relations procedures in handling new technology issues.

Measuring transient intermodulation

continued from page 47

limiting filter.

The authors are interested in measuring t.i.m. principally to test the effectiveness of anti-t.i.m. measures such as input filters, and to design low-t.i.m. monolithic amplifiers. The availability of a simple and accurate measuring system has already provided useful results, exemplified by the R.I.A.A. preamplifier shown in Fig. 12; a circuit designed around the TDA3210 stereo preamplifier i.c. The filter on the output is intended to minimize t.i.m. in the next stage. This circuit, in terms of traditional parameters, represents the current state-of-the-art in i.c. R.I.A.A. preamps in which the total harmonic distortion is 0.02% at 20kHz. The frequency response is 20Hz to 20kHz ±0.5dB and the dynamic range 100dB.

Further reading

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M. Otala – Transient distortion in transistorized audio power amplifiers *IEEE Trans. Audio and Electroacoustics*, Sept. 70, pp. 234-239.

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E. Leinonen and M. Otala – Correlation audio distortion measurements *AES Journal*, Jan. 78, pp. 12-19.

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R. Cordell – Comments on "A method for measuring TIM" and "Correlation of audio distortion measurements", *AES Journal*, April 79, pp. 295-300.

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S. Takahashi, S. Tanaka – A method of measuring intermodulation distortion, AES Convention, May 79.

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P. Nuti, Misure di Intermodulazione Dinamica, *Suono*, Nov. 77 pp. 115-120.

R. A. Belcher, An experimental investigation of test-noise signals for the measurement of non-linear distortion of sound signal, BBC report RD1974/2. □

WORLD OF AMATEUR RADIO

RAE: useful or lottery?

Some 2100 candidates are reported to have successfully passed the Radio Amateurs' Examination held last December. But despite this, this particular examination, more than any other that I can recall, has raised serious doubts about the overall fairness, effectiveness and true purpose of the RAE in its present form. Has it, people are asking, since the adoption in 1979 of the multichoice form, become little more than a lottery conducted in secret? Are those now holding the prized RAE "Pass" certificate, with or without "credit" endorsements, really so much better qualified to operate a radio transmitter than those who were unlucky enough to fail? Amateurs have not been slow to point out that RAE-alone restricts operation to 144MHz and above – the new c.b. permits, without examination, will provide speech on 27MHz.

The City and Guilds of London Institute, responsible for RAE, appears to have established a "pool" of questions from which papers for the twice yearly exams are composed; they therefore attempt to restrict circulation of genuine papers. It is only by good fortune that the December set has come my way, all 35 questions of Part 1 (mainly on licence conditions) and the 60 more general questions of Part 2. I am not impressed.

As noted in the February WoAR, C and GI recognised that one question could not be answered correctly; but it is now clear that this was not the only mistake. Among several extremely dubious and ambiguous questions there was yet another (Part 2, question 14) in which all the four "answers" are unquestionably wrong due to the printer having made capacitive reactance equal to $1fC/(2\pi)$ instead of $1/(2\pi fC)$! Several questions on radio propagation are confused, while what does one make of Question 58: "A standing wave meter is used to check: (a) stability of the oscillator; (b) efficiency of a transmitter; (c) resonant frequency of an aerial; and (d) operation of the aerial feeder"? That appears (at least to me) also virtually unanswerable.

One finds two questions (Part 2, No 6 and 11) devoted to calculations involving coulombs and microcoulombs. Yet how many amateurs ever find it necessary, or even useful, to be able to do this? In 45 years (without the benefit of an RAE) I have not needed to worry about such quantities of electricity.

Agreed that one purpose of RAE is to check that candidates are likely to benefit from the "self-training" of amateur radio: but surely not by erecting such dubious barriers? Yet the current syllabus requires *no* knowledge of the valves still used in the vast majority of amateur h.f. transmitters which, with high voltages, call for an appreciation of suitable safety precautions.

Again, with mistakes and ambiguities in the papers who can be sure that the "marking" may not be suspect? What are the pass marks? And how do these compare to the *average* probability of a candidate picking up 25 per cent by picking answers with a pin – while a "lucky" candidate, by the laws of probability, could end up with an appreciably higher "pin-score"? To try to counter this, the examiners appear to have tried to make at least some questions unduly difficult or obscure or (for Part 1) to expect candidates to commit to memory every minor detail of the licence conditions, rather than to show sufficient knowledge of needing to refer to the licence itself before attempting such modes as slow-scan tv, etc.

In 1946 the licensing authority (then the Post Office) handed responsibility for RAE to C and GI, with its long-established reputation for conducting examinations, aided by liaison with the RSGB. The Institute should examine seriously the present state of this multichoice examination, if only for the good of its own reputation, and even if 2100 people had the good "luck" to pass.

Long-path "transequatorial"?

A new twist to the unfolding story of transequatorial and chordal hop propagation has been given by the Greek amateur SV1DH. On February 16, signals were received in Athens from Zimbabwe on both 50 and 144MHz, and from South Africa on 50MHz. But he found these signals were audible *only* when his beam was pointing northwards. This makes it look as though they were arriving via the "long path" round the other side of the world and passing close to both Poles, and presumably involving some form of layer entrapment even at the very high frequency of 144MHz. On the same day, ZD8TC in Ascension Island and KP4EOR in Puerto Rico are reported to have made contact across the South Atlantic on 144MHz, yet another curious example of East/West transequatorial v.h.f. propagation.

Up the Amazon

A recent BBC2 series "Travellers in Time" featured original film of famous expeditions of the 1920s and 1930s. One programme was on the Hamilton-Rice expedition to the Upper Amazon, one of the first expeditions ever to take along an h.f. transmitter (shown in several sequences of the original film) and run from a 100-watt petrol-electric generator.

Turning to *Wireless World* of February 11, 1925 one discovers that the first British amateur to make contact with this station (SA-WJS) was the famous Gerald Marcuse, G2NM. Expedition operator J. Swanson was using a one-valve transmitter with an output at the time of only 13 watts to a "T" aerial. G2NM was told: "Your signals come in very strong on detector alone using counterpoise as receiving antenna". It is doubtful whether it would be possible to repeat this today, with so much more interference!

A few days before, on February 1, 1925, another pioneer South American amateur, Carlos Braggio, CB8, Argentina had made the first contact with a British amateur: this time E. J. Simmonds, G2OD. During this contact official messages were sent from CB8 to the RSGB and also to *The Times* – something that today would be much frowned upon as representing third-party traffic.

Here and there

The first British-built amateur radio satellite – the UOSAT project at the University of Surrey – is nearing completion and is scheduled to be launched from California into a polar earth orbit at a height of 530km on or about September 15, 1981. A report from Dr M. N. Sweeting, G3YJO, the project manager, indicates that there should be few major difficulties in clearing the final hurdles.

The RSGB are continuing to view the Home Secretary's decision to legalise 27MHz CB operation "with deep concern" although recognising that frequency-modulation will "to some extent help reduce interference problems".

The IARU Region 1 Triennial Conference is being held at Brighton from April 27 to May 1 with a crowded agenda including many band-planning and other operating recommendations to discuss. A station will operate with the callsign GB1IARU.

Mobile rallies include Midland & Stoke-on-Trent at Drayton Manor Park near Tamworth on April 26; Southend Airport Exhibition Centre on April 26; Maidstone Y. Sports Centre, Cripple Street, on May 3; Northern Mobile Rally, Victoria Hall, Victoria Park, Keighley on May 17; and East Suffolk Wireless Revival, Ipswich on May 24.

Hull University is to bestow an honorary MA degree on Brian Rix, G2DQU . . . Trisha Day, G4KYY in Saltash, Cornwall is the first "XYL" to be appointed a GB2RS newsreader . . . The French society REF has run into severe financial problems . . . A Californian amateur, K6RO, is reported to have contacted (and received confirmation of) 200 different countries in 200 days.

PAT HAWKER, G3VA

LETTERS TO THE EDITOR

ENGINEERING EDUCATION

Professor Bell raises again the question of 'fundamentals' in an engineering education (January issue). In the particular case of electronics engineers, the almost universal academic assumption is that the fundamentals of the subject are essentially physics and maths. Before abolishing engineering schools, however, should we not observe that almost the only constant factor (since the 1930s anyway) has been circuit engineering and circuit design principles? The circuit 'greats' of that era would adapt quite quickly to, say, m.o.s. dynamic logic. My own basic education over 20 years ago at Newcastle-upon-Tyne is still relevant in this area. The physics and maths of the subject have, of course, changed completely!

Incidentally, another good case can be made for teaching engineers basic sales techniques. Even the pure researcher is stymied if he or she cannot sell the idea to be worked on.

R. C. Foss
Mosaid Incorporated
Ottawa, Canada

I am not surprised that Professor Bell is concerned about the education of electronic engineers (January issue).

Since the great expansion of higher education in the 1960s was not of course matched by a corresponding increase in the number of 'high-fliers' seeking engineering qualifications a large number of school leavers of limited academic potential and with indifferent A-level results has been admitted to honours degree engineering courses: entrance requirements simply had to be reduced to fill the increased number of places made available.

Having struggled through the course with limited benefit and obtained a pass or poor honours degree these graduates have neither the potential to become innovative leaders in their profession nor the practical training to become good technician engineers, which in any case many might feel would be 'beneath' them. Meanwhile the HND courses have been deprived of many suitable applicants.

Currently industry requires a small number of highly innovative professional engineers, together with a large number of technician engineers to support them. What it is presented with is a lot of people who have been exposed to enough education to imagine they are truly professional engineers and unwilling to think of themselves and unable to perform well as technician engineers, while the supply of good technician engineers from HND courses has been severely curtailed.

This in turn might lead to a more serious social problem. If universities and polytechnics continue to turn out greatly increased numbers of engineering graduates with high expectations into an industry which cannot absorb them into constructive employment then the graduates may coalesce into an indigestible lump of discontent in the heart of the profession – some will say this has already happened. Arts graduates at least have the advantage of knowing that their qualifications are generally non-vocational and do not have such high expectations of related employment and job satisfaction.

The solution must be to reverse the expansion in higher education and curtail the number of places on honours degree engineering courses to match the limited number of opportunities in industry for engineers of this calibre. Keen competition for places will ensure entrance requirements are raised to the level required for entry into other professions, such as law and medicine, and contribute to enhancing the status of the profession. Courses for technician engineers could then be expanded to meet demand, confident of a supply of suitable applicants.

Me? Well, I left school with a 'D' and 'E' at A-level and much to my surprise was offered a place on an honours degree electrical engineering course. Qualified, and equipped at least with Professor Bell's "enthusiasm for getting things done properly" I have spent the last eight years drifting from employer to employer looking for the one that was interested in "doing things properly". All they seem to want to do is to make money – strange, isn't it?

John Harvey
Darlington
Co. Durham

The author replies

The difference between Dr Foss and me lies in the assumption of what constitutes "fundamentals". Surely circuit design *principles* are fundamental? It is not a topic in which I have specialised, but I suppose that circuit design consists of two parts: the first step, to obtain the desired frequency (or time) response and gain, is abstract and mathematical (one is even allowed to introduce things like ideal gyrators); but the second, which may be briefly described as "tolerancing", is to see whether the abstract design can be adequately approximated with available components. The first step is fundamental but the second is technological, since the tolerance on initial values, possibilities of adjustment and stability of the components will depend on whether one is working with discrete components, thick film circuits, integrated circuits or whatever the future may bring forth. Yet the general idea of tolerancing is a fundamental principle.

As regards changes in physics, I can only say that over the past 20 years I have been very grateful that I was introduced to the rudiments of wave mechanics before the transistor was invented. "Mathematics" covers such a vast range of topics that not even professional mathematicians cover all of them: on one occasion a mathematician whom I asked for help replied "There is only one man in the country who can help you with that problem." (The one man in question did get the problem solved.) All the engineer can hope to learn is a few currently useful techniques and enough basic principles and notation to enable him to seek specialist advice when needed.

Engineers recoil from the idea of "sales techniques", thinking it means persuading a customer against his better judgment. If instead it means presenting one's case in a readily understood form, it is part of the art of communicating which everyone believes in; but does it need a university course to teach that a case to be presented to higher management for the support of a project should not be written in the same form as a scientific paper recording the theory and past experimental results?

On the whole I agree with Mr Harvey. But who encourages school leavers of limited academic potential to apply for university places? The schools? The Government, in implementing the Robbins recommendation of giving a grant at a level of two Es? Each university or polytechnic department makes its own choice of the level between four As and two Es which is prima facie evidence of acceptability. As I am not now responsible for such a decision I do not want to comment on what is a suitable level, beyond saying that I do not think any department with which I have ever been associated has accepted D,E as a prima facie acceptable qualification. (One must make occasional exceptions for illness etc.)

For remedial action, adaptibility may be better than determination to stick to engineering. Some firms advertise appointments for which the qualification is "a degree in any subject": an engineering graduate should be just as eligible as an arts graduate.

As regards the need of industry for a small number of highly innovative professional engineers, see the Finniston report and the current action of the IEE in accrediting university courses of high standard.

D. A. Bell

BATTERY MARKINGS

In the article 'Battery powered instruments' in the February issue, the author remarks that "we can expect UK manufacturers to follow suit (in adopting IEC designation) in the next year or two".

I would like to point out that Berec (Ever Ready), the largest manufacturer of Leclanché (zinc-carbon) batteries in the UK, have been producing batteries in the most popular sizes with dual nomenclature (Ever Ready/IEC) since July 1979. New battery types introduced since then use the IEC designation only and, obviously, it is our future object to label all batteries in this manner.

We too regard the ending of company and national size coding as most desirable.

D. H. Spencer
Berec Group Limited
London N15

DIGITAL ELECTRONICS TEACHING

In a letter published last November I charged colleges and faculties with refusing to teach the rudiments of digital electronic design. In March, Dr F. D. Cocks asked me to reveal all about these rudiments.

Although it is difficult to publish material which is not already part of college courses because the text book publishers rightly fear they might make a loss on the project, my colleagues in CAM Consultants and I have succeeded in publishing much of the material in question. No college or faculty I know of teaches any of the very important content of our book Digital Hardware Design, pub. Macmillan 1979. For our other books, see the list of books in print at any library and look under my name.

Ivor Catt
St Albans
Herts

TELEVISION SETS FOR THE DEAF

The recent correspondence on tv sets for the deaf could lead many hearing impaired people to believe that the problem of hearing the tv sound can be overcome by the acquisition of a television set with headphone facilities. This sadly is not the case.

The headphone facilities provided on most tv sets do not give sufficient output to benefit many hard of hearing people, let alone those with a more severe hearing loss. The relatively high values of resistance wired in series with these sockets would indicate that the output is intended to give a comfortable listening level through headphones for those with normal hearing, making them useless for many hearing impaired people.

In order to hear tv sound it is very often necessary for those with hearing difficulties to have the audio output of the set taken from across the loudspeaker terminals through an isolating/matching transformer to an output socket, thus enabling them to use headphone, tv listening aid or audio frequency induction loop system. This modification has to be carried out at considerable expense to those who sometimes can least afford to pay.

Surely it is no more expensive to provide a high level of headphone output. The value of series resistance need only be sufficient to protect the audio output stage against short circuit.

Apart from the benefits to deaf people, others may wish to connect a higher quality loudspeaker to improve the tv sound and those wishing to use headphones could use a headset which incorporates volume controls.

R. F. Power (Technical Officer)
Royal National Institute for the Deaf
London WC1

SCIENCE AND SOCIETY

I would like to support strongly the basic tenor of your editorial in the November 1980 issue entitled "Microchips and megadeaths" which stresses the position of electronics engineers as a part of weapons production. However it is not just within the field of arms development that the scientist plays a crucial role. An understanding of the position of science and scientists within society is vital for all people as science now permeates the lives of everyone. Given a realisation that science is inextricably linked to the society within which it exists then we must act to ensure that science serves the people as a whole. Everyone should be involved in deciding what science should be pursued by society and how. This means that society itself will have to be changed.

I would like to bring it to the attention of your readers that there already exists an organisation that is concerned with these kinds of questions: the British Society For Social Responsibility in Science. To quote from the BSSRS policy statement: "Science is not neutral. It cannot be separated from politics. It both reflects and helps to determine the values of society . . . . . The claim that science is neutral is itself a weapon of mystification and domination. The hierarchical nature of science together with the jargon of science ensure that scientific knowledge remains accessible only to a small minority. Social and political decisions are taken behind a smokescreen of scientific 'objectivity' . . . . . We are committed to fighting for the use of science and technology by and for the benefit of working people, to demonstrating the political content of existing science, and to furthering links between scientific workers and the rest of the labour movement."

As part of this BSSRS publishes a quarterly magazine called *Science for People* and has a network of local groups, of which Edinburgh Science for People Group is one. Further, there is a number of 'work hazards groups' and a *Hazards Bulletin* is published every two months as well as occasional booklets being produced. There are also several groups concerned with particular areas including, among others: agriculture, microprocessors, energy, sociobiology, hospital hazards, radiation hazards, women and work hazards, science teachers, health, statistics.

BSSRS may be contacted at 9 Poland Street, London W1; all will be very welcome, whether scientist or non-scientist. If you are really concerned about the role of science and technology within society then join us. As the November editorial indicated, the future existence of humankind is at stake.

Alan Beard
Edinburgh Science for People Group
University of Edinburgh

BATTERY COMPARISONS WANTED

I am writing to say how helpful and informative I found Ian Hickman's article on battery powered instruments in the February issue. The information given in the tables showing estimated service life of various layer type batteries was especially useful and I wonder if you could supplement this article by persuading one of your contributors to compile a survey of the various different types of cell now available.

For instance, my camera and digital watch both use silver oxide cells. But it is possible to buy mercury hearing aid cells of the same size for a fraction of the cost. There are also alkaline and rechargeable silver/zinc cells. What are the comparative merits of these various types?

In the conventional zinc/carbon types there are Super cells, High Power cells, battery clock cells, and Power Plus cells. A comparison of these types with alkaline and nickel cadmium rechargeable cells would be useful.

If you could arrange to publish an article along these lines I am sure that many other readers who are as confused as I am about the choice of battery type would find it of great benefit.

W. A. Klos
Harrow
Middlesex

'JUST DETECTABLE' DISTORTION

As a sound recordist in the largest film unit in the world, I have listened to a lot of distortion in the last twenty years, most of it self-generated, so I was very interested to read James Moir's article on 'just detectable' distortion in the February issue.

I was pleased to see "continuous sine waves" discarded early in the article, only to be dismayed by their resurrection on the last page. There is no such thing as a continuous sine wave, but we can fool ourselves into believing in them as our brains can forget what happened when we switched on. Substituting a sine wave of an arbitrary frequency in order to measure, approximately, the equivalent harmonic distortion of a music signal is like taking out a loan of £100 then working out the interest in Altarian Dollars without knowing what the exchange rate is. Any attempt to deduce one from the experiment is sitting on the tree branch one is sawing off.

The actual total harmonic and intermodulation and other distortions (see below) can of course be measured by subtracting input from output and dividing by input, but here we start revealing the mathematical snags; do we use the peak levels, an average level, or a continuously variable level and extract the peak value of distortion as the most significant? All of these approaches are valid in differing circumstances; for instance, with crossover distortion at an inaudible 0.1% at peak level, this becomes 3.2% at −30dB, where the ear can be extraordinarily sensitive in the gaps between words etc. It is at these levels that reverberation and so on colours the whole acoustic image.

It is comfortable to think that an "exchange rate" exists between "continuous" sine wave distortion and reality, and this is good for hi-fi salesmen, but can I just list some factors not covered by this and the other parameters usually quoted such as noise and frequency response: transient intermodulation; transient clipping (undetectable as t.h.d. but removing a lot of the energy from the transient, softening it); compression, often deliberate but also inherent in the magnetic recording process; modulation distortion, often classed as noise but not measurable as such; loudspeaker Doppler distortion; and phase distortion.

This latter one is usually regarded as inaudible from tests done with (not again!) sine waves, and, up to 90 degrees, probably is. But it is cumulative, and by the time a signal has been analogue recorded twice (with tv film this can be up to eight times), some frequencies can be shifted more than 360 degrees, causing ringing on transients. This is nothing to do with frequency response, and is, I believe, the source of the "Rice Kellogg sound" of flapping paper inherent in even the best of moving-coil loudspeakers, which all sound quite different.

Mr Moir was trying to find what levels of distortion were just detectable with an already distorted signal, and I suppose this is valid with all commercially produced analogue recordings containing many percents of harmonic distortion, but it does introduce yet another imponderable, and is probably why figures for JDD varied from 0.01% to 5%, rather a large spread.

If one is to be indissolubly wedded to t.h.d. measurements, to ensure standardisation, maybe the answer is to substitute a different signal for measuring purposes. Now the most critical source to record is not music – as the most diabolical liberties are taken with the fidelity of reproduction of most music, making it sound better – but the human voice, which cannot be undetectably reproduced, compared with the original. (Try it, behind a curtain, with the best of equipment.)

If the one is too critical, and the other not enough, and neither steady enough for easy measurement, some synthetic signal is called for, and white noise, generated by a pseudo random binary sequence may prove a basis for this. It contains all components of interest, including transients, can be split into frequency bands for harmonic and enharmonic distortion measurement, and can be made cyclic so the same sequence can be used for all tests. I have experimented with top quality tape recorders and found p.r.b.s. white noise always sounds different on replay when A-B checked with the incoming. I then went on to try very short sequences, finishing up with a twenty pulse digital train . . . 11100010101010101010 . . . which contains more harmonics than one would ever need, based on a musical major chord. The transients in it show up the inadequacies of the best tape recorders on a 'scope, which also reveals shocking phase responses. Harmonic distortion can be measured using a low pass filter first, then a high pass, and intermod distortion can be measured by removing one or more of the fundamental or low harmonics, and measuring what comes back. As an audible check, it is very critical and gives a good stereo image, lacking with sine waves. My fundamental was at 87.3Hz.

If one takes, as a criterion for assessing 'just detectable' distortion, the human voice beside a loudspeaker behind a curtain, it may prove just too critical a test, and my guess is, even with the best electrostatic speakers and a steady state system distortion of less than 1%, various forms of compression distortion are going to be the bugbear. If one thinks of varying levels as having the effect of changing the acoustic image distance, which is how it sounds, then clipped transients, for instance, may make *rk*s and *t*s come from the back of the head, and a loud word audibly propel the speaker's image back a metre or so, instantly. If this is not distortion, then what is it, as it is generated by non-linearity in the overall transfer characteristic?

I'll bet you any number of Altarian Dollars, at the usual exchange rate, that Mr Moir has not found the ultimate answer to distortion levels. (Nor even the ultimate question?)

Dave Brinicombe
Stanmore
Middlesex

The author replies:

Mr Brinicombe rightly raises objection to the use of total harmonic distortion as an indication of all the subjectively judged distortions, and I would join him in this, but the contribution did not suggest that t.h.d. should be so used. Nevertheless all the international standards use this criterion as the best single measure of 'distortion' and as these standards are the result of the deliberations of hundreds of eminent engineers their views must be given due weight in coming to any decision on what criteria should be used.

My contribution was aimed at co-ordinating the previous data on 'just detectable' distortion with the more recent findings, including those of our own investigations. As the majority of the earlier data was in the form of harmonic distortion quotations I had to conform in order to make comparison possible. I doubt whether any professional engineer believes that t.h.d. figures are an accurate indication of the total distortion when this is subjectively judged, but I know of no evidence that t.h.d. is not the best indication currently in use to express the distortion performance of professional amplifiers.

Considerable experience appears to show that the 2nd and 3rd harmonics comprise almost all the distortion components in professional quality amplifiers. It is very easy to find signal waveforms that sound different at the input and output of even very good amplifiers, but to the best of my knowledge there have been no attempts to co-ordinate the objectively estimated distortion using these waveforms with the quality deterioration when the amplifier is used for reproducing music and speech. White noise, pink noise, tone bursts and d.c. pulses are a few of the test waveforms that have been used, but few supporters of these have taken the precaution of limiting the test signal bandwidth to the audio band. The use of test signals that overload the amplifier at frequencies well above the audio range produces audible effects inside the band but this is no indication that these effects are present when the test signal bandwidth is limited to that characteristic of speech and music.

The relatively simple and well understood harmonic distortion measurement techniques have almost all the advantages, except where the assessment must be made at frequencies near the upper limit of the system bandwidth. Two-frequency intermodulation tests have many advantages when working near the upper frequency limit but are of little value for tests near the lower frequency bandwidth limit. It seems unlikely that any single test will ever be produced that will assess all the distortions that occur in a system. Distortion measuring techniques have to be selected to be the most effective when used to measure the particular distortion being investigated.

Mr Brinicombe's comments about the audible effects of phase distortion are grossly exaggerated. Could I suggest that he re-reads the contribution on this subject in *Wireless World* dated March 1976? Similarly I do not think that there is any evidence that continuous sine wave test techniques and the amplifier design procedures based on such tests are inadequate to ensure a good performance in reproducing transients. However, the writer raises such a large number of red herrings that it is impossible to discuss each of them in any detail. Perhaps he could look up the July 1978 issue of *Wireless World* dealing with the subjective comparison of three amplifiers, one of the valve type and two transistor designs. Between the three of them they included almost all the design points criticised by Mr Brinicombe and yet a skilled listening panel was unable to differentiate between them.

James Moir

PARALLEL-TRACKING PICKUP ARM

I am pleased to see Mr Gutteridge has realized the excellent performance which my parallel-tracking arm design is capable of achieving (January letters), but I am surprised he has had to resort to a lathe to make the nylon slider and the pulley wheels. The latter are available from model shops – the most useful being those manufactured by Ripmax, reference numbers N906 (½in dia.), N907 (¾in. dia.) and N908 (1in dia.).

The nylon slider (which replaced the original brass/steel one) is not supplied as a ready-made part in the kit offered by J. Biles because it has to be individually fitted. However, it is so soft that it can be easily shaped with a sharp knife, and I have made several of these quite accurately using an art knife and a small file.

As for the rubber belt drive, this is essential for decoupling the motor/gearbox from the rest of the mechanism, otherwise noise will find its way to the pickup. It also provides a good deal of latitude for the mounting position of the motor/gearbox, and is most tolerant of alignment errors. The "lossy" expanded-neoprene drive bands supplied with the kit gave outstanding isolation from vibration, so there need be no qualms about this method of driving the lead screw.

As there have been many improvements to the design since it was first published, I hope to offer a follow-up article later. This will include a design of gearbox which allows rapid forward and reverse tracking, which has been called for by the majority of constructors, who want a more flexible and faster operation. The original design had a leisurely return time of 2 minutes; this has been reduced to a few seconds.

Rod Cooper
Lichfield
Staffordshire

COMPUTER ARCHITECTURE AND PROGRAMMING

Your editorial "The new bureaucracy" (February 1981) contains much that is true, but also much that is both false and silly.

It is true that the "von Neumann" architecture is a millstone round the neck of technology. But so is the internal combustion engine, and they both remain with us for much the same historical reasons. Please do not think that computer systems engineers are unaware of this: in fact, much work has been done, in university departments and in industry, to try to evolve new architectures.

The von Neumann architecture was indeed copied into today's microprocessors. But the early microprocessors were designed by electronics engineers who did not know that computer systems engineers might have advised them otherwise. I say "might", because it would have been premature in the early 1970s. We are likely to see new architectures appearing in microprocessors in the mid-1980s.

The hatchet-swinging in your final paragraphs is somewhat undirected. If I may mention university courses in computer systems engineering (often called "computer science" for bureaucratic reasons), it is certainly not the case that we produce, or wish to produce, "uninformed programmers" for a "technically uneducated parasitic bureaucracy". We never tire of telling applicants from schools that computer systems engineering is *not just programming*. Such courses consist of theory, computer systems design, and computer applications. Theory needs no excuse. Computer systems design consists of both hardware and software, taught in an integrated way. Computer applications are studied so that our students, who are *not* "ignorant of the technological nature of their machines" can go on and take a genuine and informed "interest in the customer's real problem, for which he wanted a mechanised solution".

W. Freeman
Department of Computer Science
University of York

You use your February editorial comment to attack my trade (computer programming), and that of railway information staff, with some venom. I do not propose to reply in vitriolic kind, nor to be drawn into pained self-justification – for which I contend there is no need; but I must contradict some of the supposed facts of your argument:

Firstly, it is not "the programmer class" which dictates the architecture of computers, but a mixture of history (most of us don't have this year's model), government procurement policy, what management thinks it wants and, above all, what technologists tell management it can have.

The last constraint leads to my second remark: to knock the von Neumann architecture is no more than a cheap smear unless you are offering a worthwhile alternative; yet in this matter you make no suggestions. To be sure, we have the ICL DAP, but the price of such systems, while not unreasonable, is hardly such as to make them an appropriate architecture for the microprocessor market. Moreover, a substantial number of the programmers whom you so despise are presently trying to find ways of applying this equipment to problem-solving – a task substantially more complicated than applying a von Neumann machine. And thence arise my final remarks.

Problem-solving by machine is a mechanical, not a magical, process; it is and will always be necessary to devise a method of solution and express it as a list of steps (not necessarily all sequential). At present this process is done by programmers, who, far from nurturing the "parasitic bureaucracy" you picture to your less-informed readers, have been and are notably active in devising means to mechanise ever more of the programming process, and to render the non-mechanical parts more accessible to the non-specialist (their success is attested by the transformation of the computer from academic toy to commercial tool).

Finally, this need of programming drastically (and rather obviously) undermines your argument. How, without "computer science on your back", do you propose to harness the "massive potential for social benefit" of digital electronics? Its greatest software-free contribution to the public good so far, apparently, has been the inestimable boon of the digital watch.

Without obsequies,

John Fraser
Liverpool 8

I find that ill-informed and destructive criticism is too often voiced by certain engineers about engineers of other disciplines. The prejudices behind these attacks build artificial barriers. These prevent many individuals gaining experience outside their immediate field. They disrupt the design of complete systems, lead to poor understanding, and inhibit vital cooperation.

That certain malcontents should air these views in private is regrettable. That *Wireless World* should give one editorial space is unforgivable.

Ian Miller
Leatherhead
Surrey

IS LIGHT VELOCITY A CONSTANT?

Michael M. Albahari (MMA) correctly argued in February letters that one does not need to carry out experiments in order to expose the flaws of relativity. The relativists, however, have developed a diabolically flexible logic, by which inconsistencies such as $A=B$, $A\neq B$ can be comfortably accommodated.

Unfortunately, MMA's analysis of his proposed experiment suffers from a century-old serious error: In his formulae $t_B-t_A=d(c-v)$ and $t_A-t_B=d(c+v)$ the frame relative to which the velocities c and v are referred is implicity assumed to be the solar system ($v=30$km/s is the orbital velocity of the Earth). Why the solar frame is chosen, nobody has ever explained. Why not the galactic frame? Why not the Jovian system? Indeed, why not the geo-frame? After all it is in the stark terrestrial environment that this kind of experiments are performed. It has been shown[1] that it was this failure to specify the proper reference frame for a correct analysis of these experiments that led to the ill-conceived ideas of relativity. It has also been argued that the heavy burden of the responsibility for this mistake falls squarely on Maxwell[2].

Maxwell correctly showed that "light is an electromagnetic disturbance propagated through the electromagnetic field according to electromagnetic laws."[3] Maxwell had earlier defined the electromagnetic field as "that part of space which contains and surrounds bodies in electric and magnetic conditions." On the basis of these statements one must conclude that the media through which light and electromagnetic signals (involved in terrestrial experiments) are propagated, are the electromagnetic fields that contain and surround the Earth. So the orbital velocity of the Earth cannot possibly enter into the theoretical analysis of these experiments; and the velocity of light c=300 000km/s must (in these experiments) be referred to the geocentric, and no other, frame. For the electromagnetic fields of the Earth, through which light is propagated, are firmly tied onto the Earth, not on the Sun, or Jupiter, or else. Maxwell and all his followers[4] failed to draw these simple conclusions – with literally tragic consequences.

So in MMA's formulae one must put $v=0$ and thus $t_B-t_A=t_A-t_B$. But this does not mean of course that c is constant relative to *any* frame as the relativists have supidly concluded; it simply means that the luminiterous medium – the geoether[2] – is securely attached onto the body of the Earth.

The common man does not demand that an experiment be performed in order to show that the magnetic field of the Earth is firmly tied on the body of the Earth. Numerous experiments (Michelson-Morley, Trouton-Noble, etc.) have already affirmed this inexorable fact in an unambiguous fashion. The relativists, on the other hand, have, for reasons best known to themselves, boldly abolished the geofields altogether; and they dictatorially "establish *by definition* that the time required by light to travel from A to B equals the time it requires to travel from B to A."[5] This is not science; it is worse than medieval scholasticism.

T. Theocharis
London SW18.

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2. T. Theocharis, "Maxwell's Error", 1980, unpublished.
3. J. C. Maxwell, "A Dynamical Theory of the Electromagnetic Field", *Phil. Trans. Roy. Soc. Lond. 155*, 489, 1865.
4. Except C. A. Zapffe (*Seven Short Essays on* $(1-v^2/c^2)^{-1/2}$, Lakeland Color Press, Brainerd, Minn. 1977), and T. Theocharis (see ref. 1).
5. A. Einstein, "On the Electrodynamics of Moving Bodies", *Ann. d. Phys. 17*, 891, 1905; italics in original.

The velocity of light (February letters) is obviously crucial to navigational systems which depend on the time taken by radio waves to travel over various paths; but when navigation depends on the phase difference of signals received from different transmitters (as in Decca etc.) and moreover the transmitters are widely separated in order to give world coverage by the system (as in Omega) there is the further problem of doing something which appears to be forbidden by relativity, i.e. securing simultaneity of events at widely separated places.

One might hope to achieve this by transporting a standard clock (in practice a caesium clock) from one place to another. But according to the theory of relativity, the rate of a clock will change if it is moved at an appreciable speed and this is so difficult to accept in "common sense" terms that it provides quite a crucial test of relativity theory. One should in fact use general relativity, according to which the rate of a clock depends on the gravitational potential of the point at which it is situated: this has to be mentioned, because the effect of reduced gravitational potential at a height of 10,000 metres is greater than the predicted effect of the velocity of a jet aircraft. Now the velocity effect is calculated from the special theory of relativity which is based on an inertial (non-rotating) frame of reference; and so if one sends a clock on a round-the-world flight from East to West the rotational velocity of the earth's surface must be added to the ground speed to find the velocity relative to a stationary frame of reference, but subtracted if the flight is the other way.

A pair of papers by J. C. Hafele and R. E. Keating in 1972 (*Science*, vol. 177 pp. 166-168 and 168-170) describe first the theory and second the result of an experiment in which four standard clocks were sent on round-the-world flights, (a) travelling Eastward and (b) Westward. Summarised very briefly, the theoretical and experimental values of the difference in nanoseconds between the flying clocks and a stationary clock were as follows:

	Eastward flight	**Westward flight**
Theoretical	-40 ± 23	275 ± 21
Experimental, mean of four clocks	-59 ± 10	273 ± 7

Unless someone has since produced contradictory evidence, this seems to be adequate vindication of the theory of relativity, or at least of its use as a mathematical tool.

D. A. Bell
Beverley
North Humberside

FAILURE OF DISTRESS SIGNALS AT SEA

I would like to comment on John Wiseman's letter in the August 1980 issue and John J. Boyd's reply in the December 1980 issue.

The fourth paragraph of Mr Boyd's letter notes the problem of ship design as influencing aerial system configurations. I had arrived at the same conclusion in 1971. I prepared a report on the container ship conversion problem in 1971, where a deck was added, and the antennas were reconstructed from the standard between-the-main-masts wire antenna to a top loaded vertical, and a wire antenna contained in a very small space, by folding it back. Prior to conversion, the vessel was of the "Mariner" class. At present the name of the vessel is the *American Accord*.

On the *American Accord*, and on other vessels, I have had numerous occasions of being unable to obtain any radiation on 500 kHz. I had thought that this was distinctly characteristic of the American vessels, since they are on the whole floating junk shops all the way around, and I am much surprised to learn that British ships are so afflicted. As with Mr Boyd's experience, I find that it appears that the steamship companies and the radio companies, who are licensees of the stations, seem to want to preserve the junk shop condition into perpetuity.

If it could be ascertained that the disappearance of the *Poet* without signal could be accounted for by inability to produce radiation on 500 kHz, I would not be surprised in the least.

Kenneth Cossaboom
Windham
New Hampshire, USA

Multiplex keying for organs. In the letter by L. W. Ellen in the April issue (p. 55) the fourth line in the middle column of the page should read "Widor Toccata uses just over half the capacity . . ." Apologies for a printing error which drastically altered the meaning.

ROBOTICS AND ARTIFICIAL INTELLIGENCE

I was delighted to see the interesting article by Malcolm Peltu on artificial intelligence in your January issue. It was some time ago that the Computer and Control division of the IEE set up a professional group on robotics. This reflected the increasing awareness among engineers and scientists in the UK that development of robotics could play a key role in advancing British industry and technology. In *IEE News*, September 1980, Member of Parliament Mr G. Roberts admitted that Britain needs massive investment in robots and mentioned a figure of £350 million. Is this enough?

It was also pointed out that the countries leading in this branch of the technology are somehow finding more money for this purpose, e.g. West German research projects in this field exceed £10 million a year. Robotics in the UK is lagging behind if compared with activity in the USA, Japan, West Germany, Italy and Sweden, where this, together with other fields of technology, is receiving considerable support.

A competitive industry in electronics and related fields of technology has always existed in the UK. Why shouldn't we keep it this way? Examples given by Mr Peltu in his article reflect the willingness of British researchers to put the UK a step ahead. Unfortunately this is not enough. To close the existing gap, I believe, it is necessary to make use of imported skills and equipment, and, most important of all, to launch a massive research programme on robotics.

Mr Peltu also draws attention to the running battle between computer scientists and AI researchers. Computer scientists who are worried about AI drawing off some of their resources complain that AI is too vague. No, Mr Computer Scientist, you are wrong. AI is sufficiently wide, sufficiently deep and an extremely interesting field of study having the most promising future. It can stand up firmly as a coherent discipline; it has to. There is so much to get on with. AI cannot be mistreated. It has every right to exist as a research field.

H. E. Piskobulu
Thames Polytechnic
London SE18

ELECTRONIC ORGAN TONE FILTERS

May I, through your columns, disagree with Dr Pykett's and Mr Robins's implied assertion (December 1980 letters) that the function of an electronic organ is to imitate, as closely as possible, the sound of a pipe organ. A visit to any organ showroom will make it clear that the electronic organ has long since evolved into an instrument in its own right, possessing as it does a wide range of new synthetic sounds, percussions and automated aids to performance, with comparatively few tones reminiscent of its wind-driven forbear. (This is exactly as it should be; every age has given rise to new instruments appropriate to the music of the time.) Indeed, to buy an electronic equivalent of a church or cinema organ at a reasonable price and without surplus gadgetry seems well-nigh impossible although published designs for the amateur constructor continue to appear.

After listening to many electronic organs, my own impressions are as follows: string and flute tones can be reproduced with a reasonable degree of fidelity together with some of the solo reeds. Diapasons are less satisfactory although tolerable in an instrument of the "cinema" variety where they are of secondary importance to the tibia clausa. Never, though, have I heard a remotely lifelike organ trumpet, let alone a full swell chorus.

Why must this be so? A chorus reed pipe has an extensive range of upper harmonics, but so does the sawtooth wave from which it is derived. Is it the changing phase relationship between these harmonics? Are some or all of them out of tune? Do they have differing envelopes? Does white or pink noise exist? In short, what is the difference between a waveform which is harmonically rich and one that sounds "brassy"?

If any of your contributors could answer these questions and suggest a straightforward means for realising such tones in practice then I submit they would make a very worthwhile contribution to the literature on electronic organs.

F. E. Norrington
Bromley
Kent

SPECIAL RELATIVITY

Am I the only reader of *Wireless World* with an interest in physics who finds the articles on special relativity somewhat boring? Of course special relativity is "only" an hypothesis, as are all scientific theories[1]; of course it is a sin to try and justify them as *a priori* true. Obviously there exist paradoxa in almost all the theories of what textbooks call modern physics. It is a dangerous sign that Lorentz covariance has become a methodological requirement for any theory of, say, high energy interactions. But one cannot deny that these theories can be both accurate (quantum electrodynamics) and of great explanatory power (quantum chromodynamics) and to my taste, at least, more fun. For that reason one can sympathise with the editors of *scientific* journals who set up "special provision" for the sort of articles Prof. Davies was dealing with in his *New Scientist* article[2].

When a new, more inclusive theory arises, which will embrace quantum mechanics and general relativity, I suspect that few "anti-relativists" will like the result. But boring it won't be.

Keith Burnett
Wallasey
Merseyside

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1. K. R. Popper, "Unended Quest," Fontana.
2. P. Davies, *New Scientist*, 7 August 1980, p 463.

DEDICATED LOUDSPEAKER BOX

The letter from Mr J. T. Lloyd in the February issue reminds me of some experiments which I did some time ago using a guitar as the box for a loudspeaker. What I did was to remove all the strings and place a suitable speaker face down on the guitar aperture. The speaker was then held in place with sticky tape.

Guitar tunes, kindly executed by my wife on the same instrument, were played back into this enclosure from a good cassette deck and, although there were no tears of joy, the results were remarkable. The same tape played through my hi-fi system just did not sound like the original, not even when listening with headphones.

Next I tried a cassette with pieces executed by Segovia and the sound was simply impressive. I can quite believe Mr Lloyd when he says that the effect is stunning.

The drawback is of course that only one instrument can be played on a dedicated box. But hi-fi is concerned with the exact reproduction of sound and it would not be surprising if one day we saw "variable enclosures" changing shape according to the type of music being played or multi-track tape recorders feeding several musical instruments.

D. Di Mario
Milan
Italy

OSCILLATING CRYSTALS

Reference is made to Dr Thackeray's interesting letter, August 1980 issue, and the item "Sixty years ago" in May 1980, p.60. Here Dr G. W. Pickard's heterodyning crystal radio receiver was mentioned. It is interesting to note that W. T. Ditcham's timely article appeared in May 1920, and the circuit diagram of Pickard's heterodyning receiver in *QST*, March 1920, p.44, just two months earlier. There is no question whatsoever that England originated the semiconductor era through the discovery, in 1910, by Dr W. H. Eccles, of crystal diode oscillation. It is hard to realize that it took about ten years for practical active crystal-diode circuits to appear, in spite of Ditcham's reminder – circuits that included both r.f. and a.f. amplification. The last one, at the time, was totally unknown to most "affectionados", one of them being the author of this letter.

Most of the credit for practical devices goes to O. V. Lossev, Russia, whether or not he knew of Eccles' pioneer work a decade earlier – he should have known about it; one has the right to expect that he as a qualified scientist was familiar with the world's scientific literature. Lossev is better known, however, for his amazing discovery of the light emitting diode, l.e.d., in 1923, but here we have a repetition of what happened with the oscillating crystal. The l.e.d. was discovered by H. J. Round already in 1907, and his publication occurred in *Electrical World*, February 9, 1907. Just like Eccles, Round was too busy with other fascinating things in science, and today Lossev is honoured as the father of the l.e.d.

The fact that in 1948 Bell Telephone Laboratories (BTL) totally failed to mention the amazing pioneer work done by Eccles, Lossev, Pickard, Round, and others, claiming all the credit for the transistor for themselves, may be explained away by the fact that the earlier gadget was a diode, while the transistor is a triode. However, to set the record straight, the triode oscillator/amplifier was not only invented much ahead of BTL's priority date for the transistor, but patented years earlier by a man who should have been given extensive credit. He was another genius, as they come and go, Dr J. E. Lilienfeld, of electrolytic capacitor fame. He created his non-tube device around 1923, with one foot in Canada and the other in the USA, and the date of his Canadian patent application was October 1925. Later American patents followed, which should have been well known to the BTL patent office. Lilienfeld demonstrated his remarkable tubeless radio receiver on many occasions, but God help a fellow who at that time threatened the reign of the tube. Nevertheless, forgetting about gadgets, BTL in 1948 gave the world something of unmeasurable value – the electron-hole theory.

H. E. Stockman
Sercolab
Arlington
Mass., USA

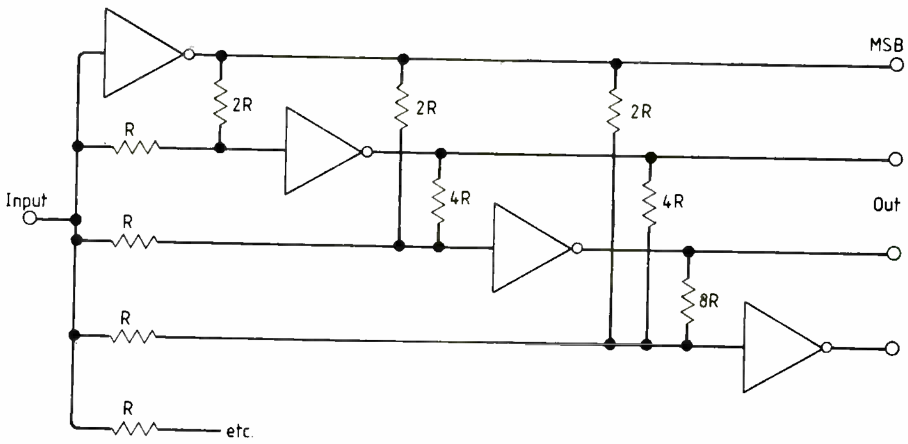
CIRCUIT IDEAS

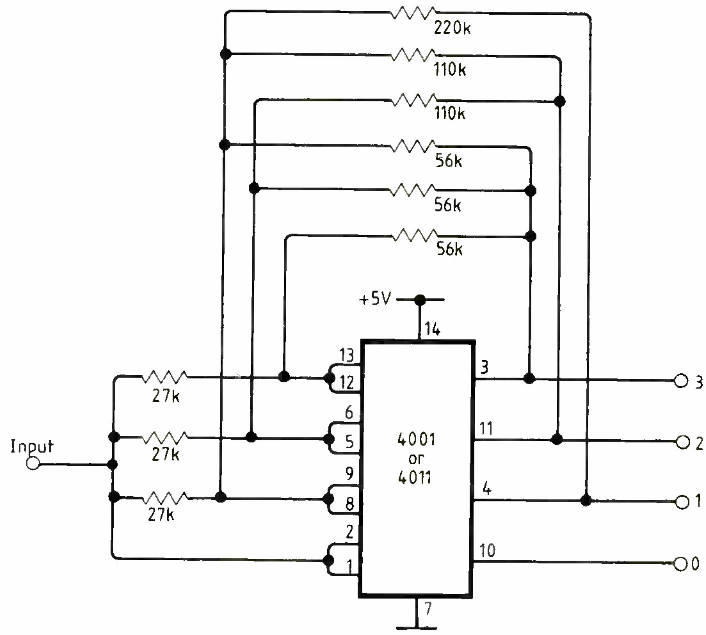
Simple a-to-d converter

A continuous a-to-d converter that can, in principle, be extended indefinitely is shown in Fig. 1. The complement of the digital word represents the input voltage, from 0 to V_{cc}, and is available at the output. The inverters must switch at $V_{cc}/2$ volts within $\pm 1/2^{n+1}-2$, where n is the number of bits generated, and their outputs must be either 0V or V_{cc}. They must also have a high input resistance and a low output resistance. These requirements are met by an op-amp, with its inverting input connected to $V_{cc}/2$ volts, in series with a c.m.o.s. inverting gate.

If 4-bit accuracy or less is sufficient, a quad 2-input NAND or NOR c.m.o.s. gate is just adequate. The input resistance of this circuit is approximately 22kΩ. Because the four gates are on the same chip, variation between switching voltages is small and to some extent self compensating, although selection of a suitable chip may be necessary.

A. E. Prinn
Newton
Merseyside

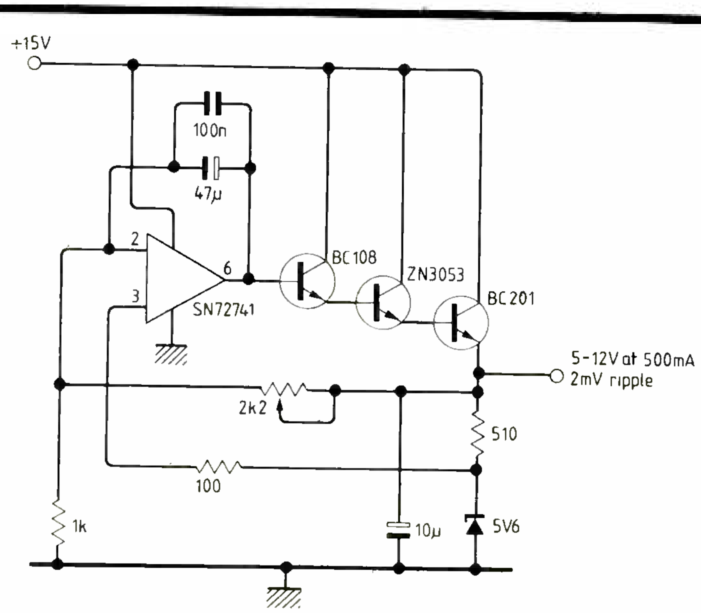




Reducing power supply ripple

Power supply ripple can be easily reduced, to 2mV in the prototype, by using an op-amp as a low-pass filter and feeding the a.c. content back through a capacitor to reduce the a.c. gain of the op-amp'

A. Bartram
Exeter
Devon

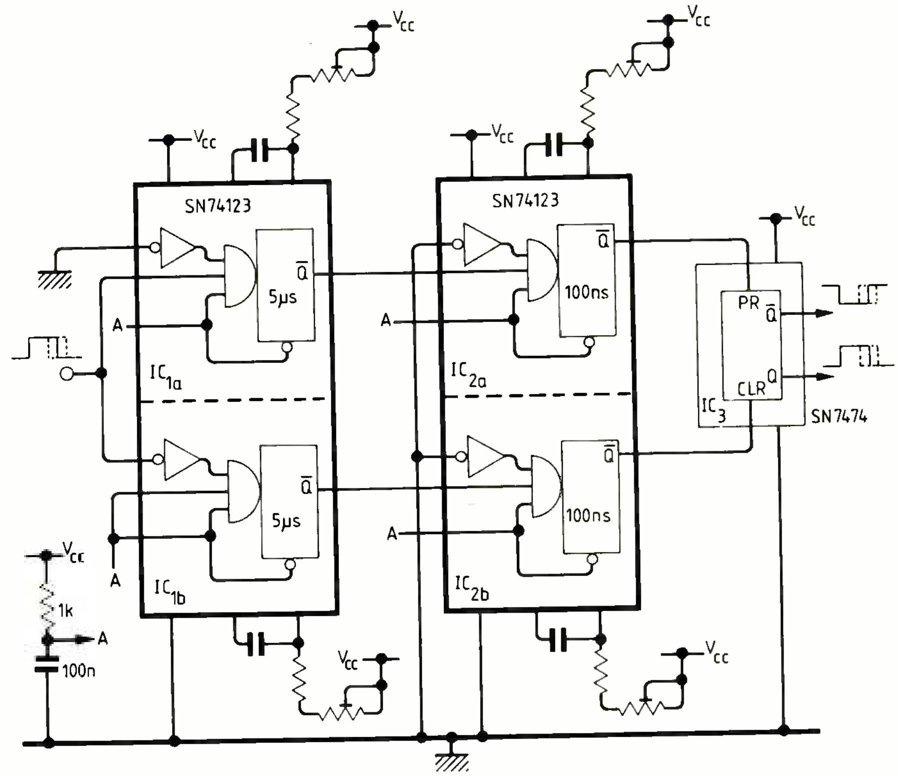


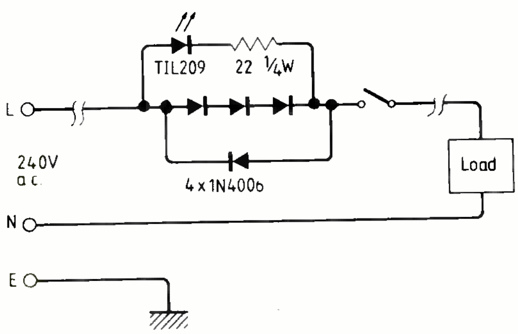
Variable-width pulse delay

If a pulse of variable length must be delayed without disturbing its length, this can be achieved with three i.cs.

The leading positive edge of the input pulse triggers monostable IC_{1a} which, after a selected time, triggers IC_{2a}. The second monostable then sets bistable, IC_3. The trailing negative edge of the input pulse repeats this action through IC_{1a} and IC_{2a} to reset the bistable. The original pulse is therefore reconstructed and delayed by IC_1, IC_{1a}. Accuracy of the circuit depends upon the equality of the delay times.

A. B. Palmer
Leeds





Power monitor for remote loads

Remote loads can easily be monitored using this simple indicator. The l.e.d. is sufficiently bright to be seen in normal daylight, and the specified diodes are suitable for loads up to 100W.

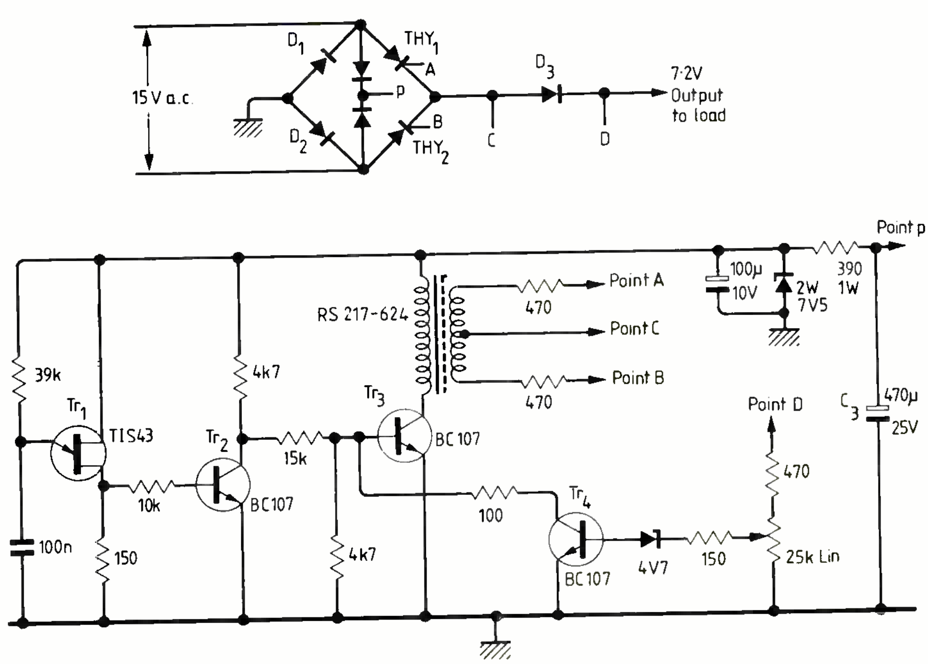
L. Ghiotto
Genova
Italy

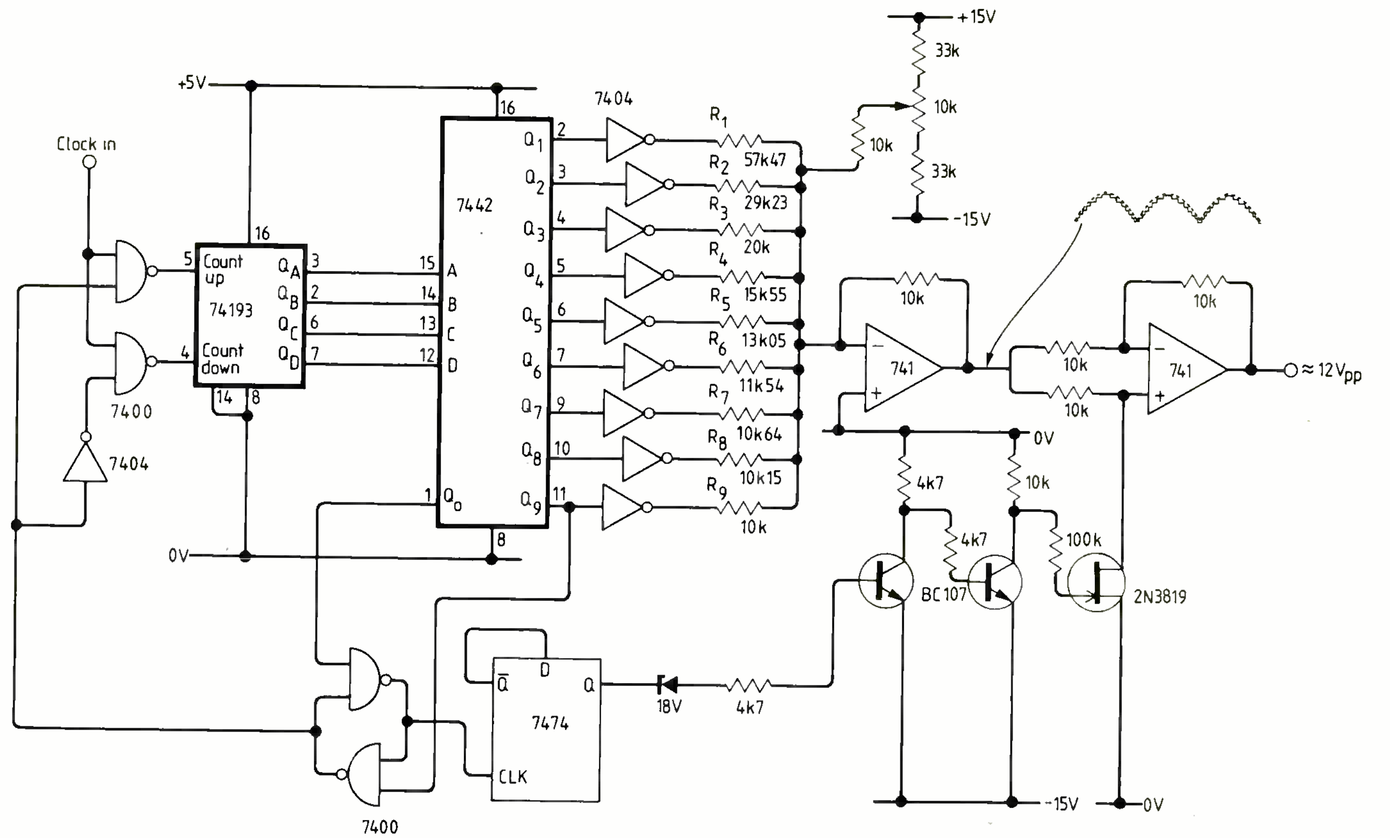
Thyristor bridge battery charger

This circuit was designed to charge a 6V, 6Ah motorcycle battery on demand from a permanent-magnet alternator, but it can also be used as a standby battery charger.

Unijunction transistor Tr_1 forms a 100Hz oscillator which is buffered by Tr_2, and antiphase signals from Tr_3 switch the thyristors. The voltage at point D is monitored by Tr_4, and when the voltage rises above the preset level, Tr_4 turns Tr_3 off. A relaxation oscillation then takes place which gradually slows down, as the battery voltage rises to equal the preset voltage, until the circuit switches off. When a load is connected, the circuit restarts and charges the battery.

G. V. Whitney
Sale
Cheshire





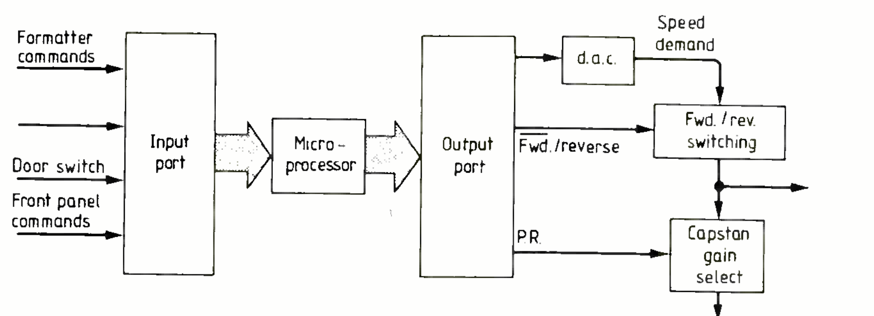
Digital sine-wave generator

By using an up-down counter and inverting part of the decoded output, a sine wave can be generated digitally without several shift registers and repeated resistor values as normally used. Weighted resistors R_1 to R_9 form the first 90° of the sine function as each is pulsed high by the inverted output of the decoder. A latch, formed by IC_{1c} and IC_{1d}, is set and reset by the falling edges of Q_0 and Q_9, and permits the 74193 to count up ten steps and then count down.

The output from the summing amplifier resembles a full-wave rectified sine wave, so inverting alternate half cycles produces a complete sine wave. Inversion is accomplished by IC_3 which acts as a unity gain buffer or an inverter, depending on the drain-source resistance of the f.e.t. and hence the Q output of the 7474. Tr_1 and D_1 provide level shifting, and Tr_2 squares the edges to prevent glitches at the zero crossing point where the f.e.t. is partially conducting.

The 7404 devices should be from the same batch so that their output voltages are similar. Offset voltage is removed by R_1, which should be adjusted until the output of IC_2 is zero when the counter is at 0000, corresponding to the zero crossing point. The circuit can be extended from 40 to 64 steps per output cycle by using a 74154 decoder and different weighting resistors. The high-frequency limit is set by the slew rate of the op-amps.
R. M. Everson
London

Microprocessor controlled servo



Use of a microprocessor to control the demand signal to a servo system can simplify the hardware and reduce component tolerance effects. In this system, which is used with a digital tape transport, the processor monitors various control inputs and changes the demand signals to the capstan servo as appropriate. In addition, on receipt of a start or stop command, the processor generates a precision ramp demand for the servo. To use the full dynamic range of the system, the digital input to the d-to-a converter is adjusted, and the appropriate gain change for the servo amplifier is made by means of the PR signal.

A temperature compensated Zener diode provides a reference voltage for the 8-bit multiplying d-to-a converter, and the current output is converted to a voltage, whose polarity is determined by the appropriate forward or reverse command from the microprocessor. The capstan servo is a standard velocity type where the speed is determined by the speed demand input and the feedback voltage from a tacho-generator. Frequency compensation networks are included in the capstan servo to ensure servo stability and to provide the required response.
D. S. Cutler
Wookey Hole
Somerset

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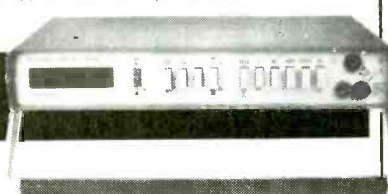

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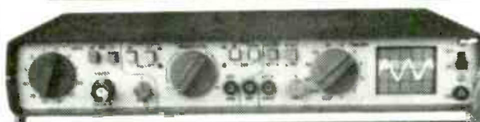

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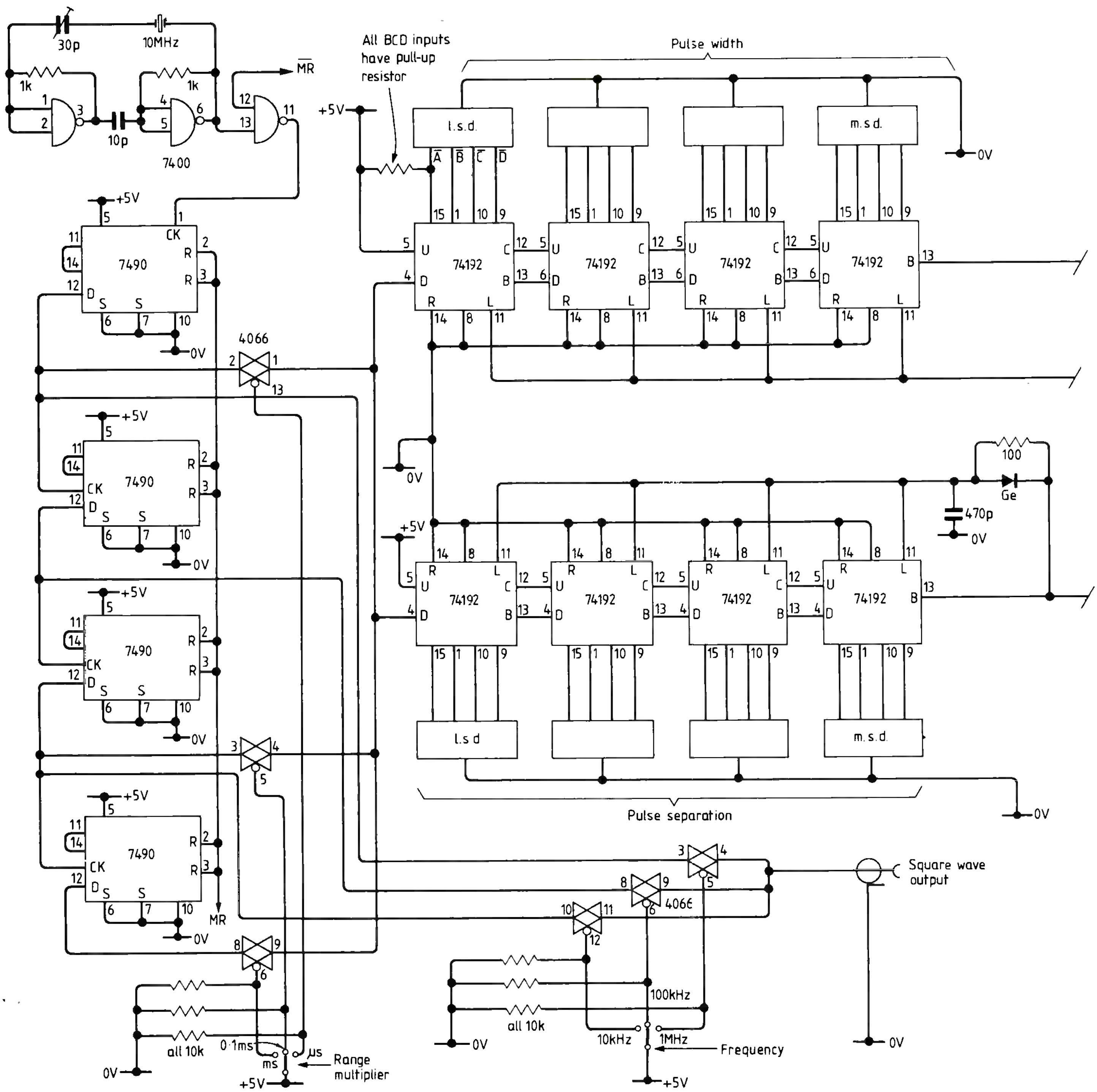
Precision pulse generator

by L. Hayward and G. E. G. Sargent

Standard pulse generators normally use an RC oscillator as a time-base and RC monostables to define the pulse width. This method gives a continuous tuning range and a simple circuit, but the accuracy is typically within 5% of the dial reading, and the pulse width and repetition frequency vary with temperature This design uses a crystal-controlled digital circuit to give high accuracy at a reasonable cost. With a suitable crystal, and oven, if necessary, the generator can be used to synthesize navigational or radar data, or to check computer systems.



This generator uses four thumb-wheel switches to select pulse width and separation from one microsecond to 9999 milliseconds in three ranges. The output is t.t.l. compatible and can provide any frequency in this range, i.e. $f = 1/t$. In addition, a standard-frequency square wave of 10kHz, 100kHz or 1MHz is available.

To prevent reflections along a coaxial connecting line, the source and receiver must match the impedance of the line. This is easily done at the receiver by padding the input with a suitable resistor. The transmitter should have its output also presented via a similar impedance, but the pulse must then be twice the required amplitude to allow for the voltage drop in a terminated receiver. Because this arrangement can lead to an accident if the termination is inadvertently disconnected and over-voltage occurs, a compromise is made. When the output is low, the line transmitter is terminated with 75Ω, and

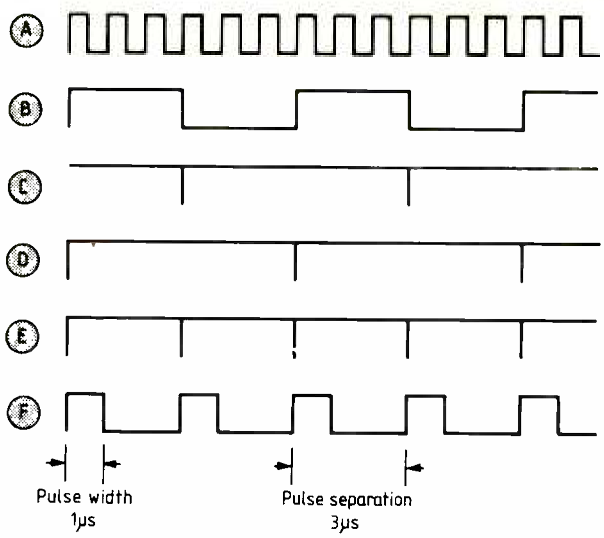


Fig. 1. Complete circuit. The thumb-wheel switches provide complement b.c.d. outputs.

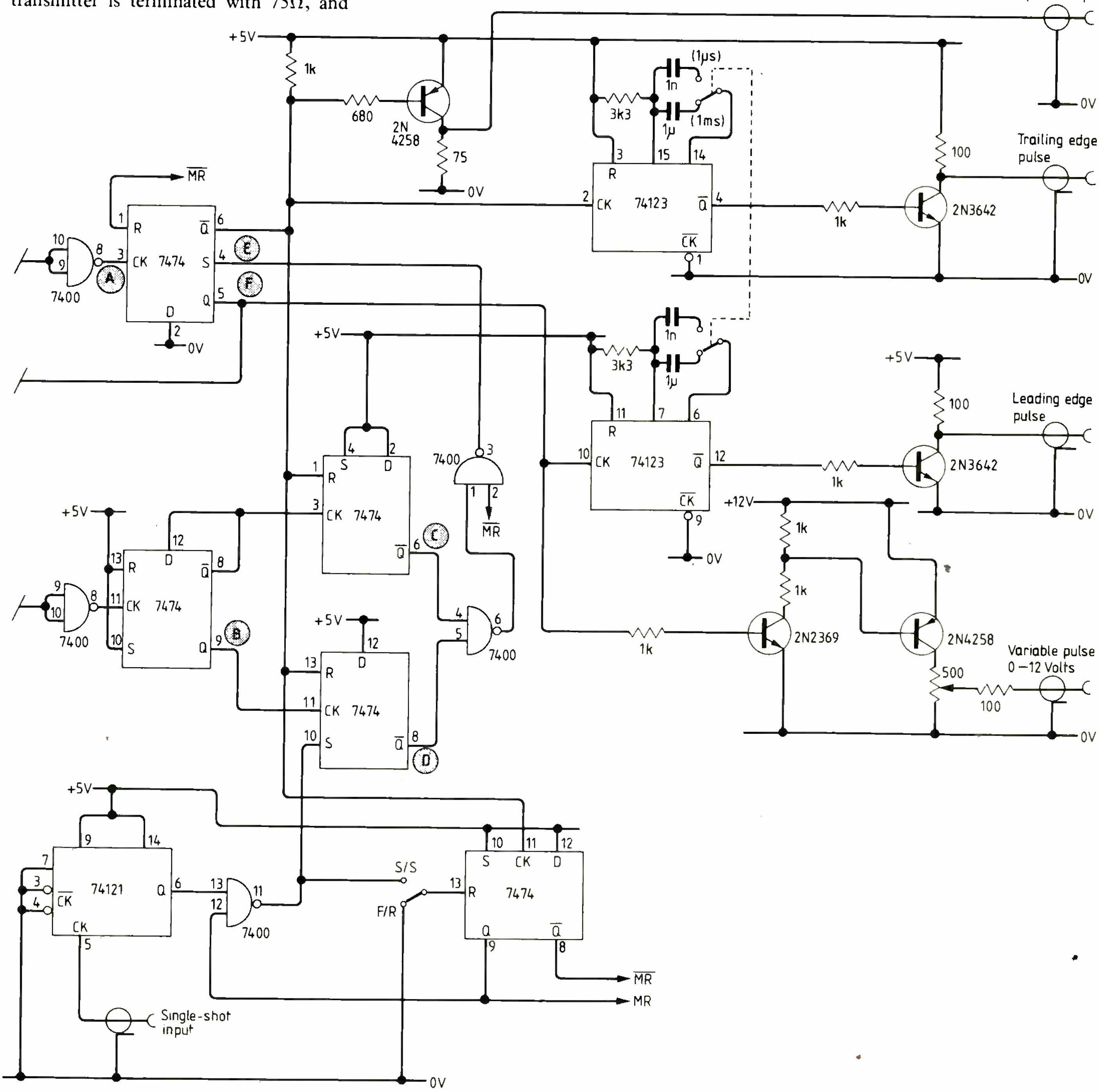


Fig. 2. Timing diagram.

when the output is high it is connected to +5V. Consequently, the terminating resistance has little effect on the voltage. Although this may appear to be bad line practice, it works well and is much better than no termination. The variable output is intended for bench testing use and is not terminated. Two further outputs are provided to give a pulse which coincides with the leading or trailing edge of the main pulse. These outputs are of fixed duration, either 1μs or 1ms, but can easily be changed.

When gating a crystal oscillator some uncertainty exists because the oscillator is not synchronous with the source. The worst error will be one clock period, 0.1μs, which with long pulses is negligible, but may be of consequence with short pulses. For this reason a single-shot input is provided and the output rises with the input after a short delay of about 30ns. The falling edge occurs after the selected duration ±0.1μs. In the free-run mode the rise and fall transition times are similar, so the timing error will be primarily that of the crystal oscillator.

A conventional t.t.l. crystal oscillator provides a timing source at 10MHz and this is divided by a chain of 7490 counters which are selected by transmission gates as shown in Fig. 1. Pulse width and separation are selected by the 74192 programmable counters which operate in the countdown mode and are wired as a wide divide-by-*n* circuit. The number selected by the decade switches is loaded into the counter, and subsequent clocking clears the counter until a borrow pulse is provided at pin 13 to reload the counter. Because this circuit is fed by a defined pulse rate, the countdown sequence lasts as long as the selected number of units. The separation counter has a pulse-stretching circuit comprising a diode, resistor and capacitor to main a sufficiently wide reload pulse. The output from the counting chains combine to set and reset the counting chains combine to set and reset the output bistable as shown in Fig 2.

In the single-shot mode the clock and divider are held at reset until a positive-going t.t.l. signal is present at the input. When this occurs, one pulse is produced and the single-shot input is then taken low, ready for the next pulse. A fast monostable i.c. is included to ensure that single-shot operation is independent of the input pulse width.

Although the circuit layout is not critical, 0.01μF ceramic capacitors should be placed across the supply rails for each i.c., together with 10μF tantalum capacitors for each row of i.cs. It is advisable to screen the entire unit with a metal box to prevent r.f. interference from affecting nearby equipment.

The use of transmission gates allows the operating switches to be fitted in a convenient position on a panel. Most of the outputs can be short-circuited without damage, but the main output will be damaged by a load below 10Ω. The current requirement of the entire circuit is about 1.2A, and a stable supply derived from a regulator is recommended. □

Viewdata Lucy gets it together

The difference in cost between an ordinary television receiver and one capable of receiving British Telecom's Prestel service could be reduced by around 30%, according to Mullard. Their new 'Lucy' integrated circuit is an l.s.i. peripheral to an 8049 micro, the new system providing much more flexibility than earlier teletext/viewdata chip sets, while reducing the package count from 19 to 4. The SAA5070 Lucy chip is already in production at Mullard's Southampton factory.

Lucy, a name which represents a major triumph for the forces of determined imagination over those of logic, is alleged to be a corruption of 'Line coupling unit u.a.r.t.', which, admittedly, is considerably less attractive than Lucy. The chip is designed to select and control various sources of information such as line, keyboard, tape, to avoid the need to interrupt micro operation to scan the inputs: the information is then presented to the micro on an 8-bit bus. (Most viewdata decoders use a micro to take account of varying levels of complication in different applications: software is more easily altered than hardware.) The software approach means also that Lucy can be used for any viewdata system – Antiope, Telidon and the Continental variations of Prestel can all be accommodated.

Among the facilities offered by the use of Lucy are tape recording and playback of pages (modified Kansas City standard), a multi-page memory r.a.m., non-volatile memory for automatically dialled telephone numbers or passwords, time-out periods to disconnect the line, extra ports (each port provided has a storage shift register) and an on-chip modem.

A keyboard can be connected to allow the writing and editing of pages on a domestic set – a facility which, were it not for restraints imposed by British Telecom on the use of telephone lines for data would make communication between terminals possible. There is provision in Lucy for data transmission at 1200 baud, in addition to the normal rate of 75 baud used for Prestel access.

Designing with microprocessors – correction

The following table is a corrected version of Table 3 (hex listing of the PRINT problem when implemented using the test-and-skip mode and the Intel 8080) which appeared in Part 6 of "Designing with microprocessors" December 1980 issue, page 73.

	Hex address	Hex listing	Mnemonics	Comments	
	1000	21	LXI H	Set memory pointer to line 40	
	01	40		on page 20 – location of the	
	02	20		first byte to be printed.	
	03	0E	MVI C	Load register C with block	
	04	n		length (n)	
L3:	05	0D	DCR C	Decrement register C	
	06	FA	JM	Go to L1, if n is −ve.	
	07	16			
	08	10			
L2:	09	DB	IN	Read printer status	Software wait
	0A	60			
	0B	07	RLC	Rotate left through carry	
	0C	D2	JNC	Jump to L2 if carry flag	
	0D	0A		is not set – that is if	
	0E	10		printer is not ready	
	0F	7E	MOV AM	Move into A next byte to be printed	
	10	D3	OUT	PRINT	
	11	61			
	12	23	INX H	Point to next byte in the block	
	13	C3	JMP	Go to L3	
	14	05			
	15	10			
L1:	16	76	HLT	Stop	

Bandpass audio filter

Active circuit design for a.m./s.s.b. radio communication

by **L. Hurst**, B.E., University of Auckland

This article describes the design of an optimum, active RC filter intended for tailoring the frequency response of communication channels to the passband 500Hz to 3kHz. Formed from two lowpass and two highpass sections, the circuit operates from a 12V supply and has a current drain of about 20mA. It will handle a maximum input signal of about 3V peak.

From tests on speech articulation, intelligibility and power spectrum, one finds that by removing all frequencies below 500Hz the articulation can remain as high as 96% while the speech power requirement is reduced to approximately 42%. Similarly, by removing all frequencies above 3kHz, articulation is still about 83% although speech power is reduced only by about 5%. As an approximation one can say that the effect of restricting the speech bandwidth to 500-3000Hz is to reduce articulation to about 80% and speech power to about 40%.

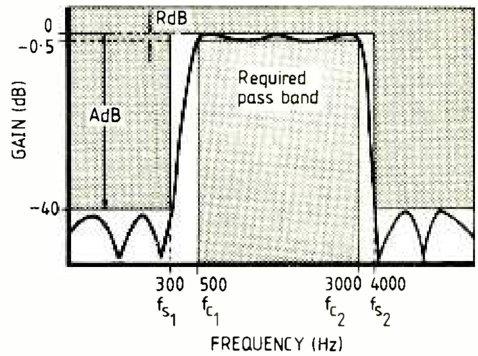
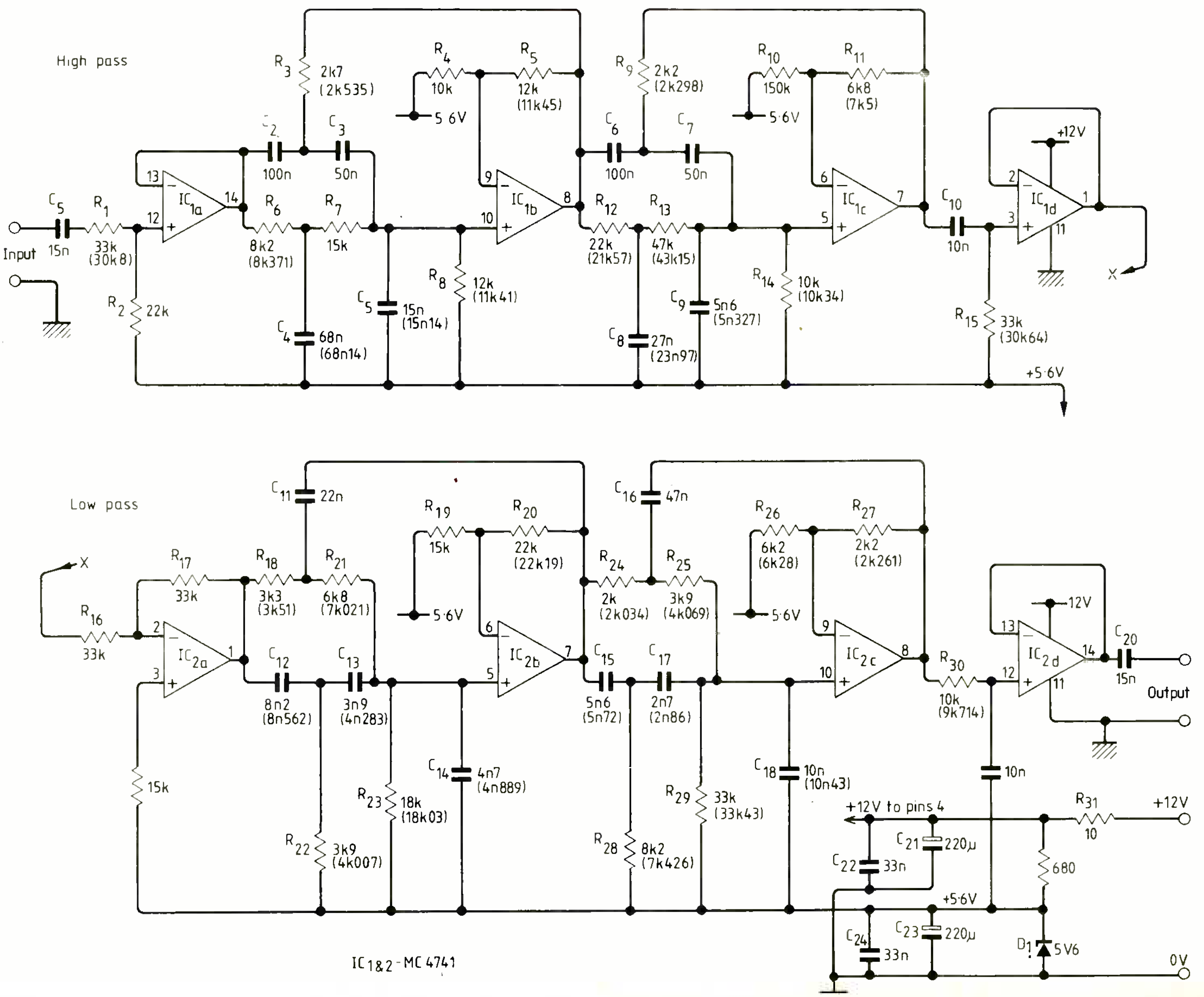


Fig. 1. Required frequency response limits for the bandpass filter.

Fig. 2. Complete circuit of bandpass audio filter. Component values in brackets are "ideal values". The actual response with preferred values is shown in Fig. 3.



Hence a considerable saving in power requirement (4dB) and spectrum bandwidth can be obtained while intelligibility will still remain close to 100% (for normal speech). In addition, when reducing the bandwidth at the receiving end of a "noisy" communication channel, the signal-to-noise ratio may be so improved as to result in better intelligibility.

For such an application the elliptic filter response is generally the most effective for the least number of components. The design offered here is an elliptic filter to give a response of 500-3000Hz with ripple of less than ½ dB in the passband and greater than 40dB in the stop band. Requiring the stop band to be below 300Hz and above 4kHz, the response limits may be drawn as in Fig. 1.

Fortunately the very extensive work of calculating the coefficients for an active elliptic filter have been done for us and applied to a particular circuit. In "Electronic Design 21", October 14th 1971, by A. B. Williams, a set of tables applied to a basic section have been given. To meet above specifications with these tables we use two filters. These are a high-pass filter, having f_{c1}=500Hz, cascaded with a low pass filter, with f_{c2}=3000Hz. For those interested, the treatment of these two filters, each of which has two sections, is given in the Appendix.

The filter sections so designed are combined to give the required overall response. It is necessary, however, to provide inter-stage buffers to give high input impedances and low output impedances for each stage. Also it is desirable to provide an overall gain of unity (unless some other specific value of gain is required). This is given by the input attenuator, where R_1 is chosen as,

$$R_1=2.2\times10^4\left(\prod_{n=1}^{4}Av_n-1\right)$$

$$=2.2\times10^4$$

$$(1.475\times0.9057\times1.565\times1.149-1)$$

$$R_1=2.2\times10^4\,(2.40-1)$$

$$R_1=30.8\text{k}\Omega-\text{use }33\text{k}\Omega$$

The complete circuit is shown in Fig. 2.

Choice of i.c.

The choice of the integrated circuit is not particularly critical. The application lends itself to the quad 741 package; thus two i.cs will complete the filter, e.g. two LM348N, MC4741-CP, etc.

Choice of resistors, capacitors

For this application a small change in f_c or f_s will not seriously affect the performance of the filter. However, if the values of R and C are not accurately chosen the amplitude response of the filter can be degraded. Component values should be selected as close as possible to those stated, but certainly should be within 2%. To minimise temperature dependence, resistors should preferably be metal oxide and capacitors polystyrene.

A plot of the measured frequency response is shown in Fig. 3. It can be seen that the initial requirement is approximately met, the minor departure from the original specification being accounted for by the non-exact component values. Closer matching of component values would reduce the departure from the original requirement.

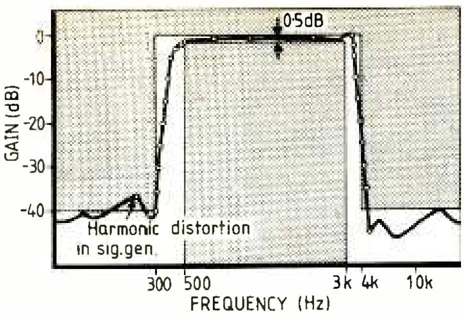


Fig. 3. Overall frequency response of the bandpass audio filter.

For use in a transmitter, the high-pass section should be used first, followed by an amplitude limiter, say 10dB of limiting. The highpass section reduces the amount of limiting required in clipping the high amplitude, low frequency, vowel sounds in speech. The low-pass filter then follows the limiter to reduce the level of distortion products generated in the limiting process.

It can be seen from the circuit diagram in Fig. 2 that the filter is designed to operate from a single + 12V supply. This is available in most solid-state equipment. Maximum current drain is about 20 mA. The maximum amplitude of signal which can be handled is approximately three volts peak, into a load resistor of not less than 2kΩ.

References

1. Radio Engineering Handbook, ed. Keith Henny, McGraw-Hill, 1959.
2. Electronic Design Vol. 21, "Design active elliptic filters easily" by A. B. Williams, October 14, 1971.
3. "The design of high performance active RC bandpass filters", Kerwin and Huelsman: Reprinted in Active Inductorless Filters, ed. Sanjit K. Mitra, IEEE Press.

Appendix: design of filter sections

The treatment of the lowpass filter is simpler, so we will deal with that first.

Lowpass filter

The basic section used for the filter is shown in Fig. 4. The number of sections required is given by $n=(N-1/2)$, where N is the order of the filter quoted in the tables.

To use the tables referred to in the main text, which are normalised for $\omega_c=1$ rad/s, we require RdB, AdB and ω_s. From our specification:

RdB≤0.5dB

AdB≥40dB

$$\omega_s\leq\frac{f_{s2}}{f_{s1}}=1.333$$

From the tables for $\omega_s=1.3054$ rad/s
AdB=39.17dB
RdB=0.28dB,
we find $n=2$ sections and the normalised component values as follows:

1st section:
R_1=0.5280 ohm C_1=2.757 F
R_2=1.056 ohm C_2=0.6127 F
R_3=0.6027 ohm C_3=1.073 F
R_4=2.712 ohm C_4=0.5368 F
K =2.479
Av=1.565

To denormalise, we use a convenient scaling factor M, so that,

$$C'=\frac{C}{2\pi f_c.M}$$

and $R'=R.M$

where R, C are the tabulated normalised values and R', C' are the denormalised component values for the chosen cut off frequency, f_c.

To find a convenient scaling factor, we choose a preferred value for C_1', hence,

$$M=\frac{C_1}{2\pi f_c.C_1'}=\frac{2.757}{2\pi3000\times2.2\times10^{-8}}=6648.3$$

$$\text{then, } C'=\frac{C}{2\pi f_c\ 6648.3}=7.9797\times10^{-9}.C$$

$$R'=R\times6648.3$$

Thus we have
R_1'=3510 ohm C_1'=22 nF
R_2'=7021 ohm C_2'=4.889 nF
R_3'=4007 ohm C_3'=8.562 nF
R_4'=18.03 kohm C_4'=4.283 nF
This is implemented in Fig. 5.

$$\left.\begin{array}{l}R_6=1\\R_7=K\text{-}1=1.479\end{array}\right\}\text{scale by }15{,}000\left\{\begin{array}{l}R_6'=15\text{ kohm}\\R_7'=22.185\text{ kohm}\end{array}\right.$$

2nd section
R_1=0.3942 ohm C_1=4.572 F

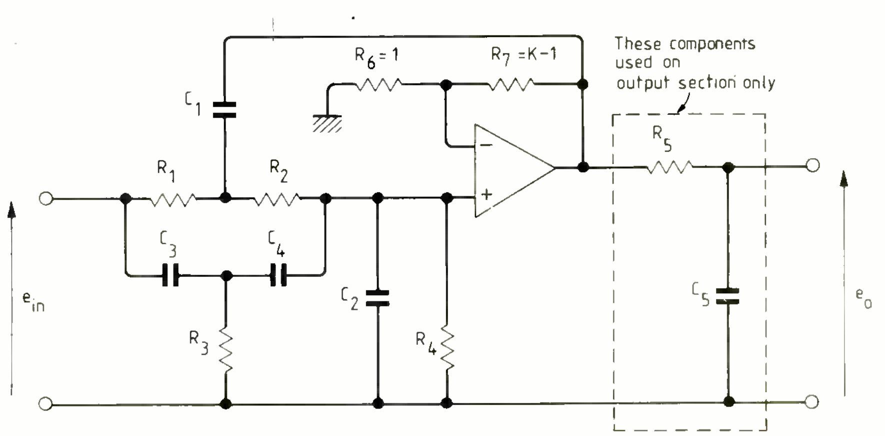


Fig. 4. Basic filter section.

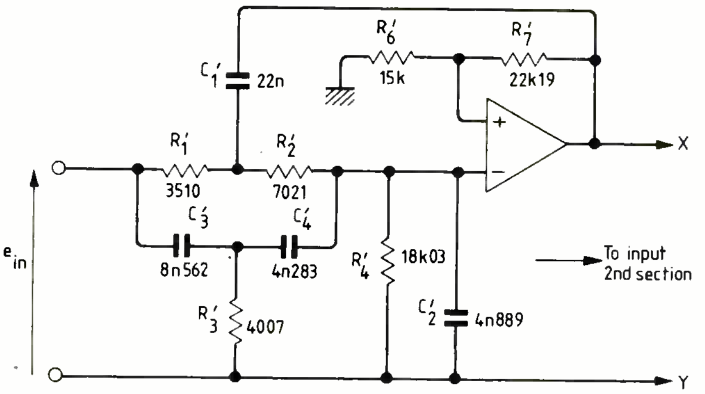


Fig. 5. First section of lowpass filter, Av=1.567.

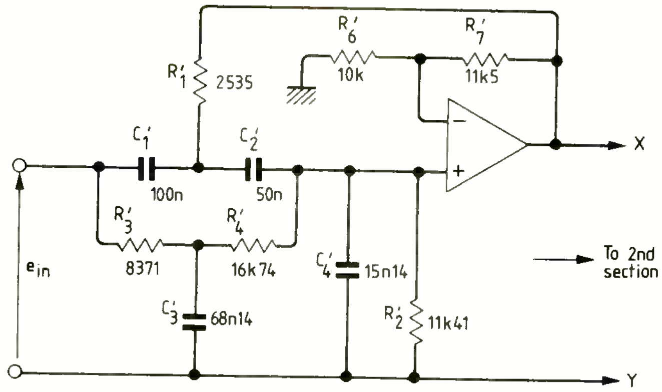


Fig. 7. First section of highpass filter, Av=1.475.

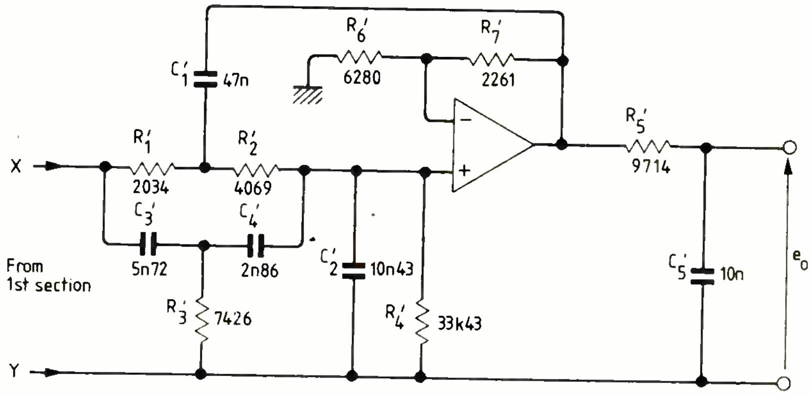


Fig. 6. Second section of lowpass filter, Av=1.149.

$R_2=0.7884$ ohm $\quad C_2=1.015$ F
$R_3=1.439$ ohm $\quad C_3=0.5564$F
$R_4=6.477$ ohm $\quad C_4=0.2782$F
$R_5=1.000$ ohm $\quad C_5=1.831$ F
$K=1.360$
Av=1.149

Scaling factor $M=C/2\pi f_c C'$
$=4.572/2\pi 3000\times0.047\times10^{-6}$
$=5160.68$
$R'=R\times5160.68$, $C'=1.028\times10^{-8}.C$
Thus, we have
$R_1'=2034$ ohm $\quad C_1'=47$ nF
$R_2'=4069$ ohm $\quad C_2'=10.43$ nF
$R_3'=7426$ ohm $\quad C_3'=5.72$ nF
$R_4'=33.43$ kohm $\quad C_3'=2.86$ nF
R_5, C_5 may be scaled independently, so choose $M=1.831/2\pi f_c 0.01\mu$F
$=9714$, hence
$R_5'=9714$ ohm $\quad C_5'=0.01\mu$F
$R_6=1$
$R_7=K\text{-}1=0.360$ } scale by 6280

$R_6'=6280$ ohm
$R_7'=2261$ ohm
This is implemented as in Fig. 6. This completes the lowpass filter design and it is only necessary to provide input and output buffers to preserve the response and gain equalisation to give unity gain. These details may be left till last and incorporated with the high pass filter.

Highpass filter

For the highpass filter we use the same basic circuit, except that the frequency response determining Rs and Cs, that is, $R_{1\text{-}5}$, $C_{1\text{-}5}$, are interchanged, i.e. resistors become capacitors and vice versa.

The reciprocal of the tabulated value is used for the new component. For example, our specification calls for $\omega_s \leqslant 500/300=1.67$, $AdB \geqslant 40$dB, $RdB \leqslant 0.5$dB. Several options are available in the tables and the choice may require a small compromise. I have selected the following table: for $\omega_s=1.7013$ (hence $f_{s1}=293.89$Hz which is close enough) $AdB=40.81$, $n=2$ sections, $RdB=0.01$, and the normalised component values for the

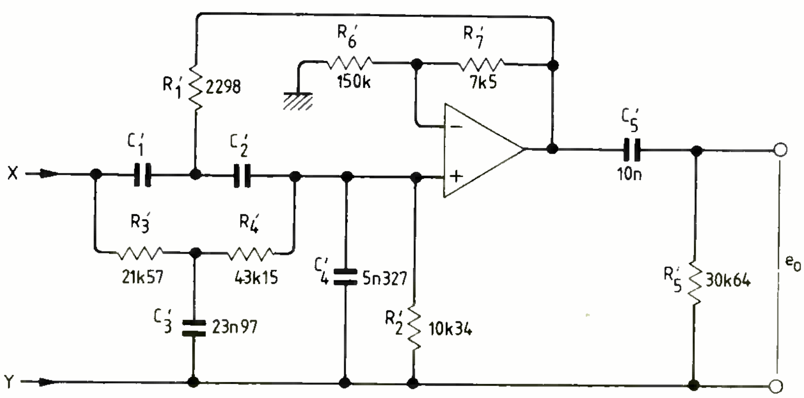


Fig. 8. Second section of highpass filter, Av=0.9057.

1st section
$R_1=0.4847$ ohm $\quad C_1=2.591$ F
$R_2=0.9695$ ohm $\quad C_2=0.5757$ F
$R_3=0.7114$ ohm $\quad C_3=0.7845$ F
$R_4=3.201$ ohm $\quad C_4=0.3923$ F
$K=2.145$
Av=1.475

Change Cs and Rs and write values as reciprocals;
$C_1=2.0631$ F $\quad R_1=0.3860$ ohm
$C_2=1.0315$ F $\quad R_2=1.7370$ ohm
$C_3=1.4057$ F $\quad R_3=1.2747$ ohm
$C_4=0.3124$ F $\quad R_4=2.5491$ ohm
Scaling factor, $M=C/2\pi f_c C'$

$$=\frac{2.0631}{2\pi 500\times 0.1\mu F}$$
$=6567.05$

$C'=4.847\times10^{-8}\times C$, $\quad R'=6567.05\times R$
hence,
$C_1'=100$ nF $\quad R_1'=2535$ ohm
$C_2'=50$ nF $\quad R_2'=11.41$ kohm
$C_3'=68.14$ nF $\quad R_3'=8.371$ kohm
$C_4'=15.14$ nF $\quad R_4'=16.74$ kohm

$R_6=1$, $R_7=K\text{-}1=1.145$ } scale by 10^4 { $R_6'=10$ kohm, $R_7'=11.45$ kohm
This is implemented in Fig. 7.

2nd section
$R_1=0.3866$ ohm $\quad C_1=3.583$ F
$R_2=0.7732$ ohm $\quad C_2=0.7963$ F
$R_3=1.613$ ohm $\quad C_3=0.3817$ F
$R_4=7.259$ ohm $\quad C_4=0.1908$ F
$R_5=1.000$ ohm $\quad C_5=1.039$ F
$K=1.050$
Av=0.9057
Change Cs and Rs and write as reciprocals;
$C_1=2.5867$ F $\quad R_1=0.2791$ ohm
$C_2=1.2933$ F $\quad R_2=1.2558$ ohm
$C_3=0.6200$ F $\quad R_3=2.6199$ ohm
$C_4=0.1378$ F $\quad R_4=5.2411$ ohm
$C_5=1.000$ F $\quad R_5=0.9625$ ohm

Scaling factor $M=C/2\pi f_c C'$
$=2.5867/2\pi 500\times0.1\mu F=8233.72$
$C'=3.866\times10^{-8}C \quad R'=8233.72.R.$
$C_1'=100$ nF $\quad R_1'=2298$ ohm
$C_2'=50$ nF $\quad R_2'=10.34$ kohm
$C_3'=23.97$ nF $\quad R_3'=21.57$ kohm
$C_4'=5.327$ nF $\quad R_4'=43.15$ kohm
R_5, C_5 may be scaled independently, so choose, $M=C/2\pi f_c C'$
$=1.000/2\pi 500\times0.01\mu F=31830.99$
$C_5'=10$nF $\quad R_5'=30.64$ kohm
$R_6=1$
$R_7=(K\text{-}1)=(1.050\text{-}1)=0.050$
Scaled by 150 { $R_6'=150$ kohm, $R_7'=7.5$ kohm
This is implemented in Fig. 8.

NEWS OF THE MONTH

Microcomputers in the home

Two announcements, almost on the same day were important in that they were both concerned in bringing computers to the man-in-the-street rather than the computer buff or hobbyist. The first was that the BBC has chosen a manufacturer for a Microcomputer to be used in conjunction with a television series on computer literacy, scheduled to commence in January 1982. The other announcement was the launching of an up-dated version of the Sinclair personal computer to be known as the ZX81.

The BBC Microcomputer is to be designed and produced by Acorn Computers and will be a condensed version of the Acorn Proton. A very long-term strategy has made it important that the computer is as flexible and as expandable as possible, so that it may be used initially as a fairly simple 'familiarization' tool and may be expanded up to serious business applications. The basic machine will have 16K of r.a.m. with add-on options to give it a maximum of 96K. A domestic cassette recorder can be used to store programs and a disc memory system will become available. With a high-quality keyboard and the addition of a printer, full word-processing facilities will be available. Another add-on facility will be a teletext receiver which will give access to all Ceefax and Oracle transmissions, including a series of computer programs which may be read off the air directly into the computer's memory. All this is to be coupled to high resolution graphics in black-and-white or colour and there will be a further add-on facility to enable the computer to be networked.

The minimum price of the BBC Microcomputer will be about £200, and in contrast, the Sinclair ZX81 is available fully built for £69.95 and in kit form for as little as £49.95. As the internal workings have been reduced to four micro-chips, the kit is comparatively easy to build. ZX81 has a 1K r.a.m., but it is claimed that with the one-key BASIC commands this actually represents considerably more than with a conventional system. Advantages over the previous ZX80 are that it uses the unused part of the tv frame as time for computing and can offer continuous and animated displays without the flicker associated with the earlier machine. With a bigger, 8K, BASIC r.o.m, it can offer full floating-point arithmetical operators and may be used as a scientific calculator with log. and trig. facilities. Like the ZX80, the new computer may expand its memory with an add-on 16K byte r.a.m. module. Further additions include a 32 column printer which can reproduce all the characters and graphics which are available from the keyboard. The operation of a 'Copy' key will instruct the printer to reproduce anything which is on the screen without need for further instruction. This printer has been demonstrated and is likely to be available very soon – in June or July. Sinclair has also developed a series of cassettes which include a number of useful programs; some games and an educational tape which can teach basic mathematics and other disciplines to children.

It seems likely that there might have been a direct connection between these two stories. At the launch of the ZX81, Clive Sinclair made clear his disappointment at not being selected by the BBC to produce their microcomputer. He indicated that he would be able to offer all the facilities that the Corporation might require at a lower price than any competitor. A BBC spokesman has said that the Corporation had taken "advice from a variety of experts" who had selected a computer which best met their requirements.

It has been rumoured that Mr Sinclair is to go ahead with a computer that will meet the BBC specification and will be a low-cost alternative to the 'official' BBC microcomputer.

The Sinclair ZX81 improves its outward as well as its operational design over its predecessor. It is shown here with a prototype of the ZX printer, available later in the year.

Pay tv pilots get go-ahead

The Home Secretary has announced the names of the successful applicants for licences to provide subscription television by cable relay. British Telecom have been granted a licence to operate in the Milton Keynes and Newport Pagnell area; Greenwich Cablevision in Greenwich; Philips in Northampton and in Tredegar, Gwent; Radio Rentals in the Medway towns of Chatham, Gillingham and Rochester, and Swindon; Rediffusion are to proceed with pilot schemes in Burnley, Hull, Pontypridd, Reading and Tunbridge Wells. The licence will run for an initial period of two years.

It is envisaged that at the beginning, the programmes will consist of feature films, all passed by the British Board of Film Censors and the Home Office has laid down certain rules: that Certificate 'X' films may not be shown before 10pm; sporting events of a national importance may not be secured on an exclusive basis; programme schedules must be submitted in advance to the Home Office.

The charge for the service is likely to be between £5 and £8 a month with an additional installation fee.

British Telecom already operate in Milton Keynes, a system of distribution of five channels of television and a full range of broadcast radio services including the local community radio station. The subscribers will get an additional channel of feature films and facilities for a community television service. Many of the other licencees have, of course, operated cable distribution of the national BBC and ITV channels and at least one, Greenwich, has had previous experience in operating a subscription service.

The Cable Television Association has welcomed the Government announcement but feel that "the terms of the licence and the scope of the pilot schemes appear to be rather restrictive". A statement from the C.T.A. reported in *Cablevision News* also said, "We cannot see why, providing our members conform to the law of the land and the dictates of good taste, they should not have precisely the same freedom to offer the same consumer choice as the book publisher, the newspaper editor, the cinema operator or the video disc manufacturer . . . Subscription tv does not require any Government funding; nor does it make claim upon that scarce public resource – space on the ether. It does not come into the home without the public seeking it".

Medical technicians get a new deal

The Institute of Science Technology has announced the formation of a new Interest Group within the Institute concerning itself with Medical Physics and Physiological Measurement technicians. At present, there are few colleges prepared to undertake the organisation of a suitable course for them so one of the aims of the MPPM Interest Group is to prepare a nationally recognised educational qualification equivalent to HNC/TEC for those attending college or who are studying privately. In this respect the IST will set a Diploma examination based on an acceptable syllabus.

Although the number of these technicians has increased and quality improved significantly, a steady decline in their status compared with their colleagues in radiology and medical laboratory sciences has been shown. Possibly their poor career structure can be improved with the Diploma examination followed by the Fellowship of the IST. The Interest Group hopes to keep open good channels of communications with other institutes and bodies relevant to the MPPM's and organized a seminar on *Biofeedback Mechanisms* at Birmingham on 9th April.

Energy from waves sponsored research

An important contract to research the operating and maintenance costs of wave energy devices has been awarded to EASAMS Limited (a GEC-Marconi company) by the Department of Energy via the Energy Technology Support Unit (ETSU).

In addition to cost assessment the contract also calls for EASAMS to act in an advisory role to the DoE. The scope of this advice extends from detail design and location of installations, to the choice of the best maintenance philosophy, methods and facilities, for both off-shore and onshore operations. This will involve the Company in regular and increasing liaison with universities, government establishments and industrial contractors.

The contract continues the work carried out by EASAMS since July 1979 in studies intended to assess and optimise the operation and maintenance cost of an offshore system to convert the energy of ocean waves into electrical power which can be fed into the UK national grid.

Research and development for such a system has received a high priority within the Department of Energy programme to investigate alternative energy sources for the UK. The geographical location of the British Isles makes wave energy a particularly attractive option especially as it is a resource for which the peak supply tends to coincide with the peak national demand over the year.

The current proposals for a wave energy conversion system involve a very large array of wave energy conversion units sited up to 20km off-shore, each unit being similar in size to an ocean going ship. Such an array, extending along 400km of coastline, could deliver the mean annual output of a typical large modern power station, which uses fossil fuels. The wave energy programme has investigated a wide and diverse range of conversion devices, and several teams at universities and research establishments are working to improve the energy conversion efficiency and reduce the capital cost of the more promising designs. One part of a more general parallel programme is also investigating component reliability and developing systems which can remotely monitor the condition of machinery, and control the converter output, according to the available wave climate.

By its very nature a wave energy system will be expected to function in sea conditions that will be a severe handicap both to the reliability of any engineering equipment and to any efforts to gain access to it or carry out maintenance work. Therefore although the basic resource is freely and indefinitely available, the annual cost of maintaining the equipment needed to collect this resource and transmit power to the shore may be a deciding factor in assessing the commercial economics of wave energy.

EASAMS contribution to the programme has thus been in this important area. It has involved an assessment of maintenance costs and identifying the factors that have a significant effect on them. These include the relative merits of different locations in terms of supply base facilities and sea and air transportation links which may be as important in the selection of a wave energy site as the actual wave climate available.

Synchronising tv sound to picture

Videotape editing facilities has been improved to a state where it is now practicable to make a high number of recording breaks and editing cuts. The BBC has found that this can play havoc with the sound track and have devised a system called Sypher-2 so that the dialogue sound and special effects can be brought together with music and added to the edited video tape in perfect synchronisation. Time codes are added to a separate video recording and a multitrack sound recording of the programme, additional music and sound effects can be recorded on the other track of the sound recorder and the Sypher-2 system can re-unite sound and picture in synchronisation using the time codes as coordinates. The synchroniser is of modular construction so that a number of 'slave' recorders may all be run in synchronisation.

Terry Newbery, of the BBC Studio Capital Projects Department, discusses the Sypher-2 sound-synchronisation system with Mike Jones, a sound supervisor. On the right is computer-assisted mixing console made by Neve which includes the control units for the Sypher-2 system.

Infra-red 'radar' detects low-level planes

British Aerospace Dynamics Group has been chosen, following a highly competitive assessment, to develop passive infra-red surveillance for low-level air-defence systems.

To date, the Company has spent some three million pounds on this vital programme which could revolutionize the detection of low flying-aircraft in the future.

Radiating active-surveillance systems will need to become increasingly more complex in order to counter the jamming and location devices likely to be used by a future enemy. One low cost solution to this requirement has been to develop a passive surveillance system with no detectable emissions, and, since 1975, the Dynamics Group have been researching into an infra-red analogue of surveillance radar.

To undertake the numerous field experiments to prove this system, the equipment has been installed in a trailer and, in a two-week trial to prove the effectiveness, 96% of engageable aircraft targets were observed and located passively at ranges which would have made engagement by a SAM system entirely practicable. The majority of those aircraft, which covered a range of types, would have been destroyed.

The infra-red system will not replace the surveillance radar, but will, in fact, be complementary.

Hardware for the first model of the military version is now available and is compact enough to be mounted on a Land Rover.

News in brief

The Government has announced its intention to back **International Computers Ltd** by providing guarantees of up to £200M for a period of up to two years and to increase financial aid towards research and development in the company. This has become necessary because, in these times of recession, customers are not buying large computers and there has been a "significant fall in orders". Most main-frame computer companies have similar experiences, according to Mr Kenneth Baker, Minister for Information Technology. The Government are, of course, major customers of ICL who have supplied the computers for the Ministry of Social Security, the whole of the tax system, and for many hospital administrations.

Components sale. Home Radio (Components) Ltd, together with Harvesons and G. P. Transformers, is holding a sale of all types of components including resistors, capacitors, pots, speakers, transformers and tools, all at exceptionally reduced prices (many below manufacturing cost). Home Radio are turning over the whole of their first floor to this sale which will run from Saturday, 25th April until Saturday, 2nd May inclusive (early closing Wednesday). The address for the sale is 269A Haydons Road, London S.W.19 which is in South Wimbledon.

Electric vehicle research – on the move

Lucas and Chloride have announced the setting-up of a joint company to merge their electric vehicle development programmes and have been granted 'substantial financial support' by the Government over a five-year period.

Battery-driven vehicles are attractive because they are able to take advantage of a wide range of energy resources and also cause less pollution – noise and atmospheric. Electric vehicles re-charging at night would not increase the burden on the National grid and would help to level the daytime load.

So far, both companies have concentrated on the urban delivery vehicle, Lucas having produced some 100 electric prototypes based on a one-tonne van, while Chloride has specialised in vehicles with gross weights of six to seven tonnes and payloads of 1½ to 2 tonnes. Over 70 'Silent Karrier' prototypes have been produced. Lucas is also developing a drive-system for hybrid-electric passenger cars, which combine the benefits of electric vehicles with the flexibility of petrol or diesel power.

The joint company, Lucas Chloride EV Systems Ltd, plan to maintain the British lead in the development of electric vehicles and to exploit a potentially very large world market.

● A different vehicle is the *Electric Monarch* an eight-berth battery-powered narrowboat, built by the Original Boat Company of Evesham. The fully-fitted, luxury canal boat is powered by a 72-volt Chloride motive power battery, as used in milk floats and industrial trucks and the fuel costs are approximately one-fifth of conventional boats with the overall running cost as little as one-seventh.

The motor used in the boat is rated at 8 hp, at 3 mph, although it is electronically governed to operate at 2.5 to 3 hp. Research was carried out by the Original Boat Company to identify the precise operating requirements. These included determining the size of the boat, the route, the time available for the journey, the location of mains supplies for re-charging, the speed limits applicable and the energy required for manoevering and carrying ancillary loads. The result is a pollution-free boat with a high degree of passenger comfort which is very easy to operate.

Low level spy plane with no pilot

Marconi Avionics Limited has now achieved the first flight of its unmanned air vehicle. Machan, the company's new research aircraft, is now undergoing flight evaluations, having made its first flight from the Royal Aircraft Establishment airfield at Bedford, England, on 19 February 1981.

The unusual shape of Machan derives from its role as an unmanned aircraft, to carry specialised, miniature, electronics payloads, including surveillance equipment. It typifies a new kind of air vehicle, capable of operating under remote control, over battlefields or other areas of interest. With a 12 foot wingspan and an 18 hp 2-stroke engine, it can carry 33 lb (15 kg) of payload for two hours, landing, at a chosen spot, on fibreglass skids.

The Machan programme, which is sponsored by the UK Ministry of Defence (Procurement Executive) and Marconi Avionics, includes development and proving of the air research vehicle, the ground control station and the all-important electronics payloads. As well as managing the overall programme, the company is developing these payloads and has produced the aircraft's advanced attitude and motion sensing system, the datalink and microprocessor-based ground control equipment. The latter is contained in a ground station, provided by the Royal Aircraft Establishment.

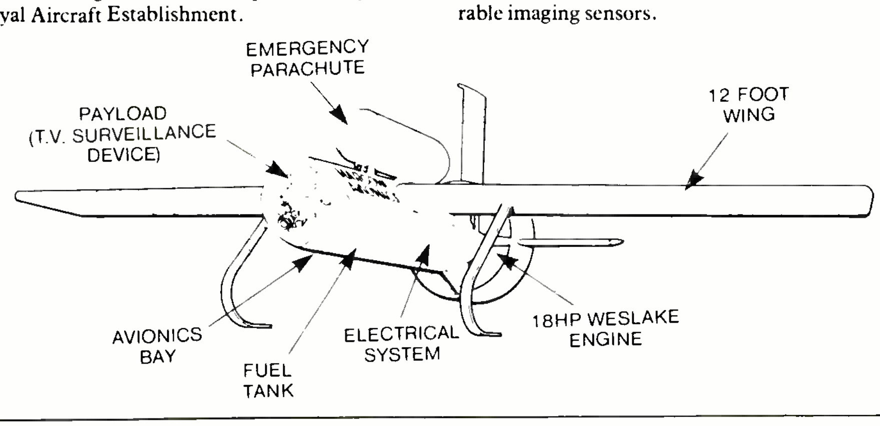
Aircraft description

Fixed shoulder-wing monoplane, with ducted pusher propeller, powered by Weslake twin-cylinder 18hp 2-stroke petrol engine. Diamond cross-section fuselage with flying controls on empennage, comprising all-flying 'tailerons' and rudder.

Leading particulars of model 01: length 7ft (2.13m), wingspan, initially, 12ft (3.66m), (to be reduced after initial handling trials), max speed (level flight) 115kt (59m/s), cruising speed 64kt (33m/s), gross t.o.w. 161 lb (73kg), payload 33lb (15kg), endurance (at cruising speed) 2 hours. Launch from tricycle 'drop-off' undercarriage, recovery by conventional approach or, in emergency, by parachute.

Avionics

Digital, microprocessor-based flight control system, with 68MHz command link. Stability augmentation and attitude reference from three axis 'strapdown' sensor package. Command and telemetry facilities can be used in conjunction with the ground station computer for investigating outer loop control without modifying equipment on board. First payload contains a non-gimballed TV camera to include stabilised, steerable imaging sensors.



NASA cuts threaten European research

THE decision by NASA to cancel the American spacecraft forming part of the two-spacecraft International Solar Polar mission (ISPM) has been rejected by the European Space Agency, the partner in this cooperation.

At a high level meeting between the two Agencies on Monday 23 February in New York, NASA explained that it had to take this decision because of the severe budgetary cuts imposed on NASA by the Office of Management and Budget in the preparation of the Reagan Administration's federal budget. ESA stated at the meeting that the cancellation of the NASA satellite, which was effected without consultation, was a unilateral breach of the Memorandum of Understanding between the two Agencies, and that this cancellation was therefore unacceptable to ESA, which requested full restoration of the programme to its original level. ESA also stressed that unilateral actions of this kind would be detrimental to future space cooperation between Europe and the United States. The ESA position is motivated by the fact that the decision was taken by NASA without consultation and by the fact that, as a result of this decision, European scientists from some 17 scientific institutes who were supplying experiments for the NASA spacecraft would no longer be able to fly them. The experiments were already in an advanced state of development, and more than 50% of the total costs had been committed and would consequently be lost without corresponding scientific return. In addition, ESA remarked that when the ISPM project was decided by the ESA Science Programme Committee in 1979, it was chosen in preference to a number of other, purely European missions because of the value ESA attached to transatlantic cooperation.

Threat to Public service broadcasting

Public service broadcasting in the USA, very much a minority service, faces proposals that it should be commercialised, as a result of the public spending reductions intended by the Reagan administration. "Perhaps the time has come for some form of limited advertising on public tv and radio" said the Republican Senator Goldwater recently. He was introducing a bill which calls for significant reduction in government funding for US public service broadcasting in 1984-86 and urges the FCC to reconsider its present restrictions on the sale of advertisement time by such stations.

Meanwhile, according to *Weekly Television Digest*, a more immediate proposal of the Reagan administration to cut the 1982-83 funding of public service broadcasting by some 25% has been staved off by the Senate Budget Committee. Members of this committee said that Congress should not rescind the appropriations as it had already committed itself through the advance funding process. One Democratic commentator said that, although he thought the administration's proposals were not a politically motivated attack on public service broadcasting, nevertheless if they were approved they "would set the precedent for further compromises of public broadcasting's independence in the future."

Selling publications by Prestel

The Technical Publications Department of Mullard Ltd has formed a 'Publications Club" which enables members with viewdata terminals to order publications direct from an index displayed on Prestel simply by feeding in an identity number, using the conventional keypad issued with all viewdata terminals. Previously it had only been possible to operate such a direct-order service if the customer had access to an alphanumeric keyboard hooked up to a viewdata terminal. The Technical Publications Department (TPD) index is displayed on page 5562014 of Prestel. Customers wishing to become members of the Publications Club should apply to Technical Publications Department, Mullard Ltd, New Road, Mitcham, Surrey CR4 4XY, for further details.

Rumblings over C.b

While welcoming the announcement from the Home Office that Citizens' Band radio is to be made legal in Autumn, The National Committee for the Legalisation of Citizens' Band Radio (Natcolcibar) are disappointed at the selection of a frequency modulated system. They argue that some 300,000 people are already using the a.m. system; the European C.B. Federation has called for the adoption of 27MHz a.m. as a pan-European system, since it is already in legal use in 12 European countries. Those countries with a legal f.m. system have experienced widespread illegal use of a.m. : a.m. equipment is readily and cheaply available on the world market.

Consequently they are making strong representations to the Home Office to get the proposals altered.

● At a recent meeting of the Joint Council for Legalisation of 27MHz Citizens' Band Radio, a number of 'breakers', as the enthusiasts call themselves, expressed their dissatisfaction with the Government proposals. The Joint Council has issued an Open Channel Preferred Specification which conforms to the U.S. Federal Communications Commission's specification with additional, more stringent specifications in respect of harmonic and spurious signal emissions, to avoid interference.

The Joint Council estimates that over a million people are using c.b. sets illegally; many of the breakers present at the meeting expressed a determination to continue to use a.m. sets even if they are not made legal by the proposed legislation. Annette Box, who uses the code-name or 'handle' of 'Yellow Peril' chose to go to Holloway Prison rather than pay the £600 fine imposed for illegal c.b. transmission.

All-Electronics Show

Sponsored for the first time by the Electronics Components Industry Federation, the fifth All-Electronics/ECIF Show runs from Wednesday, 22nd to Friday, 24th April, 1981, at the Grosvenor House, Park Lane, London.

The exhibition has a record 249 stands with over 350 companies exhibiting. Tickets may be obtained free by sending s.a.e. to Mrs Theresa Austin, The All-Electronics Show, 34-36 High Street, Saffron Walden CB10 1EP.

News in brief

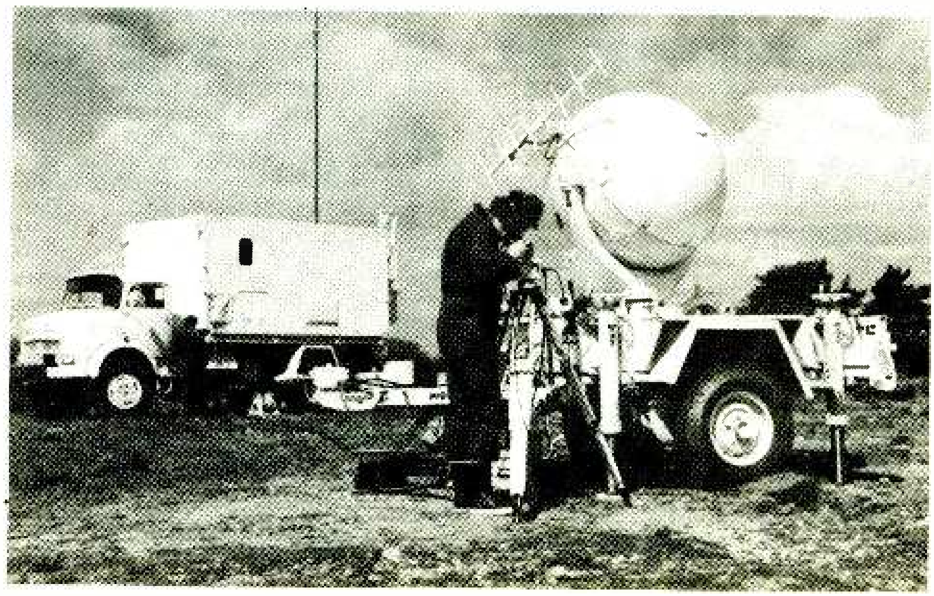
New Fellows of the Royal Society elected at a meeting of the Society on 19th March include the following who have made some 'outstanding contribution' to their field of research: Dr D. M. Brink, studies on nuclear structure and nuclear reactions; Dr J. A. Barker, statistical mechanics and thermodynamics of molecular systems; Prof I. Butterworth, meson and baryon spectroscopy; Dr B. Carter, general relativity and astrophysics; Dr E. R. Pike, statistical optical spectroscopy; Prof K. A. Pounds, solar and cosmic X-ray astronomy; Prof D. J. Wheeler, design of digital computers and programming systems. We congratulate them and the other new Fellows, recipients of the 'knighthood of British science'.

The **International Electrotechnical Commission** (I.E.C.) has pointed out to us that this year includes the 150th anniversary of the discovery of electromagnetic induction by Michael Faraday, the centenary of the first International Electrical Congress, where international standards of units of measurement were reached, as well as the 75th anniversary of the founding of the I.E.C.

The Second London Computer Fair, organised by the London Computer Clubs is due to be held at the time that this issue of WW reaches the newsagents. So if you happen to be reading this before the rest of our erudite contributions there may yet be time to dash round to the North London Polytechnic, Holloway, London N7 on 14th to the 16th April. There will be seminars, demonstrations and on the Thursday, a bring-and-buy sale.

Detecting wind speed by radar

The Plessey WF3M is currently the primary sensor of upper winds in the British Army's Artillery Meteorological System. Its light weight and basic simplicity make the WF3M ideal for use in hazardous environmental conditions. It tracks automatically after the initial acquisition of a passive balloon target. Positional data of the target is then available in digital form for computer processing and displayed on decimal indicators for manual processing if preferred. Only minimal supervision by a single operator at the control and display position is required. The use of solid state techniques ensures high reliability and ease of maintenance involving a minimum of logistic support and training.



Time sharing limited mains supplies

Automatic digital control for sharing mains power

by L. Hayward

If a number of loads on the same mains source requires more power than is available, some means of automatic power time-sharing is often the only practical way of avoiding blown fuses and overloaded generators and cables. The author was faced with the problem of using a 4kVA generator to drive a domestic cooker requiring 9kW with all its elements in operation. Although the design was originally intended for use in the kitchen it will be of value in any application where a number of cyclically heated devices are to be powered from a limited mains supply.

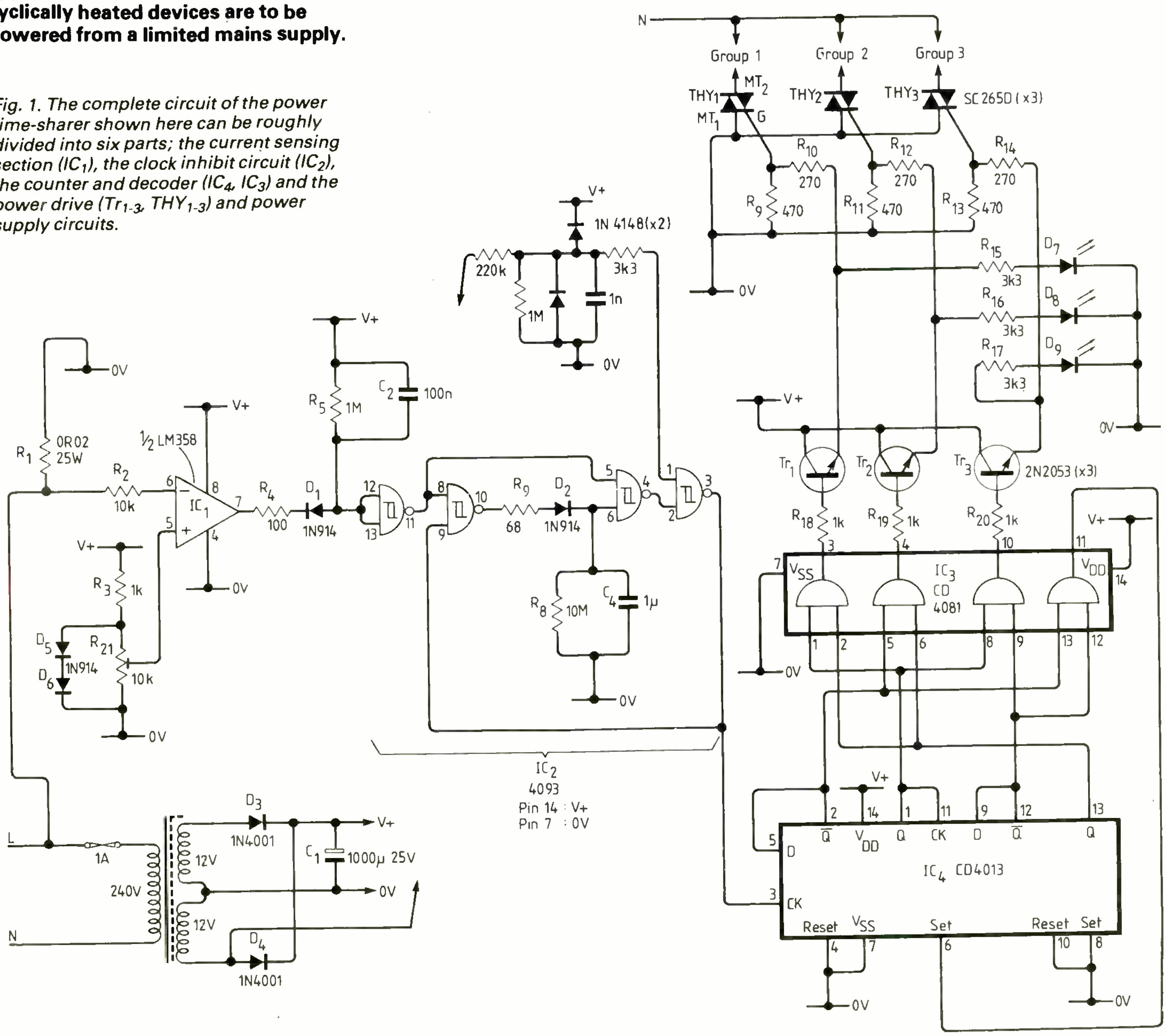
The problem that led to the designing of this circuit arose when a cooker rated at 9kW with all its elements in operation had to be driven from a 4kVA generator. Manual switching of the elements to share the power was possible but tedious and any mistake could have caused an overload, so some means of automatic power sharing was sought.

It was found that the elements of the cooker could easily be divided into three groups, each of which when driven alone would not overload the generator. All that remained was to design the following circuit to time-share the power between two or three of the groups automatically when the need arose.

Operating principle

The circuit is activated by switching on the cooker at its main terminal. To simplify the following explanation the term a 'group requiring power' is used to describe a group or part of a group which has been

Fig. 1. The complete circuit of the power time-sharer shown here can be roughly divided into six parts; the current sensing section (IC_1), the clock inhibit circuit (IC_2), the counter and decoder (IC_4, IC_3) and the power drive (Tr_{1-3}, THY_{1-3}) and power supply circuits.



switched into the circuit either by the operator via the cooker control panel or by a thermostat.

When the circuit is activated but none of the groups require power each group is scanned in a 1-2-3-1 sequence to check whether it requires power. The scanning rate is determined by the mains frequency derived clock signal. When any group requires power it is detected by a current sensing circuit and the scanning stops. That group is then powered for around seven seconds and then the scanning continues. If the power requirement of the group ceases in less than seven seconds the scanning continues from that point. Because the scan time is very small in relation to each seven second power-up time full use of the available power is made however many groups are switched in.

To summarize, if only one group requires power it receives power constantly apart from the small scan time at the end of each seven second period. If two groups require power they each receive it alternately for seven second periods. When all three groups require power each receives it in turn for seven second periods according to the 1-2-3-1 sequence.

Circuit operation

Load switching is achieved by 40A triacs sequentially driven from a ring-of-three counter and decoder whose outputs are buffered by $Tr_{1\text{-}3}$. These transistors can also be used to drive optional l.e.ds for monitoring the outputs. The triacs chosen have a higher current rating than is strictly necessary, so that heat sinks may be kept small, and to withstand enough current to trip a circuit breaker in the event of a short circuit.

The 240V a.c. input is transformed to provide the low voltage supply and clock signal. All mains current output passes through R_1 which is made up of five 0.1Ω,5W resistors connected in parallel This low resistance value was chosen to reduce dissipation and avoid wasting power. When the voltage across this resistor exceeds a preset level the comparator output changes to logic 0 on every positive half cycle. The time constant of R_1, C_2 is chosen to integrate these pulses sufficiently to provide a constant logic 1 at the output of the first Schmitt trigger. When no current is drawn from the mains the first Schmitt trigger output will be low and the output of the third trigger (pin 4, IC_2) will be high and mains frequency clock pulses will be admitted to the counter, IC_4. This counter is a modified divide by four circuit.

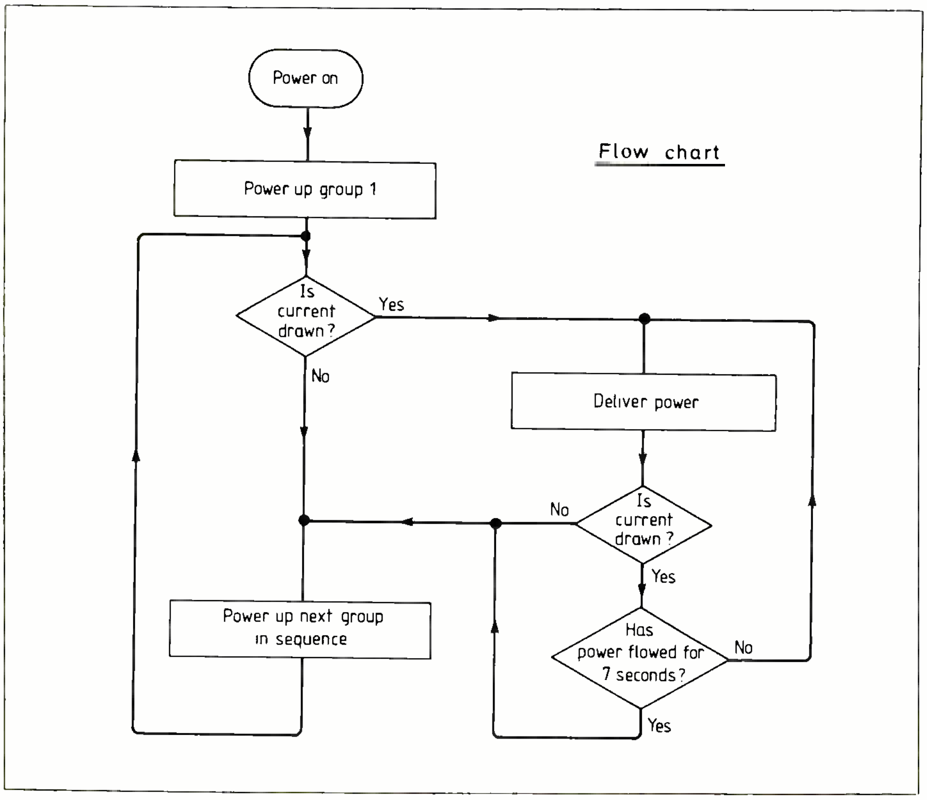
The decoder consists of four AND gates, the outputs of which go sequentially high as long as clock pulses are received by the counter. Three of the gates, when high, each trigger one triac through a buffer transistor. The fourth gate sets the counter to restart the sequence. If a load is connected to any of the triacs, the momentary triggering caused by the scan causes a voltage drop over R_1. The comparator changes state and the Schmitt trigger configuration blocks the clock pulses from the counter for a period determined by R_8/C_4 – about seven seconds. The triac concerned remains triggered for this period normally but if the load is removed from the triac within the seven seconds the comparator changes state again and the clock is no longer blocked as pin 4 of IC_2 changes state.

Construction

Although the circuit is fairly simple to construct there are one or two points which must be mentioned here for safety reasons. So that the mains live side be switched it is necessary to connect the circuit's 0V rail through R_1 to the live side of the mains. Consequently the whole circuit is live and must be enclosed to eliminate any possibility of accidental touching. The circuit must be completely isolated from its enclosure and from the chassis of the cooker. Don't forget that any heatsinks connected to the triacs will be live also. On no account should the circuit be wired such that current for the cooker is drawn through the printed circuit or Veroboard rails.

The only setting up required is the adjustment of VR_1 so that the minimum load is just sufficient to stop the counter.

In theory, if all three groups of the cooker are demanding power at the same time then the heating time per group will be three times longer than when only one group is used. In practice this has not been found to be a problem because cookers are rarely used to their ultimate temperature capability and any thermostatically controlled elements only switch on for brief periods once the set temperature is reached. □



Flow chart

Literature received

Microcomputer **analogue I/O** systems for several types of bus, together with data converter modules for lab. and industrial application, are all described in a new catalogue from Data Translation, Ltd, an American company which has its UK sales office at 430 Bath Road, Slough, Berks. SL1 6BB. WW401

Information on the Fiberfil range of flame-retardant, reinforced **thermoplastic compounds**, including processing information, is contained in a leaflet produced by Fiberfil Europe, c/o Capital Controls Division, Dart Industries, Crown Quay Lane, Sittingbourne, Kent ME10 3JE. WW402

Over 1600 **power semiconductor devices**, made by Marconi Electronic Devices Ltd (MEDL) are listed, with their salient electrical characteristics and mechanical information in a 26 page guide, which can be obtained from MEDL at Carholme Road, Lincoln LN1 1SG. WW403

Two impressive publications from **Plessey** provide an overview of the company and its products. An index of products is included. 'Plessey Product Directory' and 'Plessey Group' are available from The Publicity Liaison Unit, Vicarage Lane, Ilford, Essex. WW404

The ZIP ASR/K7 **terminal** is a printer, a keyboard and two mini-cassette drives in one unit, and will perform the function of a paper tape reader and punch terminal. A leaflet on the equipment is published by Data Dynamics Ltd, Data House, Springfield road, Hayes, Middlesex. WW405

British Standard BS3363:1980 is entitled 'Specifications for **Letter Symbols** for Semiconductor Devices and Integrated Microcircuits', replacing BS3363:1968. It is available at £16.50 from British Standards Institution, 2 Park Street, London W1A 2BS. Two supplements are also published at £12 and £9.

Universal second-order filter uses single op-amp

Design equations for hybrid i.c. filters

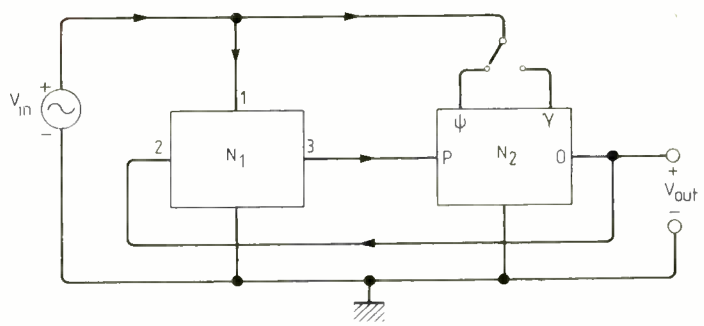
by **F. S. Atiya, A. M. Soliman** and **T. N. Saadawi,** Cairo University

This network can realise the various forms of second-order transfer functions, whether non minimum-phase transfer functions such as a notch filter or an all-pass network,or minimum-phase transfer functions such as low, high and band-pass filters. Its importance lies in using one active device. The universal network has the advantages of being canonic, always stable and capable of realizing a high pole Q. Both passive and active sensitivities are given and the effect of the one-pole roll-off model of the operational amplifier examined in detail; the circuit having low sensitivities to the gain-bandwidth product of the operational amplifier.

Integrated monolithic construction offers many advantages that are attractive to the designer of active filters. One of these is the reduction in cost, particularly if the filter is manufactured in large quantities. Unfortunately there is the problem of how to cover the numerous requirements specified by every application. A solution to this problem may be to design a limited number of standardized filter building blocks for a given frequency range. Then for a specific application, certain combinations of some of them may be used to produce a filter having the desired characteristics. The total number of building blocks can be reduced either by controlling certain characteristics of each block with a single element, or by overdesigning to satisfy excessive requirements.

The use of the first-order all-pass section as the basic building block for second-order transfer functions has been given by Moschytz[1] and Aronhime[2], but the Moschytz realization requires three or four op-amps, and Aronchime's is limited to all-pass transfer functions and requires two op-amps. Also both networks are not canonic.

Here a network based on using a first-order all-pass section is introduced. The circuit is capable of realizing the various forms of second-degree transfer functions. The universal filter has the advantages of using one op-amp, being always stable and canonic and capable of realizing a high pole Q. A unity gain factor is obtained in the case of high-pass, all-pass and notch responses. The ω_p and the pole Q sensitivities to passive and active circuit components are derived, and the effect of the limited frequency response of the op-amp given.



▲ *Fig. 1. Filter comprises passive network N_1 (Fig. 2) and an active network N_2 which can be excited at either port γ or ω.*

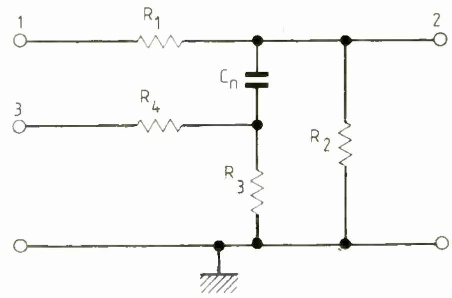


Fig. 2. Three-port one-pole network forms network N_1 in Fig. 1. ▶

General configuration

The new filter consists of two networks, Fig. 1, the first a three-port one-pole passive network N_1, the second a four-port one-pole active network N_2. Network N_1 is excited at port 1 by the input voltage V_{in}, and at port 3 by the output voltage V_0. The output voltage V_2 of the network N_1 is

$$V_2 = V_{in}T_{12}+V_0T_{32} \qquad (1)$$

where $T_{12} = \left.\frac{V_2}{V_1}\right|_{V_3=0}$ $T_{32} = \left.\frac{V_2}{V_3}\right|_{V_1=0}$

Network N_2 is excited at port P by the voltage V_2, which is the output voltage of N_1. There are three cases regarding excitations at ports γ and ψ.

Case 1: N_2 is excited at port γ by the input voltage, while port ψ is left open circuit. In this case

$$V_0 = V_\gamma T_\gamma + V_pT_p \qquad (2)$$

where $T_\gamma = \left.\frac{V_0}{V_\gamma}\right|_{V_p=0,\ \psi\,\mathrm{o.c.}}$ $T_p = \left.\frac{V_0}{V_p}\right|_{V_\gamma=0,\ \psi\,\mathrm{o.c.}}$

From equations 1 & 2 the overall voltage transfer function is

$$\frac{V_0}{V_{in}} = \frac{T_\gamma+T_pT_{12}}{1-T_pT_{32}}. \qquad (3)$$

Case 2: N_2 is excited at port ψ by V_{in}, while $V_\gamma=0$. Here

$$V_0 = V_\psi T_\psi + V_pT'_p \qquad (4)$$

where $T_\psi = \left.\frac{V_0}{V_\psi}\right|_{V_p=0,\ V_\gamma=0}$ $T'_p = \left.\frac{V_0}{V_p}\right|_{V_\psi=0,\ V_\gamma=0}$

Using equation 1 again,

$$\frac{V_0}{V_{in}} = \frac{T_\psi+T'_pT_{12}}{1-T'_pT_{32}}. \qquad (5)$$

Case 3: $V_\gamma=0$, while port ψ is left open circuit. In this case $V_0 = V_2T_p$. Therefore

$$\frac{V_0}{V_{in}} = \frac{T_pT_{12}}{1-T_pT_{32}}. \qquad (6)$$

The passive RC one-pole three-port network, Fig. 2, has the following transfer functions

$$T_{12}(s) \equiv \frac{V_2}{V_1}\bigg|_{V_3=0} = \frac{Kb}{s+b} \qquad (7)$$

$$T_{32}(s) \equiv \frac{V_2}{V_3}\bigg|_{V_1=0} = \frac{Ms}{s+b} \qquad (8)$$

where $b=\frac{R_1+R_2}{C_nR_1R_2}$, $K=\frac{R_2}{R_1+R_2}$

and $M=\frac{R_3}{R_3+R_4}$

and assuming that the resistive attenuator (R_3 and R_4) is much smaller than $1/sC_n$.

The network in Fig. 3 represents the four-port first-order network[2]. It realizes $T_\gamma(s)$ as a one-pole all-pass transfer function by applying the input voltage at terminal γ, with terminal ψ left open circuit ($R_D=\infty$), or as a one-pole low-pass transfer function with negative gain constant $T_\psi(s)$ by applying V_{in} at terminal ψ while terminal γ is earthed. At the same time, it can realize $T_p(s)$ which is a one-pole low-pass characteristic with a positive gain constant. Referring to Fig. 3 and taking into consideration the effect of finite gain of the op-amp,

$$T_\gamma(s) \equiv \frac{V_0}{V_\gamma}\bigg|_{\substack{V_p=0\\ \psi\,\text{o.c.}}} = \frac{s-\dfrac{\alpha a}{1+\dfrac{\alpha+1}{A}}}{s+a} \qquad (9)$$

$$T_\psi(s) \equiv \frac{V_0}{V_\psi}\bigg|_{\substack{V_p=0\\ V_\gamma=0}} = \frac{-ma}{s+a}\cdot\frac{1}{(1+\dfrac{\alpha+m+1}{A})}$$

$$T_p(s) \equiv \frac{V_0}{V_p}\bigg|_{\substack{V_\gamma=0\\ \psi\,\text{o.c.}}} = \frac{a(\alpha+1)}{s+a}\cdot\frac{1}{(1+\dfrac{\alpha+1}{A})}$$

where $a=\frac{1}{CR_A}$, $\alpha=\frac{R_C}{R_B}$ and $M=\frac{R_C}{R_D}$. (10)

As $A\rightarrow\infty$ the above equations reduce to

$$T_\gamma = \frac{s-\alpha a}{s+a}$$

which realizes a first-order all-pass if $\alpha=1$

$$T_\psi = \frac{-ma}{s+a} \qquad (11)$$

$$T_p = \frac{a(\alpha+1)}{s+a}$$

Also the transfer function T_p which is defined in equation 4 is

$$T_p = \frac{a(\alpha+m+1)}{s+a}. \qquad (12)$$

Filter realization and design equations

Combining the networks of Figs 2 & 3 and guided by the block diagram of Fig. 1, the universal second-order filter is obtained as shown in Fig. 4. First the realization of all-pass, notch and high-pass characteristics. Here the transfer function is given by equation 3, using equations 7, 8, 9 and 10 and as there are extra degrees of freedom choose $R_3+R_4 \gg R_A$ to minimize the effect of loading. Thus the transfer function is

$$T(s) \equiv \frac{V_o}{V_{in}} = \frac{s^2\left(1+\dfrac{\alpha+1}{A}\right) - s\left[\alpha a - b\left(1+\dfrac{\alpha+1}{A}\right)\right] + ab[K(\alpha+1)-\alpha]}{s^2\left(1+\dfrac{\alpha+1}{A}\right) + s\left[a+b-cM(\alpha+1)+a+b)\left(\dfrac{\alpha+1}{A}\right)\right] + ab\left(1+\dfrac{\alpha+1}{A}\right)}$$

As $A\rightarrow\infty$, equation 13 becomes

$$T(s) = \frac{s^2 - s[\alpha a - b] + ab[K(\alpha+1)-\alpha]}{s^2 + s[a+b-aM(\alpha+1)]+ab} \qquad (14)$$

By choosing proper values for the parameters a, b, and K the above equation can realize all-pass, notch and high-pass transfer functions having

$$\omega_p=\sqrt{ab},\quad Q_p=\frac{\sqrt{ab}}{a+b-aM(\alpha+1)} \qquad (15)$$

For simplicity of design, choose $\alpha=1$ (i.e. $R_B=R_C$). Thus equation 14 reduces to

$$T(s) = \frac{s^2 - s(a-b) + ab(2K-1)}{s^2 + s(a+b-2Ma)+ab}. \qquad (16)$$

All-pass filter

Equation 16 realizes an all-pass transfer function if $K=1$(i.e. $R_1 \ll R_2$) and $b=aM$. Using the above relation between the two time constants a and b, and for $\alpha=1$, the ω_p and Q_p of the transfer function become

$$\omega_p = a\sqrt{M},\ Q_p=\frac{\sqrt{M}}{1-M}.$$

For the case of interest, namely $Q_p \ll 1$, the above equations can be solved to give the following design formulae

$$M \approx 1-\frac{1}{Q_p} \quad \text{thus} \quad \frac{R_3}{R_4} \approx Q_p - 1$$

$$a \approx \omega_p\left(1+\frac{1}{2Q_p}\right) \qquad b \approx \omega_p\left(1-\frac{1}{2Q_p}\right)$$

In tuning the filter the potential divider R_3, R_4 is adjusted first to set Q_p to the required value and then the two capacitors are tuned to set ω_p.

Notch filter

Equation 16 realizes a notch characteristic if $K=1$, and $a=b$. Thus

$$\omega_p = a,\ Q_p = \frac{1}{2(1-M)}.$$

The design equations are

$$M = 1-\frac{1}{2Q_p} \quad \text{thus} \quad \frac{R_3}{R_4} = 2Q_p - 1 \qquad (17)$$

$$a=b=\omega_p \qquad (18)$$

High-pass filter

A high-pass transfer function is obtained if $K=1/2$ (i.e. $R_1=R_2$), and $a=b$. Thus ω_p and Q_p are the same as in the case of a notch filter, and therefore the design equations for M, a and b are given by equations 17 and 18.

Low-pass filter

The low-pass filter in Fig. 4(b) is slightly different from that in Fig. 4 (a), as terminal γ is grounded instead of being excited by the input voltage. Thus the transfer function in this case is given by equation 6. Using equations 7, 8 and 10 and substituting in 6, assuming $R_3 \gg R_A$, the transfer function is

$$T(s) = \frac{Kab(\alpha+1)}{s^2\left[1+\dfrac{\alpha+1}{A}\right] + s\left[a+b-aM(\alpha+1)+(a+b)\left(\dfrac{\alpha+1}{A}\right)\right] + ab\left[1+\dfrac{\alpha+1}{A}\right]}$$

Fig. 3. Four-port active network realizes an all-pass function with the input at γ and ω open circuit, or a low-pass function with input at γ and ψ earthed.

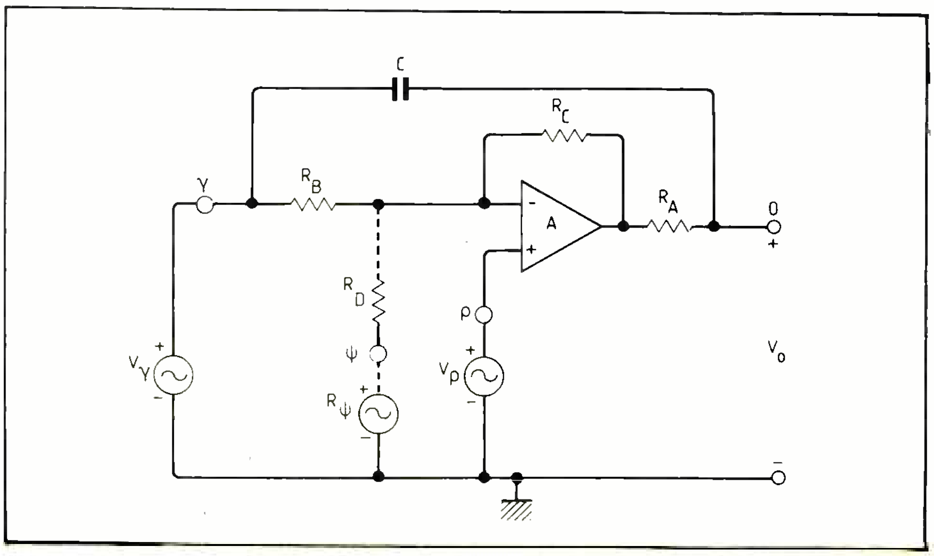
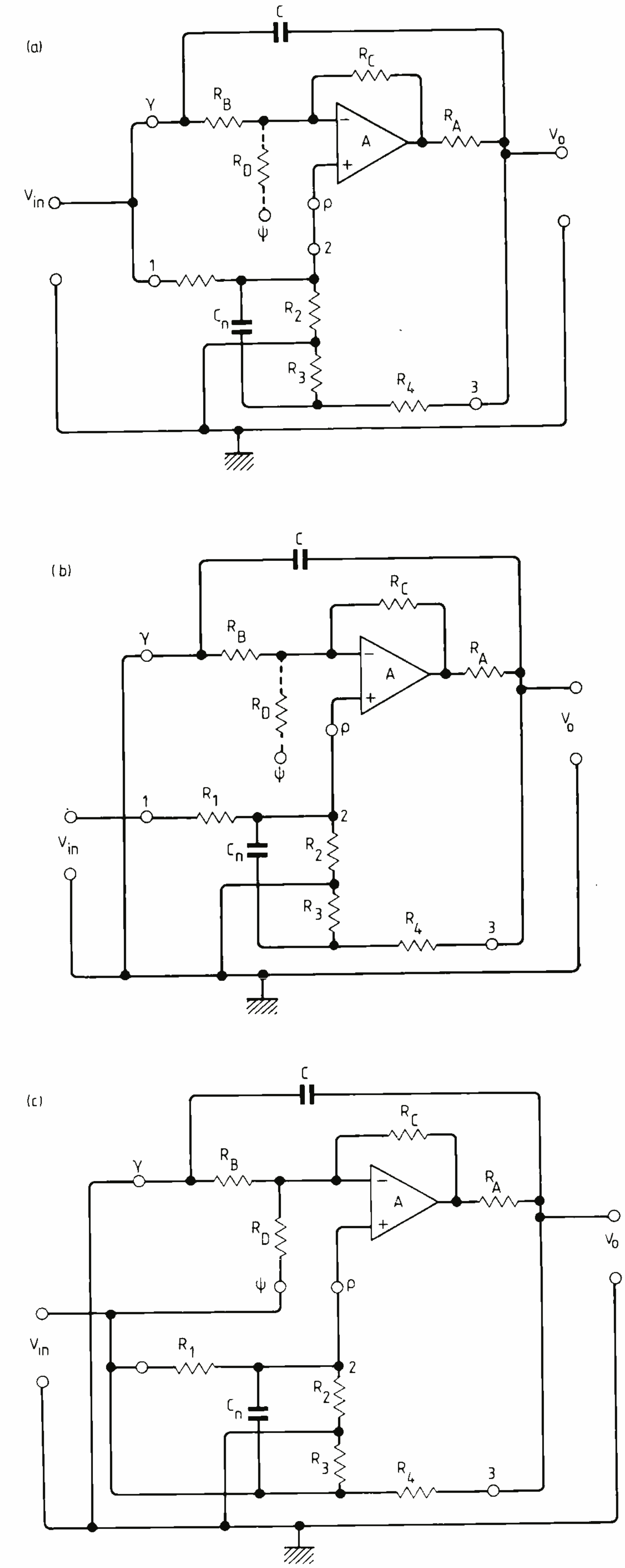


Fig. 4. All-pass, notch and high-pass functions are available by appropriate choice of parameters, a, b and K in equation 14 in circuit (a). With terminal grounded a low-pass characteristic is given (b), while the input applied to ψ gives a band-pass transfer function (c).



As $A \to \infty$, this equation becomes

$$T(s) = \frac{Kab(\alpha+1)}{s^2 + s(a+b-Ma(\alpha+1)) + ab}$$

which realizes a low-pass filter having ω_p and Q_p as given in equation 15.

Design equations: choose $\alpha=1$, thus $R_B=R_C$. For unity d.c. gain, $K=1/2$, thus $R_1=R_2$. An extra degree of freedom exists in this case, so for simplicity of design, choose $a=b$, thus $\omega_p=a$, and

$$M = 1 - \frac{1}{2Q_p}, \text{ thus } \frac{R_3}{R_4} = 2Q_p - 1.$$

The d.c. gain in the general case is $K(\alpha+1)$, and so can be adjusted to any desirable value.

Bandpass filter

Fig. 4(c) represents the bandpass filter, terminal γ is earthed and the input is applied to terminal ψ. The transfer function can be obtained by substituting equations 7, 8, 11 and 12 in equation 5. For $A \to \infty$, $\alpha = 1$.

$$T(s) = \frac{-mas + ab[K(m+2) - m]}{s^2 + s[a+b-aM(m+2)] + ab}$$

For a bandpass, $K = m/(m+2)$. The ω_p and Q_p values are

$$\omega_p = \sqrt{ab}, \quad Q_p = \frac{\sqrt{ab}}{a+b-aM(m+2)}$$

Choosing $a=b$,

$$\omega_p = a, \quad Q_p = \frac{1}{2-M(m+2)}.$$

The parameter m controls the magnitude of the gain at ω_p. If $|T(j\omega_p)|$ is required to be Q_p, $m=1$, the design equations are

$a = b = \omega_p$
$m = 1$, thus $R_C = R_D$
$K = 1/3$, thus $R_1 = 2R_2$

$$M = 1/3\left(2 - \frac{1}{Q_p}\right), \text{ thus}$$

$$\frac{R_3}{R_4} = \frac{2Q_p - 1}{Q_p + 1} \approx 2 \text{ for } Q_p \gg 1.$$

The table shows the design values for the different types of a second-order transfer function.

Effect of non-ideal op-amp

Here the frequency limitation equations of the network are given based on the one-pole roll-off model of the op-amp which is characterized by

$$A = \frac{A_0\omega_1}{s+\omega_1} \approx \frac{GB}{s} \qquad (19)$$

where A_0 is the open-loop d.c. gain of the op-amp, ω_1 is the open-loop 3-dB bandwidth, and $GB=A_0\,\omega_1$ is the gain-bandwidth product. When equation 19 is substituted in 13, the denominator of $T(s)$ becomes $D(s)=$

$$s^2+\frac{\omega_p}{Q_p}s+\omega_p^2+\frac{(\alpha+1)}{GB}s(s^2+s(a+b)+ab)$$

For the special case $\alpha=1$, $a=b$, thus

$$D(s)=s^2+\frac{\omega_p}{Q_p}s+\omega_p^2+\frac{2s}{GB}(s^2+2\omega_p s+\omega_p^2).$$

Following the Budak-Petrela analysis[3], the relative change in ω_p and Q_p due to the limited frequency response of the op-amp are

$$\frac{\Delta\omega_p}{\omega_p}=-\left(2-\frac{1}{Q_p}\right)\frac{\omega_p}{GB}\approx\frac{-2\omega_p}{GB}\quad\text{for } Q_p\gg 1/2$$

$$\frac{\Delta Q_p}{Q_p}=-\left(2-\frac{1}{Q_p}\right)\frac{\omega_p}{GB}\approx\frac{-2\omega_p}{GB}\quad\text{for } Q_p\gg 1/2$$

Passive sensitivities

From equation 14 the ω_p and Q_p sensitivities to all passive circuit components are

$$S_C^{\omega_p}=+S_{C_n}^{\omega_p}=-1/2,\quad S_{R_A}^{\omega_p}=-1/2$$

$$S_{R_1}^{\omega_p}=-1/2\left(\frac{R_2}{R_1+R_2}\right),\quad S_{R_2}^{\omega_p}=-1/2\left(\frac{R_1}{R_1+R_2}\right),$$

$$S_{R_3}^{\omega_p}=S_{R_4}^{\omega_p}=S_{R_B}^{\omega_p}=S_{R_C}^{\omega_p}=0$$

$$S_{R_1}^{Q_p}\approx\left(\frac{R_2}{R_1+R_2}\right)Q_p,\quad S_{R_2}^{Q_p}\approx\left(\frac{R_1}{R_1+R_2}\right)Q_p,$$

$$S_{R_3}^{Q_p}=-S_{R_4}^{Q_p}=\left(\frac{R_4}{R_3+R_4}\right)2Q_p$$

$$S_{R_A}^{Q_p}\approx-Q_p,\quad S_{R_C}^{Q_p}=-S_{R_B}^{Q_p}\approx Q_p$$

$$S_{C_n}^{Q_p}=-S_C^{Q_p}\approx Q_p$$

The Q_p sensitivities to the passive circuit components are proportional to Q_p as is the case with other good high frequency performance networks, refs 4-6, and the circuit in this case belongs to class 1 filters as classified by Faulkner and Grimbleby[7]. The network will perform satisfactorily only when realized in hybrid integrated circuit technology[8] for which it is intended.

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Filter type	Design values	T(s)	ω_p	Q_p
All-pass Fig. 4(a) $T_\gamma=\frac{s-a}{s+a}$	$\alpha=1$, $K=1$, $b=aM$, $M\approx1-\frac{1}{Q_p}$, $a\approx\omega_p\left(1+\frac{1}{2Q_p}\right)$, $b\approx\omega_p\left(1-\frac{1}{2Q_p}\right)$	$\frac{s^2-sa(1-M)+a^2M}{s^2+sa(1-M)+a^2M}$	$a\sqrt{M}$	$\frac{\sqrt{M}}{1-M}$
Notch Fig. 4(a) $T_\gamma=\frac{s-a}{s+a}$	$\alpha=1$, $K=1$, $a=b=\omega_p$, $M=1-\frac{1}{2Q_p}$	$\frac{s^2+a^2}{s^2+s2a(1-M)+a^2}$	a	$\frac{1}{2(1-M)}$
High-pass Fig. 4(a) $T_\gamma=\frac{s-a}{s+a}$	$\alpha=1$, $K=1/2$, $a=b=\omega_p$, $M=1-\frac{1}{2Q_p}$	$\frac{s^2}{s^2+s2a(1-M)+a^2}$	a	$\frac{1}{2(1-M)}$
Low-pass Fig. 4(b)	$\alpha=1$	$\frac{2Kab}{s^2+s[a+b-2Ma]+ab}$	$\sqrt{ab}$	$\frac{\sqrt{ab}}{a+b-2Ma}$
$V_\gamma=0$	$K=1/2$, $a=b=\omega_p$, $M=1-\frac{1}{2Q_p}$	$\frac{ab}{s^2+s2a(1-M)+a^2}$	a	$\frac{1}{2(1-M)}$
Band-pass Fig. 4(c)	$\alpha=1$, $K=\frac{m}{m+2}$	$\frac{mas}{s^2+s[a+b-aM(m+2)]+ab}$	$\sqrt{ab}$	$\frac{\sqrt{ab}}{a+b-aM(m+2)}$
$V_\gamma=0$, $T_\psi=\frac{-ma}{s+a}$	$m=1$, $K=1/3$, $a=b=\omega_p$, $M=1/3\left(2-\frac{1}{Q_p}\right)$.	$\frac{-as}{s^2+sa(2-3M)+a^2}$	a	$\frac{1}{2-3M}$

Viewdata and teletext – a national sales strategy

Following a conference held earlier this year at which representatives of the industries concerned – broadcasting; retail and rental companies; t.v. and equipment manufacturers and information providers – together with representatives of the Department of Industry, the Department has issued a paper, *UK Teletext and Viewdata: From commitment to action*. This outlines a strategy for "the active, aggressive and immediate promotion of teletext in the consumer market-place, along with Prestel's carefully targetted marketing programme at the business community, which will be the best way to accelerate the arrival of mass-market Viewdata, and consolidate the growth of teletext".

Mr Kenneth Baker, Minister for Information Technology, has written to senior management in each sector of the industry asking for their company's endorsement of the plan and their support in carrying the commitments through to action.

An attack on the North American market has been launched by the foundation of British Videotext and Teletext, the joint venture of Logica Ltd and British Telecom.

● But what of the man on a Clapham omnibus? Does he really want all that writing on his tv screen? Would he use it even if he had a teletext-adapted set? Or would he prefer to sit back and enjoy *Coronation Street*, as usual?

Op-amp tone control

A m.o.s.f.e.t.-input bipolar i.c. design using potentiometers or switch controls with optional treble curves.

by **Winthrop S. Pike,** RCA Laboratories

To the ear, linear potentiometers used as control elements for standard tone controls have little effect on the overall sound around the middle of their travel and a rather sharp increase toward the ends. This high input/low output impedance tone control, designed around a m.o.s.f.e.t. input bipolar i.c., has a control element option in the form of a rotary switch, the fixed components of which are selected to give an even spread of boost or cut over the full rotation. A variation of this switch control moves the treble turnover frequency depending on the amount of boost or cut.

The 47kΩ input impedance and low output impedance of this tone control make it suitable for connection between most audio amplifier circuits. Figure 1 shows the circuit, based on the RCA CA3140 series 'BiMOS' operational amplifier, in its simplest form. This i.c. has a m.o.s.f.e.t. input stage coupled with bi-polar output circuitry and is available in single or dual form (CA3240) and in different packages.

Understanding of the operation of the circuit of Fig. 1 may be easier if C_3 and C_4 are assumed to be short, and R_3 and R_4 assumed to be open circuits. Under these conditions, a signal at the input terminals, after d.c. blocking by C_1, is applied to the non-inverting input of the op-amp through an 11:1 (20.8dB) attenuator comprising R_1 and R_5. The output of the op-amp is fed back to the inverting input through an identical attenuator, R_2 and R_6.

In this configuration, the gain of the op-amp is $1+(R_2/R_6)$ or 11 (20.8dB), so the loss from the input attenuator and the gain of the op-amp give an overall gain of unity (0dB). The response of the system so far described will be flat throughout the audio band, the low-frequency roll-off caused by the input RC well below audibility and the high-frequency roll off caused by the op-amp well above.

With R_3 and R_4 now 'reconnected', and the slider of the treble potentiometer, P_1, moved to the extreme left, C_2 in series with R_3 will shunt the non-inverting input of the op-amp. As the reactance of C_2 decreases with increasing frequency, treble roll-off will result. Also, the entire resistance of P_1 will be inserted into the circuit between C_2 and the inverting input of the op-amp. This will increase the negative feedback around the op-amp at high frequencies, reducing the h.f. gain of the system. With the values given, about 15dB of treble cut at 20kHz will be produced.

When the slider of P_1 is moved to the extreme right, no treble roll-off occurs, but the negative feedback around the op-amp is reduced at high frequencies, resulting in about 15dB of treble boost at 20kHz. If the slider is centred, the two effects cancel, giving a flat response.

Variations in the positions of the slider of P_1 have little effect on the response below 1kHz, because below this frequency the impedance of C_2 is high compared with R_5 or R_6. Similarly, with the hypothetical short circuits on C_3 and C_4 removed, frequencies above about 1kHz are not affected by P_2, as these two capacitors are of low reactance at these frequencies.

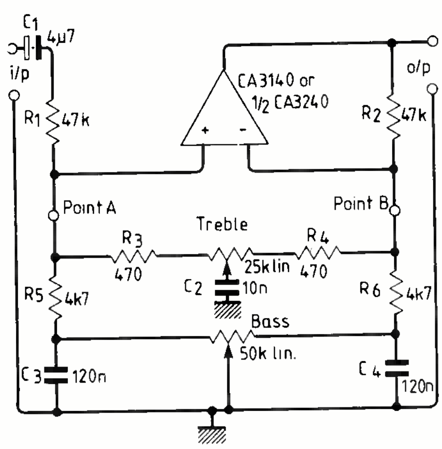


Fig. 1. Circuit diagram of the tone control in its simplest form. R_3 and R_4 may be reduced slightly to compensate for potentiometers which don't give zero resistance at the extremes of their travel.

In the bass region, the reactances of C_3 and C_4 increase as the frequency decreases and become appreciable compared with R_5 and R_6.

When the slider of the bass potentiometer, P_2, is moved to the extreme left, C_3 will be shorted out and cannot affect the signal reaching the non-inverting input of the op-amp. Capacitor C_4 is now only shunted by 50kΩ, the resistance of P_2, so the negative feedback of the op-amp circuit increases at low frequencies. This negative feedback causes 15dB of bass cut at 20Hz.

With the slider of P_2 moved to the extreme right, C_4 is shorted out and can no longer affect the negative feedback. Capacitor C_3 is now shunted by 50kΩ and the gain of the op-amp increases at low fre-

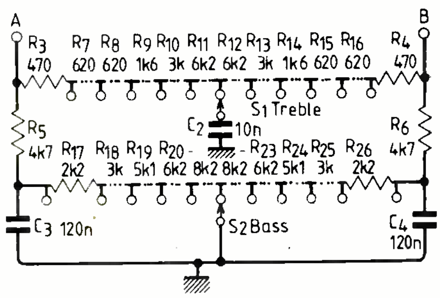
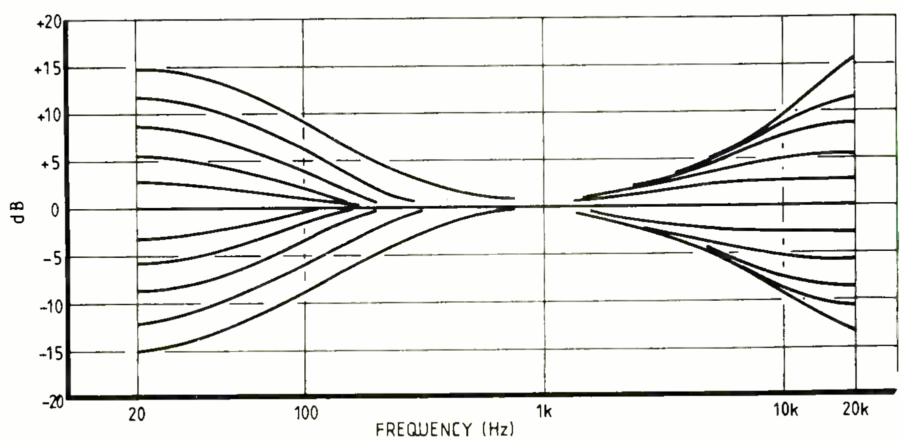


Fig. 2. To obtain more evenly spread boost and cut control, the linear potentiometers of Fig. 1 may be replaced by rotary switches and fixed resistors as shown here. The switches have make-before-break contacts.

Fig. 3. Response curves of the circuit when the switched resistor controls are used, showing the 3dB steps at 20Hz and 20kHz.



quencies, resulting in a gain of about 15dB at 20Hz.

Switch controls

In Figure 1, the linear taper potentiometers shown for the treble and bass controls are a compromise in the interests of economy and availability. Ideally, one needs potentiometers with an 'S' shaped taper, with which the rate of change of resistance with rotation is greater in the centre of the slider travel and less at each end. The 'S' type taper can be simulated using rotary switches with fixed resistors, as shown in Fig. 2, to give five steps of either cut or boost in 3dB increments at 20Hz and 20kHz. Figure 3 shows the response curves for the circuit with the switch control of Fig. 2 substituted.

An alternative circuit with variable treble turnover frequencies is shown in Fig. 4. In this version of the tone control, the bass end of the spectrum is controlled exactly as before, but the treble control is achieved by switching capacitor values. This moves the turnover point of the treble boost or cut along the frequency axis as the treble control is adjusted. Figure 5 shows the resulting response curves.

Two of the bass curves of Fig. 5, at +12dB and −9dB, have been plotted to 1kHz without truncation to show their true shape. These curves cross the 0dB axis and then return to it as do all the bass boost and cut curves between 6 and 12dB – anomalies which are also found in many commercial tone controls. As the magnitude of these inaccuracies does not exceed ±1.5dB, their effect is barely audible.

At 1kHz, the maximum level change for any combination of control settings will not exceed about ±1.5dB.

Construction

Because of the simplicity of the circuit, this section is limited to a few construction tips.

Resistors R_3-R_{26} and capacitors C_2-C_{14} may be mounted directly on the control switches (or potentiometers) so that only two unscreened leads and an earth need be run between op-amp and controls. If the leads to the inverting and non-inverting inputs of the op-amp (points A and B) are twisted together, any hum or noise picked up by the two tends to be cancelled out by the common-mode rejection properties of the op-amp.

Each op-amp supply must be by-passed by a ceramic capacitor of between 47nF and 0.22µF, positioned as close to the i.c. pins as possible.

Interfacing

One of the advantages of this tone control is its relatively high input impedance. Figure 6 shows the tone control incorporated in an audio amplifier system immediately following the volume control. The output impedance of the volume control depends, of course, on the position of its slider. In the situation shown, the maximum impedance at the slider of the potentiometer will be when the resistance of the potentiometer on the input side of the

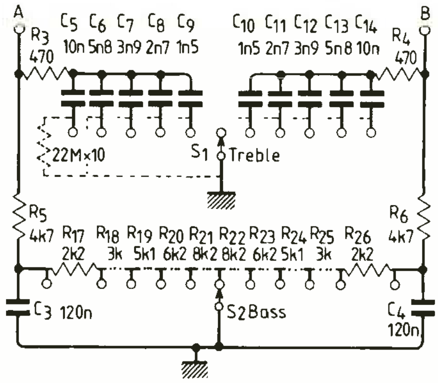


Fig. 4. This variation of the switched resistor tone control moves the treble turnover frequency as the amount of treble boost or cut is varied. The resistors shown in dotted lines are 22MΩ and may be required if static build up over the capacitors causes switching clicks.

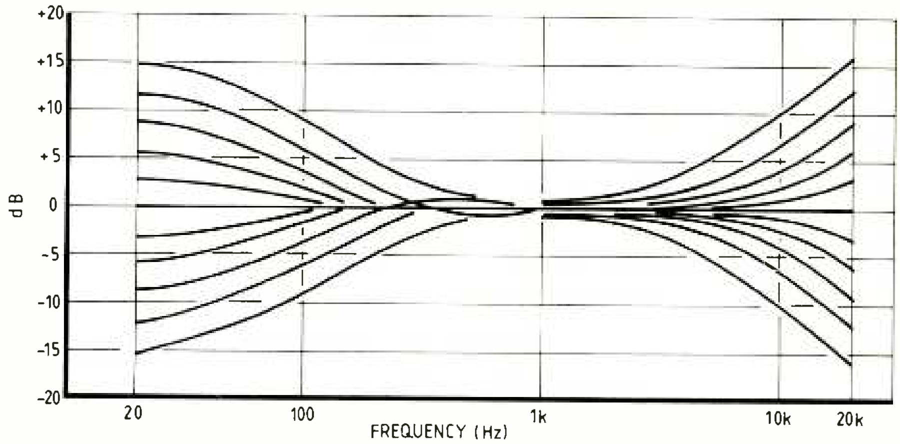


Fig. 5. Response curves of the circuit with the switch control shown in Fig. 4 substituted, showing the variations in treble turnover frequency with different boost and cut levels.

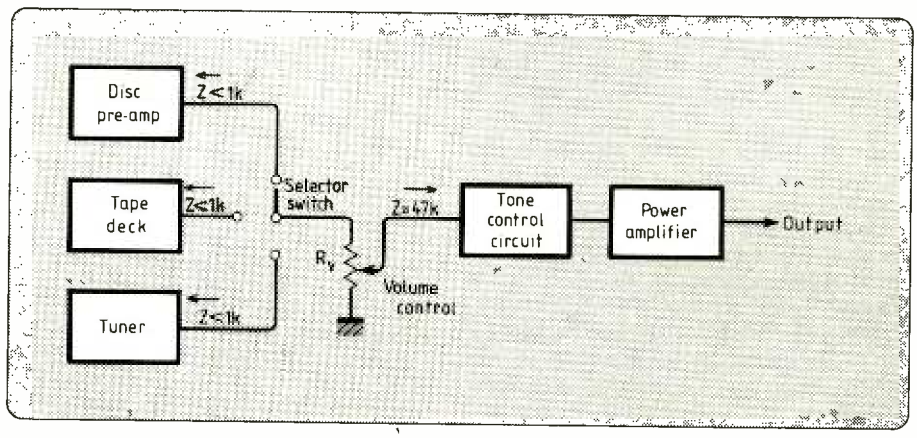


Fig. 6. Block diagram of a typical audio amplifier system with the tone control inserted after the volume potentiometer.

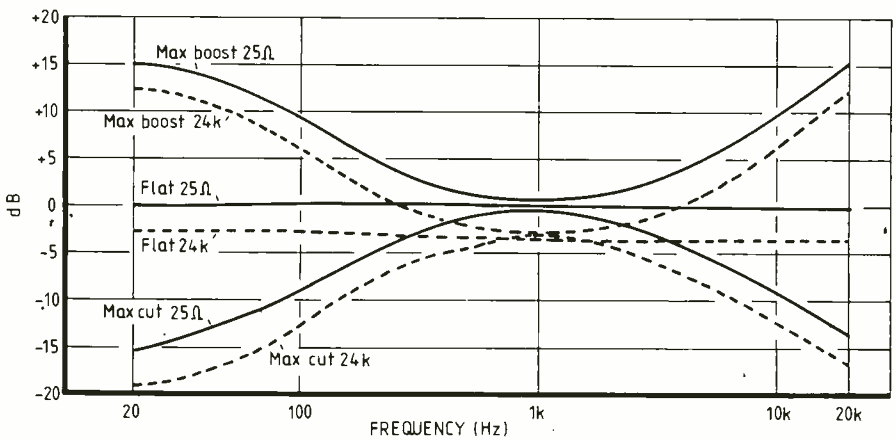


Fig. 7. Effects on the overall performance of the tone control caused by different driving impedances.

slider is equal to the resistance on the grounded side of the slider plus the input impedance of the tone control (added as parallel resistors). Taking 100kΩ as the volume control resistance, the maximum impedance driving the tone control will be about 25kΩ.

Figure 7 shows two sets of curves produced by the tone control using 25Ω (solid lines) and 24kΩ (dotted lines) driving impedances. The only significant difference between the two sets of curves is the 3dB overall loss caused by the 24kΩ driving impedance so a 100kΩ potentiometer may be used before the control without buffering. Note, however, that if such a high-resistance potentiometer is used, its law will be affected slightly by the input impedance of the tone control.

Outside the audio frequency band, boost and cut are limited to about 20dB at all frequencies but if the 3140 is used, further h.f. limiting may be applied, if required, by connecting about 27pF between pins 1 and 8 of the op-amp.

Using a prototype circuit with rather long leads and no shielding, the maximum undistorted output into 2.2kΩ was about 8V r.m.s. and with the input signal removed, residual hum and noise at the output was 0.4mV r.m.s., giving a dynamic range of 86dB. A load of less than 2.2kΩ will reduce the maximum output voltage. □

Wireless Exhibition

On the Air: The story of radio and television is an exhibition to be held at the Livesey Museum, 682 Old Kent Road, London SE15 1JF, open Monday to Saturday from 12th May to 25th July. The exhibition celebrates the history of broadcasting in Britain and considers its future.

Guglielmo Marconi's famous 'black box' which contained the 'wireless' apparatus he brought to England in 1896, will be amongst the historical exhibits. Transmissions from the Marconi stations at Chelmsford and Writtle proved so popular a public broadcasting service was opened in 1922 by the British Broadcasting Company. Photographs and original documents are used to plot the early years of the BBC which only became a public corporation in 1927.

'Wireless' was a flourishing hobby in the 1920s – many listeners made their own home-made sets from kits. A selection of valve receivers and crystal sets will be on display – amongst the crystal sets will be one in the shape of a book entitled "The Listener"!

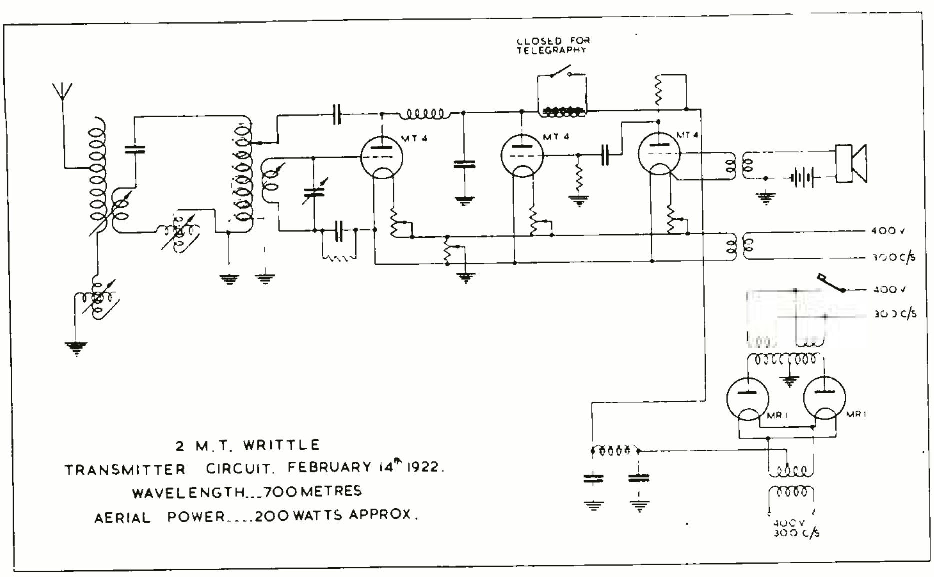
The exhibition tells the story of John Logie Baird, a one-time dealer in socks and jam, often called the "Father of Television". In 1925 visitors to Selfridges Store saw images produced by his television apparatus which was made from an assortment of army surplus valves, knitting needles and cardboard! "The Televisor", an early television receiver designed by Baird will be on display.

Radio had its finest hour during the Second World War but the young television service was closed down. Television re-opened after the war and 1955 saw the birth of commercial television – which Churchill dismissed as "that tuppenny Punch and Judy show". Colour broadcasts officially began on the new BBC 2 channel in 1967 and a demonstration will explain colour television in simple terms.

Broadcasting has always sought to educate and entertain so this exhibition will also focus on some of the most interesting aspects of present-day broadcasting. There will be sections dealing with local radio, news broadcasting and audience research. Exhibits from the very popular television series *Hitch-hikers' Guide to the Galaxy* will be displayed in the section about the studio.

The exhibition concludes with a section on cable television, broadcasting direct from satellites to viewers' homes and the latest in video equipment. The new Philips video-disc player will be on display, alongside displays of Ceefax, Oracle and Prestel, television games, an autocue system and a selection of video tapes covering subjects like local radio, recording television programmes and special 'electronic' effects used in television.

Many special events will accompany the exhibition. Capital Radio's "Capital Cruiser" will be at the museum on the 28th May during the afternoon. "Three in a Row" the BBC Radio 2 quiz game is being recorded on 19th May at the North Peckham Civic Centre (adjacent to the museum). "The Radio Enthusiast" a demonstration/talk will be given by Ralph Barrett on 16th May at 2.30pm.



2 M.T. WRITTLE
TRANSMITTER CIRCUIT. FEBRUARY 14th 1922.
WAVELENGTH...700 METRES
AERIAL POWER....200 WATTS APPROX.

Marconi Company Ltd

Literature received

Catalogue from Cambion contains information on a very wide range of **small components**, such as sockets, wire-wrap equipment, circuit cards, patch cords, jacks. It can be obtained free from Cambion Electronic Products Ltd, Castleton, nr Sheffield S30 2WR. WW 420

Two brochures from Hybritek describe the company's capability in the **processing and assembly of dies**, including t.t.l., c.m.o.s. and e.c.l. in a variety of packages. The brochures are available from Hybritek Ltd, 125 Long Lane, Chadderton, Lancs. OL9 8AY. WW 421

A range of our 200 **power supplies** from Datel Intersil is fully described in a new catalogue, which can be obtained from DI, 9th Floor, Snamprogretti House, Basingstoke, Hants. WW 422

Passive r.f. components, made by Weinschel Engineering, are imported by Marconi Instruments, who can supply a short catalogue. M.I. are at Longacres, St Albans, Herts. AL4 0JN. WW 423

An eight-page data sheet from Pascall provides preliminary details of the new Micro Networks MN5282 16-bit **a-to-d converter**, which is a low cost, thin-film circuit in a 32-pin d.i.p. Application information is included. The publication can be obtained from Pascall Electronics Ltd, Hawke House, Green Street, Sunbury-on-Thames, Middlesex, TW16 6RA. WW 424

Analogue-to-digital converters, d-to-a converters, sample/hold amplifiers, op-amps and data acquistion products are all described in a short catalogue from Zeltex, who are represented in the UK by MCP Electronics Ltd, 38 Rosemont Road, Alperton, Middlesex HA0 4PE. WW 425

Three brochures from Ocean Applied Research describe five v.h.f. automatic **direction finders**, operating in the range 25-50MHz, 27MHz or 83-110MHz. The instruments are Model ADFS-922/932/940/928/938. Brochures are obtainable from OAR at 10477 Roselle Street, San Diego, California, 92121, USA. WW 426

A large range of thumbwheel, leverwheel and pushwheel **switches** by Cherry is described in a new catalogue, which is obtainable from Cherry Electrical Products Ltd, Coldharbour Lane, Harpenden, Herts. AL5 4UN. WW 427

The range of opto-electronic components from International General Electric, includes couplers, emitters and detectors of many different types, and is described in a short catalogue from Norbain Electro-Optics Ltd, Norbain House, Arkwright Road, Reading, Berkshire RG2 0LT. WW 428

Electronic combination lock – correction

The caption of Fig. 1 on p.42 of the January issue may have given the impression that if the digits 3, 6, 9, 7 were typed in on the keyboard, the lock would operate with the given switch settings. Due to the action of the shift registers, the digits need to be typed in the reverse order. From a practical point of view, digit 1 on the drawing should be called digit 4, digit 2 becomes digit 3, etc.

An appreciation of James Clerk Maxwell, 1831-1879, part 2

Have we got the allocation of honours between Einstein and Maxwell right?

by M. G. Wellard

"The object of these experiments was to test the fundamental hypothesis of the Faraday-Maxwell theory, and the result of the experiments is to confirm the fundamental hypothesis of the theory" wrote Hertz in his book Electric Waves. The fundamental hypothesis of the Faraday-Maxwell theory was that space was not empty. This article continues an attempt to explain why we should turn the cuckoo clocks back to Maxwell and start again.

When Maxwell decided to study the science of electricity, he resolved "to read no mathematics on the subject till I had first read through Faraday's experimental researches on electricity," and a little later in the preface to his treatise he recommended the student "after he has first learned, experimentally if possible, what are the phenomena to be observed, to read carefully Faraday's experimental researches in electricity. He will there find a strictly contemporary account of some of the greatest electrical discoveries and investigations, carried out in an order and succession which could hardly have been improved if the results had been known from the first, and expressed in the language of a man who devoted much of his attention to the methods of accurately describing scientific operations and their results." Maxwell was very careful in his choice of words. He was hinting that Faraday did, more often than not, know the results of his experiments in advance; that Faraday's great electrical discoveries were experimental proof of Faraday's theories. Maxwell's insistence on accurate description of factual experiments is obvious.

Maxwell's laws are the result of his mathematical treatment of Faraday's theory that everything in the universe, including space, were different forms of one mysterious force, a manifestation of his God and a true field of force, although Maxwell filled only space, including the space permeating molecular structures, with a medium or ether having quite specific and mathematically measurable actions and reactions by "bodies" which obeyed Newton's laws of motion. Maxwell found some ideas of Faraday impossible to develop mathematically and designed himself a working model of his ether with the sole objective of using the model as an aid in developing his electromagnetic theory of light. The model's greatest success was his development of the idea of displacement current, the forces of electricity being displaced in shape as they were squeezed against the "bodily" resistance of a non-conductor of electricity. Light travels through space, a non-conductor, and his displacement current was vital to his theory that light was electricity in the form of a wave, squeezing its way through the non-conductor in space. He realised that conductors of electricity were the exception, rather than the rule, fully appreciating Faraday's analysis of conductors and non-conductors that the only continuous path through any material is via the space surrounding the material's atoms, and therefore atoms were centres of power, with the power to decide whether the space surrounding them should be a conductor or just like the rest of space outside.

Maxwell's design for space was filled with two types of ball bearings, Newton's bodies, one for electricity, and the other for magnetism. When a force acted on the electric bodies, they acted on the magnetic bodies. In all actions there were always two bodies in physical contact with each other acting equally and in opposition. The action of the electric bodies always induced a rotary action in the magnetic bodies. Magnetism was caused by a rotary action of his medium and was Maxwell's method of explaining Ampere's theory that the magnetism in magnets was caused by electric currents encircling the magnet's molecules. When the majority of the magnet's tiny electric currents were in parallel, they acted like coils of wire wound around a former. Each magnet was really an electromagnet with its coils connected in parallel rather than in series. Only when the bodies moved was electricity detectable.

The initial action on the electric bodies threw the medium into a state of stress, the stresses appearing as electric and magnetic phenomena. The stresses in his medium were analogous to the stresses produced in other media such as solids and liquids. His working model was designed specifically to help him identify the correct mathematical analogies between the forces involved in electromagnetic phenomena and forces involved in the stresses of material structures. Although the two bodies of his medium were a form of particle, the particle nature of his medium was unimportant. What was important was the changing stress in the medium which he could follow anywhere in space. His energy did not disappear at one point in space to magically reappear somewhere else, the theme of modern electromagnetic theory. Maxwell's energy was always conserved. Maxwell's medium or ether was capable of providing a force of opposite reaction. It was a form of energy capable of performing work in resisting a disturbance of its state of rest or inertness. Its inertia, its resistance to change, is known as its impedance. The disturbance of its state of rest caused by the action of a wave of light, is resisted by the medium, and the magnitude of this resistance is known as the impedance of free space, about 377 ohms. Maxwell headed page 459, volume two, of his treatise, Energy of the medium, and he meant us to take him literally.

Faraday had proved that magnetism interacted with polarized light and therefore light was most probably an electromagnetic phenomena. Included in Maxwell's thousand-page treatise is a twenty-page chapter detailing his mathematical proof that light is an electromagnetic wave phenomenon passing through his medium. He was so far ahead of experimental physics that more than twenty years were to elapse before Hertz confirmed Maxwell's maths. Maxwell then became a posthumous hero for a few years, but unfortunately the majority of physicists concentrated their speculations on the twenty-page chapter of Maxwell's treatise and ignored the rest. His medium was studied chiefly as an ether, a carrier of light waves that Michelson and Morley said acted very strangely.

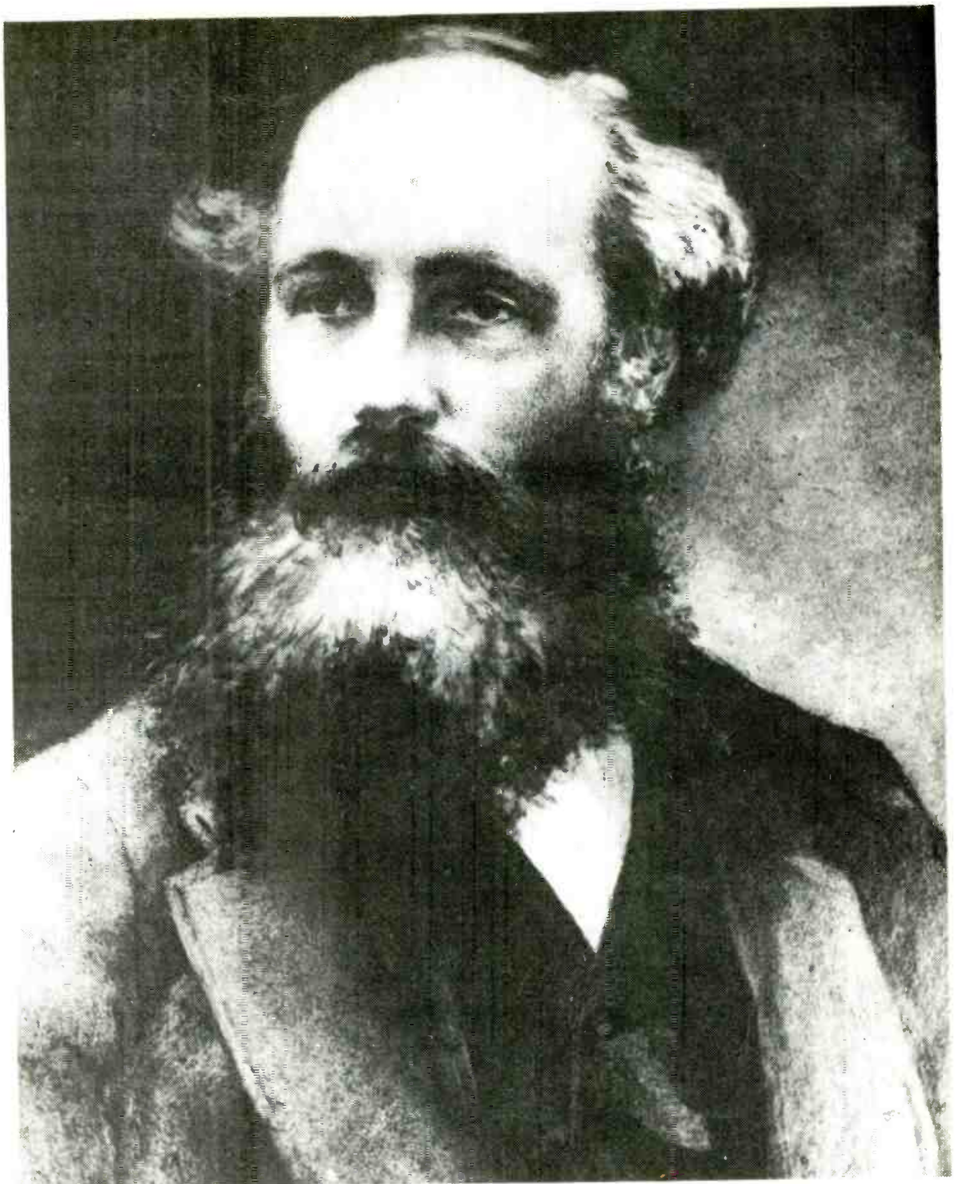
Since Newton first published his formula forecasting the attractive forces of gravity capable of acting across the space separating the centres of two pieces of matter, physics has been dominated, apart from a few years immediately following Hertz's experiment with Maxwell's waves, by action-at-a-distance theories. Maxwell devoted the last chapter of his treatise to a mathematical and almost physical attack on them. These theories say that forces can act across a distance in space without two "bodies" necessarily being in physical contact with each other. There is an exchange of the attractive force of gravity between the apple and the earth unaided by the action of any bodies in the space separating them. Time plays no part in the exchange of force, the mutual sensing of force taking place instantaneously. Faraday and Maxwell believed that forces were transmitted across space isolating two bodies from each other by the shunting action of a string of other bodies joining the centres of force, and that the shunting action was only possible if all bodies were in physical contact with each other. Forces could not be exchanged across empty space without the aid of bodies in physical contact with each other along the line of least action. Because each body along the line took a finite time to act and react, the exchange of forces always took time. In Faraday's day there was no known method of measuring the time taken to charge a capacitor, but when Hertz proved that light was an electromagnetic wave that took time to cover a distance in space, all action-at-a-distance theories in which time was not the essence were completely discredited.

During the period that Maxwell was busy writing and re-writing his treatise, all action at a distance theories involved carriers of forces. The force of gravity is carried in the centre of every piece of matter and there it stays, but the forces of electricity and magnetism move about. These moving forces were carried either by fluids, hence electric currents and an ether, or by particles. Particles were best because they slotted neatly into the infinitesimal calculus and were defined Newton bodies. Fluids became too involved mathematically and acquired remarkable properties. In the final chapter of his treatise, headed Theories of Action at a Distance, Maxwell gave a critical analysis of rival theories, first those involving electricity carried by particles, and then those involving the propagation of light by different particles. The last words of his treatise are an appeal to the common sense of those who rejected his logic, a logic he was never to see proved. The final sentence is, in more ways than one, the saddest sentence in science.

"In fact, whenever energy is transmitted from one body to another in time, there must be a medium or substance in which the energy exists after it leaves one body and before it reaches the other, for energy, as Torricelli remarked, 'is a quintessence of so subtle a nature that it cannot be contained in any vessel except the inmost substance of material things.' Hence all these theories lead to the conception of a medium in which the propagation takes place, and if we admit this medium as an hypothesis, I think it ought to occupy a prominent place in our investigations, and that we ought to endeavour to construct a mental representation of all the details of its action, and this has been my constant aim in this treatise."

Maxwell might have been a successful psychiatrist. Just before his final words extracted above he wrote:

"There appears to be, in the minds of these eminent men, some prejudice, or a priori objection, against the hypothesis of a medium in which the phenomena of radiation of light and heat and the electric actions at a distance take place. It is true that at one time those who speculated as to the causes of physical phenomena were in the habit of accounting for each kind of action at a distance by means of a special aethereal fluid, whose function and property it was to produce these actions. They filled all space three or four times over with ethers of different kinds, the properties of which were invented merely to save appearances, so that more rational enquirers were willing rather to accept not only Newton's definite law of attraction at a distance, but even the dogma of Coates that action at a distance is one of the primary properties of matter, and that no explanation can be more intelligible than this fact. Hence the undulatory theory of light has met with much opposition, directed not against its failure to explain the phenomena, but against its assumption of the existence of a medium in which light is propagated."



Following Hertz's experiment, attempts to construct a mental representation of the ether's action were short-lived. Lorenz soon discovered a simple way of re-introducing an action at a distance theory. Maxwell's ether would carry particles that carried electricity. Maxwell had said that electrical phenomena were symptoms of stresses of his medium, and magnetism the result of a rotary action of the same medium. His ether was capable of some form of motion. Lorenz's particles were extremely sensitive to actions of the ether, so much so he decided that it was in the best interest of everybody if he introduced a law forbiding the ether to move. "Since we have assumed that the ether doesn't move, why should we ever speak of a force acting upon the medium . . . Indeed this conception (his theory) rejects the equality of action and reaction . . . . " Lorenz had found a loophole in Newton's third law of motion. His initial theory had two particles that carried electricity, one positive and the other equally and oppositely negative. The negative particle is now called an electron. He never did find the other one.

In Rutherford's model of the atom (a planet) the negatively charged particle (the electron) orbits a sun, the positively charged particle (the proton). The charges are equal and opposite and therefore the inert atom is electrically neutral. Physicists using the mathematics of Newton's laws of motion discovered that although the proton was electrically opposite to the electron, it was about 1,800 times unequal. Every atom in the universe was carrying an excess of positive electricity. Many years after Lorenz re-introduced his action at a distance particles, his carrier of positive electricity was discovered, the positron. This particle is very scarce, which is just as well, because all atoms in the universe are still generating 1,800 times their mass number of excess positive electricity. It only requires someone to discover that the proton is not encircled by an electron, but by the proton's anti-particle the anti-proton, for electricity to get back to normal.

Rutherford's theory of the atom does not satisfy the principle of the conservation of energy. Without the aid of the mathematics of the quantum theory, an afterthought, it is generating an unbalanced amount of positive electricity. The quantum theory says that there are three fundamental particles, each with its own anti-particle. One particle carries negative electricity, another positive electricity, and the third is electrically neutral. The anti-particles of the first two carry an electric charge that is equal and opposite to the charge carried by its particle. These particles are the normal constituents of atoms and are capable of emitting or disintegrating into other particles and their associated anti-particles. The total number of particles and anti-particles now exceeds 200, a great improvement on Lorenz's original theory which only had two particles and no anti-particles. Their actions are now governed by 14 conservation laws, some with a corresponding anti-law.

When Lorenz's particle carrier of negative electricity, the electron, enters a slit cut in a sheet of metal, it emerges as a wave. This odd behaviour of electricity has lead to the concept of duality; electricity can choose between acting as a particle or a wave – the reason why 14 laws are required to control its actions. Oracles can always be used to dimiss all reactions to actions, and the electron is no exception. It can throw a stone into a dried-up pond and generate a water wave. Like Maxwell's equations, it can now wave through a space devoid of anything to wave. One major particle, Einstein's photon, does not have an associated anti-particle until it spins, when it then transforms into a particle and an anti-particle each with a half-spin. This transformation is necessary because no particle or anti-particle can perform a complete revolution. The photon represents the electromagnetic energy of one complete cycle of a Maxwell wave measured by Planck's constant. The second half cycle of a wave is the equal and opposite action to the reaction of the first half cycle to the action of a medium, this total action allowing both the medium and the wave to conserve their energy. The word radioactive indicates that an atom is emitting Maxwell waves which have two half cycle, equal and opposite actions. The anti-particle is the equal and opposite reaction to the action of its particle. If Planck's quantum thesis is a mistake, presumably the terms particle and anti-particle refer to the first and second half cycles of an electromagnetic wave, and an electron travelling through space is the negative half cycle of such a wave. The usual method of producing electrons is by heating a slightly radioactive piece of metal, and the frequency of the electron lies in the spectrum of heat. The uncertainty principle allowed an intercepted electron to have an amount of energy that lay along a line which followed the varying energy of one half cycle of a Maxwell wave. If a Maxwell wave oscillating at many million times per second is casually intercepted by a conductor of electricity, it is impossible to guarantee with certainty the exact energy level of the wave at its point of interception.

In a medium of constant energy level, a wave will expand spherically through the medium, both medium and wave conserving their energy. If one cycle of a Maxwell wave has an amount of energy equal to Planck's constant at its point of origin, it will have to spread that energy evenly over an ever increasing spherical wavefront. The area of a sphere varies with the square of its radius, the law of inverse squares. The wave expands spherically because the reaction of the medium to the action of the wave is perfectly balanced, and one part of the wave's front does not travel faster than another part. The law of inverse squares is symptomatic of an equal and opposite reaction aimed at the origin of a radius. The amount of energy in the light from a star that reaches the earth is only a minute fraction of the light's total energy at source, the rest of the energy is spread over the surface of a sphere whose radius is the distance between the star and the earth. With a particle, the law of inverse squares does not apply. The electrical energy of a particle at its point of destruction equals the particle's energy at its point of origin. The only way to make a particle's energy follow the energy pattern of a wave is to multiply the particle's energy by a wave equation. The mathematics of the quantum theory, wave mechanics, are a collection of equations developed by many eminent men, in no way responsible for the initial decision to ignore Maxwell, to make three equations developed from the theoretical interpretation of three single experiments satisfy the principle of the conservation of energy.

Rutherford's negative electron and positive proton theory of the atom only agreed with the atomic weight of hydrogen, the lightest atom. The weight of all other atoms was balanced by the discovery of the third fundamental electrically neutral particle, the neutron. A bomb has been named in horror of this non-existent particle. With a little bit of luck this bomb may be filled with nothing more dangerous than a few mathematical equations, the product of the only known form of organic atomic energy with intelligence.

★ ★ ★

In the chapter of his treatise headed On the Induction of a Current on Itself, Maxwell noted that the analogy between the flow of a liquid through a tube and the flow of a current of electricity along a wire was not perfect. The flow of liquid did not depend on how the tube was bent, or on the presence of anything outside the tube. The way in which a wire was bent affected the induction current, as did the presence of a piece of soft iron.

"We are therefore led to enquire whether there may not be some motion going on in the space outside the wire, which is not occupied by the electric current, but in which the electromagnetic effects of the current are manifested."

The original idea of the ether was based on the analogy between light and sound, and there are many analogies between the actions of sound and light waves, and the reactions of their media; wavelength, frequency, velocity, reflection, refraction, focusing, interference, polarization, resonance, and a close analogy between a cavity resonator and a Helmholtz resonator. There is also a close analogy between the action of a magnetic needle encircling the electricity in a cylindrical conducting wire, and a weather vane following the rotational action of a movement of air encircling cylindrical centres of high and low atmospheric pressure, especially if the current in the wire is considered to create a volume of high or low electrical pressure in the surrounding ether. Winds encircle centres of atmospheric high and low pressure to relieve a state of stress, the line of least action being a rotation because a line aimed at or from a pressure centre would not relieve the stress on the surrounding air; nothing would happen. This analogy will explain the action of magnetism as a rotary action of the normally inert ether around centres of high and low electrical pressure.

Maxwell said in his treatise his medium could become "a receptacle of two forms of energy," half potential or electric, and half kinetic or magnetic. He also proved that the potential or electric energy in his ether was equal to its kinetic or magnetic energy. In Ferraro's Electromagnetic Theory, the author goes one step further. In para. 243 headed Magnetic Energy of Electric Current, he says:

"By Ampere's theory of magnetism it follows that a system of electric currents has magnetostatic energy of amount . . . the integral extending over all space; we term this the magnetic energy of the system of currents. We shall now prove that this is equal and opposite to the potential energy of the currents."

Two "bodies" acting equally and in opposition and only one of them can be Maxwell's ether. The density of the mass of the ether was confined in Maxwell's working model to the rotating magnetic bodies, and clearly magnetism is the equal and opposite reaction of a form of energy, Maxwell's ether, to the action of the other bodies, another form of energy, electricity. Maxwell's space was "a receptacle of two forms of energy".

His equations are an elegant and infallible aid to those forecasting the weather in his ether. Unfortunately, in the 1890's, his equations were over-simplified by the removal from sight and mind of his vector-potential, his aid to the forecasting of the direction and strength of the ether wind. An atom is merely a stage in the evolution of electrical energy. A body, Newton's word for a mass described in units of his space and time, is as Newton said[2] when referring to gravity, "material or immaterial", a fact proved by Maxwell who based his equations on the application of accelerations to unidentified masses to forecast the magnitude and direction of the forces of electricity and magnetism.

If weather maps had been published in Maxwell's day, no doubt he would have spotted the analogy. The only maps he had were Faraday's lines of force, samples of which Maxwell reproduced at the end of both volumes of his treatise. He was the last of the great natural philosophers, unconcerned with the art of thinking about thinking. He was not, as is commonly supposed, an outstanding visionary and dreamer. He had both feet planted very firmly on the ground, prepared to stretch his theoretical and mathematical logic to their limits. but ever mindful of the folly of developing original ideas. He wrote his own epitaph in the preface to his treatise.

"I shall avoid, as much as I can, those questions which, though they have elicited the skill of mathematicians, have not enlarged our knowledge of science". Science has not satisfied the principle of the conservation of energy during the hundred years since Maxwell's death. It has wasted Maxwell's energy and its own. Faraday and Maxwell had developed unified pictures of the universe, and if a phenomenon of force didn't fit their picture, they were willing to wait until it did. They were completely incorruptible in their search for the unemotional modesty of the truth.

Maxwell said that Faraday's method was to begin with the whole and arrive at the parts by analysis. Having studied the whole pieced together by the democracy of astronomy, and analysed the parts of this insignificant planet that are busy proving that Darwin's theory of our evolution is an insult to monkeys, I take this opportunity of not thanking, in advance, certain physicists for their indispensible assistance in the final proof of Thom's catastrophe theory[3]. That is an illuminating, uplifting and heartwarming experiment by theorists wasting and concentrating what is a finite amount of energy in themselves and in the business end of action at a distance theories, and suggest they follow the example of Lorenz and pass a law forbidding themselves to move until they have explained exactly how and why the atoms of organic energy with intelligence are immune from the law of the conservation of energy and all that its principle implies. If organic atomic energy, with or without intelligence has a choice, its own uncertainty principle, and can avoid taking the line of least action or waste, its actions must be governed by the law of the survival of the most efficient. This law governs the behaviour of the fourth force capable of acting across a distance in space, and like the laws of Newton and Maxwell, gives silly answers to silly questions.

Einstein may have wasted an incalculable amount of energy, but he left science a legacy; experimental proof that the more an idea deviates from the 100% efficiency of the truth, the more a bureaucracy defends the idea by repression, censorship, dogma and the cult of the personality, to waste and concentrate in itself an ever increasing amount of energy attempting to prove the unprovable. Extreme ideas are propagated by portable laboratories whose only property is the mincing of words, the bigger the better, the more the merrier, especially when the words like TIME and SPACE are spelt in capital letters. They can be temporarily diverted from their avowed objective of saving us from being fools, by forcing them to save themselves by never answering an awkward question. Just as a machine that develops a loss of efficiency concentrates the wasted energy in the point of inefficiency, so did Einstein's friends condemn their successors to waste and concentrate their energy in the point of most inefficiency, a collection of atoms called Einstein. This phenomenon, known as the cult of the personality, is the reason for the strange allocation of honours between Einstein and Maxwell.

Much of this article is based on the mathematical proof that a sound wave was really a particle called a phonon, the forerunner of four-dimensional sound and the Bunkum Theory, on the books of three authors toasting "Faraday, the hero", – Maxwell's treatise, Pearce Williams' biography of Michael Faraday, and Berkson's Fields of Force – on the works of M. Thom, the Newton of the evolution of all forms of energy, and on the anti-Einstein comments, written with unemotional modesty by L. Essen, who suffered the slings and arrows of an outraged bureaucracy for daring to think for himself and the rest of us that we have a problem. □

References

1. Berkson's Fields of Force. Routledge & Kegan Paul, 1974, page 283.

2. *Ibid.* page 114. Extract from Newton's letter to Bentley.

3. René Thom, Structural Stability and Mophogenesis: an Outline of a General Theory of Models. W. A. Benjamin, 1975. The subject of the 1978 Faraday Christmas lecture for children broadcast by BBC TV from the Royal Institution.

Paul Voigt dies at 79

An audio pioneer

Paul Gustavus Adolphus Helmuth Voigt, the famous audio pioneer, died at his home in Ontario, Canada, early in February following a heart attack. Born in December 1901 in London, he was of German ancestry but his father had become a naturalised British subject late in the 19th century.

A contemporary of Alan Dower Blumlein, he was granted a total of 32 British patents between 1923 and 1953, the first being concerned with wireless transmission. In the early part of this period he designed the Edison Bell dual silicon crystal detector. (Once a good spot was found on one crystal this could be kept in reserve while trying to find a better spot on the other.) Although he developed very advanced moving coil disc cutters and pickups during the mid 1920s, Voigt will be remembered most for his work on loudspeakers, notably for his development of the moving coil loudspeaker and his domestic corner horn. The m.c. loudspeaker was in advance of its time in underlining the importance of maximum gap flux density – primarily for "damping" and only incidentally for efficiency. Other m.c. innovations were the dual diaphragm and the aluminium-wire voice coil.

The domestic corner horn loudspeaker stemmed from the earlier designs of high flux drive units and large tractrix horns he had built for cinema sound. The large corner horn enclosure incorporated a vertical tractrix horn and reflectors, covering the range above about 100Hz, combined with rear radiation of the lower frequencies using a broad bandwidth ¼-wavelength tapered pipe. This l.s. system gave a very high electro-acoustic efficiency, wide angular distribution and freedom from colouration, together with natural image characteristics consistent with monophonic reproduction. Even today a pair of these loudspeakers can offer stereo sound comparable with that from the first current low efficiency designs.

The corner horn was one of the products of his own company, Voigt Patents Ltd, which he started in 1933 after the economic slump had finished off Edison Bell. During this time he was a protagonist in the move away from massive pickup elements and produced a notable moving coil unit with minimal moment of inertia. *Wireless World* owes a lot to him for his help and advice on microphones when, in the mid 1930s, the staff were developing an automatic response curve tracer.

Paul suffered from periods of ill health and in 1950, with his wife Ida, he emigrated to Canada. Since then, although keeping abreast of audio developments, his spare time was largely devoted to studying radically new concepts of electromagnetic propagation and the nature of gravitational attraction and to proposing a unified field theory.

Voigt's outstanding contribution has already been well documented, and a complete report on the man and his work is given in: *British Kinematography, Sound and Television*, vol. 52, no. 10, October 1970, p. 316, under the title "Paul Voigt's contributions to Audio".

(Compiled from information kindly supplied by Rex Baldock and F. L. Devereux)

NEW PRODUCTS

Waveguide transitions

Double-ridged, wideband waveguide transitions, formerly only obtainable from American sources, are now made in the U.K. by Micro Metalsmiths. They are primarily intended for military use, covering WRD 475 (4.75 – 11GHz) and WRD 750 (7.5 – 18GHz) and being fitted with SMA or TNC connectors, or Type N to special order. Their voltage standing wave ratio is better than 1.2, and the insertion loss is less than 0.25 dB over the entire band. While the bodies are normally made in aluminium, copper-based alloy types can be specified. Micro Metalsmiths Ltd, Kirkbymoorside TO6 6DW, N. Yorks.

WW301

Function generator

Switch-selectable sine, square and triangle wave outputs in the range 1Hz to 100kHz are available from a 600Ω output on the latest addition to the Thandar range of measuring instruments, the TG100 function generator. A separate output is provided to drive up to 20 standard t.t.l. loads and a 39kΩ impedance sweep input can give a sweep rates of up to 1000:1. Controls of the generator are: a 0dB or –40dB output level switch with variable-potentiometer output-level control, d.c. offset switch – also with variable potentiometer control, five-decade range selector switch with fine frequency control, and function selector switches. Sinewave distortion is typically 1%, triangle waveform non-linearity 0.1% and the rise and fall times of the squarewave are 150ns into 600Ω/20pF. Sinclair Electronics Ltd, London Road, St Ives, Huntingdon, Cambs PE17 4HJ.

WW302

Optical isolator for measurement

Measurements down to 20mV can be made in the presence of 1.5kV d.c. common-mode voltages on a safely grounded test instrument, using the A6902 optically coupled voltage isolator from Tektronix. The bandwidth of this dual channel device is zero to 15MHz and calibrated attenuators, with sensitivities from 20mV to 200V/div, are provided on each channel. At 60Hz, the isolation specification is 200,000:1, or – 160dB. Standard accessories of the A6902 are two pairs of voltage probes, one set for high voltages and the other for lower voltages. There is also available an A6901 ground isolation monitor that allows one to make floating measurements to safety extra low voltage (40V) more safely. The photo shows the A6902. Tektronix (UK) Ltd, Beaverton House, P.O. Box 69, Harpenden, Herts.

WW303

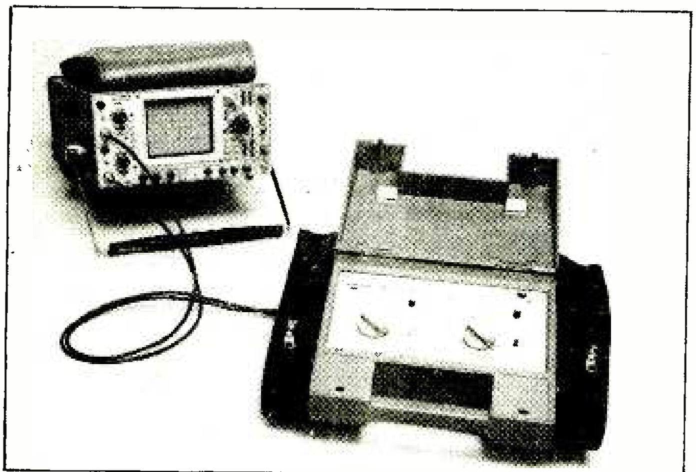
Data display monitors

High-resolution, colour data-display monitors, designed for use in v.d.u. terminals and other data-processing equipment, have been introduced to the market by Cotron Ltd. The DDC series consists of three basic models with tube sizes of 9, 12 or 14in, all available either cased or in chassis form. For the 9in version, resolution is 414 × 552 pixels and for the 12in version, 603 × 804 pixels, to enable reading of 64 and 80 characters per line respectively. A standard-resolution tube is used in the relatively low-cost 14in model for display of up to 48 characters per line. All models accept direct red, green and blue inputs at 1V peak saturation level and a negative synchronization pulse of 0.5 to 4V peak. Open frame units also accept line and field drive pulses at t.t.l. levels. Space is provided inside the cased version for further electronic circuits, such as the logic of a v.d.u. terminal, which can be driven by the monitor's power supply. Cotron say that the cost of these units is significantly below that normally associated with comparable units. Cotron Ltd, Rockland Works, Eagle St, Coventry CV1 4GJ.

WW304

Ultrasonic echo ranging system

A designer's kit, based on the ultrasonic focusing system by the Polaroid Corp, is available through Polaroid (UK) Ltd. This kit comprises two ultrasonic transducers,



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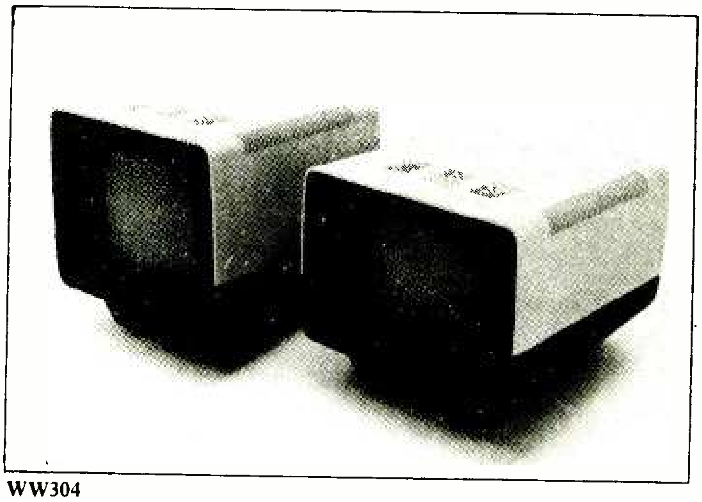

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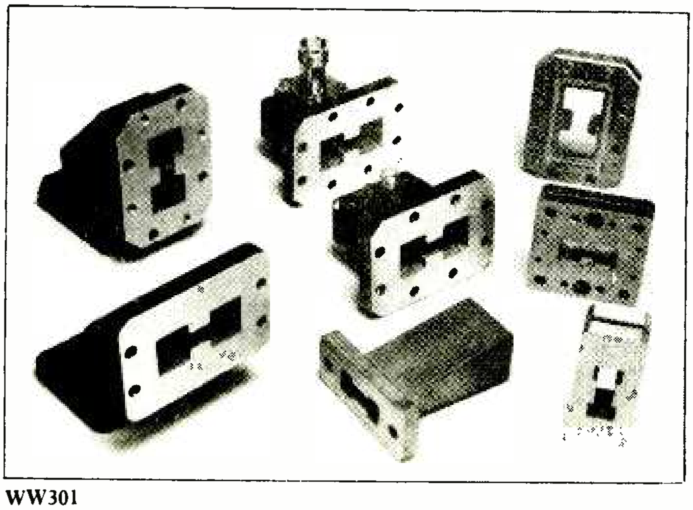

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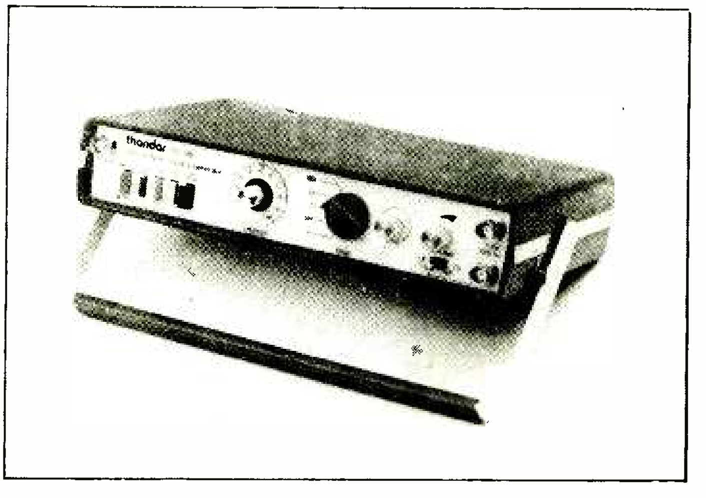


WW302

digital and analogue circuitry, wiring assemblies, an l.e.d. readout, two batteries and a technical manual. Although a digital readout is provided, this system can be interfaced with many other systems including computers. The measurement process takes 1.5ms for a distance of 25cm, increasing to 55ms for a distance of 9m, and is said to have an error of less than 1%. Among the applications suggested for the kit are low level altimeters for aircraft, warning systems for fork-lift trucks placing loads in visually inaccessible areas, giving distance measurements for calculating radiation levels for X-ray and tomography apparatus, and as an aid to the blind in a number of forms. One of the most interesting applications is for automatic focusing of liquid lenses in reading glasses for persons who have had their eye lenses removed. Polaroid (UK) Ltd, Ashley Rd, St Albans, Herts AL1 5PR.

WW305

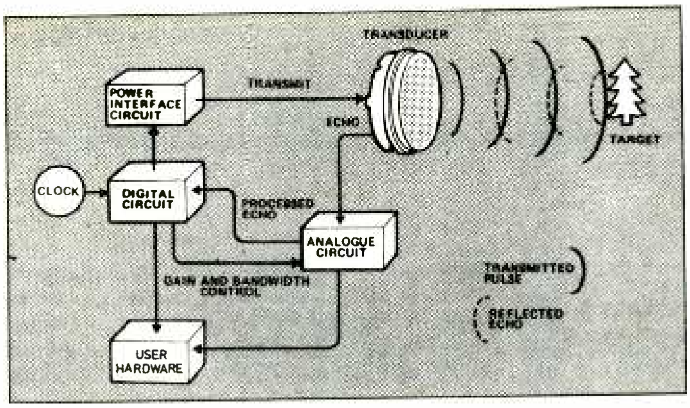
Data cassette deck

Fast forward, fast rewind, record and replay functions of the C1000 cassette deck from Monolith Electronics can be selected electrically. With interfacing circuitry, the deck can be completely controlled by a computer to store, recall and search for data. An optional Hall-effect sensor can be fitted to perform two functions, detection of tape breakage and tape spool rotation counter. An optical device is also available for use with high-speed tapes with coded windows. The deck is aimed at the home computer market and costs £42.49 (including v.a.t.) in chassis form. Monolith Electronics Co. Ltd, 5/7 Church St, Crewkerne, Somerset.

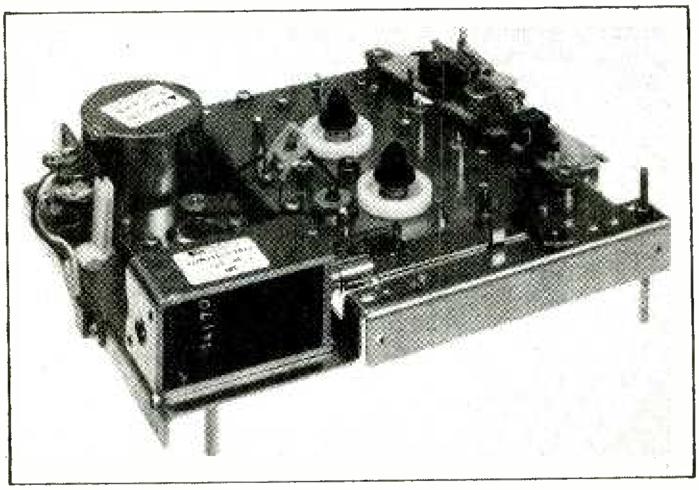
WW306

4½-digit multimeter

The Type 135 is a 4½-digit hand-held digital multimeter with l.c.d. indication similar to the maker's earlier 3½-digit model. Range and function are selected using two rotary switches. Accuracy on d.c. ranges is claimed to be 0.05%. The d.c. voltage ranges are from 2V to 1000V, the a.c. voltage ranges from 2V to 750V, while alternating and direct current ranges are 20mA and



WW305



WW306

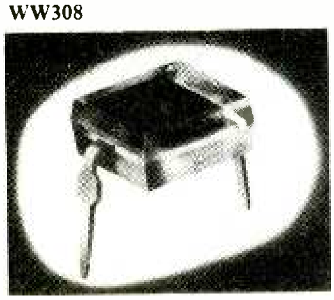
10A. The five resistance ranges are from 2kΩ to 20MΩ. There is overload protection and an annunciator warns when 10% of the battery life remains. Price is £139 plus VAT. Keithley Instruments Ltd, 1 Boulton Road, Reading, Berks, RG2 0NL.

WW307

Photodiode

Designed for use in visible and near infrared light-sensing applications, the OP905 and OP915 p-i-n photodiodes, manufactured by TRW Optron, have sensitivities of between 0.55 and 0.65 amp/watt. Peak sensitivity is at 800nm for the 905 and at 920nm for the 915. Both devices have an active area of 7.5mm^2, and a spectral sensitivity range of 400 to 1200nm. Small p.c.b. mounting packages are used, so the devices can be placed side by side to form multi-element arrays. HB Electronics, Lever St, Bolton, Lancs BL3 6BJ.

WW308



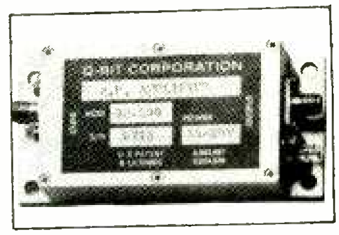
V.d.u. anti-glare coating

Fatigue caused by prolonged reading of v.d.u. screens is greatly reduced if the operator does not have to read through reflections on the screen. Chequers Ltd have introduced two products to aid the reading of v.d.us, one a range of filter materials and the other a coating, known as Glarecheq, which can be sprayed directly onto the v.d.u. screen to form a hard matt finish which reduces reflected glare to a minimum. The SpectraFilter range of filter materials is designed to provide optimum contrast ratios on l.e.d. displays and fluorescent phosphor type readouts, such as c.r. tubes, without optical aberration. These filter materials, in various colours and tints, can be supplied in diminsions specified by the user, with the anti-glare coating applied, to provide complete v.d.u. screens. Chequers (UK) Ltd, 1-4 Christina St, London EC2A 4PA

WW309

R.f. amplifier

Reverse isolation of the QB-500 linear phase r.f. amplifier, from March Microwave, is greater than −30dB over the bandwidth, 2MHz to 500MHz. Less than 1.2:1 is quoted for the input/output v.s.w.r. and the small signal gain is within ±0.5dB of 20dB across the



bandwidth. This unit is capable of providing an output power of 19dBm at 1dBm gain compression and provides reverse voltage and transient protection. Power supply requirements are from 15 to 24V d.c. at 140mA and the aluminium housing measures 3 × 1.75 × 1.07 in with a choice of either SMA or BNC connectors. March Microwave Ltd, 112 South St, Braintree, Essex.

WW310

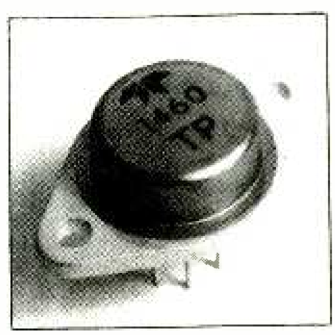
User port for ZX80

This plug-in user port is disigned around the ZX80 parallel input-/output ports and is programmable in four modes, providing access to 16 i/o data lines and four control lines. These lines are made available through a 24-pin d.i.l. socket, which also gives access to the power supply of the computer. The USR and GOSUB commands are used to transmit or receive data. Software, on a C12 cassette, and an instruction booklet are included in the price of £29. The manufacturer claims that with this package, the newcomer will be able to control d.c. motors, mains appliances, and be able to input data relating to temperature and light levels. J.M.J. Interfaces, Old School House, Rettendon Turnpike Battlesbridge, Wickford, Essex.

WW311

Wideband op-amp

Outputs of ±30V at 150mA and a slew rate of 300V/μs are specifications of the 1460 wideband op-amp from Teledyne Philbrick. The maximum operating frequency is quoted as 10MHz and with an external capacitor, unity gain is at 1GHz. A v.m.o.s. output stage is



used to reduce secondary breakdown problems usually associated with power op-amps. Technical Selling Services, Unit 5, Brunel Gate, West Portway Industrial Estate, Andover, Hants.

WW312

SIDEBANDS By Mixer

Microchips and megadeaths

It's a hazardous business, writing editorials, at the best of times. There is always someone who disagrees, and can't wait to say so in print – it proves, at least, that someone is paying attention and it makes for interesting Letters pages. But sometimes the people who write in to congratulate or castigate seem to have missed the point, and one wonders whether the latest editorial has been written in the clearest possible English. It isn't very often, though, that a leader provokes a response like that following the publication of the November 1980 piece 'Microchips and megadeaths'. From reading the letters it seems pretty clear that a lot of those who have written to us decided they thought they knew what was being written and didn't bother to read the words that were really there.

We have been accused of treachery, of consorting with the Red Menace, of incitement to rebellion – and worse, of being wet liberals. The fact is, as anyone who takes the trouble to read the piece properly can verify, that the editorial was addressed to engineers in all countries, not just ours. It was not concerned with capitalism, communism, fascism or any other kind of political activity, but with the possibility of millions of people being destroyed or horribly injured because one group of politicians thinks their way of life better than the other group's.

Armaments build-ups, new kinds of 'deterrent' and the bellicose posturings of political 'leaders' are a global sickness which has been made possible by engineers in all the developed countries, and the burden of the November editorial was that engineers are the ones to stop it.

How is it possible to disagree with that?

Traffic diversions

The trend towards cathode-ray tubes instead of 'clocks' on aircraft instrument panels seems to be starting in cars, according to a communication from Zenith Radio Corporation. What's happened, they say, is that clear trends in down-sizing, federal display legislation and competitive pressures have led to highly feature-oriented vehicles. The good news is that trans-illuminated displays are easily eye-interpreted and provide increased information density.

You've got to hand it to them: their c.r.ts may or may not be the bee's knees, but if you can't understand a word they say you're in no position to argue. Still, they tried to make it a bit more easily brain-interpreted by printing pictures and giving a list of what Zenith thinks the up-to-the-minute driver of 1987 will want to know. There's a section on comfort and convenience, which not only provides for a calculator and personal computer, but power seats (with memory). Leaving aside the somewhat alarming question of power seats, and why it is felt necessary to provide them with a memory, the spine-tingling vision of thousands of cars streaking about at high speed, while their drivers work out their income-tax returns on personal computers is one that should bring a gleam to the eye of any far-sighted insurance salesman.

All the usual facts about speed, temperature, fuel, time and whatnot will be presented, with an intruder alarm (surely you know when someone is trying to break into your car, even if you're engrossed with a personal computer), crash recorder (that computer again) and a flasher control, which I presume shows when the ice-cold jet of water is being projected at the pavement.

Finally, we are informed, there may be a game. Well, I should just think there will – the trendy driver in 1987 will not want to spend all his time computing. Zenith don't say what kind of game they have in mind; maybe it's one of those where you have to try and steer a 'car' along a twisty 'road'.

Business as usual

Forgive me for returning to the theme of doom and gloom, but I've just spotted an indication that a nuclear attack may not be quite as bad as you might have thought, and I think it deserves to be better known.

I dare say a lot of you thought that a few bombs carefully deployed over Britain would leave very little of consequence standing. If, however, you do subscribe to the school of thought that says the aftermath of such a catastrophe would be a landscape like a dark brown billiard table, only smoother, then take heart, because the Co-op will still be there. At least, the Co-op clearly has every intention of being there, because it was represented at a seminar, run by the Nuclear Protection Advisory Group, on protecting industry in a nuclear attack. One of the seminar's aims is to ". . . help business planners assess what they can do to protect their work forces and essential plant . . .".

Fair takes your breath away, it does. I mean, there they are, the half-dozen or so irradiated wrecks of humanity who manage to survive the first fortnight after the bomb, climbing out of their holes in the ground to find complete devastation all around. No people, no buildings, no trees but, wouldn't you know it? the local Co-op, advertising sweeping reductions on home decorating materials.

There'll be others, too – the ones who have protected their plant and work forces. So, some people will be left, and I can quite see that the uppermost thought in any worker's mind, after a 50 megaton bomb just wiped out umpteen million people and most of Britain, would be to get back to churning out kitchen furniture and ball-point pens as quickly as possible.

This sort of thinking is absolute nonsense. Dangerous, pathetic half-baked nonsense. If a nuclear war starts, THAT WILL BE THAT, and anyone who kids himself that there will be any significant amount of life left on this planet afterwards ought not to be in a position where he can influence the gullible.

House-trained c.b.

I don't suppose it will ever be called Open Channel. Personal radio has been c.b. for years now, and it will take more than a quirky Civil Service name-coiner to change it. Anyway, whatever its name, come the Autumn, breakers will stop being law breakers and revert to their previous state of respectability, assuming that was their previous state.

It seems probable that the majority of c.b. operators are not primarily interested in the techniques of radio and the engineering side of the hobby, and will continue to buy their equipment just for the fun of using it. Nevertheless, there are bound to be some of our readers who want to make their own rigs, so we have decided to publish a design for the construction of a transceiver, which should perform a bit better than the usual run of existing gear. It might well cost a bit more, too, but it will be professionally designed, using professional components and we think you will like it. It should be ready for the start of licit operation.

So I suppose everyone will start learning American c.b. slang now, and that does strike me as a thoroughly pointless thing to do. Slang isn't something you have to learn – it evolves naturally by use and it is relevant to the people using it, not another group several thousand miles away which has a different life-style. To address a contact whose real name is Albert Ollerenshaw or Ada Birtwhistle as "Good buddy" is a bit like singing 'On Ilkla Moor B'aht 'at' in a Welsh accent.

We might even get the Americans calling each other "mate" and signing off with "T.t.f.n.".

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HY60

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Model	Output Power RMS	Distortion Typical at 1KHz	Slew Rate	Rise Time	Signal/Noise Ratio DIN AUDIO	Price & VAT
MOS120	60W into 4-8Ω	0.005%	20V/μs	3μs	100dB	£25.88 + £3.88
MOS200	120W into 4-8Ω	0.005%	20V/μs	3μs	100dB	£33.46 + £5.02

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(Standard O-P Transistors)

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Model	Output Power RMS	Distortion Typical at 1KHz	Slew Rate	Rise Time	Signal/Noise Ratio DIN AUDIO	Price & VAT
HY30	15W into 4-8Ω	0.015%	15V/μs	5μs	100dB	£7.29 + £1.09
HY60	30W into 4-8Ω	0.015%	15V/μs	5μs	100dB	£8.33 + £1.25
HY120	60W into 4-8Ω	0.01%	15V/μs	5μs	100dB	£17.48 + £2.62
HY200	120W into 4-8Ω	0.01%	15V/μs	5μs	100dB	£21.21 + £3.18
HY400	240W Into 4Ω	0.01%	15V/μs	5μs	100dB	£31.83 + £4.77

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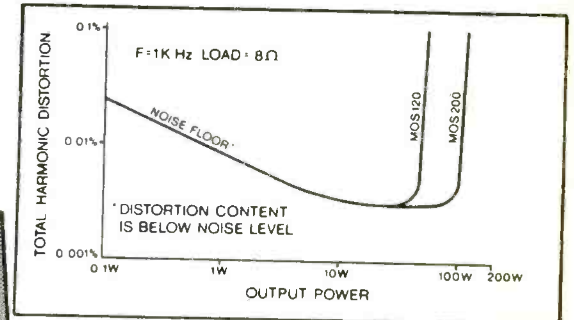
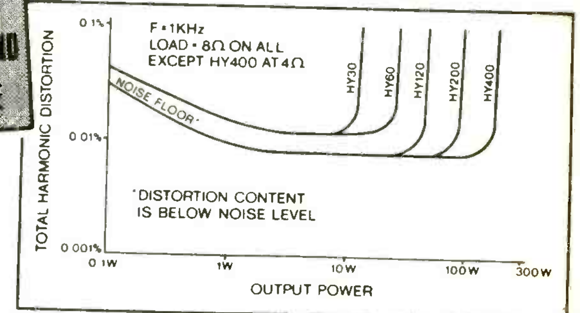


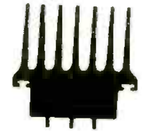
Load impedance both models 4Ω - ∞ Input sensitivity both models 500mV

Input impedance both models 100KΩ Frequency response both models 15Hz-100KHz – 3dB



Load impedance all models 4Ω - ∞ Input sensitivity all models 500mV

Input impedance all models 100KΩ Frequency response all models 15Hz-50KHz – 3dB



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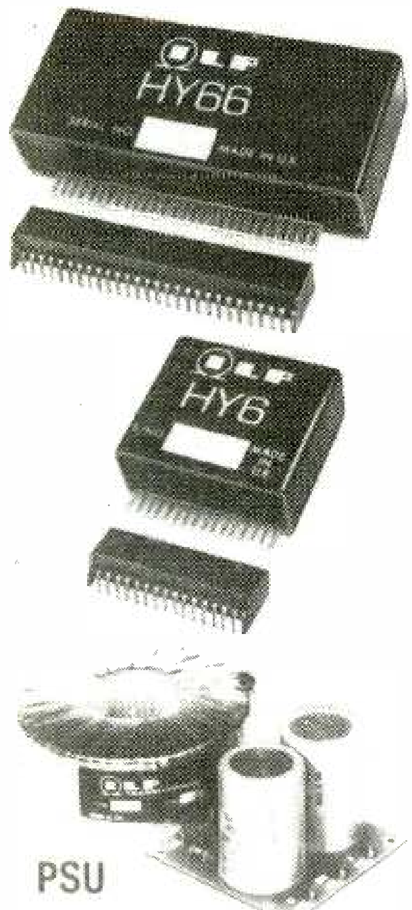
The introduction of standard heatsink extrusion for all I.L.P. power amplifiers achieves many advantages:— Research shows they provide optimum thermal dissipation and stability. Slotted shoulders allow easy mounting; standardisation enables us to keep our prices competitive. Surfaces are matt black, anodised for higher thermal conductivity. Extrusions vary in size according to module number.



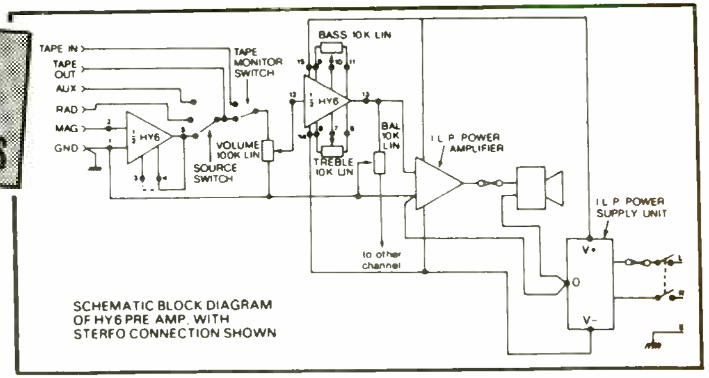
NEW PRE-AMPS

HY6 (mono) and **HY66** (stereo) are new to I.L.P's range of advanced audio modules. Their improved characteristics and styling ensure their being compatible with all I.L.P power-amps both MOSFET and BIPOLAR, giving you chance to get the best possible reproduction from your equipment. HY6 and HY66 pre-amps are protected against short circuit and wrong polarity. Full assembly instructions are provided. Mounting boards are available as below.
Sizes – **HY6** – 45 x 20 x 40 mm. **HY66** – 90 x 20 x 40 mm.
Active Tone Control circuits provide ±12dB cut and boost.
Inputs Sensitivity – Mag. PU. –3mV: Mic – selectable 1-12mV: All others 100mV. **Tape O/P** – 100mV: **Main O/P** – 500mV: **Frequency response** – D.C. to 100KHz – 3dB.

HY6 mono £6.44 + 97p VAT Connectors included
HY66 stereo £12.19 + £1.83 VAT Connectors included

B6 Mounting Board for one HY6 78p + 12p VAT
B66 Mounting Board for one HY66 99p + 15p VAT

COMPATIBLE WITH ALL ILP MODULES



SCHEMATIC BLOCK DIAGRAM OF HY6 PRE AMP. WITH STEREO CONNECTION SHOWN

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PSU36 for use with 1 or 2 HY30's	**£8.10** + £1.22 VAT
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PSU60 for use with 1 HY120	**£13.04** + £1.96 VAT
PSU65 for use with 1 MOS120	**£13.32** + £2.00 VAT
PSU70 for use with 1 or 2 HY120's	**£15.92** + £2.39 VAT
PSU75 for use with 1 or 2 **MOS120**	**£16.20** + £2.43 VAT
PSU90 for use with 1 HY200	**£16.20** + £2.43 VAT
PSU95 for use with 1 **MOS200**	**£16.32** + £2.45 VAT
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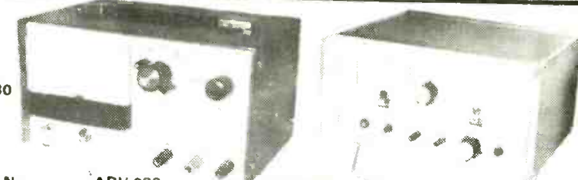

Model No.	ADV 030	ADV 025
Output Current	5 Amp	10 Amp
Output Volts	2.30 DC	0 25 DC
Input Volts	115-230-250 A/C	115-230-250 A/C
Tolerated Mains Variation	15%	15%
Ripple On Load	05%	05%
Load Regulation Better Than	.5%	5%
Protection	Both Models. Internal Fold Back. Overload. Thermal and short circuit Protected.	
Guarantee	Both Models. 2 years	
Dimensions	Height. 130 M/M mm	177 mm
	Width. 250 M/M mm	335 mm including
	Depth. 170 M/M mm	294 mm handles

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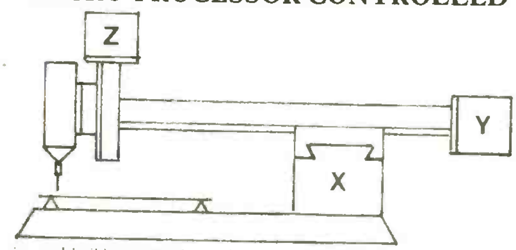

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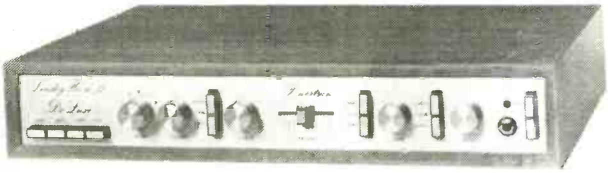
Britain's No.1 magazine for the radio enthusiast

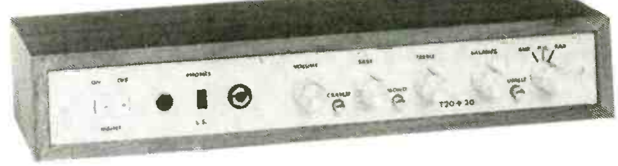
From the June issue, Practical Wireless becomes an "all radio" magazine, covering all the techniques and applications of radio, including licensed amateur radio, short-wave listening, DX (long-distance) broadcast listening and viewing, radio control, etc., plus the latest developments on the CB scene.

Practical Wireless



DE LUXE EASY TO BUILD LINSLEY HOOD 75W STEREO AMPLIFIER £85.00 + 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 while distortion is less than 0.01%.

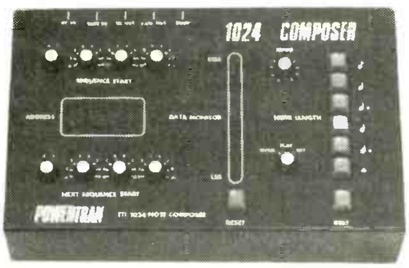


T20 + 20 20W STEREO AMPLIFIER £33.10 + VAT

This kit, based upon a design published in Practical Wireless, uses a single printed circuit board and offers at very low cost ease of construction and all the normal facilities found on quality amplifiers. A 30 watt version of this kit (T30 + 30) is also available for £38.40 + VAT

MATCHING TUNERS — See our FREE CATALOGUE!

Above 2 kits are supplied with fully finished metalwork, ready assembled high quality teak veneer cabinet, cable, nuts, bolts, etc. and full instructions — in fact everything!



Cabinet size 13.3" x 8.0" x 3.8" (rear), 3.0" (front)

1024 COMPOSER

COMPLETE KIT ONLY £89.50 + VAT!

READ ALL ABOUT IT!

IN ELECTRONICS TODAY INTERNATIONAL

Programmed from a synthesizer, our latest design to be featured in ELECTRONICS TODAY INTERNATIONAL the 1024 COMPOSER controls the synth. with a sequence of up to 1024 notes or a large number of shorter sequences e.g. 64 of 16 notes all with programmable note length. In addition a rest or series of rests can be entered. It is mains powered but an automatically trickle charged Nickel-Cadmium battery supplying the memory, preserves the program after switch off. The kit includes fully finished metalwork, fibreglass PCB, controls, wire, etc. — Complete down to the last nut and bolt!

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BLACK HOLE
CHORALIZER

The BLACK HOLE designed by Tim Orr, is a powerful new musical effects device for processing both natural and electronic instruments, offering genuine VIBRATO (pitch modulation) and a CHORUS mode which gives a "spacey" feel to the sound achieved by delaying the input signal and mixing it back with the original. Notches (HOLES), introduced in the frequency response, move up and down as the time delay is modulated by the chorus sweep generator. An optional double chorus mode allows exciting antiphase effect to be added. The device is floor standing with foot switch controls. LED effects selection indicators, has variable sensitivity, has high signal/noise ratio obtained by an audio compander and is mains powered — no batteries to change! Like all our kits everything is provided including a highly superior, rugged steel, beautifully finished enclosure.

COMPLETE KIT ONLY £49.80 + VAT! (single delay line-system)
De Luxe version (dual delay line system) also available for **£59.80** + VAT

Cabinet size 10.0" x 8.5" x 2.5" (rear) 1.8" (front)

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 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!

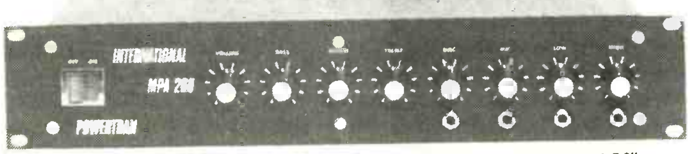
COMPLETE KIT ONLY £49.50 + VAT!

Panel size 19.0" x 3.5". Depth 7.3"

MPA 200

100 WATT (rms into 8Ω) MIXER/AMPLIFIER

Featured as a constructional article in ETI, the MPA 200 is an exceptionally low priced — but professionally finished — general purpose high power amplifier. It features adaptable input mixer which accepts a wider range of sources such as microphone, guitar, etc. There are wide range tone controls and a master volume control. Mechanically the MPA 200 is simplicity itself with minimal wiring needed making construction very straightforward.
The kit includes fully finished metalwork, fibreglass PCBs, controls, wire, etc. — complete down to the last nut and bolt.



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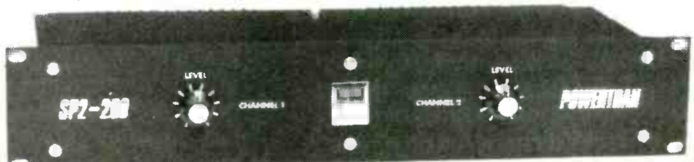
SP2-200

2-CHANNEL 100W AMPLIFIER — NEW KIT!

The power amplifier section of the MPA 200 has proved not only very economical but very rugged and reliable too. This new design uses two of these amplifier sections powered by separate power supplies fed from a common toroidal transformer. Input sensitivity is 775mV.
Even simultaneously driven, each channel delivers over 100W rms into 8 ohms.
The kit includes fully finished metalwork, fibreglass PCBs, controls, wire, etc. — complete down to the last nut and bolt!



COMPLETE KIT ONLY £64.90 + VAT!

Panel size 19.0" x 3.5". Depth 7.3"

MANY MORE KITS ON NEXT PAGE!

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PORTWAY INDUSTRIAL ESTATE
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ANDOVER
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EXPORT ORDERS: No VAT. Postage charged at actual cost plus £1 handling and postal documentation.
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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.-12 noon, 1-4.30 p.m. Monday-Thursday.

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Selective UHF V/Meter. Bands 4 & 5. USVF
Selectomat Voltmeter USWV **£450.**
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POLYSKOPS SWOB I and II.
Modulator/Demodulator BN17950/2.
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MARCONI

TF995B/2 AM/FM Signal Generator.
TF2500 Audio power meter
TF1101 RC oscillators **£65.**
6551 SAUNDERS. 1400-1700MHz. FM.
TF1066B/1. 10-470MHz. AM/FM.
TF1152A/1. Power meter. 25W. 500MHz **£50.**
TF1370A RC Oscillator **£135.**
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'Printed Motors Ltd' type G16M4. 60V DC. 5.5 amps. Continuous torque 140oz. in. 2350 rpm. Diameter 7.5". Depth 2.5". Shaft diam. ½ & ¾". Price from Printed Motors is now over £150 ea. Supplied in good, used condition, tested & guaranteed **£25 each** (postage £3).

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ADVANCE types H1, H1E, C2, SG62B, J4A.
TAYLOR 62A (AM/FM). AVO HF134.
AIRMEC 352 Sweep Generator.
MARCONI TF1066B/1 (AM/FM 10-470MHz).

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P. F. RALFE ELECTRONICS

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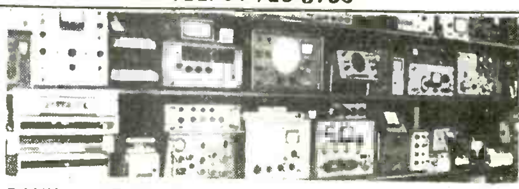

RANK KALEE 1742 Wow & Flutter Meter.
AIRMEC 314A Voltmeter. 300mV (FSD)-300V.
AIRMEC Wave Analysers types 853 & 248A.
DERRITRON 1KW Power Amplifier with control equipment for vibration testing, etc.
HEWLETT-PACKARD 8551B/851B Spectrum Analyser. 10Mhz-40GHz.
HEWLETT-PACKARD tuned amp & null detector.
HEWLETT-PACKARD 331A Distortion Meter
RADIOMETER Distortion Meter BKF6 **£125.**

LABGEAR T.V. PATTERN GENERATORS 625-line cross-hatch/dot/grey scale **£45** (£1 post).
RANK SIGNAL STRENGTH METERS UHF Channels 20-60. Battery operated **£30** (£1 post).

TELEVISION TEST EQUIPMENT

TEXSCAN VS-60B Sweep Generator. 0-1000MHz **£250.**
TEXSCAN DU-88 X-Y Display units **£95.**
TELONIC 2003 Sweep Generator System **£225.**
TELONIC 101 X-Y Display units **£75.**
TELONIC 1204 Sweepers 0-500MHz **£150.**
TELONIC 121 X-Y Display units **£95.**

OSCILLOSCOPE SALE

ADVANCE OS250. Dual Beam 10MHz **£185**
HEWLETT-PACKARD 1707A. 75MHz **£450.**
TELEQUIPMENT D75.
TELEQUIPMENT DM64 Storage scope.
DYNAMCO D7100.
HEWLETT-PACKARD 122A SB. Audio.
AIRMEC 279. 4 Beam Display Scope.
TEKTRONIX 581A, 545A & B, 544, 661, 515A.

NOTICE. All the pre-owned equipment shown has been carefully tested in our workshop and reconditioned where necessary. It is sold in first-class operational condition and most items carry our three months' guarantee. Calibration and certificates can be arranged at cost. Overseas enquiries welcome. PLEASE ADD 15% VAT TO ALL PRICES.

DC POWER SUPPLIES

★APT 10459/8, 12-14V @ 5 Amps **£25** (£2 p.p.).
★APT 10459/8, 24V @ 5 Amps **£25** (£2 p.p.)
★We can supply the above power supply at any fixed voltage between 5V and 36V at 5A **£25.**
★Mullard Dual supplies. Brand new with handbook. Pos & Neg 12V at 1A and 0.4A respectively. Dimensions 9x4x5ins. **£10** + (£1 p.p.)
★FARNELL Current limited. Dimensions 7x5x4ins. Following types available: 13-17 Volts @ 2A **£15.** 27-32 Volts @ 1A 5V **£15.** 5V @ 3A **£15.** (pp £1.50).

SPECIAL PURCHASE
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Excellent LXS Series DC power units at less than a tenth of new price. The snag? — they're all 110V AC Input. Prices as follows:
5V at 24A. LXS D5 0V R. **£25.** (List £350).
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Carriage each £2.50 extra

MODULATION METERS

AIRMEC 210 3-300MHz. AM/FM. **£125**
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ROTRON INSTRUMENT COOLING FANS

Supplied in excellent condition, fully tested:
115V, 4.5 × 4.5 × 1.5" **£4.50.** 230V **£5.** 115V, 3 × 3 × 1.5" **£4** + postage ea. 35p.

CT212 RF Signal Generators. 85KHz-32MHz **£55.**

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Type SR5. Screen size 9 × 5". New condition **£75.**

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DE FOREST ELECTRONICS TYPE MM200. DC V 0-1KV. AC V 0-700. DC 1.0-1A. AC 1.0-1A. Each in 4 ranges. Resistance 0-19.99 Mohms. 5 ranges. LED Display 1999.
BRAND NEW. SPECIAL REDUCED PRICE OF **£39,** INCLUDING VAT & P.P.

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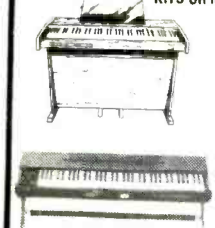
PIANOS

SPECIALISTS SINCE 1972
DOMESTIC & STAGE TYPES
KITS OR MANUFACTURED

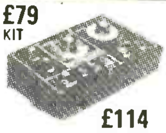


The most advanced form of Touch Sensitive action simulating piano key inertia by patented technique. Four mixable voices for serious tone variation plus electronic chorus and flanger effects. See lists for Cabinets, P.A. and Manufacture.

SIX OCTAVES £207
7¼ OCTAVES £232

Component Kits

£79
KIT



MASTER RHYTHM

User Programmable. Twenty-four patterns. Eight parallel tracks. Twelve instruments sequence operation.

£114
Built

Write or Phone for full details of our range of high quality Kit and manufactured Electronic Musical Instruments. Prices include V.A.T., Carr. & Ins. and we operate Telephone BARCLAYCARD. Visit our Showroom.

CLEF PRODUCTS (ELECTRONICS) LIMITED
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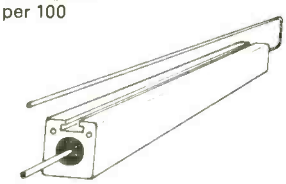
WW–041 FOR FURTHER DETAILS

Wirewound Ceramic Resistors
Axial or vertical mounting
5w-17w OR5-39K
from **£9.35**
per 100



Cable Sleeves and Markers from **£1.38** per 1,000.
Crimp Terminals from **£9.60** per 1,000.
Audible Warning Devices. Buzztone, Bleeptone, Banshee, Bedlam, etc, from **£1.14** each.
Self-adhesive Pcb guides from **£5.04** per 100.

from **£3.15** per 100.
100 off at 1000 off price during MAY, 1981.

Carbon Film Resistors ¼w 5% **£2.50** per 1,000, per value, carriage and VAT extra.
6R8 33R 100R 120R 360R 470R 560R 2K4 2K7 4K7 5K6 7K5 8K2 100K 120K 150K 220K 300K 390K 820K.

Lists available of other wattages and values on special offer.

PBRA LTD.
Golden Green, Tonbridge
Kent TN11 OLH
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Member Crystalate Group

WW–045 FOR FURTHER DETAILS

STEREO PLAYBACK SYNTHESIZER PS 2001
(Europat. Pend.)

We are German manufacturers and exporters of electronic goods and look for a reliable distributor in U.K. of this product. This item is produced also by us and pat. pend. in U.K.

Features:
★ Playbacks from all stereo equipment (tuner, cassette decks, magnet-cartridge turntable, etc.).
★ Excellent sound of your playbacks because of the most modern integrated circuits.
★ Separate knobs for "intensity" and low frequencies added (background).
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★ Fantastic price and full guarantee.
★ 220/110V.

For further information write to

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POB 7123, D-5030 Huerth-7, West Germany
Telephone: 0049-2233/33872, 0049-2235/42211
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HAMEG

OSCILLOSCOPES

Top Performance In Every Range

HM 307

HM 307 — £138

Y: Bandwidth DC-10MHz (-3dB) • Sensitivity 5mV-20V/cm (±5%)
X: Timebase 0.2s-0.2μs/cm (±3%) • Triggering 2Hz-30MHz (3mm)
Built-in component tester • Calibrator • Screen 6x7cm • 1kV

HM 312 — £220

Y: Bandwidth DC-20MHz (-3dB) • Sensitivity 5mV-20V/cm (±3%)
X: Timebase 0.2s-40ns/cm incl. x5 Magn. • Trig. 3Hz-30MHz (4mm)
Dual trace • X-Y Operation • Calibrator • Screen 8x10cm • 2kV

HM 412 — £350

Y: Bandwidth DC-20MHz (-3dB) • Sensitivity 2mV-20V/cm (±3%)
X: Timebase 2s-40ns/cm incl. x5 Magn. • Trig. DC-40MHz (5mm)
Dual trace • Algebr. addition • X-Y Operation • Screen 8x10cm
Sweep delay • Overscan, Trigger, Delay indications • Trigger filter
Z-Modulation • Calibrator • Graticule illumination • 2kV

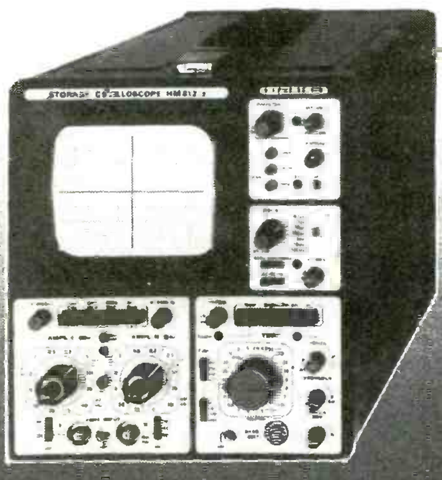
HM 512 — £580

Y: Bandwidth DC-50MHz (-3dB) • Sensitivity 5mV-50V/cm (±3%)
X: Timebase 5s-20ns/cm incl. x5 Magn. • Trig. DC-70MHz (5mm)
Dual trace • Algebr. addition • X-Y Operation • Screen 8x10cm
Delay line • Sweep delay • After delay triggering • Trigger filter
Single shot + Reset • Overscan, Trigger, Ready, Delay indications
var. Hold-off • Z-Modulation • Graticule illumination • 12kV

HM 812 — £1,458

Y: Bandwidth DC-50MHz (-3dB) • Sensitivity 5mV-50V/div. (±3%)
X: Timebase 5s-20ns/div. incl. x5 Magn. • Trig. DC-70MHz (0.5div.)
Dual trace analog storage with var. Persistence and Auto-Storage
Algebr. addition • X-Y Operation • Screen 8x10div. (7.2x9cm)
Delay line • Sweep delay • After delay triggering • Trigger filter
Single shot • Overscan, Trigger, Ready, Delay, AS indications
var. Hold-off • Z-Modulation • X-Guard circuit • Calibrator • 8.5kV

HM 812 Storage



For more information contact:

Prices U.K. List Ex. VAT

HAMEG LTD 74-78 Collingdon Street LUTON Bedfordshire LU1 1RX Telephone (0582) 413174 Telex 825484

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TRANSFORMERS
CONTINUOUS RATINGS

Please add 15% VAT after P&P

MAINS ISOLATORS

Pri 0-120, 0-100-120V (120, 220, 240V) Sec 60, 55-0-55 60 twice, to give 55, 60, 110, 115, 120, 125, 175, 180, 220, 225, 230, 235, 240.

Ref.	VA (Watts)	£	P&P
07★	20	4.84	1.20
149	60	7.37	1.20
150	100	8.38	1.44
151	200	12.28	1.72
152	250	14.61	2.04
153	350	18.07	2.12
154	500	22.52	2.20
155	750	32.03	OA
156	1000	40.92	OA
157	1500	56.52	OA
158	2000	67.99	OA
159	3000	95.33	OA

★115 or 240v sec only. State volts required. Pri. 0.220-240V.

12 or 24-VOLT

Separate 12V windings Pri 220- 240V

Ref.	12v Amps	24v	£	P&P
111	0.5	0.25	2.42	.95
213	1.0	0.5	2.90	1.00
71	2.0	1.0	3.86	1.00
18	4.0	2.0	4.46	1.20
85	5.0	2.5	6.16	1.20
70	6.0	3.0	6.99	1.20
108	8.0	4.0	8.16	1.44
72	10.0	5.0	8.93	1.60
116	12.0	6.0	9.89	1.60
17	16.0	8.0	11.79	1.72
115	20.0	10.0	15.87	1.84
187	30.0	15.0	19.72	2.04
226	60.0	30.0	40.41	OA

50 VOLT RANGE (Split Sec).

Pri 220-240V. Voltages available 5, 7, 8, 10, 13, 15, 17, 20, 25, 30, 33, 40 or 20V-0-20V and 25V-0-25V

Ref.	Amps 50v	25v	£	P&P
102	.5	1	3.75	1.20
103	1	2	4.57	1.20
104	2	4	7.88	1.44
105	3	6	9.42	1.60
106	4	8	12.82	1.72
107	6	12	16.37	1.84
118	8	16	22.29	2.20
119	10	20	27.48	OA
109	12	24	32.89	OA

30 VOLT RANGE (Split Sec)

Pri 220-240V Voltages available 3, 4, 5, 6, 8, 9, 10, 12, 15, 18, 20, 24, 30V or 12V-0-12V and 15V-0-15V

Ref.	Amps 30v	15v	£	P&P
112	.5	1	2.90	1.00
79	1	2	3.93	1.00
3	2	4	6.35	1.20
20	3	6	7.39	1.44
21	4	8	8.79	1.60
51	5	10	10.86	1.60
117	6	12	12.29	1.72
88	8	16	16.45	1.96
89	10	20	18.98	1.84
90	12	24	21.09	OA
91	15	30	24.18	OA
92	20	40	32.40	OA

60 VOLT RANGE

Pri 220-240V (Split Sec.)
Voltages available 6, 8, 10, 12, 16, 18, 20, 24, 30, 36, 40, 48, 60V, or 24V-0-24V and 30V-0-30V

Ref.	Amps 60v	30v	£	P&P
124	.5	1	4.27	1.20
126	1	2	6.50	1.20
127	2	4	8.36	1.60
125	3	6	12.10	1.72
123	4	8	13.77	1.96
40	5	10	17.42	1.84
120	6	12	19.87	2.04
121	8	16	27.92	OA
122	10	20	32.51	OA
189	12	24	37.47	OA

SCREENED MINIATURES Pri 240V

Ref.	mA	Volts	£	P&P
238	200	3-0-3	2.83	.50
212	1A, 1A	0-6, 0-6	3.14	1.00
13	100	9-0-9	2.35	.50
235	330, 330	0-9, 0-9	2.19	.60
207	500, 500	0-8-9, 0-8-9	3.05	.95
208	1A, 1A	0-8-9 0-8-9	3.88	1.20
236	200,200	0-15, 0-15	2.19	60
239	50MA	12-0-12	2.88	.50
214	300,300	0-20, 2-20	3.08	1.00
221	700 (DC)	20-12-0-12-20	3.75	1.00
206	1A, 1A	0-15-20, 0-15-20	5.09	1.20
203	500, 500	0-15-27, 0-15-27	4.39	1.20
204	1A, 1A	0-15-27, 0-15-27	6.64	1.20

HIGH VOLTAGE

MAINS ISOLATING
Pri 200/220 or 400/440
Sec 100/120 or 200/240

VA	Ref.	£	P&P
60	243	7.37	1.20
250	246	4.61	2.04
350	247	18.07	2.04
500	248	22.52	OA
1000	250	45.94	OA

AUTO TRANSFORMERS

Voltages available 105, 115, 190, 200, 210, 220, 230, 240. Voltages for step up or step down

Ref.	VA (Watts)	TAPS	£	P&P
113	15	0-115-210-240V	2.17	1.00
64	80	0-115-210-240V	4.41	1.20
4	150	0-115-200-220-240V	5.89	1.20
67	500		12.09	1.84
84	1000		20.64	2.20
93	1500		25.61	OA
95	2000		38.31	OA
73	3000		65.13	OA
80s	4000	0-10-115-200-220-240	84.55	OA
57s	5000		98.45	OA

0, 115, 220, 240 Step Up or Step Down

CASED AUTOS

240V cable input USA 115V Flat pin outlets

VA	P&P	Ref.	
20	£6.55	95	56W
75	£8.50	1.20	64W
150	£11.00	1.44	4W
200	£12.02	1.44	65W
250	£13.38	1.44	69W
500	£20.13	2.04	67W
1000	£30.67	2.20	84W
2000	£54.97	OA	95W

NEW RANGE TRANSFORMERS

Pri 0-120; 0-100-120; (120V or 220-240V). Sec. 0-36-48 twice to give 72V or 92V.

2A **£13.35** PP £1.22   4A **£20.65** PP £2.04
3A **£16.17** PP £1.96   5A **£29.30** PP £2.20

BE7 0-110-120 220 240V Sec 20V 1 Amp **£1.80**. P&P 32p + VAT.

MINIATURE TRANSFORMER

015V CT (7.5-0-7.5V

Ref	Amp	Price	P&P
171	500MA	2.30	.52
172	1A	3.26	.90
173	2A	3.95	.90
174	3A	4.13	.99
175	4A	6.30	1.10

SPLIT BOBBIN TRANSFORMER

Pri. 0-115; 0-115 (Ref. 70010). Sec. 0-12-15-20-24-30. To give 3, 4, 5, 6, 8, 10, 12, 15, 18, 20, 24, 30, 2 Amps. £4.65 P&P £1.10 + VAT.

End of line offers — **M679** 120V-2; 36V 1 6A **£3** pp 78p + VAT.
M865 100V line to 4Ω 10 watt **£1.90** pp 60p + VAT
M1126 120/240V 9-0-9 1A **£1.79** pp 71p + VAT
M616 240V Scr(1) 13-0-13 1A (2) 12V 150ma **£1.50** pp 66p + VAT

OTHER PRODUCTS

AVO TEST METERS

Latest Model 8 Mk. 5	£106.40
71 Electronics	£43.10
73 TV Service	£58.60
MM5 MINOR	£36.90
WEE MEGGER	£87.00
DA211 LCD Digital	47.00
DA212 LCD Digital	£67.00
DA116 LCD Digital	£108.90
Megger 70143 500v	87.00

Avo Cases and Accessories
P&P £1.32. VAT 15%

TOOLS

Mains Neon test screwdrivers	61p	20p
Long-nosed pliers	£2.17	35p
Precision screwdriver sets (6 per set)	£2.17	£1.93

ANTEX SOLDERING IRONS 15W **£4.58**. 25W **£4.58**
Stand for above **£1.75**. P&P 53p. VAT 15%

PANEL METERS

43mm × 43mm		82mm × 78mm	
0-50μa	£6.20	0-50μA	£6.70
0-500μ1A	£6.70	0-500μA	£6.70
0-1mA	£6.70	0-1mA	£6.70
0-30V	£6.70	0-30V	£6.70

VU Panel Ind 48 x 45mm .250μA FDS **£2.60**
Carriage 76p VAT 15%

U4315 Budget Meter 20KΩ/V Rangers to 1000V 2.5A AC/DC 500KΩ Res in steel case **£15.85**.
P&P £1.32 VAT 15%

BRIDGE RECTIFIERS

200v	2A	45p
400v	1A	25p
400v	2A	55p
100v	25A+	£2.10
200v	4A	65p
400v	4A	85p
400v	6A	£1.40
500v	12A	£2.85

P&P 20p. VAT 15%

METAL OXIDE RESISTORS £1/100

Special Offer 5% ¼W Use instead of carbon film (in 100s only) TR4 Electrosil
390Ω - 470Ω - 510Ω - 560Ω - 820Ω - 1K - 1K1 - 1K2 - 1K6 - 1K8 - 2K - 2K4 - 3K - 16K - 20K - 22K - 24K - 47K - 82K - 100K - 130K - 180K - 220K - 270K - 300K P&P 30p + VAT

Send 15p for catalogue
Prices correct at 20/2/81

Barrie Electronics Ltd.

3, THE MINORIES, LONDON EC3N 1BJ
TELEPHONE: 01-488 3316/8
NEAREST TUBE STATIONS: ALDGATE & LIVERPOOL ST.

WW – 84 FOR FURTHER DETAILS

LINSLEY-HOOD 300 SERIES AMPLIFIERS

These latest designs from the drawing board of John Linsley-Hood, engineered to the very highest standard, represent the very best that is available on the kit market today. The delicacy and transparency of the tone quality enable these amplifiers to outperform, on a side-by-side comparison, the bulk of amplifiers in the commercial market-place and even exceed the high standard set by his earlier 75-watt design.
Three versions are offered, a 30-watt with Darlington output transistors, and a 35- and 45-watt, both with Mosfet output devices. All are of identical outside appearance which is designed to match and stack with our Linsley-Hood cassette recorder 2.
As with all Hart kits the constructors interests have been looked after in a unique way by reducing the conventional (and boring) wiring almost to the point of extinction.
Any of these kits represents a most cost-effective route to the very highest sound quality with the extra bonus of the enjoyment of building a sophisticated piece of equipment.
30-watt Darlington amplifier, fully integrated with tone controls and magnetic pick-up facility. Total cost of all parts is **£81.12**. Special offer price for complete kits **£72**.
35-watt Mosfet amplifier. Total cost of parts **£98.41**. Special offer for complete kits, **£87.40**.
45-watt Mosfet amplifier. Total cost of parts **£104.95**. Special offer price for complete kits **£94.80**.
Reprints of original Articles from Hi-Fi News 50p. Post free. No VAT.
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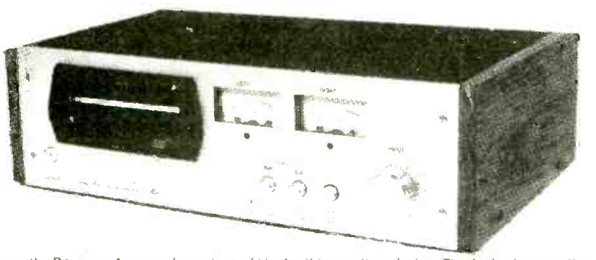
LINSLEY HOOD CASSETTE RECORDER 2

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

LINSLEY-HOOD CASSETTE RECORDER 1



We are the Designer Approved suppliers of kits for this excellent design. The Author's reputation tells all you need to know about the circuitry and Hart expertise and experience guarantees the engineering design of the kit. Advanced features include: High-quality separate VU meters with excellent ballistics. Controls, switches and sockets mounted on PCB to eliminate difficult wiring. Proper moulded escutcheon for cassette aperture improves appearance and removes the need for the cassette transport to be set back behind a narrow finger trapping slot. Easy to use, robust Lenco mechanism. Switched bias and equalisation for different tape formulations. All wiring is terminated with plugs and sockets for easy assembly and test. Sophisticated modular PCB system gives a spacious, easily-built and tested layout. All these features added to the high-quality metalwork make this a most satisfying kit to build. Also included at no extra cost is our new HS15 Sendust Alloy record/play head, available separately at **£7.60** plus V.A.T. but REPRINTS of the 3 articles describing this design **45p.** No V.A.T.
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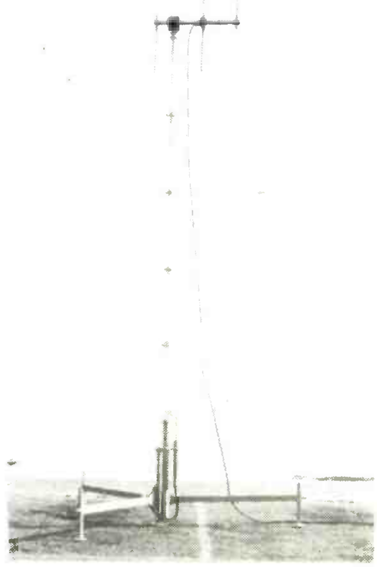

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AC125	0.29
AC126	0.29
AC127	0.29
AC128	0.35
AC141	0.32
AC141K	0.40
AC142	0.32
AC142K	0.40
AC176	0.35
AC187	0.32
AC188	0.32
ACY17	1.50
ACY18	1.32
ACY19	1.27
ACY20	1.27
ACY21	1.32
ACY39	2.88
AD149	0.86
AD161	0.40
AD162	0.40
AF106	0.40
AF114	0.86
AF115	0.86
AF116	0.86
AF117	0.86
AF139	0.38
AF186	1.15
AF239	0.45
AFZ11	4.60
AFZ12	4.60
ASY26	1.61
ASY27	1.04
ASZ15	1.38
ASZ16	1.27
ASZ17	1.15
ASZ20	2.64
ASZ21	2.88
AU113	2.88
AUY10	3.45
AU110	2.88
BA145	0.15
BA148	0.17
BA154	0.12
BA155	0.13
BA156	0.12
BAW62	0.06
BAX13	0.07
BAX16	0.07
BC107	0.18
BC108	0.18
BC109	0.18
BC113	0.17
BC114	0.17
BC115	0.21
BC116	0.22
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BC214	0.13
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BC238	0.13
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BC303	0.39
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BC328	0.14
BC337	0.14
BC338	0.14
BCY30	1.44
BCY31	1.73
BCY32	1.73
BCY33	1.27
BCY34	1.15
BCY39	3.91
BCY40	3.22
BCY42	0.35
BCY43	0.35
BCY58	0.22
BCY70	0.20
BCY71	0.21
BCY72	0.20
BCZ11	2.01
BD115	0.48
BD121	1.96
BD123	3.22
BD124	2.30
BD131	0.51
BD132	0.55
BD135	0.46
BD136	0.46
BD137	0.46
BD138	0.55
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BD140	0.58
BD144	2.30
BD181	1.38
BD182	1.36
BD137	0.62
BD238	0.62
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BDY60	3.16
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BF183	0.32
BF184	0.32
BF185	0.35
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BF196	0.15
BF197	0.16
BF200	0.46
BF224	0.29
BF244	0.32
BF257	0.31
BF258	0.31
BF259	0.32
BF336	0.39
BF337	0.38
BF338	0.41
BFS21	4.60
BFS28	2.58
BFS61	0.23
BFS98	0.23
BFW10	1.12
BFW11	1.10
BFX84	0.35
BFX85	0.35
BFX87	0.35
BFX88	0.35
BFY50	0.29
BFY51	0.29
BFY52	0.29
BFY64	0.35
BFY90	1.09
BSX19	0.31
BSX20	0.31
BSX21	0.33
BT106	1.38
BTY79/400R	2.30
BU205	1.50
BU206	1.73
BU208	2.30
BY100	0.46
BY126	0.15
BY127	0.16
BZX61 Series	0.20
BZY88 Series	0.12
CRS1/40	0.69
CRS3/06	0.52
CRS3/40	0.86
CRS3/60	1.04
GEX66	1.73
GEX541	5.75
GJ3M	1.73
GM0378A	2.02
KS100A	0.52
MJE340	0.69
MJE370	0.84
MJE371	0.82
MJE520	0.54
MJE521	0.84
MJE2955	1.50
MJE3055	1.27
MPF102	0.40
MPF103	0.40
MPF104	0.40
MPF105	0.40
MPSA06	0.30
MPSA56	0.32
MPSU01	0.61
MPSU06	0.75
MPSU56	0.79
NE555	0.52
NKT401	4.03
NKT403	2.88
NKT404	2.53
OA5	1.38
OA7	0.69
OA10	0.63
OA47	0.14
OA70	0.29
OA79	0.14
OA81	0.20
OA85	0.20
OA90	0.09
OA91	0.09
OA95	0.09
OA200	0.17
OA202	0.17
OA211	1.73
OAZ200	1.73
OAZ201	1.73
OAZ206	1.73
OAZ207	1.73
OC16	2.88
OC20	2.88
OC22	2.88
OC23	4.60
OC24	3.45
OC25	1.15
OC26	1.73
OC28	2.30
OC29	2.30
OC35	1.73
OC36	1.73
OC41	1.04
OC42	1.04
OC43	1.73
OC44	0.98
OC45	0.75
OC71	0.63
OC72	1.15
OC73	1.15
OC74	0.81
OC75	0.75
OC76	1.15
OC77	1.15
OC81	0.75
OC81Z	1.38
OC82	1.04
OC83	0.92
OC84	0.92
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OC123	2.30
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OC141	4.93
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OC171	1.44
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OC202	3.16
OC203	3.45
OC204	3.45
OC205	3.16
OC206	3.16
OC207	2.88
OCP71	2.30
ORP12	1.15
R2008B	2.30
R2009	2.59
R2010B	2.30
TIC44	0.31
TIC226D	1.38
TIL209	0.18
TIP29A	0.49
TIP30A	0.52
TIP31A	0.38
TIP32A	0.41
TIP33A	0.62
TIP34A	0.77
TIP41A	0.51
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TIP3055	0.64
TIS43	0.49
ZS140	0.29
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1S44	0.05
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1S921	0.10
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2G306	1.15
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2N708	0.29
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2N1671	1.73
2N1893	0.37
2N2147	4.60
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2N2221	0.23
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2N4126	0.18
2N4286	0.17
2N4288	0.21
2N4289	0.21
2N5457	0.37
2N5458	0.37
2N5459	0.37
2S017	11.50
2S019	13.80
2S026	28.75
2S103	1.73
2S302	2.30
2S303	1.73
2S322	4.03
2S324	4.03
2S701	2.30
2S745A	1.09
2S746A	1.09

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A1834	10.35
A2087	13.58
A2134	20.13
A2293	8.62
A2426	17.63
A2521	24.38
A2900	14.43
A3343	25.56
AZ31	1.26
AZ41	1.32
BK448	110.27
BK484	149.09
BS90	52.27
BS810	35.24
BT5	58.13
BT17	106.89
BT19	36.17
BT29	327.69
BT69	333.50
BT75	102.46
BT95	127.02
CBL31	2.30
CL33	2.30
CY31	1.15
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C3A	11.50
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DA41	21.50
DA42	12.30
DA100	112.62
DAF91	0.46
DAF96	1.15
DET22	32.78
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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
DY87	0.74
DY802	0.96
E55L	25.17
E80CC	10.13
E80CF	12.96
E80F	14.19
E80L	13.98
E81CC	6.62
E81L	14.06
E82CC	7.03
E83CC	7.16
E86C	12.48
E88C	7.12
E88CC	3.86
E90CC	9.90
E90F	10.38
E91H	5.34
E92CC	9.40
E99F	10.16
E130L	19.39
E180CC	8.86
E180F	7.83
E182CC	9.90
E186F	12.58
E188CC	9.40
E280F	25.88
E283CC	9.02
E288CC	18.54
EA52	23.69
EA76	2.30
EABC80	1.38
EAC91	0.92
EAF42	1.44
EAF801	2.02
EB41	2.30
EB91	1.01
EBC33	2.02
EBC41	1.44
EBC81	1.26
EBC90	0.97
EBF80	0.58
EBF83	1.44
EBF89	0.97
EBL31	2.88
EC90	1.28
EC91	8.69
EC92	1.44
EC157	310.50
ECC33	4.02
ECC35	4.02
ECC40	2.30
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	10.27
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
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EF39	3.16
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EF55	2.88
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EF805S	12.65
EH90	1.61
EK90	1.24
EL32	1.73
EL33	4.02
EL34TH	2.53
EL34MUI	3.16
EL36	1.84
EL41	1.44
EL42	2.02
EL81	2.88
EL83	4.03
EL84	1.15
EL86	2.88
EL90	1.10
EL91	8.21
EL95	1.51
EL156	27.60
EL360	9.77
EL500/504	2.16
EL509	3.63
EL821	11.46
EL822	12.55
EM34	5.75
EM80	1.26
EM81	1.15
EM84	1.15
EM85	1.44
EM87	1.73
EN32	16.28
EN91	2.94
EN92	6.18
EY51	2.02
EY81	1.89
EY83	2.02
EY84	10.57
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	41.40
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	14.38
GU50	14.31
GU51	13.62
GXU1	16.10
GXU2	28.43
GXU3	30.49
GXU4	32.77
GXU50	17.25
GY501	3.16
GZ32	1.44
GZ33	4.60
GZ34	2.88
GZ37	4.60
KT61	4.02
KT66	11.50
KT88	13.80
KTW61	2.02
KTW62	2.02
KTW63	2.02
M8079	12.29
M8080	9.49
M8081	11.30
M8082	9.87
M8083	8.54
M8091	11.99
M8096	4.31
M8097	4.09
M8098	5.50
M8099	5.98
M8100	9.49
M8136	9.75
M8137	9.73
M8140	5.17
M8141	5.52
M8142	7.77
M8144	4.31
M8149	5.86
M8161	9.11
M8162	10.36
M8163	5.17
M8190	5.29
M8195	4.25
M8196	7.47
M8204	6.57
M8212	12.47
M8223	3.80
M8224	4.66
M8225	2.99
M8248	13.32
MU14	1.73
MX119	58.65
MX123	67.85
MX145	58.65
MX151	17.25
MX152	135.70
MX161	166.75
MX163	23.11
MX164	25.88
MX166	142.60
MX168	48.30
N78	10.35
OA2	2.36
OA3	5.69
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	3.74
PCF201	2.45
PCF801	1.84
PCF802	2.19
PCF805	1.84
PCF806	1.84
PCF808	1.84
PCL82	1.15
PCL83	2.30
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	3.73
PL519	3.73
PL801	1.27
PL802	3.40
PY33	1.27
PY81	0.97
PY82	0.92
PY83	0.81
PY88	1.01
PY500A	2.07
PY800	0.97
PY801	0.97
QQV02-6	14.44
QQV03-20A	20.13
QQV06-40A	47.15
QQV07-50	60.66
QQZ03-20A	59.80
QQZ06-40A	55.10
QU37	14.38
QV03-12	5.13
QV04-7	2.88
QV08-100	122.26
QY3-65	57.06
QY3-125	61.02
QY4-250	70.16
QY4-400	80.44
QY5-500	168.83
QY5-3000A	333.91
QZ06-20	30.48
R10	5.75
R17	1.89
R18	4.89
R19	1.38
R20	1.66
RG3-250	35.77
RG3-250A	37.49
RG3-1250	36.23
RG4-1250	43.93
RG4-3000	89.64
RR3-250	53.54
RR3-1250	94.83
S11E12	40.25
S130	3.45
S130P	4.03
STV280-40	11.50
STV280-80	24.15
SU41	2.88
SU42	10.35
TD03-10	32.78
TD03-10E	32.78
TD03-29F	33.93
TT15	34.50
TT21	14.16
TT22	18.17
TT100	59.51
TY2-125	69.01
TW4-400	74.07
TY4-500	101.44
TY5-500	178.25
TY6-800	181.70
TY6-5000A	337.51
TY6-5000B	264.50
TY6-5000W	290.98
TY7-6000A	357.49
TY7-6000W	286.33
TZ40	17.25
U18-20	2.88
U19	15.81
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	2.88
UL84	1.38
UM80	1.15
UY41	1.44
UY85	1.20
VLS631	15.24
XG1-2500	42.04
XG2-6400	113.50
XG5-500	28.52
XG2-6400	106.15
XR1-1600A	38.53
XR1-3200	93.15
XR1-3200A	93.15
XR1-6400	102.01
XR1-6400A	164.23
YD1120	264.50
YD1240	366.62
Z759	19.32
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	15.34
2J42	89.70
2J55	239.97
2J70A	270.25
2J70B	418.34
2K25	40.25
3-400Z	57.50
3-500Z	63.25
3A5	2.70
3B24	9.20
3B28	8.63
3B29	11.50
3B240M	17.25
3B241M	17.25
3C23	18.73
3C45	28.18
3CX100A5	23.00
3E29	29.67
3S4	1.26
3V4	1.38
465A	29.15
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4-250A	41.99
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4B32	29.16
4C35	74.75
4CX250B	31.63
4CX350A	48.88
4X150A	24.41
4X150D	28.75
5B254M	23.12
5B255M	23.12
5C22	74.75
5J180E	1380.00
5R4GY	2.30
5U4G	3.86
5U4GB	2.90
5V4G	1.75
5Y3GT	0.98
5Z3	1.73
5Z4G	1.75
5Z4GT	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	4.15
6AK6	2.81
6AL5	1.01
6AM4	2.65
6AM5	8.21
6AM6	2.07
6AN5	4.45
6AN8A	3.97
6AQ5	1.10
6AS6	5.73
6AS7G	9.49
6AT6	0.98
6AU5GT	4.97
6AU6	1.24
6AV5GA	4.52
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	4.28
6BR7	4.60
6BR8	2.02
6BS7	4.60
6BW6	4.60
6BW7	1.75
6BX7GT	5.70
6BZ6	2.73
6C4	1.01
CB6A	2.86
6CD6GA	5.83
6CG7	2.62
6CH6	9.78
6CL6	4.12
6CW4	8.83
6D2	1.01
6DK6	3.00
6DQ6B	4.69
6EA8	3.38
6EB8	2.44
6EW6	1.73
6F6	2.02
6F23	1.84
6F28	1.33
6F33	29.90
6H1	14.38
6H2N	1.21
6H3N	1.21
6H6	1.73
6J4	6.10
6J6	6.21
6J7	8.07
6K4N	1.44
6K6GT	1.50
6K7	1.73
6K8	2.02
6KD6	7.31
6L6G	2.88
6L6GA	1.73
6L6GT	2.24
6L6GC	2.88
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	3.38
6V6GT	1.84
6X4	1.38
6X5GT	0.97
7B7	1.96
7C5	3.40
7C6	2.60
7H7	2.30
7R7	1.73
7S7	2.98
7Y4	1.84
7Z4	2.13
11E3	60.82
12AT6	1.38
12AT7	1.01
12AU6	2.97
12AU7	0.83
12AV6	2.55
12AV7	4.00
12AX7	1.01
12AY7	4.69
12B4A	3.62
12BA6	2.52
12BE6	2.79
12BH7	1.29
12BY7	3.11
12E1	19.67
12E11TT	19.26
12E14	34.50
13E1	123.05
19H4	28.75
19H5	40.25
24B9	55.20
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	2.88
30PL14	1.93
30PL15	2.07
35W4	0.69
50C5	0.81
75B1	5.38
75C1	2.70
85A1	8.63
85A2	2.75
90AG	14.90
90AV	14.90
90C1	2.81
90CG	16.72
90CV	17.50
92AG	14.90
92AV	14.90
95A1	7.48
150B2	3.47
150B3	6.39
150C2	2.21
150C4	2.75
211	21.85
723AB	40.25
803	11.50
805	23.00
807	4.31
811A	18.32
812A	18.26
813	85.87
833A	128.80
866A	15.23
872A	21.47
922	5.01
931A	16.97
1624	2.59
1625	1.96
2050	8.00
4212E	304.75
4212H	304.75
5544	62.10
5545	67.85
5551A	106.03
5552A	143.35
5553A	259.10
5642	6.45
5654	3.93
5651	2.65
5670	5.18
5675	19.91
5687	6.31
5696	4.35
5718	7.87
5725	5.62
5726	3.62
5727	5.42
5749	5.14
5751	4.80
5763	4.66
5814A	4.28
5840	5.06
5842	13.90
5876A	19.55
5879	5.38
5886	12.08
5963	3.38
5965	4.00
6005	5.62
6021	5.13
6057	4.02
6058	12.47
6059	4.60
6061	4.89
6062	4.31
6063	4.20
6064	8.54
6067	4.02
6072	5.80
6080	7.88
6097AxBxC	46.00
6146A	10.30
6146B	8.12
6159B	17.27
6189	10.03
6201	5.28
6442	17.25
6883B	12.77
6973	4.38
7025	2.73
7551	6.45
7586	11.66
7587	20.11
7609	36.57
7868	5.04
7895	13.25
8005	75.03
8068	6.33
8122	60.11
8136	2.48
8417	6.76
18042	8.63
18045	12.06

Tested Ex-Equipment
4CX250B 5.75

BASES

B7G unskirted	0.25
B7G skirted	0.35
B9A unskirted	0.25
B9A skirted	0.35
Int Octal	0.40
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	11.50
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 Prices on application

INTEGRATED CIRCUITS

7400	0.18
7401	0.20
7402	0.20
7403	0.20
7404	0.21
7405	0.21
7406	0.49
7407	0.49
7408	0.23
7409	0.23
7410	0.20
7412	0.33
7413	0.37
7416	0.37
7417	0.37
7420	0.21
7422	0.23
7423	0.38
7425	0.35
7427	0.35
7428	0.50
7430	0.20
7432	0.35
7433	0.46
7437	0.37
7438	0.37
7440	0.37
7441	1.04
7442	0.83
7447AN	1.35
7450	0.21
7451	0.21
7453	0.21
7454	0.21
7460	0.21
7470	0.44
7472	0.38
7473	0.44
7474	0.44
7475	0.62
7476	0.48
7480	0.64
7482	0.86
7483	1.15
7484	1.21
7486	0.45
7490	0.69
7491	0.94
7492	0.69
7493	0.69
7494	0.94
7495	0.84
7496	0.94
7497	3.62
74100	1.77
74107	0.52
74109	0.84
74110	0.59
74111	0.82
74116	2.13
74118	1.15
74119	1.77
74120	0.95
74121	0.49
74122	0.71
74123	1.36
74125	0.67
74126	0.67
74128	0.72
74132	0.83
74136	0.59
74141	1.02
74142	2.64
74143	2.99
74144	2.99
74145	1.15
74147	2.30
74148	2.02
74150	2.07
74151	1.08
74154	2.07
74155	1.04
74156	1.04
74157	0.86
74159	2.53
74170	2.76
74172	5.06
74173	1.63
74174	1.84
74175	1.17
74176	1.33
74178	1.56
74179	1.56
74180	1.38
74190	2.19
74191	2.19
74192	2.19
74193	2.19
74194	1.44
74195	1.38
74196	1.55
74197	1.55
74198	3.11
74199	2.64
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

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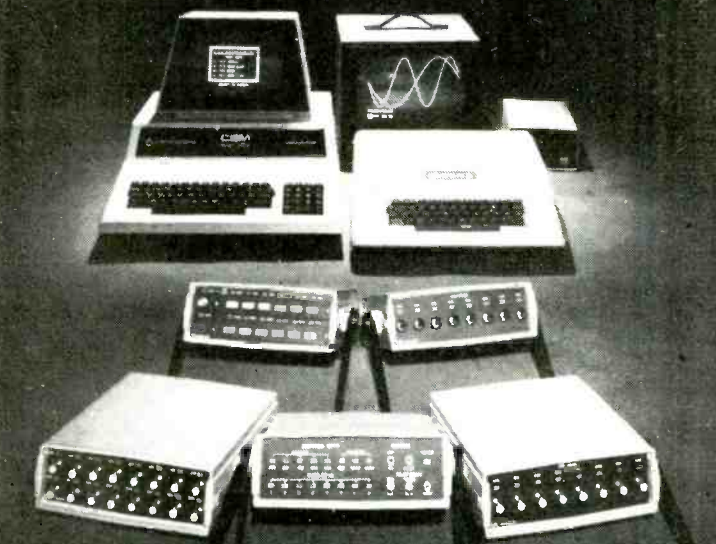

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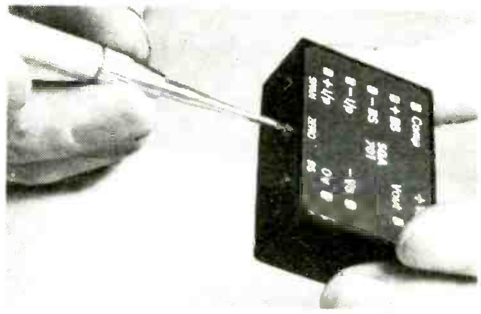

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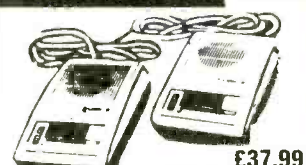

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The Siemens S43202-M-C TV Antenna Level Meter is a portable, self-contained unit which greatly simplifies antenna orientation to receive TV signals including those of foreign transmission. Signals are visually monitored on the integral 70mm diameter screen, giving the facility of detecting ghosting, unlike meters relying on directional pointers.

The unit is very accurate, yet remarkably simple to operate and embodies all the technological sophistication allied with supreme reliability for which Siemens is recognised.

Contact Telecommunications Test Equipment Department at:
Siemens Limited, Siemens House, Windmill Road, Sunbury-on-Thames, Middlesex.
Tel. Sunbury-on-Thames 85691
Telex 8951091

A Siemens tester for all standards

WW – 073 FOR FURTHER DETAILS

SONICOR

ULTRASONIC CLEANERS

SC50

- CLEANS ELECTRONIC COMPONENTS FAST
- P.C.B'S, WIREWOUND POTS, SWITCHES RELAYS ETC.
- RUGGED 55KHz GENERATORS AND LEAD ZIRCONATE TRANSDUCER
- SOLVENT CLEANING FLUIDS AVAILABLE
- UNIT ILLUSTRATED IS 2 LTR. CAPACITY (APPROX.) AND COSTS £97.
- FULL RANGE OF SIZES AVAILABLE INCLUDING INDUSTRIAL UNITS

DETAILS FROM S2

Orme Scientific Limited

P.O. Box 3
Stakehill Industrial Estate
Middleton,
Manchester M24 2RH
Tel: 061-643 9134/5/6
Telex: 669846

WW – 081 FOR FURTHER DETAILS

CB

ACCESSORIES

ANTENNAS, COAX
CONNECTORS MIKES
SWR METERS BOOKS
40 & 80 CH RECEIVERS

SPILTH ELECTRONICS

3D Barley Market Street
Tavistock, Devon

Phone 0822 5865

Telex 45236

WW – 092 FOR FURTHER DETAILS

TTLs by TEXAS

7400	11p
74S00	60p
7401	12p
7402	12p
7403	14p
7404	14p
7405	18p
7406	36p
7407	36p
7408	17p
7409	19p
7410	15p
7411	24p
7412	20p
7413	30p
7414	40p
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	75p
7448	80p
7450	17p
7451	17p
7453	17p
7454	17p
7460	17p
7470	36p
7472	30p
7473	34p
7474	30p
7475	38p
7476	32p
7480	50p
7481	100p
7482	84p
7483A	90p
7484	100p
7485	110p
7486	34p
7489	210p
7490A	30p
7491	80p
7492A	46p
7493A	36p
7494	84p
7495A	70p
7496	65p
7497	180p
74100	130p
74107	34p
74109	55p
74116	200p
74118	130p
74119	210p
74120	110p
74121	34p
74122	48p
74123	60p
74125	75p
74126	60p
74128	75p
74132	75p
74136	75p
74137	50p
74141	50p
74142	200p
74145	90p
74147	190p
74148	150p
74150	130p
74151A	70p
74153	70p
74154	120p
74155	90p
74156	90p
74157	70p
74159	190p
74160	100p
74161	100p
74162	100p
74163	100p
74164	120p
74165	130p
74166	120p
74167	200p
74170	240p
74172	450p
74173	120p
74174	90p
74175	85p
74176	90p
74177	90p
74178	160p
74180	93p
74181	160p
74182	90p
74184A	150p
74185	150p
74186	500p
74188	325p
74190	120p
74191	120p
74192	100p
74193	100p
74194	120p
74195	95p
74196	95p
74197	80p
74198	150p
74199	150p
74221	160p
74251	140p
74259	250p
74278	290p
74279	110p
74283	140p
74284	360p
74285	360p
74290	150p
74293	150p
74298	200p
74365	100p
74366	100p
74367	100p
74368	100p
74390	200p
74393	200p
74490	225p

74LS SERIES

74LS00	14p
74LS02	16p
74LS03	18p
74LS04	16p
74LS05	25p
74LS08	22p
74LS09	21p
74LS10	20p
74LS11	40p
74LS13	40p
74LS14	50p
74LS20	20p
74LS21	40p
74LS27	38p
74LS30	20p
74LS32	27p
74LS37	30p
74LS38	38p
74LS42	70p
74LS47	75p
74LS51	24p
74LS55	30p
74LS73	50p
74LS74	27p
74LS75	36p
74LS76	45p
74LS83	70p
74LS85	80p
74LS86	40p
74LS90	40p
74LS92	70p
74LS93	60p
74LS96	110p
74LS107	45p
74LS109	80p
74LS112	40p
74LS113	90p
74LS114	45p
74LS122	80p
74LS123	80p
74LS124	180p
74LS125	50p
74LS126	50p
74LS132	80p
74LS133	30p
74LS136	55p
74LS138	65p
74LS139	75p
74LS145	120p
74LS147	220p
74LS148	175p
74LS151	80p
74LS153	60p
74LS154	200p
74LS155	80p
74LS156	90p
74LS157	60p
74LS158	60p
74LS160	90p
74LS161	75p
74LS162	140p
74LS163	100p
74LS164	90p
74LS165	140p
74LS166	180p
74LS173	110p
74LS174	100p
74LS175	100p
74LS181	320p
74LS190	100p
74LS191	100p
74LS192	100p
74LS193	100p
74LS195	140p
74LS196	120p
74LS197	90p
74LS221	120p
74LS240	175p
74LS241	175p
74LS242	170p
74LS243	170p
74LS244	150p
74LS245	150p
74LS247	140p
74LS251	140p
74LS253	90p
74LS257	90p
74LS258	160p
74LS259	160p
74LS266	100p
74LS273	170p
74LS279	90p
74LS283	90p
74LS298	160p
74LS323	400p
74LS324	200p
74LS348	200p
74LS365	48p
74LS367	70p
74LS368	100p
74LS373	150p
74LS374	150p
74LS375	120p
74LS377	160p
74LS378	140p
74LS390	120p
74LS393	120p
74LS399	200p
74LS445	140p
74LS670	400p

4000 SERIES

4000	15p
4001	22p
4002	20p
4006	95p
4007	20p
4008	80p
4009	40p
4010	50p
4011	20p
4012	25p
4013	50p
4014	84p
4015	84p
4016	45p
4017	70p
4018	89p
4019	45p
4020	100p
4021	110p
4022	100p
4023	27p
4024	50p
4025	20p
4026	130p
4027	50p
4028	84p
4029	100p
4030	55p
4031	200p
4034	200p
4035	110p
4036	295p
4039	295p
4040	100p
4041	80p
4042	80p
4043	90p
4044	90p
4046	110p
4047	100p
4048	55p
4049	45p
4050	45p
4051	80p
4052	80p
4053	80p
4054	150p
4055	125p
4056	135p
4059	600p
4060	115p
4063	120p
4066	50p
4067	450p
4068	27p
4069	20p
4070	30p
4071	25p
4072	25p
4073	25p
4075	25p
4076	107p
4081	27p
4082	27p
4086	72p
4089	150p
4093	70p
4094	250p
4095	95p
4096	95p
4097	340p
4098	120p
4099	200p
40100	220p
40101	132p
40102	180p
40103	180p
40104	99p
40105	120p
40106	90p
40107	60p
40108	470p
40109	100p
40110	300p
40114	250p
4502	120p
4503	70p
4507	55p
4508	290p
4510	99p
4511	120p
4512	80p
4514	250p
4515	300p
4516	110p
4518	100p
4520	100p
4521	250p
4526	108p
4527	150p
4528	100p
4532	140p
4534	550p
4536	375p
4538	120p
4543	180p
4553	320p
4556	72p
4560	200p
4569	250p
4572	40p
4583	110p
4584	90p
4585	150p
4724	250p
40097	90p
14411	700p
14412	1100p
14433	1100p
14500	700p
14599	290p

INTERFACE ICs

AD536A	£13
AD561J	1400p
AD7524	600p
DM8123	175p
DM8131	375p
DP8304	450p
DS8835	250p
DS8836	150p
DS8838	225p
MC1488	75p
MC1489	75p
MC3446	300p
MC3480	850p
25S10	350p
75107	160p
75110	325p
75150	175p
75154	175p
75182	230p
75324	375p
75361	300p
75363	400p
75365	200p
75451/2	72p
75491/2	70p
8T26	160p
8T28	250p
8T95	180p
8T97	160p
81LS95	120p
81LS96	140p
81LS97	120p
81LS98	140p
9602	220p

93 SERIES

9301	160p
9302	175p
9308	316p
9310	275p
9311	275p
9312	160p
9314	165p
9316	225p
9321	225p
9322	150p
9334	360p
9368	250p
9370	300p
9374	200p

74S SERIES

74S00	60p
74S04	60p
74S05	75p
74S08	75p
74S10	60p
74S20	60p
74S30	60p
74S32	90p
74S37	90p
74S64	60p
74S74	90p
74S85	300p
74S86	180p
74S112	120p
74S114	120p
74S124	300p
74S132	160p
74S133	75p
74S138	225p
74S139	225p
74S157	250p
74S163	300p
74S174	250p
74S175	320p
74S194	350p
74S241	450p
74S260	70p
74S373	500p
74S374	500p

LINEAR ICs

AY1-0212	600p
AY1-1313	668p
AY1-1320	320p
AY1-5050	140p
AY3-1270	840p
AY3-8912	650p
AY5-1224A	240p
AY5-1315	600p
AY5-4007D	520p
CA3019	80p
CA3046	70p
CA3048	225p
CA3080E	72p
CA3086	48p
CA3089E	225p
CA3090AQ	375p
CA3130E	90p
CA3140E	50p
CA3160E	100p
CA3161E	140p
CA3162E	450p
CA3189E	300p
CA3280	160p
DAC1408-8	200p
FX209	750p
HA1388	260p
ICL7106	850p
ICL8038	300p
ICM7555	80p
LF13331	310p
LF351	48p
LF356P	95p
LM10C	425p
LM301A	27p
LM311	70p
LM318	200p
LM319	225p
LM324	45p
LM339	75p
LM348	95p
LM358P	50p
LM377	175p
LM380	75p
LM381AN	180p
LM386	95p
LM393	100p
LM709	36p
LM710	50p
LM725	350p
LM733	100p
LM741	18p
LM747	70p
LM748	35p
LM2917	250p
LM3302	140p
LM3900	70p
LM3909	70p
LM3911	130p
LM3914	225p
LM3915	225p
LM3916	225p
LM13600	125p
MB3712	150p
MC1310P	150p
MC1458	48p
MC1495L	350p
MC1496	70p
MC3340P	120p
MK50398	750p
ML920	775p
MM57160	620p
NE531	150p
NE555	20p
NE556	70p
NE564	420p
NE565	130p
NE566	155p
NE567	140p
NE571	425p
NE5534A	250p
RC4136	80p
S566B	270p
SAD1024A	1250p
SFF96364	1100p
SL490	[illegible]
SN76477	160p
SP8515	750p
TA7205	250p
TAA621	275p
TBA641B11	300p
TBA651	200p
TBA800	90p
TBA810	100p
TBA820	90p
TBA950	300p
TCA220	350p
TCA940	175p
TDA1004	300p
TDA1008	320p
TDA1010	225p
TDA1022	570p
TDA1024	120p
TDA1034B	250p
TDA1170	300p
TDA2002V	325p
TDA2020	320p
TL071/81	45p
TL072/82	75p
TL074	130p
TL084	110p
TL170	50p
UAA170	175p
UDN6118	320p
UDN6184	320p
ULN2003	100p
UPC1156H	300p
XR2206	300p
ZN414	90p
ZN419C	225p
ZN424E	135p
ZN425E	400p
ZN427E	750p
ZN1034	200p

VOLTAGE REGULATORS
Fixed Plastic TO-220

1A	+ve		-ve	
5V	7805	60p	7905	65p
12V	7812	60p	7912	65p
15V	7815	60p	7915	70p
18V	7818	60p	7918	70p
24V	7824	60p	7924	70p
100mA	TO-92			
5V	78L05	30p	79L05	70p
12V	78L12	30p	79L12	70p
15V	78L15	30p	79L15	70p

OTHER REGULATORS

LM309K	135p
LM317T	200p
LM323K	500p
LM723	37p
78HGKC	600p
78HO5KC	550p
78MGT2C	135p
79HGKC	600p
TL497	300p

OPTO-ELECTRONICS

2N5777	45p
OCP71	90p
ORP12	120p
ORP60	120p
ORP61	120p
TIL78	55p

OPTO-ISOLATORS

ILD74	130p
MCT26	100p
MCS2400	190p
TIL111	90p
TIL112	90p
TIL116	90p

LEDS

0.125	
TIL32	55p
TIL209 Red	13p
TIL211 Gr	20p
TIL212 Ye	25p
TIL216 Red	18p
0.2"	
TIL220 Red	16p
TIL222 Gr	18p
TIL228 Red	22p
Rectangular LEDs (R G Y)	30p

DISPLAYS

3015F	200p
DL704	140p
DL707 Red	140p
FND357	120p
FND500	110p
FND507	110p
MAN3640	175p
MAN4640	200p
NSB5881	570p
TIL311	600p
TIL312/3	110p
TIL321/2	130p
TIL330	140p
7750/60	200p

DRIVERS

9368	250p
9370	300p
UDN6118	320p
UDN6184	320p

TRANSISTORS

AC126	25p
AC127/8	20p
AC176	25p
AC187/8	25p
AF116	50p
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
BC337	16p
BC338	16p
BC461	35p
BC477/8	30p
BC516/7	40p
BC547B	16p
BC548C	9p
BC549C	18p
BC557B	16p
BC559C	18p
BCY70	18p
BCY71/2	22p
BD131/2	50p
BD135/6	54p
BD139	56p
BD140	60p
BD189	60p
BD232	95p
BD233	75p
BD235	85p
BD241	70p
BD242	70p
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	40p
BFX30	34p
BFX84/5	40p
BFX86/7	30p
BFX88	30p
BFW10	90p
BFY50	30p
BFY51/2	30p
BFY56	33p
BFY90	90p
BRY39	45p
BSX19/20	20p
BU104	225p
BU105	190p
BU108	250p
BU109	225p
BU126	150p
BU180A	120p
BU205	200p
BU208	200p
BU406	145p
E300	50p
E308	50p
E310	50p
MJ2501	225p
MJ2955	90p
MJ3001	225p
MJE340	50p
MJE2955	100p
MJE3055	70p
MPF102	45p
MPF103/4	40p
MPF105/6	40p
MPS6531	50p
MPS6534	50p
MPSA06	30p
MPSA12	50p
MPSA13	50p
MPSA20	50p
MPSA42	50p
MPSA43	50p
MPSA56	32p
MPSA70	50p
MPSU06	63p
MPSU07	60p
MPSU45	90p
MPSU65	78p
OC28	130p
OC35	130p
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
TIP54	160p
TIP120	120p
TIP122	130p
TIP142	130p
TIP147	130p
TIP2955	78p
TIP4055	70p
TIS43	45p
TIS93	30p
ZTX108	12p
ZTX300	13p
ZTX500	15p
ZTX502	18p
ZTX504	30p
2N457A	250p
2N696	35p
2N697	25p
2N698	45p
2N706A	30p
2N708	30p
2N918	45p
2N930	18p
2N1131/2	36p
2N1613	25p
2N1711	25p
2N2102	70p
2N2160	350p
2N2219A	30p
2N2222A	30p
2N2369A	25p
2N2484	30p
2N2646	45p
2N2904/5	30p
2N2906A	30p
2N2907A	30p
2N2926	9p
2N3053	30p
2N3054	65p
2N3055	48p
2N3442	140p
2N3553	240p
2N3565	30p
2N3584	250p
2N3643/4	48p
2N3702/3	12p
2N3704/5	12p
2N3706/7	14p
2N3708/9	12p
2N3773	300p
2N3819	25p
2N3820	50p
2N3823	70p
2N3866	80p
2N3902	700p
2N3903/4	18p
2N3905/6	20p
2N4037	65p
2N4058/9	12p
2N4060	12p
2N4061/2	18p
2N4123/4	27p
2N4125/6	27p
2N4401/3	27p
2N4427	90p
2N4871	60p
2N5087	27p
2N5089	27p
2N5172	27p
2N5179	90p
2N5191	90p
2N5194	90p
2N5245	40p
2N5296	55p
2N5401	50p
2N5457/8	40p
2N5459	40p
2N5460	60p
2N5485	44p
2N5875	250p
2N6027	48p
2N6041	160p
2N6044	160p
2N6052	300p
2N6059	325p
2N6107	65p
2N6247	190p
2N6254	130p
2N6290	65p
2N6292	65p
2SC1172	150p
2SC1306	150p
2SC2028	120p
2SC2029	250p
3N128	120p
3N140	120p
3N141	110p
3N201	110p
3N204	120p
40290	250p
40361/2	75p
40408	90p
40409	100p
40410	100p
40411	300p
40594	120p
40595	120p
40673	75p
40871/2	100p

DIODES

BY127	12p
BYX36-300	20p
OA47	9p
OA81	15p
OA85	15p
OA90	9p
OA91	9p
OA95	9p
OA200	9p
OA202	10p
IN914	4p
IN916	7p
IN4148	4p
IN4001/2	5p
IN4003/4	6p
IN4005	6p
IN4006/7	7p
IN5401/3	14p
IN5404/7	19p
IS920	9p

HEAT SINKS
For TO220 Voltage Regs and transistors 22p
For TO5 12p

BRIDGE RECTIFIERS

1A 50V	19p
1A 100V	20p
1A 400V	25p
1A 600V	30p
2A 50V	30p
2A 100V	35p
2A 400V	45p
2A 200V	60p
2A 600V	72p
4A 100V	95p
4A 400V	100p
6A 50V	80p
6A 100V	100p
6A 400V	120p
10A 400V	200p
25A 400V	400p

ZENERS
Range 2.7V 33V

400mW	9p
1W	15p

TRIACS PLASTIC

3A 400V	60p
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	70p
1A 400V	90p
3A 400V	100p
8A 600V	140p
12A 400V	160p
16A 100V	160p
16A 400V	180p
BT106	110p
C106D	45p
MCR101	36p
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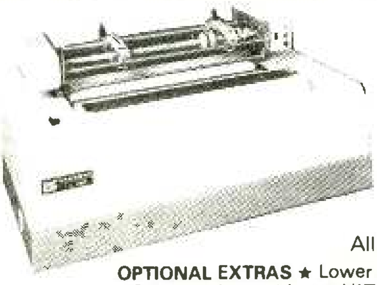

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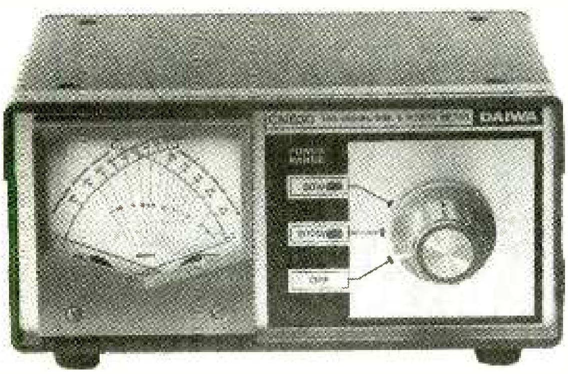

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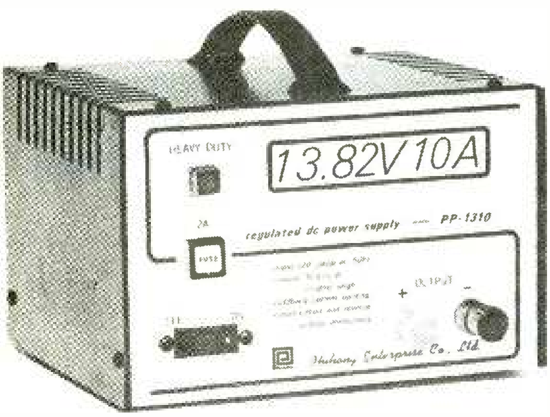

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(1054)

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(The above position is open to both men and women)

(1062)

Cripps,Sears

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Application forms from: The Personnel Officer, Preston Polytechnic, Corporation Street, Preston. Tel: Preston 51831.

Reference No.: NT/80/81/55 Closing Date: 24th April, 1981 (1022)

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Interviews in LONDON, June 18 & 19, 1981.

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(1065)

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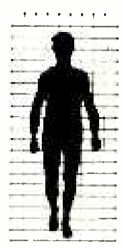

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(1059)

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(1028)

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(1058)

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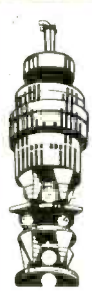

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(1044)

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Grade IV/III

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(1024)

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(1043)

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(1047)

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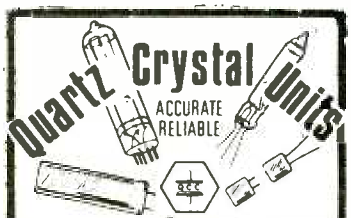

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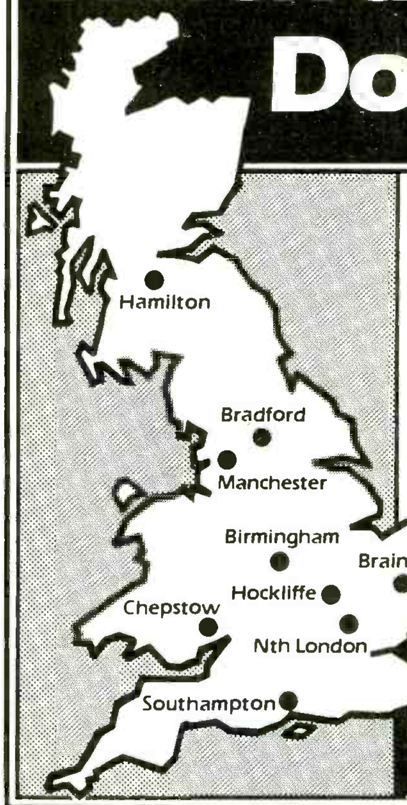

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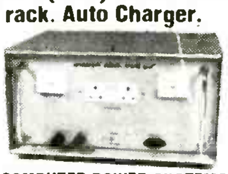

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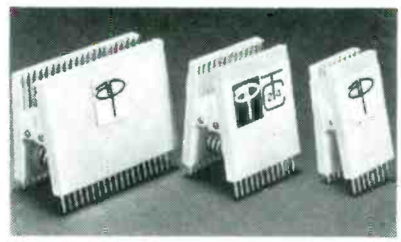

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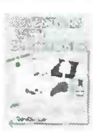

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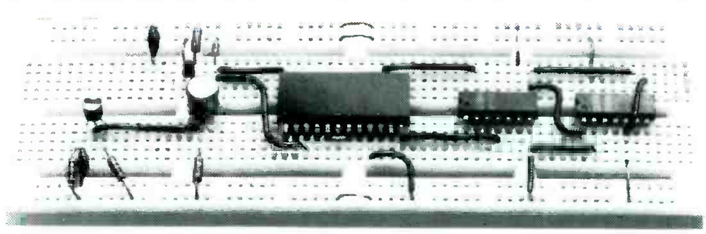

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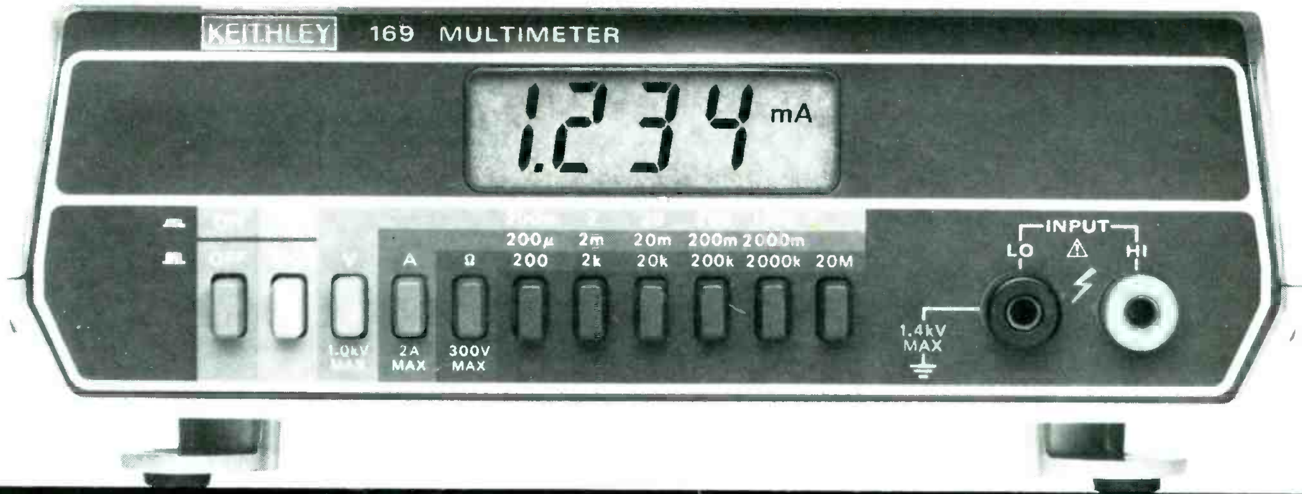

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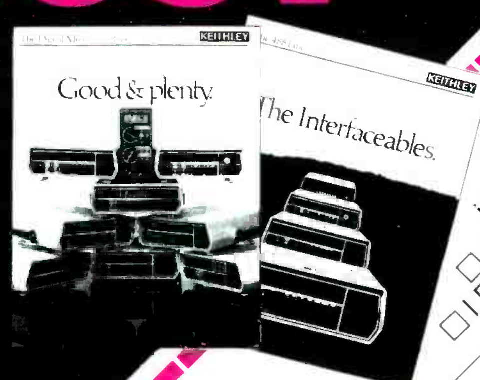

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