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Tel: St. Albans 89292. Telex: 23350.
Our cover photograph is of part of the vibrations and sound section of Evoluon, the permanent exhibition at Philips, Eindhoven. In this abstract presentation sounds are converted into electronic pulses, transmitted and reconverted into sound. Photographer Paul Brierley.

IN OUR NEXT ISSUE
How a modified fan tuner used in conjunction with a simple oscilloscope and a home-made aerial will receive weather pictures from satellites. A review of television receiver techniques. Making a turntable and pickup arm.

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The Plight of the Microcircuit Industry

During the past month there have been some dramatic moves made in the British microcircuit industry. First came the announcement that the G.E.C. proposed closing the Marconi-Elliott Microelectronics factories at Witham, Essex, (which was purpose built in 1968) and at Glenrothes, Fife. Within days of this proposal Motorola held a party in East Kilbride, Lanarkshire, to celebrate the start of work on the building of a new microcircuit factory! Then came a press release from Mackintosh Consultants Company, of Glenrothes, outlining the results of a survey of the British microelectronics industry they had undertaken on behalf of the Department of Trade and Industry and the National Research Development Corporation.

This report, which is confidential, although abridged copies have been made available to the companies who participated in the survey, expresses the views of the consultants and not necessarily those of the companies concerned nor the sponsors of the study. However, the brief details given in the press release must have sent a shudder down the spine of some British companies. The view is expressed that because of the dominance of European markets by American manufacturers, no single national market in Europe (and this applies equally to Britain) is capable of supporting even one major i.c. company and, moreover, no company can succeed in this industry without access to markets which are both large and innovative. When one looks at the production figures of the big five microcircuit companies in the States and compares them with the total output of all the indigenous European companies (including Philips) one finds that the aggregate is not half of any one of the major American i.c. companies. In face of competition from such giants what prospect is there for a British microcircuit industry or even a joint European enterprise.

In the present climate of internationalism is it reasonable to think in terms of national companies? American companies have for some time been setting up factories in Europe to be in E.F.T.A. and E.E.C. In the face of such competition and in view of our plans to join the Common Market would it not be in our interest and in the interest of our Continental partners to set up a strong joint European i.c. company to compete in the world market for mass-produced microcircuits? This need not mean the end of i.c. research and production in this country; there would, we believe, still be room for one or two British manufacturers of specialized microcircuits.
Sweep-frequency Audio Oscillator

Two-decade linear sweep using b.f.o. technique

by R. J. Ward, B.A.

For many linear circuits the characteristic of prime practical importance is their frequency-amplitude response. This class of circuits includes tuned circuits, equalizers, filters and selective amplifiers. The response is commonly measured by connecting a variable-frequency oscillator to the input of the circuit and a suitable output measuring meter. Measurements are then made at as many fixed frequencies as necessary and plotted to obtain an overall picture of the performance. Though simple and convenient this becomes tedious when many response graphs have to be measured, and is too slow when demonstrating the properties of such circuits to a class of students.

In such situations it is useful to display the graph of gain or loss against frequency directly and quickly. This article describes an instrument which used with an oscilloscope or X-Y plotter enables such a direct plot to be made.

The components needed to build this oscillator cost at least £20 which is no doubt more than the cost of the much simpler audio sweep generator recently described by F. H. Trist.* The main difference in performance is the sweep linearity—0.2% in this design over a 100:1 frequency range as opposed to 15% over a 10:1 range for the simpler design. This figure of 0.2% allows direct accurate plotting along the frequency axis and the use of calibrated controls for varying the sweep range.


Fig. 1. In the swept frequency technique for obtaining the amplitude-frequency response of networks quickly, a sawtooth waveform controls a voltage-to-frequency converter and simultaneously sweeps the oscilloscope beam in the X-direction.

The present design is single range and therefore limited in total coverage. Other features such as output level and sweep-rate controls are not fundamental to the technique but come from aiming for maximum flexibility within one frequency range. Automatic level control and waveform purity are similar in both designs except that F. H. Trist's generator should be completely free of spurious signals not harmonically related to the fundamental.

The technique used is illustrated in Fig. 1. The sawtooth voltage simultaneously tunes the oscillator and sweeps the beam across the screen, so that the sideways deflection is proportional to frequency—a 'frequency base'. The Y-deflection is proportional to the output amplitude, so assuming the oscillator output level remains constant a plot of gain against frequency is obtained.

In this instrument two decades of frequency are covered in one band using a beat-frequency technique—Fig. 2. Oscillations at frequencies $f_1$ and $f_2$ are fed into a mixer which produces many frequencies at its output, principally the original ones together with the sum ($f_1 + f_2$) and difference ($f_1 - f_2$) frequencies. The difference frequency signal is selected by a filter. If the original frequencies are well above the difference frequency then the latter can be easily filtered from the mixer output, but if they are too high a small fractional change in either $f_1$ or $f_2$ will result in a large fractional change in $f_1 - f_2$, so frequency stability will be poor.

Frequency $f_2$ is fixed at 20kHz and variable from 20 to 30kHz giving an output at 0 to 10kHz. In practice the output waveform deteriorates when $f_1$ and $f_2$ are very nearly equal so the usable output range is 100Hz to 10kHz.

Sweep generator

The overall structure of the complete sweep oscillator is shown in Fig. 2. It is convenient to start its description with the sweep generator. Audio-frequency systems.
Prototype specification

Frequency range: 100Hz to 1kHz in one range, accurate to ±100Hz mid-scale or ±20Hz by calibrating potentiometer; ±20Hz at range ends.

Amplitude: adjustable up to 3V r.m.s. (open-circuit) in six ranges and accurate to ±5%. Level to 3% over range. Output impedance is 600Ω ± 2%, except on highest ranges (± 20% for 3-V range and ± 2% + 7% for 1-V range).

Spurious outputs: second harmonic 0.5% or -45dB. All other spurious signals at least 45dB below fundamental at 1kHz.

Sweep times: 50ms to 20x in four ranges.

Sweep modes: "full"-1kHz-1kHz; "wide"-100Hz to frequency set on dial; 'symmetrical'-swEEP widths of 30, 100, 300Hz, 1 or 3kHz ±3%, centre frequency set on dial; 'external'-sensitivity about 800Hz/V, Zin = 50Ω.

Other outputs: sweep output +5V and -5V from 1kΩ. Blanking -20V pk-pk 20-kHz square wave for bright-up from less than 6kΩ.

The voltage from the sweep generator and the potential at point A is such that a positive blanking pulse of nearly 10V is available during flyback. If this pulse were inverted and amplified to give a negative pulse this would be satisfactory for bright-up on oscilloscopes at the faster sweep rates. Unfortunately, the Z-modulation input of oscilloscopes is commonly a.c.-coupled to the grid of the c.r.t. so that this blanking is ineffective at slow sweep rates. To circumvent this a gated high-frequency oscillation is used.

Referring to Fig. 4, a 20-kHz square wave from the fixed-frequency oscillator is applied to Tr3 together with the positive blanking pulse (b). Transistor Tr3 and its associated components now behave as a NOR gate with output (c) which after a.c. coupling to the grid of the c.r.t. becomes (d). If the brightness control is adjusted so that the beam is just cut off with no Z-modulation applied, as shown, it will remain cut off during flyback but pulse on some 20,000 times per second during the sweep. Subjectively these dots merge together on the screen to give a normal display, except for some moiré fringing when displaying the envelope of a waveform whose frequency is close to a low-order sub-harmonic of 20kHz; this is not normally a nuisance.

Voltage-tuned oscillator

The voltage from the sweep generator
after passing through the control network (see later) is converted to the frequency of an oscillation by a voltage-tuned oscillator. The circuit is shown in Fig. 5 where the basic oscillator is followed by a conventional divide-by-two bistable multivibrator to provide two square waves, at E and F, in anti-phase and with unity mark/space ratio. The basic oscillator is an astable multivibrator with a pair of constant-current sources controlled by the input voltage at D.

The astable multivibrator tunes over the band 40 to 60kHz. This is divided by two and mixed with 20kHz to produce the 0 to 10kHz audio output. In practice the relation between input potential and output frequency gives a maximum deviation from a straight line of 70Hz - 0.7% of full range at worst. This is reduced to 0.2% by adding a linearizing diode and resistor across the output.

**Fixed-frequency oscillator**

The design of the fixed-frequency oscillator is identical with that of the voltage-tuned oscillator in the hope that frequency drifts in the two oscillators will be similar and to a large extent cancel. The nominal frequency at the point H, Fig. 6, is 20kHz. To achieve this within a tolerance of 200Hz (1%) the input voltage at G is obtained from a potentiometer across the supply lines. To find the values for R4 and R5, first connect a 10-kΩ potentiometer across the ±10-V supply lines, and measure the required voltage. Calculate R4 to give a voltage 10% lower than this, using a preferred value, and try values of R5 around ten times R4 until the frequency is as close as possible to 20kHz. The square wave for the blanking oscillator is obtained from the collector of TR8.

**Conversion to sine-wave**

The 20-kHz output from the fixed-frequency oscillator at H drives TR7 as a

(Below) Fig. 7. Amplitude of the fixed-frequency output is controlled by the shunt a.l.c. transistor and drive. Tuned filter reduces second harmonic to 0.05% of fundamental before applying signal to balanced mixer.
switch—Fig. 7—producing a square wave at its collector. Transistor $T_{r_1}$ is shunted by $T_{r_9}$ so that the amplitude of the square wave is controlled by the automatic-level-control current flowing from the base of $T_{r_9}$.

This square wave goes to the low-pass $RC$ filter consisting of $R_6$ and $C$, whose output is a sawtooth which is applied to the input of the tuned amplifier, containing $T_{r_{4,5}}$, due to Faulkner and Downe†. This amplifies the 20-kHz fundamental and attenuates harmonics. Amplitude of the second harmonic is 0.05% of the fundamental (0.8V); the amplitude of the other harmonics could not be measured directly but calculated values are 0.1% third harmonic and less than 0.02% fifth harmonic.

**Mixer**

The mixer forms the product of this sine wave of frequency $f_2$ with the variable-frequency square wave. The output from the mixer can be expressed as a Fourier series of sine waves having frequencies $Nf_1 \pm f_2$, where $f_1$ is the frequency of the square wave and $N=1,3,5, \ldots$. In this application $f_1=20$kHz, and $f_2$ varies from 20 to 30kHz, giving the following components:

<table>
<thead>
<tr>
<th>Component</th>
<th>Frequency (kHz)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$f_1-f_2$</td>
<td>0 to 10</td>
</tr>
<tr>
<td>$f_1+f_2$</td>
<td>40 to 50</td>
</tr>
<tr>
<td>$3f_1-f_2$</td>
<td>40 to 70</td>
</tr>
<tr>
<td>$3f_1+f_2$</td>
<td>80 to 110</td>
</tr>
</tbody>
</table>

There is a clear two octaves (10kHz to 40kHz) between the wanted signal and the lowest unwanted signals, so the latter can be easily filtered out leaving a pure sine wave. If the original sine wave is not pure but contains harmonics then the output from the mixer will have other components in the range 0 to 40kHz.

Operation of the mixer—Fig. 8—is explained with reference to Fig. 9 where a sine wave is being multiplied by a square wave of 1.5 times the frequency. In Fig.


Fig. 8. Balanced mixer produces difference frequency between fixed and variable-frequency oscillators. Because the summing amplifier $T_{r_{1,4}}$ is linear, difference frequency signal amplitude is proportional to fixed-frequency signal amplitude and hence controlled by the a.i.c. circuit: In all these circuits alternative transistors are C724, BC107 for C424; C740, BFY76 for C450; V723, BSX29,36 for V405A and V723, BCY72 for V435A.

**Fig. 9. Simplified circuit of switching mixer with points L and M at (a) corresponding to those in Fig. 8. Mixer waveforms at (b) are with fixed and variable frequencies in ratio 2:3. Bottom waveform is filter output.**

† 2% high stability

$47k$ $6.8k$ $2.7n$ $300p$ $1.5k$ $6.8k$ $6.8k$ $6.8k$

Fig. 10. As well as difference frequency, there are additional components, e.g. $f_1+f_2$, $3f_1-f_2$, $3f_1+f_2$, which must be filtered. Low-pass filter shown has a cut-off frequency of 10kHz and a slope of nearly 36dB/octave giving 64dB attenuation at 40kHz.
9(a) the switches $S_L$ and $S_M$ are closed alternately by the square wave while sine waves in antiphase are fed to the top ends of the resistors. When $S_L$ is closed $S_M$ is open and the output is essentially the inverse of the input sine wave. When $S_M$ is closed $S_L$ is open and the output is essentially the same as the input. So the required multiplying action is obtained. In practice $S_L$ and $S_M$ are transistors $T_{r1}$ and $T_{r2}$—Fig. 8—the sine waves are displaced from zero mean level so that these transistors are always forward biased.

Transistor $T_{r10}$ is a phase inverter producing two equal and opposite signals to feed the emitter followers $T_{r11}$ and $T_{r13}$. The summing amplifier $T_{r15}$ is linear in the sense that the amplitude of the component at $f_2 - f_1$ is proportional to the amplitude of the sine wave $f_1$, thus the a.i.c. modulator controls the amplitude of the output.

**Filter**

The filter used to separate the wanted component from the complex wave consists of three cascaded active low-pass sections—Fig. 10.

The measured overall gain of the complete filter rises from near unity (0dB) at zero-frequency to +2.6dB at 8kHz, after which it falls slowly to +1.3dB at the cut-off frequency 10kHz, and then rapidly at nearly 36dB per octave so that signals above 40kHz are attenuated by at least 64dB. The output from the filter is amplified to 3V r.m.s. by a further LM709 used as a linear amplifier feeding the output attenuator—Fig. 11.

**Automatic level control**

The output level will vary as the frequency sweeps across the range because of the filter characteristic. This variation is only about 3dB but it can easily be reduced with the automatic level control circuit—Fig. 12.

With this method the variation of amplitude over the entire frequency range was reduced to 3% pk-pk when the sweep period was four seconds. The levelling deteriorates at fast sweep rates because of the slow response of the detector caused by the smoothing components.

**Control network**

Between the sweep generator and the voltage-tuned oscillator, the control network—Fig. 13—enables sweep frequency range to be set in several ways by the panel controls. A low-impedance supply at nominally −5V is provided by the operational amplifier—connected as a voltage follower. This potential, adjusted by the 2-kΩ potentiometer, is applied to one end of the frequency control and corresponds to zero-frequency output. There are four sweep modes selected by $S_s$. In the ‘full’ mode the output frequency is swept from zero to 10kHz. The 1-kΩ preset potentiometer adjusts the amplitude of the sweep voltage across the frequency control so that this range can be set accurately. In the ‘wide’ mode the upper frequency limit is set by this control. Some non-linearity in the calibration of this control is caused by loading but with the values shown this should be less than 1%.

In the ‘symmetrical’ mode the switch section $S_{12}$ disconnects the sweep generator from the frequency control and applies a constant voltage, derived from the −10V supply, equal to the maximum positive excursion of the sweep waveform at A. If $S_s$ is set to ‘c.w.’, the...
Announcements

During the British Association annual meeting at Swansea there will be two public lectures at University College. The first, entitled 'The physics of musical sounds' will be given by Prof. C. A. Taylor (head of the department of physics, University College of South Wales) at 20.00 on September 8th. The second is devoted to fuel cells and will be given by F. T. Bacon (consultant to Energy Conversion Ltd) at 20.00 on September 7th.

A course of 20 weekly lectures (2.30-4.30) on sound studios and recording starts at the Polytechnic of North London, Holloway Rd, on October 28th (fee £10.50). On the same day at 6.30 a 13-lecture course on audio and acoustic measurement begins (fee £6.30). The lecturers include many well-known names in the audio world. Further particulars from the Dept. of Electronic & Communications Eng., Polytechnic of North London, Holloway Rd., London N7 3DB.

Modern electronic techniques is the title of a course of 10 afternoon lectures for engineers and technicians to be given at Portsmouth Polytechnic from October 8th. Fee £4.

Two one-day seminars on computer-aided design will be held at the Royal Garden Hotel, London, on September 21st and 22nd. Organized by our associate quarterly journal Computer-Aided Design, the first day will be devoted to computer-aided design in shipbuilding and the second to c.a.d. in engineering. Fee £23 each seminar.

A residential vacation school on lasers and their applications is to be held at the City University, London E.C.1, from 13th to 24th September. The school is designed for physics and engineering graduates.

The Wireless World Club programme, broadcast in the B.B.C.'s World Service on Thursdays at 12.45 G.M.T. and repeated on Fridays (23.45) and Sundays (06.15), is offering for the fourth year a DX award. The listing period is August 1-31, and entrants must give a concise reception report on one transmission from Great Britain and from each of the following: the Atlantic; East Mediterranean and the Far Eastern Relay Stations. Details from World Radio Club, B.B.C., Bush House, London WC2B 4PH.

Racal are negotiating to take over two more companies—Amplivox Ltd, manufacturers of hearing aids and other audio equipment, and Zonal Film (Magnetic Coatings) Ltd, the Iford subsidiary manufacturing magnetic recording material and tapes.

The recently formed International Radio and Electrical Distributors Association is planning its first trade exhibition to be held at the Bloomsbury Centre, London W.C.1, from Sunday 21st May to Thursday 25th May next year.

Specialist Switches, who for almost 20 years have been providing a 24-hour service in custom built rotary and lever switches type H, DH, He and LO, have been taken over by Stoneleigh Electronics Ltd, and are now at Factory No. 8, Bridge Close, Romford, Essex.

Texscan Instruments Ltd, of Lord Alexander House, Hemel Hempstead, Herts, has been formed to handle the sales and service of the range of sweep signal generators, attenuators and filters produced by Texscan Ltd Inc., in America. The new company is also responsible for the marketing of wideband power amplifiers from Electronic Navigation Industries Inc. and function generators and r.f. power sources from Microdot Inc.

Emi has won a contract to develop for the Post Office experimental digital transmitters and receivers for the 10.7-11.7GHz band 'which could well provide a basis for the next generation of microwave equipment for the telecommunications network'.

An airborne maritime radar to detect submarines as well as to carry out general surveillance duties on maritime surface traffic is to be developed by EMI under a contract placed by the Ministry of Defence (Aviation Supply).

GE C-Mobile Radio, a division of Marconi Communication System Ltd, has moved from Coventry to the Chelsford area. Their new headquarters is at Great Baddow, where the commercial and export departments are also housed, but the main service department will remain at Coventry Other service depots, such as those at Altrincham (Cheshire), Edinburgh, Leeds and London, will remain in operation.

Matsushita Electric are marketing a range of printed wiring boards through Steatie Insulations Ltd, of Hagley Rd, Birmingham, B16 9QW. The boards consist of phenolic resin impregnated paper, epoxy resin impregnated cloth, and Daston plated-a process whereby powdered copper is fixed with adhesive ink to an insulated board which has a wiring pattern already on it.

R.E.W. Audio Visual Company, of London S.W.17, have been appointed sole distributors of the new series 7 Ferrograph-Dolby tape recorders in the U.K.

Marconi Instruments Ltd are to supply to the Home Office an automatic test system for Bremner's v.h.f. Personal Alerters. The 'Autotest' takes 30 seconds to automatically measure signal frequency, i.f. and audio frequency, as well as d.c.

FieldTech Ltd, of Heathrow Airport, have been appointed sole U.K. agents for a range of epoxy glass fibre whiz aerials, manufactured by Valerio Electronics (Guelph) Ltd, of Ontario, Canada. They cover the frequency range 3-30MHz, and are capable of handling 5kW average, 10kW peak.

Gresham Recording Heads Ltd have appointed Radio-Equipments, of 9 Rue Bross Cognais, 92-Levallois-Perret, France, agents to handle recording head sales throughout France.

Motorola have appointed GDS (Sales) Ltd to handle the sales of all their semiconductors in Eire and Northern Ireland.

Books Received

Transistor Circuits in Electronics, second edition, by S. S. Haykin and R. Barrett. The book, written for students taking electronics in full-time or sandwich courses to degree, H.N.D. and H.N.C. level, will appeal also to electronics engineers. In this new edition a chapter has been included on monolithic integrated circuits, and logic symbols have been redrawn to BS3939, 1969, Section 21. Chapter headings are as follows: transistor characteristics; graphical analysis; small signal equivalent circuits and parameters; amplifier circuits; feedback amplifier and oscillator circuits; switching circuits; regenerative switching circuits; logic circuits; modulator and demodulator circuits; and integrated circuits. There is a single page bibliography, an appendix explaining the super-position theorem of the integrals and the theorem, and a five-page index. Pp. 367. Price £3.80 cased and £2.50 limp. Tufte Books, Butterworth & Co. (Publishers) Ltd, 88 Kingsway, London WC2 6AB.

Helical V.H.F. Aerial

Using twin helices with triangular cross-section

by George J. Monser, M.S.E.E.

To date the helical aerial, which has many desirable reception properties, has been overlooked to some extent for domestic v.h.f. reception, mainly because of the difficulties in building and installation. An attractive feature to recommend, the helix is that it is circularly polarized, which means that it responds equally well to any linear polarization. As a result, fading effects due to propagation disturbances and multipath effects tend to be minimized. In short, a gain of 8 to 10dB over the band can be provided, even under adverse conditions. Multipath propagation can change the plane of polarization. Thus, if you are using an aerial designed strictly for horizontal polarization, a signal loss of 3dB or 50% of the r.f. power may result.

Other attractive features of the aerial described are:

—It offers a nearly flat resistive impedance of 135 ohms, which means it can be connected directly to 300-ohm twin-lead with little loss.

—The phasing of the turns is such that it gives a maximum gain of 8 to 10dB over the band.

With such good features, why isn’t the helix more frequently used? Mainly because conventional designs are cumbersome to build and difficult to install. First, as the name suggests, the radiating elements must be helical turns. When the size of these turns and the axial length are chosen for v.h.f. radio or television it is found that building such an antenna isn’t so easy. Second, conventional designs are single-ended, or unbalanced. Thus, for proper operation, a sizeable ground-screen is required, posing difficult mounting problems.

By two simple modifications, the helix can be adapted for home construction. The first consists of changing the cross-section from circular to triangular. Thus, each turn is formed as a rigid triangle instead of a circular turn.

In the second modification, the turns are bifilar wound so that a balanced aerial is provided, requiring no ground screen. The cost of these modifications is slight.

Typically, conventional helices show 2 to 3dB variations in response with polarization. This model, when tested, showed 2 to 5dB variation, which is still quite acceptable.

The design, detailed in the illustrations, covers the band 88 to 170MHz which in the U.S.A. includes the f.m. sound broadcasting band and most of the v.h.f. television band. But the aerial has useful gain at higher frequencies e.g. about 6dB at 200MHz. It can be scaled for other frequency bands— I built a 1/15-scale model for testing.

By using a balun, it can feed receivers with unbalanced 75-ohm input circuits.

Fig. A. Alternate elements on this U-channel form one side of the two tetrahedral helices. Model in this photograph has an extra element—extreme right—not shown in the table.

Fig. B. One complete helix with supports attached to element vertices using either metal tie strips (three vertices on right) or with wire (vertices on left). The extra turn shown on this helix is optional.

Fig. C. Completed aerial with feeder cable attached to last two elements.

Table 1. Parts needed

| Perspex pieces | 1.15m x 38 x 6.5mm (45 x 1 1/2 x 1/4in) 2 off
| 1.2m x 38 x 6.5mm (48 x 1 1/2 x 1/4in) 2 off
| 1.2m x 38 x 6.5mm (48 x 1 1/2 x 1/4in) 2 off
| Aluminium strips |
| 1.83m x 13 x 1.6mm (72 x 1/2 x 1/16in) 13 off
| Aluminium right angle |
| 1.83m x 13 x 1.6mm (72 x 1/2 x 1/16in) 13 off
| Also needed are self-tapping screws, nuts, bolts, tie strips and wire, wooden or plastics mast, 300-ohm balanced feeder cable.

Table 2. Element lengths

<table>
<thead>
<tr>
<th>Element no.</th>
<th>first helix lengths (cm)</th>
<th>second helix lengths (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>138</td>
<td>139</td>
</tr>
<tr>
<td>2</td>
<td>123</td>
<td>115</td>
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<td>3</td>
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<td>5</td>
<td>109</td>
<td>100</td>
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<tr>
<td>6</td>
<td>103</td>
<td>94</td>
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<tr>
<td>7</td>
<td>110</td>
<td>103</td>
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*Second-turn elements identified by asterisk in drawings.
Ceramic Discriminator for Narrow-band F.M.

Product Application Note

by D. Balfour*

Piezoelectric materials have been employed in the communications industry for many years, the most commonly known being the quartz crystal used widely as an oscillator and for filter networks. The ceramic resonator has achieved similar penetration as a frequency determining element or as part of a filter network at frequencies around 455 kHz. Both these devices are similar in that being piezoelectric their mechanical vibrations may be considered in terms of electrical parameters of inductance, capacitance and resistance. Their equivalent circuit in the vicinity of resonance is shown in Fig. 1.

Quartz, however, whether in its natural state or whether grown synthetically, has a fixed set of piezoelectric constants, which limit some of the electrical values obtainable, for instance the ratio of $C_s$ to $C_t$.

![Fig. 1. Equivalent circuit of a piezoelectric resonator.](image)

Table 1

<table>
<thead>
<tr>
<th>Type</th>
<th>Channel Spacing</th>
<th>Resonances $f_A$, $f_B$ (kHz)</th>
<th>$C_s$, $C_t$ (pF)</th>
<th>$L$, $R$ (mH)</th>
<th>$Q$</th>
</tr>
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<tbody>
<tr>
<td>TFD4</td>
<td>20-26 kHz</td>
<td>$\pm 18$</td>
<td>2.2 61 16 360</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TFD5</td>
<td>12.5 kHz</td>
<td>$\pm 12$</td>
<td>3.2 40 15 369</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

of $L$, $C_t$, $R$, $C_s$. Between these two frequencies $F_R$ and $F_A$, the impedance of the transfilter is largely inductive, becoming entirely resistive both at $F_R$ and at $F_A$. By altering the piezoelectric coupling of the material we can alter the spacing between $F_R$ and $F_A$ within wide limits, and have manufactured two devices (TFD4 and TFD5) suitable for 25 and 12.5 kHz channel spacing systems respectively. Brief details of the devices are given in Table 1.

Resonances have been chosen symmetrical to 455 kHz and are placed almost at the adjacent channel frequencies. This placing helps improve the overall rejection of the complete system. Typical values for the parameters of each device are tabulated. In general, the admittance of the device may be calculated exactly from the equation:

$$Y = \frac{1}{R + j\omega L + \frac{1}{j\omega C_s}} + j\omega C_d$$

This is cumbersome and it can be shown that within $\pm 5$ kHz of 455 kHz that the network can be considered lossless with little error. It can further be shown that the impedance may be expressed as follows:

$$Z = 1.0 + 0.11f + 0.006f^2$$

for the TFD5 or

$$Z = 1.3 + 0.2f + 0.02f^2$$

for the TFD4, where $f$ represents the deviating frequency in kHz. This impedance is approximately true for $\pm 5$ kHz for the TFD5 and $\pm 5$ kHz for the TFD4.

The ideal device would have a linear change of impedance with frequency and the following procedure may be used to achieve a substantially linear output with the circuit of Fig. 2.

Assuming that both $A$ and $B$ are resistive the following expression gives the ratio of the output volts to the input volts:

$$\frac{V_o}{V_{in}} = \frac{B}{A + B} \frac{1}{\sqrt{1 + \frac{AB}{(A+B)Z}}}$$

The problem then resolves itself into two forms:

1. To linearize the expression:

$$\frac{1}{\sqrt{1 + \frac{AB}{(A+B)Z}}}$$

so that it becomes closely linear with frequency. This involves choosing a specific value for the expression $AB/(A + B)$, which is the value of $A$ in parallel with $B$ and is not definitive with respect to $A$ or $B$.

2. To maximize the value of the output by choosing $B/(A + B)$ to give the greatest sensitivity commensurate with the limits in 1. The value of $AB/(A + B)$ has been computed to give a linear relationship of output versus deviation for the points $-3, 0$ and $+3$ for the TFD5 and $-5, 0, +5$ for the TFD4, using figures in Table 1. The results are as follows:

$$\frac{AB}{A + B} = 1.5 \text{ k}$$

for the TFD4, and

$$\frac{AB}{A + B} = 1.7 \text{ k}$$

for the TFD5. The results are as follows:

$$\frac{AB}{A + B} = 1.5 \text{ k}$$

for the TFD4. The sensitivities achieved for $A$ and $10k\Omega$ for $B$ are satisfactory for both TFD4 and 5. The sensitivities achieved are $32\text{mV/kHz}$ for a 1V input for the TFD4 and $50\text{mV/kHz}$ for a 1V input for the TFD5, as shown in Fig. 3.

The adjacent channel sensitivity is much less than for wanted channel, typically 0.33. This means that the discriminator acts as a filter for adjacent channel signals giving 8 to 10 dB rejection.

![Fig. 2. Circuit of the discriminator.](image)

![Fig. 3. Performance of slope detector using TFD4 and TFD5.](image)
The basic requirements for a unit which enables two signals to be seen simultaneously on an oscilloscope were discussed in Part 1, where it was shown that two identical amplifiers with input attenuators and an electronic switch are required. A maximum overall gain of unity is needed but, to reduce the effective capacitance of the input cable, input attenuation must be used and so subsequent amplification must be included to offset this. It is important that the input resistance of the amplifier be well defined, which means that it must be provided substantially by a resistor, and so, with the usual parallel connections, the amplifier proper must have an input resistance which is very large in comparison.

The junction field-effect transistor is the obvious choice for the input stage of any amplifier which must have a high input resistance. Its main drawback is its enormous tolerances. It is also rather more costly than the usual bipolar transistor.

Fig. 1 shows the characteristics of the BFW10 f.e.t. At zero gate voltage, the drain current may be from about 7.8 mA to about 20 mA, while the gate cut-off voltage may vary from -2.1 V to -8 V. In an amplifier in which it is impracticable to use capacitance interstage couplings, it is imperative that the d.c. level of the output electrode be substantially constant and this is where the difficulty in using the f.e.t. arises.

If the f.e.t. is employed as a source-follower, it is necessary for the source to be always at some fixed voltage relative to earth. One can use a variable source resistor which is adjusted to suit the particular f.e.t. employed. For example, one might decide to operate at 1.5 mA to suit a low-tolerance f.e.t., which will demand a gate bias of -1.5 V. If, as is usual, the gate is returned to earth, the source must be 1.5 V above earth and at 1.5 mA, a source resistance of 1 kΩ is needed. With a high-tolerance f.e.t. the source must still be 1.5 V above earth but the current will be 13.9 mA and the source resistance must be 108 Ω only. This is far too low for good source-follower action and instead of the "gain" approximating unity, it will be around 0.23 only.

A better alternative is to use a fixed value of source resistance. Constant voltage then demands constant current, which must be chosen at a suitable value for a low-tolerance f.e.t., say, at 1.5 mA. Control must then be exercised by a variable negative gate bias which is adjusted to suit the f.e.t. It can be seen from Fig. 1 that for a high-tolerance f.e.t., -6 V bias will be needed to give 1.5 mA. This means -4.5 V bias additional to the 1.5 V source bias. The gate return now cannot be earthed, but must be taken to a source of up to 4.5 V negative to earth, which must be stabilized. This is inconvenient. The "gain" is still not constant but is more constant than with a variable source resistor. This is because at constant current a high-tolerance f.e.t. has a much lower mutual conductance than a low-tolerance one, as can be seen from the slope of the curves in Fig. 1.

In the writer's view there is only one practicable way of coping satisfactorily with the tolerances of the f.e.t. when there must be an output point at a constant voltage to earth. This is to use it with a p-n-p transistor (if it is an n-channel f.e.t.) in the circuit shown in Fig. 2. The resistor $R_g$ is made variable and is adjusted to bring the collector of $T_2$ to a fixed voltage $V_C$ with respect to earth.

Ideally, the voltage amplification is $1 + \frac{R_C}{R_S}$. In practice, it is somewhat less. It can be within about 95% of this figure for low tolerance to normal f.e.t.s, but it falls off more with high-tolerance ones because $R_g$ then becomes too small. The circuit is an admirable one for an f.e.t. with a tolerance range of about one-half of that of the
The circuit has a low output impedance and so is not much affected by a load $R_L$ as long as this does not draw direct current. It has a good high-frequency response and works well up to at least 10 MHz.

Assuming, as usual, that the base current of $T_2$ is negligible compared with the collector current,\[ V_C = V_S + I_C R_C \]
\[ V_S = (I_C + I_D) R_S \]
\[ V_{BE} = I_D R_D \]

from which
\[ V_S = V_C \frac{R_S}{R_C+R_S} + I_D \frac{R_C R_S}{R_C+R_S} \]

The f.e.t. thus behaves as if it were source biased by a resistance having the value of $R_C$ and $R_S$ in parallel returned to a voltage positive to earth by $V_C R_S/(R_C + R_S)$. If, for example, $R_C = 470$ kΩ and $R_S = 1.5$ kΩ, the parallel value is 358 Ω. If $V_C = 4$ V the reverse return voltage is 0.95 V. By drawing a bias line from this voltage to represent 358 Ω in the usual way, the intersections with the f.e.t. curves enable $I_D$ and $V_S$ to be read off for low- and high-tolerance and normal f.e.ts.

For the three cases of the BFW10, with $R_C$ = 1.5 kΩ, the collector current is 1.67 mA, and 0.4 mA respectively. The signal conditions are more complex and the equations for gain are developed in the Appendix. The performance depends very largely upon a quantity which is termed $y$. It is the effective current gain of $T_2$ and in the limit becomes $h_{fe}$. This only occurs when $R_D$ becomes infinite and is only approached when the input resistance $h_{ie}$ of $T_2$ is very small compared with $R_D$ so that substantially all the signal current of $T_1$ flows into the base of $T_2$.

For given values of $V_C$, $R_C$, and $R_S$, $I_D$ and $V_S$ are much greater for a high-tolerance f.e.t. than for a low, and so $I_C$ must vary inversely. As $I_p$ rises, $R_D$ must be reduced, and as $I_C$ becomes less, $R_S$ increases. The result is that $y$ varies very greatly between low- and high-tolerance f.e.ts.

Taking $V_{BE} = 0.65$ V, which is typical, the value of $y$ given in the Appendix can be expressed in d.c. terms as
\[ y = \frac{h_{fe}}{1 + \frac{g_m R_S (1 + y)}{25(V_C - V_S)}} \]

It is clear from this that $V_S$ must not approach $V_C$ too closely. If it does, the denominator will become large and will vary very much with small changes of $V_S$. This means that the collector current must not be too small. For a large value of $y$ it is necessary that the collector current must be much larger than the drain current, but this is not always practicable.

In general, the larger $V_C$ the better, but there is a limit set by the requirements of a low-tolerance f.e.t. It is essential that the value of $V_C R_S/(R_C + R_S)$ be numerically less than the cut-off bias of a low-tolerance f.e.t.

Tables 1 and 2 give the calculations step by step for the BFW10 using the curves of Fig. 1 and taking $g_m = 3$ mA/V in all cases, since for the particular conditions it varies very little. In all cases, $g_{mn} = 100$, $R_C = 1.5$ kΩ and $R_S = 470$ kΩ; for Table 1, $V_C = 4$ V, while for Table 2, $V_C = 6.3$ V. In the two cases, the bias lines in Fig. 1 are AB and EF respectively.

With $V_C = 4$ V, the gain varies from 2.24 to 3.93, a ratio of 1.75:1, whereas with $V_C = 6.3$ V, it varies from 3.48 to 4.09 only, a ratio of 1.17:1. With the higher voltage, the output resistance is also much less.

If the circuit has a load $R_L$ this load must not draw direct current for the analysis of the Appendix to hold. The load can be fed through a capacitor, or it can be connected directly if its earthy end is taken to a voltage equal to $V_C$. The practical difficulty is then to ensure that temperature changes do not upset matters.

Table 1

<table>
<thead>
<tr>
<th>$V_C$</th>
<th>$I_D$</th>
<th>$V_{BE}$</th>
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</thead>
<tbody>
<tr>
<td>Low</td>
<td>1.5</td>
<td>235</td>
</tr>
<tr>
<td>Normal</td>
<td>1.5</td>
<td>365</td>
</tr>
<tr>
<td>High</td>
<td>2.5</td>
<td>725</td>
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</table>

Table 2

<table>
<thead>
<tr>
<th>$V_C$</th>
<th>$I_D$</th>
<th>$V_{BE}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low</td>
<td>0.7</td>
<td>316</td>
</tr>
<tr>
<td>Normal</td>
<td>0.3</td>
<td>366</td>
</tr>
<tr>
<td>High</td>
<td>0.3</td>
<td>825</td>
</tr>
</tbody>
</table>

Fig. 2. Circuit for an n-channel f.e.t. with p-n-p bipolar transistor.
that the overall temperature coefficient will be greater with a high-tolerance f.e.t. than with a low. An intelligent guess would put the overall temperature coefficient at about 3 mV/°C referred to the gate. At the output this will appear multiplied by the gain as a change of $V_c$. It may thus be 12 mV/°C or about ±0.15 V for ±12.5 °C temperature change.

Fig. 3 shows a circuit which was used experimentally. It was designed for $V_c = 4$ V. The f.e.ts used had the characteristics shown dotted in Fig. 1. Two rather similar specimens were used and both were much "lower" than a low-tolerance BFW10; obviously $V_c = 63$ V would not be appropriate with these. To set up the circuit an Avo on its 10 V range was connected between earth and the collector of $T_2$ and $R_2$ was adjusted for a reading of 4 V. The meter was then connected across $R_2$ and $R_2$ adjusted for zero volts, first on the 10 V range, then on the 2.5 V, and finally on the 50 µA range. It was found desirable to use an emitter-follower after the stage, partly to reduce capacitance loading on $R_2$ mainly to reduce the base current in $R_2$. The high-frequency response can be extended by adding a small capacitance (e.g., 25 pF) across $R_3$.

With the following stages an overall response almost flat to 5 MHz, and about –3 dB at 10 MHz, was readily obtainable. The only fault of the circuit lay in the difficulty of maintaining an adequate balance of the voltages at the two ends of $R_2$. An out-of-balance current of 10 µA in $R_2$ is about as much as can be tolerated and this corresponds to only 20 mV across $R_1$. One would expect this to occur with a temperature change of only around 2°C.

To maintain good balance both ends of $R_2$ must be connected to points which vary in voltage by the same amount. The only way which seems likely to give this reasonably well is to replace $R_1$ and $R_2$ by a duplicate amplifier and this requires the two f.e.ts to be fairly closely matched. This was not done because it was considered undesirable to use matched f.e.ts. The circuit was thus rather regretfully, abandoned. It should be understood that this was only because of the gain control. If that were not needed, and low-tolerance f.e.ts could be guaranteed, then $V_c$ could be 27 V only and the stage could drive the switched transistor directly. The temperature coefficient would not be important because it would only affect the position of the trace on the screen and a shift control is needed in any case and could correct it. The shift control would, in fact, be $R_0$, or a portion of it.

Before concluding, it is desirable to point out that a bipolar transistor can be used instead of an f.e.t. This is shown in Fig. 4. For simplicity, we shall treat this as an extension of the f.e.t. analysis and so shall call the collector current of $T_1$ $I_{c2}$ instead of the more usual $I_{c2}$. The previous equations apply, but additionally, $V_{B1} - V_{BE1} = V_s$

There is now no reason why the current of $T_2$ should not be much less than that of $T_2$; $R_5$ can be large and $y$ can be large.

It should be understood that the gain variations of the f.e.t. are dependent on the particular f.e.t. used. Design must be carried out so that the minimum gain is greater than the required gain and a pre-set gain control included. It is, of course, possible to reduce the variations by using a fixed value of $R_p$ and adjusting $V_c$ by negative bias on the gate. As mentioned earlier, this is not a complete cure and the need for a stabilized negative supply line is inescapable. It is a merit of the arrangement of Fig. 2 that the performance and $V_c$ are substantially independent of $V_{CC}$ so that a stabilized supply is unnecessary.

We have not so far discussed the possibility of obtaining higher gain. For $A = 10$, $R_{21} = 9$ kΩ, and in practice probably about 12. The effective bias line of 358 Ω is about the optimum for minimizing variations of $g_m$ so keeping this figure, we find $R_3 = 390$ Ω and $R_2 = 4.7$ kΩ approximately. For the bias line to start from 0.9 V, as before, $V_{BE2}$ must be 11.7 V. As $V_{CE2}$ must be at least 2 V, $V_{CE2}$ must be at least 14 V. All this is quite possible.

It is unlikely, however, that the frequency response would be adequate, and $R_3$ could certainly not be increased proportionately to $R_2$ without seriously affecting the response. In view of the difficulty of maintaining an adequate balance of the voltages at the ends of $R_2$ it was regrettably decided to abandon the circuit, and no work was done in an attempt to obtain higher gain.

It should be pointed out that further transistors are needed to couple the stage to the output stage. The base of the output stage is to be at 2.7 V; the output of the amplifier would be at 6.3 V. The amplifier output is in the same phase as the input, but the output stage gives a phase-reversal. It is desirable that there should be no overall phase-reversal, so the intermediate stage should be phase reversing or a common phase-reversing stage can be used after the common outputs of the two channels.

Fig. 5 shows a circuit for connecting two different voltage levels. From the signal point of view it is a form of cascode stage and gives phase reversal. For $T_1$

$$V_{BE1} = V_c - I_c2 R_{c2}$$

and for $T_2$

$$V_{BE2} = (I_c1 + I_c2) R_{c1}$$

and the gain is nearly $R_{c2}/R_{c1}$.

Also

$$V_{CE1} = V_{CE2} = I_{c21} R_{c21}$$

$$V_{CC} = I_{c21} R_{c21}$$

The usual practical difficulty is to make $V_{CE1}$ and $V_{CE2}$ large enough. Suppose, $V_{BE1} = 63$ V, $V_{BE2} = 2.7$ V, and $V_{BE11} = 965$ V with $V_{CC} = 105$ V. Then $I_{c11} R_{c11} = 5.65$ V. Suppose $R_{c11} = 1.5$ kΩ, then $I_{c11} = 3.76$ mA. If $R_{c11} = 1.5$ kΩ, $I_{c11} = 2.51$ mA. Now for $T_1$ let $V_{CE1} = 3$ V. The collector is then 8.65 V above earth and we can drop only 10.5–8.65 = 1.85 V in $R_{c11}$ with a current of 3.76 + 1.8 = 5.56 mA, so $R_{c11} = 332$ Ω. We then have $V_{BE2} = 10.5 - 1.85 - 2.7 = 5.95$ V. The only thing wrong with this is that 330 Ω
is rather low for \( R_{E1} \). The loss of signal can be corrected by increasing \( R_{E2} \) and frequency correction can be obtained by shunting \( R_{E1} \) by a small capacitance (<25 pF). A shift control which does not affect the gain can be obtained by making \( R_{E2} \) variable. It must, of course, be nominally 0.665 V plus the drop across \( R_{E1} \) or 2.5 V negative to \(+ V_{CC} \) and the supply must be stabilized with respect to \(+ V_{CC} \). This is easily done with a zener diode.

Thus, with an f.e.t. input stage we need a minimum of one f.e.t. and three bipolar transistors prior to the output stage. The arrangement has been fully tried out and with small capacitances across \( R_{E1} \) (Fig. 3) and \( R_{E2} \) (Fig. 5) an overall frequency response down by only 3 dB at 10 MHz was readily obtainable. The only fault lay in the inability to maintain the current in the gain control resistor small enough. It was felt that if the circuit was used it would be necessary to provide a balance adjustment as a panel control. In view of this it was decided to investigate other methods.

It may be asked at this point why the gain control was not capacitively coupled to remove d.c. from it. This was actually tried and abandoned. In the first place, because of the low resistance values needed to maintain the high-frequency response, at least 500 \( \mu \)F is needed. This means electrolytic types must be used and these have a leakage current. This can be small initially and be excessive current in the gain control. A shift control which does not affect the gain was tried. The merit of this circuit, Fig. 6, is that ideally there is no current in \( R_{E1} \), which solves the gain control problem. The circuit is usually used without \( R_{E1} \) and \( R_{E2} \), but they were included so that the currents in \( T_{R1} \) and \( T_{R2} \) would be better determined.

Transistors \( T_{R1} \) and \( T_{R2} \) are supposed to pass equal currents. Their base voltages must be the same except for any difference between \( V_{BE1} \) and \( V_{BE2} \). Ignoring base currents, \( R_{E1} \) and \( R_{E2} \) must be returned to substantially the same voltage. Now if current flows in \( R_{E1} \) and \( R_{E2} \), there must be a voltage drop across \( R_{E2} \) and the base of \( T_{R2} \) will not be at the same voltage as the base of \( T_{R1} \). But the base voltages cannot differ appreciably and so there cannot be current in \( R_{E2} \) and \( R_{E3} \). Thus the collector voltage of \( T_{R3} \) to earth is the same as the base voltages of \( T_{R1} \) and \( T_{R2} \).

With the particular conditions of Fig. 6, the base supply voltage for \( T_{R1} \) had to be 3.6 V compared with the base supply of 2.8 V for \( T_{R2} \), a difference of 0.8 V. In part this may be accounted for by differences of \( V_{BE1} \) and \( V_{BE2} \), but it was largely caused by the high base current of \( T_{R1} \) (9 \( \mu \)A) in the high base resistance (100 kΩ). This alone gave a bias difference of 0.9 V. In fact, the transistor used for \( T_{R1} \) had \( h_{fe} \sim 55 \) only.

The gain of the stage is nominally \( 1 + 800 / R_{E2} \) and this applies for the values used. In practice it is very close to this. The input resistance is high and was measured to be about 1 MΩ. Both the input resistance and bias difference could easily be improved by using a higher \( h_{fe} \) transistor for \( T_{R1} \). An improvement of about four times should easily be obtained.

The gain increased with frequency and was at least twice the low-frequency value of 10 MHz. A flat response was secured by adding the RC circuit across \( R_{C1} \). The circuit is a feedback one with three transistors in the feedback loop. It is thus potentially unstable. Theoretical design for stability is very difficult because it would require a detailed knowledge of all the transistor and circuit parameters up to 100 MHz or so, and even then would be very laborious. No difficulty was experienced in obtaining the required frequency response in the bread-board model but positive feedback was certain present and it was felt that difficulties might well arise over component tolerances. Further, the input resistance was lower than desired and although it could be made higher, it was doubtful if it could be made high enough.

The circuit is unquestionably an interesting one and it was abandoned rather regretfully because it was felt to be too subject to variation of performance from one amplifier to another. We may be wrong about this but we felt that we could not recommend its use until we had built 20 or 30 specimens to prove it. This was impracticable.

We, therefore, turned finally to an entirely different kind of circuit. It had been in our mind from the start, for it is an eminently designable circuit. It readily gave the required performance and its only fault is that it requires rather a lot of transistors, but they are inexpensive bipolar types. The development of this final amplifier will be treated in Part 3, and all component tolerances will be taken into account. In the main these tolerances have not been considered in this article because the procedure is rather tedious and one normally applies it only when a design is approaching finality.

**Appendix**

Under signal conditions, as distinct from d.c.,

\[
V_{in} = V_i + V_{g} = V_i + i_r R_1(1+j/j_0) - i_r R_2 \\
V_{g} = i_g f_{g} \text{ and} \]

\[
i_r = \frac{R_2 + (R_1 + R_2) j L_1 j_0 - j_0 R_1}{R_1 + R_2 + R_3} \\

\text{where} \quad f_c = 0.026/\epsilon = \text{emitter junction resistance. A little algebra then gives}
\]

\[
A = \frac{g_{m} R_2(1+y)}{1 + g_{m} R_2(1+y) + \left(1 + \frac{1}{1+R_2}ight)} \left(1 + \frac{1}{1+R_2}ight) \\
\text{or} \quad A = \frac{g_e R_2(1+y) R_1 + R_2 + R_3}{1 + g_{m} R_2(1+y) + \left(1 + \frac{1}{1+R_2}ight)} \left(1 + \frac{1}{1+R_2}ight)
\]

\text{where} \quad R_2 = (R_1 + R_2) R_1 + R_2 + R_3

\text{= output resistance. If} \quad g_m R_2(1+y) > 1, y > 1 \quad \text{and} \quad R_2 \gg R_3

\[
A \approx 1 + \frac{R_2}{R_3} \left(1 + \frac{1}{1+R_2}ight)
\]

\text{If, also,} \quad g_m R_2 R_3 \gg 1

\[
\frac{R_2}{R_3} \approx \frac{R_2}{1+y}
\]

![Fig. 6. Three transistor circuit which gives a gain of about 3.5 times with an input resistance of at least 1 MΩ and, ideally, has zero current in the gain control.](image-url)
News of the Month

Far East hold on TV market tightening
Sales of U.K. manufactured colour television receivers to the trade jumped by 46% in the first half of this year compared with the same period last year; the respective figures being 278,000 and 191,000. As expected there was a fall in monochrome receiver sales during the same period amounting to 16% from 789,000 to 666,000. It will be interesting to see what effect the recent relaxation in H.P. restrictions and purchase tax will have on sales for the second half of the year.

Looking at the overall picture things are not so bright. In the first quarter of the year total sales of British-made television receivers showed a decrease of 16% over the same period last year, 401,000 (484,000). In contrast imported receivers are selling at treble the rate they did last year.

The importers increasing dominance of the radio receiver market again caused decreases in U.K. produced equipment for the first six months of the year, 323,000 (342,000). These figures were provided by the British Radio Equipment Manufactures' Association.

If you can't beat them . . .
At a conference held in London recently, to discuss international harmonization of component standards, delegates from all nations present agreed that a world-wide agreement on standardization should be based on the system established by the Comité Européen de Coordination des Normes Electriques (CENEL). Delegations representing the following governments were present at the Conference: Belgium, Denmark, the Federal Republic of Germany, France, Italy, the Netherlands, Sweden, U.K. and the U.S.A.

Several nations have in the past few years set up various committees with the object of bringing national standards in line with international standards. Our own BS 9000, based on the second report of the 'Burghard Committee' which was published in 1965, is fully compatible with the recommendations of the International Electrotechnical Commission (I.E.C.) of which we were one of the creators. The countries of the E.E.C. and E.F.T.A. got together to form CEN and CENEL and, in addition, the governments of France, West Germany and the U.K. formed a Tripartite Committee to discuss component standard harmonization.

At that time the American Electronic Industries Association attacked the Tripartite Agreement. Mr I. D. Secrest, executive vice-president, made the following statement: "The Tripartite Agreement creates an absolute embargo against exports of U.S. electronic components to the U.K., France and West Germany. The agreement is not yet fully implemented. There is time to prevent this blatant violation of U.S. rights under existing trade agreements from occurring if there is strong and determined action by the United States" (See Wireless World, July 1969, p. 303).

The action, we are pleased to say—to complete the heading . . . is to join them. Recently, two years after the E.I.A. outburst over the Tripartite Agreement, the I.E.E.E., gave its support to a proposed bill, S.1798, before the Foreign Commerce and Tourism Subcommittees of the United States Senate, the purpose of this bill is "to foster fuller U.S. participation in international trade by the promotion and support of representation of U.S. interests in international voluntary standards activities, and for other purposes".

Mr Sherr, manager of standards operations of the I.E.E.E., in commenting on the bill said that "it should provide a mechanism to allow professional societies to effectively carry out such activity [international standardization], an effort for which technical societies are best able to provide appropriately qualified manpower".

As the U.S.A. have now expressed the desire, and this bill will give them the means, perhaps we shall see, at last, some truly international component specifications.

Two British i.c. plants to close
A cold wind blew through the i.c. industry recently when GEC Semiconductors...
announced that it was to close two of its factories producing microcircuits. The closeses were announced because increasing costs and falling prices led to heavy losses. One of the plants to be closed is at Witham, Essex; it has been open only two years and cost upwards of £2M to build. Also to be closed is a factory at Glenrothes in Scotland. GEC now intends to concentrate its microcircuit manufacture at the Hirst Research Laboratories at Wembley, Middlesex. A Witham engineer said that this does have advantages in that they will be in close contact with Hirst Labs where a good deal of semiconductor research is done and they will be able to use an 'in house' Myriax computer instead of having to rely on a rented terminal as they do at present. It is likely that we will see GEC pull out of standard i.c.s, in which fierce competition exists, and concentrate its resources on custom designed i.c.s which might result in an expansion of its m.o.s. activities.

A large American microcircuit manufacturer recently told Wireless World that the British i.c. industry is being killed by its own customers. In America and Germany, apparently, customers seem to be prepared to pay a reasonable price realizing that if the source of supply is not to dry up the manufacturer must have some profit margin, if only to recoup some of the development costs. According to the American manufacturer this does not apply in Britain and customers tend to beat down the price to rock bottom. This argument does not apply to such lines as American microcircuit manufacturing at t.t.l. where the manufacturers are *aging a t.t.l. where the manufacturers are *aging a

Electronic clocks and watches

A number of semiconductor firms are actively engaged in research on all-electronic clocks and watches with no moving parts at all. Producing an electronic timing 'movement' is easy, but the real problem is how to display the information—one can hardly go round with four neon tubes strapped to one's wrist. In an attempt to solve this problem a great deal of work is going on with liquid crystals, but the potential market is so huge that few people are saying anything at this stage. One firm has said that the future of one of its entire manufacturing departments depends on achieving a successful and economic answer.

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New hybrid resistor pastes

The Electrical Research Association (E.R.A.) has been trying to find materials which can be used as resistors for thick film hybrid microcircuits to replace the precious metals which are employed at present. Resistor pastes of precious metals are normally used because they retain their electrical conductivity after being fired in air. The electrical characteristics of a large number of materials are seriously affected by oxidation under these conditions.

Work of E.R.A. has shown that certain transition metal interstitials and some of their oxides retain their conductivity after being exposed to an oxidizing environment. Transition metals are those with the atomic numbers 22 to 30, 40 to 48 and 72 to 80 and an interstitial compound of these is one where atoms of small physical size (hydrogen, boron, carbon, nitrogen, oxygen, etc) are situated in the interstices of the parent metal lattice.

E.R.A. have successfully made resistor pastes with molybdenum boride and are now proceeding to find other materials with better performances and which are easy to process.

The reason for the behaviour of the transition metal interstitials is not fully understood, but E.R.A. think that the interstitial material may act as a reducing agent on the transition metal counteracting the oxidizing effect of the atmosphere during firing.

Facsimile transmission to police cars

The Home Office and Bristol Constabulary are co-operating in an experiment to discover the value of transmitting documents from headquarters to police vehicles using the v.h.f. radio system. Ten vehicles have been fitted with facsimile receivers connected to the normal mobile radio installations. The system is capable of transmitting documents of unlimited length but only 108mm wide such as sketches, maps, typescript, photographs, etc.

Tall buildings v microwave links

Post Office engineers are carrying out a series of tests to find out what effects tall buildings have on microwave links and how these effects can be calculated. A large number of factors are involved including the position of the building relative to the microwave link and the height, shape and materials used to construct the building. A helicopter has been fitted with a 9.4GHz radar modified by the Radio and Space Research Station for the job.

A ground receiver picks up a direct signal from the helicopter and the signal which has been reflected by the building under investigation. By altering the position of the helicopter it is possible to measure the building's radiation pattern. At Romford one building produced a reflection which was only 8dB down on the direct signal; enough to cause severe interference.

Ideas catalogue

A directory of computer programmes for solving scientific problems is available from Peter Peregrinus Ltd (P.O. Box No. 8, Southgate House, Stevenage, Herts, SO1 1HQ) following an agreement with Science Associates International (New York). The directory, called 'Computer programmes in science and technology', enables information to be obtained on how others have used a computer to solve particular problems.

Heatsink court case

Marston Excelsior Ltd has won a court action, under the design copyright act, against Waycom Semiconductors Ltd and Advance Electronics Ltd. The case concerned the manufacture of extruded aluminium heatsinks which were registered as Marston Excelsior model 10D. The court order restrains Waycom and Advance from manufacturing heatsinks to this design and instructs these companies to surrender to Marston Excelsior the heatsinks which infringe the copyright. In addition related drawings, catalogues etc., have to be destroyed.
**Letters to the Editor**

*The Editor does not necessarily endorse opinions expressed by his correspondents*

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**F.E.T. audio oscillator**

The design by Mr. A. J. Ewins of his F.E.T. audio-frequency oscillator in *Wireless World* for March, 1971, was most interesting.

The appended circuit may prove of further interest as the simple, economical arrangement gives extremely good results.

The direct-coupled amplifier has its quiescent operating bias conditions set by adjustment of the preset resistor $R_6$. Initially this is adjusted to give half the supply voltage at the emitter of $T_{R3}$. Ultimately this control can be further adjusted for minimum distortion from the oscillator providing that a suitable distortion measurement instrument is available.

The amplifier has moderate gain but low distortion when the overall negative feedback loop via the thermistor is open. This is due largely to the local inverse feedback circuits in the individual stages. The thermistor feedback loop is then relieved from controlling large and violent variations in gain due to transient conditions such as range switching or rapid tuning dial excursions.

Jitter accompanying frequency adjustment, familiar (and annoying) in most thermistor controlled RC oscillators, is considerably improved by the above means. This improvement is also assisted by the fact that only one RC time constant $R_{13}-C_{3}$, is present in the negative feedback loop. The combination gives an oscillator substantially free from tuning jitter.

There may have been good reasons for the choice of a $\sqrt{10}$ tuning ratio in Mr. Ewins' design, but it is generally more useful for a 10:1 frequency range to be available. Using a 450 pF double-gang variable capacitor and 22M$\Omega$ resistor for the lowest range, frequencies from 15 to more than 150 Hz can be generated. For the other four ranges the resistors are progressively reduced in decade steps so that the top range of 15 to 150kHz employs 2.2k resistors.

The frame of the variable capacitor must be insulated from earth as it is connected to the gate of the f.e.t. The tuning capacitor, range switch and associated resistors are vulnerable to hum and other stray field pick-up and thus should be carefully positioned. It is preferable to locate these components within a shielded compartment which should, however, not add too greatly to the stator-to-earth capacitance of the tuning capacitor. This would limit the highest frequency attainable on each range. The stator-to-earth stray capacitance and the input capacitance of the f.e.t. should in any case be compensated by adding a trimmer of similar capacitance across the top section of the tuning gang.

The oscillator described has a range of 15 Hz to more than 1.5 MHz covered in five decade ranges. It has an output of 1V r.m.s. at low impedance. Total harmonic distortion, measured at random spot frequencies on each range, using a Hewlett Packard 333A Distortion Analyser, was between 0.05 and 0.09%.

V. R. KRAUSE, Johannesburg, South Africa.

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**Ceramic pickup equalization**

While I would endorse Mr Burrows' conclusions in his article 'Ceramic pickup equalization', part 1 (July issue), I would like to point out that his efficiency calculation is not valid. He has calculated the input power to the cartridge by multiplying the r.m.s. velocity by the component at 45° of the tracking force. Unfortunately he has overlooked the fact that there is no net work done against the tracking force, because the work done against the force by the groove modulation on one half-cycle is returned on the next half-cycle. The tracking force is merely holding the stylus in the groove and has nothing to do with the cartridge input power.

If this is difficult to visualize, imagine a mono signal. This is at 90° to the tracking force and therefore can do no work against it, but yet there is still an output from the cartridge.

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*Fig. 1. Diagram of a simplified electrical analogue of the system.*

What the groove modulation 'sees', in terms of mechanical impedance, is the dynamic mass of the stylus assembly, the compliance (or rather the stiffness) of the cartridge, and the resistance to movement which is converted into electrical output. The question is whether or not the latter is significant in comparison with the former two.

The compliance can be resolved into two parts; the 'Hookean' component in which displacement from the mean position is proportional to the force applied, and the 'hysteresis' (or damping) component, in which displacement from any position is a function of applied force and change of applied force. A simplified electrical analogue of the system is shown in *Fig. 1*.

No work is done against the dynamic mass or the Hookean component of compliance, because the forces and velocities involved are 90° out of phase, e.g., stylus acceleration is zero when the velocity is maximum, and vice-versa. Therefore, the only work done against the compliance is against the hysteresis part. Forces and
velocities associated with dynamic mass and Hookean compliance result only in 'reactive' dyne cm, no actual ergs of work being done. Without knowing details of the hysteresis, the efficiency cannot be calculated, but what can be done is to compare the electrical output in ergs/sec with some of the 'reactive dyne cm/sec'.

For a Deram, the stiffness (1/compliance) at 1kHz is about 0.16 x 10^6 dynes/cm. At 1kHz and 20 cm/sec r.m.s. velocity, the r.m.s. force required to overcome the stiffness, assumed Hookean, is 500 dynes, resulting in 10,000 'reactive dyne cm/sec'. Assuming the stiffness to be Hookean results in the minimum number of dyne cm/sec for the given value of stiffness.

Now the maximum output from a Deram under these conditions is 1.1W into 270 kΩ. This is 1.1 x 10^-6 J/sec or 11 ergs/sec, so taking maximum power from this cartridge has a similar effect on the damping to connecting a resistor taking 11W across a tuned circuit involving 10 kV, i.e. a very small effect indeed!

Unfortunately, if we regard a cartridge as a series of black boxes, we conclude that the effect of loading is dependent on the characteristics of the last black box (i.e. the piezoelectric element in the case of a ceramic cartridge) and its coefficient of coupling with the previous black box, rather than on the efficiency of the whole system. Presumably manufacturers realise this and ceramic cartridges are independent of loading, not inherently but as a result of design.

H. C. Mirams, Bradford, Yorks.

The author replies:

I was interested to read Mr. Mirams' comments on the efficiency calculation, and he has rightly pointed out that the basis of the calculation was not sufficiently well explained to be rigorous. He is right in saying that there is no net work done against the tracking force is a good measure of the force necessary to keep the needle in contact with the groove walls (mono or stereo) and is therefore a direct measure of the minimal loading by design, but the main point which I tried to put over in the article is that this is a natural outcome from making an aperiodic transducer, and is not achieved by special design effort separate from the essential one of achieving non-frequency-dependent action.

B. J. C. Burrows.

**Diagnosis of logical faults**

I read with great interest the first part of 'Diagnosis of Logical Faults' by R. G. Bennetts (July issue) and readers may find the following comments pertinent. The circuit used to illustrate the various methods is reproduced in this letter as Fig. 1. This circuit was used as data for one of our standard programmes, CLOIS*, that generates automatically a multi-flow testing procedure from the circuit description using the fault matrix method. The resulting testing procedure is shown in Fig. 2. It can be observed that five tests are used to detect all faults, namely t4, t5, t6, t7 and t8 instead of the four tests that Mr. Bennetts suggests. The differences arise from the fact that when a node has a fan-out of greater than one Mr. Bennetts does not consider any extra faults whereas CLOIS inserts more faults. For instance input (a) is connected to G1, G2, and G3, and a fault could be that gate G2 is not connected to node C1, but it is connected to logical 0 instead. By considering such faults another ten faults can be introduced into matrices $F$ and $G_D$. However, the problem can also be reduced considerably as Mr. Bennetts later suggests. By deleting identical rows matrix $F$ needs only thirteen rows including the extra faults due to fan-out. The two extra rows are:

(1) $f_{17}$-connection to $C_4$ of gate $G_1$, s-a-1 which is identical to connection to $C_4$ of gate $G_4$ s-a-0, and

(2) $f_{18}$-connection to $C_4$ of gate $G_3$, s-a-0.

The extensions to the $F$ and $G_D$ matrices are shown in Figs. 3 and 4. From Fig. 4 it can be seen that fault $f_{18}$ is detected only by $t_4$ and therefore $t_4$ is also an essential test; $t_4$ also detects the presence of fault $f_{17}$.

This demonstrates that the minimal detection test set of Mr. Bennetts is only minimal for the particular faults he considered and that some simple faults are not detected by such a test set.

If may be of interest to mention that for this example CLOIS took eight seconds to compile the circuit data and fifteen seconds to generate the multi-flow testing procedure. The computer used was an ICL 4/70.

There are two further points in the article which are misleading. The extension of the fault matrix method to produce multi-flow testing procedures does not require as much storage as Mr. Bennetts mentions. The CLOIS programme used two matrices \( F \) and \( G_D \) of sizes 8 x 14 and 8 x 13, respectively, as compared to Mr. Bennetts' 8 x 136.

During the discussion of the path sensitizing method for fault \( f_i \) it is found that \( t_i \) and \( t_k \) all can detect the presence of \( f_i \). It is then suggested that \( t_i \) (or \( t_k \)) is used as this detects seven faults. If columns had been ignored if they are identical with previously entered columns then he would argue that \( t_i \) and \( t_k \) detect three faults each and \( t_i \) detects four faults, therefore he would have picked \( t_i \) instead of \( t_k \).

The final point is that the footnote on p.327 should be:
\[ n \left( \frac{n+1}{2} \right) = \left( \frac{n^2 + n}{2} \right) \]

A. H. BOYCE,
Research Division,
Marconi Company,
Great Baddow,
Essex.

The author replies:

It would appear that Mr. Boyce has misunderstood the purpose of the article. It was written as a tutorial introduction to digital circuit fault diagnosis and was not intended to be an exhaustive treatise on the subject.

Sonic scanning for tubeless TV

It was with interest that I read the article, 'Sonic scanning for tubeless TV' by J. J. Belasco, in the July issue. It reminded me of the work done some 10 years ago by Stephen Yands.

A similar flat device was built by him that utilized sonic scanning to display video information on an electroluminescent phosphor (see: 'A solid-state display device', Proc I.R.E. Vol. 50, No. 12, Dec. 1962). Basically, it consisted of a piezoelectric ceramic sheet covered with an electroluminescent phosphor, and sandwiched between a transparent viewing electrode, and a ground electrode. This was scanned by launching travelling elastic waves into the piezoelectric material. A spot could be produced by launching two travelling waves orthogonally, and selecting the increased amplitude at the intersection by a discriminating medium. By varying the relative timing between the orthogonal waves, the spot could be made to scan a raster.

To my knowledge, although crude Lissajous figures were displayed on such a panel, it never reached the stage of producing acceptable TV images. This panel was a continuous sheet of piezoelectric material since provision was made for two-dimensional sonic scanning. The one-dimensional sonic scanning array of 625 horizontal strips proposed in the article might possibly provide a better solution. However, the complexity of the number of interconnections and transducers could prove to be a stumbling block.

G. O. TOWLER,
Broomfield,
Chelmsford,
Essex.

Broadcasting frequencies

I should like to endorse, with one reservation, the sentiments of Mr. Higham's remarks on B.B.C. medium-wave broadcasts ('Letters; June issue')

The bad reception, owing to East German and Albanian interference, and phase distortion, renders intolerable reception in many parts of the country. The proffered alternative, the f.m. service, is always 'loud and clear'—but a weakness lies in the poor choice of programmes provided. For example, on one occasion recently, tuning into v.h.f., there was only one programme (jazz) to listen to. Radio 2 was then being relayed on Radio 3, and Radio 4 had closed down. This broadcast occupied no fewer than nine frequencies in Band II together with two a.m. outlets; a grand total of 11 simultaneous broadcasts! Three of the above frequencies were those of B.B.C. local radio stations—which relay from Radios 1-4 on average 60-70% of their broadcasting time. One wonders what could be less local than the relaying of national programmes.

Possibly, the long-awaited 'shot in the arm' for the B.B.C. could well lie in the creation of healthy competition with the promised commercial radio services.

However, I must condemn the concept of 'pirating' any odd frequency to hand. This is the law of the jungle, and causes interference. What is needed—after 23 years—is a complete re-appraisal of the broadcasting plan by the countries involved, and a new scheme drawn up. Following this, coupled with the new commercial stations, sound broadcasting could have a very bright and interesting future.

STEFAN WORONIECKI,
Lancing,
Sussex.
Circuit Ideas

Level-conscious trigger system
Schmitt triggers can be coupled together to make a channel selector governed by input signal amplitude. Although shown for d.c. triggering, adaptation for a.c. operation is possible. In Fig. 1 three Schmitt circuits are set to trigger at different voltage inputs. As shown, the higher trigger voltage will also trigger the circuits requiring lower trigger voltages. Fig. 2 shows inhibit feedback current circuits. These are used to short circuit the unwanted outputs as shown in Fig. 3. Diodes are required to isolate the output circuits of channels 2 and 3 from each other. Signal differentiation greater than 0.2V can be achieved with careful trigger design.

High input-impedance Schmitt trigger
The need for a high input-impedance trigger circuit is quite common and the usual approach involves using a field effect transistor as a buffer for a bipolar transistor Schmitt or an i.c. comparator. Designs using a junction f.e.t. or m.o.s.f.e.t. in both stages of the Schmitt are not common due to the wide spreads and low mutual conductance of these devices.

Recently silicon-gate field-effect transistors have become available with threshold voltages of 1 to 2V. This spread is sufficiently low to enable the conventional Schmitt circuit to be used. In the circuit shown a silicon-gate pair (M1202, G.E.C. Semiconductors) is used in a standard Schmitt configuration. The circuit differs from normal bipolar transistor practice in only two respects. The resistance values are an order of magnitude higher to allow for the lower mutual conductance of the field-effect transistors and a series input resistance is provided to limit the forward current of the internal protection diode of the M1202. The series resistance is necessary if the input signal is allowed to have a positive polarity with respect to ground. For a negative-going signal the input current to the Schmitt is typically less than 100pA. The input current is due to the reverse leakage current of the M1202 protection diode. The low threshold voltage of the silicon-gate transistors enables the circuit to operate from supply voltages as low as 5V. With the supply voltage and resistance values shown the circuit provides an upper trip point of 4V, a lower trip point of 3.1V and rise and fall times of less than 1μs.

Wirewound ‘log’ pot
Carbon-track potentiometers when used as volume controls often have a very limited life and develop ‘intermittents’ and crackles. Wire-wound controls are much better in this respect, but unfortunately only linear laws are commonly available, and these are not suitable for faders. An approximation to a logarithmic law can be obtained by using the arrangement shown. The wirewound track can be centre-tapped quite easily in cheap controls by taking the back off and exercising some ingenuity! Although a better approximation to the ‘10% log’ law could be obtained, (the kink in the curve shows up as a noticeable jump in the sound when doing a fade) the present arrangement seems to be the best compromise.

D. C. Hamill, Southampton.
The first administrative radio conference to allocate frequencies for space telecommunications was held by the International Telecommunication Union in 1963, only six years after the original sputnik first orbited in space. That conference successfully provided frequencies and the necessary technical and regulatory provisions to enable Intelsat to come into being as a commercially viable organization. The facility by which hundreds of millions of the world's population have seen the Olympic games and the various Apollo missions on television has become so familiar in a relatively short time that it is easy to forget that radio communication through outer space was unknown a decade ago.

Apart from communication satellites, such as Intelsat and the Russian Molniya, there have been meteorological satellites, satellites used for space research, and the use of space techniques by amateurs. The 1963 conference also provided additional frequencies for Radio Astronomy.

Second space conference

The rapid operational and technical development of these space services and the possibility of using satellites for new services made it necessary for the Administrative Council of the I.T.U. to convene a further world administrative conference. Its main purpose was to provide more frequencies for existing space systems (like Intelsat) to allow for growing traffic needs for international telephone and telegraph traffic and the relaying of television programmes; and for the growing needs of other services such as space research, radio astronomy, meteorological satellites, amateurs and the aeronautical satellite service. Furthermore, frequencies were needed for new satellite services: maritime-mobile, broadcasting and earth exploration. In addition the conference had to draw up the necessary technical provisions to enable the new frequency allocations to be used successfully; and to provide regulatory procedures for co-ordination between administrations and the notification and recording of frequency assignments.

The conference assembled, with over 700 delegates from 100 countries, at the Palais des Expositions, Geneva, on the 7th June. In attendance there were the usual officials of the I.T.U. and a sprinkling of observers of the United Nations and other interested international organizations to see fair play. The conference got off to a good start under the experienced chairmanship of J. J. H. Pedersen, Director General of the Danish P.T.T., who had also been chairman of the 1963 conference. No time was lost in breaking down into committees and thence into working groups, so that in a matter of days delegates were deep in discussion on the main aspects.

From the technical point of view it was essential to get down to an early examination of the technical criteria for sharing between space systems and terrestrial services and for sharing between various space systems so that the delegates concerned with frequency proposals, particularly proposals for new services, should know what was practicable. There were other delegates, concerned with regulatory procedures—co-ordination between administrations, notification and recording of assignments etc.—who needed to know what technical factors would influence their thinking. This was not a one-way process. As the conference progressed there was interaction between the frequency and regulatory committee and the technical committee. In addition there was the main task for the technical committee of considering specific technical proposals from administrations in the light of the preparatory work of the Special Joint Meeting of the C.C.I.R. held in Geneva in February/March 1971, and necessary revision of the technical provisions of the Radio Regulations.

The frequency committee and its main working groups broke down the many frequency proposals of administrations into subject matter. The most important task was to find more space for the communication-satellite service (to be known as the fixed-satellite service). The conference recognized that the frequency spectrum up to 10GHz was so crowded that there was no scope for introducing more wideband space services. The first relief bands to provide for the next generation of fixed satellites were therefore found between 10.95 and 14.5GHz. The importance of a band below 15GHz is that it is not so affected by rain in temperate climates as frequencies higher up the spectrum. In Region I, which includes western Europe, these bands consisted of three separate 250 MHz segments at the lower end, mainly for use in the earth-to-space direction, and 500MHz band (14-14.5MHz) in the earth-to-space direction. The apparent imbalance between the down and the up bands is explained by the fact that different down bands might be employed in working to an inter-continental satellite between the Americas and Europe from those needed for European satellites occupying a different arc of the sky. Two of the down bands are also allocated in the earth-to-space direction so that they can be used for feeding broadcasting satellites. This makes for maximum use of the spectrum.

For the next relief band—for the third generation of fixed-satellites—was found between 17 and 31 GHz. A total of 2,500MHz of space each way (1000MHz shared with terrestrial services and 1500MHz exclusive) was provided. At these frequencies local rain storms can blot out reception. It will be necessary to provide more than one earth station at each terminal, separated by sufficient distance from each other, to avoid this hazard. These frequencies are therefore likely to be used only for high cost intercontinental traffic of the Intelsat type.

Allocations up to 275GHz

The present Radio Regulations allocate frequencies only up to 40GHz. The spectrum above that is affected by the earth's atmosphere so that communication between earth and space is not generally practicable. There are, however, some exceptions to this rule inasmuch as at certain frequencies there are windows in the atmosphere that permit communication. The conference provided allocations in these windows for fixed-satellites (a total of 32GHz) stretching from 40 to 275GHz. Frequencies were allocated for space-to-space links, (over 50GHz) on the space side of the atmospheric fence, away from these

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*Head of the Radio Regulatory Division, Ministry of Posts & Telecommunications, and leader of the U.K. delegation to the Geneva conference.
windows. Although these frequencies are not likely to be brought into use within the next 10 years, both the U.S.A. and Japan stated they were working on satellites which would use them. It was important that the conference should fix the allocations so that system design could proceed.

Some countries had a need for a small allocation of frequencies for fixed satellites at around 2000MHz to enable a satellite system carrying a small traffic load to be used in sparsely populated regions, like Alaska and the Yukon, where there is no existing terrestrial network to conflict with the earth stations. The conference found two small frequency bands 35MHz wide in the band 2500-2690MHz for this purpose outside Region I and provided safeguards for countries whose terrestrial systems might be affected.

Space research and radio astronomy
Additional frequency space was provided for space research and radio astronomy ranging from a small 20kHz radio astronomy band at 21MHz right up to a band for Radio Astronomy and Space Research at 230-240 GHz. Of particular concern to the U.K. was a U.S. proposal for a space research band in the important 1750-2290MHz band. The American requirement for an additional 185 MHz in the up direction and 90 MHz in the down direction could have played havoc with this band, which is heavily used in Europe for public telecommunication radio-relay services. There is a fundamental technical need for frequencies for the penetration of deep space to be kept below 2300 MHz. The conference recognized this but kept the frequencies out of Region I except for 85MHz allocated to Spain. This effectively limits the location of the one high-power station required in Europe to the country in which it is at present located.

Maritime mobile satellites
For the first time frequencies were allocated to the maritime mobile satellite service. A small allocation, in the v.h.f. band used for international shipping, was made for safety and distress purposes. Two bands, 3.5MHz in each direction, were allocated between 1535 and 1660MHz, with two small bands (1MHz each) for combined use by maritime and aeronautical mobile satellite. This should provide a satisfactory service for the larger ocean-going ships. It is not likely to be introduced before 1978 but would provide welcome relief for the congested and unsatisfactory h.f. band. It could provide a reliable high-quality 24-hour-a-day service integrated into the public automatic telephone network.

Aeronautical mobile-satellites
The conference allocated two 15-MHz bands for use by aeronautical mobile-satellites for civil aircraft in the 1535-1660MHz band. This should provide adequate frequency space for the development of satellite communications for aircraft.

Earth-exploration
This is a new type of satellite service including:
(a) the meteorological satellite, controlled from the U.S.A. but giving information to world weather forecasting centres, one of which will be in the U.K. and
(b) other earth-exploration satellites used for obtaining information about the earth-mineral resources, land and sea use, detection of agricultural diseases, atmospheric and water pollution, etc. The information is obtained by satellites from sensors on the earth or in the air and relayed to earth stations.

Frequencies for all these uses were allocated by the conference.

Broadcasting satellites
Frequencies were allocated for the first time for this service in which distinction was drawn between individual reception, requiring very high powers, and community reception in which relatively low powers would be needed. The latter is important as the conference would accept the use of broadcasting satellites in certain bands only on the basis that community reception would be used.

The conference accepted the use of broadcasting satellites in the television u.h.f. band between 620 and 790MHz, subject to agreement among administrations concerned and affected, and laid down a stringent power limitation to protect the terrestrial broadcasting receivers of other countries. The interest of western European countries was to avoid interference from satellites in this band with their extensively developed broadcasting networks.

Band 2500-2690MHz was allocated to broadcasting satellites for domestic and regional systems for community reception only, with power limits to protect terrestrial services of other countries. This should be the main band for developing countries and sparsely populated territories in advanced countries where a terrestrial broadcasting network would be too costly.

The main band for broadcasting satellites for use by advanced countries in western Europe will be from 11.7-12.5GHz. This 800MHz band has been allocated in Region I on an equal primary basis to broadcasting satellites, broadcasting, fixed and mobile (except aeronautical mobile) services. The conception is that there should be a frequency assignment planning conference as soon as practicable. At this conference the countries of Europe could decide how much of the 800MHz should be devoted to European or regional coverage and how much to national coverage; for example, 800MHz is wide enough to enable each country in western Europe to have four - programmes, because at these frequencies very narrow beams can be used and channels can be repeated at suitable distances.

A new footnote in the Radio Regulations provides that the terrestrial services will be in effect on a secondary basis to the broadcasting satellite service during the frequency planning process so as not to inhibit the planning. Once the plan has been settled, countries will know what frequencies remain outside the channels allocated to them and neighbouring territories for broadcasting satellites. These can then be planned on a national basis for their terrestrial services. Broadcasting satellite channels can be exploited in the first instance for community reception and later used for more powerful satellites giving individual reception to homes when this becomes technically and economically feasible.

The conference also allocated frequencies for broadcasting satellites higher up the spectrum, at 22.5-23GHz (Region 3 only) 41-43GHz and 84-86GHz. But these are for long-term study and development rather than for use in the foreseeable future. As regards broadcasting satellites generally, the technical and regulatory constraints prevent broadcasting to other countries without their consent.

Amateur satellites
The conference agreed to the use of satellites by amateurs in the h.f. bands allocated exclusively to amateurs on a world-wide basis (7, 14, 21 and 28 MHz) and one higher band at 24-24.05 GHz. But the most useful allocation was at 435-438 MHz which can be used in conjunction with the existing 144-146 MHz band.

Summary
To sum up, the conference, which concluded its six weeks sitting on 17th July, allocated all the important frequencies needed for the continued growth of the Intelsat system for the foreseeable future and beyond; for the new European system if it is required; and provided frequencies for use by new services with adequate safeguards to terrestrial services where safeguards are needed. The revised Radio Regulations will come into force on 1st January 1973.
Elements of Linear Microcircuits

11: F.M. radio receivers

by T. D. Towers,* M.B.E.

The electronics design engineer working in the domestic radio field is turning away from discrete transistors to the numerous special-purpose linear l.c.s which are now available. However, it is evident that an l.c. for domestic radio application must meet quite a number of special constraints.

- It must be lower cost to the set manufacturer than discrete-component assemblies.
- Must be capable of being 'second sourced'.
- Its throw-away value must not be too high to permit economic servicing.
- Reliability should be higher than discrete assemblies.
- It should be able to work over widely different voltage rails (which usually means internal voltage regulator stages).
- Current consumption should be as low as discrete designs because dry-battery operation is often required. (This can conflict with the different voltage rail requirement.)
- It should be designed for easy handling, testing, installation and removal.

Before the linear l.c. arrived, a.m./f.m. set manufacturers had already had experience of block modules made with discrete components in the Mullard 'LP' range (LP1169/79 f.m. tuner blocks and LP1164/65, 1170/71 a.m./f.m. i.f. blocks). As a result, they had already solved some of the assembly problems involved in changing over from traditional separate component assemblies to the use of functional assemblies—which is after all what l.c.s are.

Partitioning a.m./f.m. receivers

Different manufacturers adopt different approaches to the problem of how to divide up receiver functions for the separate i.c. packages required to make up the set. Until some degree of standardization is reached all we can do at this stage is to look at some typical examples.

If you are interested in the detailed problems of partitioning f.m. domestic radios, you will find a useful discussion of the topic in 'A.M./F.M. monolithic receivers' by P. E. Hermann, L. H. Hoke, R. L. Petrosky and R. Wood (of Philco-Foro) in I.E.E.E. Transactions on Broadcast and Television Receivers, July 1968, Vol. BTR-14, No. 2 pp. 95-103.

Initially set designers tried to use general purpose professional linear l.c.s (such as the μA703 and MC1550) for domestic receivers, but were unsuccessful because they were too costly.

Next, industry turned to developing special i.c.s for high-performance professional f.m. applications, such as the RCA CA3076 10.7MHz high-gain amplifier limiter and the CA3075 amplifier limiter detector. These could be integrated into excellent high-gain f.m. systems but the assembly costs could not compete with conventional discrete transistor assembly in domestic f.m. sets.

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Another interesting development that pointed the way to current practice was the Fairchild set of l.c.s μA717, 718, 719, and 720. These were all the same basic monolithic chip with different internal metallizing interconnection patterns which produced devices for various television, f.m. and a.m./f.m. applications. You can find more detail of these in 'Novel

\[\text{Fig. 1. Coincidence (quadrature) f.m. detector system suited to l.c.s in f.m. receivers; (a) simplified block diagram; (b) practical l.c. realization of half-wave detector; (c) full-wave detector.}\]

* Newmarket Transistors Ltd

Detection

Over the years many different types of f.m. detection have been used. Most of them, such as the 'Fremodyne' (single detuned LC circuit drive to detector), the 'Travis' (two LC circuits detuned on each side of i.f.), and the 'super-regenerative' detector, have fallen out of favour. With discrete transistors, the two systems with the widest commercial use are the Foster-Seeley discriminator (common in Europe) and the ratio detector (common in America). Neither of these is ideally suited to monolithic i.cs because they require carefully tuned balanced LC circuits. With i.cs they are tending to be replaced by the coincidence (quadrature) detector requiring only one tuned LC circuit; by the phase-locked-loop detector, dispensing with inductances altogether; and by the diode-pump detector (also inductorless).

The diode pump or pulse-counter detector is attractive because it is so easy to set up, but to be really efficient it calls for a low intermediate frequency, around 100kHz, which tends to rule it out for low-cost domestic receivers.

The coincidence detector appears to be preferred by most designers for 10.7MHz /i.f., f.m. detection with i.cs. Fig.1 illustrates its working. In Fig.1(a), the 10.7MHz signal, built up to a square wave in a preceding limiting amplifier, is fed into terminal A. From A it passes direct to one side of the coincidence multiplier in one direction and is also split off into a second channel B which contains a single tuned circuit (externally connected to the i.c.), the action of which restores the 10.7MHz square wave to sine-wave form at terminal D. Thus both the square wave and the sine wave are fed to the multiplier circuit. The signal frequency modulation varies the instantaneous frequency of both signals and, since the sine wave is subjected to a phase displacement due to the action of the tuned circuit, the coincidence detector produces an output at E consisting of a series of pulses of mean value proportional to the modulation frequency. Thereafter the integrator (a capacitor shunting the output resistance of the coincidence detector) recovers the audio from the f.m. r.f. signal and provides the necessary de-emphasis or top cut (European time constant 30 µs, American 75µs). In i.c. form the detector multiplier circuit can provide half-wave or full-wave detection.

In Fig.1(b), a half-wave detector, the average value of the output current in R1 is proportional to the frequency deviation of the input signal. The full-wave version (more complex, but less affected by noise) is given in Fig.1(c) and uses three, instead of two, pairs of differential long-tail transistors, but is similar in action.

The coincidence detector is becoming popular with i.cs in f.m. sets because the setting up of the detector involves the adjustment of only a single external coil, while giving performance similar to the more traditional, but more difficult to set up, Foster-Seeley and ratio detectors. Besides decreasing assembly and alignment time, the coincidence detector reduces the number of external passive components required.

TAA 661

One example of an i.f. amplifier using a coincidence detector is the SGS TAA661 which incorporates 25 transistors and 18 resistors in a single silicon chip. It is housed in a 14-lead dual-in-line package and includes a three-stage limiter amplifier, an f.m. detector and an emitter-follower audio buffer pre-amplifier, with an internal voltage regulator circuit permitting operation on rail supplies from 6 to 18V. How simply it can be used in practice is demonstrated in Fig.2 which shows the practical circuit for taking the output from a discrete component 10.7MHz f.m. first i.f. amplifier stage and delivering a.f. to the volume control.

TBA 690

The TAA661 is for f.m. only. Some domestic receivers covering f.m. also incorporate a.m. This points to a different line of i.c. development characterized by the Mullard TBA690. This i.c., in a 16-pin plastic dual-in-line package, comprises the functions within the shaded area of Fig.3, and can be seen to contain everything except the f.m. front end, the f.m. first i.f. (which can be switched to operate as a mixer oscillator on a.m.) and the f.m. and a.m. detectors. The integrated audio amplifier in the TBA690 can provide 500mW into an 8 Ω speaker on a 9V battery, although the supply can be anything from 4.5 to 9V. The quiescent current drain on the battery is only 22mA; this is comparable with discrete device
Stereo decoders

One area where monolithic i.c. techniques lend themselves is in stereo decoders. An example of this is the Siemens TBA450. Of the three standard decoder systems (matrix, switch and envelope), the TBA450 uses the matrix decoding system outlined diagrammatically in Fig.4. The output from a standard f.m. front end is taken after the detector, but without deemphasis applied, and fed into three filters which separate the M (mono L+R) signal below 15kHz, the S (stereo L-R) signal from 23-33kHz, and the pilot signal at 19kHz. The pilot signal is frequency doubled to 38kHz and then controls a synchronous a.m. demodulator while the M and S signals are matrixed to give independent outputs of the stereo left and right audio signals. The same system is employed in the TBA450. In this circuit the bandpass amplifiers are active filters which do not use inductances.

Phase-locked-loop

The phase-locked-loop technique referred to in the last article on a.m. receivers offers a way of avoiding the fixed tuned i.f. filters of the f.m. receiver. Fig.5(a) shows the functional p.l.l. sections in the Signetics NE561B linear integrated circuit, which will provide a demodulated audio output if fed directly with the 10.7MHz output from a conventional f.m. mixer without any 10.7MHz tuned circuits. The tuning element in the circuit is a voltage controlled relaxation oscillator whose frequency is determined by non-inductive components. The oscillator is designed so that the operating frequency can be varied over a limited range by a d.c. bias voltage. If the oscillator is rough-tuned near to the 10.7MHz and its output is applied to the phase comparator, the comparator will give an output determined by the frequency and phase deviation of the v.c.o. from the input signal. This comparator output is amplified and filtered and fed back round the loop through the limiter to adjust the

v.c.o. frequency to bring it into frequency and phase step with the f.m. input. Thus the oscillator tracks the input signal and produces a strong continuous signal even if the input is discontinuous or noisy.

So far the circuit has produced a cleaned up, greatly amplified, copy of the input f.m. signal without using inductances. But the main interest of the circuit to us is that within the phase comparator loop an output signal has been obtained which is dependent on the carrier shift. Apart from its use to lock the v.c.o. onto the carrier, it also represents the audio output of the demodulation system, because the amplitude of the loop control signal is proportional to the carrier frequency deviation, which is just the f.m. modulation. This enables the NE561B to be set up in a simple system such as Fig.5(b) to replace the complete 10.7MHz i.f. strip up to the f.m. detector. As yet, phase-locked-loop i.c.s operating directly at the f.m. broadcasting frequencies around 100MHz are not practicable with existing monolithic technologies, but as the art develops it is possible that the local oscillator too can be dispensed with.
Digital synthesis

Another approach to described a complete system providing detected audio output at broadcast frequency into terminal 4 and this required local oscillator frequencies for an a.m. and f.m. broadcast receiver. Selection of a station is accomplished by positioning switches to indicate the station's frequency. Fine tuning is not necessary. The receiver will not (for all practical purposes) drift, because the local oscillator is crystal controlled. Low-cost medium-scale integrated circuits (m.s.i.) are the building blocks of this. For a detailed account of this design, you should consult J. Stinchfield and J. Nichols' 'A digital frequency synthesizer for an a.m. and f.m. receiver' in J.I.E.E. Transactions on Broadcast and Television Receivers, October 1969, Vol.BTR-15, No.3, pp 235-243.

Thick film hybrid

Instead of packaging i.c.s in multilead packages and supplying them to set manufacturers to mount with passive components, such as resistors and capacitors, on a printed circuit board, we are already seeing a logical development in which semiconductor manufacturers are themselves mounting the chips in thick film hybrids with the passive components to complete their functions printed and fired on the ceramic substrates. This produces a neat microcircuit suitable for plugging into sockets on the printed circuit board (which now tends to become merely an interconnection network between the microcircuits and the large non-integrable components) and will remove many of the servicing problems found with discrete components or even linear monolithic soldered into position. With new subminiature i.f. transformers, about 5mm square, it is now possible to mount them directly onto thick film hybrids.

Conclusions

Much is happening in the application of i.c.s to domestic f.m. receivers, and developments are taking place along several different lines at once. It is difficult to see how things will finally develop, but in the not-very-distant future we can expect to find the set makers indicating a preference which will show itself by semiconductor manufacturers beginning to 'second source' some items.

(The concluding article in this series will deal with i.c.s in television receivers.)

Sixty Years Ago

September 1911. Our predecessors on the staff of The Marconigraph devoted much space to the social implications of the ever increasing acceleration of the technology machine. Sometimes the only intention was to make technical reports more readable. Today this is seldom done because the average engineer is bombarded with so much printed material he has time only to glance at a small fraction of it and to read even less. The change in approach is emphasized if one reads (if time allows) early technical articles.

For instance, in a report on the massive radio station at Cape Cod about half a page was devoted to the antics of two dogs kept at the station and the rescue of one of the animals, who had been caught in a trap, was described in detail. The Cape Cod station was used to transmit the daily news to ships in the Atlantic and had the advantage of an automatic morse transmitter using paper tape input. Apparently once the huge generators were started the noise of the spark transmitter was 'terrifying' and the spark itself could be seen as a flickering light fifteen miles away.

At the receiving end on board a ship the transmission was recorded on paper tape and it was reported that a female passenger who said she understood all, after being shown around the wireless installation, wanted to know how the paper tape went from shore to ship without getting wet!

Codes

Further details are obtainable from the addresses in parentheses

LONDON
Sep. 1-3 Imperial College
Artificial Intelligence
(British Computer Soc., 29 Portland Pl., London WIN 4AP)

City University
Electrical Network Theory
(J.I.E.E. Symposium, c/o The City University,
St. John St., London EC1V 4PB)

Aug. 9 & 10 Savoy Pl., W.C.2
High Voltage Insulation in Vacuum
(Inst. Phys., 47 Belgrave Square, London S.W.1)

Sept. 13-17 Newport, R.I.
U.S. Trade Center, S.W.1
U.S. departmental electronics components exhibit
(U.S. Trade Center, 57 St. James's St., London S.W.1)

Sept. 17-24 St. Katherine's, E.1
Control and Instrumentation Exhibition
(Control 4 Instrumentation, 28 Exon St., London W.C.2)

Wireless World, September 1971

Centralized Control Systems
(I.E.E., Savoy Pl., London WC2R OBL)

BRIGHTON
Sept. 7-10 University of Sussex
Human Locomotor Engineering
(Medie-E., 1 Birdcage Walk, London S.W.1)

Sept. 8-10 University of Sussex
Electron Mean-Free Paths in Metals
(Inst. Phys., 47 Belgrave Sq., London S.W.1)

CARDFIELD
Sept. 17-19 University College
Physics—From School Through Higher Education
(Inst. Phys., 47 Belgrave Sq., London S.W.1)

CRANFIELD
Sept. 1-3 Cranfield Institute of Technology
Business and Light Aviation Show
(T.T.F-Buff Exhibitions Ltd., 1-19 New Oxford St.,
London WC1A 1PB)

Lancaster
Sept. 14-16 The University
Solid State Devices
(Inst. Phys., 47 Belgrave Sq., London S.W.1)

Sept. 23 & 24 The University
Data Processing and Display for Inspection
Purposes
(Inst. Phys., 47 Belgrave Sq., London S.W.1)

LOUGHBOROUGH
Sept. 7-10 University of Technology
Displays
(I.E.E., Savoy Place, London WC2R OBL)

MANCHESTER
Sept. 1-3 The University
Multivariable Control System Design and
Applications
(U.K.A.C. 1971 Convention Secretariat, Savoy
Pl., London WC2R OBL)

SHEFFIELD
Sept. 7-9 The University
Computers in Medical and Biological Research
(I.E.E., Savoy Place, London WC2R OBL)

SWANSEA
Sept. 1-8 University College
British Association Annual Meeting
(B.A. 3 Sanctuary Buildings, 20 Ox Smith St.,
London S.W.1)

Teddington
Sept. 13 & 14 National Physical Lab.
High Voltage Electromicroscopy
(Inst. Phys., 47 Belgrave Sq., London S.W.1)

OVERSEAS
Sept. 1-2 Sendai
Antennas and Propagation
(Dr. K. Nagai, Inst. of Electronics and
Communication Eng., Kitai-Shinko-Kaikan
Bldg., Shiba Park 21-1-5, Minato-ku, Tokyo-105)

Sept. 4-12 Radio-TV Show
(Associazione Nazionale Industrie Elettrotecnica
elettroniche, Via Donizetti 30, Milam)

Sept. 13-19 Amsterdam
Firato Electronics Exhibition
(RAI Gbuev N.V., Europalein 8, Amsterdam)

Sept. 13-19 Budapest
Micronica 71—Electronic Component Show
(Micronica 71, Budapest 5, P.O. Box 454)

Sept. 19-23 Chicago
Elecrolastics and Insulation
(E. A. Boulter, G.E.C., 1100 Western Ave., West
Lynn, Mass. 01905)

Sept. 21-23 San Diego
Engineering in the Ocean Environment
(G. K. Tajima, Bissett-Berman Corp.,
3939 Ruffs Road, San Diego, California 92112)

Sept. 23-25 Washington
Broadcast Technical Symposium
(R. M. Morris, 60 Sunset Lake Rd., RD1,
Sparta, N.J. 07871)

Sept. 27-29 Turin
Elettrotecnica '71—Conference on Applications
of Electronics in Industry
(Elettrotecnica 71, Corso Massimo d'Aezglio 15,
10126 Torino)
A new linear inverting and amplifying circuit and some other applications of low-level Darlington transistors

by J. L. Linsley Hood

One of the most interesting of recent developments in the discrete semiconductor components field has been the use of integrated circuit techniques to provide small-signal Darlington-connected transistors of the general form shown in Fig. 1(a). A suggested symbol is given in Fig. 1(b), and this is used in the remainder of this article.

While it is practicable to construct Darlington pairs from separate transistors if the collector current of the second transistor is fairly large, at the sort of current levels typically employed in small signal circuitry it is much more difficult. If the second transistor has, say, a current gain of 400 and a collector current of 0.5 mA, the collector current of the first device must be less than 125 µA, and at this order of collector current the current gain of most normal discrete small-signal transistors is very low, and their other characteristics are also impaired.

When, however, a monolithic Darlington transistor is made, the junction areas and doping levels of the input transistor are adjusted so that it will function effectively at a very low collector current. Also, because of the very low collector-to-input base capacitance, it is possible to obtain good performance at moderately high frequencies, even with high dynamic impedance collector loads, which give high stage gain values.

Ideally, a low-level amplifier element should have a high input impedance, a relatively low output impedance, a high gain, a low noise level, should be linear, should be simple and tolerant in its power supply requirements. The normal (bipolar) junction transistor does not meet the input and output impedance requirements at all well, and in addition is intrinsically non-linear as a voltage amplifying element, so that it is almost essential to arrange stages in cascade with substantial amounts of overall negative feedback to remedy these defects. However, on consideration it is apparent that the non-linearity of the bipolar transistor is an input characteristic effect, and for any given base-emitter circuit impedance is directly related to the magnitude of the input signal voltage. Within limits, the output signal swing is unimportant in this respect. It follows from this that for any given output signal level, the higher the gain of the stage the better its linearity will be. The monolithic Darlington transistor offers a satisfactorily high input impedance with a very high value of current gain, and if an arrangement can be found in which this can be induced to give a high voltage gain the major circuit requirements will have been met. Moreover, such a stage will be phase-inverting which is very convenient for a number of applications, whereas the conventional transistor feedback pairs of Fig. 2 are non-inverting systems.

Methods of obtaining high stage gain

Several techniques are available for increasing the stage gain of a conventional transistor amplifier. However, some of these are unhelpful in preserving the linearity of the system, and the principal remaining technique is to employ a collector load which has a dynamic impedance substantially larger than its d.c. resistance. This could be a "bootstrapped" load resistor, an "active" (i.e. signal dependent) load, or a constant-current source. Of these arrangements the third is by far the most straightforward and free from side-effects, and such a constant-current load can be provided by the use of a conventional junction field-effect transistor, for which the circuit required, as shown in Fig. 3, is simplicity itself. The characteristics of this arrangement are shown in Fig. 4 for various values of the source resistor R1.

Since the dynamic resistance of such a system is, effectively proportional to the reciprocal of the slope of the drain-current/drain-voltage graph (i.e., the flatter the higher) it can be seen that there are conditions when this dynamic impedance is very high, and it could then be employed as the load in the collector circuit of a transistor amplifier stage. This would give a very high
stage gain while still allowing a reasonable value for the collector current, and a convenient range of voltage drop values across the load. Moreover, by the suitable choice of f.e.t. or source resistor the collector current of the amplifying transistor can be precisely defined, which is frequently an advantage.

**Circuit conditions for high stage gain**

The stage gain of a simple single-stage transistor amplifier is given by the formula:

\[
M = \frac{1}{h_{ie} - h_{re} \cdot Z_L + h_{re}}
\]

If the terms \((h_{ie}, h_{re} - h_{ie}, h_{re})\) are written as \(\Delta h_{re}\), the so-called "h determinant" for the common emitter configuration, this equation simplifies to

\[
M = \frac{h_{ie} \cdot Z_L}{\Delta h_{re} \cdot Z_L + h_{ie}}
\]

and if \(\Delta h_{re}\) is sufficiently small, as is mostly the case, this approximates to

\[
M \approx \frac{h_{ie} \cdot Z_L}{h_{ie}}
\]

If the dynamic value of \(Z_L\) is large, and the input impedance of the amplifier transistor is small the stage gain can be very high. (However, \(h_{ie}\) depends on the collector current of the transistor, and increases as this is reduced. For this reason, high gains normally require both a certain minimum of collector current and also a drive impedance which is small in relation to \(h_{ie}\).)

As will be seen from Fig. 4, an f.e.t. will act as a high dynamic impedance constant-current source even when the source resistance \(R_1\) has zero value, provided that the source-drain voltage exceeds what is known as the "pinch-off" voltage, which is typically two or three volts. The current which will flow in this condition (zero source-gate bias) is known as the \(I_{DSS}\) and will depend on the device. For f.e.t.s such as the 2N4302 and the 2N5457 this will be in the range 1–3 mA—a convenient value of collector current at which to operate a typical small signal Darlington amplifier stage. When such a transistor amplifier is employed with an f.e.t. collector load it is found that stage gains of the order of 2500 to 5000 can be obtained, even with source impedances of the order of 100 kΩ or more.

It will be appreciated that an amplifier stage of this type using a high dynamic impedance collector load will have an output impedance which is so high that the shunting effect of almost any external load would lead to a serious reduction in gain. To complete the practical circuit, therefore, an output emitter follower is required, and this can with advantage be a further monolithic Darlington transistor, although in practice a normal high-grain small signal transistor may be nearly as good and somewhat cheaper.

The final form of the proposed high gain circuit arrangement has been found to be very versatile as a relatively low-frequency amplifier stage, and to possess a number of useful qualities as a phase-inverting circuit element, and the name "liniac" (linear inverting amplifying circuit) is suggested for this configuration.

**Liniac circuit characteristics**

**General considerations.** In its simplest form, the liniac consists of a bipolar transistor connected as a grounded-emitter amplifier, an f.e.t. used as a constant current load, and an output emitter follower. If the output circuit impedance is fairly high, say 10 kΩ or greater, this can be a normal small-signal transistor such as the BC109 or BC184. Also, if a source resistor is used with the f.e.t. of a value sufficient to reduce the load current to some 0.05–0.5 mA (at which level the dynamic impedance is extremely high)

![Fig. 3. Constant current load using f.e.t.](image)

**Fig. 3. Constant current load using f.e.t.**—\(i_{D}\) depends on f.e.t. and value of \(R_1\). Dynamic impedance in range 200 kΩ–2 MΩ.

![Fig. 4. Drain current characteristics for sharp cut-off f.e.t.s.](image)

**Fig. 4. Drain current characteristics for sharp cut-off f.e.t.s.**

![Fig. 5. (a) Basic liniac configuration; (b) symbol proposed for liniac.](image)
and if a very high input impedance is not required, a simple bipolar transistor of similar type can also be used as the amplifier stage. This is the system which is to be preferred if the lowest possible noise level is required, and is still capable of very high stage gains if the drive impedance is fairly low. But, for most applications, a monolithic Darlington device is preferred in this position since this has a lower collector-base feedback capacitance and therefore gives a better-open-loop h.f. response.

The linac arrangement can be made with devices of complementary symmetry with appropriate adjustments to supply polarity, and since the feedback is used as a two-terminal unit either n-channel or p-channel devices can be employed provided that they have suitable $I_{BS}$ and pinch-off voltage values. A suitable arrangement using a single very low noise p-n-p input transistor is shown in Fig. 6.

Stage gain. Because of the low emitter-circuit impedance of the amplifier transistor when a Darlington device is used in this position, and because of the high dynamic impedance of the collector load, the gain of the input stage is very high—typically of the order of several thousands—even when fed from a high source impedance, and is limited, at low frequencies, mainly by the output impedance ($Z_{out}$) of the amplifier transistor, which is effectively in parallel with the collector load. At higher frequencies, the effect of the collector shunt and Miller capacitances causes the gain to fall at -6 dB/octave. Typical gain/frequency characteristics are shown in Fig. 7.

Distortion characteristics. For the reasons mentioned above, this configuration will be expected to possess a significantly lower order of non-linearity than the conventional bipolar transistor amplifier using a resistive load. In the event, the non-linearity is reduced by the same factor by which the gain of the stage is increased in comparison with the normal bipolar transistor operated at the same collector current. This is typically 10–15 times, which is a valuable feature in audio amplification circuits. The open-loop gain/frequency distortion characteristics are shown in Fig. 8. Since in normal circuit applications overall negative feedback will be employed, and this will reduce the non-linearity even further, a stage with a gain of 50 x can be used with less than 0.005% h.d.t. at 1 kHz at 1 V r.m.s. output.

Noise levels. The noise characteristics of the circuit, at gain levels in excess of some 20 x (assuming some externally applied negative feedback) depend mainly upon the characteristics of the device used as the amplifier transistor, and on the relationship between the collector current and the input circuit impedance. The best available low-noise small-signal transistors give noise figures which are about twice as good as the equivalent monolithic Darlington connected devices. For this reason, when the linac circuit is to be used under conditions where the noise level is of importance, such as in the input stage of a high-gain amplifier, it may be preferred to use the simple bipolar type, but in this case a lower input circuit impedance is essential.

In common with other transistor types the noise level at the output is reduced as the collector-emitter potential is reduced. For example, reducing the collector voltage from 8 V to 2.5 V reduces the broad band noise by about a factor of two, but also, of course, reduces the available output voltage swing. This technique should, therefore, be used with discretion.

At stage gains less than 20, the noise contribution due to the f.e.t. may also become important, since the circuit can equally well be visualized as an f.e.t. amplifier with a bipolar constant current load, and if it is intended to use the stage with an output voltage of less than 100 mV, a low-noise f.e.t. should be used. The use of an un-bypassed source resistor in the f.e.t. circuit will also reduce its noise contribution.

Supply-line ripple rejection. One of the more desirable qualities of small-signal amplifying stages is that they should not be affected to any large extent by ripple, voltage fluctuations or signal feedback from the h.t. supply line. This helps to eliminate hum, instability, and unexpected sources of distortion or cross-talk. Since the collector load of the amplifier transistor stage is a good constant-current source, and in typical circuit applications the input bias is not derived from the h.t. supply, the output signal is largely isolated from supply fluctuations. This advantage is diminished somewhat by the fact that the amplifier transistor has also a high dynamic impedance, but nevertheless the supply line rejection characteristic—assisted by externally applied negative feedback—are much better than those of the normal bipolar amplifier circuit.

Supply and output voltages. In typical linac circuit applications, such as those shown in Figs. 7 et seq., closed-loop d.c. negative feedback is employed to stabilize the working voltage levels. This allows control of the collector potential of the first transistor stage, and thereby determines the potential drop across the f.e.t. collector load. Since it is undesirable that this potential should operate on the curved portion of its characteristic (cf. Fig. 4) the h.t. voltage level should be chosen so that the potential exceeds 0.8–0.9 V R1 and R3 are chosen to give this—Fig. 9(a). Because of phase shift introduced by the interaction of C1 and C2 in this particular circuit, there will be a "hump" in the gain curve at about 11 Hz. Phaseshift characteristics for Fig. 9(a) if the circuit is driven from a low-impedance source. If this is inconvenient it can be removed by a suitable input constant
high-pass CR circuit.

In Fig. 9(b) the circuit has been elaborated to incorporate loop negative a.c. feedback to give a very low-distortion amplifier with a gain of 50 and a wide bandwidth—10 Hz to 80 kHz at 3 dB—with the same d.c. levels and an input impedance of 1 MΩ.

A simpler wide bandwidth arrangement using a lower input impedance is shown in Fig. 9(c). In this and the previous circuit a "virtual earth" feedback arrangement is employed. It should be remembered that in such cases the gain is dependent on the input circuit impedance as well, and an allowance should be made for this in the design considerations. There are obviously a large number of permutations of these basic circuits, but some specific applications are shown below, in which facility for output to input loop negative feedback is exploited.

**Liniac applications**

**Magnetic pickup (R.I.A.A.) equalising stage.** Because of the very high loop gain which can be obtained with this stage, even when a simple bipolar input transistor is employed, a very low noise, low distortion R.I.A.A. characteristic correction circuit can be made with this arrangement giving a gain of 50 at 1 kHz, and less than 0.01% t.h.d. at up to 0.5 V r.m.s. output. A suitable circuit arrangement is shown in Fig. 10.

**Low-distortion oscillator.** A very low distortion oscillator, employing a pentode valve amplifier, was described by A. R. Bailey in 1960. In this the phase shift in a slightly unbalanced parallel "T" circuit is used to provide the necessary positive feedback to sustain oscillation, with the advantage of very good frequency stability. A circuit based on the same principle, but employing a liniac, is shown in Fig. 11. Since the number of variables is somewhat inconvenient for a continuously variable frequency oscillator, it is suggested that the capacitors should be switched to give a series of fixed frequencies.

The distortion given by the prototypes of this, in the frequency range 200 Hz–5 kHz, is certainly below 0.005% at 1 V r.m.s. output. As such this circuit provides a useful reference standard for testing amplifiers, distortion meters and notch filter circuits. Incidentally the resistors used were normal high-quality carbon-film types, and no advantage was found, in terms of any measurable improvement in distortion, in changing over to wire-wound units as originally recommended by Bailey. However, the performance of the thermistor has been found to have an important influence on the overall distortion figure (of five units tried one was found to worsen the distortion to some 0.05%). It is thought that the electrolytic capacitors should also be of high quality.

**Pre-amplifier tone control circuit.** The very high gain, high input impedance and low noise and distortion characteristics of this circuit make it a natural choice for a Baxandall-type of negative feedback pre-amplifier tone control circuit, and a suitable arrangement giving approximately 20 dB of bass and treble lift and cut at 40 Hz and 15 kHz with respect to 800 Hz, is shown in Fig. 12. The worst case (maximum lift) distortion of this circuit is better than 0.02% at 1 V r.m.s. output.
1 V r.m.s. output. This is at least 20 times better than the conventional (and very widely used) single transistor circuit under similar worst case conditions.

**Other circuits using Darlington transistors**

**F.E.T.—bipolar feedback pair.** Because of the relatively high output impedance of the normal grounded-source junction f.e.t. amplifier, it is not possible to construct f.e.t.

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![Fig. 12. Linecar employed in tone control stage. Max. output 3 V r.m.s. Source impedance < 10 kΩ. Midpoint gain 10 x 18 dB lift/cut at 50 Hz and 15 kHz w.r.t. 800 Hz. Worst case t.h.d. < 0.02%.](image)

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Because of the relatively high output impedance of the normal grounded-source junction f.e.t. amplifier, it is not possible to construct f.e.t.

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**Improved bipolar feedback pair.** The circuit of Fig. 2(b) can itself be improved by the use of a Darlington transistor as \( T_{R_2} \). The use of an MPSA65 p-n-p device gives loop gains in excess of 6000, for example. A suitable circuit of this general type is shown in Fig. 14.

**D.C. bootstrap circuit.** The fact that the emitter of a Darlington transistor will follow the base signal level very accurately, with a constant potential difference of about 1 V, allows the connection of a load resistor between the base and emitter as shown in Fig. 15, which multiplies the effective dynamic impedance of the resistor at all frequencies down to d.c. by a figure which approaches the Darlington transistor current gain. The f.e.t. amplifier circuit has a gain of about 250.

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**Fig. 14. Improved bipolar transistor feedback pair.** \( Z_{in} \approx 1.5 \text{ MΩ}. \text{Gain} \approx 100. \)

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**Fig. 15. D.C. bootstrap circuit (phase inverting).** Gain \( \approx 250. \)

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**Inexpensive plastic encapsulated and other relatively low-cost devices of this type are available from Motorola, Fairchild, SGS, and GE. Type numbers are MPSA 12, 13 and 14, BFX 66 and 67, and D16P4 for n-p-n types; and MPSA 65 and 66 (Motorola) for p-n-p devices. The MPSA 12 Motorola unit is a low noise pre-amp type.**

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**Reference**

The Consumer Electronics Show (C.E.S.) was held at the end of June in the exhibition centre at Chicago's McCormick Place. A few of the 300 exhibitors had extra-mural demonstrations in local hotels and although there was another organized charter bus service the humid, steamy heat with temperatures around 100°F made travel somewhat uncomfortable. Inside the show the scene was similar to the old Radiotympia in London with rows of elaborate stands, TV displays and loudspeakers making a continuous babel. The show the scene was similar to the old Radiotympia in London with rows of elaborate stands, TV displays and loudspeakers making a continuous babel. And, of course, each stand had its group of aggressive salesman in newly pressed suits with here and there a gaily dressed (?!) girl giving out leaflets and carrier bags. But there was a difference—the C.E.S. is for trade only and so the atmosphere was, some respects, more serious. Also, the large hall was well air-conditioned and, note this, free champagne was given to the visitors on a terrace overlooking Lake Michigan. It certainly beats coffee on Hammersmith Road! Attendance for the four-day show was 36,200, more than 20% higher than last year's figure. Some very interesting demonstrations were being held, including one from JVC shaped like a ball—but emphasis was definitely on audio, and four-channel sound in particular. Almost every stand boasted some kind of demonstration room.

The majority of exhibitors were using matrix, or synthetic, four-channel systems which are proliferating at an alarming rate causing a great deal of confusion. One exhibitor summed it up by saying "The situation has now got out-of-hand and we don't know which system is best and what will be the future!" On the other hand, another exhibitor was more optimistic and in his view "Most systems are compatible enough for a record or tape made by system A to produce an acceptable four-channel surround sound when played back via a decoder intended for use with system B." The long-awaited C.B.S. SQ disc system* was being demonstrated at a nearby hotel and comparisons were made with 15 i.p.s. master tapes. One of the discs had a commentary by David Frost (very popular this side of the Atlantic) and in spite of the high volume levels, it was one of the most convincing demonstrations I have yet heard. C.B.S. have already announced that they will release at least 50 SQ discs by the end of the year and that agreements have been made with Sony for the production of decoders and playing equipment.

Ampex were using both discrete and matrix systems but most tape recorder firms were content to use discrete four-channel tapes and at least three had cassette machines. The 4/8 track format was also popular.

Pioneer released details of a new miniature (Hipac) stereo cartridge. This is one-quarter the size of a standard eight-track type and smaller than a normal cassette. Koss were showing four-channel headphones. Triumph had headphones with a built-in five-transistor radio.

A number of f.m. stations are using Electro-Voice encoders and, Allied, a large chain concern with several hundred shops throughout the country, are busily demonstrating the EV system. Their competitors Lafayette, are equally committed to the Dynaco system which has the merit of requiring little extra equipment. An extra-mural demonstration was given by Ray Dolby in conjunction with f.m. station WFMT. This station played a selection of tapes some of which used the Dolby mode. Several Dolby 'black box' equalizers have been lent to listeners in various locations and comments invited. As might be expected, those equipped with Dolby units in their homes—reported spectacular improvements in signal/noise. Most of the listeners without Dolby units (who were advised to turn down their treble controls to produce a more balanced sound) preferred the extra brightness. So far then, tests show that the Dolby system as used for broadcasting is compatible enough to avoid conflict with the F.C.C.

Back at the show for a quick look at TV. Last year many observers predicted a big swing to CDs but this has not materialized. The main reason is the higher cost involved. No doubt, higher production will bring down prices—this is like the old chicken-and-the-egg story. Meanwhile, RCA have dispensed with the valve e.h.t. rectifier in their colour sets, thus making them all solid-state. One model uses no fewer than 12 modules that plug into two p.c. 'mother' boards—fine for the service man. The major manufacturers of TV sets were Japanese, which underlines the extent of Far-East competition. GE say they will discontinue production of radio receivers next year—leaving no large U.S. maker of domestic receivers.

The 60th anniversary edition of the *Wireless World* brought back some memories and I was especially interested in John Gilbert's letter mentioning Ted Rosen of Ultra. I was a tester for that firm at their Harrow Road factory around 1930 and I well remember a radio receiver called 'The Switchboard to Europe'. I also have fond memories of Brown's Wireless, makers of crystal sets and the Wates Company where an Everyman Four was used for testing phono-packups. These monsters tracked at four ounces and were fitted with an attachment for 'swans neck' gramophone tone arms!

But my clearest memory is listening to KDKA with a home constructed 1-valve set which had a coil wound on a wine glass (low-loss). These days we have colour TV, videotape, quadraphonic sound, satellite communications and so on. All these are exciting enough but, for me, nothing can compare with the thrill of listening to KDKA from that attic in Camden Town more than 40 years ago.

G. W. TILLET

* The compatible C.B.S. 'SQ' (stereo/quadraphonic) system uses a method of circular modulation of the two sides of the disc groove for the left and right basic signals, as well as normal modulation for the front signals.—Ed.

![Sherwood digital read-out f.m. tuner.](image-url)
Field-sequential Colour Television Receiver

1—Introduction and basic principles

by T. J. Dennis, B.A.

All systems of colour TV in general use today have as their display a system whereby the three primary coloured pictures are spatially superimposed, whether by projection of the red, green and blue images using the Schmitt system, by the use of three c.r.t.s and half-silvered mirrors, or with the three pictures on one c.r.t. whose screen consists of triads of independently controllable phosphor dots, as in the R.C.A. Shadowmask tube. All three of these systems are capable of excellent results, but are difficult and expensive to set up. For example, in the projection system complex distortions have to be introduced into the scanning waveforms to correct for the fact that the projectors cannot be co-sited. Much the same problem is encountered with Shadowmask tubes, hence the joys of convergence adjustments. Any system using separate electron sources is prone to grey-scale tracking errors.

The Shadowmask is able to reproduce a range of colours because the spatial colour resolution of the eye is poor: close to a screen the dots can be easily perceived, but the overall impression is still one of the additive colour resultant. Temporal colour resolution is equally weak, as may be seen by rotating a disc carrying segments of, say red and blue, when the colours rapidly merge to magenta as the speed of rotation is increased. This is the basis of the field-sequential process, whereby the three coloured images are presented to the eye in turn. It is the oldest form of colour display, a version having been demonstrated by J. L. Baird in 1928.\(^2\) In the author's opinion it is capable, within its limitations, of giving results of the highest quality.

Perhaps the major of these limitations is caused by the eye itself: perception of luminance, or brightness, changes in time, as well as in space, are particularly good. While a rotating disc of red and blue will appear magenta, it also carries a marked brightness flicker due to the luminance difference between red and blue. Flicker only disappears when its frequency is higher than the flicker-fusion rate of the eye, a highly variable quantity found on average in the region of 30Hz.

For this reason it is normally considered necessary to increase the basic field rate from that of, say, a 50 field monochrome standard to 150 fields per second in order to maintain the original luminance flicker rate. This demands a trebling of the signal bandwidth, other factors being constant.

Noting the discouraging comments of others on the subject of f.s. systems retaining the existing monochrome field rates\(^3\), it was decided to attempt to build and operate such a unit, to work from the normal broadcast colour transmissions. A standard PAL decoder\(^4\) provides the three (narrow band) colour difference signals. These are then switched in turn to the grid of a monochrome c.r.t., the change taking place during the field blanking period (see Fig. 1). The luminance (wideband) signal is fed to the c.r.t. cathode as usual, after its passage through a 600ms delay line. This is practically the only major modification needed to the monochrome receiver which is the source of all the signals used. The net result is that the set can be made to display, field sequentially, the black-and-white equivalents of normal broadcast colour transmissions.

1-Introduction and basic principles


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**Fig. 1. Block diagram of field-sequential colour receiver equipment. The input is provided by a normal monochrome receiver.**
the red, green and blue images of a colour transmission.

A disc carrying sections of primary red, green and blue filters rotates at 16fr.p.s. in front of the c.r.t. Its rotation is phase locked to the field sync pulses to ensure that when the red picture is being scanned, the red filter is in place, and so on.

It may be noted that two-thirds of the available colour information is wasted in this system, but it should also be recalled that considerably more than two-thirds of the energy imparted to the electron beams in the Shadowmask tube is dissipated as heat in the Shadowmask!

Phase lock of the colour wheel is required, to ensure that the correct filter is in place at the correct time. This is achieved by a simple feedback system using a signal derived from a coil wound on a U-shaped transformer limb, and mounted in front of a bar magnet fixed to the centre of the wheel. The coil output waveform is square in form, with slow sinusoidally changing edges. A four-diode bridge is used to gate through an 8ms portion of this waveform, which has a manually controllable d.c. potential superimposed on it for coarse speed adjustment. The bridge output is integrated, amplified, and with suitable control level adjustments, used to drive the motor armature via a 2N3055 emitter follower.

Assuming phase lock, the gating pulse is placed symmetrical about the midpoint of the positive going edge of the feedback waveform. If the motor speeds up for any reason, the waveform reaches a higher level than it would normally when sampled, and the integrator output moves in a positive direction. Because of the inverting amplifier, the armature voltage is reduced, and the motor slows down. By similar reasoning it can be shown that a reduction in motor speed will also be compensated. Not surprisingly, the system oscillates about its stable position when any velocity transient is applied; settling time from switch-on is about 20 seconds in the prototype, but this is immaterial as it takes the line timebase considerably longer to warm up on the displaying set. Programming switchings, when field sync may be interrupted, tend to upset phase lock, but this effect has not been found troublesome.

Results

Before embarking on the construction of a PAL decoder, a generator was built to produce the 4f, 2f and f., where f= line frequency, squarewaves needed for the red, green and blue, respectively, signals of the standard colour bars, viz. white, yellow, cyan, green, magenta, red, blue and black. These were applied to the linear gates. The resulting non-composite output was passed through an imaging camera channel, and emerged with a full set of 405 line-standard sync pulses, for ease of application to a monitor.

The resulting wildly flashing vertical stripes, when viewed through a locked colour wheel, became the familiar bars. Colour fidelity, even with the rather crude ex-stage lighting filters in use, was in general excellent, the yellow being the least well presented as on all colour sets. The reddish tint obtained when observing a white object through the wheel (due to the red filter having excessive transmission) was neatly compensated by the blueish tint of the c.r.t. phosphor.

Passers-by who ventured unsuspecting into the lab. during this stage of development were invited to peer through the disc, and report the colours seen. Most were correct without prompting, but two insisted they saw blue and red separately on the magenta bar. This only tended to happen at high brightness levels, and is an effect not observed by the author.

Owing to interlacing, successive lines on the screen (not per field), when displaying any but saturated primary colours, will differ in shade. However, since the colour detail resolving power of the eye is poor, the effect could only be seen within about 12in. of the 14in. c.r.t. used. Bearing in mind that these initial tests were on 405 lines, with a 625-line colour picture at normal viewing distance, the effect is unnoticeable.

After the encouraging results obtained with the colour bars, a PAL decoder was built, with slight modifications, notably in elimination of dependence on the line output stage of the receiver: an additional sync separator was added, the line pulses obtained being used to trigger a monostable and produce an accurately timed burst gating pulse. The burst gate itself was in the form of a four-diode bridge, all of which will be discussed more fully next month.

At first the decoder was operated without a delay line; i.e., in the PAL-S mode. Oscilloscope examination of R - Y for the colour bars with careful adjustment of L4 of the May 1969 W/W. article enabled results to be obtained which did not differ appreciably line by line. Stability over long periods, however, was not good due to mechanical vibration and thermal changes. Hanover bars were then obtained. Addition of a PAL delay line effected a complete cure.

Adjustment of the R - Y, B - Y and G - Y drives to the sequential switches enabled colour pictures to be obtained whose fidelity was indistinguishable from Shadowmask results, with the advantages of full luminance bandwidth (a notch filter has been found unnecessary; some commercial receivers do not include them), and total elimination of the necessity for complex convergence and grey-scale tracking adjustments. With the latter, even if the filters do not give an exact white, there can be no failure, since the same gun is used for all three pictures. Problems will arise, however, if any attempt is made to provide switched compensation for filters of widely incorrect characteristic.

As mentioned above, field-sequential systems working at low field rates suffer from luminance flicker effects. Another problem is colour fringing, obtained when there are differences between adjacent fields, i.e., when the scene contains movement.

Fortunately, both have proved a far less serious drawback than was expected.

Perception of flicker depends on many factors including background light level, degree of dark adaption and size of the field under consideration. Thus, viewing a f.s. picture under well lit conditions results in the flicker being highly objectionable; the colours are desaturated, and may not be seen at all. This seems to be true whatever the brilliance of the displayed image, which has in any case to be high to overcome the effects of reflected light from c.r.t. screen and colour wheel.

The improvement when pictures are viewed in either total darkness, or very low ambient lighting is considerable, particularly once dark adaptation has taken
place. Flicker due to the luminance difference between the red, green and blue images in a black-and-white transmission is negligible, while there is no sensation of colour at all.

In general, flicker in coloured pictures increases with increasing area of colour, its saturation and luminance level, and is greater for the primary colours, particularly green, than the complementsaries. The latter is true, since the mark-space ratio with the saturated primary colours is 1:2 (i.e., one field out of three is displayed), while for saturated cyan, magenta and yellow, this ratio is 2:1.

Most programme material does not, however, carry large areas of saturated colour, and the viewer may be unaware of flicker, depending on the content of the programme and its degree of 'viewer involvement'.

A warning is due here: it is probably unwise for anyone susceptible to flicker, as in some cases of epilepsy, to view colour television in this way, as it contains, as well as major components at 16Hz and 50Hz, smaller components at 25 and 8Hz due to interlacing. The latter particularly is close to the so-called danger frequency of 7Hz. However, the author, who does not suffer from epilepsy, has used himself as guinea-pig in viewing trials as long as three hours, with no ill effects, apart from a crick in the neck from the difficult viewing position necessary with the prototype: the colour wheel is 10in. in diameter, and close to the eye, while the raster is on a 17in. c.r.t. 4ft away.

The second problem of colour splitting is, of course, only apparent on images carrying movement; it has, however, been found that any movement has to be quite fast before splitting becomes visible, the gesticulations of an orchestral conductor being particularly susceptible. In most cases, though, the subject of attention in a scene is kept stationary on the screen, while the background moves. An example is a horse-race, where the rails can be seen by a conscious effort as red, green and blue bars.

Possible forms of colour wheel

The prototype colour wheel was a simple affair, and is shown in Fig. 2.

Two aluminium discs were cut out using a woodworker’s routing machine. One was thinner, the other 16 gauge. The three cutouts were then made with the same tool, which proved remarkably efficient, a bolt being placed through the centre of the disc and router plate so that the cutting edge of the router was at the required radial distance. The disc was then rotated slowly, leaving the radial arms of the wheel. Straight sections were cut with a hacksaw. Pieces of red, green and blue gelatine filters (as used for stage lighting) were sandwiched between the discs, which were clamped together by the screws through the machined mounting plate, and 6BA screws into holes tapped in the thinner disc periphery. The angular position of the magnets in relation to the pickup coil is adjusted so that the required section of filter moves down the c.r.t. with the field scan carrying that colour, giving a maximum segment of the wheel through which the correct colours can be seen. This implies that the colour picture can only be viewed with one eye through the side of the disc; however, if the viewer moves back about two feet, the right-hand side of the picture can be seen with the left eye and vice versa, with only small (top right, bottom left) areas cut off.

An alternative form of disc uses spiral areas of colour, which follow the field scan down the screen, and enables the colour picture to be seen through the top of the wheel. The spiral wheel can be made slightly smaller than its simple counterpart, thus a specimen for operation directly in front of a 10 or 11 inch c.r.t. is feasible.

Perplex is an ideal material from which to fabricate a spiral wheel, as the diameter can then be made the minimum possible. It is very easy to work, the routing machine again being ideal for cutting out the two inch thick discs required. The discs are fitted to an identical mounting boss to that used with the simple wheel, but care should be taken with clamping bolts, as the plastic tends to shatter under pressure. Aluminium discs of radius dimension y should be placed on each side of the Perplex at the centre to spread this load. Periphery clamping screws should be countersunk 6BA types, and no longer than necessary, to minimize windage. Again, they should not be overtightened.

In order to obtain a 9.6in x 7.2in (12in diagonal) colour picture, a 23 inch diameter specimen of this type has been manufactured, with successful results. Careful balancing of a wheel of this size is...
necessary, and this was carried out by placing it, with a 6in length of shaft through the centre, between two horizontal edges, and adding pieces of lead to the screws through the protective aluminium discs, until the wheel would remain stationary in any angular position.

The following instructions, in conjunction with Fig. 3, can be used to construct the spiral holes. The figure can be conveniently drawn on the protective paper covering the Perspex sheets at purchase.

1. Calculate the desired radius of the disc from the selected values of x and y. (x can be determined from the relation 5x = diagonal of raster used, since the diagonal and two of the sides of a 4:3 raster make the '3-4-5' triangle of elementary geometry.)

2. Divide the height of the picture into—twelve sections of length a (i.e., a = 3x/12).

3. Divide a 120° segment of the disc into the same number of segments, here twelve of ten degrees each, drawing radial lines.

4. Draw a line of length 4x perpendicular to, and bisected by, the radius pointing towards the top of the paper, at a distance 12a + y, (i.e., height of picture + y), from the centre of the circle.

5. Repeat step (4) with each radial line, moving it in an anticlockwise direction, and reducing the distance of the perpendicular from the centre by length a each time, until the 13th radius is reached, when a line distance y from the centre should be drawn.

6. Repeat steps (3) to (5) for the remaining 120° segments of the circle, starting where the innermost perpendicular of the previous spiral was drawn.

This process builds up an envelope of the spiral holes needed, which can be completed freehand. Using a greater number of increments will, of course, increase the accuracy, but tend to clutter the diagram somewhat.

Slices of the coloured filters should be cut and sandwiched between the discs after removal of all paper but that carrying the design. Small pieces of adhesive tape can be used to secure the filters in position during final assembly, after which all areas of the wheel needed to be opaque should be coated with blackboard paint.

(To be concluded)
is provided with a temperature-compensated reference voltage consisting of the drop across \( D_3 \) and the \( I_{S} \) drop of \( T_{B} \).

The current flowing in each half of the ring is adjusted to the desired operating current by the variable resistors. These are wire-wound trimming potentiometers having temperature coefficients of 80 p.p.m.

The fixed resistors are metal-film types of 1% tolerance, having temperature coefficients of 50 p.p.m.

The same cannot be said for the dependence of the zener voltage \( V_{D3} \) on the operating current as, from the 25°C curve of Fig. 4, an increase of 2.5mA above the recommended value, the temperature coefficient (measured over the range -55 to 100°C) is about +0.002%/deg C. A similar coefficient, but of opposite sign, is obtained for the same temperature range when \( I_{2} \) is reduced to 5mA (2.5mA below the recommended value). It may be concluded, therefore, that the temperature coefficient of \( D_3 \) may be considered independent of operating current, and within the manufacturer's specification of ±0.002%/deg C, provided \( I_{2} \) is held constant at any value within ±33% of 7.5mA.

The same cannot be said for the dependence of the zener voltage \( V_{D3} \) on the operating current as, from the 25°C curve of Fig. 2, an increase of 2.5mA above the recommended 7.5mA causes a change in \( D_3 \) of 34mV, an increase of 0.55%. This is due to the dynamic impedance of \( D_3 \) which is about 12 ohms at 25°C and 7.5mA. A 2.5mA reduction in the recommended 7.5mA (at 25°C) causes a change in \( D_3 \) of 37mV, a reduction of about 0.6%. Thus

\[
\frac{dV_{D3}}{dI_{2}} = 0.6/2.5mA = 0.24%/mV (1) \]

referred to \( I_{2} = 7.5mA \).

Comparing the two coefficients, a 26% increase in \( I_{2} \) from 7.5 to 9.45mA causes \( V_{D3} \) to change by 0.47%. On the other hand, a 26% increase in temperature from 25 to 100°C, causes \( V_{D3} \) to change by only 0.15%. The \( I_{2} \) coefficient is therefore more than three times greater than the temperature coefficient and in most instances will determine the overall stability of the circuit shown in Fig. 1.

To maintain an overall stability of \( V_{D3} \) versus \( I_{2} \), no worse than that of \( V_{D3} \) versus temperature, the total variation in \( I_{2} \) should produce a change in \( V_{D3} \) which is small compared with that produced by a total excursion of temperature within the accepted range. Assuming, for example, a working temperature range of 0 to 50°C, the expected overall stability of \( V_{D3} \) versus temperature is 50 x 0.002% = 0.1%.

If the maximum allowable variation of \( V_{D3} \) versus \( I_{2} \) is made 0.5%—half that allowed for the total temperature variation—then from expression (1) \( I_{2} \) must be maintained within ±0.2mA of the recommended value, i.e. \( I_{2} \) must lie within the limits 7.3 to 7.7mA. This, therefore, is the current demanded from the circuit shown in Fig. 1 for an overall stability of \( V_{D3} \) of ±0.15%.

Fig. 2. Because the \( V_{D3} \) stability with respect to \( I_{2} \) is worse than with temperature—graph shows three times worse—\( I_{2} \) is restricted to 7.5 ±0.2mA, for a stability of 0.05%.

Fig. 3. From these measured temperature stability curves, overall stability is 0.065% referred to the 30°C value.

Fig. 4. From these measured voltage stability curves overall stability is 0.016% or 1mV referred to 30V.

References
Electronic Building Bricks

15. Measuring information

by James Franklin

Throughout this series there have been frequent references to ‘information’ and how it may be represented electrically and processed in electronic systems. By now most readers will have understood that this ‘information’ is not merely something which we read or hear, but can be a varying physical quantity such as the height of the mercury in a thermometer or an electromotive force coming from a microphone. Within electronic systems information is conveyed as signals, waveforms or electric states. When we design communications or other processing systems it is often necessary to be able to measure this information—or, more precisely, the rate at which the information has to be conveyed. This is because equipment for handling a high rate of information is more difficult to design, and costlier, than equipment for a low information rate (e.g. a closed-circuit television system as against a telephone circuit) so it is uneconomic to provide for a higher information rate than you really need. How, then, are information, and information rate, measured?

Engineers measure information in units called ‘bits’, which is a contraction of ‘binary digits’. Information rate is measured in bits per second (telegraph engineers call them bauds). The binary digit is used as a measure of information for two reasons. First, it allows the number of bits of information conveyed to be calculated very simply (e.g. on and off). Second, it is related to the binary number system;* a black area and a white area; or a hole and the absence of a hole (in punched cards or tape). Represented on paper these could be ‘yes’ and ‘no’; the digits ‘1’ and ‘0’ as in the binary number system;* a black area and a white area; or a hole and the absence of a hole (in punched cards or tape). Represented in electrical form these states could be the ‘on’ and ‘off’ states of a switch; two different voltages; two different currents; the presence of a pulse and the absence of a pulse. Such a principle can be applied to any physical variable.

The binary digit is used as a measure of information for two reasons. First, it allows a choice to be made from two entities and thence, by further sub-division, a choice from a whole family of entities. Secondly, in electrical form the two possible states of the binary digit can be represented very clearly and non-ambiguously (e.g. on and off). Fig. 1 shows how a choice may be made of one entity (the letter F) from a family of entities (an eight-letter alphabet) by a series of three binary choices (left or right). Therefore the number of bits of information contained in the knowledge that one letter has been selected from an alphabet of eight† is 3. If this whole selection is made in, say, a tenth of a second the information rate is 30 bits per second.

Now let us see how this principle can be applied to information in electrical signals. First of all turn Fig. 1 on its side and in place of the eight letters write a family of eight voltages on a scale, then add a horizontal time scale to allow a signal to be represented as a voltage/time graph. The result is Fig. 2(a). We can now select by binary choices any one voltage from a family of eight voltages, and the information contained in the knowledge that this particular voltage has been selected is 3 bits. The signal is not actually drawn in as a continuous voltage/time graph line but is defined approximately by the sequence of points marked where the invisible graph line passes through the individual voltages. If we doubled the number of voltages in the family to 16 the signal would be defined more accurately by more points, as shown in (b), but because more binary choices would be required to allow this, the information content in any one point on the graph would become 4 bits. In theory to define any signal perfectly would require an infinite number of points and voltage levels. In practice it is not all that great; for example, a television signal calls for a minimum of 8 binary choices—8 bits—which means selection from a family of 256 voltage levels.

The information rate of the signal in Fig. 2 (a) is determined by the time intervals between the voltage points defining the graph, and here this varies between 60 milliseconds (giving 16.6 bits/second) to 360 milliseconds (giving 2.8 bits/second). In practice the engineer has to allow for the highest information rate necessary for the class of signal he is dealing with. For example, a television signal calls for a maximum information rate of about 11 million bits/second, while a broadcast sound signal needs a maximum rate of about 30,000 bits/second and a telephone signal a maximum rate of 8,000 bits/second.

* A number system based on the radix 2 instead of the familiar radix 10 of the decimal number system.
† The generalized formula is: number of bits = log₂N, where N is the number of entities in the family.
Sampling Oscilloscopes and Sampling Adaptors

A simple explanation of how sampling is applied to oscillography and the benefits that can be obtained

by E. B. Callick* and A. Lawson*

The design and development of radar, communications equipment, fast computers, counters and timers depends upon accurate display of high-frequency waveforms. Because currently available general-purpose oscilloscopes do not give acceptable performance above 100MHz, special wide bandwidth oscilloscopes have been developed, but their design becomes increasingly complex and expensive as the bandwidth is increased. This is due mainly to the difficulty of designing a cathode-ray tube and deflection system to give adequate brightness and deflection sensitivity. The limit set by the present state of the art is around 250MHz, but within the next few years this may be extended to 500MHz with a corresponding increase in cost.

An alternative way of displaying high-frequency waveforms is called signal sampling which is a means for displaying or recording waveforms which are above the upper frequency limit of the indicating instrument. In a typical case, signals at frequencies up to 1GHz can be displayed using a tube and deflection system with a bandwidth of only 150kHz. The sampling unit can either be part of the oscilloscope or an entirely separate unit.

Unlike a conventional oscilloscope, on which the waveform of the signal to be observed is drawn during a single X-sweep in a time related to the period of the input signal, a sampler builds a replica of the waveform over a period covering many cycles of the input signal. It will be assumed, for the purposes of description, that the input signal is applied to a sampling gate which is opened for a very short time once each input cycle. Each time the gate is opened the sampler measures the input signal and causes a dot (or sample) to appear on the face of the c.r.t. which represents the amplitude of the input waveform at the time the sample was taken. The sampler has a memory circuit which enables each dot to be displayed until shortly before the next sample is taken. It also provides a scan signal which places each dot at the correct position on the X-axis. The frequency at which the gate opens is made lower than the input frequency, so that each sample represents a different, later part, of the input signal. Thus a replica of its waveform is built from a number of samples taken over a period equal to many cycles of the signal. Because the memory retains a signal representing the amplitude of the sampled waveform, it is necessary only to increase or decrease that signal by an amount representing the increment in signal amplitude between successive samples. This up-dating of the memory is done in a short gating period during and after sampling. It is not essential that a sample be taken during each cycle of the input signal. If the sampling frequency is such that the gate is opened once during every tenth, hundredth or thousandth cycle of the input signal, this will produce a corresponding increase in the effective bandwidth of the sampling system, but the time taken to build the replica waveform will also increase in the same proportion. This implies that an authentic display will be obtained only when the input signal is time invariant over the period in which image is built up.

Fig. 1 is a simplified block diagram of a typical sampling system. Fig. 2 shows how a replica of one cycle of input signal is produced. To allow time for the trigger circuit to operate, the input signal is delayed by 50ns before being applied to the sampler. As the trigger and gate generator circuit operate in about 40ns, this gives a 10ns visible delay on the display (i.e. the first sample can be taken 10ns before the signal arrives at the sampler, so allowing the leading edge of pulses to be displayed).

After the initial trigger signal is derived from the input waveform there is a delay of about 40ns before the sampler and memory gates are opened and the first sample is taken. During the 2µs when the memory charges, the display is blanked, the staircase generator advances one step, and the c.r.t. spot moves to the required position where it is displayed until the next sample is taken. The staircase is used for two purposes; first to position the display spot horizontally during the blanking period and secondly to increase the trigger circuit delay so that successive samples are taken increasingly later after the initial trigger. As this always occurs at the same point on the input signal waveform, the increase in trigger delay with staircase amplitude ensures that successive samples are taken later and later during the input cycle so that the whole of the input signal waveform is sampled as the staircase progresses.

* G. & E. Bradley Ltd.
The staircase resets when a fixed level is reached so that a constant amplitude X-scan is obtained. The number of steps per scan can be varied from about 50 to 1000, allowing the display to be built up from any number of dots (samples) in this range.

The effective scan rate of the display is set by adjusting the sensitivity of the trigger variable delay circuit so that staircase steps cause the required incremental delay between samples. The oscilloscope sensitivity is adjusted by varying the gain of the sample amplifier. If a sufficient number of samples is used to build the display, the dots will merge to give a continuous outline as on a conventional oscilloscope.

A typical sampling oscilloscope may have sampler and memory gating periods of 350ps and 2μs respectively. The minimum time between samples is roughly 3μs. The time taken to build a replica is proportional to the sampling interval, so that this should be kept to the minimum, but this makes design of the gating circuits more complex and expensive. The chosen figure of 3μs is a working compromise between these two conflicting requirements. When the input signal has a period of 32.35μs or less, one sample is taken every 32.35μs so that the time taken for one complete X-scan of 1000 samples is roughly 32μs. For input signals with periods greater than 32.35μs (frequencies below approximately 3kHz), one sample is taken from each cycle.

At low frequencies this results in a very slow X-scan. For example, an input signal frequency of 1kHz (1ms period) results in an X-scan time of 1 second if 1000 samples are used to build the display. Thus the effectiveness of sampling for visual displays is limited by display flicker for low repetition rate signals unless a long persistence display tube is used.

The parameters which limit the performance of a sampling system are the signal gating period and the ability of the memory circuit to generate a signal which is at all times representative of the input waveform.

The maximum frequency at which the system will operate is determined by the signal gating period because the sampler output is proportional to the mean signal level during this time. Thus the sampler output will decrease rapidly when the signal period falls below 700ps, and be zero at 350ps. This implies that the frequency response of the system is limited well above 1GHz. It is independent of the bandwidth of the indicating oscilloscope provided this is sufficient for it to follow the variation in memory output from sample to sample. With a memory gating period of 2μs this implies a bandwidth not less than 150kHz. This can be reduced at the expense of brilliance of the trace by extension of the blanking period. In practice, the blanking signal generated usually has a duration slightly longer than the memory gating period, so that acceptable performance can be obtained with oscilloscopes having bandwidths down to 100kHz.

The fidelity of the sampling system is determined by the ability of the memory to be correctly up-dated during its gating period. In simple terms, the memory is a capacitor charged by a control circuit which can deliver a limited current during the gating period.

Accurate representation of the input signal will therefore depend on the difference in amplitude from sample to sample. With a large number of samples per scan this increment will be small, permitting the sampler to build an accurate replica of the input waveform. As the number of samples is reduced, the increment will become progressively larger, so that ultimately the memory will not be fully up-dated during its gating period. Thus the response of the sampler to a sinewave input will diminish in amplitude as the frequency increases above a critical value, and representation of a fast rising step function will be degraded so that the risetime appears longer. The maximum possible number of samples should therefore be used to ensure accurate representation of the input signal. This will be accompanied by a corresponding increase in the time taken to build the replica waveform. If this is unacceptable, the number of samples per scan may be reduced until distortion of the displayed waveform sets a lower limit to the sampling rate. The response of the sampler is also modified by the delay line transmission characteristics, which become a major obstacle at frequencies much above 1GHz.

An understanding of the basic principles of sampling enables a sampling oscilloscope or adaptor to be used as easily and reliably as a conventional oscilloscope. The number of samples per scan used to build a replica of the input signal is typically variable over a range of at least 50 to 1000. This allows the number of samples per scan to be reduced when signals with low repetition rate are examined and so permit building of a replica image in a reasonably short time. Degradation of the waveform, which occurs when the number of samples per scan is insufficient to allow an accurate replica to be built may cause inexperienced users to doubt the authenticity of sampled displays. Correct operation is obtained when the maximum possible number of samples per scan is used. Authenticity is then limited by the...
intrinsic capability of the instrument.

Against the obvious advantages of sampling both from the operational and cost points of view must be set two inherent properties of sampling systems which may prove to be disadvantageous in some cases. First, 'single shot' operation is not possible, as samples must be taken from many input signal cycles to build a display. Secondly, the scan rate is slow when the input signal repetition rate falls below about 1000Hz. The effect of slow scan rate can be largely overcome by using a c.r.t. with a long-persistence phosphor so that display flicker is reduced. It should be noted that slow scan rate is an advantage when it is required to record the sampled waveform, as a wide bandwidth recording system is not required.

An oscilloscope or sampling adaptor such as we have considered is ideal for measurements of c.w. and pulsed waveforms in v.h.f. communications and radar equipment. The typical fastest effective sweep rate of 0.1ns/cm enables fast computer and counter logic waveforms to be examined in detail, and time measurements such as signal path delays and semiconductor signal transit times to be made easily and accurately. Circuit faults caused by parasitic oscillations or ringing due to fast transients often cannot be detected with general purpose oscilloscopes. Such effects are easily located with a sampling oscilloscope which will often bring to light unsuspected design faults.

A sampling oscilloscope or sampling adaptor is therefore a good alternative to a general purpose oscilloscope at frequencies up to 50MHz provided that the input signal repetition rate is above about 100Hz. At higher frequencies its performance is superior to that of expensive special purpose wideband oscilloscopes except when 'single shot' displays are required.

Sound Synthesizers

A sound synthesizer comprises a system of voltage controlled oscillators and amplifiers, modulating networks, and combining and keying facilities. For a synthesizer to be of value to a composer the sound generated must be fully prescribed by switch positions. Only then can the system be brought under sensible control.

Three new synthesizers have been introduced in the U.K.—two as imports from America, the third home grown.

Tonus of Massachusetts make the ARP 2500 and the smaller 2600 systems, both available from F.W.O. Bauch Ltd, 49 Theobald St, Boreham Wood, Herts.

The 2500 system for all its complexity and versatility avoids 'patchcords' by employing a modular bus-bar system with midget slide switches. The input, output and control of each module is determined by a vertical slide that connects it to any horizontal bus-bar. In this manner controls can be cascaded and waveform shapes combined in almost any pattern. The 2600 system combines keyboard and sound generators in a neat portable assembly operating from the mains. Bauch are holding a series of lecture-demonstrations and readers can ring 01-953 0091 for details.

From Electronic Music Studios (London) Ltd (49 Decoar Road, S.W.15), the Synthi A attache case synthesizer sells at less than £200 and provides a considerable variety of effects, as may be judged from the photograph.
Elapsed Time Graph for Tape Recording

A simple method for determining the remaining recording time on partially used tapes

by B. W. Lingard*

Any user of a tape recorder will, sooner or later, wish to know the length of recording time still available on partly recorded tracks. If he has been methodical and noted the length of existing recordings the answer is simple—if not, it is only very approximately obtainable. Graduated "protractors" are available which can be fitted on top of the spool and the time read off. However, the graduations are extremely close over the outer third of the reel and are correct only when the reel hub is of the correct diameter and the tape of the nominal thickness. The digital counter reading which on most recorders is proportional to the number of turns of the left-hand suppliespool, has no linear relationship to recording time. A straight line graph is not obtainable even if logarithmic graph paper is available. A curve (3) may be plotted on linear graph paper, but a different graph will have to be plotted for each reel size and tape thickness—in some cases for different makes of tape, because of the variation in hub diameters and tape thickness. What are the relationships concerned?

A reel of tape when full has \( N_T \) turns and an outer radius of \( R_2 \) inches. If the hub radius is \( R_1 \) inches it follows that the mean radius is \( (R_1 + R_2)/2 \) and that the tape length

\[
L_T = 2\pi R_1 + R_2 \frac{N_T}{2} = \pi N_T (R_1 + R_2) \quad (1)
\]

However, if the tape thickness is \( T \) inches it is also apparent that

\[
N_T = \frac{R_2 - R_1}{T} \quad \text{and hence} \quad T = \frac{N_T}{R_2 - R_1} \quad (2)
\]

If \( N_1 \) turns are supplied from this reel (on the l.h. spool) the radius falls from \( R_2 \) to \( R_2 - N_1 T \) and the length delivered is

\[
L_1 = 2\pi R_1 + R_2 - N_1 T \frac{N_1}{2} = \pi N_1 (R_2 - N_1 T) \quad (3)
\]

Recorded time is proportional to length so that

\[
\frac{L_1}{T} = \frac{2\pi R_1 + R_2 - N_1 T}{N_1} = \pi N_1 \left(\frac{R_2 - N_1 T}{N_1}\right) \quad (4)
\]

and the relationship is of the form

\[
y \propto x^2 - x^3
\]

Strangely enough a suitable graph can be constructed using a square law graph upside down! Consider, with a square law graph each ordinate is placed at a distance from the l.h. origin proportional to the square of the number of the ordinate i.e. \( s \propto x^2 \). If such a graph is constructed up to the value \( x_T \) and then inverted the ordinates will now be found to be distant from the new l.h. origin by

\[
s \propto x^2 - \left(x_T - x\right)^2 = 2xT - x^2 \quad (5)
\]

It follows that if a square law graph is constructed and inverted a graph of time (vertical linear scale) against counter reading will plot as a straight line provided that:

\[
\frac{2R_2}{T} = 2x_T \quad \text{or} \quad x_T = R_2 \frac{T}{2} \quad (6)
\]

In practice \( T \) varies between makers (for the same nominal thickness of tape) and it is best to substitute from (2)

\[
x_T = \frac{R_2 N_T}{R_2 - R_1} \quad (7)
\]

However an additional complication arises in that the counter does not usually count turns directly. If \( N = kN' \) (where \( N' \) is the actual counter reading) (4) above is more properly expressed:

\[
\text{Time} \propto \frac{2k}{T} \frac{R_2 N'}{N_1 - k^2 N'^2} \quad (8)
\]

and \( x_T = R_2/kT \). But also \( N_T = kN_T' \) so that

\[
x_T = \frac{2k R_2 N_T'}{k(R_2 - R_1)} = \frac{R_2 N_T'}{R_2 - R_1} \quad (9)
\]

For one specific tape recorder \( x_T \) is found to vary as follows:

<table>
<thead>
<tr>
<th>S.P.</th>
<th>L.P.</th>
<th>D.P.</th>
</tr>
</thead>
<tbody>
<tr>
<td>5 in</td>
<td>1450</td>
<td>2010</td>
</tr>
<tr>
<td>5%</td>
<td>1800</td>
<td>2310</td>
</tr>
<tr>
<td>7 in</td>
<td>2050</td>
<td>3060</td>
</tr>
</tbody>
</table>

If a standard play tape is not normally used a value of \( x_T = 3200 \) will be found to give acceptable results.

The graph is constructed as follows:

1. A convenient base to start from is 0–8 with quarter sub-divisions.

2. The vertical graph lines are set out distant from the l.h. origin as follows

\[
100 \quad 156 \quad 225 \quad 346 \quad 490 \quad \text{etc.} \quad (12)
\]

\[
1 \quad (1.25)^2 \quad (1.5)^2 \quad (1.75)^2 \quad (2)^2
\]

up to 64.00 (= 8²) a suitable scale factor (C) being chosen such that 64C is somewhat less than the width of the page.

3. The graph is then inverted and the ordinates are labelled 0, 100, 200, etc. Note that the penultimate ordinate is 2800 and the last 3200.

4. The horizontal lines are evenly spaced and numbered from 0–130 to fill the space available. This will be suitable for 3/4 i.p.s. tape speed and the normal range of reels.

5. Finally, for any reel of tape of a given size and time gauge, run the tape off the l.h. spool and note \( N_T' \). Plot on the graph a point \( N_T'/\text{nominal time} \) and join it to the labelled origin with a straight line. Generally any time obtained from the graph for a given counter reading will be found to be within 2 minutes of the correct value. Further straight lines can be constructed for other reel sizes and types. It should be noted that at 3/4 i.p.s. nominal times for 1800, 1200 and 900 feet are 96, 64 and 48 minutes respectively. Note also that \( x_T \) relates to the length of the base line of the original graph in arbitrary units. It is not the same as \( N_T \) or \( N_T' \), and in all cases given \( N_T' \) (which is the actual point plotted) will be found to be less than 2400 and hence easily accommodated.

A typical graph is shown in the illustration.

* Royal Military College of Science, Shrivenham.
Centimetric Television Broadcasting

Experimental 12GHz transmissions

by J. C. G. Gilbert, F.I.E.R.E.

At the Radio Administrative Conference held in Geneva in 1959 the centimetric band of 11.7 to 12.7GHz was reserved for several services including television broadcasting. The German Post Office Telecommunications Research Institute started an investigation into propagation problems in this band and in 1969 Dr. J. Feldmann, who led this investigation, read a paper at the Montreux Television Symposium on the feasibility of TV broadcasting in Band VI*.

Most of the available channels in the v.h.f. and u.h.f. television bands are already in use in Germany, and as she wishes to increase the number of programmes two possible lines of attack are open. One is the possible use of stationary satellites and the other is to explore the use of centimetric transmissions from ground stations. Research spread over several years followed three main topics: (1) the propagation behaviour of centimetric waves, (2) the technical conditions to be satisfied at the transmitter and (3) the technical problems at the receiver.

Centimetric waves in the order of 2.5cm behave like light waves and are reflected by obstacles and greatly attenuated by roof structures and walls thus making the use of room aerials impracticable. The atmospheric effects of rain and fading measured over a long period indicate that for 1% of the time a loss of 0.4dB per km can be expected, while for 99% the propagation is hardly affected.

The research team decided that the transmitter should have the following objectives: it must be capable of high-quality pictures and that in order to make the system economically viable the receiving equipment should be cheap, simple, require the minimum of maintenance, and that current commercial TV receivers should be readily adaptable. These considerations therefore defined the transmitter as using vestigial sideband amplitude modulation for vision and frequency modulation for sound. For the earlier measurements a low-power transmitter of some 3-4W was used in which both the video and audio signals were combined at low level. This system can be used economically up to 100W. For higher power transmitters up to 1kW using multicavity klystrons, it has not been found practicable to amplify the vision and sound channels in one tube without introducing cross-modulation. Therefore for higher power transmitters the video and audio channels are kept separate and are combined only at a directional coupler that feeds the transmitting aerial. The specification of the transmitter now in use for experimental transmissions is:

- Power output: 0.1 to 1kW
- Modulation: vision—vestigial sideband a.m.; sound—C.C.I.R. standard f.m.
- Range: 10-15km
- Signal-to-distortion ratio for cross modulation: 51dB
- Frequency band: 11.8 to 12.2GHz
- Transmitter aerial: omni-directional or aerial with sector-shaped pattern and cosec characteristic for vision and audio together (low power) or separate for high powers
- Signal processing: Polarity of far electrical field: vertical, Stability of transmitter: better than ±100Hz per month

At the receiver the signal is converted into a spare channel in Bands I, III, IV or V. The receiving aerial uses a parabolic reflector which has a gain of 25-35dB for a diameter of 65cm. The side lobe attenuation in the range of ±10° off the main beam is >20dB and for the remaining range >25dB. Between the output from the aerial and the mixer stage is a band limiter to improve the signal-to-noise ratio, and also prevent the local oscillator radiation. The local oscillator frequency is dependent on the receiver channel to be used, and the stability is stated to be better than ±75kHz per year. The bandwidth of the converter is at least 80MHz which gives a total of eight possible channels.

The most important criterion of the receiver converter is that it should have as low as possible a noise figure and freedom from distortion. The use of a push-pull mixer reduces noise considerably as it suppresses the f.m. noise of the local oscillator. Fortunately the atmospheric and cosmic noise in the 12GHz band is low and with a vertically polarized receiving aerial it remains below 200°K. Where one is dealing with a large communal system it becomes economical to use a parametric pre-amplifier which improves the noise figure, but for single receivers Schottky-barrier diodes are used.

Stability of the local oscillator is required to attain a very high standard, and a simple free-running microwave oscillator may vary several megahertz in an hour. In order to achieve the necessary stability a relatively low-frequency crystal oscillator is employed followed by frequency multiplier stages. Provided that mass produced harmonic crystals are aged they are satisfactory and in order to prevent warming up drift, the power to the crystal oscillator is always connected. A pilot signal is radiated by the transmitter as a reference signal which can be fed to the local oscillator thus maintaining its stability within the required limits. Both the pilot signal and the TV signal are converted to the i.f., amplified and the pilot frequency extracted and fed to a frequency discriminator. The output from the frequency...
discriminator then provides a control voltage for the stabilization of the local Gunn oscillator.

Research is continuing with alternative methods of frequency stabilization and two suggested methods use a cavity resonator with an extremely inflexible glass construction or alternatively a cavity resonator using a gas pressure controlled membrane which compensates for changes of temperature.

Considerable effort is being applied to the problems of receiver installation, which demands accurate siting and positioning of the antenna. Wind resistance of a solid paraboloid demands a rigid, guyed mast with means of directmg the aerial within 1° to the transmitter. Alternative designs make use of a wire mesh paraboloid using very thin rustproof wire with the crossing points welded and with a stiffening rim. The paraboloid can be mounted either at the top of the mast or in front of it. A rectangular waveguide is used as a feeder and it can be terminated either with a horn or preferably with a circular reflector disc about 3cm in diameter which is supported on a hollow dielectric support. By using miniaturizing techniques the mixer and i.f. amplifier can form part of the waveguide and only the local oscillator is mounted behind the paraboloid.

An alternative form of receiving aerial is a slotted waveguide, and this is acceptable in high field strength areas as its gain is only 15dB compared with a horn-paraboloid combination of 35dB.

During a recent visit to the new German Post Office Research Centre demonstrations were given of reception from three transmitters located some 15km from the receiver. The weather varied from heavy drizzle to drizzle to rain but the standard of the received picture was of a very high order.

During a recent visit to the new German Post Office Research Centre demonstrations were given of reception from three transmitters located some 15km from the receiver. The weather varied from heavy drizzle to drizzle to rain but the standard of the received picture was of a very high order. Intervening tall buildings are viewed on the television monitor from the mast head camera, and a correlation made with the plotter.

Currently three transmitters are in operation and about 100 receivers placed at strategic positions to assess the variations of received quality with changing atmospheric conditions. It is thought that by mass production methods the cost of the aerial-converter can be as low as £15-£20 plus the cost of the guyed mast.

Demonstrations of the reception of these transmissions will be given during the Radio & Television Exhibition in Berlin from August 27th to September 5th.

Acknowledgement is made to Dr. J. Feldmann and his colleagues at the Fernmeldetechnisches Zentralein Berlin for much of the information given in this article.

Books Received

D.C. Amplifiers by B. Mirtes, edited in translation by E. W. Firth. The work is primarily concerned with explaining analysis, design and application of directly-coupled differential operational amplifiers employing semiconductors, and of single-ended drift-corrected op-amps. There is a brief treatment of op-amps using thermionic valves. Other d.c. amplifiers covered include directly-coupled amplifiers without feedback, sensitive chopper-type amplifiers, electrometer amplifiers, d.c. voltage and current stabilizers, and drift-corrected amplifiers designed to amplify low-level floating voltages. The contents fall into three parts. The first includes a practical and theoretical discussion of electronic devices. The second deals with fundamentals of analysis and design of directly-coupled, amplifying circuits and systems. The third part discusses directly-coupled, chopper-type and drift-corrected operational amplifiers. There are six pages of bibliography and a twelve-page index. Pp.520. Price £4.50 (cased version only). Iliffe Books, Butterworth & Co. (Publishers) Ltd, 88 Kingsway, London WC2 6AB.

Selected Papers on Frequency Modulation edited by Jacob Klipper. This collection is divided into four sections—general f.m. theory and basic experiments, f.m. circuit theory, f.m. threshold reduction, and digital f.m. Armstrong's famous paper "A Method of Reducing Disturbances in Radio Signalling by a System of Frequency Modulation" opens the first section. It was Armstrong who first successfully used f.m., demonstrating its greater immunity to noise interference compared with a.m. systems. The compilation is intended as a "reference work for the practitioner, as a guide for those interested in entering the field, and as a textbook in f.m. principles". Forty further references are given in a bibliography at the end. Pp.417. Price £3.75. The imprint is Dover Publications, Inc., but it is available in the U.K. from Constable and Co. Ltd, 10 Orange Street, London WC2H 7EG.

Corrections

Charging. We apologise to readers and to 'Cathode Ray' for the inclusion by the printers of a wrong diagram for Fig.1 on p.391 of the August issue. Here is (we hope!) the correct diagram of the familiar circuit used to study the charging of a capacitor:

Stereo Mixer. In Fig.8(a), Part 1, May issue, $R_s$ is a 'select on test' resistor in the range 200-700kΩ or a 1kΩ preset adjusted for 16.5V at the emitter of $Tr_e$. The voltage at the emitter of $Tr_e$ in Fig.7 is 16.5V. For Fig.7 66dB s/n ratio is referred to 450mV on 200Ω (not 45uV as incorrectly stated on p.300 (June issue)). In Part 2 (June) the series resistor to the main balance control, Fig.11, should be 4.7kΩ not 50V and the current limit is set by $VBEIR_c$, not $93dB$ as quoted in col. 3 p.296. In Fig.13, a 0.25kHz coupling capacitor should be connected between the first 22kΩ resistor and the input to give d.c. isolation. In Fig.19(a) the reservoir capacitor should be 2000µF at 50V and the current limit is set by $VBEIR_c$, not $VBEIR_c'$ as stated in the text col.2 p.296.

Darlington Output Transistors. In the protection circuit for use with complementary Darlington output transistors (August issue, p.399) the two complementary transistors were incorrectly shown as MPS1090. They should be MPSA20 (n-p-n) and MPSA70 (p-n-p).
Amateur satellite service

A new ‘amateur satellite service’ has been defined internationally and amateurs will be able to conduct space communications experiments on 7, 14, 21, 28, 144 (already in use) and 433-438 MHz and 24 GHz bands, including the use of geo-stationary orbits. These, then, are the main changes in the world of amateur radio which will result from decisions made at the I.T.U. World Administrative Radio Conference in Geneva*. This outcome is a considerable improvement on what, at one stage, seemed likely. As reported last month, the delegations from a number of European countries—particularly those from Western European countries most closely associated with the Conference of European Posts and Telecommunications (C.E.P.T)—placed little value on the amateur radio service; indeed in some cases this amounted to active hostility towards amateurs. It was only at the last minute—in the Plenary sessions—that many of these improved facilities (at present amateurs can officially conduct space experiments only in the 144 MHz band) were secured by a reversal of some of the recommendations of the Working Parties. Proposals that amateurs should be permitted to use their 1215, 5650 and 10,500 MHz bands for space experiments were however not accepted.

Many amateurs feel the need to place on record that their proposals received notable support from the official U.K. delegation, led by Don Baptiste, of Minpostel, and from such countries as New Zealand and the United States. The prefix GZ2T and G6ABC/T of Eggbuckland, near Plymouth. He has had many two-way ‘television’ exchanges with amateur stations all over the world, including stations in Portugal in the period April to June. Pictures have been exchanged with KL7DRZ (Alaska), VK6ES (Western Australia), K4P4GN (Puerto Rico), ZL4AOY (New Zealand) a number in Italy and Greece and very many in the United States. Many of his contacts represented the first time British s.s.tv. pictures had been exchanged with stations in the countries concerned. His station is a mixture of home-built and commercially manufactured equipment including Trio transmitter and receiver. According to the latest figures, there are now over 200 stations licensed for amateur television, although the number concerned with slow-scan transmission is still quite small.

Minpostel is believed to be sympathetic to the view that means should be found to allow amateur double-sideband TV transmissions to continue when the 70-cm band is narrowed.

British slow-scan TV activity

We have referred several times to the growing interest in the U.K. in international slow-scan television operation on the h.f. bands, in which a picture is sent every 7.2 seconds with narrow-bandwidth. One of the most successful British exponents of this art is H. Jones (G52T and G6ABC/T) of Eggbuckland, near Plymouth. He has had many two-way ‘television’ exchanges with amateur stations all over the world, including stations in Portugal in the period April to June. Pictures have been exchanged with KL7DRZ (Alaska), VK6ES (Western Australia), K4P4GN (Puerto Rico), ZL4AOY (New Zealand) a number in Italy and Greece and very many in the United States. Many of his contacts represented the first time British s.s.tv. pictures had been exchanged with stations in the countries concerned. His station is a mixture of home-built and commercially manufactured equipment including Trio transmitter and receiver. According to the latest figures, there are now over 200 stations licensed for amateur television, although the number concerned with slow-scan transmission is still quite small. Minpostel is believed to be sympathetic to the view that means should be found to allow amateur double-sideband TV transmissions to continue when the 70-cm band is narrowed.

More long-delay echoes?

Two years ago (‘W.o.A.R.’ August 1969), we drew attention to the efforts of a team at the Radiosience Laboratory, Stanford University, California, to enable amateur co-operation in re-opening the 40-year-old mystery of long-delay echoes of periods up to and sometimes well beyond five seconds. Such echoes were originally reported by Stormer and Van der Pol in the 1920s.

During the past two years a significant number of new instances of apparently authentic echoes of this type have come to light, including several reported by British amateurs, and the number of useful reports is now approaching 100. There have also, it must be said, been a number of reports made in good faith which have later proved to have been the result of elaborate hoaxes. Several possible mechanisms for this strange phenomenon have been postulated, including ‘way-out’ theories that these echoes may be deliberately-induced by space probes coming from outside our solar system, although the Stanford investigators believe that the eventual explanation may prove far less spectacular. The team is still seeking any further details of these rarely occurring (if in fact they do occur) echoes.

In brief

M. G. Whitaker, G31GW, has recently worked several South American stations on 1.8 MHz and also ZD8AY in Ascension Island bringing to 50 the number of countries he has worked on ‘Top Band’. Eric Trebloch, a long-time keen listener to amateur stations who lives in Australia, has now had over 300 countries confirmed—a remarkable score for a non-transmitting amateur. Peruvian stations have been authorized to use the prefix OB instead of OA this year to mark 150 years of Peruvian independence. Extended range v.h.f. conditions were much in evidence on 144 MHz during mid-July with many West European stations received in southern England. The prefix JE is now in use in Japan. The Scottish V.H.F. Convention is to be held at the Carlton Hotel, Edinburgh, on Sunday, October 3 with speakers including Tom Douglas, G3BA, and Geoff Stone, G3FZL, and there will be an exhibition of equipment (details from V. M. Stewart, GM30WU, 9 Juniper Avenue, Juniper Green, Midlothian EH14 5AJ).

PAT HAWKER, G3VA

Slow-scan picture received by H. Jones from the United States (W4LAS).
Stephan S. Forte, B.Sc., Ph.D., F.I.E.E., and Robert Pace have been appointed joint managing directors of General Instrument Microelectronics Ltd following the resignations of G.S. Brookings. Mr. Forte joined G.I.M. in 1970 as marketing director having previously been with Marconi-Elliott Microelectronics since its formation in 1961. He became chief engineer in 1959 and went to A.B.C. Television Definition Films where he worked. He then joined E.M.I. in 1965 where he held a number of posts including engineering manager, manager for custom circuits and, finally, manager of the m.o.s. products division. Mr. Forte spent several years in the Marconi Company R & D Laboratories prior to transferring to M.E.M. Mr. Pace, whose basic patents issued in the m.o.s. field, has been with General Instrument Corp. (parent company of G.I.M.) since 1965 where he held a number of posts including director of engineering and, latterly, assistant to the general manager of the m.o.s. division. Prior to 1965 Mr. Pace was head of engineering at General Microelectronics. G.I.M. was formed in 1968 to design and manufacture m.o.s. large-scale integrated circuits for the U.K. and E.P.T.A. markets.

J. Stuart Sansom, M.I.E.R.E., technical controller of Thames Television (one of the I.T.A. programme contractors for Lon- don), is the 1971/2 chairman of council of the Royal Television Society. Mr. Sansom, who is 42, spent two years with the Royal Corps of Signals before joining E.M.I. In 1953 he joined High Definition Films where he worked for four years on telerecording equipment. He then joined Television Wales in 1955 and in 1959 went to A.B.C. Television where he became chief engineer in 1966.

Ian C. Macarthur has been appointed managing director of the Service Division of RCA Ltd which he joined in 1961. Mr. Macarthur, who is 35, was formerly manager of the Service Division's government and project services. He was most recently responsible for all installation, operation and maintenance projects of the company, including the ballistic missile early warning system, the Suffolk radio research facility, the European Space Research Organization station in Reda, Belgium, and the Skynet S.R.D.E. station at Christchurch. Mr. Macarthur replaces Warren Werner, who is returning to the United States to take up a new position in the Service Division's International Marketing Organization.

Daphne F. Jackson, D.Sc., F.Inst.P., A.R.C.S., reader in nuclear physics in the Department of Physics in the University of Surrey, has been appointed professor and head of the department. Dr. Jackson, who is 34, is believed to be the first woman to be appointed as head of a physics department in any university in the U.K. She took her degree at Imperial College in 1948, and went to the University of Surrey, then Battersea College of Technology, to take her Ph.D. in the field of theoretical nuclear physics. She joined the staff as an assistant lecturer in 1960 and was appointed reader in nuclear physics in 1967. During 1963-64 she joined the University of Washington, Seattle, as research assistant professor and has just accepted an invitation to become visiting professor to the University of Louvain, Belgium.

Leonard F. Knott (43) has joined Minster Automation Ltd, of Wimborne, Dorset, as chief engineer. He joins Minster from Plessey, where he was latterly responsible for the engineering of Ministry contracts in the fields of transmission lines and logic switching for use in data handling. His technical experience includes eight years with the Post Office Engineering Department, national service with the Royal Navy Electrical Branch and fourteen years on telephone switching and remote control systems.

J. Don Sinclair was recently appointed managing director of Astro Communication Laboratory (U.K.), of Coventry, the U.K. subsidiary of Aiken Industries Inc. Astro manufacture surveillance and telmetry receivers and computer peripherals. Mr. Sinclair was previously with Litton Industries as vice-president and general manager of Litton Precision Products International Inc., the European sales and marketing group for electronic components and microwave products. He was at one time a director of Amplivox and also has been head of facsimile communication sales with Muirhead. His engineering background in electronics was in microwave systems development at the Cavendish Laboratory, Cambridge.

Exel Electronics Ltd, who recently moved from Reading to Branks- some, Poole, Dorset, has appointed the appointment of Roy S. Bibby as sales director and Ray J. Chapman as production director. Mr. Bibby, who is 40, joined Exel in June 1970 from Courant Electronics, to set up and develop a marketing team for the company's new range of digital panel meters. He served with the Royal Signals and spent seven years with Advance Electronics digital division before joining Courant. Mr. Chapman (31) also joined Exel in June 1970 from Courant Electronics, to act as production manager. He served his apprenticeship with Fairey Aviation and worked as a draughtsman with Dawe Instruments and design engineer with De La Rue Frigistor.

A. R. Pritchard has joined English Electric Valve Co. Ltd as sales engineer with responsibilities for power valves, power klystrons and vacuum capacitors. Mr. Pritchard was previously with The Marconi Company for 10 years, latterly as sales engineer in the radio communications division.

Recently announced academic appointments include the following: David S. Campbell, D.Sc., technical manager, capacitor division of the Plessey Company, has been appointed to a chair of electrical engineering at Loughborough University of Technology. K. D. Stephenson, F.I.E.E., is to be assistant lecturer in the department of electrical and electronic engineering in the Heriot-Watt University, Edinburgh, which has been appointed to the new full-time post of director of television at the University. Professor J. H. H. Merriman, C.B., O.B.E., F.I.E.E., senior director, telecommunications development, in the Post Office has been appointed by the I.E.E. to serve for four years on the governing body of the Imperial College of Science, London. The University of Birmingham has appointed R. Mellitt, B.Tech., and A. W. Rudge, Ph.D., to be lecturers in electronic and electrical engineering. At the Heriot-Watt University P. H. Etherington, B.A., (ass't. lecturer at Kenya Polytechnic) is to be a lecturer in the department of electronic and electrical engineering.

K. R. Sturley, Ph.D., B.Sc., F.I.E.E., who has been professor of communications and head of the Electrical Engineering Depart-
New Products

H.F. linear amplifier
Racal-Mobilcal's TA-940 100-watt h.f. linear amplifier has been designed to increase the power output of low- and medium-power h.f. s.s.b. manpacks. Coverage of the h.f. range of 1.6 to 30MHz is provided and continuous 'key-down' operation is possible to full specification -100 watts output for entire duty cycle. The amplifier will operate with inputs, pre-set internally, between 10mW and 5W. Operation is from a negative earth 28V d.c. power supply. An aerial tuning unit and range of aerial systems are available for use. Racal-Mobilcal Ltd, 464 Basingstoke Road, Reading, Berkshire, RG2 0QU.
WW309 for further details

Cassette data recorder
A standard Philips tin tape cassette is used on the TEAC R-70 recorder (marketed in the U.K. by the Industrial Import Division of Dodwell Ltd) to provide simultaneous four-channel recording, using f.m. or a.m., with the additional facility of putting announcements on to channel four, using a microphone. The recording range is 0.1 to 625Hz (f.m.) and the tape speed is 1.875in/s. The three-digit built-in tape counter, size is 100 x 340 x 244mm, and weight approximately 6.5kg. Price is £750.
Dodwell & Co Ltd, Industrial Import Division, 18 Finsbury Circus, London E.C.2.
WW310 for further details

Wirewound trimmers
Contelec type 025 and 037 wirewound 22-turn trimming potentiometers, are available from Kynmore. Housed in anodized aluminium cases, the units are claimed to be resistant to the effects of humidity and immersion. Type 025 is for panel-mounting, and type 037 is side-mounted. Resistance range is 10Ω to 125kΩ. Both units have a power rating of 1.5W at 85°C. Temperature range is -55 to 170°C. Model 025 is 6.35mm in diameter, and 34mm long. Type 037 measures 6.35 x 9.50 x 31.77mm.
WW320 for further details

Waveform generator
Model F220A waveform generator from Microdot Inc.—available in the U.K. from Texscan Instruments—generates sine, square, triangle, ramp and offset sine waveforms over the frequency range 0.005Hz to 3MHz and provides outputs at both 50 and 600Ω impedances. Triggered, gated or tone-burst outputs can be selected in addition to normal c.w. operation and the generator frequency can be controlled by an external d.c. or wideband a.c. voltage. Output is variable up to a maximum of 32.5V at 600Ω, and Model F220A provides fixed level outputs for each of the waveforms. Accessories available include a power amplifier, signal level monitor and portable power source. Texscan Instruments Ltd, Lord Alexander House, Hemel Hempstead, Herts.
WW323 for further details

Mains input filters
A series of mains input filters from Waycom are primarily designed to offer protection against mains-borne asymmetrical transient voltage spikes. They are suitable for equipment taking up to 4A single phase (3A three phase). The degree of protection offered is such that for a 2kV pulse with rise time of 0.5μs, the transient current flowing will not exceed 20mA, which in typical circuitry means voltage transients of less than 200mV. Waycom Semiconductors Ltd, Wokingham Road, Bracknell, Berks.
WW 302 for further details

Very accurate recording system
A tape recording system manufactured by Gresham Recording Heads is capable of recording and replaying signals in such a way that time intervals are reproduced with an error of less than 0.005%. Noise and distortion are less than 1% in the range 5 Hz to 90 kHz. The analogue signal to be recorded is fed into an A-D converter having a sampling rate of 2 x 10^6 samples/s. Each sample is then converted into an 8-bit binary word which is fed, in parallel fashion, into 8 channels of a 9 channel digital tape recorder. A timing pulse from a master oscillator having a frequency error less than 1 part in 10^6 is fed into the 9th channel of the recorder.
The nine channels, each having a data rate of 200 kilobits/s, are then recorded on 0.5in magnetic tape at a speed of 120 l.p.s. A 3200 l.p.s. (flux reversals per inch) double-gap recording head has been developed to cope with the high recording accuracy. Read output is 22mV p-p at 150 i.p.s. using an optimum write current of
50 ± 10 mA at 1600 f.r.p.i. Crossfeed (write to read) is less than 0.3mV p-p and intertrack crosstalk better than 28dB under worst-case conditions. To reproduce the recording signals, the replayed data is first fed via a time displacement restoration logic unit, and then via a D-A converter to reconstitute the original signal. This converter is followed by a low-pass filter enabling the continual reproduction of the signal within the specified bandwidth to be obtained. The accuracy of the timing of the reconstituted signal is dependent upon the stability of the master oscillator. Gresham Lion Group Ltd, Twickenham Road, Hanworth, Middx.

WW325 for further details

De-soldering tool
A de-soldering tool, known as the Soldavac, is available from Henri Picard & Frere. Suction in the Soldavac is created by a spring-loaded plunger, contained within the body of the tool. The tool has steady rests for the fore and middle fingers, and a trigger placed for thumb pressure.

Once fired, it can be re-loaded using the same hand only, either by the action of the thumb or by pressing the plunger tab against the edge of a table. The trigger also acts as a lever for ejecting the nozzle so that the barrel can be emptied and cleaned. Price £1.95. Henri Picard & Frere Ltd, 34/35 Furnival Street, London E.C.4.

WW319 for further details

Double balanced mixers
A range of sub-miniature double-balanced mixers in a low-profile flat-pack configuration is available from Anzac through Wessex Electronics Ltd. Type MD-123 provides conversion loss of 8dB maximum over the range 10 to 3000MHz. Inputs to any two ports will produce the sum and difference frequencies at the third port. The device may be used with local oscillator inputs ranging from 7 to 20dBm. Precision balanced circuits provide negative transients or contact closure are possible. Display can be stored if required. Full count is 999999, plus over-range indication. Input sensitivity of 10mV and input impedance of 1MΩ/20pF permit the use of high-frequency passive probes. Stability is provided by a crystal-controlled oscillator with a temperature coefficient of less than 1 p.p.m./°C. An external clock can be used. A 3 parts in 10⁶ fast warm-up reference is available as an option. Price £345 approx. SE Laboratories (Engineering) Ltd, North Feltham Trading Estate, Feltham, Middx.

WW324 for further details

Axial-lead polystyrene capacitors
The Mial 616 range of non-encapsulated polystyrene-dielectric capacitors from Waycom have axial leads of 0.6mm or 0.8mm diameter, depending on capacitor size. The range of values is 20–100,000 pF in tolerances of ±20, 10, ±5 and 2.5% and a voltage of 25–630V. Working temperature is from -40 to 85°C. Waycom Ltd, Wokingham Road, Bracknell, Berks.

WW321 for further details

De-soldering wick
Bradwick de-soldering wick, available from Light Soldering Developments, is impregnated with a flux enabling it to remove molten solder from joints by absorption. It is available in transparent plastic packs in lengths of approximately 1.5m. There are four widths of wick for use with different wattage soldering irons. Price 90p per pack. Light Soldering Developments Ltd, 28 Sydenham Road, Croydon, CR9 2LL.

WW329 for further details

Versatile counter-timer
The SM 201 universal counter-timer from SE Laboratories measures frequency, period, period average, time interval, count, pulse width and frequency ratio. Single- or double-line gating with positive or negative transients or contact closure is less than 0.3mV p-p and pulse width and frequency ratio. Single-period, period average, time interval, count, SE

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Once fired, it can be re-loaded using the same hand only, either by the action of the thumb or by pressing the plunger tab against the edge of a table. The trigger also acts as a lever for ejecting the nozzle so that the barrel can be emptied and cleaned. Price £1.95. Henri Picard & Frere Ltd, 34/35 Furnival Street, London E.C.4.

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Double balanced mixers
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two-tone third-order i.m. ratios of better than 100dB with −30dBm input tones. The full range comprises MD-123
to 124 (10-3000MHz), MD-113 (10-1000MHz),
MD-125 (0.5-500MHz), and MD-124
(50Hz-200MHz). Wessex Electronics Ltd.,
Stover Trading Estate, Yate, Bristol BS17
5QP.
WW301 for further details

Linear-law potentiometers
A range of single-turn precision potentiometers—
the B-Line from Bourns—employs low temperature coefficient long-
life elements. The range is available in diameters of 2in,
1½in and 2in, bushing or servo mount.
Specification:
resistance value
20Ω to 100kΩ
power rating at 70°C
20W to 20W for 2in max.
Max. operating
temperature
125°C
output smoothness
0.1% of v.r.
linearity
from ±0.5% to ±0.1%
insulation resistance
1000 MΩ
vibration tolerance
15G
shock tolerance
50G

Bourns (Trimpot) Ltd, Hodford House,
17/27 High Street, Hounslow, Middx.
WW318 for further details

High-permittivity ceramic
GEC Hirst Research Centre has
developed a new class of high permittivity
material for use as a microcircuit
substrate at the lower microwave
frequencies. The material is a zirconate
ceramic of permittivity 35 compared
with conventional alumina’s 10. Thus
smaller size microstrip circuits can be used at
u.h.f. or low microwave frequencies.
The photograph shows equivalent ring
resonators for use at 5GHz deposited on
(left) a zirconate ceramic substrate and
(right) standard alumina substrate, showing a 2:1 linear size advantage for
the zirconate. The new material possesses
a very low dielectric loss (Q=2000) and a
low controllable temperature coefficient of
permittivity, so that temperature-stable
resonators can be made in a relatively
small size. The ceramic may be used to
load phase shifters (e.g. for phased array
aerials) to give higher performance. GEC
Hirst Research Centre, East Lane,
Wembley, Middlesex.
WW313 for further details

Low distortion oscillator
Model CR116 oscillator in the NF Instruments
Co. range of test instruments, available
in the U.K. from Tekmar Electronics,
covers 5Hz—540kHz in five ranges.
Frequency response is flat ±0.2dB from
20Hz to 50kHz and distortion down to
0.015% between 200Hz and 10kHz. Out-
put level is +16dB maximum (open
load) with a 600Ω balanced load. Operation is from
the mains and the price is £266.62. A portable
version, the CR117CT which employs a
NiCd battery, costs £201.96. Tekmar
Electronics Ltd, 102 High Street,
Harrow-on-the-Hill, Middx.
WW311 for further details.

Wide-range signal generator
Combining the techniques of the frequency
sweeper and an a.m./f.m. signal generator
the TF2008 from Marconi Instruments
covers the range 10kHz to 510MHz.
This range is provided in eleven switch-
selected bands and the instrument incor-
porates two primary signal sources—a
manually-controlled oscillator and a
voltage-controlled oscillator. When the
latter is in use it can be coupled to an
internal sweep-drive generator which gives
continuous sweep over the whole, or any
part, of each tuning band. Narrow-band
sweep is possible when the instrument is
used as a manually-tuned signal gene-
or. Price £1700. Marconi Instruments
Ltd, St. Albans, Herts.
WW317 for further details

Digital indicators
Newton Indicator Tubes from FR
Electronics are 7-segment indicators
incorporating directly viewed incandescent
filaments allowing viewing angles up to
140°. The units have a normal operating
voltage of 5V with a segment current drain
of 20mA, and are i.c. compatible. The
brightness of the display can be varied to
suit all ambient light conditions, permitting
viewing even in direct sunlight. FR
Electronics, Wimborne, Dorset BH21 2BJ.
WW312 for further details

Sensitive reed relays
Pye TMC has introduced a range of
sensitive reed relays with a variety of
switching modes encapsulated in a tough,
stable, moisture-resistant epoxy resin.
The range is particularly designed for high-
Discoidal lead-through capacitors

A range of discoidal lead-through capacitors, type DLT/10,000, from Oxley, employ multi-layer construction using a high 'K' ferro-electric ceramic for high capacitance per unit volume. The discoidal construction, which permits a radial current flow in the capacitor electrodes, is said to result in self inductance considerably smaller than that inherent in a capacitor having a more conventional construction. The component is mounted in a 2BA clearance hole. The body is a 4BA hexagon section, with a gold finish, the lead-through wire being 20 s.w.g. tinned copper.

Characteristics:
- test voltage: 250V d.c.
- working voltage: 100V d.c.
- operating temperature range: -55 to +125°C
- capacitance: 10,000pF ±20% or ±80% -10% Oxley Developments Co. Ltd, Priory Park, Ulverston, North Lancs.

WW304 for further details

Digital multimeter

Model 460 self-contained digital multimeter, from Bach-Simpson, provides 26 ranges including alternating current. A battery pack is built in along with a charger unit which operates automatically when the instrument is mains operated. Polarity and over-range indication are automatic. Ranges (which are measured without the use of external shunts) are as follows:
- volts a.c./d.c. 100µV-1000V
- amps a.c./d.c. 100mA-2A
- resistance 190mΩ-20MΩ

The system is protected against overload.

It weighs 3kg (with batteries) and measures 11 x 24 x 20cm (approx.). Price £150. Bach-Simpson Ltd, 331 Uxbridge Road, Rickmansworth, Herts, WD3 2DS.

WW315 for further details

Push-button switches

A range of illuminated multi-pole Compu-Lite Series 11 push-button switches from Guest International Ltd. are designed for front panel fixing. They are

WW316 for further details
enclosed and sealed and switch up to 5A at 250V. Each switch allows one pole to be switched in before the remaining poles make contact. Gold contacts are available for low-level switching.

A wide range of coloured bezels and screen split or full legends can be supplied, and a number of different switching actions is also available. Maximum depth is only 38mm. Series 11 switches can be made available with AMP-type terminals. Guest International Ltd, Nicholas House, Brigstock Road, Thornton Heath, Surrey. **WW307 for further details**

### Solid tantalum capacitors

A life of 1000 hours operation in the temperature range –55 to 125°C is guaranteed for a range of metal-cased solid tantalum electrolytic capacitors available from Seatronics (UK). Capacitance tolerance is ± 20% in the range of 0.35 to 330µF, at voltages from 6.3 to 50V d.c. Leakage current is 0.002µA/µF max., and tan delta is 0.06 max. The 1000-off price ranges from 17p to 72p each, the latter being the cost of a 50V 22µF unit. Seatronics (UK) Ltd, 22-25 Finsbury Square, London EC2A 1DT. **WW326 for further details**

### Transistor amplifiers for 3.4 to 4.2GHz

A series of solid-state amplifiers for the 3.4 to 4.2GHz range is announced by Watkins-Johnson Company. The WJ-5102 amplifiers provide a 7dB noise figure, ±0.3dB gain flatness, +25dBm intercept point and 1:2:1 v.s.w.r. Time-delay distortion is small: linear component is 1 x 10⁻³ ns/MHz, parabolic component, 1 x 10⁻⁶ ns/MHz²; residual ripple, 0.2ns peak-to-peak. The design is a microstrip employing chip components. There is a choice of gains from 10dB to 50dB and power output as great as +20dBm at the 1dB compression point. These amplifiers are available with or without integrated power supplies. Watkins-Johnson International, Shirley Avenue, Windsor, Berkshire. **WW332 for further details**

### Polyester foil capacitors

Available in a capacitance range of 1000pF to 1µF, new ISKRA KMFU high-quality polyester foil capacitors from Guest International are non-inductive

**WW303 for further details**

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**Low thermal e.m.f. reed switch**

The MRA-230 reed switch from FR Electronics has a thermal junction e.m.f. of 10µV/°C. It is of form A construction (contacts normally open) and its miniature size can be gauged from the photograph. The switch has been designed for use at r.f. up to 30MHz. F R Electronics, Wimborne, Dorset BH21 2BJ. **WW316 for further details**

**Incremental indicator**

The Comark incremental indicator type 1211-30 is a battery powered portable instrument which will measure direct voltages from 0 to 30mV with a resolution better than 10mV. The instrument has an accurate backing-off source built in, which is used to provide 30 ranges up to 1mV f.s.d. Comark Electronics Ltd, Brookside Avenue, Rustington, Littlehampton, Sussex. **WW305 for further details**

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**Miniature d.c. motors**

The Escap 20 series ironless rotor d.c. motors from Portescap employ self-supporting skew windings, to provide low inductances and short time constants. The motors incorporate gold alloy brushes, precious-metal commutators and self-lubricating sintered bronze bearings. Built-in reduction gearheads with ratios 1:4, 1:15 and 1:59 can be supplied with the motors which offer output powers from 0.15 to 3.1W, starting torques from 6 to 132gcm, and no-load speeds up to 17,300 r.p.m. They measure between 20 and 33mm long by 20mm in diameter, and weigh only 20-65g. Portescap (UK.) Ltd, 204 Elgar Road, Reading RG2 0DD. **WW328 for further details**

**Thick-film amplifier/oscillator modules**

Redac have announced a modular select-to-order fixed frequency oscillator and a compatible frequency-selective amplifier. Both modules employ thick-film circuit techniques and require a 12V supply. Oscillator module, type TF002, offers a fixed frequency of operation in the range 100Hz to 1MHz with a tolerance of 1% maintained over 0 to 45°C. Two outputs are provided-IV at 300Ω and 10mV at 1kΩ. Frequency selective type
For further information on any item include the appropriate WW number on the reader reply card

**ACTIVE DEVICES**
A 22-page product summary brochure covers all the integrated circuits in production at Picessy’s Swindon factory, Picessy Microelectronics, Cheney Manor, Swindon, Wilts. WW401

MCP Electronics Ltd, Aplerton, Wembley, Middlesex, HAO 4PE, are distributors of Telefunken semiconductors and have available a short-form catalogue dealing of their diodes, transistors and integrated circuits WW402

The following data sheets from RCA, Sunbury-on-Thames, Middlesex, describe new high-frequency transistors and microcircuits:

2N6093, 75W (p.e.p.), 2-3MHz, 13dB gain WW403

TA7993, 2W, 2GHz, 8.2dB gain (W, 1GHz, 12dB) WW404

TA7486, 200mW, 1GHz, 12dB gain WW405

TA7994, 5W, 2GHz, 7dB gain (15.3W, 1GHz) WW406

TA7023. Microwave broadband i.e., 225-400MHz, 16W, 6dB gain at $f_m = 280$ WW407

TA7477. Integrated circuit power combiner/divider 225-400MHz, powers up to 40W, $Z_{in} = Z_{out} = 50$ WW408

AEI Semiconductors, Carlyle Rd, Lincoln, have available a revised price list covering their micro wave semiconductors, regulator diodes, rectifier diodes, thyristors and triacs, and thyristor/rectifier assemblies WW409

**PASSIVE COMPONENTS**
Toggle, rocker, walter and slide switches are described in a catalogue from Lorlin Electronic Co. Ltd, Billinghamhurst, Sussex WW410

Minicature d.c. motors (Escap 26 series) with very low rotor inertia for instrument application are described in a leaflet from Portescap U.K. Ltd, 204 Elgar Rd, Reading RG2 9LJ, that gear-heads, with ratios from 1:4:1 to 6:1 are also described WW411

Four 13A sockets with a switch and neon indicator in a box form a mains distribution panel that has been added to the Leckcroft range. A leaflet describes the panel and explains the Leckcroft system of construction; A.P.T. Electronic Industries Ltd, Cherstey Rd, Byfleet, Surrey WW412

We have received the following literature from Errie Electronics Ltd, South Denes, Gr. Yarmouth, Norfolk:

Stock catalogue listing a wide range of capacitors, resistors, potentiometers and semiconductor devices WW413

Data sheet R/20. Describes a range of $\pm$ and $\pm$W resistors 2.2k to 5.1M $\Omega$, 5% WW414

Data sheet R/21. Carbon composition resistors, $\pm$ and $\pm$W, 107 to 22M in 5, 10 and 20% tolerance, Wire wound. WW415

Saft (U.K.) Ltd, Castle Works, Station Rd, Hampton, Middlesex, have sent us the following data sheets on cadmium nickel batteries and associated equipment: VR series, Cylindrical 0.5 to 10Ah WW416

VB series, Button packs available in sintered plate or plastic sleeve construction, 2.4 to 12V, 90 to 1,750mA WW417

S1000T. Constant current battery charger for up to 2A in a chassis incorporating a timing charging rate adjustable from 10mA to 1A WW418

A range of relays, called the ‘GFR300 series’, manufactured by Fye/TMC, Components Division, Roper Rd, Canterbury, Kent are the subject of a leaflet. Various coil and contact combinations are possible WW419

The plugs and sockets distributed by F. C. Lane Electronics Ltd, Silnfold Lodge, Horsham, Sussex, are described in a short-form catalogue WW420

**APPLICATION NOTES**
We have received three application notes from Waycom Semiconductors Ltd, Wokingham Rd, Bracknell, Berks, RG12 1ND:

1: ‘Pulse transformers for thyristor firing circuits’ deals with the theory, makes some recommendations and highlights some pitfalls WW421

2: ‘Harmonics generated by thyristor controlled circuits—Part 1’. The nature of the problem is discussed and a general LC suppression method is given WW422

3: ‘Harmonics generated by thyristor controlled circuits—Part 2’. Deals mostly with the suppression of interference from shunt wound motors from 150kHz to 30MHz WW423

We have received the literature listed below from RCA, Sunbury-on-Thames, Middlesex:

`An h.f. power transistor for linear applications’, discusses the 2N6093 and concludes with a 150W, wideband (2-3MHz) linear amplifier design WW424

ST4700. ‘Integrated circuit stereo decoder does everything’, describes in detail the phase- locked-loop decoder which was mentioned last month (p. 377) WW425

CAS088E. ‘A.M. receiver sub-system and general-purpose array’ gives data and circuitry for a complete a.m. receiver i.e., WW426

ST4596. ‘Advances in f.m. receiver design’, describes new f.m. receiver i.e. which incorporates f.i. stages, detector, a.f. output, turning meter output, a.g.e. output, decoder disable line and facilities for a select control WW427

CAS089E. Data sheet for above WW428

Recent advances in the design of micropower operational amplifiers’, deals with operational amplifiers that have no internal resistors and gives some uses for them .................. WW429

ST3857. ‘Microwave power generation using r.f. power transisters’ describes the construction of p.a. and power transformers before giving application information WW430

Power circuits—d.c. to microwave’, 448-page book of circuits and explanations, price £1.30 WW431

‘ Gunn diode circuit handbook’ is a useful 40-page booklet published by Microwave Associates Ltd, Cradock Rd, Luton, Beds LU4 0JQ WW432

**EQUIPMENT**

Addition, subtraction, multiplication, division, ‘chain multiplications’, calculations with a stored constant, raising to a power and mixed calculations may all be done with a pocket printing calculator from Computer Ancillaries Ltd, Radio House, Central Trading Estate, Staines, Middlesex. Results are printed on a carbon roll of paper type—price is £179. A leaflet gives a full description WW432

Temperature measurement can be made remotely so that environmental conditions are not disturbed using the KT12 infra-red radiation thermometer which is described in a booklet from the Scientific Instruments Division of Quest International Ltd, Nicholas House, Brickstoke Rd, Thornton Heath, Surrey WW433

A new computer, Satellite One, is described in a brochure from Computer Technology Ltd, Eaton Rd, Henel Hempstead, Herts. WW434

‘The complete guide to your digital instrument requirements’ is the rather misleading title of a booklet from SE Laboratories (Engineering) Ltd, North Falsham Trading Estate, Feltwell, Middlesex. One would expect (from the title) a complete survey of the whole field of digital instruments when in fact only one type of equipment is mentioned. However, a useful section on using digital instrumentations included WW435

Details of a comprehensive range of microwave components are given in a 125-page catalogue prepared by Microwave and Electronic Systems Ltd, Letchford Industrial Estate, Newbridge, Midlothian, Scotland WW436

J Beam Engineering Ltd, Rotherthorpe Cres., Northampton, have published leaflets in English, French and German describing a 450-470MHz glass fibre colinear aerial (type 7058) with a 10dB gain over a half-wave dipole:

English WW437
French WW438
German WW439

An analogue signal converter (type PSC 300), intended for use as an interface unit in instrumentation systems when the process signal and the instrument signal are incompatible, is described in a brochure from Mimic Diagrams and Electronics Ltd, Maxim Rd, Crayford, Kent WW440

An optical colour comparator for setting-up colour television receivers, a colour film assessor and a light-meter calibrated in foot-Lamberts are described in a brochure from Grafikon (Engineers) Ltd, 75 South Western Rd, Twickenham, Middlesex WW441

**PROSPECTUSES (1971-'72)**
Department of Telecommunication and Electronics, Northwood Technical College, Knight’s Hill, London E.S.27.

Hendon College of Technology, The Burroughs, Hendon NW4 4BT.

Faculty of Engineering, Brighton College of Technology, Pelham St, Brighton BN1 4FA.

Department of Engineering, Twickenham College of Technology, Egerton Rd, Twickenham, Middlesex.

Compendium of Degree Courses 1971, Council for National Academic Awards, 3 Devonshire St, London W1N 2RA.

**GENERAL INFORMATION**
Our associated book company, The Butterworth Group, 86 Kingsway, London WC2B 6AB, has produced the following book catalogues:

Books on radio WW442
Selected books on radio and television WW443
Books on television WW444
Postgraduate books on electronics WW445

A catalogue of electrical and electronic hobbyist books may be obtained from Tab Books, Blue Ridge Summit, Pennsylvania 17214, U.S.A.

An RCA publication ‘Beam-lead devices’ graphically explains how this type of chip is constructed. RCA, Sunbury-on-Thames, Middlesex WW446

Details of the 3M wildlife recording contest are given in a leaflet available from 3M House, Wigmore St, London W1A 1ET. The first prize is a natural history holiday worth £150.
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AND HIGH ACCURACY. These are some of the features that make Levell portable voltmeters an essential part of your operation. Add solid state design, large overload ratings, long battery life, and you’ll see why Levell instruments are a very good buy. All A type instruments have $3\frac{1}{2}''$ scale meters, and case sizes $5''$ x $7''$ x $5''$. B types have $5''$ mirror scale meters and case sizes $7''$ x $10''$ x $6''$. Optional extras include mains units and leather cases.

A.C. MICROVOLTMETERS

**VOLTAGE & db RANGES:** $15\mu V$, $50\mu V$, $150\mu V$, $500V$ f.s.d. Acc. $\pm 1\% \pm 1\% f.s.d. \pm 1\mu V at 1\text{kHz}$. $-100$, $-90$ $-50 \text{dB scale}$. $-20 dB / +6 dB rel. to 1 \text{mW} / 600 \Omega$. **RESPONSE:** $\pm 3\text{dB}$ from $1 \text{Hz}$ to $3 \text{MHz}$. $\pm 0.3\text{dB}$ from $4 \text{Hz}$ to $1 \text{MHz}$ above $500\mu V$. Type TM3B can be set to a restricted B.W. of $10 \text{Hz}$ to $10 \text{kHz}$ or $10 \text{kHz}$. **INPUT IMPEDANCE:** Above $50\mu V$: $> 4.3 \text{M} \Omega < 20\text{pf}$. On $50\mu V$ to $50\mu V$: $> 5 \text{M} \Omega < 50\text{pf}$. **AMPLIFIER OUTPUT:** $150\mu V$ at f.s.d.

£49

<table>
<thead>
<tr>
<th>Type</th>
<th>TM3A</th>
<th>TM3B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Price</td>
<td>£49</td>
<td>£63</td>
</tr>
</tbody>
</table>

D.C. MULTIMETERS

**VOLTAGE RANGES:** $3\mu V$, $10\mu V$, $30\mu V$ ... $1kV$. Acc. $\pm 1\% \pm 1\% f.s.d. \pm 0.1 \mu V$. **CURRENT RANGES:** $3pA$, $10pA$, $30pA$ ... $1mA$ ($1A$ for TM9BP). Acc. $\pm 2\% \pm 1\% f.s.d. \pm 0.3pA$. **RESISTANCE RANGES:** $3 \Omega$, $10 \Omega$, $30 \Omega$ ... $1 k\Omega$ (linear). Acc. $\pm 1\% \pm 1\% f.s.d. up to $100M \Omega$. **RECORDER OUTPUT:** $1V$ at f.s.d. into $> 1k \Omega$ on L2 ranges.

£75

<table>
<thead>
<tr>
<th>Type</th>
<th>TM9A</th>
<th>TM9B</th>
<th>TM9BP</th>
</tr>
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<tbody>
<tr>
<td>Price</td>
<td>£75</td>
<td>£89</td>
<td>£93</td>
</tr>
</tbody>
</table>

BROADBAND VOLTMETERS

**H.F. VOLTAGE & db RANGES:** $1\mu V$, $3\mu V$, $10\mu V$, ... $3V$ f.s.d. Acc. $\pm 5\% \pm 1\% f.s.d. at 30\text{MHz}$. $-50 \text{dB}$, $-40 \text{dB}$, $-30 \text{dB}$ $10 \pm 20 \text{dB Scale}$. **CURRENT RANGES:** $3pA$, $10pA$, $30pA$, ... $1mA$ ($1A$ for TM9BP). **RECORDER OUTPUT:** Square wave at $20Hz$ on H.F. with amplifier proportional to square of input. As TM3 on L.F.

£85

<table>
<thead>
<tr>
<th>Type</th>
<th>TM6A</th>
<th>TM6B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Price</td>
<td>£85</td>
<td>£99</td>
</tr>
</tbody>
</table>

Send for further information:

Levell Electronics Ltd. · Park Road · High Barnet · Herts. Tel: 01-449 5028 ·

WW—020 FOR FURTHER DETAILS
BRIDGE RECTIFIERS
Four silicon rectifiers interconnected as single-phase full-wave bridge in one four-terminal package. Current handling from 1 to 5A dc. and voltage ratings from 100 to 420V dc. First code number reflects dc. current and last three dc. voltage ratings—D1100—1A, 100V.
Send for Information Bulletin VB

DIGITAL I.C.'s
A range of gates, flip flops, etc. in both "DTL 930," and TTL "74" series. Normally in dual-in-line packages, but TO5 or flat pack available. NKT codings enable immediate identification with corresponding "930" or "74" series; e.g. NKT DIC 936=DTL 936 and NKT DIC 7400=SN 7400.
Send for Information Bulletin VG

DUAL TRANSISTORS
Two isolated high-gain, low-leakage, low-noise transistor chips mounted in close physical and thermal proximity in an industry standard 6-lead TO5 package, and closely matched for \( V_{BE} \) and \( h_{FE} \) provide best low-drift front end for instrumentation differential amplifiers.
Send for Information Bulletin VD

LINEAR IC'S
NKT has an expanding range of industrial linear I.C.'s, such as the LIC 709C (=\( uA709C \)), LIC 722C (=\( uA722C \)), and LIC 741C (=\( uA741C \)). Packages are normally 14-lead dual-in-line (indicated by "14") after type number, but TO5 ("5") and 8-lead dual-in-line ("8") are available.
Send for Information Bulletin VA

DIFF. AMP. PAIRS
Transistors, f.e.t.s. or diodes available in closely matched pairs, loose or in special heat sinks. Available as standards (such as the BC555 \( h_{FE} \) matched pair) or with special close-tolerance matching of other parameters such as \( V_{CC} \), \( h_{FE} \), etc. or less.
Send for Information Bulletin VH

OPTOELECTRONICS
The NKT 7000 range contains infra-red emitting diodes (LED'S), visible light diodes (VLED'S), photo-transistors, photo-cf's, photo-resistors, photo-voltaic cells and optical couplers. Both plastic and hermetic glass-metal-seal packages are available.
Send for Information Bulletin VQ

DIODES
Germanium and Silicon diodes for most switching and small signal purposes including such standards as 1N914, 1N4148, OA91, and OA47. Germanium junction high-current diodes also available. Special selections for \( V_{D} \), \( C_{D} \), \( I_{D} \), etc. on request. Thermal biasing diodes a speciality.
Send for Information Bulletin VR

FET's
NKT markets a range of N-channel, junction-gate f.e.t.s (field effect transistors) covering dc., a.f., r.f. and switching applications. The NKT 80420 series are in four-lead TO72 metal cans and the PN 3819 in plastic TO18 style. Special selections of \( V_{p} \) and \( I_{ss} \) can be provided.
Send for Information Bulletin VF

OPTOELECTRONICS
The NKT 7000 range contains infra-red emitting diodes (LED'S), visible light diodes (VLED'S), photo-transistors, photo-cf's, photo-resistors, photo-voltaic cells and optical couplers. Both plastic and hermetic glass-metal-seal packages are available.
Send for Information Bulletin VQ
non-transistors from Newmarket Transistors

PLASTIC TRANSISTORS
A wide range of plastic transistors with code numbers identifiable with the related metal-can industrial types e.g. PN70/71/72 (=BCY 70/71/72) PN 107/8/9 (=BC 107/8/9), PN 918 (=2N 918), PN 1613/1711 (=2N 1613/1711), PN 2904-7 (=2N 2904-7), PN 3054 (3A NPN “tab” power). Send for Information Bulletin VP.

MICRO DEVICES
As manufacturers of thick film hybrid circuits, NKT specialises in the supply of microminiature semiconductor active devices for attachment to film circuits—the range includes unencapsulated chips, leadless inverted devices (LID’s), microtab and flexible lead types. Send for Information Bulletin VS.

UNIJUNCTIONS
In unijunctions, NKT has available the well tried industry-standard metal-can 2N 2646/7 and 2N 16718, as well as economical plastic devices for less onerous applications where cost is the overriding factor. Send for Information Bulletin VU.

RECTIFIERS
Small flying lead rectifiers with ½ and 1A current ratings at voltages from 100 to 1000V in industry standard package. Apart from such standards as the 1N4001-4007 series, NKT provides special selections on characteristics such as leakage or forward voltage drop. Send for Information Bulletin VR.

THYRISTORS
NKT specialises in the area of low current (up to 1A) thyristors in industrial metal can and economical plastic packages. The range stretches from the plastic NTS 311 (30V, 0.6A) to the TO5 metal can NTS 1500 (500V, 1A) via the TO18 NTS 0600 (60V, 0.6A). Send for Information Bulletin VT.

ZENER DIODES
Completing the array of standard non-transistor devices, NKT provides a useful range of zener diodes. As well as the industry standard 400mW “work horse” (BZY 88/3.3-30V), the range features an economical 1W zener range, the NKT 10C-V-(11-30V). Send for Information Bulletin VZ.

For further details contact one of the distributors listed below. (In the case of large scale requirements you can save time by referring direct to Newmarket).

Eastern Aero Electrical Services Ltd., Building 202, Enfield Road, London (Heathrow) Airport, Enfield, Middlesex. Tel: 01-759 1314
S.D.S. (Portsmouth) Ltd., Hilsia Industrial Estate, Portsmouth PO3 3JW Hampshire. Tel: 0715/63311 Telex: 08114
L.S.T. Electronic Components Ltd., 7 Costford Road, Brentwood, Essex. Tel: Brentwood 26470 Telex: 99443
Coventry Factors Ltd., Coronet House, Upper Well Street, Coventry CV1 4AF Warwickshire. Tel: 0203-210515 Telex: 311243
G.S.P.K. (Sales) Ltd., Hesketh Park, Horrogate, Yorkshire. Tel: Horrogate 6258 Telex: 57852
Hird-Brown Electronics Ltd., Lever Street, Bolton BL3 6JY Lancashire. Tel: Bolton 27311 Telex: 83478
NEWMARKET TRANSISTORS LTD., EXNING ROAD, NEWMARKET, SUFFOLK. Tel: 0638-3381 Telex: 81358
New Constant Voltage/Constant Current 'L' Series

Units Available

<table>
<thead>
<tr>
<th>Model</th>
<th>Range</th>
<th>Description</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>L.30A</td>
<td>0-50V at 500mA</td>
<td>£36</td>
<td></td>
</tr>
<tr>
<td>L.30B</td>
<td>0-30V at 1A</td>
<td>£36</td>
<td></td>
</tr>
<tr>
<td>L.30C</td>
<td>0-10V at 3A</td>
<td>(with adjustable overvoltage crowbar circuit) £48</td>
<td></td>
</tr>
<tr>
<td>L.30D</td>
<td>0-30V at 2A</td>
<td>£56</td>
<td></td>
</tr>
<tr>
<td>L.30E</td>
<td>0-30V at 5A</td>
<td>£82</td>
<td></td>
</tr>
<tr>
<td>L.30F</td>
<td>0-12V at 10A</td>
<td>(with adjustable overvoltage crowbar circuit) £86</td>
<td></td>
</tr>
<tr>
<td>L.30A/T</td>
<td>2 x 0-50V at 500mA</td>
<td>£72</td>
<td></td>
</tr>
<tr>
<td>L.30B/T</td>
<td>2 x 0-30V at 1A</td>
<td>£72</td>
<td></td>
</tr>
<tr>
<td>L.30D/T</td>
<td>2 x 0-30V at 2A</td>
<td>£112</td>
<td></td>
</tr>
</tbody>
</table>

Features

- Continuous variability of voltage and current settings
- Constant voltage or constant current operation
- Programmable output
- Extremely stable output against load/line variations
- Separate on/off switching of mains input and DC output
- Adjustable current limiting facility on all units
- Variable SCR over-voltage crowbar circuit on L.30C and L.30F.
- Clean functional design with precise monitoring of voltage and current by clear scale meter.

FARNELL INSTRUMENTS LTD.,
Sandbeck Way, Wetherby, Yorkshire
Telephone: 0937 3541/6
London Office: Telephone: 01 802/5359

TELFORD RANGE OF Oscilloscope Cameras

Modular type A designed to suit every application.

- Viewing systems include parallax-free viewing during exposure.
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- Adaptors for all popular scopes.
- Wide range of fully interchangeable accessories.
- Film backs: Polaroid 10 second prints with roll, pack or cut film, conventional photo materials including 35mm.

TELFORD PRODUCTS LTD.
4 WADSWORTH ROAD GREENFORD MIDDLESEX ENGLAND TEL 01 998 1011
THE ATTIC PHOTO-OPTICAL COMPANY OF THE BENTIMA GROUP

WORLD'S LEADING MANUFACTURER OF OSCILLOSCOPE CAMERAS
## PARTS AND COMPONENTS FOR TELECOMMUNICATION ENGINEERING AND ELECTRONICS

### EXPORT—IMPORT

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<th>Capacitors</th>
<th>Potentiometers</th>
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<td>Connectors, sockets</td>
<td>Switches</td>
<td>Relays</td>
</tr>
<tr>
<td><em>Electroacoustic Components</em></td>
<td>Microphones</td>
<td>Earphones</td>
<td>Loudspeakers</td>
</tr>
<tr>
<td><em>Miscellaneous Parts and Components</em></td>
<td>Transformers</td>
<td>Fluorescent tube and mercury-vapour lamp adapters</td>
<td>Ferrites</td>
</tr>
</tbody>
</table>

### IMPORT

- Vacuum tubes, special lamps
- Semiconductor devices
- Integrated circuits

---

**ELEKTROMODUL**

Hungarian Trading Company for Electrotechnical Components

**BUDAPEST, XIII., VISEGRADI UTCA 47 a-b**  
Telephone: 495-340; 495-940. Telex: 22-5154, 22-5155

*WW—024 FOR FURTHER DETAILS*
PRINCIPAL PROFILES

AT 50/60 Hz

LOG/LIN RF POWER METER MODEL 1009, 100MHz to 18GHz 50dB
DYNAMIC RANGE, BCD OUTPUT 1000 READINGS PER SECOND

LOG/LIN AC DIGITAL VOLT METER MODEL 1010, 10Hz to 50Hz 96dB
DYNAMIC RANGE, BCD OUTPUT 1000 READINGS PER SECOND

AC LOG COMPRESSION AMPLIFIER MODEL 1023,
10Hz TO 100KHz 80dB DYNAMIC RANGE

LOG ARITHMETIC CONVERTER MODEL 1002, DC
AND PULSE 120dB DYNAMIC RANGE

LOG FREQUENCY TO VOLTAGE CONVERTER
MODEL 1017, 10Hz TO 10MHz

AC/DC LOG CONVERTER MODEL 1020,
5Hz TO 100KHz TRUE RMS 80dB
DYNAMIC RANGE, DC AND PULSE 120dB DYNAMIC RANGE

Aveley Electric are now marketing the most advanced and complete range of Log and dB instruments available in the world. All Pacific Measurements instruments feature 50/60Hz operation, 115/230V Power, and Calibration traceable to the Bureau of Standards. All circuits are 100% solid-state and carry a one-year warranty.

*Catalogue or individual leaflet is available on request.

JERMYN

50p BARGAIN PACKS

All fully coded, all from well-known manufacturers and now available, while stocks last, at better than bulk-buyer's prices! Cash with order only.

THIS MONTH:

1N4148 Signal Diode (=1N914)
18 for 50p

1N5060 1 Amp Rectifier 400V
(=A14D) avalanche protected
7 for 50p

2N2926 NPN Silicon Transistor
(Red) hfe 55 - 110
8 for 50p

2N2923 NPN Silicon Transistor
hfe 90 - 180
7 for 50p

2N2646 Versatile Unijunction
Post and packing 10p for 1 or 2 packs;
3 packs or more post free
Order any quantity, till sold (but we regret packs cannot be subdivided).

P.O. or Cheque payable Jermyn Industries,
Vestry Estate, Sevenoaks, Kent.

RECORDE AMPLIFIERS

150 series DIFFERENTIAL
DC AMPLIFIERS

Wide dynamic range—
high common mode rejection
Low noise, low drift performance
Modular or cased presentation
also

MINI-AMP FE-251-GA
differential dc pre-amplifier
Compatible modules and cards ensure ease of application and great flexibility.

FYLDE ELECTRONIC LABORATORIES LIMITED
16 OAKHAM COURT, PRESTON (0772) 57560

WW—055 FOR FURTHER DETAILS
The single-channel radio link PM 1/160 (156-170 MHz) allows to connect up the most isolated places with the national and international telephone network, or alternatively, it may be employed as a fixed station for radiotelephone communications in mobile means networks. Its high reliability warrants a constant and safe service even in the most difficult environment conditions.

ITALTEL s.p.a.
20149 Milan (Italy) - 12, piazzale Zavattari - phone 4388

WW—026 FOR FURTHER DETAILS
We're sensitive to everyone's needs.

Different people have very different requirements in Hi-Fi, so Goldring developed a comprehensive range of stereo magnetic cartridges that are superb in performance and realistic in price. From the G800 Super E for those who seek perfection down to the G850 for systems on a budget, the Goldring range offers unsurpassed quality and value.

Your request will bring full details of these and other Goldring products. Goldring Manufacturing Company (GB) Limited, 10 Bayford Street, Hackney, London E8 3SE. Tel: 01-985 1152.

Goldring® Series 800
Stereo Magnetic Cartridges.

**DC300 DUAL-CHANNEL POWER AMPLIFIER**

<table>
<thead>
<tr>
<th>Specification</th>
<th>DC300 Specifications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frequency Response</td>
<td>± 0.1db Zero-20KHz at 1 watt into 8 ohms, ± 0.6db Zero-100KHz.</td>
</tr>
<tr>
<td>Phase Response</td>
<td>Less than 5° 1KHz.</td>
</tr>
<tr>
<td>Power Response</td>
<td>± 1db Zero-20KHz at 150 watts RMS into 8 ohms.</td>
</tr>
<tr>
<td>Power at Clip Point</td>
<td>Typically 190 watts RMS into 8 ohms, 340 watts RMS into 4 ohms per channel.</td>
</tr>
<tr>
<td>Total Output (DB)</td>
<td>Typically 420 watts RMS into 8 ohms, 800 watts RMS into 4 ohms.</td>
</tr>
<tr>
<td>T.H.D.</td>
<td>Better than 0.05% at 1KHz.</td>
</tr>
<tr>
<td>I.M. Distortion (60-7KHz 6:1)</td>
<td>Less than 0.1% from 0.01 watt to 150 watts RMS into 8 ohms, typically below 0.05% (max 0.05%).</td>
</tr>
<tr>
<td>Damping Factor</td>
<td>Greater than 200 (Zero to 1KHZ into 8 ohms at 150 watts RMS).</td>
</tr>
<tr>
<td>Hum and Noise (20-20KHz)</td>
<td>100db below 150 watts RMS output (unweighted, typical 110db).</td>
</tr>
<tr>
<td>slewing Rate</td>
<td>8 volts per micro-second. S-R is the maximum value of the first derivative of the output signal.</td>
</tr>
<tr>
<td>Dimensions</td>
<td>19in. standard rack mount (W.E. hole spacing), 7in. height, 9.5in. deep (from mounting surface).</td>
</tr>
<tr>
<td>Weight</td>
<td>40 pounds net weight.</td>
</tr>
<tr>
<td>Finish</td>
<td>Bright-anodized brushed aluminium front-panel with black-anodized front extrusion, access door, and chassis.</td>
</tr>
</tbody>
</table>

**CARSTON ELECTRONICS LTD.**
**SHIRLEY HOUSE**
**27 CAMDEN ROAD**
**LONDON, N.W.1 9LN**
**01-267 2748**

WW—027 FOR FURTHER DETAILS

WW—028 FOR FURTHER DETAILS
Thank you gentlemen.


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the highest standards of soldering attainable, maximum operator efficiency, minimum risk to components.

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the lightest, best engineered 'irons available, consistently reliable performance, minimal maintenance problems.

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the lightest, best engineered 'irons available, consistently reliable performance, minimal maintenance problems.

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Telephone: 01-688 8589 & 4559

INTRODUCING

the new FPC 1000 COLOUR CAMERA from SHIBADEN

This is the colour camera the U.K. market have been waiting for... a camera that combines excellent colour fidelity and stable performance with the simplest operation. This new camera employs broadcast proven techniques whilst the design ensures that all the essential features for studio television equipment have been included — even though the price is ultra-keen.

And this includes a precision dichroic-mirror optical system coupled with the well established three tube design of the colour system. Because the FPC-1000 has the simplest of set-up procedures, it is possible to be 'ON THE AIR' with the minimum of adjustment and the camera is as easy to use as a conventional monochrome model.

THESE OUTSTANDING FEATURES MAKE THE FPC-1000 THE LEADER IN ITS FIELD
- Dichroic Mirror Optical System • Removable Viewfinder
- Automatic Iris Control • Built-in Colour Bar Generator
- High Fidelity Three Tube Colour System • Intercom and Tally System
- Parallel Set Pick-up Configuration • Easy White Balance Adjustment
- Built-in Encoder • Built-in Colour Temperature Compensation Filters
- Built-in 2:1 Interface Sync System • Lens Interchangeability

Write today for your fully detailed brochure of the FPC-1000 and the other outstanding SHIBADEN range of CCTV equipment.

WW—031 FOR FURTHER DETAILS
Acoustic Research has measured the response of more than a million high-fidelity speakers.

Here are some things we have learned about listening.

Fidelity means accuracy.
Accuracy distinguishes high-fidelity speaker systems from the speakers in simple radios and gramophones. It is therefore reasonable that evidence of accuracy should take precedence over descriptions of a speaker system’s size, shape or theory of design. Acoustic Research offers exact measurement data for AR speaker systems to all who ask for it: music listeners, audio enthusiasts, science teachers, even competitors.

The accuracy of a speaker system can be evaluated by listening tests or by measurement. Both methods give the same information in different ways.

Testing for accuracy.
To perform a listening test, an extremely accurate recording must be made and played back alongside the original source of sound. Amplifier and speaker system controls are adjusted to obtain as close a match as possible; and the speaker system judged by the degree of similarity. Acoustic Research has presented public concerts at which the Fine Arts Quartet and other musicians could be compared with recordings played back through AR speaker systems; even seasoned critics were deceived. Obviously, listening tests cannot be made with commercial recordings of music since the listener has no way of knowing which adjustment is most accurately reproducing the recording.

Objective measurements.
While it is not always convenient to carry out scientifically controlled listening tests, properly conducted measurements can give the same information in permanent, quantitative form. AR knows something about this, having already tested the response of well over a million speakers—every one that we have ever made, and many made by competitors. Our findings are that the most important measurements required to assess the accuracy of a speaker system are (1) frequency response on-axis, (2) frequency response off-axis, (3) integrated power output.

AR speakers are now available in pine, and start at £38.95 including purchase tax. Write to Bell & Howell for more information, and a list of dealers.
NEW CELESTION LOUDSPEAKERS

MODEL: PS12 TC 1798 (15 OHMS)
PS12 TC 1920 (8 OHMS)
TYPE: DUAL CONE 12"
RANGE: 40Hz - 12KHz
POWER: 20 WATTS RMS
FLUX: 128,000 MAXWELLS
IMPEDANCE: 15 or 8 OHMS
PRICE (R.R.P.) £9.00

MODEL: PS8 TC 9470
TYPE: DUAL CONE 8"
RANGE: 50Hz - 125K
POWER: 6 WATTS RMS
FLUX: 38,500 MAXWELLS
IMPEDANCE: 15 OHMS
PRICE (R.R.P.) £2.90

* Both recommended for Unilex

NOW AVAILABLE

The Celestion "Ditton 120"

Placed in top Hi-Fi class by reviewers
Supplied in matched pairs — Teak or Walnut
Superb Performance — Economical Price £48.00 pair

CELESTION 'POWER RANGE'

MODEL: G12M
RANGE: 40Hz - 8KHz
POWER: 25 WATTS RMS
FLUX: 145,000 MAXWELLS
IMPEDANCE: 8 or 15 OHMS
PRICE (R.R.P.) £12-95

MODEL: G12H
RANGE: 40Hz - 8KHz
POWER: 30 WATTS RMS
FLUX: 180,000 MAXWELLS
IMPEDANCE: 8 or 15 OHMS
PRICE (R.R.P.) £15-75

'POWER RANGE'
The finest Loudspeakers made for electronic guitars

Loudspeakers for the Perfectionist
Please write for details.

ROLA CELESTION LIMITED
DITTON WORKS, FOXHALL ROAD, IPSWICH, SUFFOLK IP3 8JP
Telephone (0473) 73131
Telex 98385

WW—033 FOR FURTHER DETAILS

Soft magnetic alloys

Mumetal alloys
This is the best known and widest used Telcon group of high permeability alloys. They possess low hysteresis and total losses and are available in strip, rod, bar, wire and core form. Typical applications include: many types of transformers, bridge ratio arms, inductors, h.f. chokes, blocking oscillators, filter circuits, magnetic amplifiers, saturable reactors, modulators, flux gate magnometers, storage circuits, shift registers, transformers, logic switching circuits and a variety of magnetic shielding applications.

Radiometal alloys
Almost as well known as the Mumetal group, these high permeability alloys, with their high saturation induction and low electrical losses, are extensively used for transformers and chokes where the operating flux density is higher than is possible with Mumetal and where a higher permeability than that of silicon iron is required. The six grades have a variety of applications including: relay circuits, pulse and radar transformers, transductor and convertor cores, magnetic amplifiers and saturable reactors.

Permendur alloys
Permendur has the highest saturation ferric induction of all known alloys commercially available. It also has a correspondingly high incremental permeability at high inductions. It is extensively used for stator laminations, telephone diaphragms, magnetic circuits of loudspeakers and equipment operating at high temperatures. Its excellent magnetostrictive properties are frequently used in echo sounders and ultrasonic devices. A special grade of alloys, known as 'Rotelloy', which have superior mechanical properties have also been developed for use in high speed rotating equipment such as aircraft generators.

Telcon Metals Ltd.,
Manor Royal, Crawley, Sussex.
(Crawley 28800)

Telcon

WW—034 FOR FURTHER DETAILS
NEW temperature controlled soldering iron.

THE
ORYX 50

*Screw adjustment range 200°C to 400°C.
*Heat settings accurate to ±2°C.
*One tip for all temperatures.
*Temperature adjustable whilst iron is on.
*Cool, comfortable handle.
*Standard tip — long life iron coated.
*Choice of 11 tip sizes.
*Built-in indicator lamp — thermostat controlled.
*Rated at 50 watts.
*12, 24, 50, 115 or 210/250v. a.c. models.

Send for Technical Literature to

W. GREENWOOD ELECTRONIC LIMITED

We command attention!

New—‘Toa’ Transistor Megaphones...
Clearly the best you’ve heard!
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### Wireless World, September 1971

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<td>Portable Strip-Chart Recorder</td>
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<td>Type H390</td>
<td>Multi-range universal Strip-Chart Recorder</td>
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<td>Low distortion Oscillator 20 ranges sines - square - RIAA</td>
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<td>R, G &amp; L BOXES VOLTAGE DIVIDERS WHEATSTONE BRIDGES UNIVERSAL BRIDGES for educational purposes</td>
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Bass Control -15dB at 20 cps. 

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Further details are available from Telequipment, 313 Chase Road, Southgate, London N14 6JJ. Telephone: 01-882 1166. Telex: 262004. A division of Tektronix U.K. Ltd.

WW—064 FOR FURTHER DETAILS
Our cover photograph is of part of the vibrations and sound section of Evoluon, the permanent exhibition at Philips, Eindhoven. In this abstract presentation sounds are converted into electronic pulses, transmitted and reconverted into sound. Photographer Paul Brierley.

IN OUR NEXT ISSUE
How a modified fan tuner used in conjunction with a simple oscilloscope and a home-made aerial will receive weather pictures from satellites.
A review of television receiver techniques.
Making a turntable and pickup arm.

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SE's Model SM 215 is the most accurate and linear digital volt meter in the world today. It's the one in a million DVM with unequalled performance: typical daily stability ± 1 part per million, coupled with linearity of ± 1 in a million, and annual stability of ± 10 parts per million.

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In spite of its superb specification, this DVM is compact and easily portable to give you standards-room precision wherever you need it, plus SE's true value for money. If you need the best DVM there is, write or ring for details about SE's one-in-a-million SM 215.

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See how the earpiece mounted on a universal joint can be positioned for optimum wearer comfort. When in use it barely touches the ear, when not required it can be swung completely away.

For the first time—a new Amplivox headset offering full communications facilities yet under 2oz in weight.

The New Amplivox MINILITE—a breakthrough in super-lightweight headset design. MINILITE is feather light. No wearer fatigue. No wearer discomfort. New acoustic techniques have led to an earpiece that need barely touch the ear. So it's hygienic as well as comfortable. MINILITE is so light that it can be attached to the frame of a normal pair of spectacles. The telescopic 'Boom' is an acoustic tube that gives highest speech intelligibility. For all situations where the wearer has to use a headset continuously MINILITE pays off handsomely in terms of performance, comfort and operator satisfaction at a truly economical price.

Minilite is Wearer Right
Send for full MINILITE details straight away.

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better made at a more realistic price

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Single-phase or three-phase transformers are available from 2kVA up to 400kVA.

Townley transformers are custom built to your individual needs and if you send a full specification we can quote you by return.

Write or telephone for full details of construction and the information we require for quoting.

Harmsworth, Townley

Harmsworth, Townley & Co. Ltd.,
Harehill, Todmorden, Lancs.
Telephone: Todmorden 2601
RCA's five new IC arrays give you the design flexibility and cost-effectiveness of discrete devices

RCA linear IC arrays offer cost-conscious design engineers an ideal way to achieve new economies—they are priced as low as 6p (5p in volume) per transistor.

Here are five new monolithic, active-device arrays that combine the performance and versatility of discrete devices, with the inherent reliability and match of integrated circuits to provide a new approach to design problem solving.

Check into the:

- CA3081 and CA3082—for 7-segment incandescent and LED display drivers and other current switching applications including relay control and thyristor triggering.
- CA3083—for high current signal processing, thyristor triggering, and driver applications from DC to 120 MHz.
- CA3084—p-n-p type for dynamic loads, level shifting, bias circuitry, and small-signal amplification (including complementary configurations).
- CA3086—5-transistor array for maximum economy and performance in signal processing systems operating in the DC to 120 MHz range.

For further information on these devices and RCA's complete line of linear IC arrays, see your local RCA Representative or RCA Distributor. For a copy of RCA's Integrated Circuit Product Guide (or a specific technical bulletin by File No.) write to RCA Solid State, Europe, Sunbury-on-Thames, Middx., or on the continent to 2-4, rue du Lievre, 1227 Geneva, Switzerland.

<table>
<thead>
<tr>
<th>Type</th>
<th>Package</th>
<th>Description</th>
<th>Technical Bulletin File No.</th>
<th>Price (1000-unit level)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CA3086</td>
<td>14-lead DIP</td>
<td>The economy five</td>
<td>483</td>
<td>£0.27</td>
</tr>
<tr>
<td>CA3084</td>
<td>14-lead DIP</td>
<td>P-n-p array</td>
<td>482</td>
<td>£0.97</td>
</tr>
<tr>
<td>CA3083</td>
<td>18-lead DIP</td>
<td>Five independent 100-mA p-n-p transistors, with $V_{CEO} = 15$ V, and $Q_1$ and $Q_2$ are matched at low currents, i.e. 1 mA</td>
<td>481</td>
<td>£0.92</td>
</tr>
<tr>
<td>CA3082</td>
<td>14-lead DIP</td>
<td>Seven 100-mA transistors with $U_{CEO} = 16$ V (common-emitter array)</td>
<td>480</td>
<td>£1.00</td>
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<tr>
<td>CA3081</td>
<td>16-lead DIP</td>
<td>Seven 100-mA transistors with $U_{CEO} = 16$ V (common-emitter array)</td>
<td>480</td>
<td>£1.00</td>
</tr>
</tbody>
</table>
P. & O. Lines provide top-grade artistes to entertain passengers in their luxury cruise liners. Now P. & O. have selected the Shure Vocal Master Sound System to enable the passengers to enjoy every nuance of the performances to the full. The Shure Vocal Master Vocal Projection System provides studio quality sound reproduction at sea or on land, indoors or outdoors, with completely flexible control and is fully portable. Send now for full information on the Shure Vocal Master Model VA302-E.

Shure Electronics Limited, 84 Blackfriars Road, London, SE1 8HA Telephone 01-928 3424 Telex 22443

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You can, for example, see a black cat in a dark room, clearly, sharply, continuously – with light levels as low as $10^{-4}$ foot candles. To do this a high-sensitivity 3-inch image isocon is used fibre-optically coupled to a compact image intensifier which amplifies light 150 times. Sensitive though this unit is, it can't be put out of action by bright lights. Applications include night observation, astronomy, microscopy and nuclear physics.
Certain scientific work, or surveillance applications, might demand tubes that are sensitive to infra-red or ultra-violet light. EEV vidicons are available with special photosurfaces to satisfy these requirements. They're also available as short-lag types for high light levels or long-lag types for integrating light over 1 to 3 seconds, the latter for viewing repetitive light of low levels, such as radar screens emit.

In the EEV image isocon range there's a tube that can give radiologists a bright, moving X-ray picture in daylight—without exposing a patient to high X-ray dosage. In fact dose rates as low as 5 micro-Rontgens per second can be used, so enabling prolonged diagnostic study. Ask for details of these or any other EEV camera tubes for industrial and specialist applications.

EEV know how.
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Continuous variable by coarse and fine potentiometers on front panel

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### Output Current Control
Current metering jack located on rear panel

### Output Polarity
Reversible (Except on Model 907)

### Output Plug and Socket
Brandenburg design moulded in polythene

### Output Ripple
0.01 %

### Source Impedance
Less than 2,000 ohms

### Stability
0.01 % (against ± 7.5% mains change)

### Drift
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High fidelity Monolithic Integrated Circuit Amplifier

Two years ago Sinclair Radionics announced the World's first monolithic integrated circuit Hi-Fi amplifier, the IC.10. Now we are delighted to be able to introduce its successor, the Super IC.12. This 22 transistor unit has all the virtues of the original IC.10 plus the following advantages:

1. Higher power.
2. Fewer external components.
3. Lower quiescent consumption.
4. Compatible with Project 60 modules.
5. Specially designed built-in heat sink.
6. Full output into 3, 4, 5 or 8 ohms.
7. Works on any voltage from 6 to 28 volts without adjustment.
8. NEW 22 transistor circuit.

Output power 6 watts RMS continuous (12 watts peak).
Frequency Response 5 Hz to 100KHz ± 1 dB.
Total Harmonic Distortion Less than 1%. (Typical 0.1%) at all output powers and all frequencies in the audio band.
Load Impedance 3 to 15 ohms.
Power Gain 90dB (1,000,000,000 times) after feedback.
Supply Voltage 6 to 28 volts (Sinclair PZ-5 or PZ-6 power supplies ideal).
Size 22 x 45 x 28 mm including pins and heat sink.
Input Impedance 250 Kohms nominal.
Quiescent current 8mA at 28 volts.

With the addition of only a very few external resistors and capacitors the Super IC.12 makes a complete high fidelity audio amplifier suitable for use with pick-up, F.M. tuner etc. Alternatively, for more elaborate systems, modules in the Project-60 range such as the Stereo 60 and A.F.U. may be added. The comprehensive manual supplied with each unit gives full circuit and wiring diagrams for a large number of applications in addition to high fidelity. These include car radios, oscillators etc. The very low quiescent consumption makes the Super IC.12 ideal for battery operation.

Price, inc. FREE printed circuit board for mounting. £2.98 Post free

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Telephone St Ives (04806) 4311

WW-073 FOR FURTHER DETAILS
Sinclair Project 60

The World's leading range of high fidelity modules

Project 60 offers more advantage to the constructor and user of high fidelity equipment than any other system in the world. Performance characteristics are so good they hold their own with any other available system irrespective of price or size. Project 60 modules are more versatile - using them you can have anything from a simple record player or car radio amplifier to a sophisticated and powerful stereo tuner-amplifier. Either power amplifier can be used in a wide variety of applications as well as high fidelity. The Stereo 60 pre-amplifier control unit may also be used with any other power amplifier system, as can the AFU filter unit. The stereo FM tuner operates on the unique phase lock loop principle to provide the best ever standards of sensitivity and audio quality. Project 60 modules are very easily connected together by following the 48 page manual supplied free with all Project 60 equipment. The modules are great space savers too and are sold individually boxed in distinctive white and black cartons. With all these wonderful advantages, there remains the most attractive of all - price. When you choose Project 60 you know you are going to get the best high fidelity in the world, yet thanks to Sinclair's vast manufacturing resources (the largest in Europe) prices are fantastically low and everything you buy is covered by the famous Sinclair guarantee of reliability and satisfaction.

Typical Project 60 applications

<table>
<thead>
<tr>
<th>System</th>
<th>The Units to use</th>
<th>together with</th>
<th>Cost of Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Simple battery record player</td>
<td>2.30</td>
<td>Crystal P.U., 12V battery volume control</td>
<td>£4.48</td>
</tr>
<tr>
<td>Mains powered record player</td>
<td>2.30, PZ.5</td>
<td>Crystal or ceramic P.U. volume control etc.</td>
<td>£9.45</td>
</tr>
<tr>
<td>20 + 20 W stereo amplifier for most needs</td>
<td>2 x 2.30s, Stereo 60, PZ.5</td>
<td>Crystal, ceramic or mag. P.U., F.M. Tuner, etc.</td>
<td>£23.90</td>
</tr>
<tr>
<td>20 + 20 W stereo amplifier with high performance speakers</td>
<td>2 x 2.30s, Stereo 60, PZ.6</td>
<td>High quality ceramic or magnetic P.U., F.M. Tuner, Tape Deck, etc.</td>
<td>£28.90</td>
</tr>
<tr>
<td>40 + 40 W R.M.S de-luxe stereo amplifier</td>
<td>2 x 2.50s, Stereo 60, PZ.8, mains trsfmr</td>
<td>As above</td>
<td>£34.88</td>
</tr>
<tr>
<td>Indoor P.A.</td>
<td>2.50, PZ.8, mains transformer</td>
<td>Mic., guitar, speakers, etc., controls</td>
<td>£19.43</td>
</tr>
</tbody>
</table>

F.M. Stereo Tuner (£25) & A.F.U. Filter Unit (£5.98) may be added as required.
from a simple amplifier to a complete stereo tuner amplifier with Project 60 modules

Z.30 & Z.50 power amplifiers

The Z.30 and Z.50 are of advanced design using silicon epitaxial planar transistors to achieve unsurpassed standards of performance. Total harmonic distortion is an incredibly low 0.02% at full output and all lower outputs. Whether you use Z.30 or Z.50 amplifiers in your Project 60 system will depend on personal preference, but they are the same size and may be used with other units in the Project 60 range equally well.

SPECIFICATIONS (Z.30 units are interchangeable with Z.30s in all applications).

- Power Outputs: 20 watts R.M.S. into 8 ohms using 35 volts; 30 watts R.M.S. into 8 ohms using 30 volts.
- Frequency response: 30 to 30,000Hz ±1dB.
- Distortion: 0.02% into 8 ohms.
- Signal to noise ratio: better than 70dB unweighted.
- Input sensitivity: 250mV into 100 Kohms.
- For speakers from 3 to 15 ohms impedance.
- Size: 14 x 80 x 57 mm.

Z.30
Built, tested and guaranteed with circuits and instructions manual. £4.48

Z.50
Built, tested and guaranteed with circuits and instructions manual. £5.48

Power Supply Units

Designed special for use with the Project 60 system of your choice. Use PZ.5 for normal Z.30 assemblies and PZ.6 where a stabilised supply is essential.

PZ.5 30 volts un unstabilised £4.98
PZ.6 35 volts stabilised £7.98
PZ.8 45 volts stabilised (less mains transformer) £7.98
PZ.8 mains transformer £9.98

The Sinclair Guarantee

If within 3 months of purchasing Project 60 modules directly from us, you are dissatisfied with them, we will refund your money at once. Each module is guaranteed to work perfectly and should any defect arise in normal use we will service it at once and without any cost to you whatsoever provided that it is returned to us within 2 years of the purchase date. There will be a small charge for service thereforer. No charge for postage by surface mail. Air-mail charged at cost.

Project 60 Stereo F.M. Tuner

First in the world to use the phase lock loop principle

The phase lock loop principle was used for receiving signals from space craft because of its vastly improved signal to noise ratio. Now, Sinclair have applied the principle to an F.M. tuner with fantastically good results. Other original features include varicap diode tuning, printed circuit coils, an I.C. in the specially designed stereo decoder and squelch circuit for silent tuning between stations. Good reception is possible in difficult areas, and often a few inches of wire are enough for an aerial. In terms of a high fidelity this tuner has a lower level of distortion than any other tuner we know. Stereo broadcasts are received automatically as the tuning control is rotated, a panel indicator lighting up as the stereo signal is tuned in. This tuner can also be used to advantage with any other high fidelity system.

SPECIFICATIONS — Number of transistors: 16 plus 20 in I.C. Tuning range: 87.5 to 108 MHz. Capture ratio: 1.5dB. Sensitivity: 2µV for 30dB quieting; 7µV for full limiting. Squelch level: 20µV. A.F.C. range: ±120 KHz. Signal to noise ratio: >95dB. Audio frequency response: 10Hz – 15 KHz (-1dB). Total harmonic distortion: 0.1% for 30% modulation. Stereo decoder operating level: 2µV. Cross talk: 40dB. Output voltage: 2 x 150mV R.M.S.

Operating voltage: 25-30 VDC. Indicators: Mains on; Stereo on; tuning.

Size: 93 x 40 x 207 mm.

Built and tested. Post free. £25

Stereo 60 Pre-amp/control unit

Designed for Project 60 range but suitable for use with any high quality power amplifier. Again silicon epitaxial planar transistors are used throughout, achieving a really high signal-to-noise ratio and excellent tracking between channels. Input selection is by means of push buttons and accurate equalisation is provided for all the usual inputs.

SPECIFICATIONS — Input sensitivities: Radio — up to 3mV. Mag. p.u. 3mV: correct to R.I.A.A curve ±1dB 20 to 35,000 Hz. Ceramic p.u. — up to 3mV. Aux. — up to 3mV. Output: 150mV. Signal to noise ratio: better than 70dB. Channel matching: within 1dB. TONE controls: TREBLE ±15 to —15dB at 10 KHz; BASS ±15 to —15dB at 100Hz. Front panel: brushd aluminium with black knobs and controls. Size: 86 x 40 x 207mm.

Built and tested. £9.98

A.F.U. High & Low Pass Filter Unit

For use between Stereo 60 unit and two Z.30s or Z.50s, and is easily mounted. It is unique in that the cut-off frequencies are continuously variable, and as attenuation in the rejected band is rapid (12dB/octave), there is less loss of the wanted signal than has previously been possible. Amplitude and phase distortion are negligible. The A.F.U. is suitable for use with any other amplifier system. Two filter stages — rumble (high pass) and scratch (low pass). Supply voltage — 15 to 35V. Current — 3mA. H.F. cut-off (—3dB) variable from 28KHz to 5KHz. L.F. cut-off (—3dB) variable from 25Hz to 100Hz. Distortion at 1KHz (35V supply) 0.02% at rated output. Size: 66 x 40 x 90 mm.

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Model F 25-05 Model K 307R2 £25.60
Model A 12-05 Model K 307R £15.90
Model A 15-05 Model K 307R £21.75
Model 51 Model 393 £11.00
Model 55 Model 393 £15.00
Model 111 Model 393 £22.25

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138 GRAYS INN ROAD, W.C.1 Phone: 01/837/7937

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Type S1
★ 2 x 0 to 20 V, 0.5 A each.
★ Accuracy: voltage ± 2% ± 0.1 V,
current ± 2% F.S.D.
★ ± 10% supply voltage gives ± 0.1% output change.
★ Ripple: 300 µV r.m.s.
★ Can be used in series for 40 V, 0.5 A.
★ Can be used in parallel for 20 V, 1 A.
★ 2 ammeters.
★ Indefinite shorting without damage.
★ Size: 8 1/2 x 6 1/2 x 3 1/2 in (21 x 17 x 17 cm).
★ £48.00 net U.K.

Type S7
★ 2 x 0 to 30 V, 1 A each.
★ Accuracy: voltage ± 2% F.S.D.
current ± 2% F.S.D.
★ ± 7% supply voltage gives ± 0.1% output change.
★ Ripple 300 µV r.m.s.
★ Can be used in series for 60 V, 1 A.
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★ 2 meters, calibrated volts and amperes.
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ADDRESS

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| INPUT CAPACITANCE | 4 pf. |
| INPUT NOISE | 1μV rms (12F-1a) |
| UNITY GAIN FREQUENCY | 10 MHz |
| SMALL SIGNAL RESPONSE | 2 Hz to 1 MHz |
| LOAD RESISTANCE | 1 K ohm minimum |
| SUPPLY VOLTAGE | ± 10v to ± 15v |

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OUTPUT is dependent upon gain.

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Primary: 200-250 Volts Secondary: 240 Volts Centre Earth or Atypical (125V) and Earth Shunted

Also Available with 115/120V Secondary Windings

<table>
<thead>
<tr>
<th>Ref.</th>
<th>VA</th>
<th>Weight</th>
<th>Size cm.</th>
<th>P &amp; P</th>
</tr>
</thead>
<tbody>
<tr>
<td>100</td>
<td>0.5</td>
<td>0.1</td>
<td>7.0 x 7.0 x 7.0</td>
<td>0-12V ± 15V x 2</td>
</tr>
<tr>
<td>79</td>
<td>1.0</td>
<td>2.0</td>
<td>7.0 x 6.4 x 6.0</td>
<td>0-12V ± 15V x 2</td>
</tr>
<tr>
<td>22</td>
<td>2.0</td>
<td>4.0</td>
<td>7.0 x 4.0 x 4.0</td>
<td>0-12V ± 15V x 2</td>
</tr>
<tr>
<td>117</td>
<td>6.0</td>
<td>7.0</td>
<td>10 x 9 x 10</td>
<td>0-12V ± 15V x 2</td>
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<td>89</td>
<td>10.0</td>
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<td>14 x 10 x 14</td>
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50 VOLT RANGE

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<td>124</td>
<td>0.5</td>
<td>0.4</td>
<td>8.3 x 9.5 x 6.7</td>
<td>0-24-30-40-48-60V</td>
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<tr>
<td>129</td>
<td>1.0</td>
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<tr>
<td>127</td>
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<td>123</td>
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<td>130</td>
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<tr>
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<td>15 x 13 x 13</td>
<td>0-24-30-40-48-60V</td>
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Lead Acid Battery Charger Type

Primary: 200-250 Volt for Charging of 6 or 12 Volt Batteries

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<tr>
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<td>0.8</td>
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<td>13 x 13 x 13</td>
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<td>16 x 16 x 16</td>
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<tr>
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<td>6.0</td>
<td>18 x 18 x 18</td>
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<tr>
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<td>10.0</td>
<td>8.0</td>
<td>21 x 21 x 21</td>
<td>7-10 days</td>
</tr>
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</table>

Totally Enclosed 115V Auto Transformer

115V 500 Watts remotely controlled with FULL AUTO TRANSFORMER, mains lead and two 115V output sockets: 60-240V 60Hz. QUANTITY PRICES ON APPLICATION

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<tr>
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**2,000,000 SILICON PLANAR TRANSISTORS**

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<td>1000</td>
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**LINEAR INTEGRATED CIRCUIT**

708/PC S.G.S.

TO-5 can 8 lead, Full specification high gain Operational Amplifier data supplied. Lowest offer price.

**QUANTITY**

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<th>Price (P.)</th>
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<td>£1.75</td>
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- **E.M.I.** 13 x 8 in. (10 w) with two tweeters and crossover 7/8 in. ohm models £3.25, P.P. 25p.
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<table>
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<th>DC Gain Accuracy</th>
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<td>1. ASTRODATA Type 460 WIDE BAND DIFFERENTIAL DC AMPLIFIER</td>
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<td>2. EDDYSTONE Type 908 R.F. AMPLIFIER</td>
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<td>0 Hz to 10 kHz</td>
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<tr>
<td>3. EDDYSTONE Type 908 R.F. AMPLIFIER</td>
<td>±0.1%</td>
<td>0 Hz to 10 kHz</td>
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   - **Type 4300 MUTUAL INDUCTANCE COIL**
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12. **1. MUIRHEAD**
    - **Type 74600 PUSHBUTTON ATTENUATOR**

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13. **1. CROYDON PRECISION INSTRUMENT Precision Type 7 (AC-DC VACUUM JUNCTION).**

### REFERENCE

Wireless World, September 1971

**Total Number of Pages:** 1

**Total Number of Lines:** 273

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**Total Number of Sentences:** 97
BROKERS

SQUARE WAVE GENERATORS

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TONE GENERATORS

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VOLTAGE AND CURRENT GENERATORS

1. ECCO

- Type 100V D. C. TONE GENERATOR: Provides 0 V to 100 V d.c. output in 20 V steps. Coverage of 10 Hz to 20 kHz.

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- Type 100V A.C. TONE GENERATOR: Provides 0 V to 100 V a.c. output in 20 V steps. Coverage of 10 Hz to 20 kHz.

3. E.I.L.

- Type 100V D. C. TONE GENERATOR: Provides 0 V to 100 V d.c. output in 20 V steps. Coverage of 10 Hz to 20 kHz.

- Type 100V A.C. TONE GENERATOR: Provides 0 V to 100 V a.c. output in 20 V steps. Coverage of 10 Hz to 20 kHz.

4. SANGAMO WESTON

- Type 100V D. C. TONE GENERATOR: Provides 0 V to 100 V d.c. output in 20 V steps. Coverage of 10 Hz to 20 kHz.

- Type 100V A.C. TONE GENERATOR: Provides 0 V to 100 V a.c. output in 20 V steps. Coverage of 10 Hz to 20 kHz.

5. DAWE INSTRUMENTS

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- Type 100V A.C. TONE GENERATOR: Provides 0 V to 100 V a.c. output in 20 V steps. Coverage of 10 Hz to 20 kHz.

6. DAWES INSTRUMENTS

- Type 100V D. C. TONE GENERATOR: Provides 0 V to 100 V d.c. output in 20 V steps. Coverage of 10 Hz to 20 kHz.

- Type 100V A.C. TONE GENERATOR: Provides 0 V to 100 V a.c. output in 20 V steps. Coverage of 10 Hz to 20 kHz.

7. E.I.L.

- Type 100V D. C. TONE GENERATOR: Provides 0 V to 100 V d.c. output in 20 V steps. Coverage of 10 Hz to 20 kHz.

- Type 100V A.C. TONE GENERATOR: Provides 0 V to 100 V a.c. output in 20 V steps. Coverage of 10 Hz to 20 kHz.

8. SANGAMO WESTON

- Type 100V D. C. TONE GENERATOR: Provides 0 V to 100 V d.c. output in 20 V steps. Coverage of 10 Hz to 20 kHz.

- Type 100V A.C. TONE GENERATOR: Provides 0 V to 100 V a.c. output in 20 V steps. Coverage of 10 Hz to 20 kHz.

9. SANGAMO WESTON

- Type 100V D. C. TONE GENERATOR: Provides 0 V to 100 V d.c. output in 20 V steps. Coverage of 10 Hz to 20 kHz.

- Type 100V A.C. TONE GENERATOR: Provides 0 V to 100 V a.c. output in 20 V steps. Coverage of 10 Hz to 20 kHz.

10. SANGAMO WESTON

- Type 100V D. C. TONE GENERATOR: Provides 0 V to 100 V d.c. output in 20 V steps. Coverage of 10 Hz to 20 kHz.

- Type 100V A.C. TONE GENERATOR: Provides 0 V to 100 V a.c. output in 20 V steps. Coverage of 10 Hz to 20 kHz.

11. SANGAMO WESTON

- Type 100V D. C. TONE GENERATOR: Provides 0 V to 100 V d.c. output in 20 V steps. Coverage of 10 Hz to 20 kHz.

- Type 100V A.C. TONE GENERATOR: Provides 0 V to 100 V a.c. output in 20 V steps. Coverage of 10 Hz to 20 kHz.

12. SANGAMO WESTON

- Type 100V D. C. TONE GENERATOR: Provides 0 V to 100 V d.c. output in 20 V steps. Coverage of 10 Hz to 20 kHz.

- Type 100V A.C. TONE GENERATOR: Provides 0 V to 100 V a.c. output in 20 V steps. Coverage of 10 Hz to 20 kHz.

13. SANGAMO WESTON

- Type 100V D. C. TONE GENERATOR: Provides 0 V to 100 V d.c. output in 20 V steps. Coverage of 10 Hz to 20 kHz.

- Type 100V A.C. TONE GENERATOR: Provides 0 V to 100 V a.c. output in 20 V steps. Coverage of 10 Hz to 20 kHz.

14. SANGAMO WESTON

- Type 100V D. C. TONE GENERATOR: Provides 0 V to 100 V d.c. output in 20 V steps. Coverage of 10 Hz to 20 kHz.

- Type 100V A.C. TONE GENERATOR: Provides 0 V to 100 V a.c. output in 20 V steps. Coverage of 10 Hz to 20 kHz.

15. SANGAMO WESTON

- Type 100V D. C. TONE GENERATOR: Provides 0 V to 100 V d.c. output in 20 V steps. Coverage of 10 Hz to 20 kHz.

- Type 100V A.C. TONE GENERATOR: Provides 0 V to 100 V a.c. output in 20 V steps. Coverage of 10 Hz to 20 kHz.

16. SANGAMO WESTON

- Type 100V D. C. TONE GENERATOR: Provides 0 V to 100 V d.c. output in 20 V steps. Coverage of 10 Hz to 20 kHz.

- Type 100V A.C. TONE GENERATOR: Provides 0 V to 100 V a.c. output in 20 V steps. Coverage of 10 Hz to 20 kHz.

17. SANGAMO WESTON

- Type 100V D. C. TONE GENERATOR: Provides 0 V to 100 V d.c. output in 20 V steps. Coverage of 10 Hz to 20 kHz.

- Type 100V A.C. TONE GENERATOR: Provides 0 V to 100 V a.c. output in 20 V steps. Coverage of 10 Hz to 20 kHz.

18. SANGAMO WESTON

- Type 100V D. C. TONE GENERATOR: Provides 0 V to 100 V d.c. output in 20 V steps. Coverage of 10 Hz to 20 kHz.

- Type 100V A.C. TONE GENERATOR: Provides 0 V to 100 V a.c. output in 20 V steps. Coverage of 10 Hz to 20 kHz.

19. SANGAMO WESTON

- Type 100V D. C. TONE GENERATOR: Provides 0 V to 100 V d.c. output in 20 V steps. Coverage of 10 Hz to 20 kHz.

- Type 100V A.C. TONE GENERATOR: Provides 0 V to 100 V a.c. output in 20 V steps. Coverage of 10 Hz to 20 kHz.

20. SANGAMO WESTON

- Type 100V D. C. TONE GENERATOR: Provides 0 V to 100 V d.c. output in 20 V steps. Coverage of 10 Hz to 20 kHz.

- Type 100V A.C. TONE GENERATOR: Provides 0 V to 100 V a.c. output in 20 V steps. Coverage of 10 Hz to 20 kHz.
### Oscilloscopes

**Oscilloscope Types and Specifications**

<table>
<thead>
<tr>
<th>Model</th>
<th>Type</th>
<th>Description</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Type 1</td>
<td>Oscilloscope Camera</td>
<td>Complete with camera</td>
<td>£95.00</td>
</tr>
<tr>
<td>2. Type 10</td>
<td>Oscilloscope Camera</td>
<td>Complete with camera</td>
<td>£250.00</td>
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<td>3. Type 20</td>
<td>Oscilloscope Camera</td>
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<td>4. Type 30</td>
<td>Oscilloscope Camera</td>
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<td>5. Type 40</td>
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<td>9. Type 80</td>
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<td>10. Type 90</td>
<td>Oscilloscope Camera</td>
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### Electronics

**Electronic Components and Specifications**

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<td>1K</td>
<td>500 mA</td>
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<td>2. Capacitor</td>
<td>0.1 uF</td>
<td>500 mA</td>
<td>£15.00</td>
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<td>3. Inductor</td>
<td>0.1 mH</td>
<td>500 mA</td>
<td>£20.00</td>
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<tr>
<td>4. Transformer</td>
<td>0.1 VA</td>
<td>500 mA</td>
<td>£25.00</td>
</tr>
<tr>
<td>5. Diode</td>
<td>0.1 A</td>
<td>500 mA</td>
<td>£30.00</td>
</tr>
<tr>
<td>6. Vacuum Tube</td>
<td>0.1 V</td>
<td>500 mA</td>
<td>£35.00</td>
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### Power Supplies

**Power Supply Specifications**

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<th>Price</th>
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<td>1. Type 1</td>
<td>Power Supply</td>
<td>500 mA</td>
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<td>2. Type 2</td>
<td>Power Supply</td>
<td>1 A</td>
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<tr>
<td>3. Type 3</td>
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<tr>
<td>4. Type 4</td>
<td>Power Supply</td>
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<tr>
<td>5. Type 5</td>
<td>Power Supply</td>
<td>4 A</td>
<td>£30.00</td>
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### Oscilloscope Cameras

**Oscilloscope Camera Types and Specifications**

<table>
<thead>
<tr>
<th>Camera</th>
<th>Type</th>
<th>Description</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Type 1</td>
<td>Oscilloscope Camera</td>
<td>Complete with camera</td>
<td>£95.00</td>
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<tr>
<td>2. Type 2</td>
<td>Oscilloscope Camera</td>
<td>Complete with camera</td>
<td>£250.00</td>
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<tr>
<td>3. Type 3</td>
<td>Oscilloscope Camera</td>
<td>Complete with camera</td>
<td>£300.00</td>
</tr>
<tr>
<td>4. Type 4</td>
<td>Oscilloscope Camera</td>
<td>Complete with camera</td>
<td>£450.00</td>
</tr>
<tr>
<td>5. Type 5</td>
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<td>6. Type 6</td>
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<td>7. Type 7</td>
<td>Oscilloscope Camera</td>
<td>Complete with camera</td>
<td>£900.00</td>
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<tr>
<td>8. Type 8</td>
<td>Oscilloscope Camera</td>
<td>Complete with camera</td>
<td>£1050.00</td>
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<tr>
<td>9. Type 9</td>
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<tr>
<td>10. Type 10</td>
<td>Oscilloscope Camera</td>
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### Pulse Shaper

**Pulse Shaper Specifications**

<table>
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<tr>
<td>1. Type 1</td>
<td>Pulse Shaper</td>
<td>Complete with camera</td>
<td>£95.00</td>
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<tr>
<td>2. Type 2</td>
<td>Pulse Shaper</td>
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<td>£250.00</td>
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<tr>
<td>3. Type 3</td>
<td>Pulse Shaper</td>
<td>Complete with camera</td>
<td>£300.00</td>
</tr>
<tr>
<td>4. Type 4</td>
<td>Pulse Shaper</td>
<td>Complete with camera</td>
<td>£450.00</td>
</tr>
<tr>
<td>5. Type 5</td>
<td>Pulse Shaper</td>
<td>Complete with camera</td>
<td>£600.00</td>
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### Power Units

**Power Unit Specifications**

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<th>Unit</th>
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<th>Description</th>
<th>Price</th>
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<tr>
<td>1. Type 1</td>
<td>Power Unit</td>
<td>500 mA</td>
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<tr>
<td>2. Type 2</td>
<td>Power Unit</td>
<td>1 A</td>
<td>£15.00</td>
</tr>
<tr>
<td>3. Type 3</td>
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<td>£20.00</td>
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<tr>
<td>4. Type 4</td>
<td>Power Unit</td>
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<tr>
<td>5. Type 5</td>
<td>Power Unit</td>
<td>4 A</td>
<td>£30.00</td>
</tr>
</tbody>
</table>

### Oscillators

**Oscillator Types and Specifications**

<table>
<thead>
<tr>
<th>Oscillator</th>
<th>Type</th>
<th>Description</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Type 1</td>
<td>Oscillator</td>
<td>Complete with camera</td>
<td>£95.00</td>
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<tr>
<td>2. Type 2</td>
<td>Oscillator</td>
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<td>£250.00</td>
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<tr>
<td>3. Type 3</td>
<td>Oscillator</td>
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<td>4. Type 4</td>
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<td>5. Type 5</td>
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<td>6. Type 6</td>
<td>Oscillator</td>
<td>Complete with camera</td>
<td>£750.00</td>
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<td>7. Type 7</td>
<td>Oscillator</td>
<td>Complete with camera</td>
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<td>8. Type 8</td>
<td>Oscillator</td>
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<td>£1050.00</td>
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<tr>
<td>9. Type 9</td>
<td>Oscillator</td>
<td>Complete with camera</td>
<td>£1200.00</td>
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<tr>
<td>10. Type 10</td>
<td>Oscillator</td>
<td>Complete with camera</td>
<td>£1350.00</td>
</tr>
</tbody>
</table>
PEN RECORDERS

- **Brothers Precision Potentiometers**

- **Three Turn 780° Rotation**
- **Fifteen Turn 180° Rotation**
- **TRIM POTENTIOMETERS**
- **NEW CHANNEL TIME & EVENT RECORDER**

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**SEMICONDUCTORS**

- **UNIVERSAL MULTIPORT**
- **NEW MULTIPORT RECORDERS**
- **NEW MULTIPORT RECORDERS 100-150°C**

---

**TAPE RECORDERS**

- **Honeywell Model 6000 Incremental Digital Positioner**

---

**MEMORY PLANES**

- **Tape Recorder**

---

**POWER SIGNAL GENERATOR**

- **Rohde & Schwarz Type SMLP (BN40415)**

---

**MOTORS**

- **Low Torque Hysteresis Motor MA23**
- **Clutch Motors**
- **New Low Inertia Integrating Motors**

---

**Brothers Precision Potentiometers**

- **Pen Record**

---

**SEMICONDUCTORS**

- **New Universal Multipoint**

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**Tape Recorder**

- **Honeywell Model 6000 Incremental Digital Positioner**
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WE OFFER FROM STOCK AN EXCLUSIVE RANGE OF BRAND NEW CERAMIC FULL SPECIFICATION LOW COST TIL 7400 INTEGRATED CIRCUITS

<table>
<thead>
<tr>
<th>Part</th>
<th>Description</th>
<th>Price and Qty.</th>
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</thead>
<tbody>
<tr>
<td>7400</td>
<td>Quadruple 2-input Nand Gates</td>
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<td>7402</td>
<td>Dual 2-input Schmitt Trigger</td>
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<td>7403</td>
<td>Hex Inverter with open collector</td>
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<td>7404</td>
<td>Dual 2-input Positive Nand Gates (with open collector output)</td>
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<tr>
<td>7405</td>
<td>Quadruple 2-input Positive Nor Gates (with open collector output)</td>
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<tr>
<td>7406</td>
<td>Dual 2-input Schmitt-Trigger</td>
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<tr>
<td>7407</td>
<td>Dual 2-input Positive Nor</td>
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<td>7409</td>
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<td>7415</td>
<td>Dual 2-input Positive Or-and-Inv</td>
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SEMI-CONDUCTORS

LOOK AT THESE PRICES FOR QUANTITIES FROM STOCK

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</tr>
<tr>
<td>BC240 Mullard 75p</td>
<td>25</td>
<td>100 + 150</td>
</tr>
</tbody>
</table>

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The instrument is of modern appearance, small, light in weight, convenient to use and portable. A wide range of flashing rates is covered by the large accurately calibrated dial, allowing operation at low frequencies for strobo photographic experiments and at high speeds for observation of rapidly rotating or reciprocating phenomena.

The external triggering facility permits single shot operation by an external closing contact and also provides a synchronising input for high and low speed repetitive phenomena which might otherwise be difficult to maintain in exact phase.

Light source: High intensity Xenon tube mounted in a parabolic reflector.
Flashing rate: 1-250 flashes/second in 3 ranges.
Frequency accuracy: Typically ± 2% of each full scale.
Trigging: (a) by internal oscillator
(b) by external closing contacts.

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50µA  £3.60
5µA  £4.20
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50µA  £2.60
5µA  £3.10
10mA  £3.60
1 mA  £4.20
500µA  £4.80
5µA  £5.40

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A.C. £3.00
M.A. £3.00
P.A. £4.00

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TE-45 VALVE VOLTMETER

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**SAVE UP TO 33% OR MORE**

SEND S.A.E. FOR DISCOUNT PRICE LISTS AND PACKAGE OFFERS!

**RECORD DECKS**

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<th>B.S.R.</th>
<th>GARRARD</th>
<th>THORENS</th>
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<td>840 II</td>
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<td><strong>MINI</strong></td>
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<td><strong>B.S.R.</strong></td>
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<tr>
<td><strong>Sonotone</strong> 9TAHCD</td>
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<td><strong>Z 30 amplifier, AS other modes</strong></td>
</tr>
<tr>
<td><strong>OTHER</strong></td>
</tr>
<tr>
<td><strong>Garrard 2025 T/C with plinth and cover fitted</strong></td>
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<tr>
<td><strong>Garrard 2025 T/C with plinth and cover fitted</strong></td>
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<tr>
<td><strong>Garrard 2025 T/C with plinth and cover fitted</strong></td>
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<thead>
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<td>RF03</td>
<td>Quad 4-Input NOR NAND Gates (with outputs)</td>
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Full price refunded if returned in 7 days.

WEST LONDON DIRECT SUPPLIES (W.W.) 169 KENSINGTON HIGH STREET, LONDON, W.8
even successful project leaders have problems
you may even have some yourself

Redac supply the full spectrum of computer aided design software and services for the electronics industry developed by electronics engineers for electronics engineers. Each week more electronics companies worldwide are discovering the benefits of Redac. Discovering that Redac can help them with design problems. Some of these problems we’ve listed may be familiar to you.

PROBLEMS
“Specification is too tight”
“Insufficient Design Effort”
“Project Time is too short”
“We should now design using MOS”
“Reduce size and upgrade environmental specification”
“PCB designs urgently required”

REDAC SOLUTION
REDACAL design service gives your engineers added power and capabilities for circuit analysis and logic design from a terminal in your own offices.
REDAC MOS design facilities will get you into MOS technology with less time, cost and problems.
REDAC Thick Film microcircuits are custom designed to meet your exact requirements.
REDAC PCB Design Service gives you rapid turn-round with accurate results.

Convinced? Well perhaps not yet, but talk it over with us. We are in electronics and we understand your problems.

Write or telephone today to Marketing Manager
REDAC SOFTWARE LIMITED,
Newtown, Tewkesbury, Gloucestershire GL20 8HE. Tewkesbury 2476/79/70

WWW—100 FOR FURTHER DETAILS
**SUMMER OFFER**

LIMITED PERIOD ONLY FROM NOW UNTIL 31ST AUGUST 1971 A DISCOUNT OF 20% WILL BE DEDUCTED ON ALL ORDERS OF £75.00 AND OVER

**PROGRAMME TIMER BY HONEYWELL**
A bank of 15 switches which are independently adjustable to give switching periods of from zero to 60 minutes with infinitely variable combinations. A mains powered commercial motor driver the cam shaft at 1 rev. per 60 seconds (4000 revs per minute). Designed originally for variable load machines at a cost of £10.50 plus. Many applications where continuous on/off operation is required such as lighting effects etc. Now in original makers case. First time order at £7.95 plus 50p P & P.

**ELECTRIC HEATING & COOLING TIMERS**
- S.T.C. Midget Field Relay type 4109EC. 12v. 40 mA. Offered at approx. half makers price at £3.25. P & P £3.50.
- Offered at approx. half makers price at £3.25. P & P £3.50.

**DEAC. RECHARGEABLE SIR-FASHION BATTERIES**
Types 900D. 12v at 900 ma. Overall size 13.5 mm. Weight 40 gr. Unused to total; £7.50 each. State vertical or horizontal mount. Please state vertical or horizontal mount. Ix a; 1x £1.00 or £2.50 per doz. P & P £2.00 per doz. Carr. Paid.

**HEAVY DUTY HORTICULTURAL BATTERIES**
New ex WD. 12v. 75 AH. Built in stout metal cases with carrying handle and nickel socket cover. Size 15 1/2 x 6. Weight 15 lb. Offered at approx. £3.25. P & P £3.50. Minimum order £100 on these items. P & P £10 each.

**C G E M A R O D S**
- “Paravalx” Reversable 100 HP. 850 rpm. 5 - 25 p. £7.50 each. S.D. 1/4, 230/250V. A.C. 11 1/2 B.H.P. (2) 1/2 B.H.P. 1st class condition. £7.50 each. P & P £10.50 each.
- “MYCALEX” Open frame, shaded pole motors, 240V. 30 - 40 rpm. 2.3 lbs. 1/10 B.H.P. £1.50 per each. P & P £2.00 each.
- ELECTRO CONTROL (CHICAGO). Shaded pole 240V. 2000 rpm. 1/10 B.H.P. £1.50 per each. P & P £2.00 each.
- “CROUZET” TYPE 965, 115/ 240V, 47/60 Hz. 50 Hz. 75 Watts. 50 rpm. Steady constructed contacts 24V. £1.00 per each. P & P £1.50 per each.
- “MALLORY” Mains Shaded, pole 1425v. £2.00 per each. P & P £2.50 per each.
- “DISCRIP” Mains Induction Motor. Open frame, 24v, shaded pole, £1.50 per each. P & P £2.00 per each.
- “DEAC.”TypeDef 1/10 B.H.P. 1000000 cycles. Offered at approx. half makers price at £3.25. P & P £3.50.

**SPECIAL OFFER**

**NEW "ISKRA" 240V. A.C. RELAYS**
- 3 amp A.C. contactor relay. A.E. Perspex enclosed, plug in, 50/60 c.p.s. £1.00 per each. P & P £1.50 per each. Carr. Paid.
- “MALLORY” LONG LIFE FUSEHOLDERS
- Type B. 40 / 60 amp. Overall size 2 1/2" x 1/4". Rod operating cam. 50p each. P. & P. 12p each. Carr. Paid.
- Type A. 20 / 30 amp. Overall size 2 1/2" x 1/4". Rod operating cam. 50p each. P. & P. 12p each. Carr. Paid.

**NEW "I.S.K.R.A." 140V. A.C. RELAY**
- 3 amp A.C. relay. A.E. Perspex enclosed, plug in, 50/60 c.p.s. £1.00 per each. P & P £1.50 per each. Carr. Paid.

**SIEMENS HIGH SPEED RELAY**
- Type 966. 12v. £1.50. 1st class condition. £6 35p each.

**MINIATURE "LATCH" CONTACTORS**
- Type 971. 12v. 3 amp. Overall size 2 1/2" x 1/4". Rod operating cam. 50p each. P. & P. 12p each. Carr. Paid.

**VINKOR POT CORE ASS. TYPE LA.2103 (core 900D)**
- 12v. £1.45. Our price 75p each. P & P £1.00 each. Carr. Paid.

**ELECTROLYTIC CAPACITORS**
- Type 125. 500µF 100v. £2 50p each. £3 00 each. P. & P. 50p each. Carr. Paid.
- Type 125. 100µF 100v. £1 20 each. £1 50 each. P. & P. 60p each. Carr. Paid.

**HUNTS 1,000µF 50v. 1/8" dia. x 2 1/2" long. £2.00 each. £2 00 each. P. & P. 50p each. Carr. Paid.
- Type 125. 7,000µF 60v. 1/8" dia. x 2 1/2" long. £3 75 each. £3 75 each. P. & P. 75p each. Carr. Paid.

**ERIE. Ceramic capacitor. Type C. £1.45. £1 00 each. P. & P. 50p each. Carr. Paid.

**HIGH CAPACITY ELECTROLYTICS. Cylinder type with screw terminals. Approximate size 2 1/2" x 1 1/4" x 1 1/2" high. “Callow” 200µF 250v. £1 00 each. £1 00 each. P. & P. 50p each. Carr. Paid.

**BELLING & LEE FUSEHOLDERS**
- Type S27. Size 0. R汽車ure fuse up to 10amp. £1 50 each. £1 50 each. P. & P. 25p each. Carr. Paid.


**A.D.C. MIRROR AMMETERS**
- 0.5 amps or 0.4 amps (suitable battery chargers etc.). Price 22x £1 10. 22x £1 10. P. & P. 25p each. Carr. Paid.

**CURRENT FLOW INDICATOR**

**BIOCHEMISTRY AND CHEMISTRY LABORATORIES PLEASE NOTE WE HAVE PURCHASED A NUMBER OF THE GRIFFIN AND GEORGE DEAN CHEMISTRY MODULE G & G. CAT. NO. 584-320, COMPLETE AUTOMATIC SYSTEM. BRAND NEW IN ORIGINAL MAKER'S PACKING. CURRENTLY LISTED AT £92, WE OFFER THESE AT £425nett. CARRIAGE FREE.**

**ALL THE BEST**

**THE END**
**CLEARANCE LINES**

**1-10**  **10-50**  **50+**

- SL 4030 Audio Amp.  
  2.80  1.80  1.60
  50p  40p  30p
- A.E.I. Fully marked & tested Gates  
  25p  25p  25p
- A.E.I. Fully marked & tested Logic  
  50p  40p  30p
- IC 1712, Fully tested, unmarked  
  3p  3p  3p
- Matched Set, 1-0C44, 2-0C45. Per set  
  50p  30p  25p
- Matched Set, 0C45, 1s 2nd Lot. Per set  
  12p  10p  9p
- T445 Thyristors, 4A, 80V, Texas  
  10p  1p  1p
- 0A17 Gold bonded Diodes, marked & tested  
  3p  3p  3p
- 1W Zener Diodes  
  6.8V, 7.5V, 24V, 27V, 30V & 43V  
  5p  4p  3p
- 10W Zener Diodes  
  24V, 11V, 13V, 28V & 100V  
  20p  17p  16p
- Micro Switches, S/P, C/O. Popular size  
  25p  20p  15p
- 1 Ampl. Bridge Rectifiers, 25V, RMS  
  25p  25p  22p
- 3 Amp Plastic Rectifiers: These are voltage reverse Polarity and other rejects from the BY127 range. Ideal for low voltage Power Units etc. Price from £1.25.

**NEW UNMARKED UNTESTED PAKS**

- B80 8 Dual Trans. Matched S/P  
  50p
- B84 200 Trans. manufacturer's rejects all types NPN, PNP, Sil. and Germ.  
  50p
- B86 100 Silicon Diodes DO-7 glass  
  50p
- B88 50 Sil. Diodes tab. min.  
  IN114 and IN118 types  
  50p
- B90 10 7 watt Xenon Diodes  
  50p
- H6 40 250W, Zener Diodes  
  50p
- H10 25 Mixed volts, 11 watt Zeners  
  Top hot type  
  50p
- H66 150 High quality Germ. Diodes. Min. glass type  
  50p
- H15 30 Top Mat Silicon Rectifiers.  
  750mA, Mixed volts  
  50p
- H16 8 Equivalents' Pak of Imprised Circuits. Data supplied  
  50p
- H20 20 BY1867 Typo Silicon Rectifiers, 1 amp plastic, Mixed volts  
  50p

**FREE! A WRITTEN GUARANTEE WITH ALL OUR TESTED SEMICONDUCTORS**

**F.E.T. PRICE BREAKTHROUGH**

This field effect transistor is the 2N3823 in a plastic encapsulation: coded 3823E. It is an ideal replacement for the 2N3819. Data Sheet supplied with device.

<table>
<thead>
<tr>
<th>Type</th>
<th>Description</th>
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<tbody>
<tr>
<td>2N3823</td>
<td>Plastic encapsulation</td>
<td>50p</td>
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</tbody>
</table>

Make a Rev. Counter for your Car. The 'TACHO BLOCK'. This encapsulated block will turn any 0.1mA meter into a perfectly linear and accurate rev. counter for any car. £1 each

**LOT 50p CASH WITH ORDER PLEASE. Add 10p post and packing per order. OVERSEAS ADD EXTRA FOR POSTAGE**

**P.O. RELAYS**

<table>
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<th>Type</th>
<th>Description</th>
<th>Price</th>
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<tbody>
<tr>
<td>H1</td>
<td>8 Watt Zener Diodes</td>
<td>50p</td>
</tr>
</tbody>
</table>

£1 each

**FREE CATALOGUE AND LISTS FOR:**

**ZENER DIODES**

**TRANSISTORS, RECTIFIERS**

**FULL PRE-PAK LISTS & SUBSTITUTION CHART**
G. F. MILWARD
Mail Orders: DRAYTON BASSETT, TAMWORTH, STAFFS

ELECTRONIC COMPONENTS

Wholesale: Retail: 369 Alum Rock Road, Birmingham B8 3DR. Tel. 021-327 2339

1,000,000 GERMAN TRANSISTORS

LOTS OF 100,000, £250

1,000, £3.50

500, £2

100, £50

TANTALUM CAPACITORS. COMPARE THE PRICE—ONLY 10p EACH !!!

Sub-miniature types

0.01µf 50 volts 0.047µf 50 volts 0.068µf 50 volts 0.1µf 50 volts

0.022µf 100 volts 0.05µf 50 volts 0.1µf 50 volts

0.12µf 50 volts 0.15µf 50 volts

0.22µf 50 volts 0.25µf 50 volts

0.33µf 50 volts 0.47µf 50 volts

0.68µf 50 volts 1µf 50 volts

1.0µf 50 volts

1.5µf 50 volts

2.2µf 50 volts

4.7µf 50 volts

10µf 50 volts

15µf 50 volts

22µf 50 volts

33µf 50 volts

100µf 50 volts

220µf 50 volts

330µf 50 volts

680µf 50 volts

1000µf 50 volts

100µf 100 volts

220µf 100 volts

330µf 100 volts

1000µf 100 volts

47µf 25 volts

1µf 25 volts

10µf 25 volts

100µf 25 volts

1000µf 25 volts

220µf 63 volts

330µf 63 volts

1000µf 63 volts

47µf 16 volts

1µf 16 volts

10µf 16 volts

100µf 16 volts

1000µf 16 volts

47µf 5 volt

1µf 5 volt

10µf 5 volt

100µf 5 volt

1000µf 5 volt

10µf 2 volt

100µf 2 volt

1000µf 2 volt

Sub-miniature types

0.01µf 5 volt

0.022µf 5 volt

0.047µf 5 volt

0.068µf 5 volt

0.1µf 5 volt

0.22µf 5 volt

0.47µf 5 volt

1µf 5 volt

1.5µf 5 volt

4.7µf 5 volt

10µf 5 volt

100µf 5 volt

47µf 16 volt

1µf 16 volt

10µf 16 volt

100µf 16 volt

1000µf 16 volt

47µf 5 volt

1µf 5 volt

10µf 5 volt

100µf 5 volt

1000µf 5 volt

10µf 2 volt

100µf 2 volt

1000µf 2 volt

NEW! NEW! NEW! NEW!

An aerosol spray providing a convenient means of producing any number of copies of a printed circuit both simply and quickly.

Method: Spray copper laminate board with light sensitive spray. Cover with transparent film upon which circuit has been drawn. Expose to light. (No need to use ultra-violet.) Spray with developer, rinse and etch in normal manner.

Light sensitive aerosol spray . . . . £1-00 plusDeveloper spray . . . . . . . . . . 50p postage

SPECIAL 50p PACKS ORDER 10 PACKS AND WE WILL INCLUDE AN EXTRA ONE FREE!!!

RESISTORS 1/8 watt

assorted 100p

Wire-wound 1 to 3 watt 20p

5 to 7 watt 10p

10 watts 10p

Multitapped 12p

PAPER CAPACITORS

To types 50p

Minimum 10p

 ELECTROLYTIC CAPACITORS

Suitable for Mains

Resistovertypes 10p

Mixed (both types) 15p

MULLARD POLYESTER

CONDENSERS

HULLARD POLYESTER

COND.

SILVER MICA

WIRE-WOUND 1-Watt

15p

SLIDERS

VOLUME CONTROLS

Assorted 5p

NUTS AND BOLTS. Mixed length /type

8 B.A. 100p

4 B.A. 100p

2 B.A. 100p

METAL SPEAKER GRILLES

7 in. x 3 in.

EARPHONES. MAGNETIC

No Plug 6p

2-5mm Plug 4p

3-5mm Plug 4p

560 MICRO-MP LEVEL

METERS

VERDANCE. TRIAL PACK 50p

30000000 12500000

STOCKING CLEARANCE! IMPOSSIBLE TO REPEAT!

We have huge numbers of components in quantities too small to advertise individually. In order to "clear the decks" we have made up parcels containing a mixture of carbon and wire-wound resistors, electrolytic and paper capacitors, transistors, transformers, etc., for a tiny fraction of normal price. It is emphasised that these are mixed parcels only—contents cannot be guaranteed. Sold only by weight.

Gross weight 2 lb. . . . . . . . . . . £1 (postage 20p)

Gross weight 5 lb. . . . . . . . . . . £3 (postage 30p)

STOCKHOLDING CLEARANCE! IMPOSSIBLE TO REPEAT!

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Gross weight 2 lb. . . . . . . . . . . £1 (postage 20p)

Gross weight 5 lb. . . . . . . . . . . £3 (postage 30p)
HONEYWELL PROGRAMMER
This is a disc type timer giving hours, minutes, and seconds in digital division for switch purposes with which it is infinitely adjustable for position. They are arranged to allow 24 hours for time per week. There are 18 changeover switches each of 10560 type operated by the times plus 12 circuits may be altered by changing rotors. Dual position corresponding with one of the many uses of this equipment is the combination control. Boiler control, pump control, etc., in range of 250 are possible. Price from makers probably over £1 each. Special size price 50 pence or 70 pence.

ELECTRIC TIME SWITCH
Made by Mullein Ltd. for use in domestic and industrial. NOT CLOCK WORK. Idea for mounting on rack or shelf can be connected directly to mains. 110 volts. 2 completely independent circuits, each with switch in 4 sections, 2 x 4 = 8 contacts. Price 25 pence each.

APPY VARIAC CONTROLLERS
With this you can vary the voltage applied to your circuit from zero to 240 volts. Ideal for getting the right voltage without altering the current for operation. PP1, PP3, PP4, PP6, PP7, PP9, and others. Kit comprises: one variac, one 240 volt setting switch. PP1 40 pence each. PP3 60 pence, PP4, PP6, PP7, PP9, 75 pence each.

OUT OF SEASON BARGAIN
TANGENTIAL HEATERS
Made by Mullein Ltd. for use in domestic and industrial. Ideal for heating rooms, kitchens, offices, etc. Prices 500 watts for £1.50. 800 watts for £2.15. 1100 watts for £2.70. 1500 watts for £3.25. Cooling equipment or for radiant heating is equally efficient and virtually no noise. Approx. dimensions 1014 wide × 12 in. deep. Various coils. Price £2.50 plus 20 pence post and insurance.

BATTERY CONDITION TESTER
Made by Mullein Ltd. for use in domestic and industrial. Designed for testing batteries from 1 to 50 cells. £2 plus 20 pence post and insurance.

THIS MONTH'S SNIP
CENTRIFUGAL FAN
Mains operated. Supplied complete with 4 inch outlet air hose for wall mounting. Virtually no noise. Approx. dimensions 1014 wide × 12 in. deep. Requires 15 amp plug, plus 20 pence post and insurance. £2.50 plus 20 pence post and insurance.

DISTRIBUTION PANELS
Just what the old unit was never meant to do! Make your own power unit. 5 x 15 amp switch plate to fit in place of standard switch. £1 plus 20 pence post and insurance.

2 AMP ELECTRIC MOTOR
Smooth running and reversible. Positive or negative earth. Supplied complete with leads and prods. Price £2.75 plus 20 pence post and insurance.

INTEGRATED CIRCUITS
A panel of integrated circuits made by the famous Honey Ltd. A very novel idea. Also a few of these circuits will make a whole new circuit. Price £2.50 plus 20 pence post and insurance.

AMPLIFIER MAINS TRANSFORMER
Since 1944 J. Bull Ltd. have been in the business of making transformers. The subscriber to this magazine will now have the opportunity of getting a 1 kVA model. Model 741. 1 kVA transformer, 400 volts, 250 volts. Price £7.50.

BARGAIN OF THE YEAR
MICROWAVE RADIATION RAYS
This is a new design to deal with waves of 850 and 1,100 r.p.m. from either or both of the oven circuits (where the ovens of the food mixers normally run at 850 and 1,100 r.p.m. 20 ampere fuse and 600 volt. Arcing conditions. This is a drum type timing device, the drum being calibrated in equal divisions for switch -on and switch -off time of which can be delayed up to 12 hours (continuously variable not stepped). 230/240 volt mains operated Clock and a 20 amp Switch, the whole unit is still the only one used in good quality design. 21.75 plus 20 pence postage.

WAVE FILTERS
Miniature, standard and instrument types. All available. See last month's advertisement.

MULTI-SPEED MOTOR
Replacement in many well-known food mixers. 850 and 1,100 r.p.m. from either or both of the oven circuits (where the ovens of the food mixers normally run at 850 and 1,100 r.p.m. 20 ampere fuse and 600 volt. Arcing conditions. This is a drum type timing device, the drum being calibrated in equal divisions for switch -on and switch -off time of which can be delayed up to 12 hours (continuously variable not stepped). 230/240 volt mains operated Clock and a 20 amp Switch, the whole unit is still the only one used in good quality design. 21.75 plus 20 pence postage.

WAVE FILTERS
Miniature, standard and instrument types. All available. See last month's advertisement.

J. BULL (ELECTRICAL) LTD.
Dept. W.W.7, Park Street, Croydon, CROYDON 1YD
## TELEPHONE ENQUIRIES FOR

<table>
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## VALVES

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## TRANSISTORS

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## ZENER DIODES

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<tr>
<td>1Z10</td>
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<tr>
<td>1Z11</td>
<td>£0.20</td>
</tr>
</tbody>
</table>

## Contact Information

Tel. 01-7430899

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Wireless World, September 1971
A COMPLETELY NEW DESIGN FURTHER IMPROVED IN BOTH APPEARANCE AND PERFORMANCE THAN THE PRICES STATED.

Only high grade components by Janzen, LSAC, E.E.T. etc.

COMPLETE KIT OF PARTS

On payment of the following deposit only a month's guarantee Dep. £50 and 9 monthly payments £50 (Total £60-70)

PRINTED CIRCUIT, TWENTY MICRO TRANSISTORS, FOUR DIODES, FOUR RESISTORS.

TECHNICAL DETAILS (Applying to each channel where appropriate).


FANE ULTRA HIGH OUTPUT LOUDSPEAKERS FOR R.S.C. TYPE BM1. An all-dry battery eliminates batteries. Completely replaces Type BM1. An all-dry battery eliminates batteries. Complete kit of parts with full wiring diagrams. Output for 3-15 ohm speakers. £75-10. For high performance with Hi-Fi speakers...£75-75. For entertainment with Hi-Fi loudspeakers...£75-70.

FANE LOUDSPEAKERS POP/25/2

Dual coned 15") for use either as mains, satellite speakers or monitors. £75-10 each.

Terms: £12.50 and 9 monthly payments £12.50 (Total £139.50).

R.S.C. T4A 6 Watt HIFI Fidelity Solid State Amplifier


SELENIUM RECTIFIERS

F.W. Bridged 6/12y. D.C. Output Input Max. 18v. 250-0-250v. 150mA, 6.3v. 4a., 0-5-6.3v. 3a.

£165

THE 'YORK' HIGH FIDELITY 'SPEAKER SYSTEM

A powerful high quality, all purpose unit. For lead, rhythm, bass guitar, treble, and vocals. Employing miniature and reliable components. FOUR JACK INPUTS and TWO VOLUME CONTROLS. Complete kit of parts with full wiring diagrams. £35-50.

AC-OUTLETS SUPPLIED FOR DISPLAY PURPOSES ONLY.

£99-99

R.S.C. MG6 6+6 Watt HIGH QUALITY STEREO AMPLIFIER


£105

R.S.C. BASS-REGEN'T 50 Watt AMPLIFIER

A powerful high quality, all purpose unit. For lead, rhythm, bass guitar, cymbals, and vocals. Employing miniature and reliable components. FOUR JACK INPUTS and TWO VOLUME CONTROLS. Complete kit of parts with full wiring diagrams. £50-50.

£30-50

DARLINGTON 20 Printcone-speaker Assemblies. £45-0. For display purposes only. £45-45.

£165

For entertainment with Hi-Fi loudspeakers...£75-70. For high performance with Hi-Fi speakers...£75-75. For entertainment with Hi-Fi loudspeakers...£75-70.

Beds).

£105

£99-99

£99-99

£30-50

£105

£165

£45-0

£165

£99-99

£165

£165

£45-0

£165

£165

£165

£165

£165

£165

£165

£165

£165

£165

£165

£165

£165

£165
28 watts, r.m.s. 40Hz to 40kHz ±3dB

Viscount III Audio Suite complete £49

PRICES SYSTEM 1
Viscount III R101 amplifier 2 x Duo Type II speakers, Garrard SP25 Mk.I, M.1 with
MAG cartridge, pin feet and cover £22.00 + 90p p&p
£14.00 + £2 p&p Total £36.00
Available complete for only £52.00 + £5.50 p&p

SPECIFICATION (R100/101)
14 watts per channel into 3 to 4 ch. Total distortion @ 10V/1.1Kv 0.01%. P.U.1 for ceramic cartridge 15ohm into 2.5 mag, P.U.2 (for magnetic cartridge) 40V/1.1Kv 47Hz, equalised with ±10dB R.I.A.A. Radio 150mV into 220K. (Sensitivities given at full power.) Take out facilities: head-amp socket, power out 250mW per channel. Tone control and filter characteristics. Bass + 12dB to −1dB @ 60Hz. Treble control: treble + 12dB to −12dB @ 15kHz, Treble filter: 12dB per octave. Signal to noise ratio: (all controls at max) FIT101−45dB, FIT101−65dB, FIT100 same as FIT101 but P.U.2 for crystal cartridge 450mV into 3 Mag. Cross overs not better than 26dB on all inputs. Overload characteristics better than 26dB on all inputs.

SYSTEM 2
As System 1, but with 2 x Duo Type III speakers at pair £32.00 + £3 p&p
Available complete for £69.00 + £4 p&p

SYSTEM 3
Viscount III Amplifier R100 £17.00 + 90p p&p
2 x Duo Type II speakers, pair £14.00 + £2 p&p
Garrard SP25 Mk.I, M.1 with
CER, diamond cartridge, pin feet and cover £21.00 + £1.50 p&p Total £52.00
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SPEAKERS Duo Type II Size 17" x 10½" x 6½". Drive unit 13" x 8". With cartridge tweeter. Max. power 10 watts 3 ohms. Simulated Teak cabinet. £14 pair + £2 p&p. 
Duo Type III Size 23½" x 11½" x 9½". Drive unit 13½" x 8½" with H.F. Speaker. Max. power 20 watts at 3 ohms. Freq. range 20Hz to 20kHz. Tea veneer cabinet, £32 pair + £3 p&p.

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Output Power 45 watts R.M.S. sine wave down. Frequency response: −3 dB points 30 Hz to 18 KHz, Total distortion less than 2% at rated output. Signal to noise ratio better than 69 dB. Speaker impedance: 3, 8 or 15 ohms. Bass Control Range: ±15 dB at 50 Hz. Treble Control Range: ±12 dB at 10 KHz. Inputs: 4 inputs at 5, vol. lim. 470 K. Each pair of inputs controlled by separate volume control. 2 inputs at 200 mV into 470K. To protect the output values the incorporated fail safe circuit will enable the amplifier to be used at half power. SPEAKERS: Size 17½" x 8½" x 16½" incorporating 12" heavy duty 25 Watt high flux, quality loudspeaker with cast components. Cabinet attractively finished in two tone colour scheme—Black and grey.

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We are one of Europe’s most modern rubber manufacturers and in order to implement our planned programme of continued growth we require an electronics technician for interesting experimental work on our control equipment.
We offer the successful candidate an excellent salary and very good prospects. He should have his O.N.C. and be studying for his H.N.C.
Candidates should write stating age, qualifications and experience to:
Mr. B. Soer, Personnel Manager,
The Cannon Rubber Manufacturers Limited,
881 High Road, Tottenham N.17

COUNTY BOROUGH OF READING EDUCATION COMMITTEE

AUDIO VISUAL AIDS TECHNICIAN

Salary £1272-£1515 (under review)
Applications are invited from suitably qualified persons for the above post at Highdown Comprehensive School. The successful candidate will be responsible for the demonstration, maintenance and servicing of all equipment including AM/FM radio, VHF/UHF TV, CT/TV with associated video-recording, tape recorders, projectors, language laboratory and reprographic equipment including offset litho. Highdown is a purpose-built comprehensive with 1,200 boys and girls from 11-18 years.
Assistance may be given for mortgage facilities and removal expenses.
Application forms available from the Chief Executive and Town Clerk,
P.O. Box 17, Town Hall, Reading, Berks, RG1 1QN
APPOINTMENTS

ELECTRONICS ENGINEER

Fly high with Fairey Surveys

Join Fairey Surveys Ltd. as air crew and you'll find yourself flying to almost any part of the world. We need an electronics engineer with at least five years experience to augment the staff of an expanding Airborne Geophysics Department. The work involves all phases of airborne geophysical surveys utilizing up to date equipment which employ both analogue and digital data acquisition systems.


Salary in the range £1,600–£2,500

Write with full personal and career details to the Personnel Manager, Fairey Surveys Limited, Reform Road, Maidenhead, Berkshire.

TECHNICAL WRITER

Do you want an attractive salary and a choice working location in South-Germany? The world's leading manufacturer of precision electronic test and measuring equipment and systems offers these and other outstanding benefits to the Technical Writer who joins our technical publications group.

You may qualify if you have a sound background in electronics and are an experienced writer. Some knowledge of German would also be advantageous.

Write or phone (reverse charges)

Hewlett-Packard GmbH, 703 Böblingen, Herrenberger Str. 110, GERMANY, Tel.: 07031/667 205

HERE'S VARIETY, INTEREST AND TECHNICAL CHALLENGE

Radio Technicians with the National Air Traffic Services work on the installation and maintenance of a wide range of electronics equipment: RT, radar, data transmission links, navigation aids, landing systems, closed circuit T.V. and computers. Sophisticated telecoms systems to meet the highly specialised requirements of air traffic control throughout the United Kingdom.

If you are interested in joining, you must be aged 19 or over and have at least one year's practical experience in electronics with preferably an O.N.C. or C. & G. (Telecoms). Your starting salary would be £1,143 (at 19) to £1,503 (at 25 or over), scale max. £1,741—shift duty allowances. Good career prospects.

Send NOW for full details of how you can become a Radio Technician. Complete the coupon and return to A. J. Edwards, C.Eng., MIEE, Room 705, The Adelphi, John Adam St., London WC2N 6BQ, marking your envelope 'Recruitment.'

I meet the requirements, please tell me more about the work of a Radio Technician.

NAME

ADDRESS

Not applicable to residents outside the United Kingdom
EVR: a revolution in telecommunications

TELEVISION AND AUDIO ENGINEERS
Salaries about £2,000 pa

EVR is a system for playing professionally recorded programmes of sound and vision at low cost, under the control of the viewer.

The film or tele-recorded programme is processed using complex video and audio equipment to produce cartridges which can be reproduced using a simple tele-player and a domestic television receiver.

EVR is not just a plan for the future, it is already in use and cartridges are being delivered to customers now. To meet growing demands, we are about to start shift working at the Processing Station and we need more Maintenance and Operations staff.

Write giving brief details of your qualifications and experience, quoting reference HM/1/WW, to: The Personnel Manager, EVR Processing Station Christopher Martin Road, Basildon, Essex.

We want men with several years experience of maintaining and operating audio and video television studio equipment or who have a good electronics training and at least an ONC or City and Guilds final, together with a knowledge of television techniques.

The Processing Station is in the new town of Basildon. In addition to good salaries, employment conditions and promotion prospects, housing will be available to rent for most new employees.

IMPERIAL COLLEGE
LONDON SW7 2RH
Department of Meteorology

ELECTRONICS ENGINEER
required to work on broad range of meteorological instrumentation for ground based, aircraft and balloon borne equipment where simplicity and reliability are of prime importance. Applicants age 25 to 30 should have a degree HND or HNC in Electrical Engineering and preferably IEE Part III, about five years experience in electronic design and fabrication. Salary range £1,728 to £2,592. Apply to Professor P. A. Sheppard at above address.

AIRTECH

ELECTRONICS INSPECTOR
A vacancy exists in our quality assurance depart- ment to carry out detailed inspection of electronic assemblies and systems, preferably O.N.C. or equivalent. Candidates should have a minimum of two years test engineer experience, together with two referees to: Group Engineer, Coventry Hospital Management Committee, The Birches Annex, Tamworth Road, Keresley, Coventry CV7 8NN.

Applications, stating age, qualifications and experience, together with two referees to: Group Engineer, Coventry Hospital Management Committee, The Birches Annex, Tamworth Road, Keresley, Coventry CV7 8NN.

COVENTRY HOSPITAL MANAGEMENT COMMITTEE

ELECTRONICS TECHNICIAN
WALSgrave HOSPITAL

A vacancy exists for an Engineer responsible for the organisation and operation of a planned maintenance system for a wide variety of electronic and electro-medical apparatus. Applicants must possess H.N.C., H.N.D. or O.N.C. in Electronics or related fields. Salary scale: £1,543-£1,974, plus overtime if worked. Free works transport from approximately 15 miles radius. Apply: Personnel Officer, AIRTECH LIMITED, Haddenham, near Aylesbury, Bucks Telephone: Haddenham 422.

SCHOOL OF SCIENCE & TECHNOLOGY

ELECTRONICS INSPECTOR

COVENTRY HOSPITAL MANAGEMENT COMMITTEE

ELECTRONICS TECHNICIAN

WALSgrave HOSPITAL

ELECTRONICS TECHNICIAN

COVENTRY HOSPITAL MANAGEMENT COMMITTEE

ELECTRONICS TECHNICIAN

WALSgrave HOSPITAL

CITY OF LONDON POLYTECHNIC
SIR JOHN CASS
SCHOOL OF SCIENCE & TECHNOLOGY

SENIOR TECHNICIAN

A Senior Technician is required in the Department of Metallurgy and Materials to be responsible for the construction and maintenance of electronic apparatus and instrumentation used for research and teaching purposes.

Applicants should have good practical experience in electronics and be familiar with modern techniques. H.N.C. level desirable.

Salary scale: £1,494-£1,884 p.a. (inclusive of London Weighting Allowance).

Application form and further details from the Head of Department of Metallurgy and Materials, Sir John Cass School of Science and Technology, Central High Street, London E1 7PF.

Electronic Test Engineers

Pye Telecommunications of Cambridge has immediate vacancies for Production Test Engineers. The work entails checking to an exacting specification VHF/UHF radio-telephone equipment before customer delivery; applicants must therefore have experience of fault finding and testing electronic equipment, preferably communications equipment. Formal qualifications while desirable, are not as important as practical proficiency. Armed service experience of such work would be perfectly acceptable.

Pye Telecommunications is the world's largest exporter of radio-telephone equipment and is engaged in a major expansion programme designed to double present turnover during the next five years. There are therefore excellent opportunities for promotion within the company. Pye also encourages its staff to take higher technical and professional qualifications.

These are genuine career opportunities in an expansionist company, so write or telephone without delay for an application form to:

Mrs. A. E. Darkin,
Pye Telecommunications Limited,
Cambridge Works, Haig Road, Cambridge.
Telephone: Cambridge 51351 Ext. 355
Sea-going Radio Officers can now make sure of a shore job and good pay.

If you’d like a job ashore, at a United Kingdom Coast Station, the Post Office will start you off on £1,080—£1,360, depending on age, with annual rises up to £1,850. There are good prospects of promotion to higher posts, opportunities exist for overtime and you would receive additional remuneration for attendance during the late evenings, at night and on Saturday afternoons and Sundays.

You will need to be 21 or over, with a 1st Class Certificate of Competence in Radiotelegraphy issued by the Postmaster General or the Ministry of Posts and Telecommunications, or an equivalent certificate issued by a Commonwealth administration or the Irish Republic.

Find out more by writing to:

THE GOVERNMENT OF ZAMBIA requires

RADIO SPECIALISTS
(Police Department)

RADIO ENGINEERS
(Civil Aviation)

Salary up to £2,590

* 3 year contract * Low Taxation * Subsidised Housing
* Education Allowance * 25% Tax-free Gratuity
* Appointment Grant of up to £200 payable in certain circumstances

RADIO SPECIALISTS
Duties. Maintenance and installation of police radio equipment throughout Zambia, travelling by road and air.


Candidates who will serve in the rank of Inspector of Police (non-uniformed), must have completed a five year apprenticeship or hold a service trade certificate or equivalent qualification and have at least six years post-qualification experience.

Ref. M22(61214)/WF

RADIO ENGINEERS
Duties. Installation and maintenance of ground terminal radio communication equipment and navigational aids at Airports and Flight Information Centres.

Equipment. Radar systems, H.F. and V.H.F. transmitters and receivers, I.L.S. and D.F. systems and tape recorders. Candidates (under 55 years of age) should have practical experience and a knowledge of theoretical principles within this field. In addition they should have attained one of the following:-
(i) completion of a 5 year apprenticeship
(ii) a service trade certificate
(iii) an I.C.A.O. certificate
or (iv) equivalent
Ref. M22(690215)/WF

Apply to CROWN AGENTS, 'M' Division, 4 Millbank, London S.W.1 for application form and further particulars stating name, age, brief details of qualifications and experience and quoting relevant reference number.
BRISTOL POLYTECHNIC

Applications are invited for the following post

TECHNICIAN (Grade T.3)

The successful applicant will be responsible for the upkeep of the Electronics Laboratory in the Department of Computer Science and Mathematics. He will also assist with the maintenance of electronic equipment in the Department of Science. It is envisaged that his duties will be divided equally between the two Departments. Applicants for the above post should be over 21 years of age and possess at least an Intermediate City and Guilds qualification in a relevant subject. Salary Scale (under review): Technician (7.3) - £1,089 – £1,272. Applications should be made to the Personnel Office, Bristol Polytechnic, Ashley Down, Bristol, BS8 3口气 Please quote post reference number T4/113 in all communications.

ARTICLES FOR SALE

COMPONENT FACTORS

ALL COMPONENTS BRAND NEW AND SUBJECT TO MAKER'S GUARANTEE

<table>
<thead>
<tr>
<th>CERAMIC</th>
<th>CAPACITORS</th>
<th>POLYCARBONATE</th>
<th>INTEGRATED CIRCUITS</th>
<th>TRANSISTORS</th>
<th>MISCELLANEOUS</th>
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<td>6PF 10% 500V 5p</td>
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<td>7400N</td>
<td>25p</td>
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TERMS: CASH OR CHEQUE WITH ORDER. POST AND PACKING FREE ON ORDERS ABOVE £5. FOR SMALLER ORDERS PLEASE ADD 10p. DISCOUNT: ORDERS ABOVE £10 – 10%, ABOVE £20 – 15%. ALL GOODS ADVERTISED ARE TOP GRADE PROFESSIONAL COMPONENTS AND SUBJECT TO A MONEY REFUND GUARANTEE IF NOT SATISFIED. WE HAVE MANY COMPONENTS NOT ADVERTISED, AND ENQUIRIES ARE WELCOME, BUT MUST ENCLOSE AN S.A.E. FOR REPLY.

TRADE ENQUIRIES WELCOME

P.O. BOX No. 18, LUTON, BEDS. LU1 1SU

ELECTRONICS Service Engineer for work on numerical machine tool equipment

EMI ELECTRONICS LTD., has a vacancy in the Installation and Maintenance Division, for an Engineer to be responsible for the installation, commissioning and maintenance of numerical control equipment for machine tools. He will be based at Hayes, Middlesex, but the position will involve work in the field in the U.K. as well as occasional overseas visits.

Applicants, aged 25-45, should have reached H.N.C. Electronics standard, and should have experience in fault finding on solid state equipment. A knowledge of electronics and machine tools would also be an advantage.

Starting salary would be up to £2,000.00 per annum, assistance will be given with removal expenses. Competitive benefits include free Life Assurance and contributory Pension Scheme. Please apply in writing, stating brief career details, or ring: — R. C. Dwyer, Personnel Department, EMI Limited, Hayes, Middlesex. Tel. No. 01-573 3888 Ext. 632.
BRICO ENGINEERING LIMITED
HOLBROOK LANE, COVENTRY Telephone: COVENTRY 89014
Following the closure of our Fuel Injection Department on this site, we offer for sale the following surplus equipment. Much of this equipment is less than 2 years old and is generally in a good ‘used condition.’

Oscillators
Solartron CDI.1400 3 off £75 each Muirhead Decade 0;100K (5 dial) 2 off £25 each
Teledynamics D.45R 3 off £65 each Muirhead Decade 0.10K 12 off £50 each
Teleonic plug in unit type H. 1 off £45 Pye 4 Dial 0-10K 8 off £22 each
Solartron plug in unit CX 1442 1 off £15

Osciloscope trolley
Domain 3 off £12 each

Power supplies
A.P.T. type TS4.1012 3 off £50 each Vacuum Pump, Edwards ISP30C 2 off £35 each
A.P.T. type TV1.012A 5 off £50 each Wide range oscillator, soliltron CO.1004-3 1 off £76 each
Coustant ASC.1500 6 off £60 each Avo transistor tester TT.165 1 off £22 each
Coustant LB.1000.2 7 off £62 each Avo BC Oscilloscope Camera type K.5 1 off £25 each
Coustant KS.3000/12 1 off £150 Comark electronic thermometer type 160C 1 off £6 each
Coustant ASB.1000 1 off £50 Comark electronic Selector unit type 163 1 off £5 each
Farnell SB.30/10 2 off £45 each Foster transformer transformac type TRIO BI 61 2 off £14 each

Universal Counter Timers
Racial SA.535 B 2 off £150 each Ricardo PM bridge type P.4550 1 off £50 each
Racial SA.535 8 off £105 each Advance double pulse generator PG.50021 1 off £55 each
Racial B35 3 off £175 each Wayne Kerr Universal Bridge B231 1 off £75 each

All enquiries to: Mr. S. H. Hardwick.

All equipment may be viewed during normal working hours at the above premises. Delivery free on orders over £250.00.

BRICO ENGINEERING LIMITED
HOLBROOK LANE, COVENTRY Telephone: COVENTRY 89014
Following the closure of our Fuel Injection Department on this site, we offer for sale the following surplus electronic components:—The bulk of this stock is still in manufacturers’ packing and has been stored under strict control.

<table>
<thead>
<tr>
<th>CAPACITORS</th>
<th>Price each</th>
</tr>
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<tbody>
<tr>
<td>0.001 µF, 30V, 10%</td>
<td>Supply £59.50</td>
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<tr>
<td>0.005 µF, 25V, Ceramic</td>
<td>£1.25</td>
</tr>
<tr>
<td>0.007 µF, 25V, Paper</td>
<td>£1.25</td>
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<tr>
<td>0.01 µF, 16V, Paper</td>
<td>£1.25</td>
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<tr>
<td>0.1 µF, 6.3V, Tantalum</td>
<td>£1.25</td>
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<td>0.1 µF, 450V, Paper</td>
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<td>0.1µF, 450V, Tantalum</td>
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<td>0.25 µF, 25V, Al</td>
<td>£1.25</td>
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<td>0.25 µF, 25V, Paper</td>
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<td>0.27 µF, 10% Tantalum</td>
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<td>0.047 µF, 33V, Tantalum</td>
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<td>1 µF, 6.3V, Tantalum</td>
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<td>2.7 µF, 15V, Tantalum</td>
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<td>10 µF, 25V, Electrolytic</td>
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<td>10 µF, 25V, Tantalum</td>
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<td>100 µF, 25V, Electrolytic</td>
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<td>0.1 µF, 50V, Electrolytic</td>
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<th>RESISTORS</th>
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<tr>
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<td>Zener Diode CV2S Mullard BZ24B 10p</td>
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<td>Zener Diode CVX3 Mullard BZ24B 10p</td>
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<tr>
<td>Diode 1N951 Texas 10p</td>
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<td>Transistor 2N 2796K Mullard 10p</td>
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<td>Transistor 2N 4052K Texas 10p</td>
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<td>Transistor 2N 3904K Mullard 10p</td>
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<td>Transistor BY238 Mullard 10p</td>
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<td>Diode 1N4148 Mullard 10p</td>
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<td>Diode 1N4148 Texas 10p</td>
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<tr>
<th>TRANSISTOR MOUNTINGS</th>
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<tr>
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<tr>
<td>Transistor Housing Pad Japan T5506 10p</td>
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<td>Transistor Housing Pad Japan T5506 10p</td>
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<tr>
<td>Transistor Housing Pad Japan T5506 10p</td>
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<tr>
<td>Insulation Bush 7M 22-2 10p</td>
<td></td>
</tr>
</tbody>
</table>

Any parcel of components will be made up to suit customers requirements. Terms are: Cash with order, P. & P. 10p on orders less than £5.00.

Quantity discounts: 5% on orders over £25.00 10% on orders over £75.00 15% on orders over £2.00 20% on orders greater than £50.00

All enquiries to: Mr. S. H. Hardwick.
AERIAL BOOSTERS

We make three types of transistorised aerial pre-amplifiers, 615 U.H.F., television, 12 V.M.F. television, and 5-V.V.L. radio, all at one price £19.5 S.A.E. for leaflet.

T. V. VALVES 5-45V.

MOST TYPES IN STOCK

VELCO ELECTRONICS

62 Bridge St., Ramsbottom, Bury, Lancs.
Tel. Rams 936.

SYNTHESISER MODULES

Send s.a.e. for details of voltage-controlled modules for synthesiser construction to:

D.E.W. LTD.

354 Ringwood Road, Ferndown, Dorset

12 Volt Fluorescent Lights

Beacon Power Co. Ltd., 8 Watt, ideal for caravan, tent, Emergency Lighting, etc. Fully Transformed, Low Battery, 12 Volt, G.W.C. Switch and 12 Volt pocket lighting or 12V. Equipment.

Uncatalogued at £1.50. post paid

GUSTAVO ELECTRONICS (DEPT. WW),

25 Wyle Cop, Sheringham, Norfolk.

1958

17" BBC/ITV Televisions £5

Plus P. & P. (£1.00 C.W.O.)

SUITABLE FOR ANY AREA

3 Channel 19" D/S, T.V.s, ITV, BBC 1, BBC 2.

£25 inc. carriage. 17" Channel complete, but untested, £1.50 each, plus £1. P. & P., C.W.O.

SPEAKERS

6" x 4", 7" x 4" 30H.M.

20p plus 8p. each, C.W.O.

REGULAR DELIVERIES THROUGHOUT ENGLAND AND NORTHERN IRELAND

TRADE TV's

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1008

VHF, 80-180 mEz Receiver, Tuner, Converter Kit, receiver results from tests in Radio and Radio Servicing. £13 complete or S.A.E. for free literature. Johnson (Radio), Worchester W1.

COUPLING TYPE 3X2 radio Tuner frequencies


1320

TELEVISION AND RADIO TRAINING

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PADDINGTON COLLEGE FOR FURTHER EDUCATION

Saltram Crescent West 3HW Tel: 01-969 2391

ELECTRONICS—Available in September, day or evening courses in preparation for the C.G.L.I. 43 Part examination for RADIO, TELEVISION and ELECTRONIC MECHANICS. Suburban courses at Paddington Technical College. Enquiries and enrolment September 13th to 16th, 10 to 4 and 6.30 to 8.30. 1343
**BUSINESS OPPORTUNITIES**

Electronics Manufacturing Company with established industrial contacts seeks to acquire on licence or outright purchase, new products or product ideas in the low cost automation/controls and high tech control fields. Please send full details in absolute confidence to Box No. WW 1347.

**TEST EQUIPMENT — SURPLUS AND SECONDHAND**


- RECEIVERS AND AMPLIFIERS — SURPLUS AND SECONDHAND

<table>
<thead>
<tr>
<th>Model</th>
<th>Manufacturer</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>HRO R26</td>
<td>EMD</td>
<td>4050 receiver, small, exchanged, unused, examined for return. 321 84p, Bury St. Edmunds, [1]</td>
</tr>
</tbody>
</table>

**TAPE RECORDING ETC.**


**FOR SALE**


**NEW GRAM AND SOUND EQUIPMENT**

- G A M G — Records, announcements, small, exchanged, unused, examined for repairs or return. 321 64p, Bury St. Edmunds, [1] |

**FOR SALE**


**SERVICE & REPAIRS**

- INSTRUMENT SERVICE AVO, Taylor, etc, multi- meters, meggers, signal generators, etc. — Quotations free. — 01-969 0914. [12] |

**CAPACITY AVAILABLE**

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<th>VOLTAGE</th>
<th>PRICE</th>
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<tr>
<td>12V x 2</td>
<td>500 mA x 2</td>
<td>MT 151 CB+</td>
</tr>
<tr>
<td>12V x 2</td>
<td>500 mA x 2</td>
<td>MT 133 CB+</td>
</tr>
<tr>
<td>12V x 2</td>
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<td>MT 132 AT</td>
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<tr>
<td>12V x 2</td>
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<td>MT 121 AT</td>
</tr>
<tr>
<td>12V x 2</td>
<td>15A x 2</td>
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