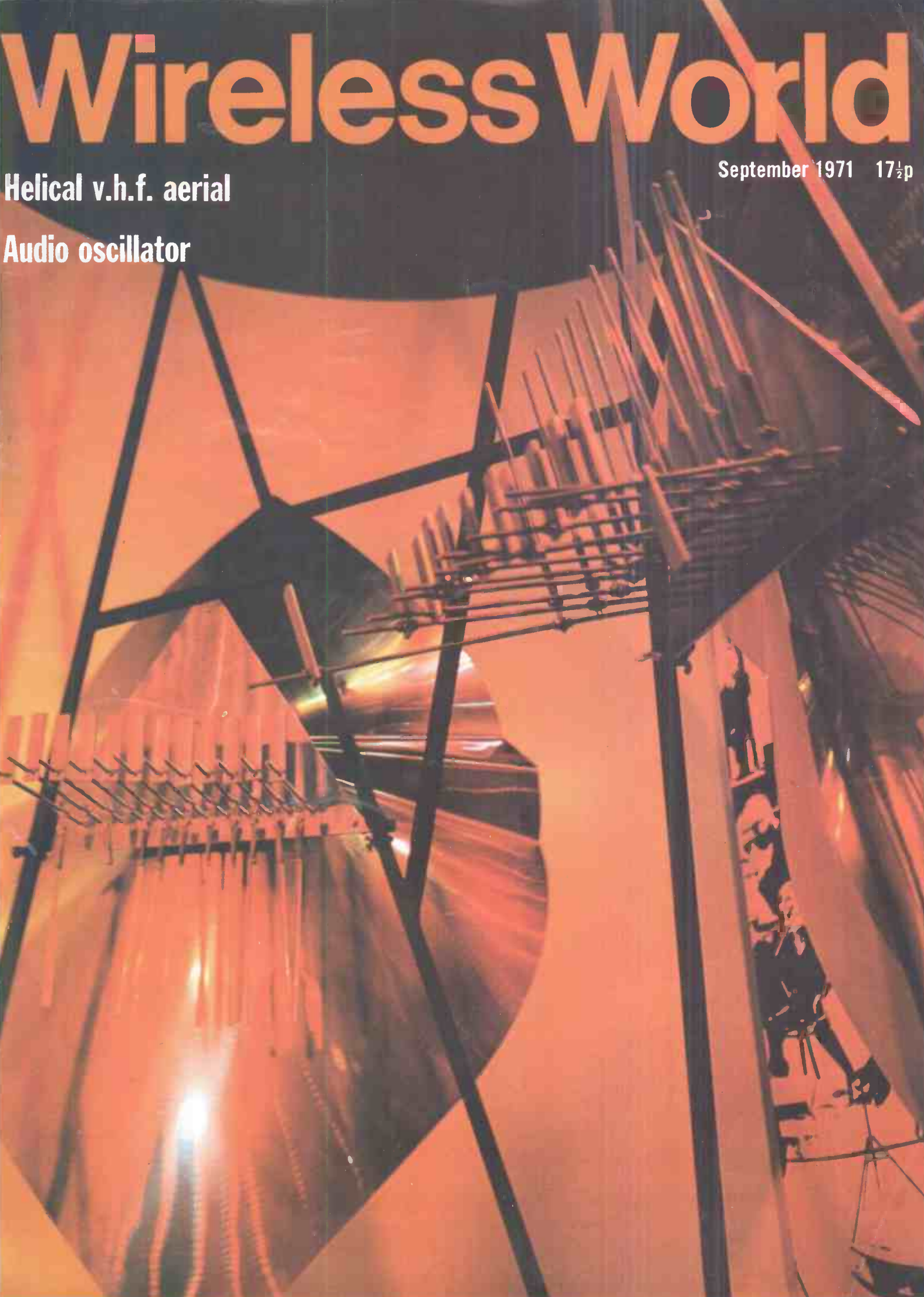
Wireless World

September 1971 17½p

Helical v.h.f. aerial

Audio oscillator



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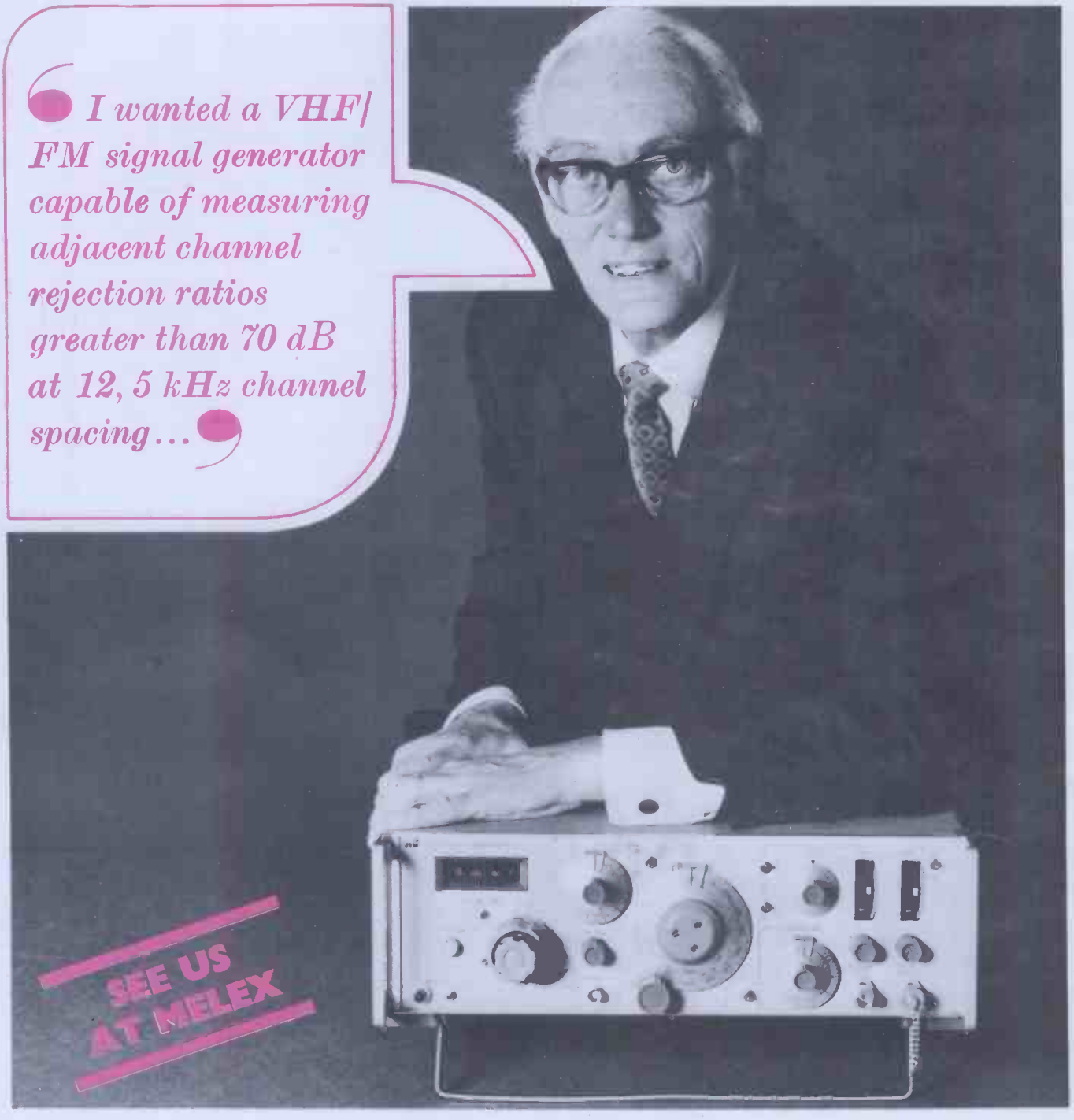

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Wireless World

Electronics, Television, Radio, Audio

Sixty-first year of publication **September 1971** **Volume 77 Number 1431**

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 f.m. 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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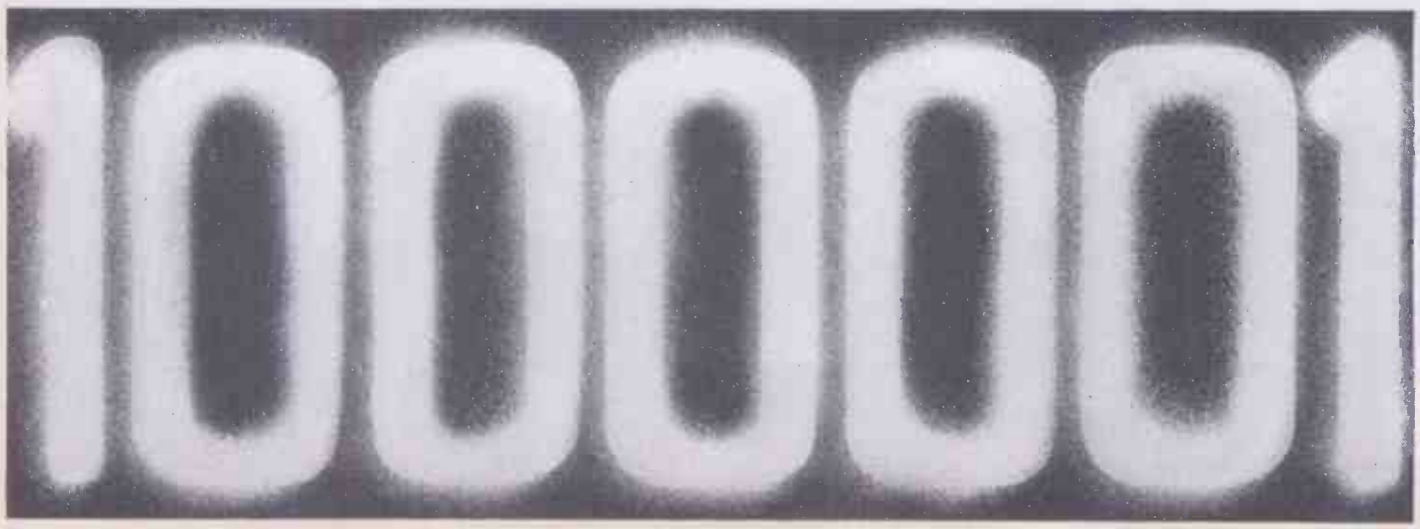

WW—065 FOR FURTHER DETAILS

Wireless World

The Plight of the Microcircuit Industry

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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 spite of this, it has been announced by the Italian finance organization I.R.I. that it has taken over SGS and ATES and, reading between the lines it would appear that a national electronic components company—both passive and active—may emerge.

To get back to the British scene, there were, of course, the inevitable questions in the House of Commons and the letters in the Press condemning the proposed G.E.C. closures as, to use the words of Brian Harrison, Conservative M.P., it would be little short of a national tragedy if Government action was not taken to prevent the expertise associated with microcircuit production being lost to Britain. Similar sentiments were expressed in a letter in *The Times* from the general secretary of the Electrical, Electronic and Telecommunications Union who concluded with the words 'the Government must act now or the future of the British electronics industry must surely be at risk'.

Only a few days before these chilly winds blew through the industry Mr. John Davies, the Secretary for State, stated, in the course of a debate on the conditions in another industry, that the Government would not finance 'lame ducks'. It will, however, be recalled that grants to the tune of £5M were made by the National Research Development Corporation to three British-owned i.c. manufacturers (one was Marconi-Elliott) only three years ago. This money is recoverable by levy on the sales of i.cs.

What then are the long-term prospects for this country's microelectronics industry? 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.

* Audio Sweep Generator by F. H. Trist, *Wireless World*, vol. 77 July 1971 pp. 335-8.

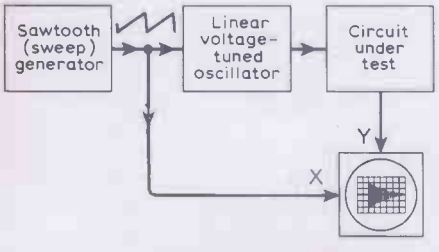


Fig. 1. In the swept frequency technique for obtaining the amplitude-frequency response of networks quickly, a sawtooth waveform controls a voltage-to-frequency converter and simultaneously sweeps the oscilloscope beam in the X-direction.

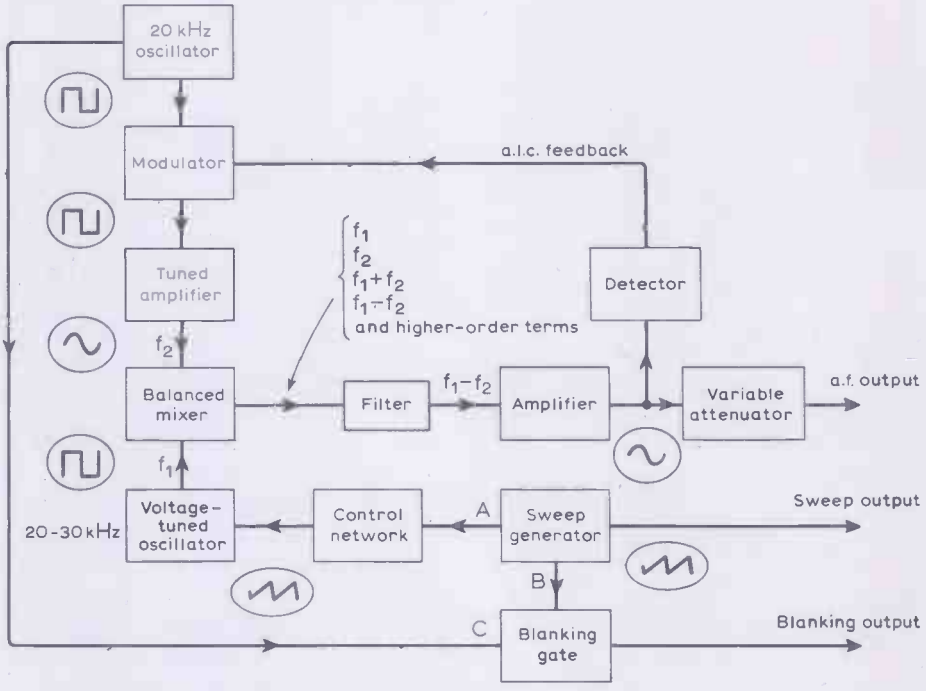


Fig. 2. Using the beat frequency technique two decades can be covered without switching. As well as the f_1-f_2 signal others are generated which must be filtered out.

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 f_1 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.

Swept 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 10kHz 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 20s in four ranges.

Sweep modes: 'full'–100Hz-10kHz; '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, Z_{in}=50kΩ.

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

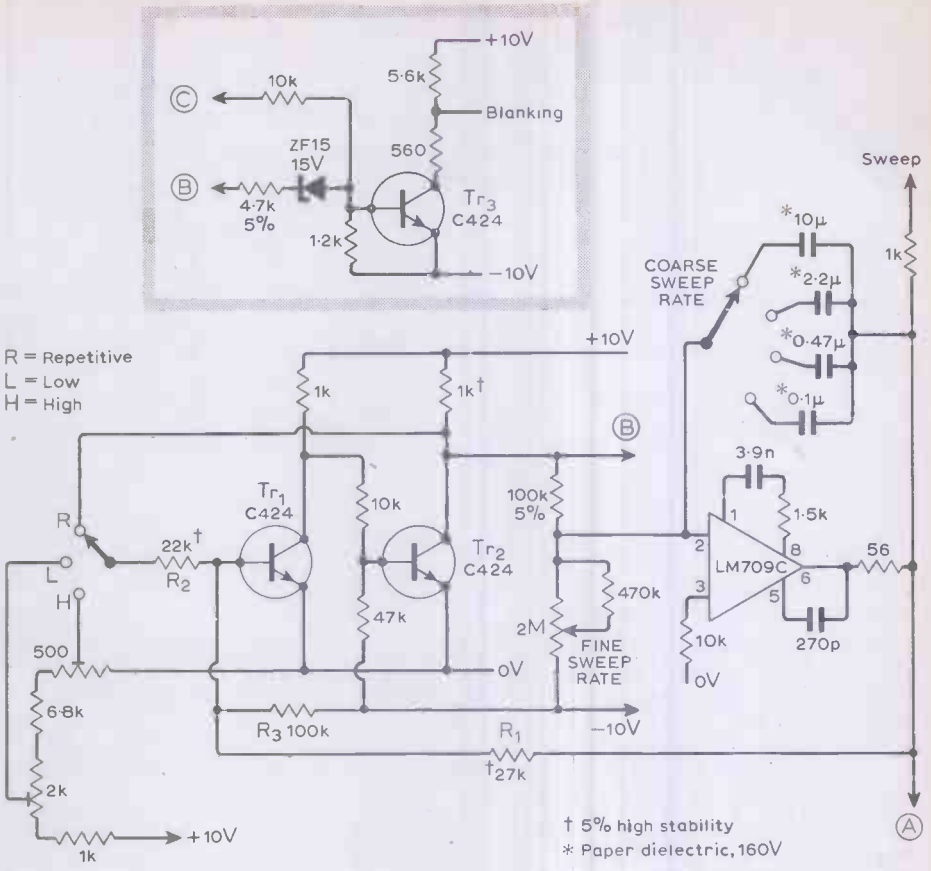


Fig. 3. Sweep generator circuit comprising bistable multivibrator and integrator achieves sweep times as low as 20s. Beam-blanking waveforms are shown in Fig. 4. In this and subsequent circuits the LM709C integrated circuits require +10V on lead 7 and −10V on lead 4. Resistors are ¼-watt, 10% tolerance unless shown otherwise.

can easily have resonances with a width of tens of Hz or less with corresponding response times longer than one tenth of a second; very slow sweep rates are needed if such detail is not to be lost. The circuit used to achieve sweep rates down to 20s per sweep is shown in Fig. 3.

Transistors Tr_1 and Tr_2 are coupled together as a bistable multivibrator with R_1, R_2 and R_3 chosen so that when the potential at point A is greater than +5V it switches over to the condition with Tr_1 saturated. When the potential at point A is more negative than −5V the circuit switches over to the condition with Tr_2 saturated. The operational amplifier is used as an integrating amplifier, the associated capacitor being selected by the coarse sweep-rate control.

When the R-L-H switch is in position R, the sweep starts with Tr_2 saturated and point A at −5V. Point B is then nearly at zero potential and current flows from the input of the integrator through the fine sweep-rate control to the negative supply rail, raising the potential at the output of the integrator. When this reaches +5V the circuit switches over leaving B at nearly the positive supply potential; current flows into the integrator and the potential at the output returns comparatively quickly to −5V. The cycle then repeats.

With the switch in position L the sweep generator takes up the stable non-oscillatory condition with A at near −5V, the precise value being set by the 2-kΩ potentiometer. In this condition Tr_1 and Tr_2 behave as a high-gain amplifier feeding any difference between the desired and actual potential at A to the input of the integrator in such a sense as to bring the potential at A back to the value desired. When the switch is turned to H, Tr_1 cuts off and Tr_2 saturates. The output of the integrator changes in precisely the same manner as in position R and so does the output frequency. When the potential at A reaches +5V this time it stops changing because the circuit has reached a stable condition with the precise output potential set by the 500-Ω potentiometer. Similarly when the switch is turned back to L the voltage at A flies back to −5V. By manipulating the switch in this way a manual sweep is obtained which is useful for X-Y plotters. The ability to hold the potential of A at either end of the sweep range is needed to calibrate correctly.

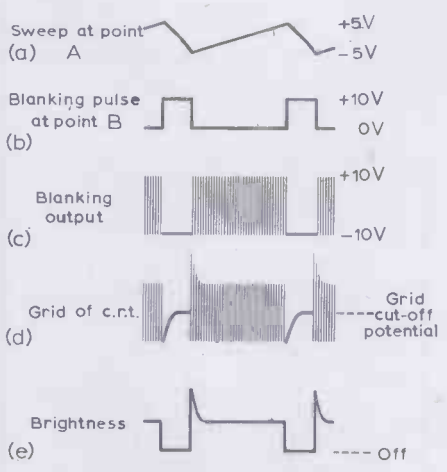


Fig. 4. Beam blanking is achieved with an h.f. waveform because input to the c.r.t. grid is often a.c.-coupled. Waveform from Tr_3 is at (c), and (d) is at c.r.t. grid.

The potential at B (Fig. 3) 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 Tr_3 together with the positive blanking pulse (b). Transistor Tr_3 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

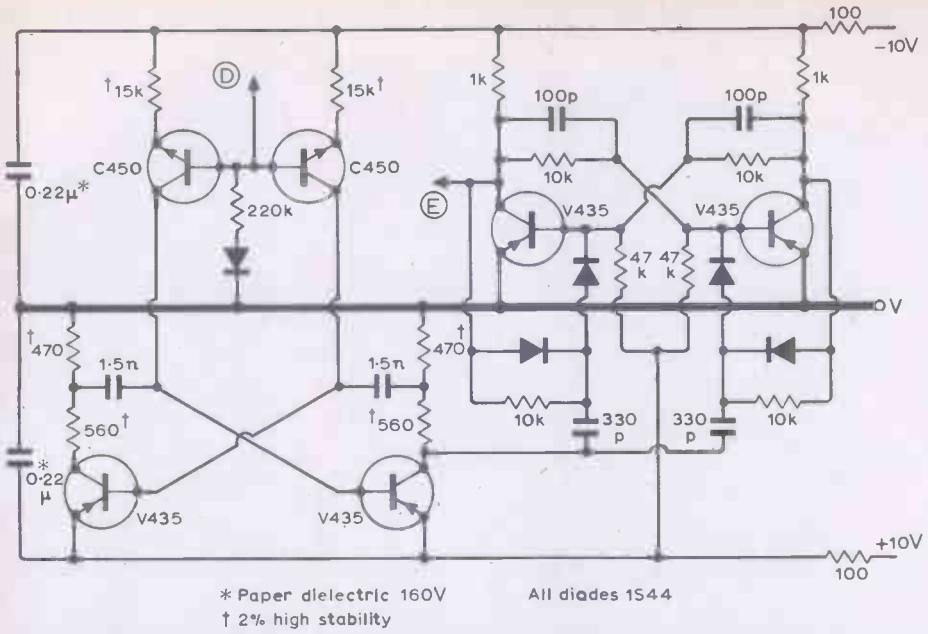


Fig. 5. Astable multivibrator—with constant-current sources controlled by input voltage at D—acts as the voltage-tuned oscillator covering 40 to 60kHz. Bistable multivibrator provides anti-phase outputs with 1:1 mark:space ratio at E and F at 20 to 30kHz.

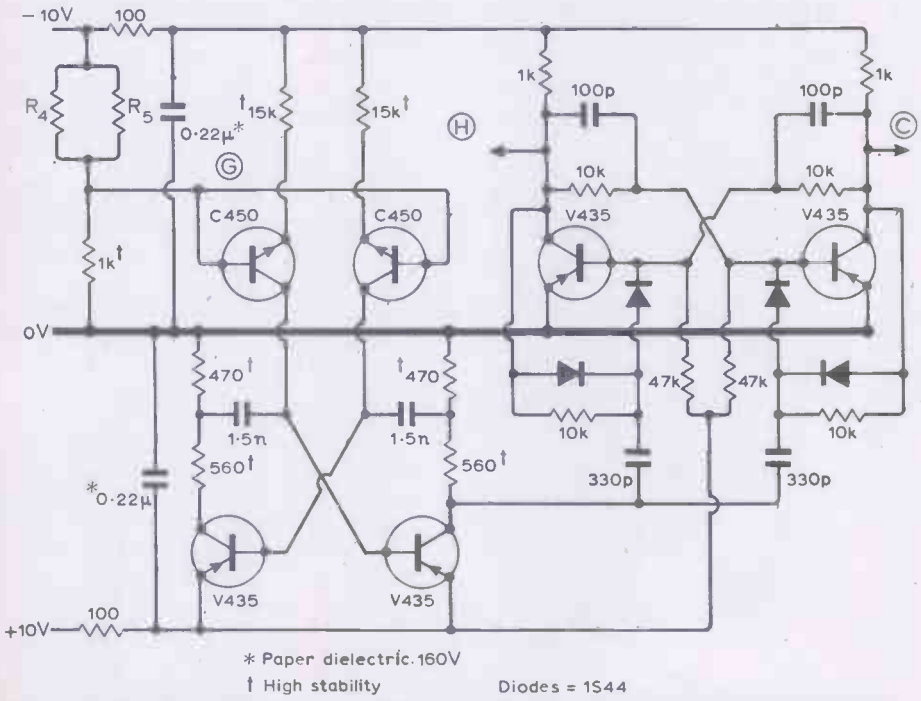


Fig. 6. In the hope that frequency drifts in the fixed and variable-frequency oscillators will cancel, this fixed frequency oscillator is identical to Fig. 5.

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.

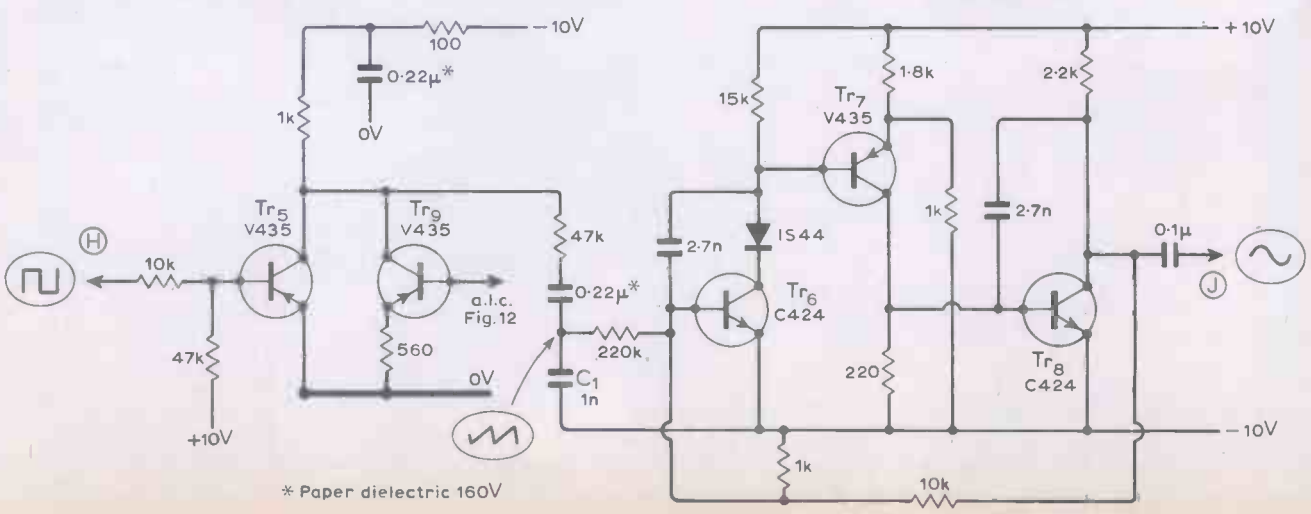
Fixed-frequency oscillator

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 R_4 and R_5, first connect a 10-kΩ potentiometer across the $\pm$10-V supply lines, and measure the required voltage. Calculate R_4 to give a voltage 10% lower than this, using a preferred value, and try values of R_5 around ten times R_4 until the frequency is as close as possible to 20kHz. The square wave for the blanking oscillator is obtained from the collector of Tr_4.

Conversion to sine-wave

The 20-kHz output from the fixed-frequency oscillator at H drives Tr_5 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 Tr_5 is shunted by Tr_9 so that the amplitude of the square wave is controlled by the automatic-level-control current flowing from the base of Tr_9.

This square wave goes to the low-pass RC filter consisting of R_6 and C_1 whose output is a sawtooth which is applied to the input of the tuned amplifier, containing Tr_{6-8}, 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 $f_2 = 20$kHz, and f_1 varies from 20 to 30kHz, giving the following components:

component	relative amplitude	frequency (kHz)
$f_1 - f_2$	1	0 to 10
$f_1 + f_2$	1	40 to 50
$3f_1 - f_2$	$\frac{1}{3}$	40 to 70
$3f_1 + f_2$	$\frac{1}{3}$	80 to 110

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.

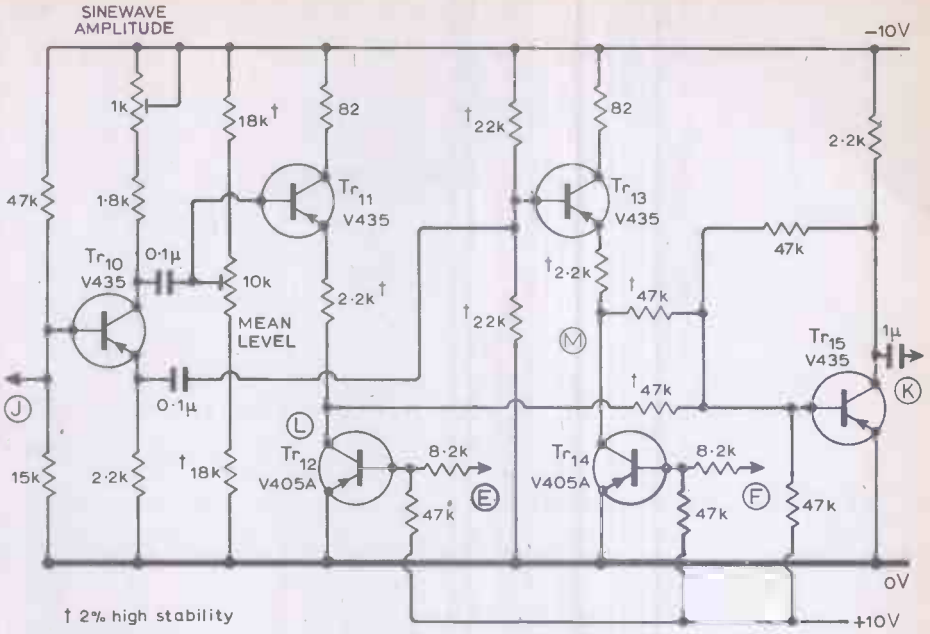


Fig. 8. Balanced mixer produces difference frequency between fixed and variable-frequency oscillators. Because the summing amplifier Tr_{15} is linear, difference frequency signal amplitude is proportional to fixed-frequency signal amplitude and hence controlled by the a.l.c. circuit: In all these circuits alternative transistors are C724, BC107 for C424; C740, BFY76 for C450; V723, BSX29,36 for V405A and V723, BCY72 for V435A.

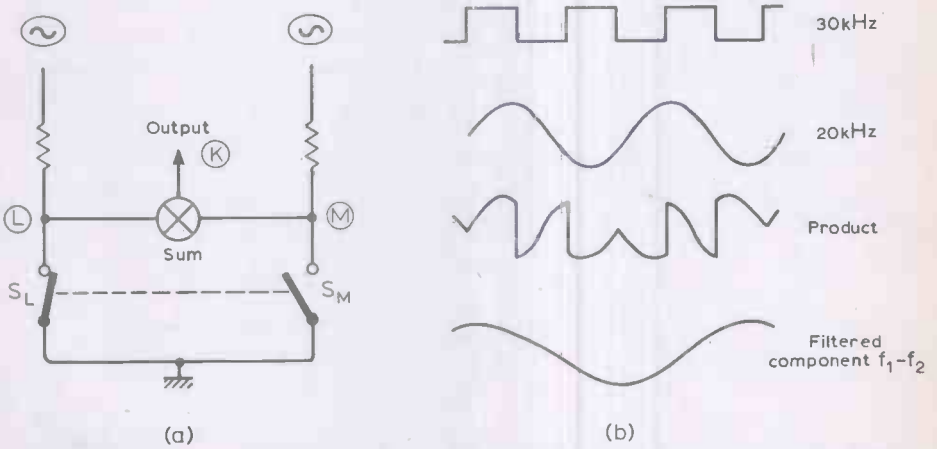


Fig. 9. Simplified circuit of switching mixer with points L and M at (a) corresponding to those in Fig. 8. Mixer waveforms at (b) are with fixed and variable frequencies in ratio 2:3. Bottom waveform is filter output.

†'Second-order active filter circuit for tuned amplifiers and sinusoidal oscillators', E. A. Faulkner and Viscount Downe, *Electronic Engineering*, vol. 39 1967, p.287.

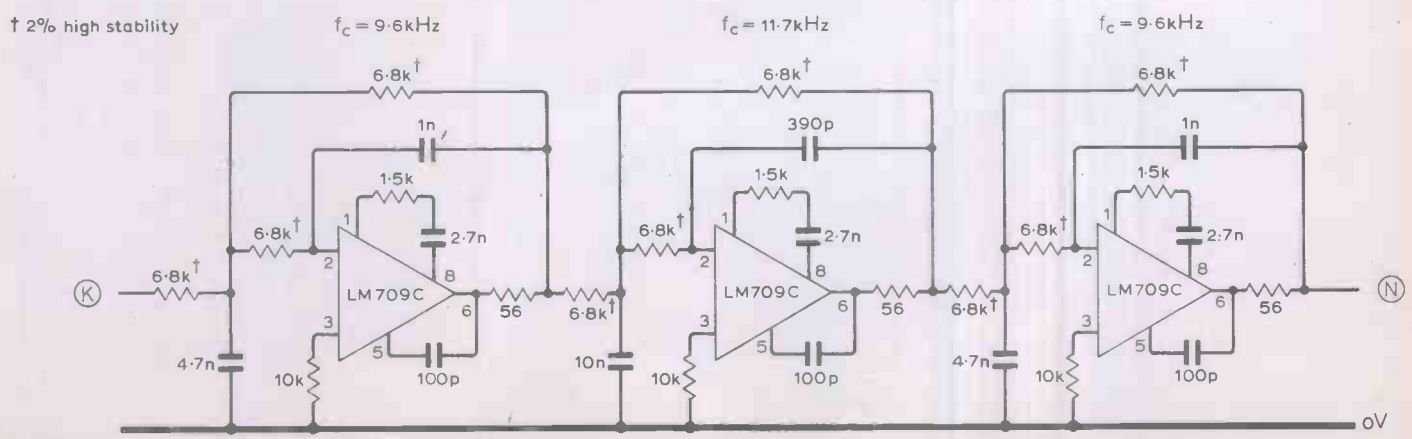


Fig. 10. As well as difference frequency, there are additional components, e.g. $f_1 + f_2$, $3f_1 - f_2$, $3f_1 + f_2$, which must be filtered. Low-pass filter shown has a cut-off frequency of 10kHz and a slope of nearly 36dB/octave giving 64dB attenuation at 40kHz.

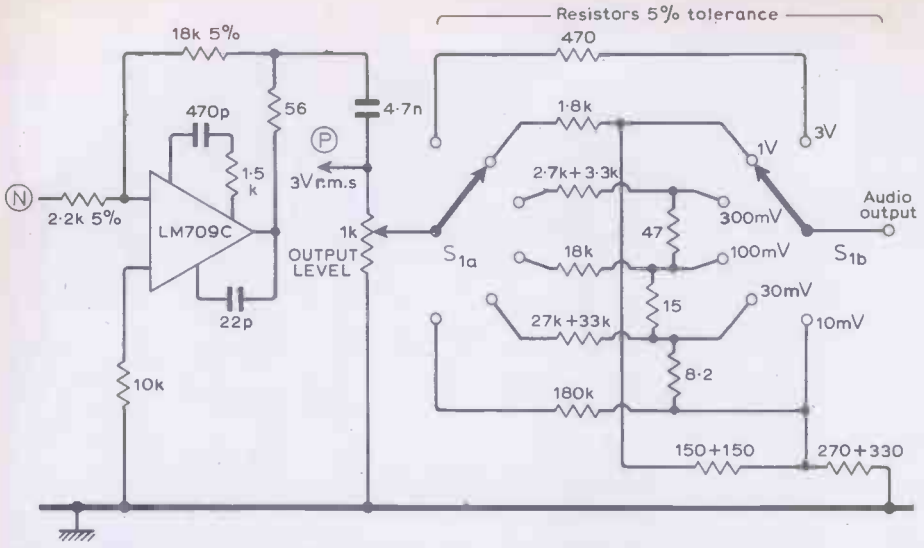


Fig. 11. Signal level is amplified to 3V r.m.s. and fed to a switched attenuator, accurate to 5%.

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 Tr_{12} and Tr_{14}–Fig. 8–the sine waves are displaced from zero mean level so that these transistors are always forward biased.

Transistor Tr_{10} is a phase inverter producing two equal and opposite signals to feed the emitter followers Tr_{11} and Tr_{13}. The summing amplifier Tr_{15} is

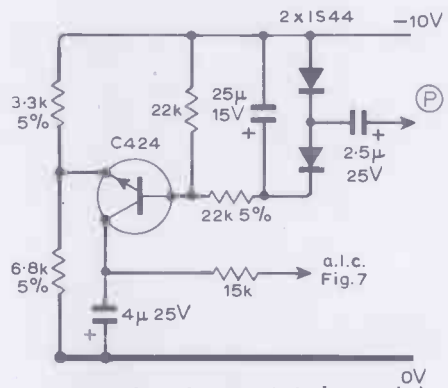


Fig. 12. Filter characteristic has a rise of 2.6dB at 8kHz, but is reduced to 3% pk-pk with a.l.c. (at 4s sweep time). Level control signal is obtained by rectifying signal from D in Fig. 11.

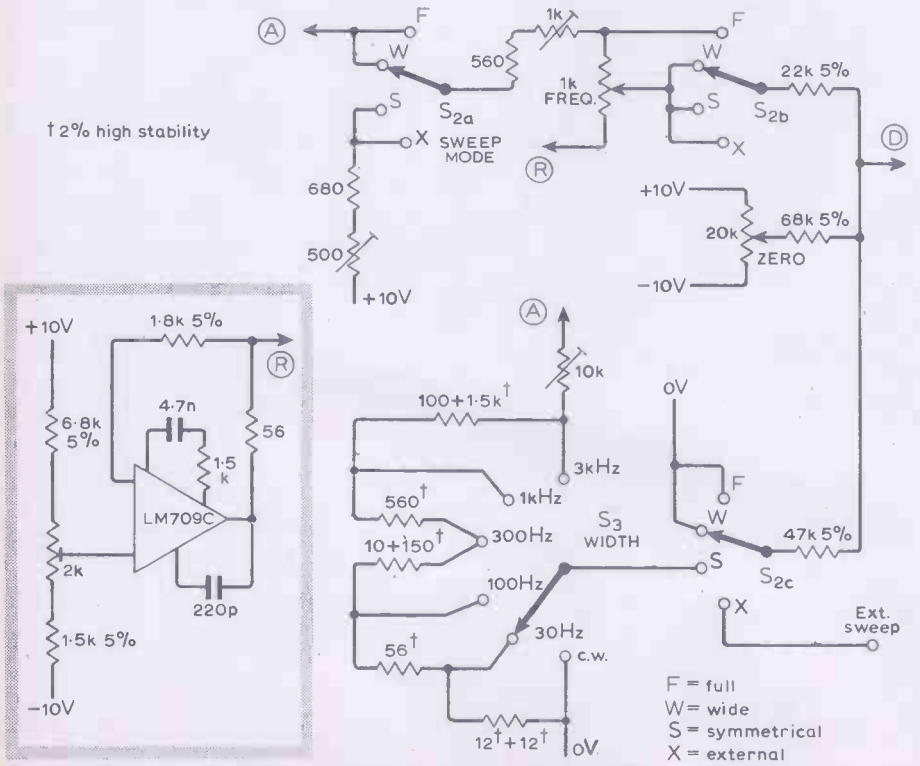


Fig. 13. Sweep control circuit—between sweep generator and voltage tuned oscillator—enables various sweep modes to be set. The integrated circuit provides a low-impedance supply at 5V for setting zero-frequency output. Upper frequency limit is variable in switch positions W, S and X.

linear in the sense that the amplitude of the component at f_1-f_2 is proportional to the amplitude of the sine wave f_2, thus the a.l.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.

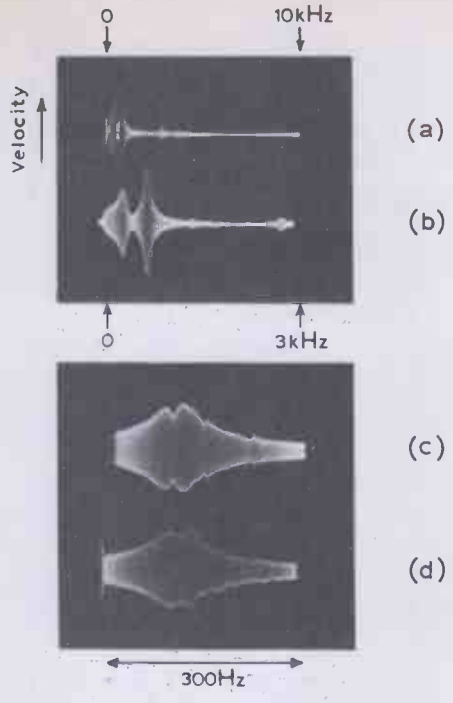
With this method the variation of amplitude over the entire frequency range was reduced to 3% pk-pk when the sweep period was four seconds. The levelling deteriorates at fast sweep rates because of the slow response of the detector caused by the smoothing components.

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_2. 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 frequency 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_{2a} 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_3 is set to 'c.w.', the



To illustrate the application of the sweep generator, the response of an earphone was investigated by another earphone 2mm from the diaphragm. Trace (a) shows voltage across the coil—proportional to velocity—with a 10-kHz frequency base. Trace (b) shows the trace expanded using 'wide' mode with a base of 3kHz. Second peak is resolved by using 'symmetrical' mode with a 770-Hz centre frequency and a 300-Hz sweep width (c). Decreasing sweep time from 7s per sweep to 0.5s per sweep shows the loss of resolution and spurious effects caused by too fast a sweep rate (d).

frequency control adjusts the output frequency (unswept) with the same calibration as it had in the 'wide' mode. With S_2 and S_3 so set, the instrument thus behaves simply as an ordinary sine-wave signal generator. This is useful for setting the centre-frequency of a sweep to, say, the peak of a system's response and also for examining the output waveform of the oscillator itself. Symmetrical sweep about this mean frequency is provided in five calibrated widths by S_3. A similar arrangement holds for 'external' sweep waveforms with the mean frequency adjusted by the frequency control. The sensitivity for external sweep is approximately 800Hz per volt.

stabilized, both at less than 100mA. The constancy of the ratio between these two voltages is more important for frequency stability than any common change in the supply voltages.

The oscillators were not sure-start if the two supplies were switched on simultaneously, and the +10V supply should be switched on first.

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 6th. 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 15-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 8DB.

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 £25 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 **World Radio 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 (08.15), is offering for the fourth year a DX award. The listening 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 Ilford 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, Hc 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).

GEC-Mobile Radio, a division of Marconi Communication Systems Ltd, has moved from Coventry to the Chelmsford area. Their new headquarters is at Great Baddow, where the commercial and engineering 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 Steatite Insulations Ltd, of Hagley Rd, Birmingham, B16 8QW. The boards consist of phenolic resin impregnated paper, epoxy resin impregnated glass, and Duston 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 firemen'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 **whip aerials**, manufactured by Valeriote Electronics (Guelph) Ltd, of Ontario, Canada. They cover the frequency range 2-30MHz, and are capable of handling 5kW average, 10kW peak.

Gresham Recording Heads Ltd have appointed Radio-Equipements, of 9 Rue Ernest Cognacs, 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 and the theorems of Thévenin and Norton, and a five-page index. Pp. 367. Price £3.80 cased and £2.50 limp. Iliffe Books, Butterworth & Co. (Publishers) Ltd, 88 Kingsway, London WC2 6AB.

A Dictionary of Electronics by S. Handel, third edition. Five years have passed since the second edition of this reference work appeared. The first edition published in 1962 contained 384 pages and cost 7s 6d. The new edition contains 413 pages and costs 45p. Penguin Books Ltd, Harmondsworth, Middx.

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 multi-path 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.

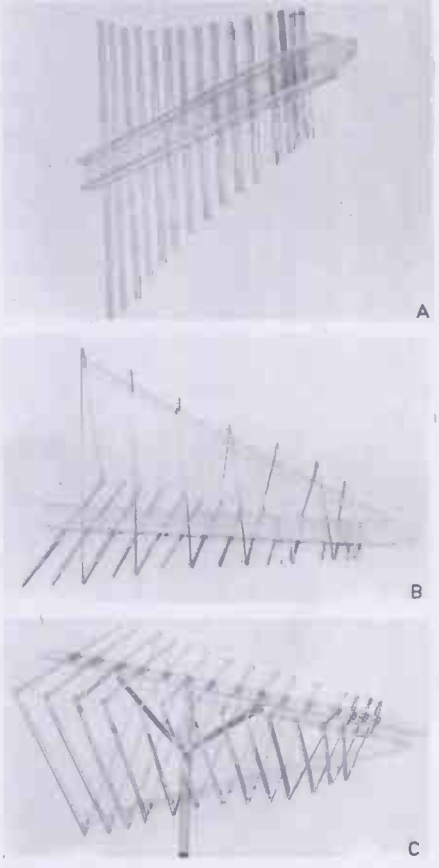


Fig. A. Alternate elements on this U-channel form one side of the two tetrahedral helices. Model in this photograph has an extra element—extreme right—not shown in the table.

Fig. B. One complete helix with support 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.

Fig. 1. Cut the aluminium strips to element lengths given in the table, and drill 3-mm holes as shown.

Fig. 2. For the element supports, cut the Perspex pieces and make notch as shown.

Fig. 3. Make the U-channel from three of the pieces shown in Fig. 2 (A, B & C) by drilling 3-mm holes, 25-mm deep at 76-mm intervals along both sides as shown and insert self-tapping screws.

Fig. 4. Attach the support—Perspex piece D—to the U-channel by drilling a 3-mm hole through notch and support, and fixing with nut and bolt.

Fig. 5. Cut 14 aluminium angle brackets to length shown, drill four 3-mm holes in each and bolt centrally to elements—numbers 1, 4, 7, 10, 13, 16 and 19 of both helices, see Fig. 6.

Fig. 6. Drill holes in U-channel to take elements and brackets as shown.

Fig. 7. Add remaining elements, completing one helix before starting the other. Open out lower support and fix to upper vertices in photographs with straps or wire. Support can be made more rigid by drilling a second hole at the notch and fixing with nut and bolt. Some holes at element joins may need redrilling.

Fig. 8. Bolt completed aerial to wood or plastics mast using four aluminium diagonal supports.

Table 1. Parts needed

Perspex pieces

1.15m × 38 × 6.5mm (45 × 1½ × ¼in) 2 off
1.2m × 76 × 10mm (48 × 3 × ⅜in)
1.2m × 38 × 6.5mm (48 × 1½ × ¼in)

Aluminium strips

1.83m × 13 × 1.6mm (72 × ½ × 1/16in) 13 off

Aluminium right angle

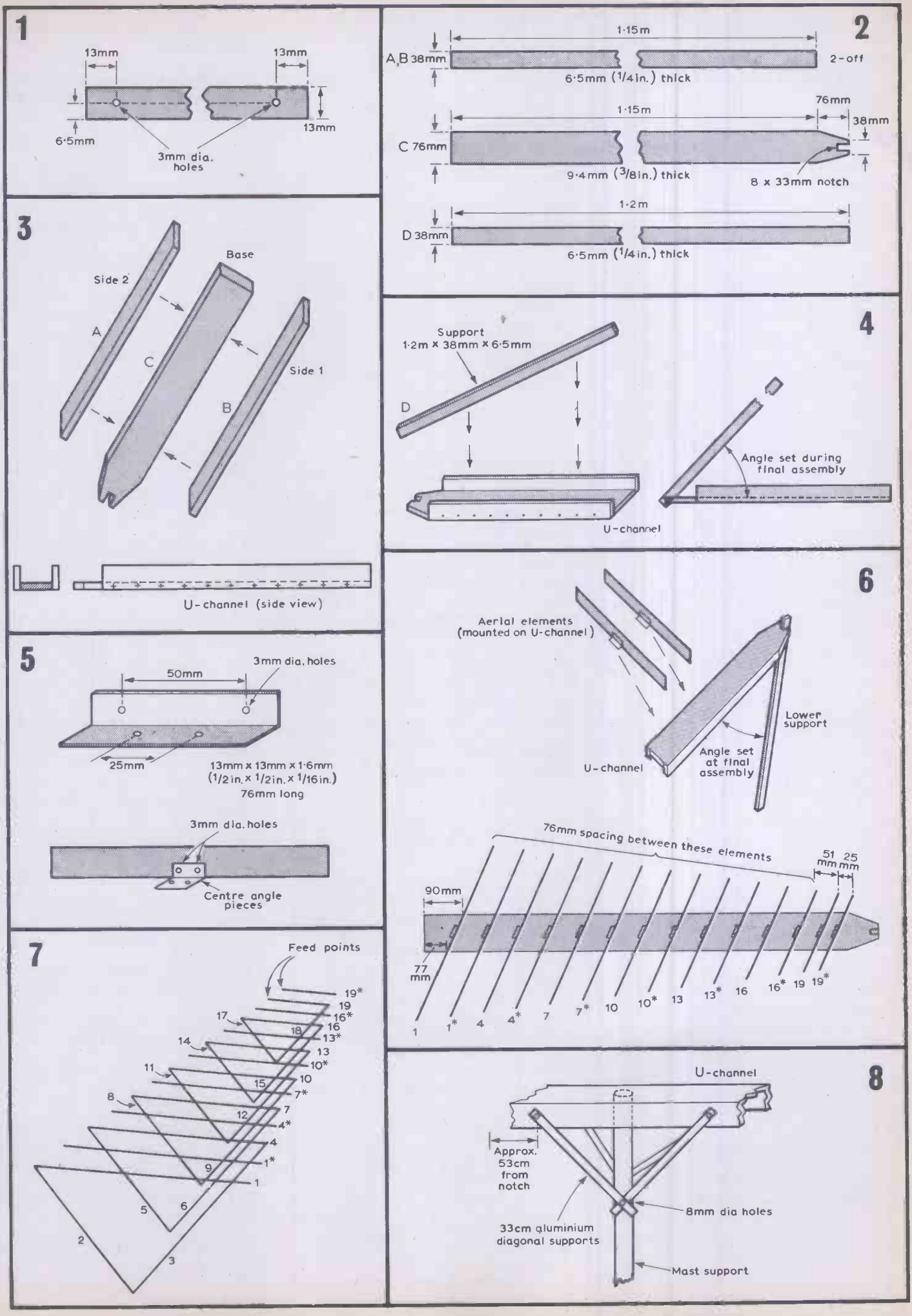
1.83m × 13 × 13 × 1.6mm (72 × ½ × ½ × 1/16in)

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

Element no.	first helix lengths (cm)	second* helix
1	138	131
2	123	115
3	118	111
4	123	116
5	109	100
6	103	94
7	110	103
8	93	86
9	89	81
10	96	90
11	79	72
12	74	66
13	82	76
14	65	56
15	59	51
16	68	61
17	50	43
18	46	37
19	40	39

*Second-turn elements identified by asterisk in drawings.


1
13mm
13mm
6·5mm
13mm
3mm dia. holes
2
1·15m
A,B 38mm
2-off
6·5mm (1/4in.) thick
1·15m
76mm
38mm
C 76mm
9·4mm (3/8in.) thick
8 x 33mm notch
1·2m
D 38mm
6·5mm (1/4in.) thick
3
Base
Side 2
A
C
B
Side 1
U-channel (side view)
4
Support
1·2m x 38mm x 6·5mm
D
Angle set during final assembly
U-channel
5
3mm dia. holes
50mm
25mm
13mm x 13mm x 1·6mm
(1/2in. x 1/2in. x 1/16in.)
76mm long
3mm dia. holes
Centre angle pieces
6
Aerial elements
(mounted on U-channel)
U-channel
Lower support
Angle set at final assembly
76mm spacing between these elements
51 mm
25 mm
90mm
77 mm
1
1*
4
4*
7
7*
10
10*
13
13*
16
16*
19
19*
7
Feed points
19*
19
16*
16
13*
13
10*
10
7*
7
4*
4
1*
1
2
3
5
6
8
9
11
12
14
15
17
18
8
U-channel
Approx. 53cm from notch
8mm dia holes
33cm aluminium diagonal supports
Mast support

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_1.

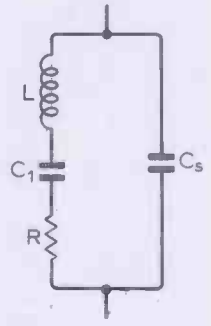


Fig. 1. Equivalent circuit of a piezoelectric resonator.

Ceramic can have its piezoelectric values altered over a wide range, which enables a more flexible series of designs to be achieved. Ceramic is, however, less stable both with temperature and time than quartz, hence the use of ceramic filters at 455 kHz, where the stability with respect to temperature in absolute terms is equal to that of a quartz filter at 10.7 MHz.

An analysis of the equivalent circuit of Fig. 1 shows that the impedance plot is characterized by a minimum at a frequency F_R, very close to the resonance of the series arm LC_1R and an impedance maximum at a frequency F_A, where C_S has a capacitive impedance equal to the inductive impedance

Table 1

Type	Channel spacing	Resonances ref. 455kHz	L mH	C_1 pF	R Ω	C_s pF
TFD4	20-25 kHz	± 18 kHz	2.2	61	15	360
TFD5	12.5 kHz	± 12 kHz	3.2	40	15	369

of LC_1R. 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:—

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

This is cumbersome and it can be shown that within ±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:

jZ where $Z =$
$1.0 + 0.11f + 0.006f^2$ kΩ (TFD5) or
$1.3 + 0.24f + 0.02f^2$ kΩ (TFD4)

where f represents the deviating frequency in kHz. This impedance is approximately true for ±3 kHz for the TFD5 and ±5 kHz for the TFD4.

The ideal device would have a linear

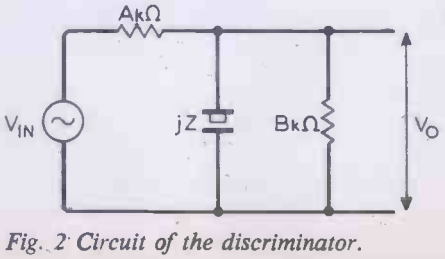


Fig. 2 Circuit of the discriminator.

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:—

$$V_o = \frac{B}{A+B} \cdot \frac{V_{in}}{\sqrt{1 + \left(\frac{AB}{(A+B)Z}\right)^2}}$$

The problem then resolves itself into two forms:—

1. To linearize the expression:

$$\frac{1}{\sqrt{1 + \left(\frac{AB}{(A+B)Z}\right)^2}}$$

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 $f = -3$, 0 and +3 for the TFD5 and $= -5, 0, +5$

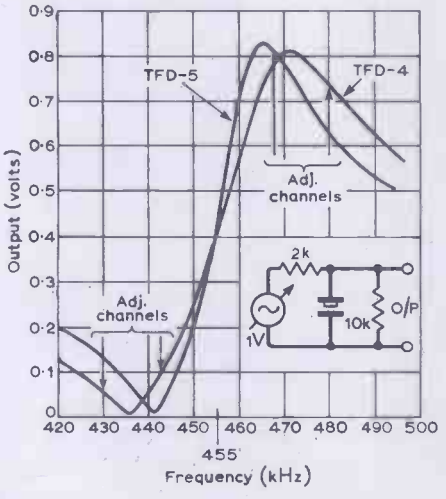


Fig. 3. Performance of slope detector using TFD4 and TFD5.

for the TFD4, using figures in Table 1. The results are as follows:—

$$\text{TFD5}\ \frac{AB}{A+B} = 1.5\ \text{k}\Omega$$

$$\text{TFD4}\ \frac{AB}{A+B} = 1.7\ \text{k}\Omega$$

For practical purposes values of 2kΩ for A and 10kΩ for B are satisfactory for both TFD4 and 5. The sensitivities achieved are 32mV/kHz for a 1V input for the TFD4 and 50mV/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.

* Vernitron Ltd

Dual-trace Oscilloscope Unit

2. Field-effect transistor amplifier

by W. T. Cocking, F.I.E.E.*

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.

*Editor in Chief, *Wireless World*

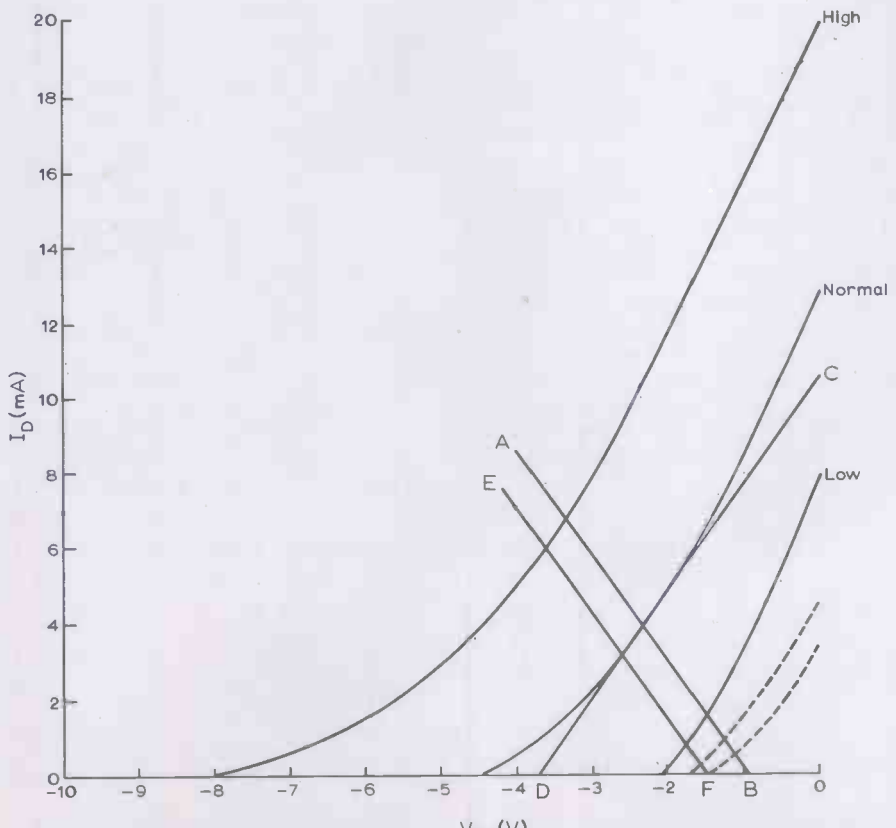


Fig. 1. Curves of the BFW10 f.e.t. showing the large tolerances. The bias line AB is for the circuit of Fig. 2 with V_C = 4V, R_S = 470 Ω and R_C = 1·5 kΩ. The line EF is for the same values but V_C = 6·3 V. CD is drawn tangentially to the f.e.t. curve at its intersection with AB and its slope gives the mutual conductance. The dotted curves are for two specimens of the TIS58 which were used in the experiments.

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 resistor 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" approaching 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_D is made variable and is adjusted to bring the collector of Tr_2 to a fixed voltage V_C with respect to earth.

Ideally, the voltage amplification is $1+R_C/R_S$. In practice, it is somewhat less. It can be within about 95% of this figure for low tolerance to normal f.e.ts, but it falls off more with high-tolerance ones because R_D 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

BFW10. Such f.e.ts are available, but naturally tend to cost more.

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 Tr_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, $R_S = 470\,\Omega$ and $R_C = 1{\cdot}5\,k\Omega$, the parallel value is $358\,\Omega$. If $V_C = 4$ V the effective return voltage is 0·95 V. By drawing a bias line from this voltage to represent $358\,\Omega$ in the usual way, the intersections with the f.e.t. curves enable I_D and V_S to be

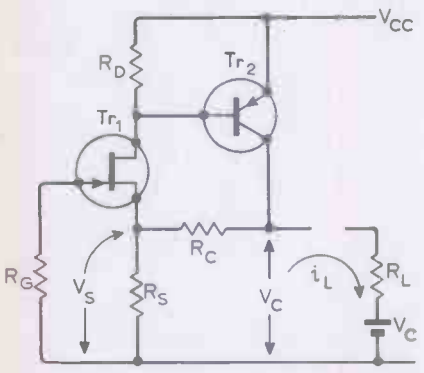


Fig. 2. Circuit for an n-channel f.e.t. with p-n-p bipolar transistor.

read off for low- and high-tolerance and normal f.e.ts. The line AB in Fig. 2 represents the conditions. For a low-tolerance f.e.t., $V_S = 1{\cdot}5$ V, $I_S = 1{\cdot}5$ mA; for a normal f.e.t., $V_S = 2{\cdot}35$ V, $I_S = 3{\cdot}9$ mA; and for a high-tolerance f.e.t., $V_S = 3{\cdot}4$ V, $I_S = 6{\cdot}8$ mA, within the accuracy limitations of small-scale graphs.

The required value of R_D is V_{BE}/I_D. Taking $V_{BE} = 0{\cdot}65$ V, R_D is $433\,\Omega$, $166\,\Omega$ and $95{\cdot}5\,\Omega$ in the three cases. In practice, there is a manufacturing tolerance on V_{BE} which is usually of the order of ± 75 mV. This is covered by providing R_D with a somewhat greater range of resistance.

At this stage I_D, V_C, V_S and R_D are known. The collector current is

$$I_C = \frac{V_C - V_S}{R_C}$$

For the three cases of the BFW10, with $R_C = 1{\cdot}5\,k\Omega$, the collector current is 1·67 mA, 1·1 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 there termed y. It is the effective current gain of Tr_2 and in the limit becomes h_{fe}. This only occurs when R_D becomes infinite and is only approached when the input resistance $h_{fe}r_e$ of Tr_2 is very small compared with R_D so that substantially all the signal current of Tr_1 flows into the base of Tr_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_D rises, R_D must be reduced, and as I_C becomes less, r_e increases. The result is that y varies very greatly between low- and high-tolerance f.e.ts.

Taking $V_{BE} = 0{\cdot}65$ V, which is typical, the value of y given in the Appendix can be expressed in d.c. terms as

$$y = \frac{h_{fe}}{1 + \dfrac{h_{fe} I_D R_C}{25(V_C - V_S)}}$$

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 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, $h_{fe} = 100$, $R_C = 1{\cdot}5\,k\Omega$ and $R_S = 470\,\Omega$; for Table 1, $V_C = 4$ V, while for Table 2, $V_C = 6{\cdot}3$ 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 $V_C = 6{\cdot}3$ 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

	Low	Normal	High	
V_S	1·5	2·35	3·4	V
I_D	1·5	3·9	6·8	mA
$V_C - V_S$	2·5	1·65	0·6	V
I_C	1·67	1·1	0·4	mA
R_D	433	166	95·5	Ω
r_e	15·6	23·6	65	Ω
R_D/h_{fe}	4·33	1·66	0·955	Ω
$r_e + R_D/h_{fe}$	19·99	25·26	65·955	Ω
y	21·65	6·6	1·45	
$g_m R_S(1+y)$	31·9	10·7	3·45	
$\dfrac{g_m R_S(1+y)}{1+g_m R_S(1+y)}$	0·97	0·915	0·775	
$1 + \dfrac{R_C}{R_S} \cdot \dfrac{y}{1+y}$	4·05	3·77	2·89	
A	3·93	3·45	2·24	
R_o	122·5	345	905	Ω

Table 2

	Low	Normal	High	
V_S	1·575	2·62	3·65	V
I_D	0·7	3·16	6	mA
$V_C - V_S$	4·725	3·68	2·65	V
I_C	3·15	2·45	1·77	mA
R_D	925	206	108	Ω
r_e	8·25	10·6	14·7	Ω
R_D/h_{fe}	9·25	2·06	1·08	Ω
$r_e + R_D/h_{fe}$	17·5	12·66	15·78	Ω
y	52·9	16·3	6·85	
$g_m R_S(1+y)$	76	24·4	11·1	
$\dfrac{g_m R_S(1+y)}{1+g_m R_S(1+y)}$	0·987	0·96	0·916	
$1 + \dfrac{R_C}{R_S} \cdot \dfrac{y}{1+y}$	4·13	4	3·79	
A	4·09	3·84	3·48	
R_o	53	161	337	Ω

Rather surprisingly, there is little published information on the temperature characteristics of the f.e.t. Two different effects exist. There is the usual negative effect of a junction which results in the drain current increasing with temperature, but there is a positive effect in the bulk material which has the opposite effect. At one particular low current the two can cancel, but at normal drain currents the junction has the greater effect, and normally drain current increases with temperature.

The bipolar transistor itself behaves normally, of course. However, the change of V_{BE} affects I_C by an amount which depends greatly upon the value of R_D. If R_D is very large, V_{BE} hardly affects I_C at all, but it can exercise almost its full effect when R_D is small. It can be expected, therefore,

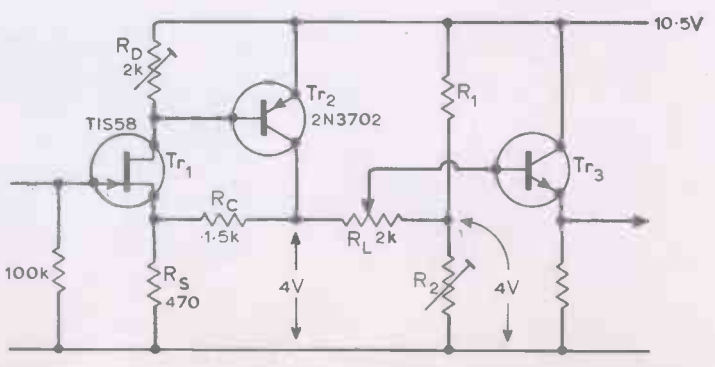


Fig. 3. The circuit of Fig. 2 elaborated to include a gain control; R_D is adjusted to bring the collector of Tr_2 to a design value and R_2 is adjusted for zero volts across R_L

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 $V_C = 6{\cdot}3$ 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 Tr_2 and R_D was adjusted for a reading of 4 V. The meter was then connected across R_L 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_L but mainly to reduce the base current in R_L. The high-frequency response can be extended by adding a small capacitance (e.g., 25 pF) across R_S.

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_L. An out-of-balance current of 10 μA in R_L is about as much as can be tolerated and this corresponds to only 20 mV cross R_L. One would expect this to occur with a temperature change of only around 2°C.

To maintain good balance both ends of R_L 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 2·7 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_D, 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 Tr_1 I_D instead of the more usual I_{C1}. The previous equations apply, but additionally,

$$V_{B1} - V_{BE1} = V_S$$

There is now no reason why the current of Tr_1 should not be much less than that of Tr_2; R_D can be large and y can be large.

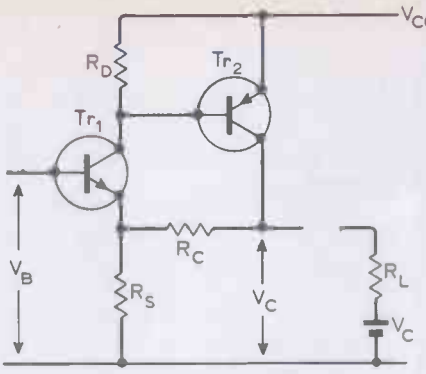


Fig. 4. The circuit of Fig. 2 but with an n-p-n transistor in place of the f.e.t.

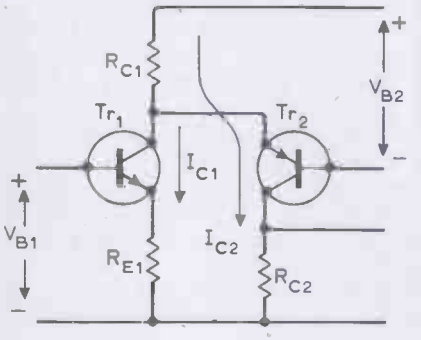


Fig. 5. A form of cascode circuit using n p n and p n p transistors which is useful for passing a signal between points at different d.c. voltage levels. A shift control which does not affect gain can be obtained by adjusting V_{B2}. The gain tends in the limit to R_{C2}/R_{E1} but in practice is a little lower.

Ignoring the internal resistance of the emitter junction of Tr_1, the input resistance is

$$R_{in} = h_{fe1} R_S (1+y) \frac{R_C + R_C/(1+y)}{R_C + R_L + R_S}$$

and it can easily be several megohms. Notice, however, that R_{in} is reduced by a finite value for R_L. This is physically obvious for when R_L is present some of the collector current of Tr_2 flows through it instead of it all passing through R_S. The feedback, upon which the high input resistance depends, is thus reduced.

The gain equation is now very nearly the ideal of $1 + R_C/R_S$, since g_m for a transistor is usually 30 mA/V or more and y can easily be made 50 or more. It will rarely be less than the ideal by more than 5%. Also the output resistance is much smaller and is nearly

$$R_o = \frac{R_C}{1+y}$$

With this circuit it is possible to obtain with a load of 2 kΩ an input resistance of at least 2 MΩ, an output resistance of around 15 Ω and a gain of about four times and it is useful up to at least 10 MHz. If R_D is fairly large, as it can be, (e.g., 1 kΩ) changes of V_{BE2} have little effect. However, changes of V_{BE1} are subject to the full gain. Thus, changes of 2 mV/°C become changes of 8 mV/°C at the output.

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_D 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 undesirable. 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 $A = 10$, $R_C/R_S = 9$ ideally, 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 $R_S = 390\ \Omega$ and $R_C = 4{\cdot}7$ kΩ approximately. For the bias line to start from 0·9 V, as before, V_C must be 11·7 V. As V_{CE} must be at least 2 V, V_{CC} must be at least 14 V. All this is quite possible.

It is unlikely, however, that the frequency response would be adequate, and R_L could certainly not be increased proportionately to R_C without seriously affecting the response. In view of the difficulty of maintaining an adequate balance of the voltages at the ends of R_L it was regretfully 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 very useful circuit for connecting two difficult voltage levels. From the signal point of view it is a form of cascode stage and gives phase reversal. For Tr_1

$$V_{B1} - V_{BE1} = I_{C1} R_{E1}$$

and for Tr_2

$$V_{B2} - V_{BE2} = (I_{C1} + I_{C2}) R_{C1}$$

$$V_o = I_{C2} R_{C2}$$

and the gain is nearly R_{C2}/R_{E1}.
Also

$$V_{CE1} = V_{CC} - I_{C1}(R_{C1} + R_{E1}) - I_{C2} R_{C1}$$

$$V_{CE2} = V_{CC} - I_{C1} R_{C1} - I_{C2}(R_{C1} + R_{C2})$$

The usual practical difficulty is to make V_{CE1} and V_{CE2} large enough. Suppose, $V_{B1} = 6{\cdot}3$ V, $V_o = 2{\cdot}7$ V, and $V_{BE1} = V_{BE2} = 0{\cdot}65$ V with $V_{CC} = 10{\cdot}5$ V min. Then $I_{C1} R_{E1} = 5{\cdot}65$ V. Suppose, $R_{E1} = 1{\cdot}5$ kΩ, then $I_{C1} = 3{\cdot}76$ mA. If $R_{C2} = 1{\cdot}5$ kΩ, $I_{C2} = 2{\cdot}7/1{\cdot}5 = 1{\cdot}8$ mA. Now for Tr_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_{C1} with a current of 3·76 + 1·8 = 5·56 mA, so $R_{C1} = 332\ \Omega$. We then have $V_{CE2} = 10{\cdot}5 - 1{\cdot}85 - 2{\cdot}7 = 5{\cdot}95$ V. The only thing wrong with this is that 330 Ω

is rather low for R_{C1}. The loss of signal can be corrected by increasing R_{C2} and frequency correction can be obtained by shunting R_{E1} by a small capacitance ($\approx$ 25 pF). A shift control which does not affect the gain can be obtained by making V_{B2} variable. It must, of course, be nominally 0·65 V plus the drop across R_{C1} 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_S (Fig. 3) and R_{E1} (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 capacitatively 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 μF is needed. This means electrolytic types must be used and these have a leakage current. This can be small initially if their voltage rating is high compared with the actual voltage across them, and a trial showed it to be negligible. However, according to the books an electrolytic capacitor used on a low voltage gradually reforms to a working voltage near to that applied and then passes a relatively high leakage current. If this does occur, it means that after three months or so, there would be excessive current in the gain control.

A second reason for avoiding coupling capacitors is that it would be necessary to include protective diodes and resistors. Without them, there is no more certain way of obtaining a heavy mortality in transistors! The trouble occurs when switching on and off. Protective circuitry not only adds to the cost, but tends to reduce the high-frequency response. We tried capacitors without such circuitry and several transistors died!

Before concluding this part, it may be well to say a few words about another circuit which was tried. The merit of this circuit, Fig. 6, is that ideally there is no current in R_{B1}, 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 Tr_1 and Tr_2 would be better determined.

Transistors Tr_1 and Tr_2 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_{B1} and R_{B2} must thus be returned to substantially the same voltage. Now if current flows in R_{B1} and R_{B2} from Tr_3, there must be a voltage drop across R_{B2} and the base of Tr_2 will not be at the same voltage as the base of Tr_1. But the base voltages cannot differ appreciably and so there cannot be current in R_{B1} and R_{B2}. Thus the collector voltage of Tr_3 to earth is the same as the base voltages of Tr_1 and Tr_2.

With the particular conditions of Fig. 6, the base supply voltage for Tr_1 had to be 3·6 V compared with the base supply of 2·8 V for Tr_2, 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 Tr_1 (9 μA) in the high base resistance (100 kΩ). This alone gave a bias difference of 0·9 V. In fact, the transistor used for Tr_1 had h_{fe} = 55 only.

The gain of the stage is nominally $1+R_{B1}/R_{B2}$ and this is 3·45 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 Tr_1. 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 symptoms were certainly 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.

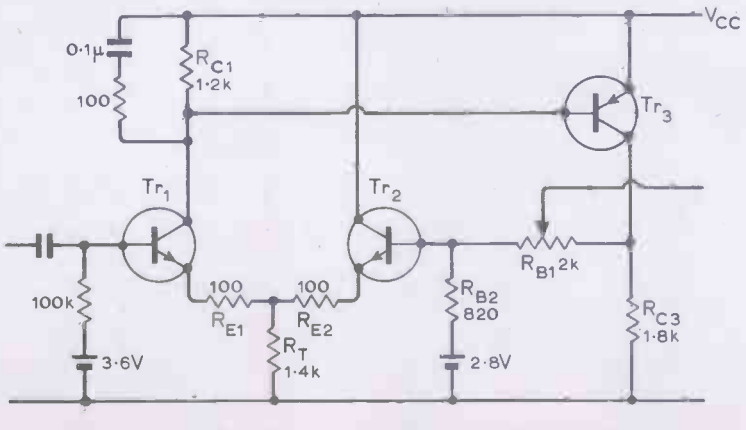


Fig. 6. Three transistor circuit which gives a gain of about 3·5 times with an input resistance of at least 1 MΩ and, ideally, has zero current in the gain control.

Appendix

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

$$V_{in} = V_s + V_{gs} = V_{gs} + i_d R_s(1 + i_c/i_d) - i_L R_s$$

Now $V_{gs} = i_d/g_m$

and

$$\frac{i_L}{i_d} = \frac{R_s + (R_c + R_s)\, i_c/i_d}{R_c + R_L + R_s}$$

Therefore,

$$A = \frac{V_s}{V_{in}} = \frac{g_m R_L i_L/i_d}{1 + g_m R_s(1 + i_c/i_d - i_L/i_d)}$$

Now

$$\frac{i_c}{i_d} = \frac{R_D}{r_e + R_D/h_{fe}} = y$$

where $r_e = 0{\cdot}026/I_C$ = emitter junction resistance. A little algebra then gives

$$A = \frac{g_m R_s(1+y)\,\dfrac{R_L}{R_c + R_L + R_s}}{1 + g_m R_s(1+y)\,\dfrac{R_L + R_c/(1+y)}{R_c + R_L + R_s}}$$

$$\left[1 + \frac{R_c}{R_s}\cdot\frac{y}{1+y}\right]$$

$$= \frac{g_m R_s(1+y)}{1 + g_m R_s(1+y)}\left[1 + \frac{R_c}{R_s}\cdot\frac{y}{1+y}\right]\frac{R_L}{R_L + R_o}$$

where $R_o = (R_c + R_s)\,\dfrac{1 + g_m \dfrac{R_c R_s}{R_c + R_s}}{1 + g_m R_s(1+y)}$

= output resistance.

If $g_m R_s(1+y) \gg 1$, $y \gg 1$ and $R_L \gg R_o$

$$A \approx 1 + \frac{R_c}{R_s}$$

If, also, $g_m \dfrac{R_c R_s}{R_c + R_s} \gg 1$

$$R_o \approx \frac{R_c}{1+y}$$

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 Manufactuers' 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 representating 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 occuring 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".

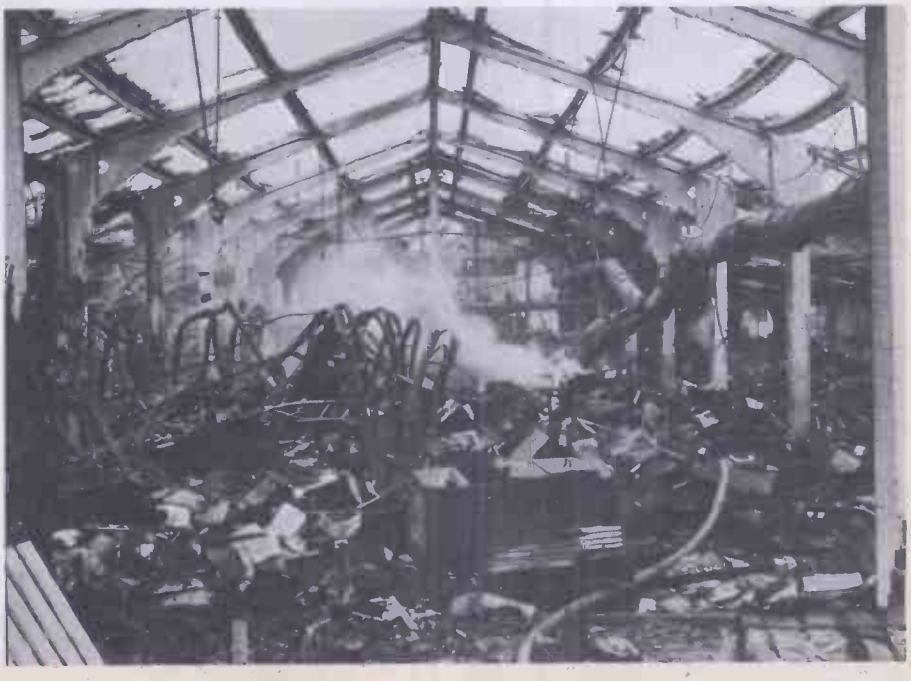
Mr Sherr, manager of standards operations of the I.E.E.E., in commenting on the bill said that "it should provide a mechanism to allow professional societies to effectively carry out such activity [international standardization], an effort for which technical societies are best able to provide appropriately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

The result of a recent fire at KEF Electronics packing and despatch department at Maidstone. The fire was thought to be caused by some kind of electrical failure in the roof and damage in excess of £80,000 was estimated. Within 24 hours of the disaster KEF were delivering stocks to a new temporary warehouse and a new cabinet assembly line is being set up with improved test facilities.



announced that it was to close two of its factories producing microcircuits. The closures 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' Myriad 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.cs, in which fierce competition exists, and concentrate its resources on custom designed i.cs 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 t.t.l. where the manufacturers are waging a fierce price cutting war themselves to the customer's advantage, but usually, to their own disadvantage.

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.

Motorola have produced a development prototype electronic clock that uses a crystal oscillator for timing and integrated electronics for division and display driving, which will be the standard pattern of things in all clocks and watches.

It employs 72 GaAs diodes for the display. There is an outer circle of 60 to display minutes and seconds and an inner circle of 12 for the hours. Two miniature batteries will last a year.

Another approach we have heard about is the use of micro-miniature stepping motors, consuming only a few microamps, which drive conventional hands. We can look forward to a great deal of interesting activity as microcircuit manufacturers strive to develop devices for the very large consumer market (watches, clocks, cars, plus who knows what) in an effort to stay in business. A company who can 'steal a march' on its competitors in this direction could reap rich rewards and perhaps use the extra income to finance unprofitable industrial device production lines.

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 oxidization 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

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 Tr_3. Ultimately this control can be further adjusted for minimum distortion from the oscillator providing that a suitable distortion measurement instrument is available.

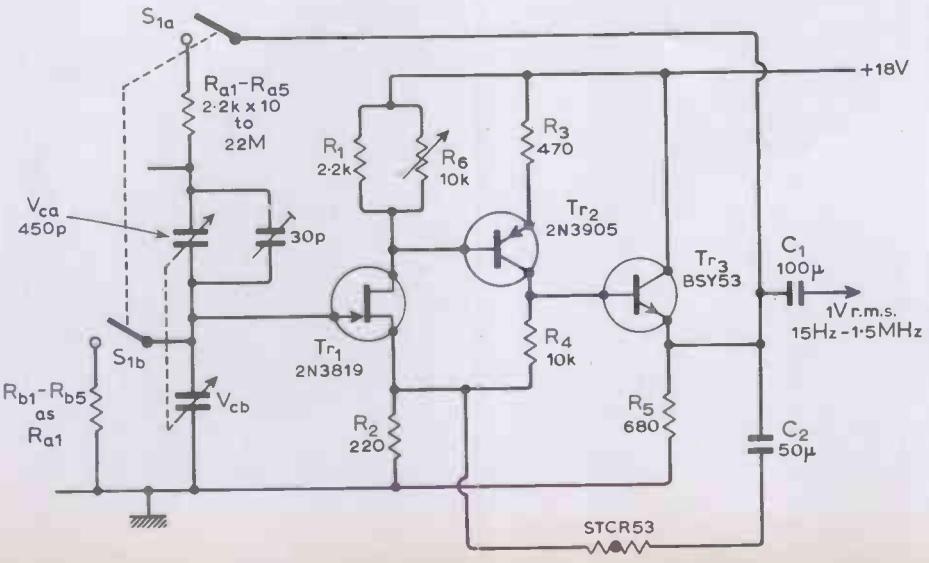
The amplifier has moderate gain but low distortion when the overall negative feedback loop via the thermistor is open. This is due largely to the local inverse feedback circuits in the individual stages. The thermistor feedback loop is then relieved from controlling large and violent variations in gain 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_{53}-C_2, 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 22MΩ 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%.

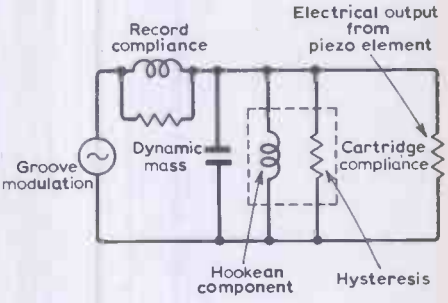


V. R. KRAUSE,
Johannesburg,
South Africa.

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.



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 45° is about 0.16×10^6 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 1.1μW into 270 kΩ. This is 1.1×10^{-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 kVA, 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 (i.e. power $= \vec{v} \cdot \vec{F}$ and not $\vec{v} \times \vec{F}$) but of course there was nothing in the article to infer that the calculation was made assuming it to be a cross product.

Mr. Mirams is, I am sure, mistaken in believing that the tracking force has nothing to do with the cartridge input power. On the contrary, 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 lateral forces on the needle. So by knowing the tracking force, one knows the force necessary to keep the stylus in the groove at maximum modulation velocities and the calculation was performed for this case.

Taking Mr. Mirams' second point that no work is done against the dynamic mass or the Hookean component of compliance, this is of course true, work is done when there is hysteresis or damping present. I think where I would disagree is in the relative magnitude of the resistive and reactive components of the needle tip mechanical impedance. In the vicinity of 1kHz this impedance is mainly resistive and was assumed wholly resistive for the calculation. It is mainly resistive here because at around 1kHz the two reactive impedances (i.e. the compliance and the dynamic mass) cancel out as in a series tuned circuit at resonance; so, to avoid a high Q resonant system, considerable damping has to be added to the pickup system.

Mr. Mirams' very simplified electrical analogue—which rather confusingly used capacitance as the analogue of mass, where it is conventional to use inductance as the analogue—should be compared to Mr. S. Kelly's electrical analogue as published in *W.W.* December 1969 which shows the number of damping elements present in a conventional stereo ceramic pickup.

Finally with reference to Mr. Mirams' last paragraph, it can be seen that this point was made in the original article under the heading 'Reasons for low efficiency'.

I certainly endorse Mr. Mirams' conclusion that ceramic pickups are independent of 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 t_4, t_1, t_3, t_2 and t_7 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 G_1, G_2 and G_3 and a fault could be that gate G_2 is not connected to node C_1 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_2 of gate G_1 s-a-1 which is identical to connection to C_1 of gate G_2 s-a-0, and

(2) f_{18}—connection to C_1 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.

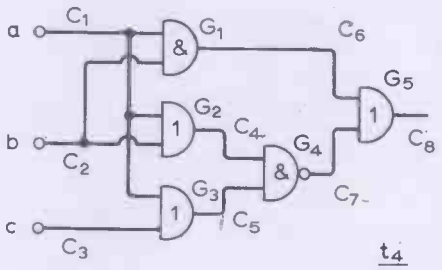


Fig. 1.

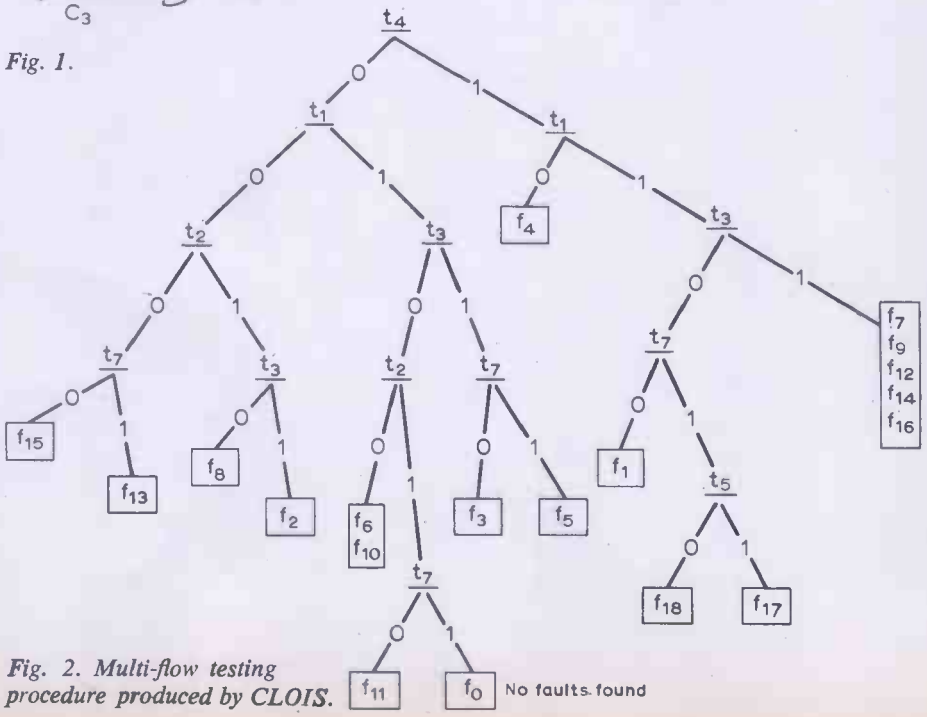


Fig. 2. Multi-flow testing procedure produced by CLOIS.

*Boyce, Emmerson, Stringer and West: 'Simulation of binary logic circuits by digital computers', *The Marconi Review*, Vol. XXXIV, No. 181, 2nd. Quarter 1971, pp. 121-142.

Test	f_{17}	f_{18}
t_0	1	1
t_1	1	1
t_2	1	1
t_3	0	0
t_4	1	1
t_5	1	0
t_6	1	1
t_7	1	1

Fig. 3. Extra columns for matrix F.

Test	$(f_0\ f_{19})$	$(f_0\ f_{18})$
t_0		
t_1		
t_2		
t_3		
t_4	1	1
t_5	1	
t_6		
t_7		

Fig. 4. Extra columns for matrix G_D.

It 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 8×14 and 8×13, respectively, as compared to Mr. Bennetts' 8×136.

During the discussion of the path sensitizing method for fault f_1 it is found that t_4, t_5 and t_7 all can detect the presence of f_1. It is then suggested that t_4 (or t_5) 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_4 and t_5 detect three faults each and t_7 detects four faults, therefore he would have picked t_7 instead of t_4. The resulting minimal set would then have been t_7, t_3, t_2, t_1. It was just by chance, although fortunate, that his minimal set by the path sensitizing method is the same as that obtained by CLOIS.

The final point is that the footnote on p.327 should be

$$n\,[(n+1)/2] = (n^2+n)/2$$

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—indeed, if he now reads Part II published last month, he will see that I have in fact referred the reader to not only a more general review paper but also separate papers for each technique.

Returning to Mr. Boyce's comments in detail, he is of course absolutely correct in considering separate faults on fan-in/fan-out lines—a point I made in the footnote to col. 3 p.326.

I believe also that Mr. Boyce has confused 'multi-flow testing procedures' (defined on p.326) with the formation of the G_L matrix. The theoretical maximum for this matrix is, as stated, 8×136. This is given by $\binom{n+1}{2}$* and although some reduction based on indistinguishable fault sets can be effected, it is inconceivable that this would reduce to the same size as the G_D matrix. What Mr. Boyce has in fact done, is to create a partition based on the F and G_D matrices, i.e. he has combined the two techniques of fault matrix and partitioning to derive a detection test set in a similar manner to that indicated by me in Part II (compare the form of his Fig. 2 with my Fig. 11).

The times quoted by Mr. Boyce for deriving the test set using CLOIS are interesting. The approach at Southampton University is based primarily on the Boolean Difference technique and for the circuit in the article the programme takes 11 seconds to accept a topological description, derive the Boolean expression and then proceed to manipulate this to eventually generate a detection test set. This is using the University's ICL 1907 computer.

One final point. The equation in col. 1, p.327 should read:

$$t_i f_j + t_j f_k = 1$$

R. G. BENNETTS.

*This is an alternate form (used by Kautz incidentally) for $n+1C2$ and unfortunately, the printer thought I had omitted the dividing line.

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 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.

A. R. BIDWELL,
West Molesey,
Surrey.

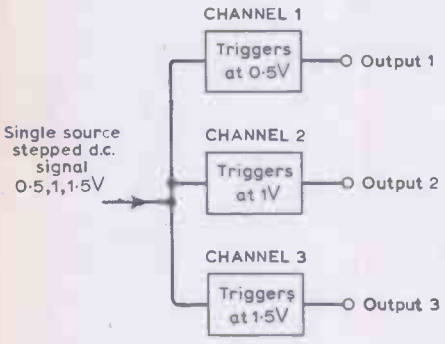


Fig. 1

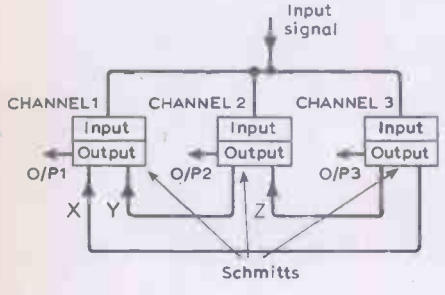


Fig. 2

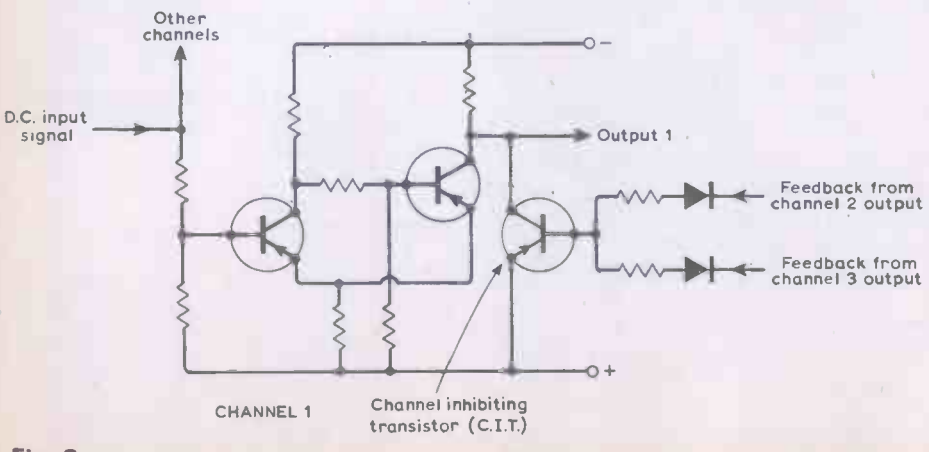
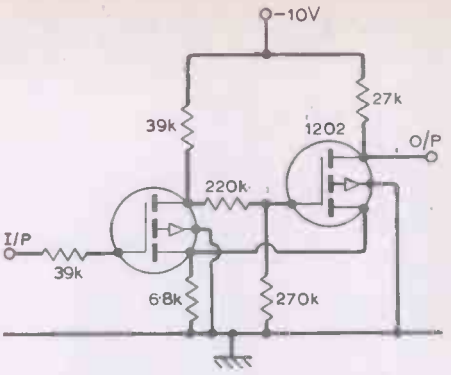


Fig. 3

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.

J. A. ROBERTS,
J. DRISCOLL,
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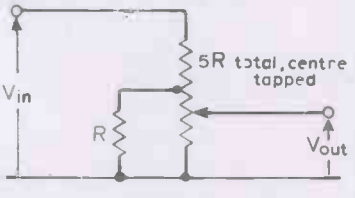
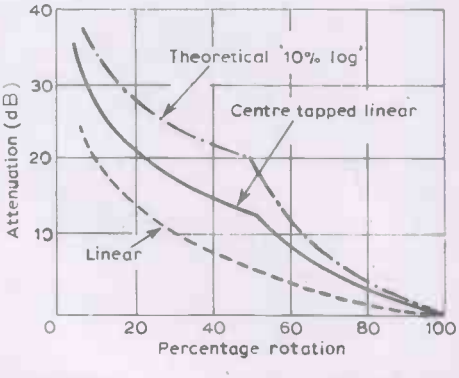
Essex.

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.

Frequencies for Space Communication

World radio conference in Geneva

*by D. E. Baptiste**

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 Gunnar 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 should influence their thinking. This was not a one-way process. As the conference progressed there was inter-action 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 space-to-earth direction, and one 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 a European satellite 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.

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 1,500MHz 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. In addition frequencies were allocated for space-to-space links, (over 50GHz) on the space side of the atmospheric fence, away from these

*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 space research 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, 7.5MHz 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 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 i.cs which are now available. However, it is evident that an i.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 i.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 i.cs 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-Ford) 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 i.cs (such as the μA703 and MC1550) for domestic receivers, but were unsuccessful because they were too costly.

Next, industry turned to developing special i.cs 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. (A full description of the CA3075/6 and their applications can be found in 'High-performance integrated circuits for high-gain f.m.-i.f. systems' by R. T. Peterson in *I.E.E.E. Transactions on Broadcast and Television Receivers,* Nov., 1970, Vol. BTR-16, No. 4 pp 257-263.)

Another interesting development that pointed the way to current practice was the Fairchild set of i.cs 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

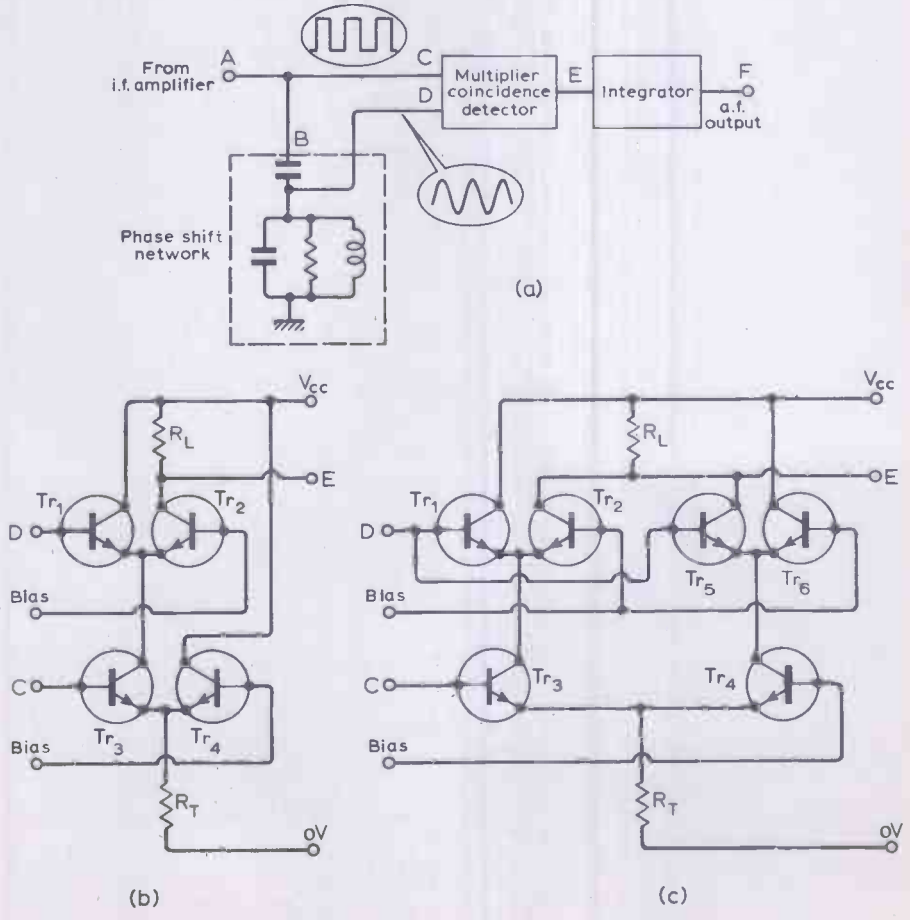


Fig. 1. Coincidence (quadrature) f.m. detector system suited to i.cs in f.m. receivers; (a) simplified block diagram; (b) practical i.c. realization of half-wave detector; (c) full-wave detector.

* Newmarket Transistors Ltd

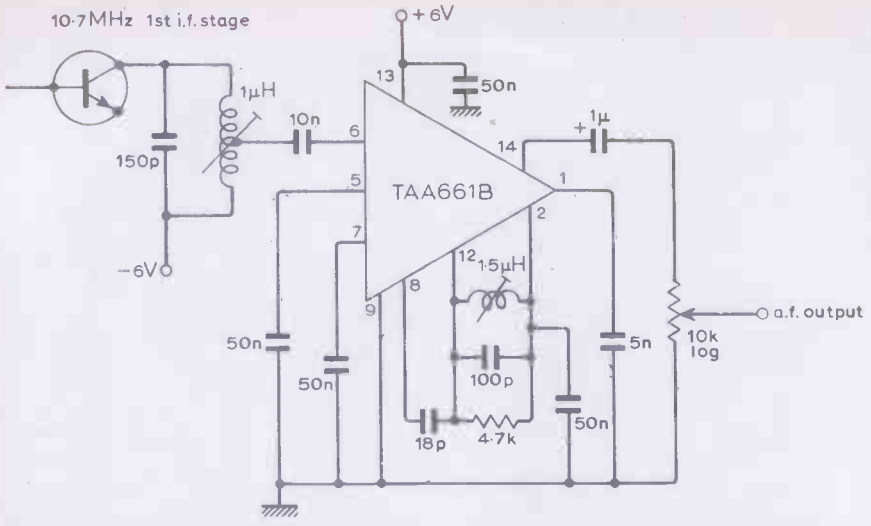


Fig. 2. Typical circuit using the TAA661 f.m. i.f. amplifier and coincidence detector.

multi-purpose l.i.cs introduce new concepts into circuit design' by David Bingham in *I.E.E.E. Transactions on Broadcast and Television Receiver*, July, 1967, Vol. BTR-13, No. 2 pp 108-115.

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 the U.S.A.) and the ratio detector (common in Europe). 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 terminal C of the coincidence multiplier in one direction and it 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 50μs, 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 R_L 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

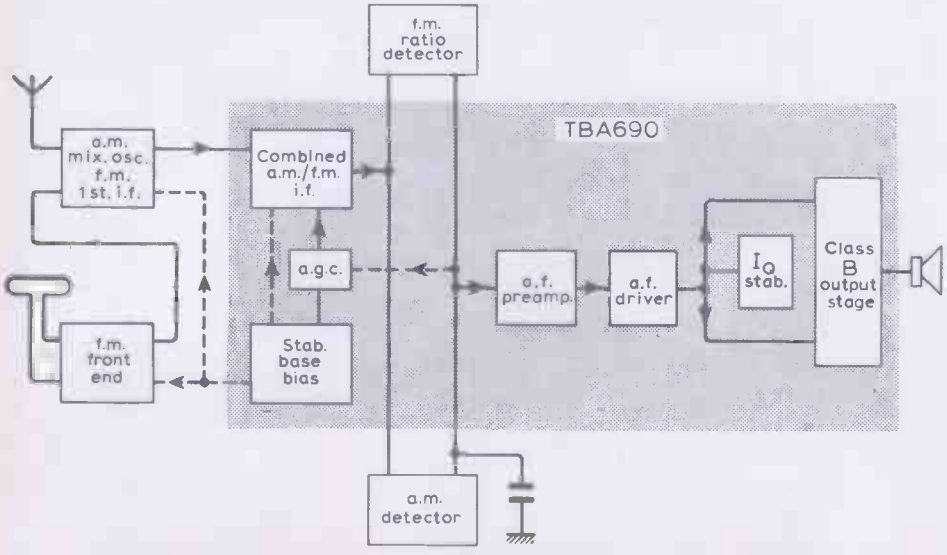


Fig. 3. How the Mullard TBA690 integrated circuit incorporates in a single package all stages of an a.m./f.m. portable 9V receiver except the f.m. front end, the a.m./f.m. input stage and the a.m. and f.m. detectors.

designs. (A companion i.c., the TBA700, can operate from 4.5 to 12V on the rail and at 12V can supply an output of 1.5W into 8 Ω.)

It is not immediately evident from Fig.3 that the TBA690 does not of itself supply the selectivity provided in a discrete-component receiver by the r.f. front end tuned circuits and the fixed-tuned i.f. circuits. In the arrangement of Fig.3, the r.f. selectivity is provided by the separate external input blocks, and the i.f. selectivity is provided by lumped *LC* or ceramic filter circuits between the a.m. mixer oscillator/f.m. first i.f. and the i.c. input. Equally the two detectors call for external tuned *LC* transformers. [A new i.c. has just been announced (CA3089, see Literature Received) which combines the following functions: i.f. amplifier, quadrature detector a.f. pre-amp,. with outputs for a.g.c., a.f.c., muting (squelch) and tuning meter.—Ed.]

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 de-emphasis applied, and fed into three filters which separate the M (mono L + R) signal below 15kHz, the S (stereo L-R) signal from 23-53kHz, 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

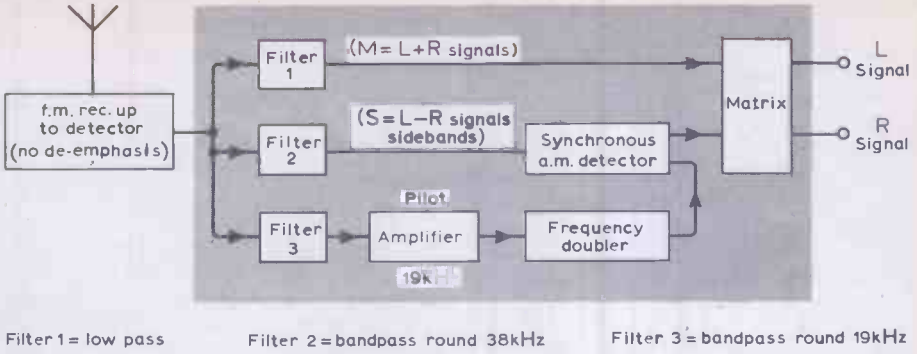


Fig. 4. Stereo decoder integrated circut block diagram of matrix decoder system.

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.cs 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.

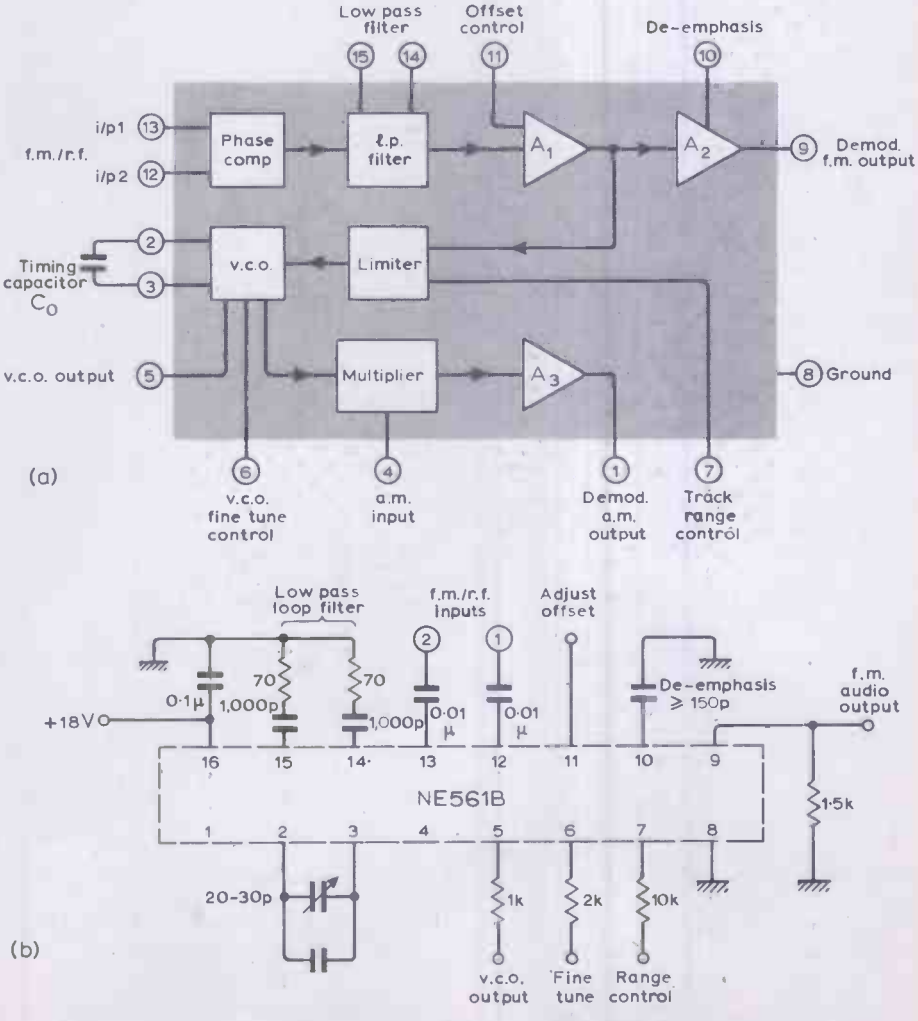


Fig. 5. Phase-locked-loop integrated circuit (Signetics NE561B) enabling complete inductorless substitute for conventional f.m. i.f. strip plus f.m. detector. (a) Internal functional sections of i.c., (b) connection as 10.7MHz a.m./f.m. i.f. strip up to volume control.

The multiplier feeding the amplifier A_3 in Fig.5(a) is an additional a.m. detector that enables the NE561B to be switched to a.m. to provide an a.m./f.m. system. For this the a.m. is fed directly at the broadcast frequency into terminal 4 and the v.c.o. locks onto the carrier; the system providing detected audio output at terminal 1. [In last month's issue an article described a complete p.l.l. stereo decoder on a single chip which is manufactured by RCA.—Ed.]

Digital synthesis

Another approach to eliminating tuned circuits with i.cs is the digital frequency synthesizer, which combines the phase-locked-loop with a master crystal oscillator. Frequency synthesizer circuits have been designed that generate the 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. Stinehelfer and J. Nichols' 'A digital frequency synthesizer for an a.m. and f.m. receiver' in *I.E.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. chips 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-integratable components) and will remove many of the servicing problems found with discrete components or even linear monolithics 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.cs 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.cs 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!

Conferences and Exhibitions

Further details are obtainable from the addresses in parentheses

LONDON

Sept. 1-3 — Imperial College
Artificial Intelligence
(British Computer Soc., 29 Portland Pl., London W1N 4AP)

Sept. 6-10 — City University
Electrical Network Theory
(I.E.E.E. Symposium, c/o The City University, St. John St., London EC1V 4PB)

Sept. 8 & 9 — Savoy Pl., W.C.2
High Voltage Insulation in Vacuum
(Inst. Phys., 47 Belgrave Square, London S.W.1)

Sept. 13-17 — U.S. Trade Center, S.W.1
U.S. Electromechanical & Electronic Components
(U.S. Trade Center, 57 St. James's St, London S.W.1)

Sept. 20-24 — St. Katherine's, E.1
Control and Instrumentation Exhibition
(Control & Instrumentation, 28 Essex St., London W.C.2)

Sept. 28-Oct. 1 — Savoy Pl., W.C.2
Centralized Control Systems
(I.E.E., Savoy Pl., London WC2R OBL)

BRIGHTON

Sept. 7-10 — University of Sussex
Human Locomotor Engineering
(I.Mech.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)

CARDIFF

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

CRANFIELD

Sept. 1-5 — Cranfield Institute of Technology
Business and Light Aviation Show
(ITF-Iliffe 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 Gt. Smith St., London S.W.1)

TEDDINGTON

Sept. 22 & 23 — National Physical Lab.
High Voltage Electron Microscopy
(Inst. Phys., 47 Belgrave Sq., London S.W.1)

OVERSEAS

Sept. 1-3 — Sendai
Antennas and Propagation
(Dr. K. Nagai, Inst. of Electronics and Communication Eng., Kikai-Shinko-Kaikan Bldg., Shiba Park 21-1-5, Minato-ku, Tokyo 105)

Sept. 4-12 — Milan
Radio-TV Show
(Associazione Nazionale Industrie Elettrotecniche ed Elettroniche, Via Donizetti 30, Milan)

Sept. 10-19 — Amsterdam
Firato Electronics Exhibition
(RAI Gebouw N.V., Europaplein 8, Amsterdam)

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

Sept. 19-23 — Chicago
Electrical/Electronics 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 Ruffin 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
Elettronica '71—Conference on Applications of Electronics in Industry
(Elettronica 71, Corso Massimo d'Azeglio 15, 10126 Torino)

The Liniac

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 1·25 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.

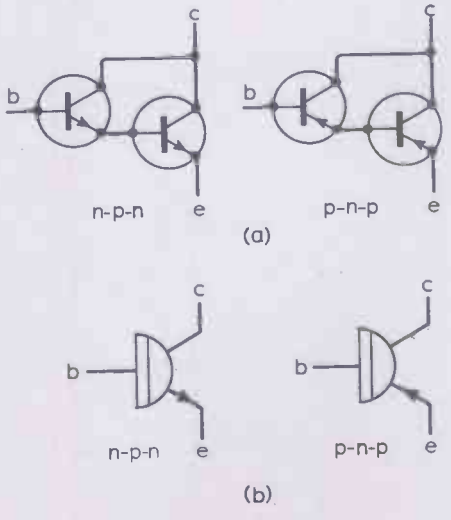


Fig. 1. (a) Darlington transistor arrangements; (b) suggested symbol for monolithic Darlington devices.

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 R_1.

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

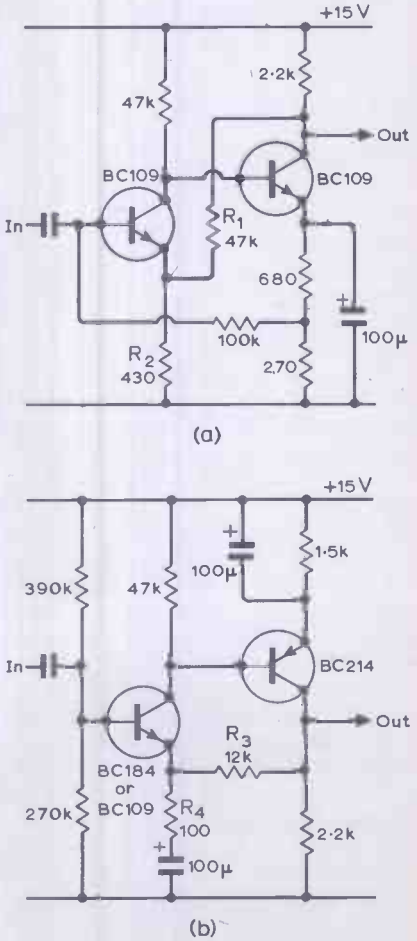


Fig. 2. Feedback stabilized non-phase-inverting transistor pairs. (a) n-p-n/n-p-n feedback pair. Gain depends on R_1, R_2 (as shown $M \approx 100$). Input impedance $\approx 68\ k\Omega$. Open loop gain ≈ 2000. (b) n-p-n/p-n-p pair. Gain depends on R_3, R_4 (as shown $M \approx 100$). Input impedance $\approx 50\ k\Omega$. Open loop gain ≈ 2000.

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.

$$M = \frac{1}{h_{re} - \frac{h_{ie}}{Z_L}\left(\frac{1+h_{oe}.Z_L}{h_{fe}}\right)}$$

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

$$M = \frac{h_{fe}.Z_L}{\Delta h_e.Z_L + h_{ie}}$$

and if Δh_e is sufficiently small, as is mostly the case, this approximates to

$$M \approx \frac{h_{fe}.Z_L}{h_{ie}}$$

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

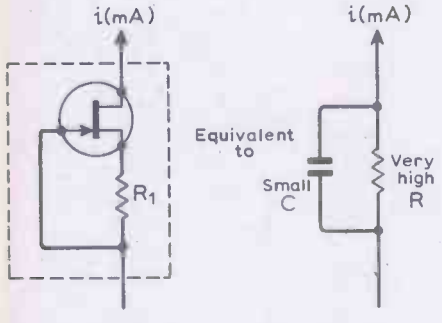


Fig. 3. Constant current load using f.e.t.— i depends on f.e.t. and value of R_1. Dynamic impedance in range 200 kΩ–2 MΩ.

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.ts 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

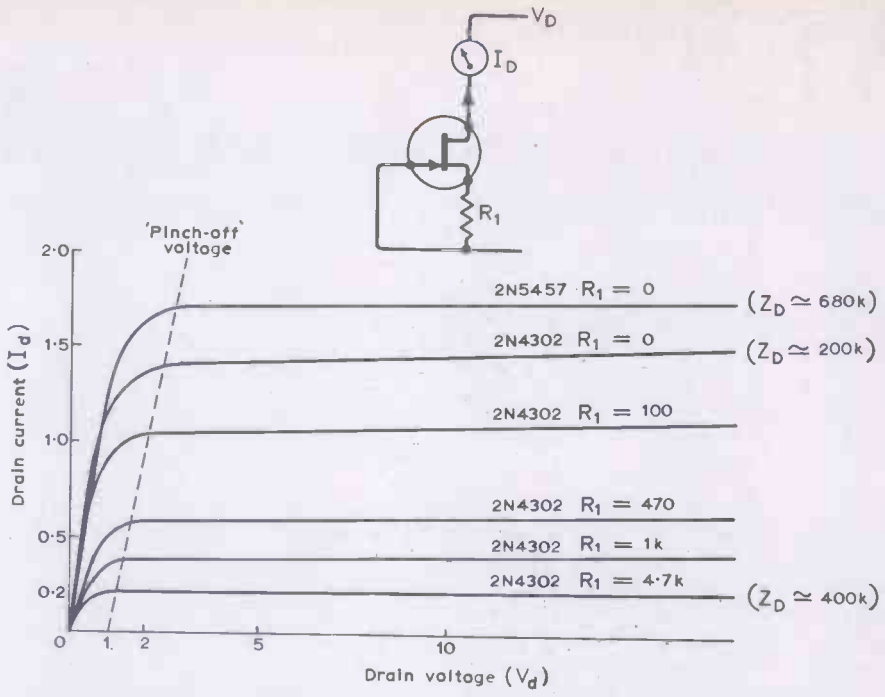


Fig. 4. Drain current characteristics for sharp cut-off f.e.ts.

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 combination is shown in Fig. 5(a), and for convenience as a "shorthand" form in Fig. 5(b). This 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 10–50 μA (at which level the dynamic impedance is extremely high)

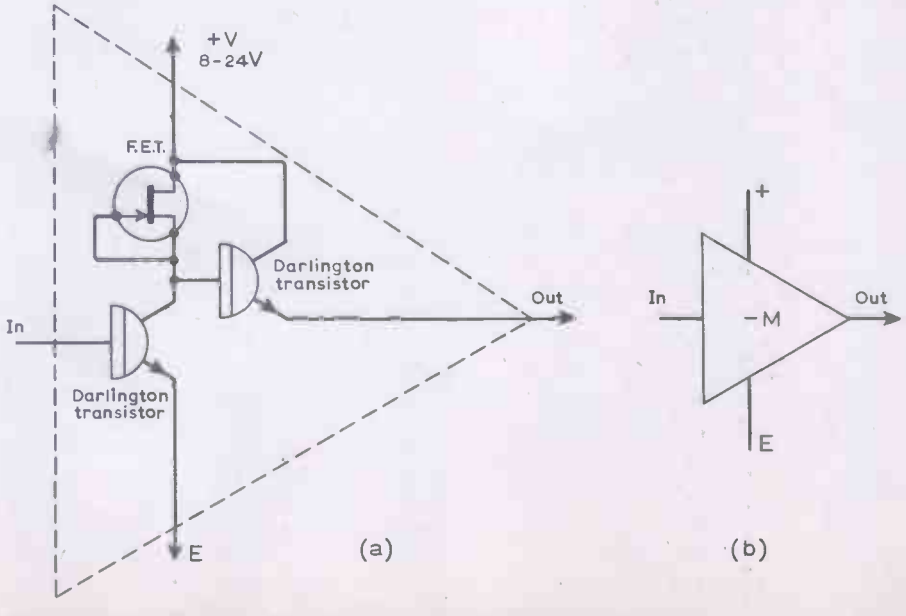


Fig. 5. (a) Basic liniac configuration; (b) symbol proposed for liniac.

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 liniac arrangement can be made with devices of complementary symmetry, with appropriate adjustments to supply polarity, and since the f.e.t. is used as a two-terminal unit either n-channel or p-channel devices can be employed provided that they have suitable I_{DSS} 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 circuit 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_{oe}) 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 normal 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 circuitry. The output-voltage/total-harmonic 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× can be built with less than 0·005% t.h.d. 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× (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 liniac 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.

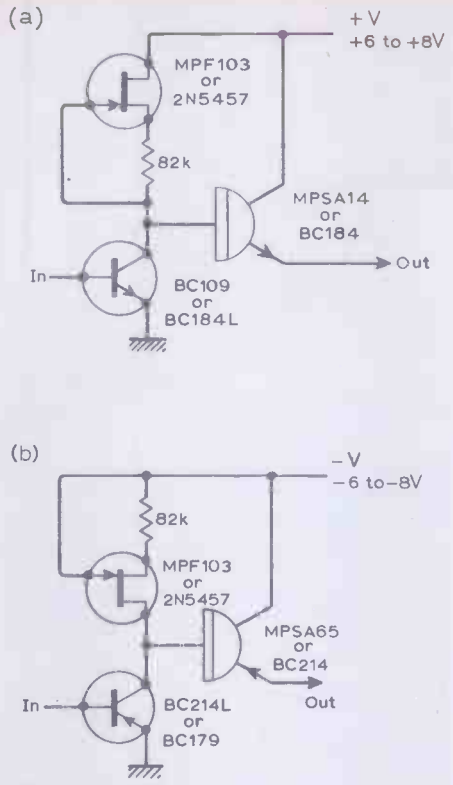


Fig. 6. Very low noise modified liniac arrangements. Gain 2000–4000.

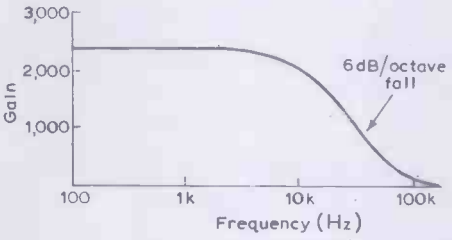


Fig. 7. Typical open-loop gain/frequency characteristics of liniac using Darlington input stage (as circuit of Fig. 9(a)).

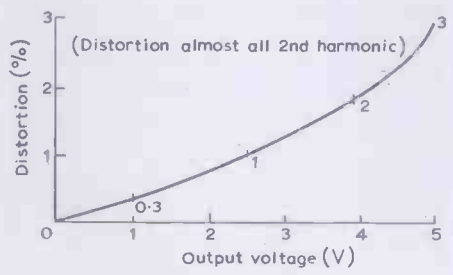


Fig. 8. Output signal voltage/distortion characteristics of liniac stage without negative feedback—Fig. 9(a). $V_c(Tr_1) = 8$ V.

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 unbypassed 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 transistor amplifier stage is a good constant-current source, and in typical circuit applications the input bias is not derived from the h.t. line 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 characteristics—assisted by externally applied negative feedback—are much better than those of the normal bipolar amplifier circuit.

Supply and output voltages. In typical liniac circuit applications, such as those shown in Fig. 9 *et seq*, closed-loop d.c. negative feedback is employed to stabilize the working voltage levels. This allows precise 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 should operate on the curved portion of its characteristic (*cf.* Fig. 4) the h.t. voltage level should be chosen so that there is at least 3 V across the f.e.t. at the peaks of the signal swing. Since the amplifier transistor should also be biased so that there is a minimum of some 2 V across it at the bottom end of the signal swing, the appropriate voltage levels may be determined simply if the output voltage swing is specified.

For example, if it is desired that the output should be 2 V r.m.s., which is 2·83 V peak, the collector voltage of the amplifier transistor should be at least 2 plus 2·83 V—say 5 V. Similarly the h.t. supply should be 3 V plus 2·83 V above this level—say 11 V. Since the forward base-to-emitter voltage drop of the Darlington transistor is some 0·9 V, the output level corresponding to the desired first transistor collector potential will be 4·1 V, assuming a Darlington device is used as the output emitter follower. If a simple transistor is employed the desired output voltage level will be 4·5 V.

The Darlington transistor used in the first stage will conduct when the base emitter potential exceeds 0·8–0·9 V R_1 and R_3 are chosen to give this—Fig. 9(a). Because of phase shift introduced by the interaction of C_1 and C_2 in this particular circuit, there will be a "hump" in the gain curve at about 10 Hz (with the capacitor values quoted) if the circuit is driven from a low-impedance source. If this is inconvenient it can be removed by a suitable input time 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 imepdance 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.

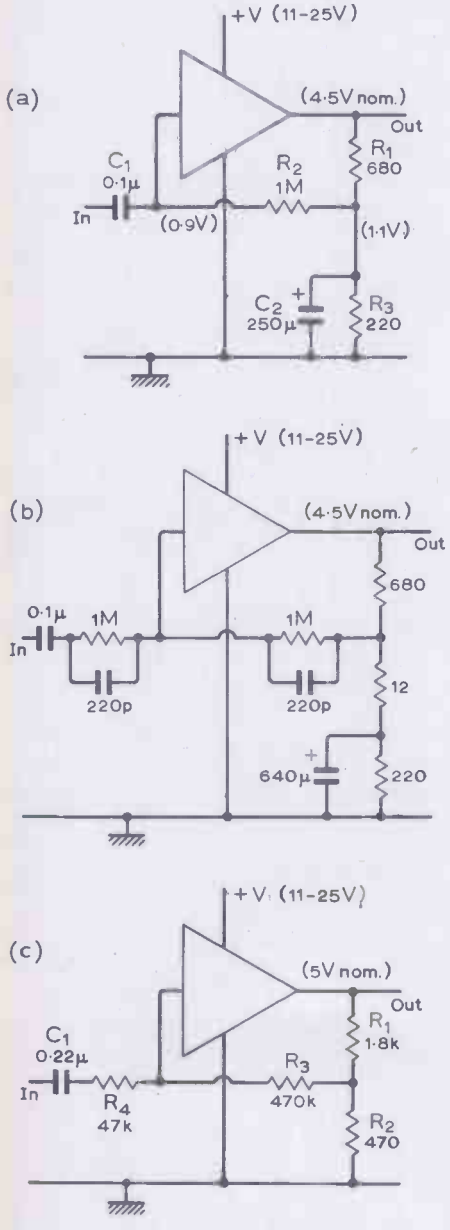


Fig. 9. (a) Typical high-gain liniac amplifier stage V_{out} = 2 V r.m.s. (max.), Gain ≈ 2500. Input impedance ≈ 100 kΩ. (b) High input impedance liniac arrangement. V_{out} = 2 V r.m.s. (max.). Gain ≈ 50. Input impedance ≈ 1 MΩ (and 120 pF). Bandwidth (−3 dB) 10 Hz–80 kHz. (c) Low distortion liniqc amplifier stage. Gain ≈ 50. T.H.D.< 0·01% at 2 V r.m.s. output (1 kHz).

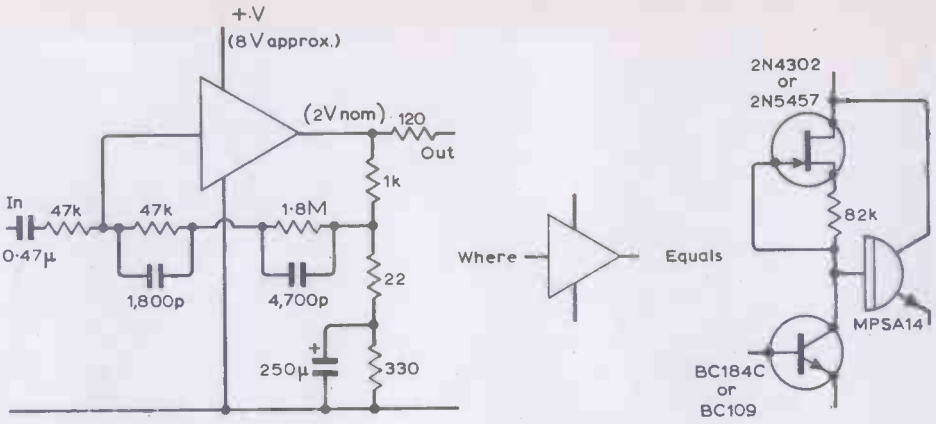


Fig. 10. Very low noise, low-distortion magnetic pickup input equalization stage. Z_{in} = 47 kΩ. Gain = 50 at 1 kHz. T.H.D. <0·01% at 0·5 V r.m.s. output at 1 kHz.

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[1]. 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.

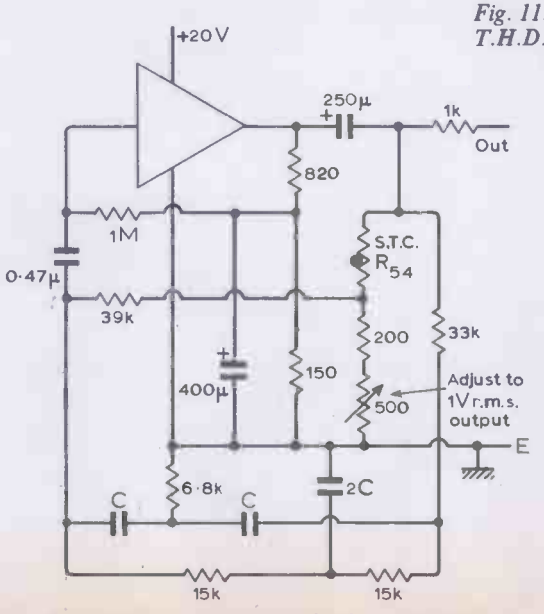


Fig. 11. Very low distortion oscillator. T.H.D. <0·005% at 1 V r.m.s. output.

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. 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.

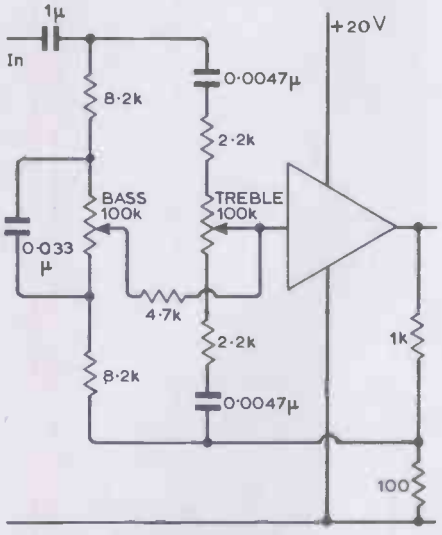


Fig. 12. Liniac employed in tone control stage. Max. output 3 V r.m.s. Source impedance ≤ 10 kΩ. Midpoint gain 10 × ±18 dB lift/cut at 50 Hz and 15 kHz w.r.t. 800 Hz. Worst case t.h.d. < 0·02%.

—bipolar feedback pairs of a form analogous to the excellent circuit arrangements typified by Figs. 1(b) and 1(c), without the overall gain being much reduced by the inevitable mismatch at the drain of the f.e.t. However, if the second transistor is a Darlington device, the mismatch is avoided, and open loop gains of 4000 × are feasible, in the non-inverting mode. The circuit arrangements is shown in Fig. 13. For comparison, the same circuit with a 2N4058 or BC214 as Tr_2 has only a gain of 100.

Improved bipolar feedback pair. The circuit of Fig. 2(b) can itself be improved by the use of a Darlington transistor as Tr_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.

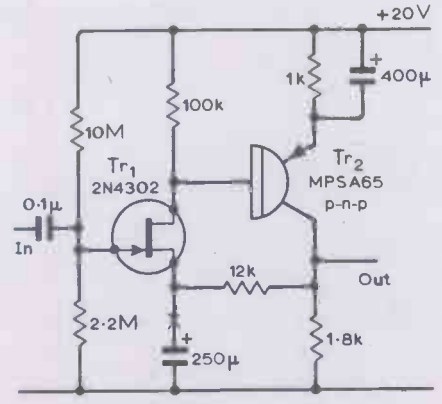


Fig. 13. F.E.T./Darlington pair. High-gain high-input impedance.

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.

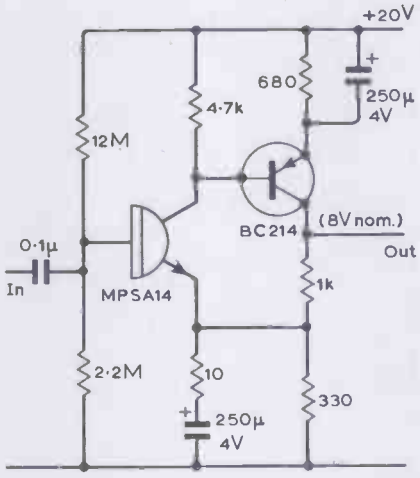


Fig. 14. Improved bipolar transistor feedback pair. $Z_{in} \approx 1{\cdot}5$ MΩ. Gain ≈ 100.

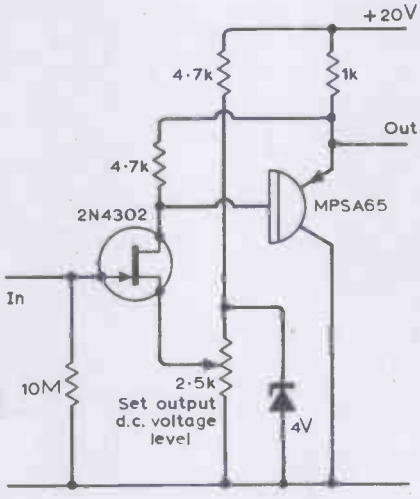


Fig. 15. D.C. bootstrap circuit (phase inverting). Gain ≈ 250.

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.

Reference

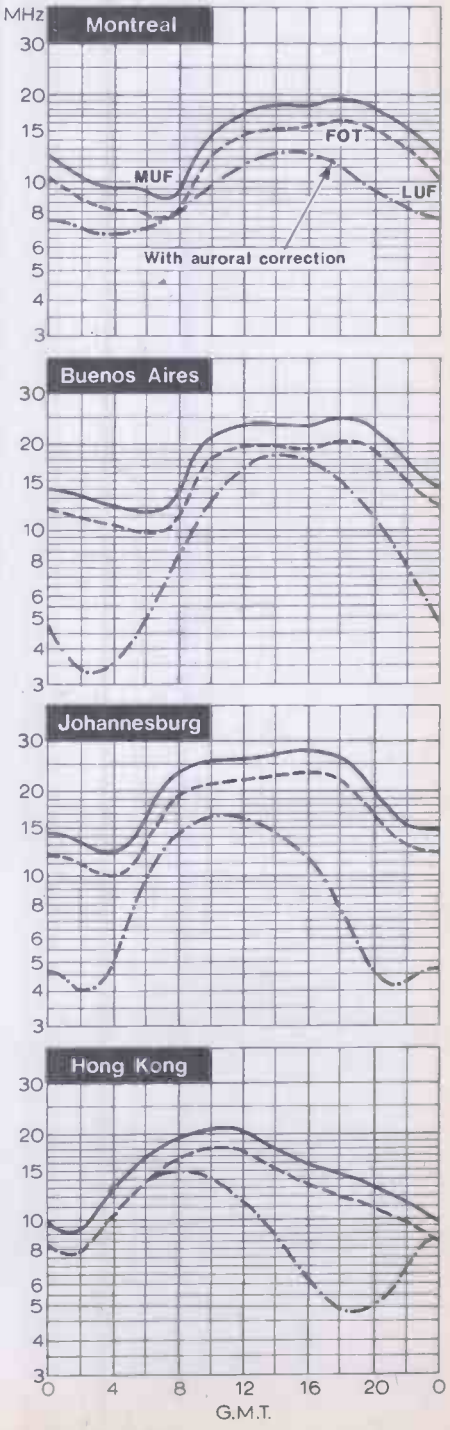
1. Bailey, A. R., *Electronic Technology*, Feb. 1960, pp. 64–67.

H.F. Predictions—September

Solar activity is now steadily declining as this table of Ionospheric Index IF2 shows.

	1966	1969	1971
Jan.	15	95	94
Feb.	21	104	85
Mar.	33	127	83
Apr.	37	122	74
May	46	118	70
June	55	119	(70)
July	55	114	(68)
Aug.	53	122	(65)
Sept.	42	115	(63)
Oct.	47	110	(59)
Nov.	64	106	(57)
Dec.	66	108	(55)

Forecast values are given in brackets. The years 1969 and 1970 were almost identical and constitute the maximum of the current sunspot cycle. A minimum is expected in 1975.



Letter from America

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 a well-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 Radiolympia in London with rows of elaborate stands, TV displays and loudspeakers making a continuous babel of sound. And, of course, each stand had its group of aggressive salesmen 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, in 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 TV sets were to be seen—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 dealer 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 work with which encoder". On the other hand. another dealer 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 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 records 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—especially in fringe areas—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 i.cs but this has not materialized. The main reason is the higher cost involved. No doubt, higher production will bring down prices—but 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 great majority of exhibitors of TV receivers 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 Brownie Wireless, makers of crystal sets and the Wates Company where an Everyman Four was used for testing phono-pickups 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. TILLETT

Sherwood digital read-out f.m. tuner.

* 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 back signals, as well as normal modulation for the front signals.—Ed.

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.ts 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[1] tube.

All three 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 600ns 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

[1]Herold, E. W., 'Methods suitable for TR color kinescopes,' *R.C.A. Review*, Vol. 12, Sept. 1951, p. 445 et seq.

[2]'TV in natural colours demonstrated', *Radio News*, Vol. 10, p. 320, October 1928

[3]Goldmark, P. C., et al., 'Color Television', Part I, *Proc. I.R.E.*, Vol. 30, pp. 162-182, April 1942.

[4]See T. D. Towers on principles of colour TV, Jan.-Dec., 1967, *Wireless World*.

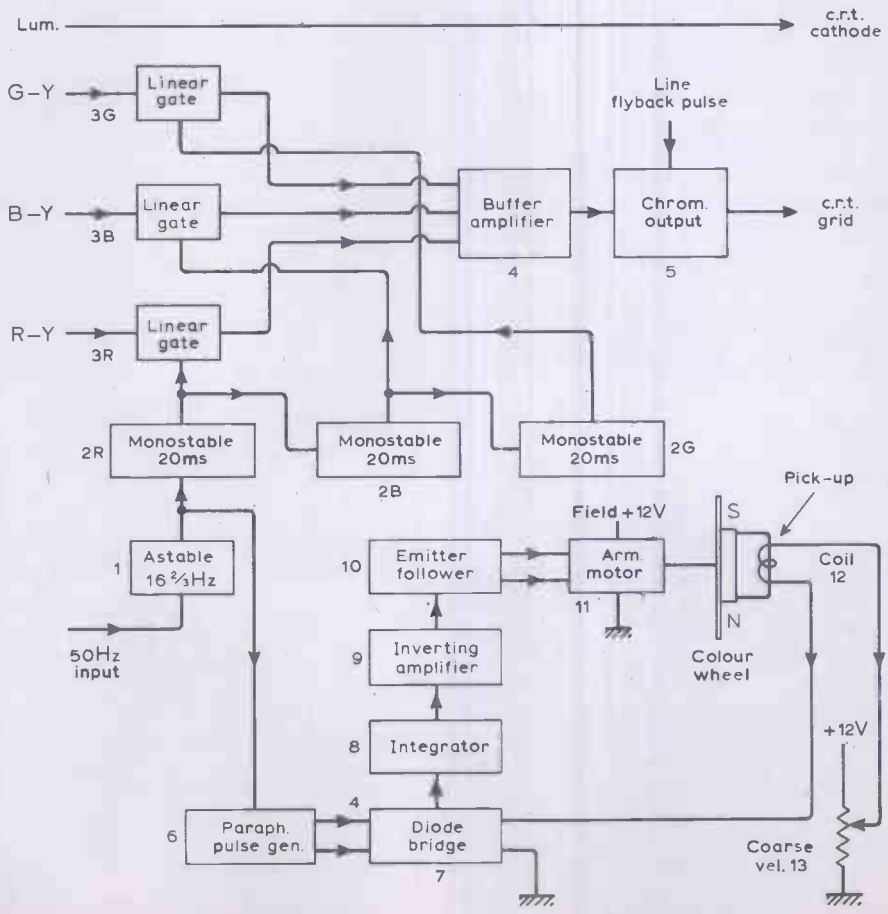


Fig. 1. Block diagram of field-sequential colour receiver equipment. The input is provided by a normal monochrome receiver.

the red, green and blue images of a colour transmission.

A disc carrying sections of primary red, green and blue filters rotates at $16\frac{2}{3}$r.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 d.c. level adjustments, used to drive the motor armature via a 2N3055 emitter follower.

Assuming phase lock, the gating pulse is placed symmetrically about the mid-point 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. Programme switchings, when field sync may be interrupted, tend to upset phase lock, but this effect has not been found troubleseome.

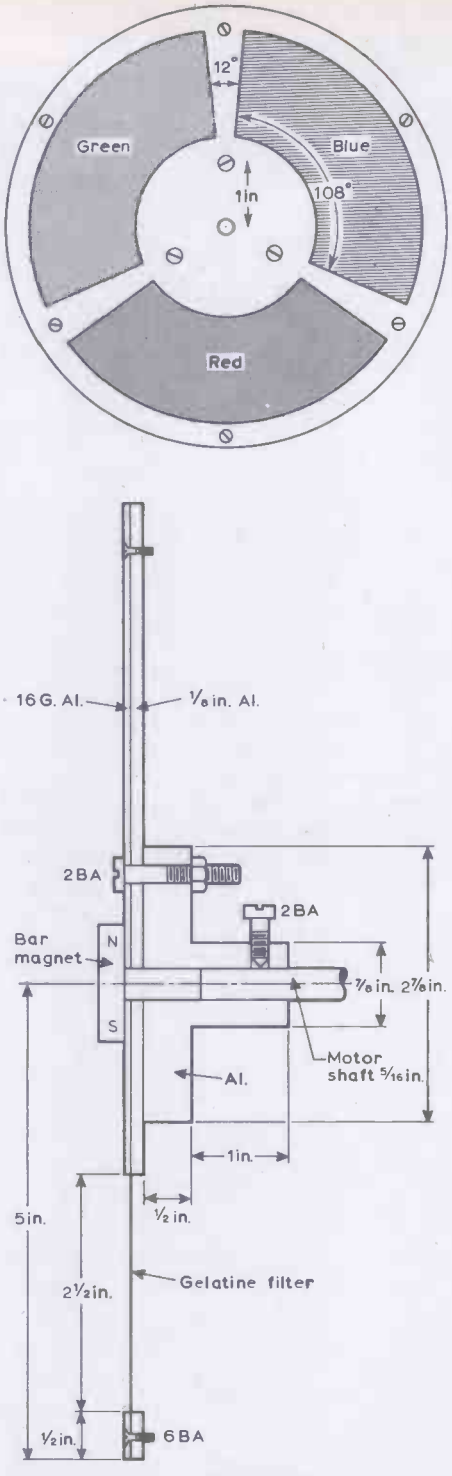


Fig. 2. Front view (a) and section (b) of a simple colour wheel.

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 blue, red and green, 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 then passed through an existing 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 L_6 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 wildy 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 adaption 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 complementaries. 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 $16\frac{2}{3}$Hz and 50Hz, smaller components at 25 and $8\frac{1}{3}$Hz 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 $\frac{1}{8}$in. thick, 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 $\frac{1}{8}$in. disc periphery.

The angular position of the magnet in

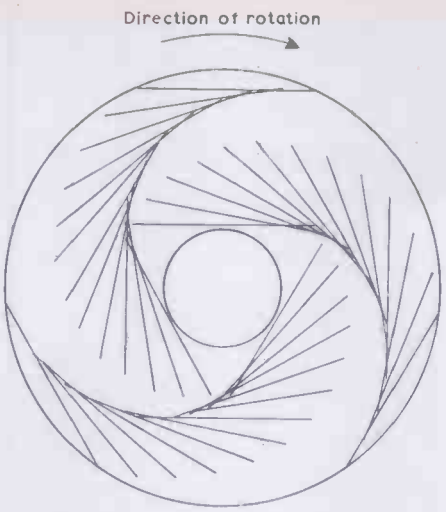


Fig. 3. Spiral colour wheel. The spiral cut-outs are represented by the position of scanning lines seen through the disc at 1/12th field intervals. This figure is drawn for a raster of dimensions 6 × 4.5 units, the central area having a diameter of 4 units.

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.

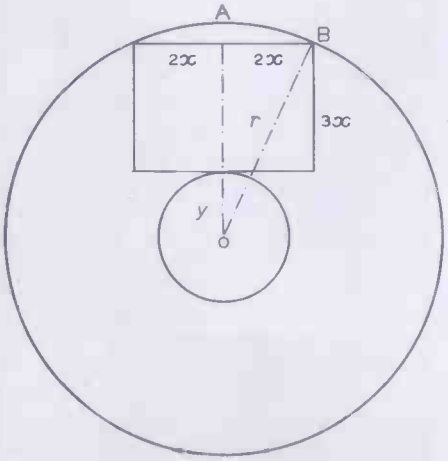


Fig. 4. Disc radius for given raster size. Spiral colour wheel mounted in front of the c.r. tube. Rotation is anticlockwise. The automatic phase-control components are mounted at the rear of the equipment on the colour wheel shaft.

Fig. 3 shows the basic form of the spiral holed wheel, while the calculations for the diameter of it for given raster size are illustrated in Fig. 4.

Let the dimensions of the raster be $4x$ by $3x$, assuming a standard 4:3 aspect ratio. Then in triangle OAB,

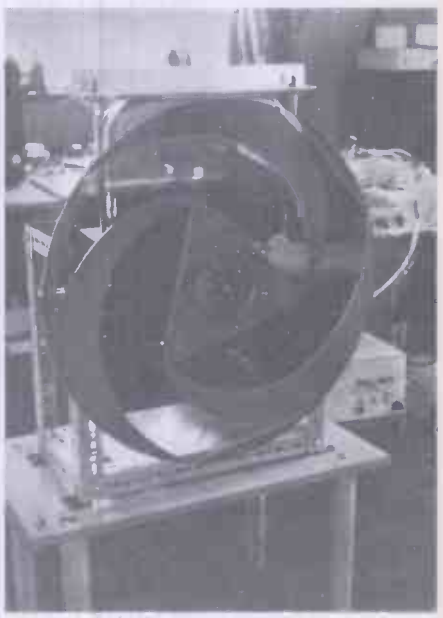
$$OB^2 = r^2$$
$$= AB^2 + AO^2$$
$$= 4x^2 + (3x+y)^2$$
$$= 13x^2 + 6xy + y^2,$$

whence, by taking the square root, r can be determined.

The dimension y is determined by the physical size of the driving motor, and other factors such as mounting arrangements, but a useful rule for a minimum value is to make y = one-third picture width.

The radius required for this type of disc is clearly less than that for the simple wheel first described:

For a simple wheel, radius$^2 = 18.25x^2 + 8xy + y^2$, by similar reasoning to that above, compared with $r^2 = 13x^2 + 6xy + y^2$ for the spiral disc.



Spirally cut colour drum in front of the cathode-ray tube.

Perspex 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 $\frac{1}{8}$th 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 Perspex 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 × 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—say—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.

Synchronizing magnet and pick-up coil.

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 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 to shape, 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)

Voltage Reference Source

Constant-current drive with 0.08% stability

by H. A. Cole, M.I.E.R.E.*

Specially constructed zener diodes having very low temperature coefficients (less than ±0.002%/deg C) are now readily available at moderate cost, and are intended for applications in which a highly stable voltage reference is required. However, unless the operating current of such diodes is maintained within closely defined limits, the advantage of a low temperature coefficient will be lost due to voltage variations occurring across the internal impedance of the diode.

There are many ways in which a constant operating current can be provided for a reference diode but one of the simplest and most effective method is by use of the 'ring-of-two' circuit introduced by Williams in 1966 (references 1). Unfortunately, although this circuit performs extremely well over a wide range of supply voltage variations, its inherent temperature dependence (about −4mV/deg C) makes it unsuitable for use in circuits subjected to wide variations in temperature. The principal cause of its high temperature dependence is variations in V_{be} of the two transistors (typically −2mV/deg C each).

At first sight it might appear feasible to compensate for dV_{be}/dT by selecting zener diodes used in the ring with temperature coefficients identical to those of the transistor V_{be}. Unfortunately, although such an arrangement is not impossible, the difficulty of obtaining a zener diode having the desired voltage *and* temperature coefficient (of the desired sign) is considerable. A better solution is to use zener diodes which have a negligible temperature coefficient and then connect an ordinary forward-biased diode in series with each. An arrangement like this lends itself readily to the use of a dual transistor with matching V_{be}, as the base-emitter junction of one transistor can be used as the compensation diode for variations in V_{be} of the other transistor. Unfortunately, because of unequal currents in the two junctions, complete compensation cannot be expected. A circuit based on this arrangement, but using transistors with unmatched base-emitter voltages, is now described.

A high-stability reference diode–D_3–is supplied with a constant current of 7.5mA by the remainder of the circuit connected to operate as a ring-of-two, each half providing 3.75mA (Fig. 1). The reference voltage for each half of the ring is formed from the series connection of a zener diode having a very low temperature coefficient (typically +0.5mV/deg C at 3.75mA), and the base-emitter junction of a transistor operated as a forward-biased diode. The overall temperature coefficient of each series connection is about −1.5mV/deg C and provides reasonable temperature compensation for variations in V_{be} of the transistor which it supplies. In Fig. 1, therefore, the zener voltage of D_1, plus the V_{be} drop of Tr_{2b} forms a temperature-compensated reference voltage for the transistor Tr_{2a}. In a similar way Tr_{1a}

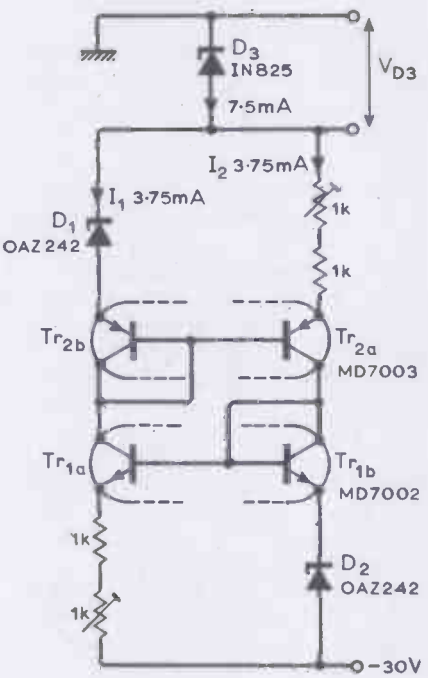


Fig. 1. To compensate for temperature sensitivity in the transistor V_{be} of the ring-of-two voltage reference, dual transistors with matching V_{be} are used. One base-emitter junction is used as the compensation diode for V_{be} variations of the other transistor. From Fig. 2, circuit is required to give 7.5±0.2mA through D_3.

*A.E.R.E., Harwell

is provided with a temperature-compensated reference voltage consisting of the drop across D_2 and the V_{be} drop of Tr_{1b}.

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.

At the recommended operating current of 7.5mA, the temperature coefficient of D_3 (type 1N825) is at its minimum value, as shown by the curves[2] of Fig. 2. When the operating current (I_z) of D_3 is increased to 10mA (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_z 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_z is held constant at any value within ±33⅓% 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

$$\frac{dV_{D3}}{dI_z} \simeq \frac{0.6\%}{2.5\text{mA}} = 0.24\%/\text{mA} \quad (1)$$

referred to I_z=7.5mA.

Comparing the two coefficients, a 26% increase in I_z 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_z 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_z no worse than that of V_{D3} versus

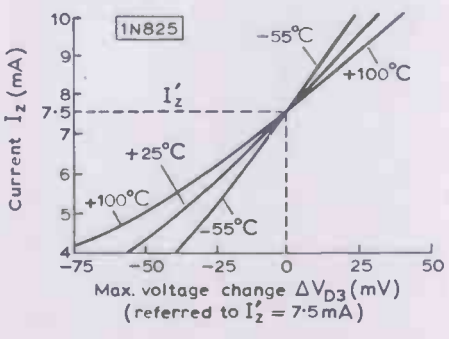


Fig. 2. Because the V_{D3} stability with respect to I_z is worse than with temperature–graph shows three times worse–I_z is restricted to 7.5±0.2mA, for a stability of 0.05%.

temperature, the total variation in I_z 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 × 0.002=0.1%.

If the maximum allowable variation of V_{D3} versus I_z is made 0.5%—half that allowed for the total temperature variation—then from expression (1) I_z must be maintained within ±0.2mA of the recommended value, i.e. I_z must lie within the limits 7.3 to 7.7mA. This, therefore, is the current

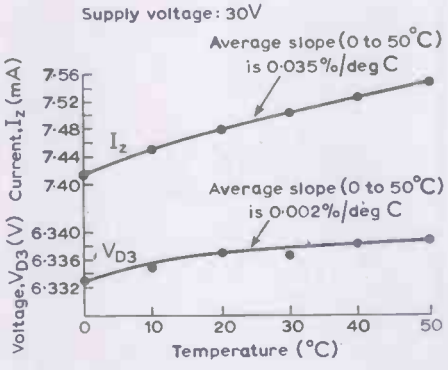


Fig. 3. From these measured temperature stability curves, overall stability is 0.065% referred to the 30°C value.

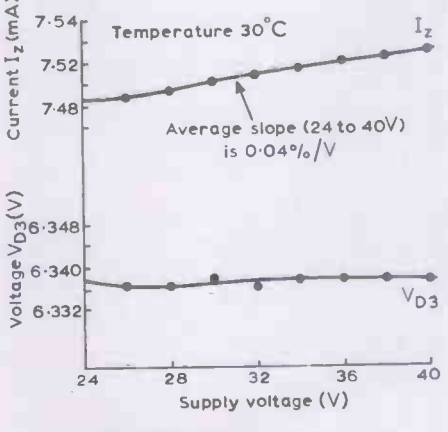


Fig. 4. From these measured voltage stability curves overall stability is 0.016% or 1mV referred to 30V.

stability demanded from the circuit shown in Fig. 1 for an overall stability of V_{D3} of ± 0.15%.

Experimental results

The performance of the circuit shown in Fig. 1 was evaluated by measuring the currents in each half (I_1 and I_2) and V_{D3} for various values of supply voltage (V_S) and temperature. Measurements were made using a five-digit voltmeter.

In the first experiment, I_1 and I_2 were set approximately equal (at 30°C) to 3.75mA (I_z= 7.5mA), with V_S=30V. The temperature was varied from 0 to 50°C with V_S steady. As can be seen from Fig. 3 I_z increases almost linearly with temperature, its average slope over the full temperature range being about 0.035%/deg C. The corresponding slope for V_{D3} is about 0.002%/deg C, its overall stability referred to 30°C value being better than 0.065%.

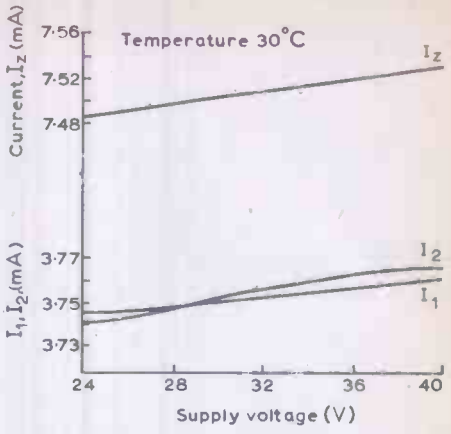


Fig. 5. Relation between currents in the two halves for varying V_S shows very close 'tracking'.

In the second experiment, the temperature was held steady at 30°C and V_S varied over the range 24 to 40V ($I_1 = I_2 = 3.75$mA at V_S=30V). In Fig. 4 the I_z curve has a positive coefficient of about 0.04%/V. The curve for V_{D3} has an overall stability (referred to the 30-V value) of better than 1mV i.e., 0.016%, and within the resolving capability of the voltmeter, this corresponds to a voltage coefficient of less than 0.001%/V.

The relationship between I_1, I_2 and I_z, for variations of V_S, is shown in Fig. 5. Currents I_1 and I_2 track very closely at all points and make almost identical contributions to the total current I_z.

Conclusion

The circuit shown in Fig. 1, when operated at temperatures between 0 and 50°C, and with supply voltages between 24 and 40V, produces a reference voltage which has an overall stability of better than 0.08%.

It is expected that even better results would have been obtained if the dual transistors used in Fig. 1 had matching base-emitter voltages.

References

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G. N. E. Pasch, 'Constant-current circuits' (letter). *Wireless World*, May 1967, p.228.
P. Williams, 'Ring-of-two reference'. *Wireless World*, July 1967, p.318-22.
2. Motorola Ltd, 'Temperature-compensated reference diodes 1N821-9'. Data sheet DS8007.

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 an element which may have one or other of two distinct states. 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

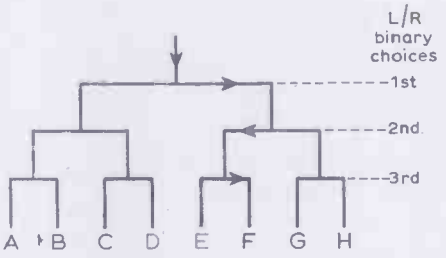


Fig. 1. Showing how one symbol may be selected from a set of eight by a series of left/right binary choices.

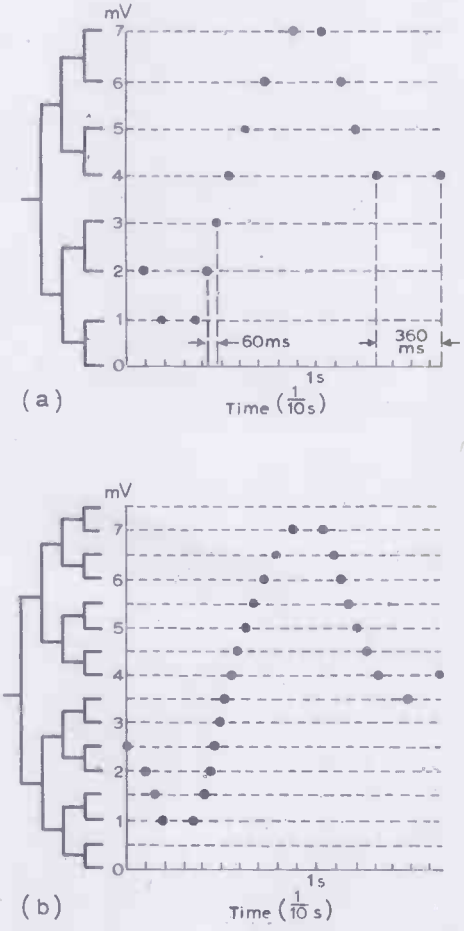


Fig. 2. The binary choice principle of Fig. 1 applied to values in voltage/time graphs, i.e. signals. At (a) the signal is defined by selection from eight levels of voltage; at (b) by selection from 16 levels.

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 $= \log_2 N$, 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 in 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.

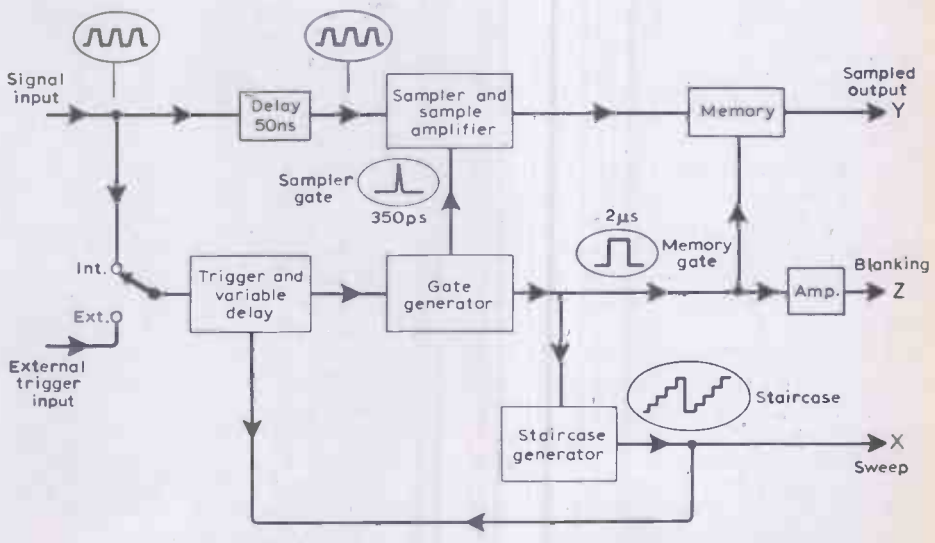


Fig. 1. A typical oscilloscope sampling system.

* G. & E. Bradley Ltd.

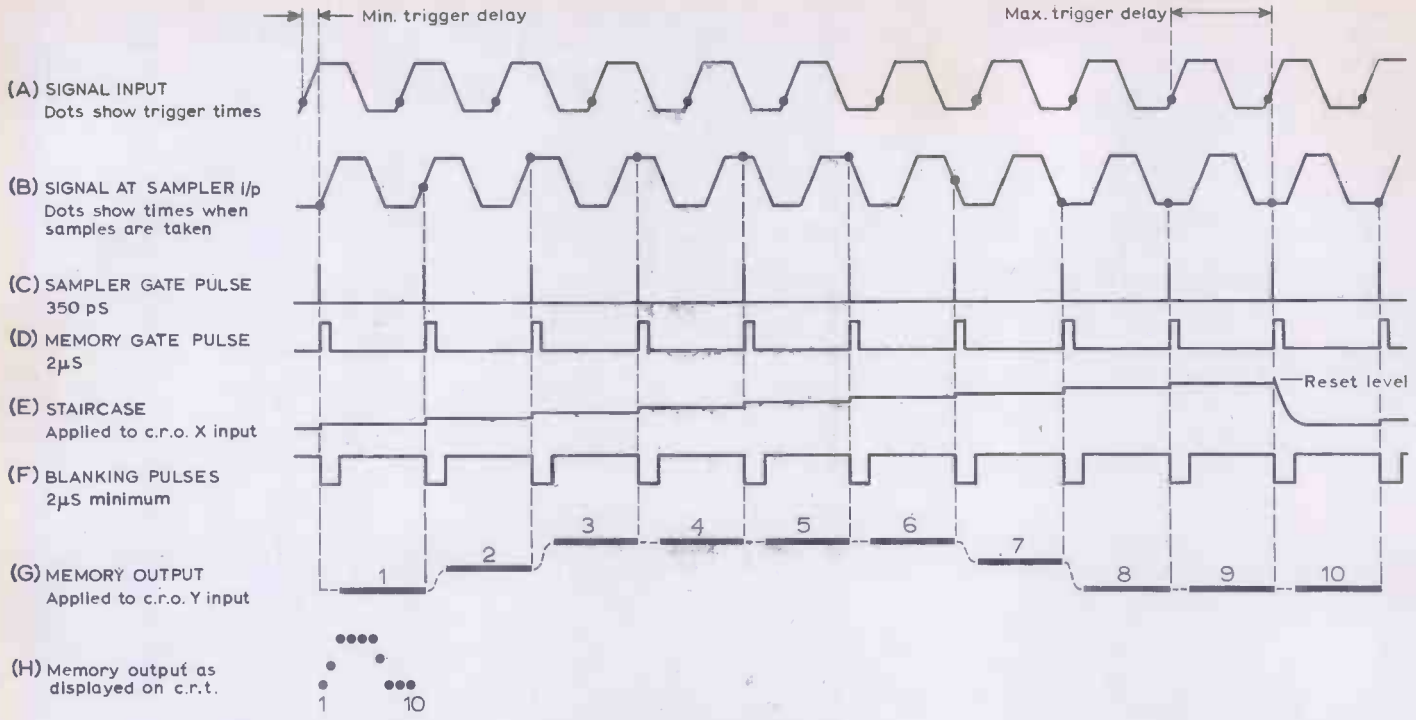


Fig. 2. How one cycle of the input signal is reproduced in a sampling system.

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 30μs. 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 30μs 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 32ms. For input signals with periods greater than 32.35μs (frequencies below approximately 30kHz), 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 extends 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 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.

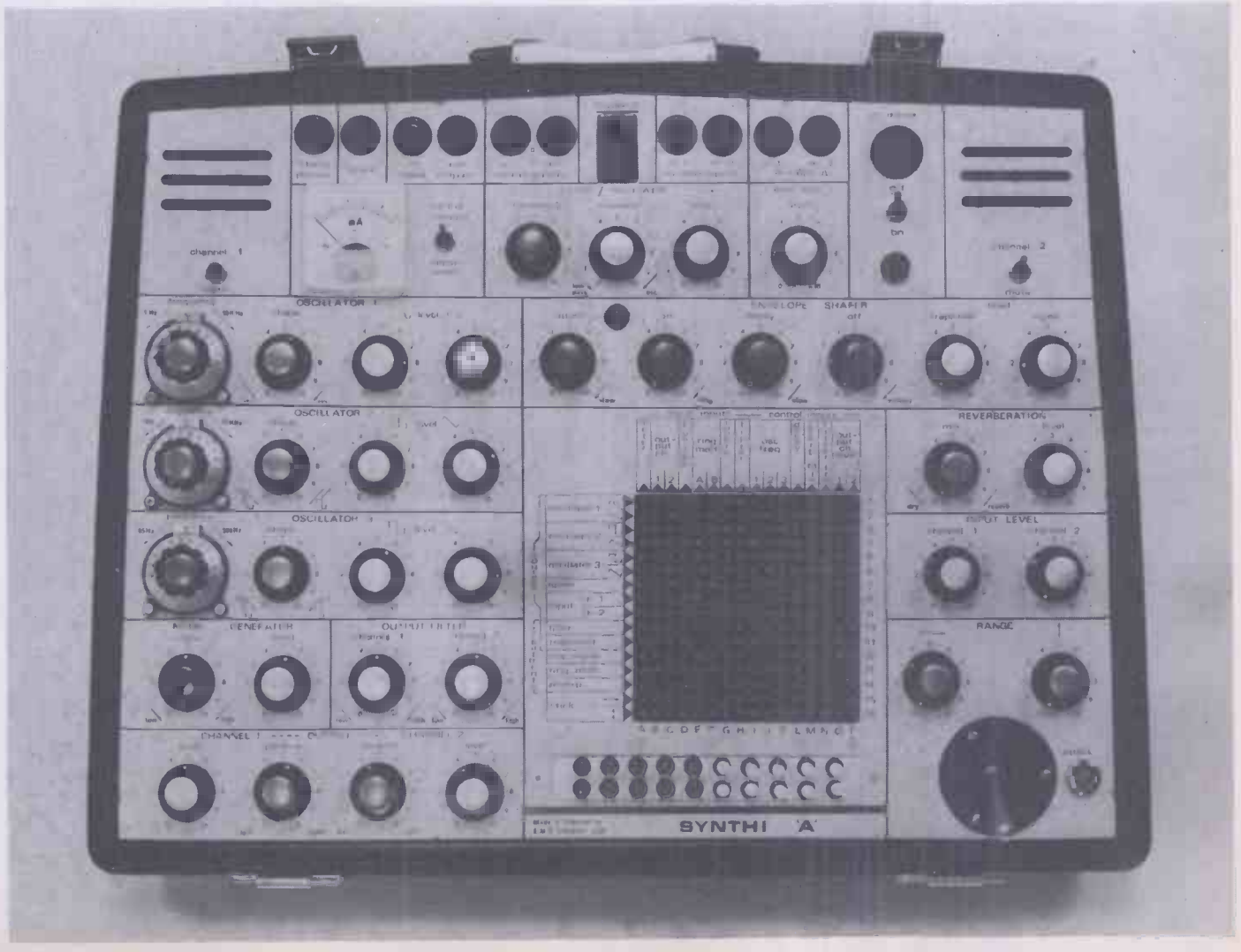
Sound Synthesizers

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 Deodar 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 duration 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 supply spool, has no linear relationship to recording time. A straight line graph is not obtainable even if logarithmic graph paper is available. A graph (curved) can 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

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

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

$$N_T = \frac{R_2-R_1}{T} \text{ and hence } \frac{1}{T} = \frac{N_T}{R_2-R_1} \quad (2)$$

If N_1 turns are supplied from this reel (on the l.h. spool) the radius falls from R_2 to R_2-N_1T, and the length delivered is

$$L_1 = 2\pi \frac{R_2+R_2-N_1T}{2} N_1$$

$$= \pi N_1(2R_2-N_1T) \quad (3)$$

Recorded time is proportional to length so that

$$\text{Time} \propto \frac{2R_2}{T} N_1 - {N_1}^2 \quad (4)$$

and the relationship is of the form

$$y \propto Ax-x^2.$$

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

$$s \propto {x_T}^2-(x_T-x)^2 = 2x_Tx-x^2 \quad (5)$$

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:

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

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

$$x_T = \frac{R_2N_T}{R_2-R_1} \quad (7)$$

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:

$$\text{Time} \propto \frac{2R_2k}{T} {N'}_1 - k^2{N'}_1{}^2 \quad (8)$$

and $x_T = R_2/kT$. But also $N_T = kN'_T$ so that

$$x_T = \frac{2R_2kN'_T}{k(R_2-R_1)} = \frac{R_2N'_T}{R_2-R_1} \quad (9)$$

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

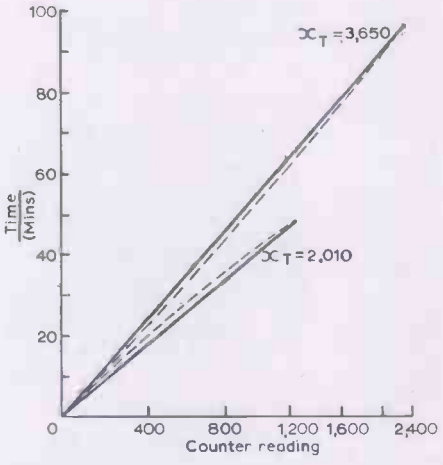
	S.P.	L.P.	D.P.	
5 in.	1450	2010	2880	
$5\frac{3}{4}$ in.	1800	2310	3650	x_T
7 in.	2050	3060	4280	

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

1·00	1·56	2·25	3·06	4·00	etc.
(1^2)	$(1{\cdot}25^2)$	$(1{\cdot}5^2)$	$(1{\cdot}75^2)$	(2^2)	



up to 64·00 (= 8^2) 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 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 $3\frac{3}{4}$ 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/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 $3\frac{3}{4}$ 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, nor 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. Where a specific reel size and tape gauge is always used the graph can be constructed with the correct x_T when full agreement between graph and measured time will be obtained.

*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 multi-cavity 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
Signal processing	vision and audio together (low power) or separate for high powers
Polarization of far electrical field	vertical
Stability of transmitter	better than ± 100Hz per month

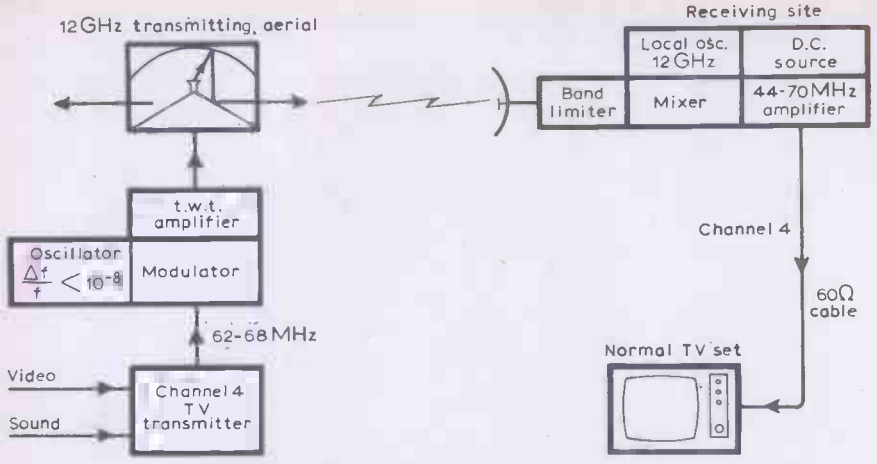
At the receiver the signal is converted into a spare channel in Bands I, III, IV or V. The receiving aerial uses a parabolic reflector which has a gain of 25-35dB for a diameter of 65cm. The side lobe attenuation in the range of ± 10° off the main beam is >20dB and for the remaining range >25dB. Between 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.

Omnidirectional transmitting aerial housed in plastic. Signals are reflected from the 'roof' to the cone and radiated.

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

* *Wireless World*, July 1969 p.325.



Block schematic of 12GHz transmitting and receiving system.

'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 the receiver installation, which demands accurate siting and positioning of the aerial-converter unit. Wind resistance of a solid paraboloid demands a rigid, guyed mast with means of directing 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 rain but the standard of the received picture was of a very high order. We were also given the opportunity of inspecting a mobile field strength van which has a telescopic mounting for the aerial 40 metres high. Also mounted on the top of the mast is a television camera in line with the receiving aerial. Remote control from the interior of the van enables the operator to rotate the mast head and to automatically record the received field strength from the remote transmitter on an X-Y plotter. 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 Zentralamt in Berlin for much of the information given in this article.

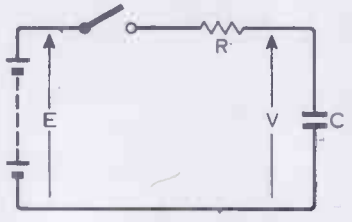
Books Received

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 amplifies without feedback, sensitive chopper-type amplifiers, electrometer amplifies, 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 fundmentals 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 Klapper. 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_5 is a 'select on test' resistor in the range 200-700Ω or a 1kΩ preset adjusted for 16.5V at the emitter of Tr_3. The voltage at the emitter of Tr_5 in Fig.7 is 16.5V. For Fig.7 66dB s/n ratio is referred to 450μV on 200Ω (not 45μV 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 100Ω, the bass control should be a 100kΩ lin. not 10kΩ, and the emitter resistor of Tr_{14} 15kΩ. The residual noise level for Fig.11 is −98dB, not −93dB as quoted in col. 3 p.296. In Fig.13, a 0.22μF 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 V_{BE2}/R_1, not V_{BC2}/R_1 as stated in the text col.2 p.298.

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 MPS1000. They should be MPSA20 (n-p-n) and MPSA70 (p-n-p).

World of Amateur Radio

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 435-438 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 attitude of the C.E.P.T. administrations appears to be in the tradition of earlier I.T.U. conferences and accounts for the serious disadvantages under which amateurs in Region I operate.

In a press interview after the ending of the Conference, Mr. Baptiste is quoted in *The Times* as saying of amateurs: "They provide a laboratory of thousands of enthusiasts all over the world and undoubtedly add to the sum of human knowledge".

The presence at Geneva of amateur advisors—such as Roy Stevens, G2BVN—financed by the national amateur radio societies, undoubtedly helped to reverse some of the adverse recommendations of the working parties.

See 'Frequencies for Space Communication' p.431.

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 (G5ZT and G6ABC/T) of Eggbuckland, near Plymouth. He has had many two-way 'television' exchanges with amateur stations all over the world, including over 100 in the period April to June. Pictures have been exchanged with KL7DRZ (Alaska), VK6ES (Western Australia), KP4GN (Puerto Rico), ZL_1AOY (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.

Slow-scan picture received by H. Jones from the United States (W4LAS).

More long-delay echoes?

Two years ago ('W.o.A.R.' August 1969), we drew attention to the efforts of a team at the Radioscience Laboratory, Stanford University, California, to enlist 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, G3IGW, 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 Trebilock, 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 144MHz 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, GM3OWU, 9 Juniper Avenue, Juniper Green, Midlothian EH14 5AJ).

PAT HAWKER, G3VA

Personalities

Stephen 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 resignation of **G. Brookes.** Dr Forte joined G.I.M. in 1970 as marketing director having previously been with Marconi-Elliott Microelectronics since its formation in 1964 where he held successively the posts of applications engineering manager, manager for custom circuits and, finally, manager of the m.o.s. products division. Dr. Forte spent several years in the Marconi Company R & D Laboratories prior to transferring to M.E.M. Mr. Pace, who holds several of the 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 UK. and E.F.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 London), 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 and the West 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 Redu, 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.

Semicomps Ltd, of Wembley, Middlesex, have appointed **Tony Manning** as sales manager. Mr. Manning was with Mullard for 13 years where he was commercial product manager for discrete semiconductors. Before he joined Mullard, he had five years' experience as a development engineer in guided weapons with G.E.C. at Stanmore.

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 telemetry 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 Branksome, Poole, Dorset, have announced 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 Coutant 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 Coutant. Mr. Chapman (31) also joined Exel in June 1970 from Coutant 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.

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 1958, 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 visited 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.

Bryn Tinton, who joined Ericsson Marine U.K. as technical co-ordinator in March, is in charge of the new training programme for ships' radio officers now being provided by Ericsson Marine, at the Norway Trade Centre in Pall Mall, London. Before joining Ericsson he spent five years with Cunard Brocklebank, latterly as senior radio officer. He has held an amateur radio licence for eight years. His call sign is G3SWC.

K. R. Sturley, Ph.D., B.Sc., F.I.E.E., who has been professor of communications and head of the Electrical Engineering Department of the Ahmadu Bello University, Zaria, Nigeria, for the past three years, is returning to the U.K He has completed his work as chairman of a technical committee of Nigerian telecommunications engineers set up by the Federal Military Government to advise them on the modernization of Nigerian broadcasting. A graduate of Birmingham University Dr. Sturley obtained his doctorate for research in electrothermal storage problems. In 1936 he joined the staff of the Marconi College, Chelmsford, and was assistant principal when he left in 1945 to join the B.B.C. as head of the engineering training department. From 1963 to 1968 he was chief engineer of external broadcasting in the B.BC.

Peter Sinclair, who joined Circaprint Ltd, the printed circuit designers and manufacturers of Maidstone, Kent, last year from Palmer Aero Products Ltd, has been appointed sales manager. Mr. Sinclair, who is 47, was sales manager of the printed circuits division of Palmer Aero Products.

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. Stephen,** B.Sc., F.I.E.E., senior lecturer in the department of electrical and electronic engineering in the Heriot-Watt University, Edinburgh, 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., (asst. lecturer at Kenya Polytechnic) is to be a lecturer in the department of electrical and electronic engineering, and **J. Helszajn,** M.Sc., Ph.D., is to be a part-time senior research fellow in the department.

New Products

H.F. linear amplifier

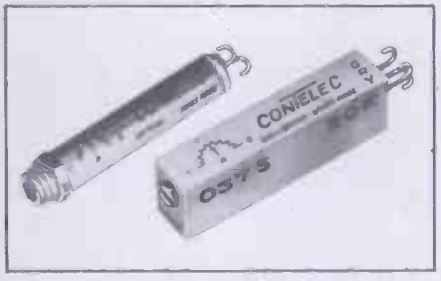
Racal-Mobilcal's TA-940 100-watt h.f. linear amplifier has been designed to increase the power output of low- and medium-power h.f. s.s.b. manpacks. Coverage of the h.f. range of 1.6 to 30MHz is provided and continuous 'key-down' operation is possible to full specification – 100 watts output for entire 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 Basingstock Road, Reading, Berkshire, RG2 0QU.
WW309 for further details

Cassette data recorder

A standard Philips $\frac{1}{8}$in 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 100Hz to 8kHz (a.m.) with a tape speed deviation of ±1% at 4.75cm/s (1.875in/s). Wow and flutter is 0.5% r.m.s., or less, and an 'anti-rolling' tape transport mechanism gives steady tape travel and vibration-resistant operation. The data recorder is not affected by external vibration or dust. Four power sources are available: six dry batteries will provide two hours of recording/playback; an optional rechargeable battery gives four hours of continuous operation; an external 11 to 16V d.c. power source can be connected; and a built-in 220V a.c. −10% supply unit used. A 110 and 115V a.c. supply unit is available if required. The input impedance is 100kΩ (f.m.). An optional input filter can be fitted to improve signal-to-noise ratio. The input signal can be monitored from the check terminal and recorded data can be located using the three-digit built-in tape counter. Size is 100 × 340 × 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 × 9.50 × 31.77mm. Kynmore Engineering Co. Ltd, 19 Buckingham Street, London W.C.2.
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 600 Ω 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

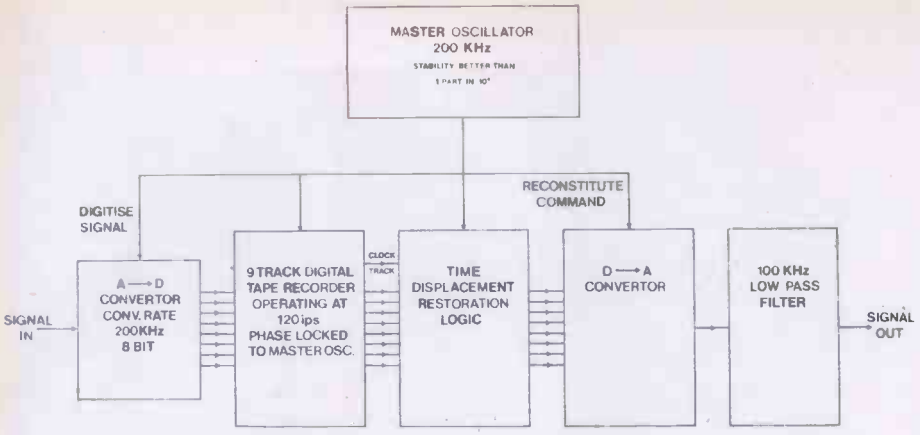
Mains input filters

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-90 kHz. The analogue signal to be recorded is fed into an A-D converter having a sampling rate of 2×10^5 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 i.p.s. A 3200 f.r.p.i. (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



BLOCK DIAGRAM OF SPECIAL PURPOSE RECORDING SYSTEM

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 replayed signals is dependent upon the stability of the master oscillator. Gresham Lion Group Ltd, Twickenham Road, Hanworth, Middx.
WW325 for further details

De-soldering wick

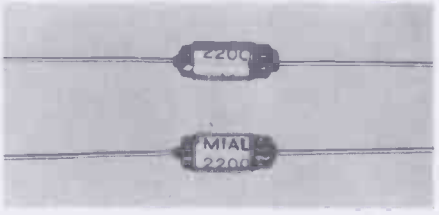
Bradewick de-soldering wick, available from Light Soldering Developments, is impregnated with a flux enabling it to remove molten solder from joints by absorption. It is available in transparent plastic packs in lengths of approximately 1.5m. There are four widths of wick for use with different wattage 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 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 10^9 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



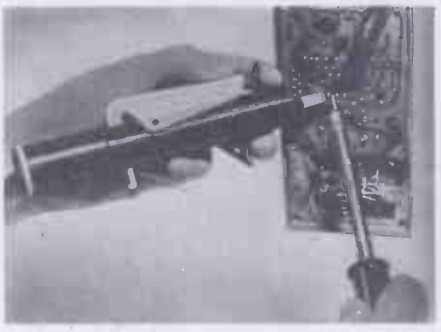
size. The range of values is 20–100,000 pF in tolerances of ±20, 10, 5 and 2.5% and a voltage of 25–630V. Working temperature is from −40 to 85°C. Waycom Ltd, Wokingham Road, Bracknell, Berks.
WW321 for further details

Quartz crystal filters

Salford Electrical Instruments have introduced a wide range of crystal filters to meet the selectivity requirements of British Post Office specifications for marine and land-based h.f. communications systems. At 100kHz, 1.4MHz and 1.6MHz, a single filter can be supplied which meets both transmitter and receiver requirements. Insertion loss is typically 2dB. At 5.2MHz four filters are available to meet either transmitter or receiver specifications, including filtering for A3 (a.m.) and A3H (s.s.b. full carrier) modes. Each of the four filters has a volume of 19cc. The filters operate over the temperature range −10 to +55°C within their overall response specification. Salford Electrical Instruments Ltd, Peel Works, Barton Lane, Eccles, Manchester M30 0H1.
WW327 for further details

De-soldering tool

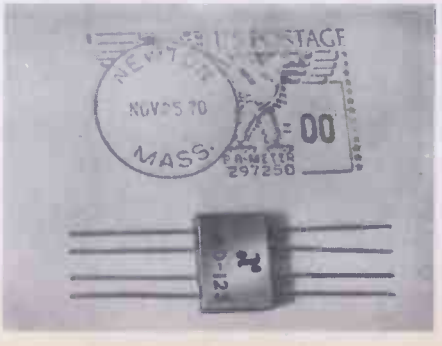
A de-soldering tool, known as the Soldavac, is available from Henri Picard & Frere. Suction in the Soldavac is created by a spring-loaded plunger, contained within the body of the tool. The tool has steadying rests for the fore and middle fingers, and a trigger placed for thumb pressure.



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



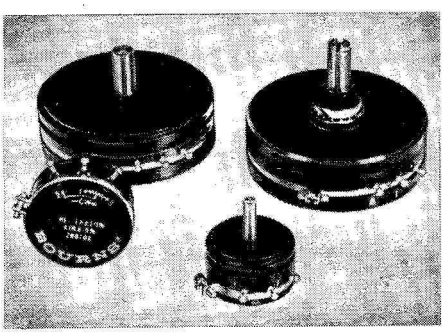
two-tone third-order i.m. ratios of better than 100dB with −30dBm input tones. The full range comprises MD-123 (10-3000MHz), MD-113 (10-1000MHz), MD-125 (0.5-500MHz), and MD-124 (50Hz-200MHz). Wessex Electronics Ltd., Stover Trading Estate, Yate, Bristol BS17 5QP.
WW301 for further details

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 $\frac{7}{8}$in, $1\frac{1}{16}$in and 2in, bushing or servo mount.

Specification:

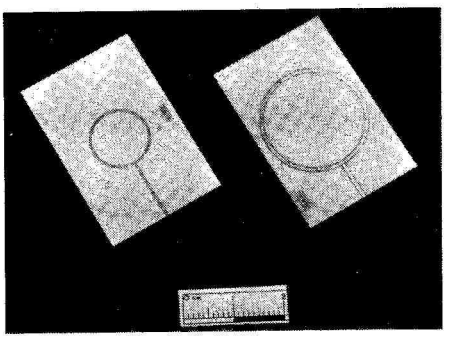
resistance value	20Ω to 100kΩ
tolerance	±10%
power rating at 70°C	1.0W for $\frac{7}{8}$in — 1.25W for $1\frac{1}{16}$in 2.0W for 2in
Max. operating temperature	125°C
output smoothness	0.1% of v.r.
linearity	from ±0.5% to ±0.1%
insulation resistance	1000 MΩ
vibration tolerance	15G
shock tolerance	50G



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 ceramic dielectric 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

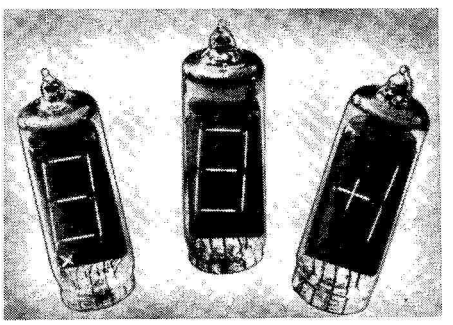
Model CR116 oscillator in the NF Instruments Co. range of test instruments, available in the U.K. from Tekmar Electronics, covers 5Hz—540kHz in five ranges. Frequency response is flat ±0.2dB from 20Hz to 50kHz and distortion down to 0.015% between 200Hz and 10kHz. Output level is +16dB maximum (open circuit), +10dB when feeding 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 incorporates 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 generator. Price £1700. Marconi Instruments Ltd, St. Albans, Herts.
WW317 for further details

Digital indicators

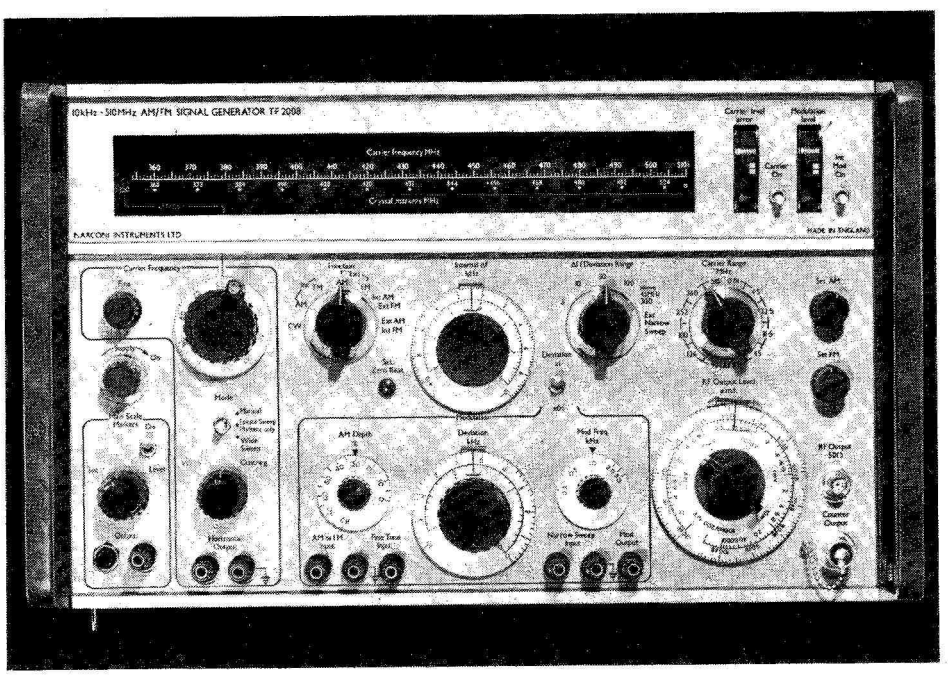
Newtron Indicator Tubes from FR Electronics are 7-segment indicators incorporating directly viewed incandescent filaments allowing viewing angles up to 140°. The units have a normal operating

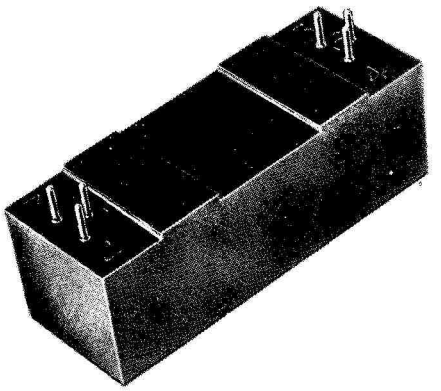


voltage of 5V with a segment current drain of 20mA, and are i.c. compatible. The brightness of the display can be varied to suit all ambient light conditions, permitting viewing even in direct sunlight. FR Electronics, Wimborne, Dorset BH21 2BJ.
WW312 for further details

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-





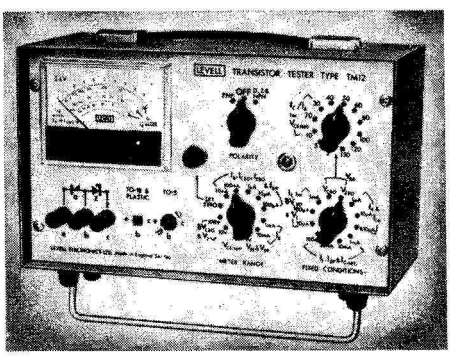
speed switching and alarm type contacts. A built-in magnetic shield prevents interaction between closely stacked relays. The connections are for printed circuit 0.100 matrix and are polarized to prevent wrong assembly. The relay is available in three variants—latching, normally-closed or normally-open. Pye TMC Ltd, Components Division, Roper Road, Canterbury, Kent.
WW322 for further details

Optical position sensor diode

New to the United Detector Technology range of position-sensing Schottky barrier photodiodes is type SC-50 with an active area 1.40 inches square. In common with the other diodes in this series the SC-50 senses the position of a light spot in two dimensions and gives position sensing information independent of the spot size. Resolution and null sensitivity are independent of incident power changes and the null point may be shifted electrically. Position sensitivity is 0.4μA/mW/0.001in at the spectral peak, and non-linearity at 0.05in from the centre is $\pm$1%. Techmation Ltd, 58 Edgware Way, Edgware, Middlesex HA8 8JP.
WW304 for further details

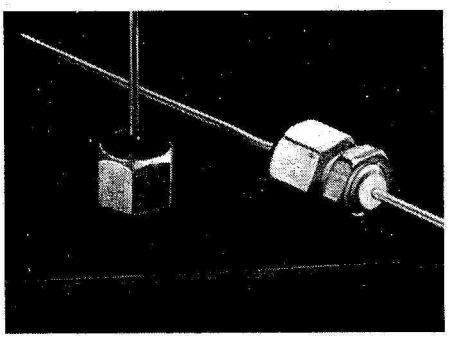
Semiconductor tester

A semiconductor tester from Levell, type TB12, measures the characteristics of bipolar transistors, diodes and zener diodes. Leakage currents down to 0.5nA can be determined from 2V to 150V, current gain of transistors checked at collector currents from 1μA to 100μA, and breakdown voltages up to 100V measured at currents of 10μA, 100μA and 1μA. The collector-to-emitter saturation voltage of a transistor is measured at collector currents of 1, 10, 30 and 100mA for I_C/I_B ratios of 10, 20 and 30. The instrument is powered by a 9V battery and contains a transistor d.c. to d.c. converter to produce 150V. The state of the battery is indicated by a neon panel lamp. Price £65. Levell Electronics Ltd, Park Road, High Barnet, Herts.
WW308 for further details



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.

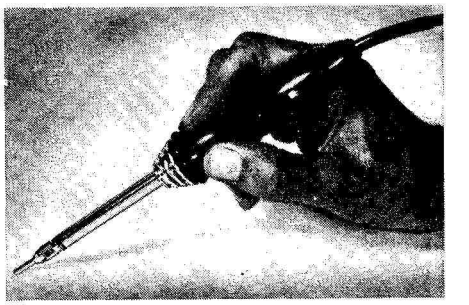
Characteristics:

test voltage	250V d.c.
working voltage	100V d.c.
operating temperature range	-55 to $+125$°C
capacitance	10,000pF $\pm$20% or $+80\%$ -10%

Oxley Developments Co. Ltd, Priory Park, Ulverston, North Lancs.
WW314 for further details

Temperature-controlled soldering iron

The Oryx 50, from W. Greenwood Electronic, gives simple adjustment for any temperature between 200 and 400°C, without changing the tip. Heat settings are accurate to $\pm$2%. Tip temperature variations during soldering are negligible and temperature changes can be made in seconds whilst the iron is on. Oryx 50 operating temperatures can be much lower than with conventional uncontrolled irons. An indicator lamp, controlled by the



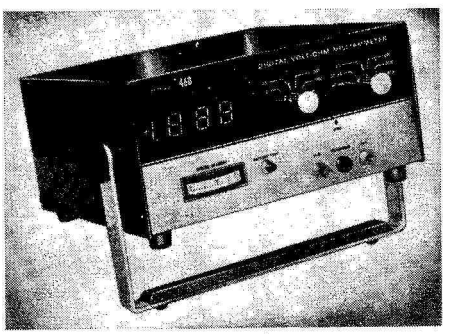
thermostat, is built into the handle. The instrument is fitted with a long iron-coated tip as standard. There is a range of eleven tips in all—long-life or copper/nickel plated to choice. The iron weighs 77 g, is rated at 50W, and heats up in 45 seconds. Operating voltages are 12, 24, 50, 115 or 210/250V a.c. Price with long tip is £3.75. Stand £1.25. W. Greenwood Electronic Ltd, 21 Germain Street, Chesham, Bucks.
WW306 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.	100nA–2A
resistance	190mΩ–20MΩ

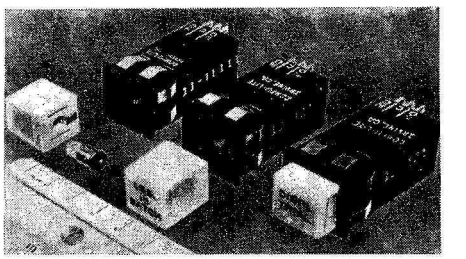
The system is protected against overload.



It weighs 3kg (with batteries) and measures 11 $\times$ 24 $\times$ 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

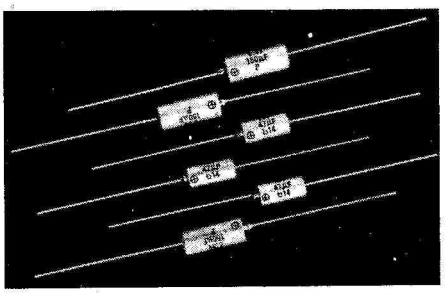


enclosed and sealed and switch up to 5A at 250V. Each switch allows one pole to be switched in before the remaining poles make contact. Gold contacts are available for low-level switching.

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). Capaci-



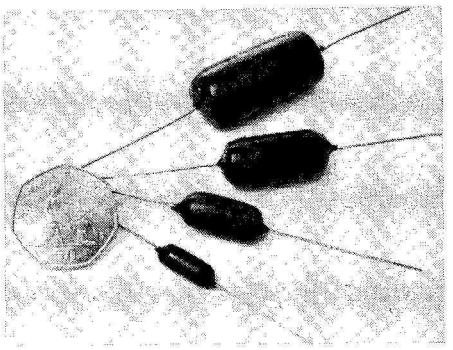
tance tolerance is ± 20% in the range of 0.35 to 330μF, at voltages from 6.3 to 50V d.c. Leakage current is 0.002μA/μFV max., and tan delta is 0.06 max. The 1000-off price ranges from 17p to 72p each, the latter being the cost of a 50V 22μF unit. Seatronics (UK) Ltd, 22-25 Finsbury Square, London EC2A 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 1×10^{-3} ns/MHz, parabolic component, 1×10^{-6}ns/MHz^2; 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

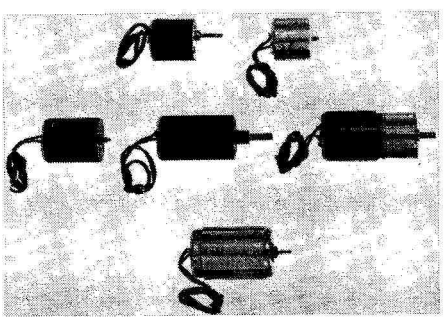
Available in a capacitance range of 1000pF to 1μF, new ISKRA KMFU high-quality polyester foil capacitors from Guest International are non-inductive



(< 20nH). They can be used at high frequencies and with pulse waveforms. Insulation resistance is very high (> 30,000MΩ at 20°C, 100V d.c.) allowing safe use at high temperatures. Ex-stock voltage range is 125, 250, 400, 630 and 1000V d.c. A 1500V d.c. capacitor is available to order. Guest International Ltd, Nicholas House, Brigstock Road, Thornton Heath, Surrey.
WW330 for further details

Miniature d.c. motors

The Escap 20 series ironless rotor d.c. motors from Portescap employ self-supporting skew windings, to provide low inertias 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



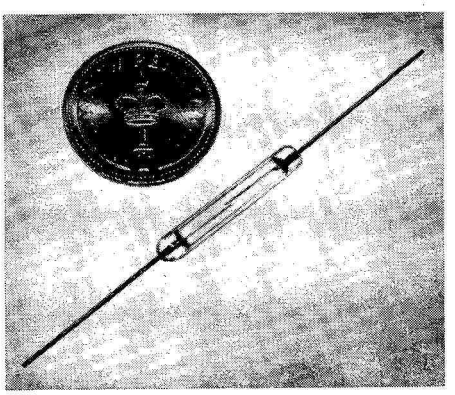
0.15 to 3.1W, starting torques from 6 to 132gcm, and no-load speeds up to 17,300 r.p.m. They measure between 20 and 33mm long by 20mm in diameter, and weigh only 20-65g. Portescap (U.K.) Ltd, 204 Elgar Road, Reading RG2 0DD.
WW 328 for further details

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-1V at 300Ω and 10mV at 1kΩ. Frequency selective type TF003 gives a voltage gain of 1000 over 100Hz to 1MHz with input and output impedances of less than 1kΩ and greater than 100Ω respectively. Gain bandwidth is 15%. Size 36 × 36 × 10mm. Redac Software Ltd, Newtown, Tewkesbury, Gloucester, GL20 8HE.
WW303 for further details.

Low thermal e.m.f. reed switch

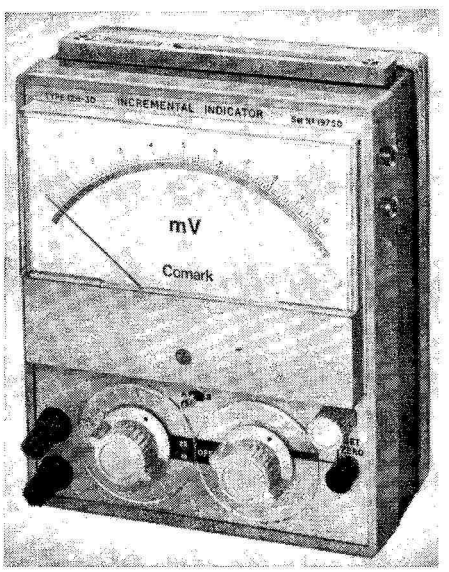
The MRA-230 reed switch from FR Electronics has a thermal junction e.m.f. of 10μV/°C. It is of form A construction (contacts normally open) and its miniature



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

Literature Received

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 Plessey's Swindon factory. Plessey Microelectronics, Cheney Manor, Swindon, Wilts. WW401

MCP Electronics Ltd, Alperton, Wembley, Middlesex, HA0 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.), 2-30MHz, 13dB gain WW403

TA7993. 2W, 2GHz, 8.2dB gain (3W, 1GHz, 12dB) WW404

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

TA7994. 5W, 2GHz, 7dB gain (13.5W, 1GHz, 11dB) WW406

TA7702/3. Microwave broadband i.c., 225-400MHz, 16W, 6dB gain at $V_{cc} = 28$V WW407

TA7747. Integrated circuit power combiner/divider 225-400MHz, powers up to 40W, $Z_{in} = Z_{out} = 50\Omega$

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

PASSIVE COMPONENTS

Toggle, rocker, wafer and slide switches are described in a catalogue from Lorlin Electronic Co. Ltd, Billingshurst, Sussex WW410

Miniature d.c. motors (Escap 26 series) with very low rotor inertia for instrumentation are described in a leaflet from Portescap U.K. Ltd, 204 Elgar Rd, Reading RG2 0DD. Reduction gear-heads with ratios from 1.4:1 to 560:1 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 Lecktrokit range. A leaflet describes the panel and explains the Lecktrokit system of construction; A.P.T. Electronic Industries Ltd, Chertsey Rd, Byfleet, Surrey WW412

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

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

Data sheet R/20. Describes a range of $\frac{1}{8}$ and $\frac{3}{4}$W resistors 2.2Ω to 5.1MΩ ±5% WW414

Data sheet R/21. Carbon composition resistors, $\frac{1}{4}$ and $\frac{1}{2}$W, 10Ω to 22MΩ in ±5, 10 and 20% tolerance 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 1,750mAH WW417

S1000T. Constant current battery charger for up to 20 cells in series, incorporating a timer; charging rate adjustable from 10mA to 1A WW418

A range of relays, called the 'GPR300 series', manufactured by Pye/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, Slinfold 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 circuitry—Part 1'. The nature of the problem is discussed and some general *LC* suppression methods are given WW422

3: 'Harmonics generated by thyristor controlled circuitry—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 (2-30MHz) 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

CA3088E. 'A.M. receiver sub-system and general-purpose array' gives data and circuitry for a new a.m. receiver i.c. WW426

ST4698. 'Advances in f.m. receiver design', describes a new f.m. receiver i.c. which incorporates i.f. stages, detector, a.f.c. output, tuning meter output, a.g.c. output, decoder disable line and facilities for a squelch control WW427

CA3089E. 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 transistors' describes the construction of overlay and interdigitated transistors before giving application information WW430

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

'Gunn diode circuit handbook' is a useful 40-page booklet published by Microwave Associates Ltd, Cradock Rd, Luton, Beds LU4 0JQ WW431

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 cassette 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 Guest International Ltd, Nicholas House, Brigstock Rd, Thornton Heath, Surrey WW433

A new computer, Satellite One, is described in a brochure from Computer Technology Ltd, Eaton Rd, Hemel 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 Feltham Trading Estate, Feltham, Middlesex. One would expect (from the title) a complete survey of the whole field of digital instruments when in fact only SE Labs' equipment is mentioned. However, a useful section on using digital instrumentationis included WW435

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

J Beam Engineering Ltd, Rothersthorpe 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, Norwood Technical College, Knight's Hill, London S.E.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 2BA.

GENERAL INFORMATION

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

Books on radio WW442

Selected books on radio and television . WW443

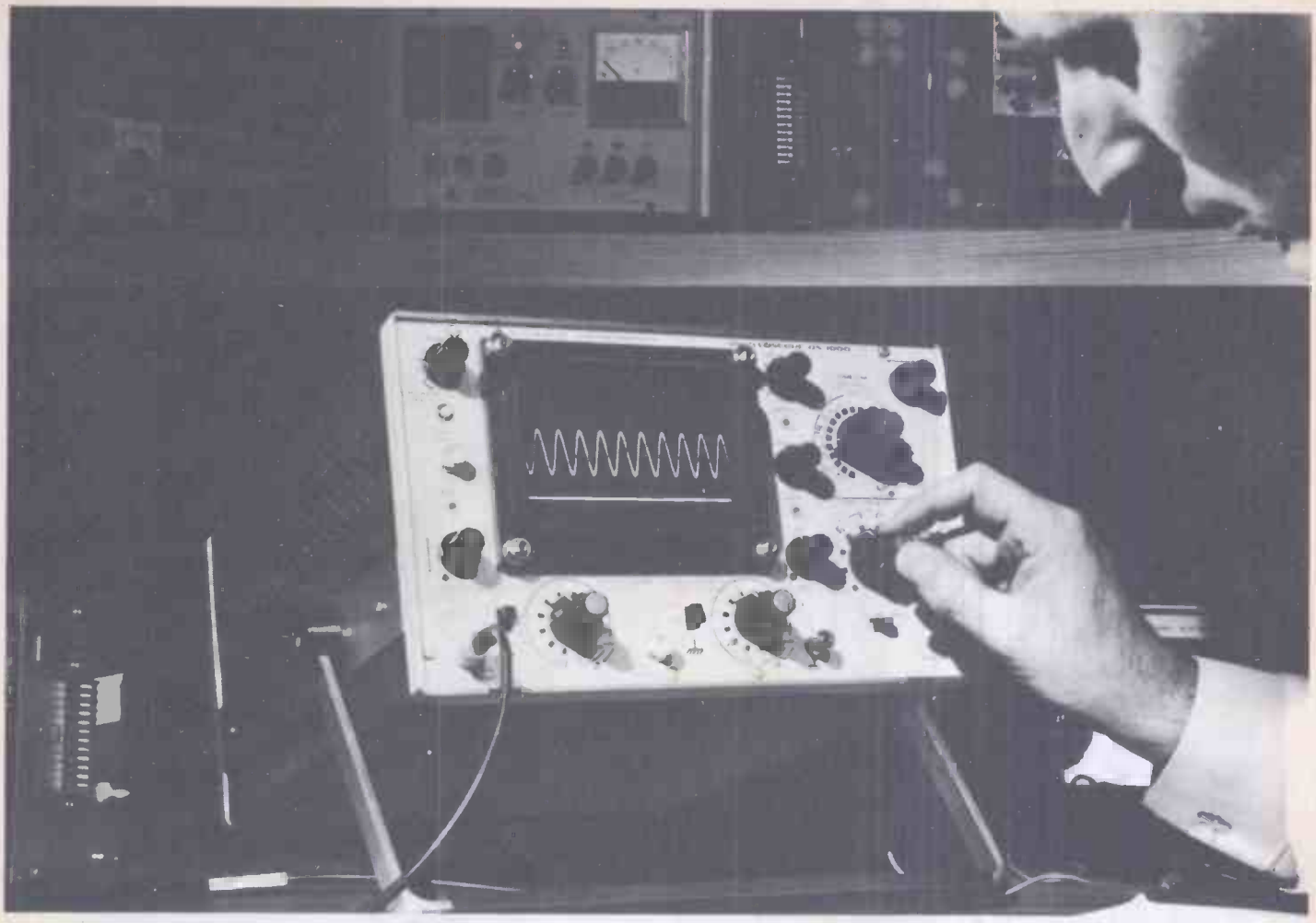
Books on television WW444

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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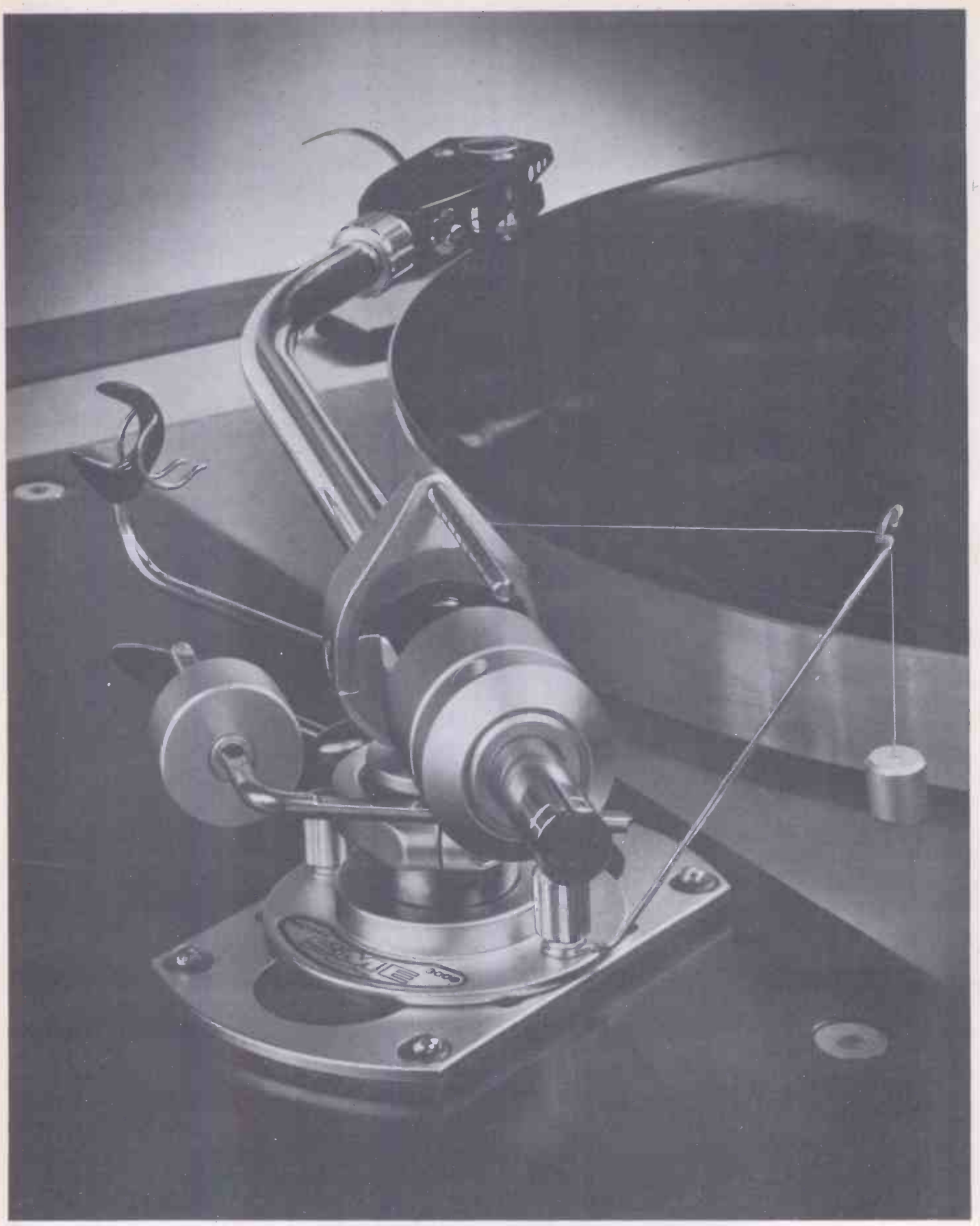

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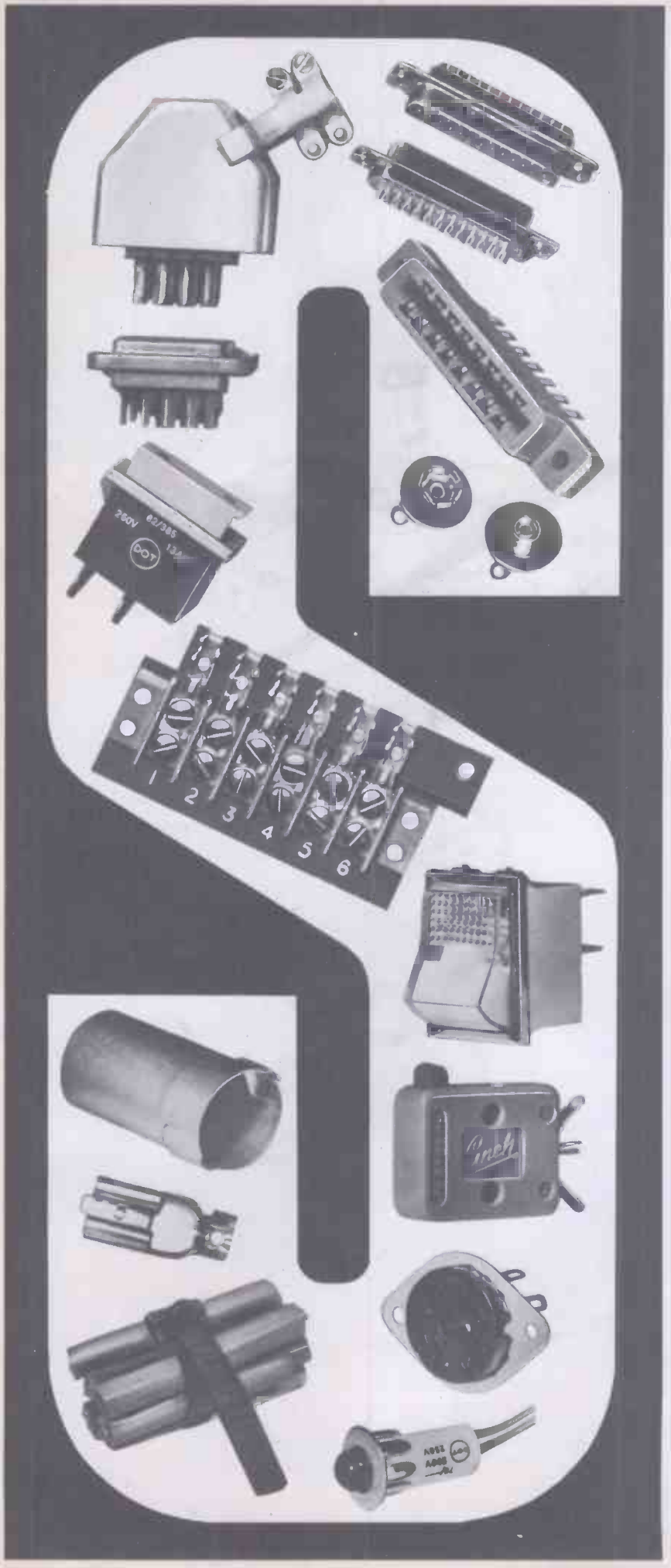

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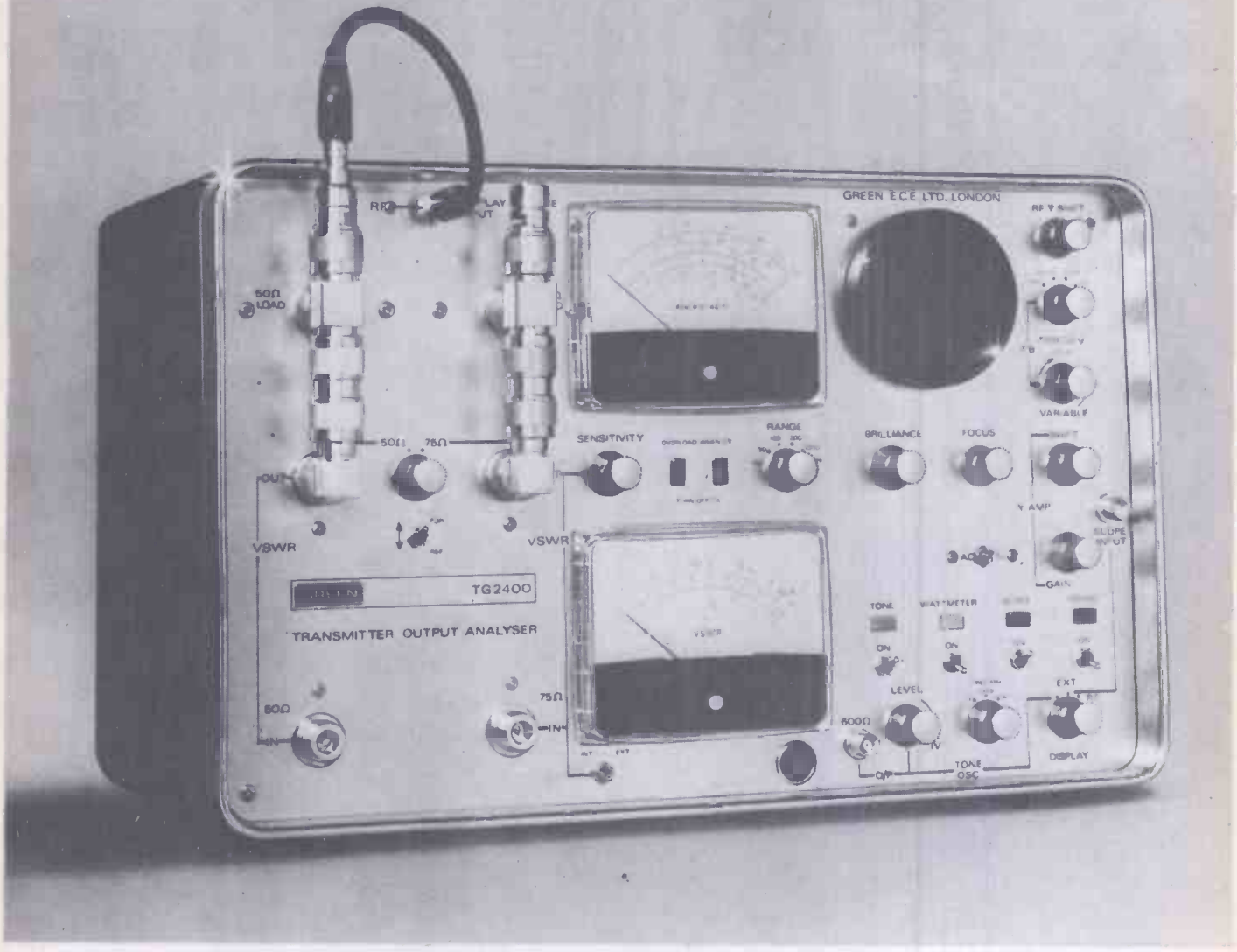
WW—009 FOR FURTHER DETAILS

TOTAL TX TESTING



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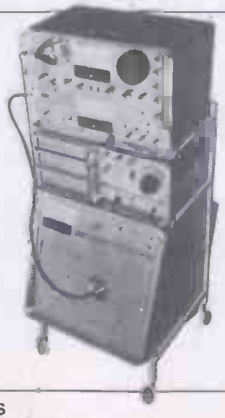

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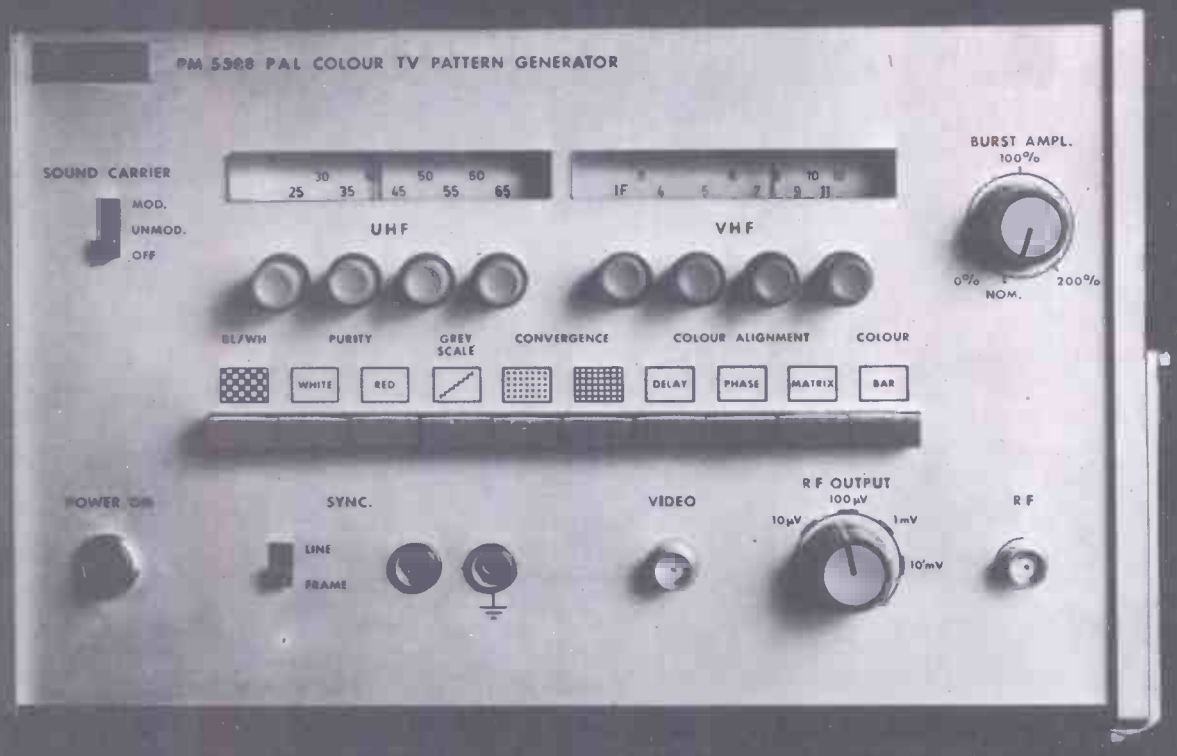
PHILIPS



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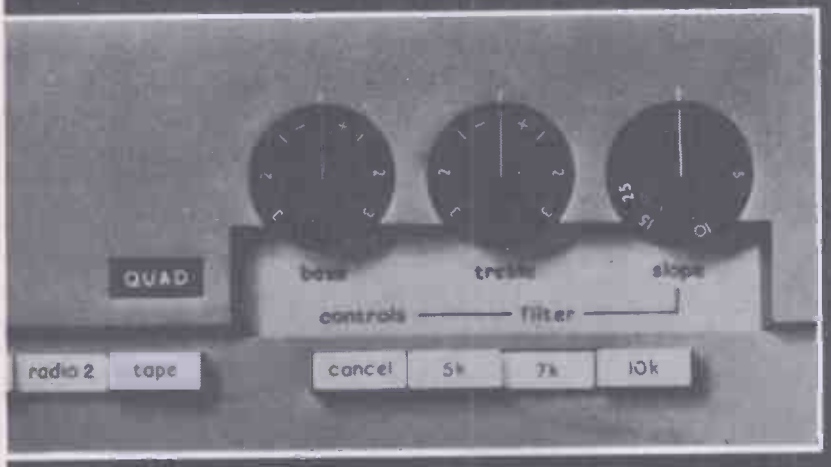

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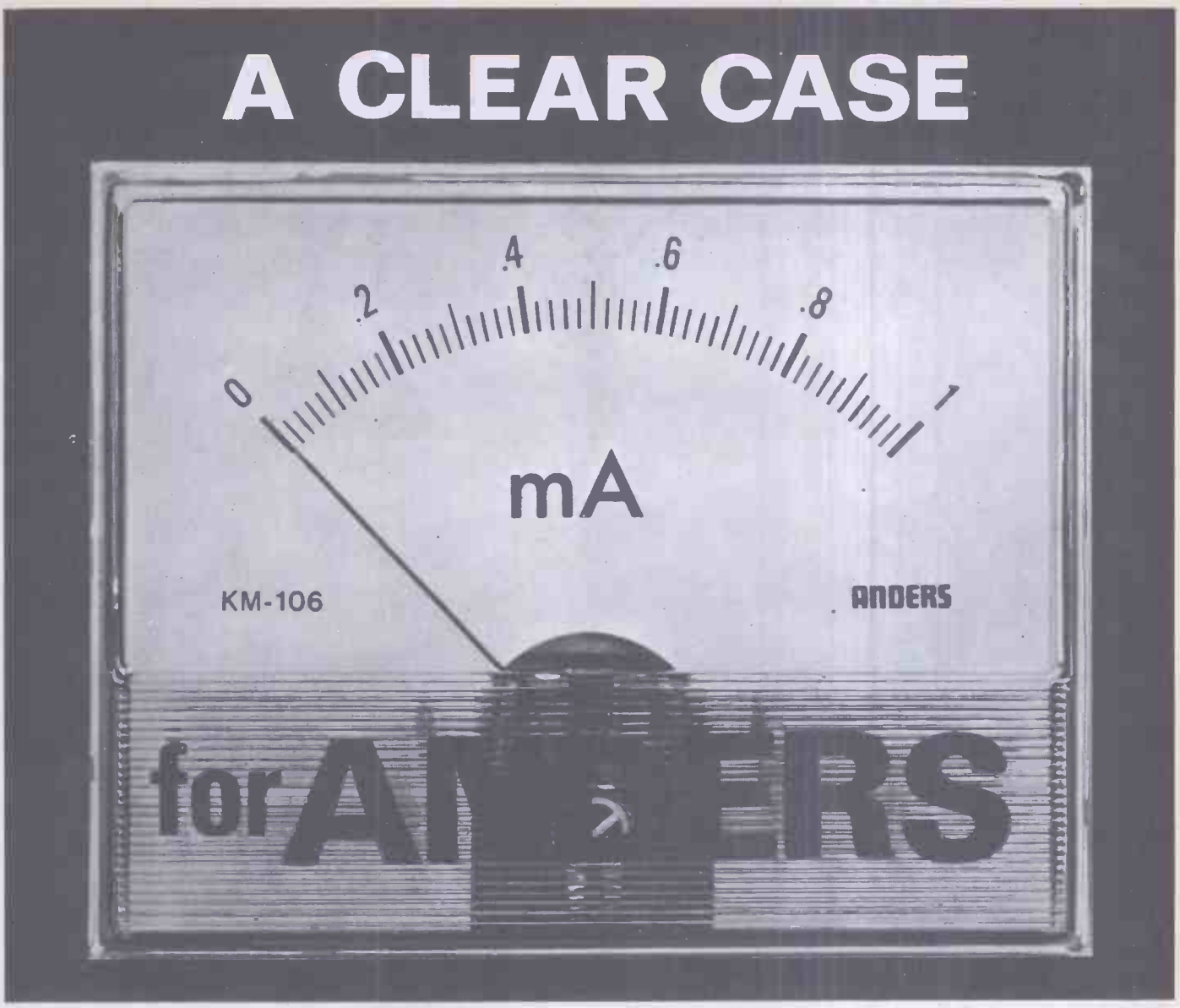

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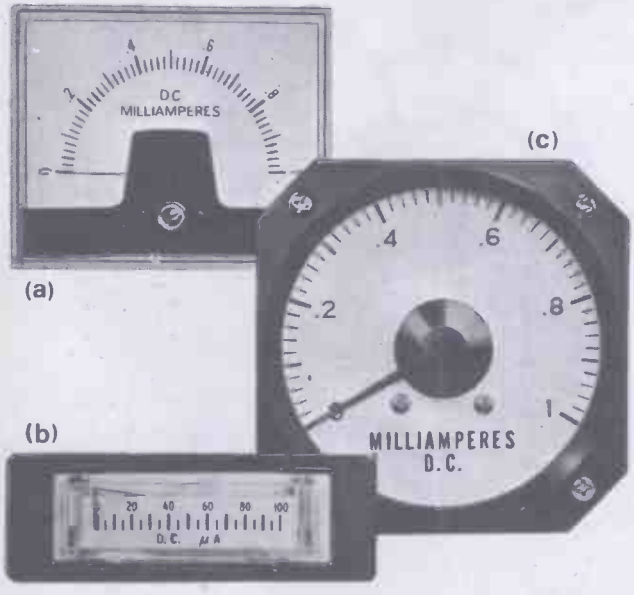

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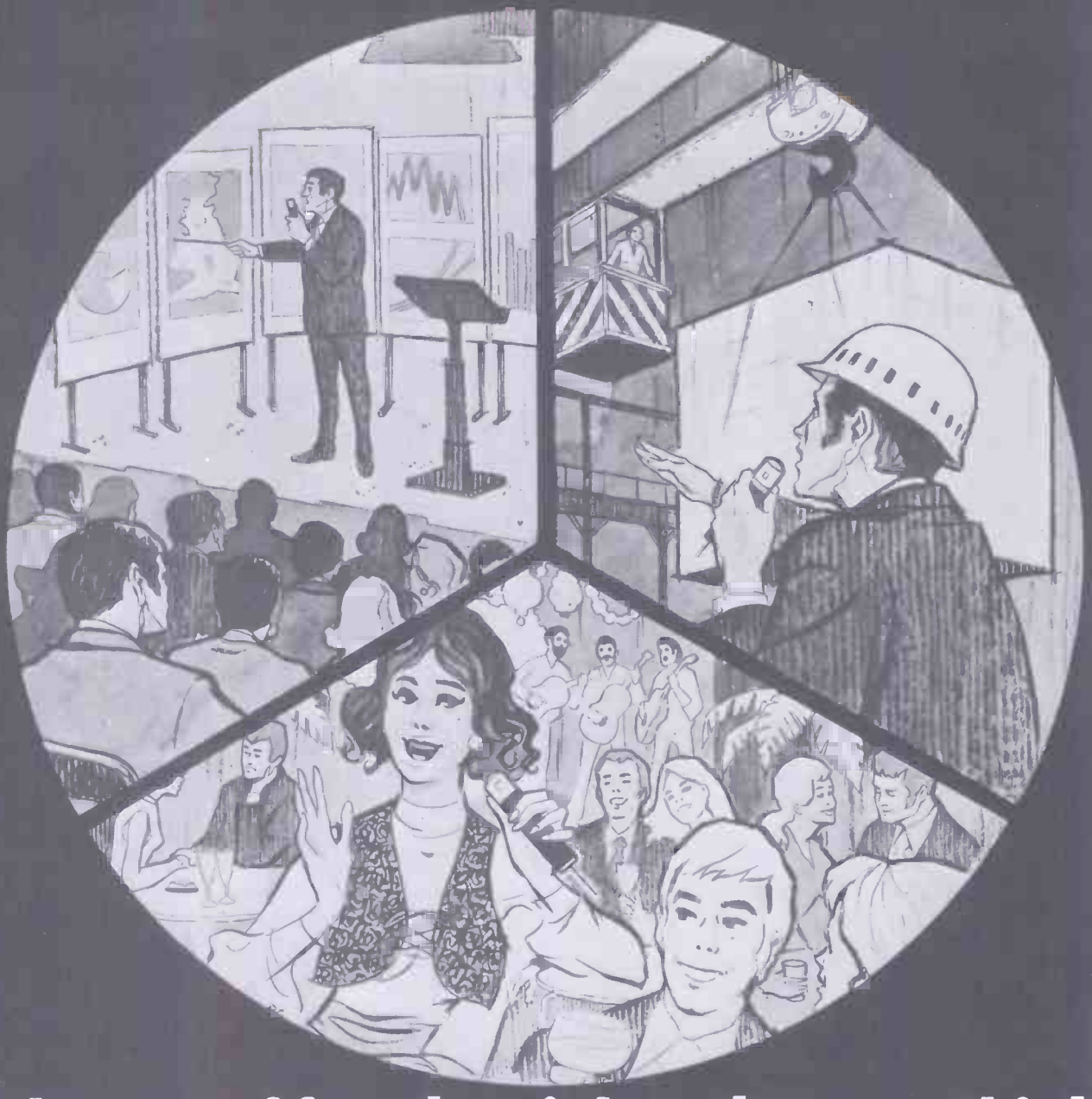
WW—018 FOR FURTHER DETAILS



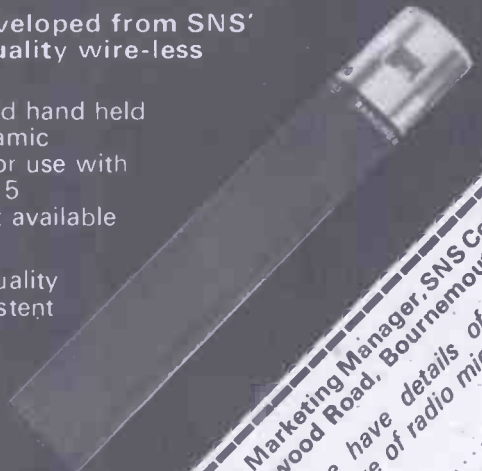
"The cost of freedom is less than you think"

This superb new Radio microphone has been developed from SNS' many years experience in manufacturing high quality wire-less systems.

The new series V range includes a *light weight* moulded hand held transmitter, incorporating a studio quality cardioid dynamic microphone capsule, or a separate pocket transmitter for use with lavalier microphone. The new Receiver, allowing up to 5 simultaneous systems, includes many new facilities not available previously on Radio microphone systems.

The total system has been engineered to the highest quality broadcast and recording studio standards, and is consistent with the rest of the SNS range of audio products.

We would be delighted to arrange for a 7 day free trial or further technical details, please phone or write.



S.N.S.

SNS Communications Ltd.,
851 Ringwood Road,
Bournemouth, BH11 8LN
Tel: Northbourne (020 16) 5331

Mike Reynolds, Marketing Manager, SNS Communications Ltd.,
851 Ringwood Road, Bournemouth, BH11 8LN.

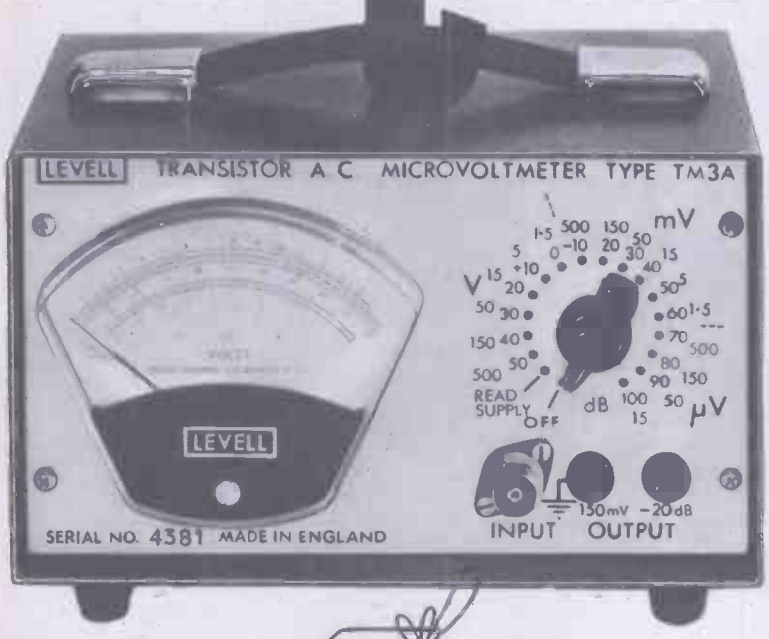
Please let me have details of the new series V range of radio microphones.

Name .....
Address .....
Phone .....

WM1.

WW—019 FOR FURTHER DETAILS

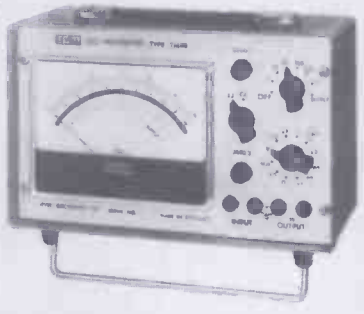
PORTABILITY



WITH LOW COST

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 $3\frac{1}{4}$" 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.

£49



D.C. MULTIMETERS

VOLTAGE RANGES: 3μV, 10μV, 30μV ... 1kV.
Acc. ± 1% ± 1% f.s.d. ± 0·1μV. LZ & CZ scales.

CURRENT RANGES: 3pA, 10pA, 30pA ... 1mA (1A for TM9BP)
Acc. ± 2% ± 1% f.s.d. ± 0·3pA. LZ & CZ scales.

RESISTANCE RANGES: 3 Ω, 10 Ω, 30 Ω ... 1kM Ω linear.
Acc. ± 1%, ± 1% f.s.d. up to 100M Ω.

RECORDER OUTPUT: 1V at f.s.d. into > 1k Ω on LZ ranges.

£75 type TM9A

£89 type TM9B

£93 type TM9BP

A.C. MICROVOLTMETERS

VOLTAGE & db RANGES: 15μV, 50μV, 150μV ... 500V f.s.d. Acc. ± 1% ± 1% f.s.d. ± 1μV at 1kHz. − 100, − 90 ... + 50dB. scale − 20dB/+ 6dB rel. to 1mW/600 Ω.

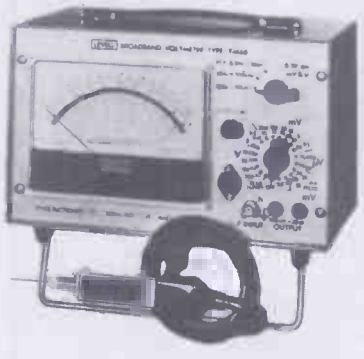
RESPONSE: ± 3dB from 1 Hz to 3MHz, ± 0·3dB from 4Hz to 1MHz above 500μV. Type TM3B can be set to a restricted B.W. of 10Hz to 10k Hz or 100kHz.

INPUT IMPEDANCE: Above 50mV: > 4·3M Ω < 20pf. On 50μV to 50mV: > 5M Ω < 50pf.

AMPLIFIER OUTPUT: 150mV at f.s.d.

£49 type TM3A

£63 type TM3B



BROADBAND VOLTMETERS

H.F. VOLTAGE & dB RANGES: 1mV, 3mV, 10mV ... 3V f.s.d. Acc. ± 4% ± 1% of f.s.d. at 30MHz. − 50dB, − 40dB, − 30dB to + 20dB. Scale − 10dB/+ 3dB rel. to 1mW/50 Ω. ± 0·7dB from 1MHz to 50MHz. ± 3dB from 300kHz to 400MHz.

L.F. RANGES: As TM3 except for the omission of 15μV and 150μV.

AMPLIFIER OUTPUT: Square wave at 20Hz on H.F. with amplitude proportional to square of input. As TM3 on L.F.

£85 type TM6A

£99 type TM6B

Send for further information:

LEVELL
PORTABLE INSTRUMENTS

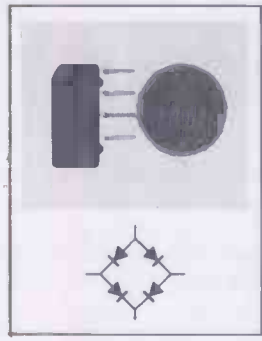
PORTABLE VOLTMETERS

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

WW—020 FOR FURTHER DETAILS

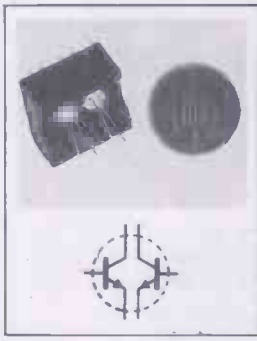
"many a mickle maks a muckle"

(small gains mount up)



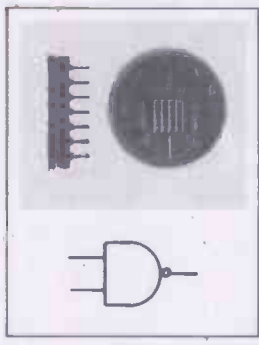
BRIDGE RECTIFIERS

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



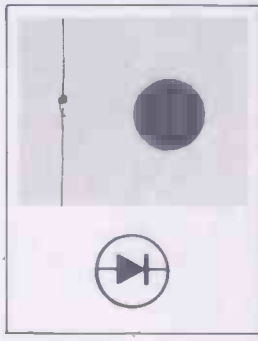
DIFF. AMP. PAIRS

Transistors, f.e.t.s. or diodes available in closely matched pairs, loose or in special heat sinks. Available as standards (such as the BCY55 h_{FE}/V_{BE} matched pair) or with special close-tolerance matching of other parameters such as V_F, V_P, I_{DSS}, I_{CBO} or I_{GSS}.
Send for Information Bulletin VH



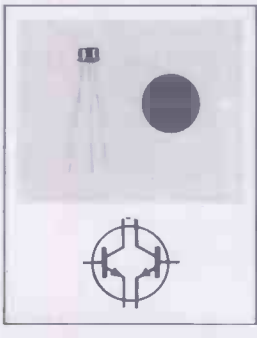
DIGITAL I.C.'s

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



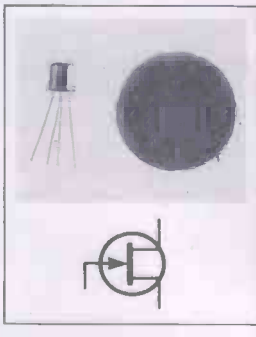
DIODES

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_F, C_D, I_R, etc. on request. Thermal biasing diodes a speciality.
Send for Information Bulletin VR



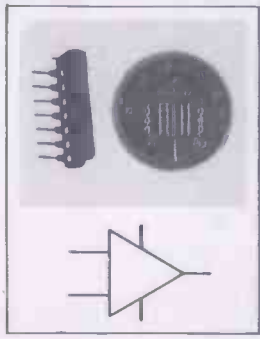
DUAL TRANSISTORS

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



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_{DSS} can be provided.
Send for Information Bulletin VF



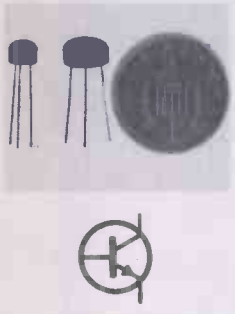
LINEAR IC'S

NKT has an expanding range of industrial linear I.C.'s, such as the LIC 709C (=uA709C), LIC 723C (=uA723C), 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

OPTOELECTRONICS

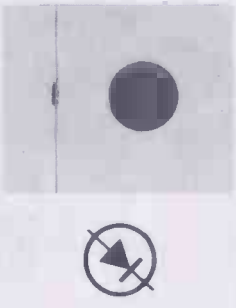
The NKT 7000 range contains infra-red emitting diodes (LED'S), visible light diodes (VLED'S), photo-transistors, photo-scr's, photo-resistors, photo-voltaic cells and optical couplers. Both plastic and hermetic glass-metal-seal packages are available.
Send for Information Bulletin VO

non-transistors from Newmarket Transistors



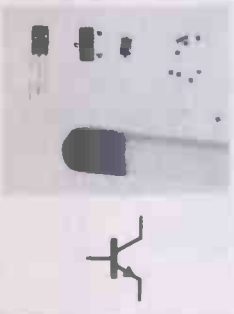
PLASTIC TRANSISTORS

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



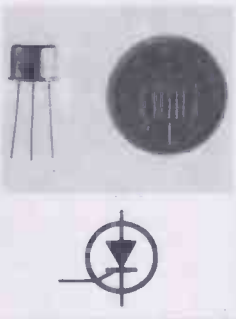
RECTIFIERS

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



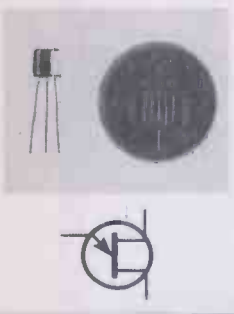
MICRO DEVICES

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



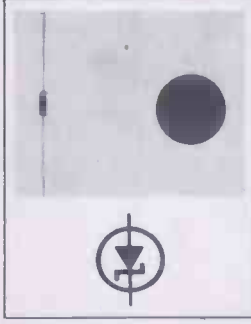
THYRISTORS

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 T018 NTS 0660 (60V, 0.6A). Send for Information Bulletin VT



UNIJUNCTIONS

In unijunctions, NKT has available the well tried industry-standard metal-can 2N 2646/7 and 2N 1671B, as well as economical plastic devices for less onerous applications where cost is the overriding factor. Send for Information Bulletin VU



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

Distributors

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,
Hounslow, Middlesex.
Tel: 01-759 1314

S.D.S. (Portsmouth) Ltd.,
Hilsea Industrial Estate,
Portsmouth PO3 5JW Hampshire.
Tel: 0715/65311
Telex: 86114

I.T.T. Electronic Services Ltd.,
Edinburgh Way,
Harlow,
Essex.
Tel: 02796—26777
Telex: 81146

L.S.T. Electronic Components Ltd.,
7 Coptfold Road,
Brentwood,
Essex.
Tel: Brentwood 226470
Telex: 99443

G.S.P.K. (Sales) Ltd.,
Hookstone Park,
Harrogate,
Yorkshire.
Tel: Harrogate 86258
Telex: 57962

Hird—Brown Electronics Ltd.,
Lever Street,
Bolton BL3 6BJ
Lancashire.
Tel: Bolton 27311
Telex: 63478

Coventry Factors Ltd.,
Coronet House,
Upper Well Street,
Coventry VC1 4AF
Warwickshire.
Tel: 0203—21051/5
Telex: 311243

NKT

NEWMARKET TRANSISTORS LTD.,
EXNING ROAD, NEWMARKET, SUFFOLK.
Tel: 0638-3381. Telex 81358

Farnell

New Constant Voltage/ Constant Current 'L' Series

Units Available		Prices
L.30A	0-50V at 500mA	£36
L.30B	0-30V at 1A	£36
L.30C	0-10V at 3A (with adjustable overvoltage crowbar circuit)	£48
L.30D	0-30V at 2A	£56
L.30E	0-30V at 5A	£82
L.30F	0-12V at 10A (with adjustable overvoltage crowbar circuit)	£86
L.30A/T	2 x 0-50V at 500mA	£72
L.30B/T	2 x 0-30V at 1A	£72
L.30D/T	2 x 0-30V at 2A	£112

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

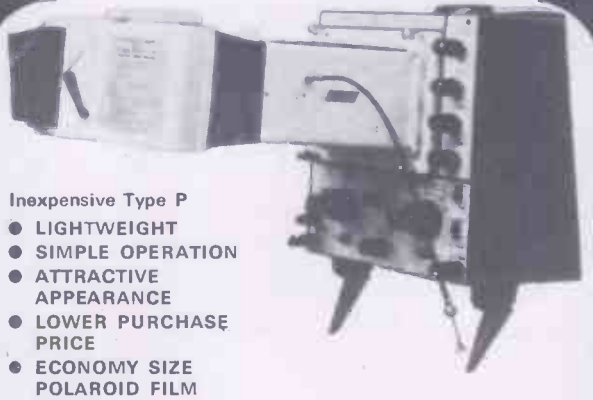
FARNELL INSTRUMENTS LTD.,
Sandbeck Way, Wetherby, Yorkshire
Telephone: 0937 3541/6
London Office: Telephone: 01 802/5359

WW—022 FOR FURTHER DETAILS

TELFORD RANGE OF Oscilloscope Cameras

Modular type A designed to suit every application.

- Viewing systems include parallax-free viewing during exposure.
- Lenses f1.3, f1.5, f1.9, f2.8 and f3.5.
- 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.



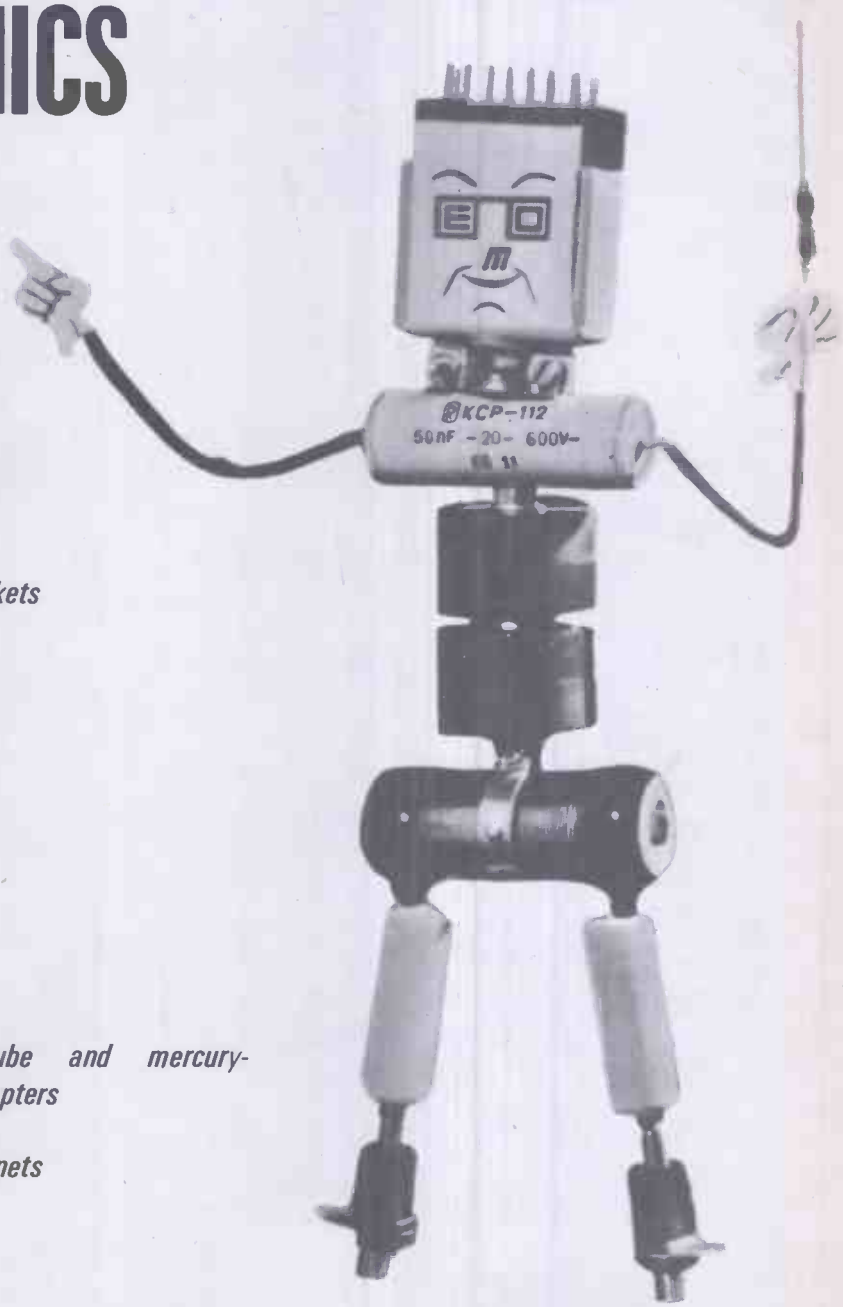
Inexpensive Type P

- LIGHTWEIGHT
- SIMPLE OPERATION
- ATTRACTIVE APPEARANCE
- LOWER PURCHASE PRICE
- ECONOMY SIZE POLAROID FILM TYPE 20
- PRE-EXPOSURE VIEWING
- LENS f4.5 2.4" (61mm) lens provides reproduction of trace and graticule with good linearity. The object/image ratio is 1:07 (nom).
- SHUTTER SPEEDS include fixed exposure 1/25th sec. (nom) time and brief.
- ADAPTORS Camera models available for most popular oscilloscopes.

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

WW—023 FOR FURTHER DETAILS

PARTS AND COMPONENTS FOR TELECOMMUNICATION ENGINEERING AND ELECTRONICS



EXPORT—IMPORT

RC-Elements
- ☐ *Resistors*
- ☐ *Capacitors*
- ☐ *Potentiometers*

Electromechanical Components
- ☐ *Connectors, sockets*
- ☐ *Switches*
- ☐ *Relays*
- ☐ *Pilot lamps*
- ☐ *Rotary buttons*

Electroacoustic Components
- ☐ *Microphones*
- ☐ *Earphones*
- ☐ *Loudspeakers*

Miscellaneous Parts and Components
- ☐ *Transformers*
- ☐ *Fluorescent tube and mercury-vapour lamp adapters*
- ☐ *Ferrites*
- ☐ *Permanent magnets*
- ☐ *Aerials*

IMPORT

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

ELEKTROMODUL

BUDAPEST

ELEKTROMODUL

Hungarian Trading Company for Electrotechnical Components

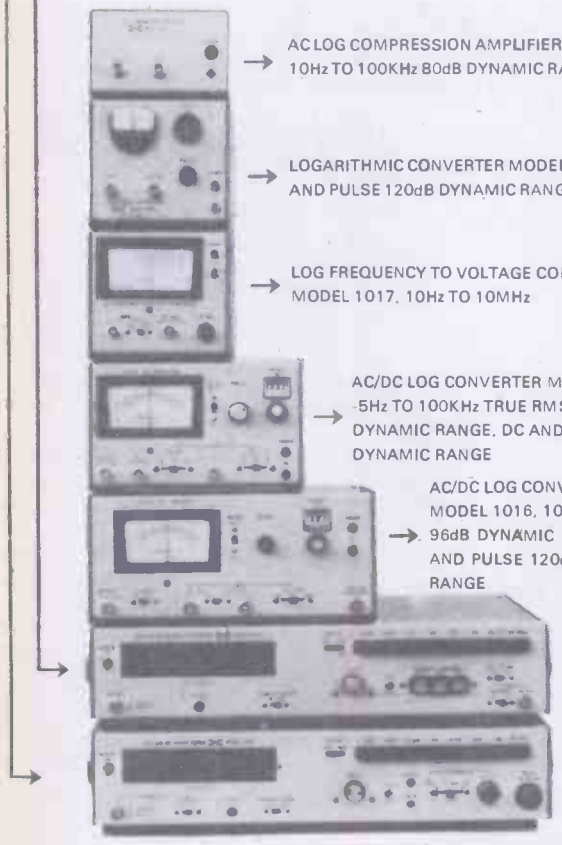
BUDAPEST, XIII., VISEGRADI UTCA 47 a-b
Telephone: 495-340; 495-940. Telex: 22-5154, 22-5155

WW—024 FOR FURTHER DETAILS

PACIFIC PM PROFILES AT 50/60 Hz

LOG/LIN RF POWER METER MODEL 1009, 10MHz TO 18GHz 50dB DYNAMIC RANGE, BCD OUTPUT 1000 READINGS PER SECOND

LOG/LIN AC DIGITAL VOLTMETER MODEL 1010, 10Hz TO 5MHz 96dB DYNAMIC RANGE, BCD OUTPUT 1000 READINGS PER SECOND



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

LOGARITHMIC 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

AC/DC LOG CONVERTER MODEL 1016, 10Hz TO 5MHz 96dB 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.

aveley electric LTD

Arisdale Ave
South Ockendon Essex

Tel: Sth Ockendon 3444
Telex: 24120 Avel Ockendon

WW—053 FOR FURTHER DETAILS

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 (=1N914)	Signal Diode	18 for 50p
1N5060 (=A14D)	1 Amp Rectifier 400V avalanche protected	7 for 50p
2N2926 (Red)	NPN Silicon Transistor hfe 55 – 110	8 for 50p
2N2923	NPN Silicon Transistor hfe 90 – 180	7 for 50p
2N2646	Versatile Unijunction	3 for 100p

Post and packing 10p for 1 or 2 packs; 3 packs or more post free

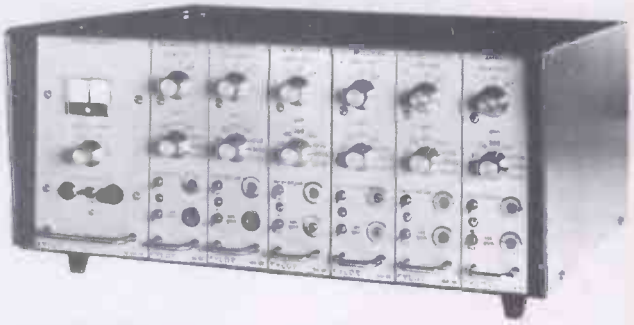
Order any quantity, till sold (but we regret packs cannot be subdivided).

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

WW—054 FOR FURTHER DETAILS

RECORDER AMPLIFIERS

AND INSTRUMENTATION SYSTEMS



150 series DIFFERENTIAL DC AMPLIFIERS

Wide dynamic range— high common mode rejection

Low noise, low drift performance

Modular or cased presentation

also

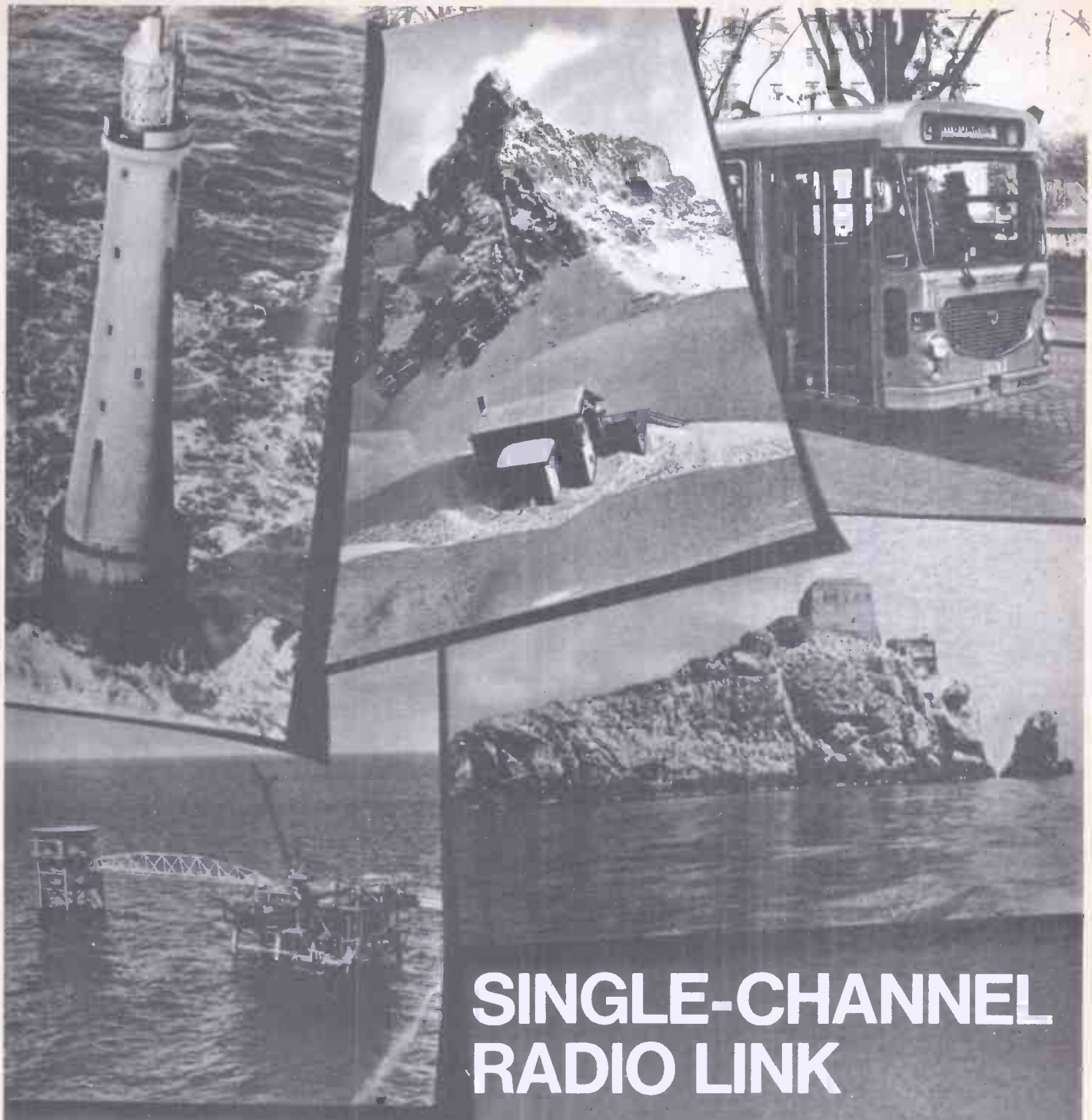
MINI-AMP FE-251-GA

differential dc pre-amplifier

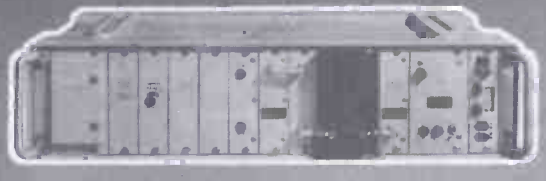
Compatible modules and cards ensure ease of application and great flexibility.

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

WW—055 FOR FURTHER DETAILS



SINGLE-CHANNEL RADIO LINK



Particularly versatile because of its modular structure, 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.

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ITALTEL s.p.a.

20149 Milan (Italy) - 12, piazzale Zavattari - phone 4388

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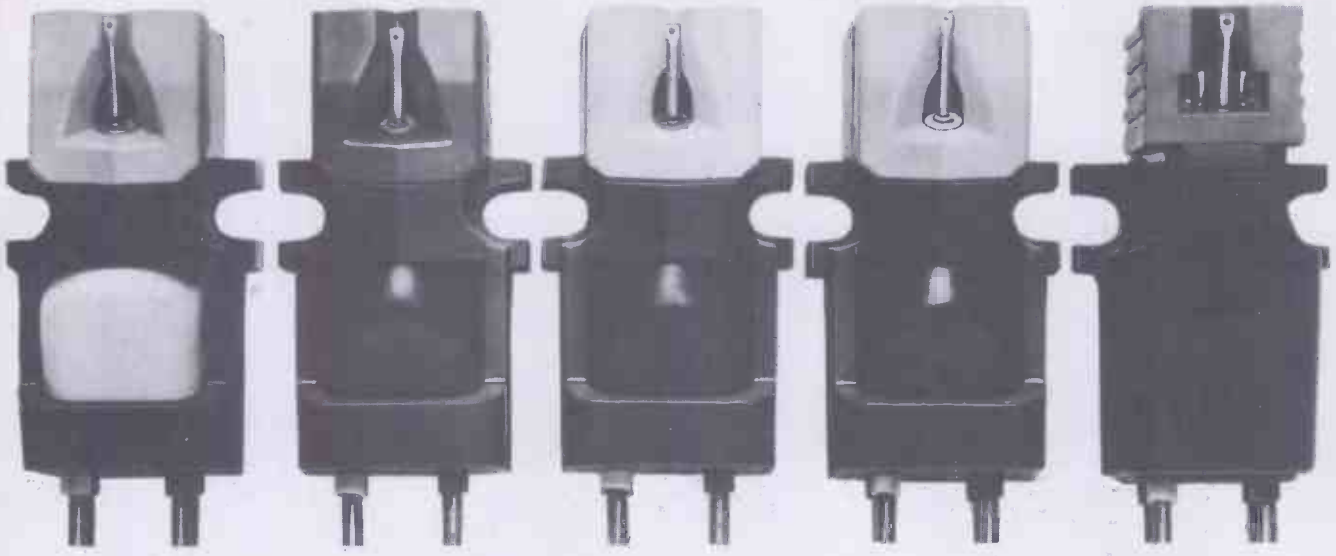

Different people have very different requirements in Hi-Fi, so Goldring developed a comprehensive range of stereo magnetic cartridges that are superb in performance and realistic in price.

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.

WW—027 FOR FURTHER DETAILS

DC300

DUAL-CHANNEL POWER AMPLIFIER

Frequency Response	± 0.1db Zero-20KHz at 1 watt into 8 ohms, ± 0.6db Zero-100KHz.
Phase Response	Less than 5° 0-10KHz.
Power Response	± 1db Zero-20KHz at 150 watts RMS into 8 ohms.
Power at Clip Point	Typically 190 watts RMS into 8 ohms, 340 watts RMS into 4 ohms per channel.
Total Output (IHF)	Typically 420 watts RMS into 8 ohms, 800 watts RMS into 4 ohms.
T.H.D.	Better than 0.03% at 1KHz at 190 watts level.
I.M. Distortion (60-7KHz 4:1)	Less than 0.1% from 0.01 watt to 150 watts RMS into 8 ohms, typically below 0.05% (max 0.05%.
Damping Factor	Greater than 200 (Zero to 1KHZ into 8 ohms at 150 watts RMS).
Hum and Noise (20-20KHz)	100db below 150 watts RMS output (unweighted, typical 110db).
Slewing Rate	8 volts per micro-second. S-R is the maximum value of the first derivative of the output signal.
Dimensions	19in. standard rack mount (W.E. hole spacing), 7in. height, 9¼in. deep (from mounting surface).
Weight	40 pounds net weight.
Finish	Bright-anodized brushed-aluminium front-panel with black-anodized front extrusion, access door, and chassis.

★ DC-Coupled throughout!

★ Short Circuit proof!

★ 500 Watts RMS Mono.

★ 70 Volt Balanced line out!

★ UNEQUALLED QUALITY!

★ 3 YEAR PARTS WARRANTY!

★ ONLY £320 inc. DUTY!

CARSTON ELECTRONICS LTD.
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WW—028 FOR FURTHER DETAILS

Thank you gentlemen.

Department of Trade & Industry, British Rail, Port of London Authority, United Kingdom Atomic Energy Authority, Carphones Ltd., Caledonian//British United Airways, Central Electricity Generating Board, Automobile Association, C.W.S. Limited, Chubb Alarms Ltd., City of London Police, Turriff Construction Corp., Marks & Spencers Ltd., Prestcold (Southern) Ltd., Wasco Electronics Ltd., Appledore Shipbuilders Ltd., Boots Pure Drug Co. Ltd., British Steel Corporation–Tubes Division, Calor Gas (Ireland) Ltd., Helsinki Transport Board (HKL), Esso Petroleum Co. Ltd., Ford Motor Co. Ltd., Imperial Chemical Industries Ltd., Kellogg & Co. Ltd., Kodak Ltd., Mobil Oil Co. Ltd., Pilkington Bros. Ltd., Spanish Police, St. Etienne Taxi Union, Reed Group Ltd., Shell-Mex & B.P. Ltd., Royal Malaysian Police, Vauxhall Motors Ltd.,

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And they've helped to make us one of the world's leading radiotelephone companies.

So thanks again, gentlemen.

If you'd like STAR, too, write to: ITT Mobile Communications Limited, Radlett Works, Colney St., St. Albans, Herts. Tel: Radlett 4711

ITT Mobile

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

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

YOU APPRECIATE low cost, a wide choice of instrument sizes, good delivery and service, inexpensive spares, British design and quality.

YOU NEED Litesold **SOLDERING IRONS**

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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

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- Built-in Encoder • Built-in Colour Temperature Compensation Filters
- Built-in 2 :1 Interlace Sync System • Lens Interchangeability

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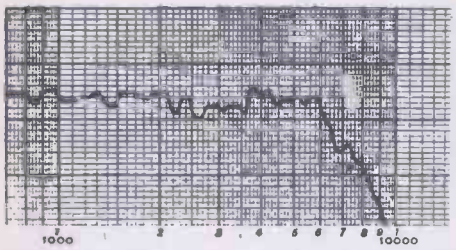
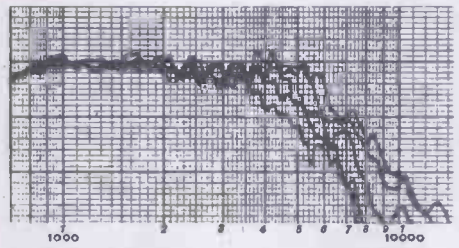
WW—031 FOR FURTHER DETAILS

Acoustic Research has measured the response of more than a million high-fidelity speakers.

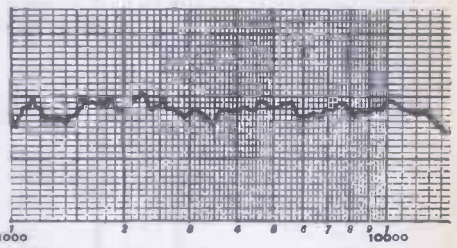
Here are some things we have learned about listening.



1. The frequency response of a midrange driver unit of an AR-3a, on axis. This corresponds to what one would hear outdoors, listening directly in front of a speaker.

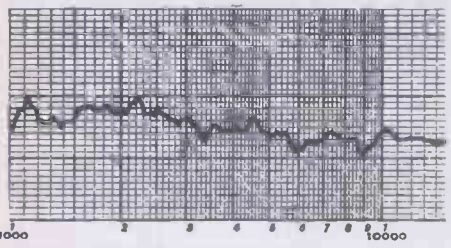


2. What happens when a listener moves over to one side of the speaker in 15° increments.

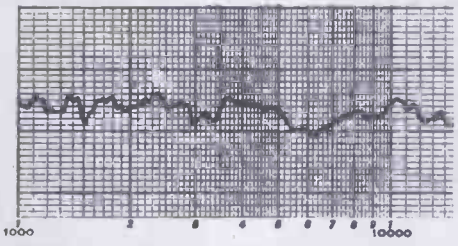


3. The integrated power output of the AR-3a above 1000 Hz, measured in a special reverberant chamber. Reflection from the walls of the chamber mixes together all of the sound emitted by the speaker system in all directions, an effect much more like that of a listening room than the anechoic chamber used for 1 and 2. A speaker system which measured well in both types of chamber would be accurate under almost all listening conditions.

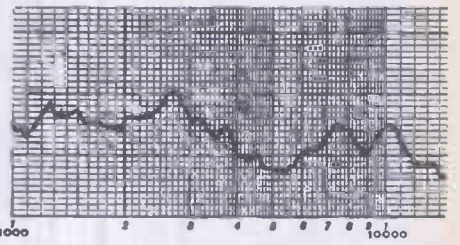
Integrated power output curves.



AR-3a and AR-5 with high-priced magnetic cartridge. It is interesting to see that the cartridge introduces somewhat more degradation of the signal than the speaker system, at least in the frequency range observed. Nevertheless, a small adjustment of the amplifier treble control could restore uniformity of response.



AR-2ax with moderately-priced magnetic cartridge. Although not as accurate as the AR-5 or AR-3a the AR-2ax displays the same kind of performance, that is, its integrated power output curve is relatively level. Because its dispersion, especially in the lower midrange, is less uniform the AR-2ax is more dependent on optimum placement than the others.



A 'multi-directional' system and a very expensive cartridge. Such systems are designed to take advantage of room reflections to smooth response and create spatial effects.

Vertical divisions ½ dB

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.

AR BELL & HOWELL

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WW—032 FOR FURTHER DETAILS

Celestion

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 - 12·5KHz
POWER: 6 WATTS RMS
FLUX: 38,500 MAXWELLS
IMPEDANCE: 15 OHMS
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* *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

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FLUX: 145,000 MAXWELLS
IMPEDANCE: 8 or 15 OHMS
PRICE (R.R.P.) £12·95

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RANGE: 40Hz - 8KHz
POWER: 30 WATTS RMS
FLUX: 180,000 MAXWELLS
IMPEDANCE: 8 or 15 OHMS
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'POWER RANGE'

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Loudspeakers for the Perfectionist

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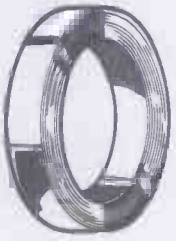
Telephone (0473) 73131 Telex 98365

WW—033 FOR FURTHER DETAILS

Soft magnetic alloys

TELCON OFFER THE WIDEST RANGE



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 'Rotelloys', which have superior mechanical properties have also been developed for use in high speed rotating equipment such as aircraft generators.

T
M

TELCON

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

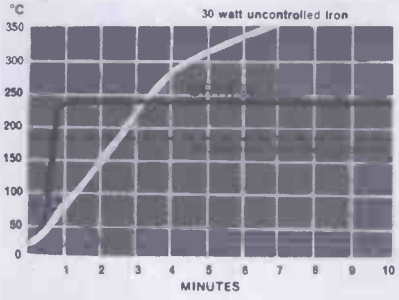
WW—034 FOR FURTHER DETAILS

NEW temperature controlled soldering iron.

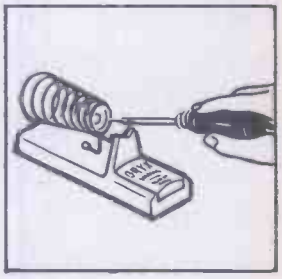
THE ORYX 50

- *Screw adjustment range 200°C to 400°C.
- *Heat settings accurate to ± 2%.
- *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.

TYPICAL CURVE OF THE ORYX 50



Price
with long life tip.
£3·75
STAND :
£1·25



Send for Technical Literature to **W. GREENWOOD ELECTRONIC LIMITED**
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Clear, dynamic sound. 'Non-howling' design eliminates feed-back. Most models waterproof for all-weather use. With pistol grip or hand-mike to allow speaker to be shoulder-slung or stand-mounted. Light. Easy to use. Volume controllable. Rechargeable types eliminate battery-changing. Also Continuous Siren, or Burglar-alarm broadcasting types.

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AIR SPACED VARIABLE CAPACITORS and TRIMMERS ...

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SUB MINIATURE TRANSFORMERS
We have facilities for the manufacture of miniature transformers to customers' own designs—and would welcome any enquiries.

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RADFORD

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Two instruments having a superior performance than any others of this type regardless of price. Now accepted as standard equipment by Broadcasting Authorities, recording studios, magazine equipment test laboratories, and audio research and development laboratories all over the world.

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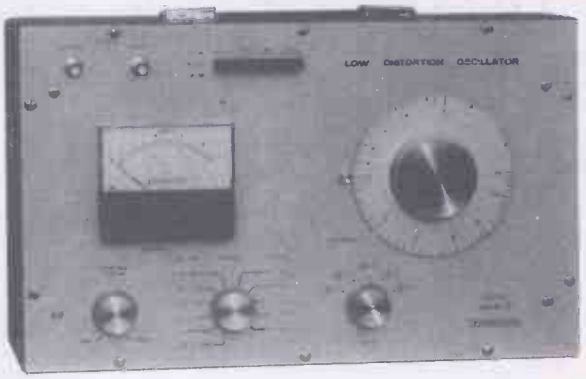

An instrument of high stability providing very pure sine waves, and square waves, in the range of 5 Hz to 500 kHz. Hybrid design using valves and semiconductors.

Specification

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Output Impedance:	600 Ohms.
Output Voltage:	10 Volts r.m.s. max.
Output Attenuation:	0-110 dB continuously variable.
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Size:	17¼ × 11 × 8 in
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Price:	£150

DISTORTION MEASURING SET

A sensitive instrument for the measurement of total harmonic distortion, designed for speedy and accurate use. Capable of measuring distortion products as low as 0.002%. Direct reading from calibrated meter scale.

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Distortion Range:	0.01%-100% f.s.d. (9 ranges)
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Meter:	Square law r.m.s. reading.
Input Resistance:	100 kOhms.
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Frequency Response:	±1 dB from second harmonic of rejection frequency to 250 kHz.
Power Requirements:	Included battery.
Size:	17¼ × 11 × 8 in.
Weight:	15 lb.
Price:	£120.

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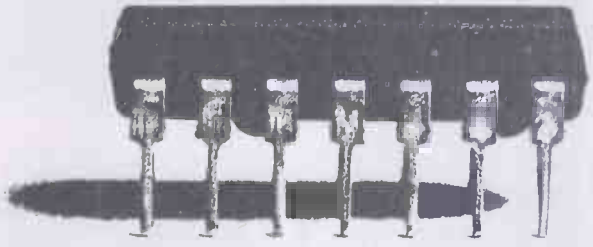
RADFORD LABORATORY INSTRUMENTS LTD.
BRISTOL BS3 2HZ
Telephone: 0272, 662301

WW—038 FOR FURTHER DETAILS

Match of the day.



Specify the Motorola Dual Transistor and you get more than just 'two chips in one can'.

You get two perfectly matched transistors giving excellent tracking over a widely varying temperature range.

So not only do you save space with the Motorola Dual Transistor, you gain greater efficiency too.

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Motorola make four main categories of dual transistor. You're sure to find just what you want among them. Quads are also available.

For more information send for a data sheet. Write to:

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MOTOROLA Semiconductors

MANUFACTURING FACILITY AT EAST KILBRIDE, SCOTLAND

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Brenell Transistorised Hi-fi Tape Link

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First, the appearance. Diminutive, neat, wipe-clean cycolac case with shock and magnetic field proof steel liner. Controls are simple and easy to use.
Second, the range. The Minitest measures a.c. and d.c. voltages d.c. current and resistance over 20 ranges to a sensitivity of 20,000 and 2,000 ohms per volt d.c. and a.c. respectively.
Third, high voltage probes. These extend the range to 25 or 30kV d.c.
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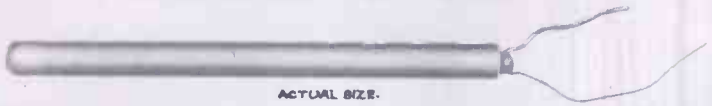
SEI GEC

WW—041 FOR FURTHER DETAILS

The element of the new ANTEX Model CCN soldering iron is completely enclosed inside a ceramic (aluminium oxide) shaft to ensure maximum reliability. This material combines great strength with near-perfect insulation. Live transistors can be soldered with complete safety; leakage is negligible.



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The iron has passed a 4000v A.C. test and production models are routine-tested at 2000v A.C. Officially approved even by the Swiss Electricity Authorities. Available with our standard long-life iron-coated bit which fits snugly over the element or with the new 7 Star bit for yet more efficient heat-transfer. 7-Star bits are iron-coated nickel plated and chromium plated.

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With some 400°C at the tip rapid recovery of heat and a soldering speed of one joint per second, productivity gains are spectacular. The complete iron comes with 6ft of 2-core flexible lead, secured against twist and strain by an insulated screw and tailpiece.

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(Prices subject to quantity discount)

from electrical and radio shops or by Free Post (No stamp required) to:

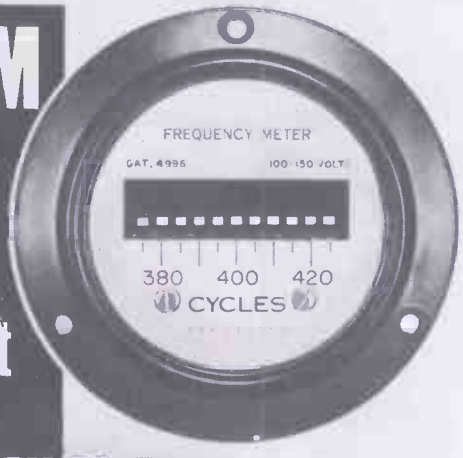
PRECISION MINIATURE SOLDERING IRONS ANTEX

ANTEX LTD, FREEPOST, PLYMOUTH PL1 1BR.
Telephone: 0752-67377/8 Giro No: 2581001

WW 9

WW—042 FOR FURTHER DETAILS

FRAHM



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- Not sensitive to voltage or temperature changes, within wide limits
- Unaffected by waveform errors, load, power factor or phase shift
- Operational on A.C., pulsating or interrupted D.C., and superimposed circuits
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FRAHM Resonant Reed Frequency Meters are available in plastic and hermetically sealed cases to British and U.S. Government approved specification. Ranges 10–1700 Hz. Literature on these meters and Frahm Resonant Reed Tachometers available on request. Manufacture and Distribution of Electrical Measuring Instruments and Electronic Equipment. The largest stocks in the U.K. for off-the-shelf delivery.

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48/56 Bayham Place, Bayham Street, London NW1. Tel: 01–387 9092

Anders means meters

WW—043 FOR FURTHER DETAILS

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Now available with 3 OUTPUTS making these units more versatile for:

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Type VRU/30/20*—£144·35

*OUTPUT 1, 0-30V 20A DC.
Will provide accumulator performance from AC mains for production testing and servicing of battery operated equipment. Output continuously variable 0-30V at up to 20A.

*OUTPUT 2, 0-80V 10A AC.
For the testing and development of low voltage AC equipment.

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Send for publication WPU9

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WW—044 FOR FURTHER DETAILS

STRIP-CHART PEN RECORDERS ★ FROM STOCK

Portable Strip-Chart Recorder Type H352

Writing mechanism	syphon ink pen
Type of movement	Moving coil
Full scale deflection	1mA D.C.
D.C. resistance of movement	10570Ω
Accuracy	±1.5%
Chart width	100 mm
Chart speeds (through change gears)	20-60-180-600-1800-540 mm/hour
Chart drive	230V A.C.

Record is produced on curvi-linear coordinates. For accurate measurements a separate 'zero' marking pen is fitted for use as a reference line.

PRICE, with six charts **£52.00**

Multi-range universal Strip-Chart Recorder Type H390

Writing mechanism	syphon ink pen
Type of movement	Moving coil with rectifier on A.C. ranges
Accuracy	±1.5% D.C.: ±2.5% A.C.
Switchable ranges:	
D.C. Volts	150mV-5-15-50-150-250-500V
A.C. Volts	5-15-50-150-250-500V
A.C./D.C. Amps	5-15-50-150-250-500mA 1.5-5Amps
Chart width	100 mm
Chart speeds (through change gears)	20 to 540 mm/hour
Chart drive	230V A.C.

Record is produced on recti linear coordinates. Separate 'zero' marking pen is fitted to produce reference line for accurate reading.

PRICE, with 10 charts **£78.00**

Ten-channel event Recorder Type H30

Instrument will provide permanent record of duration and sequence of up to ten operations.

Writing mechanism	Syphon ink pen
Type of movement	Rotary electro-magnetic relay
Relay supply voltage	12V D.C.
Minimum energizing time	0.1 sec.
Chart width	100 mm
Chart drive	230V A.C.
Chart speeds (through change gears)	20-5400 mm per hour

Record is produced in the form square pulses approx. 2.5 mm high.

PRICE, complete with 10 charts **£52.00**

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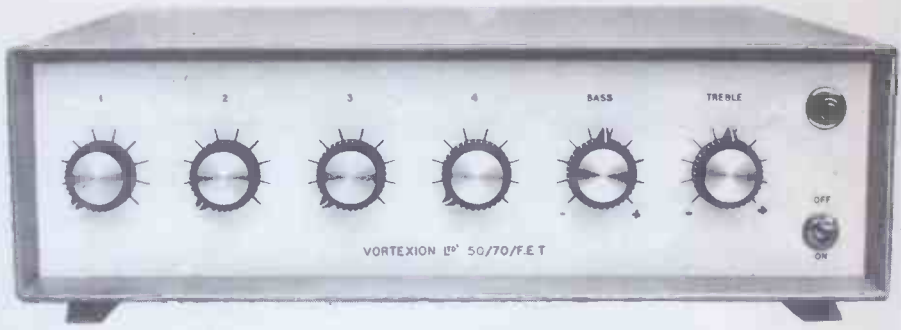
Vortexion

50/70 WATT ALL SILICON AMPLIFIER WITH BUILT-IN 4-WAY MIXER USING F.E.T.s.



This is a high fidelity amplifier (0.3% intermodulation distortion) using the circuit of our 100% reliable 100 Watt Amplifier with its elaborate protection against short and overload, etc. To this is allied our latest development of F.E.T. Mixer Amplifier, again fully protected against overload and completely free from radio breakthrough.

The mixer is arranged for 2-30/60Ω balanced line microphones, 1-HiZ gram input and 1-auxiliary input followed by bass and treble controls. 100 volt balanced line output or 5/15Ω and 100 volt line.

50/70 WATT ALL SILICON AMPLIFIER WITH BUILT-IN 5-WAY MIXER USING F.E.T.s This is similar to the 4-way version but with 5 inputs and bass cut controls on each of the three low impedance balanced line microphone stages, and a high impedance (10 meg) gram stage with bass and treble controls plus the usual line or tape input. All the input stages are protected against overload by back to back low noise, low intermodulation distortion and freedom from radio breakthrough. A voltage stabilised supply is used for the pre-amplifiers making it independent of mains supply fluctuations and another stabilised supply for the driver stages is arranged to cut off when the output is overloaded or over temperature. The output is 75% efficient and 100V balanced line or 8-16Ω output are selected by means of a rear panel switch which has a locking plate indicating the output impedance selected.

100 WATT ALL SILICON AMPLIFIER. A high quality amplifier with 8 ohms–15 ohms or 100 volt line output for A.C. Mains. Protection is given for short and open circuit output over driving and over temperature. Input 0.4 V on 100K ohms.

THE 100 WATT MIXER AMPLIFIER with specification as above is here combined with a 4 channel F.E.T. mixer, 2-30/60Ω balanced microphone inputs, 1-HiZ gram input and 1-auxiliary input with tone controls and mounted in a standard robust stove enamelled steel case. A stabilised voltage supply feeds the tone controls and pre amps, compensating for a mains voltage drop of over 25% and the output transistor biasing compensates for a wide range of voltage and temperature. Also available in rack panel form.

CP50 AMPLIFIER. An all silicon transistor 50 watt amplifier for mains and 12 volt battery operation, charging its own battery and automatically going to battery if mains fail. Protected inputs, and overload and short circuit protected outputs for 8 ohms–15 ohms and 100 volt line. Bass and treble controls fitted.
Models available with 1 gram and 2 low mic. inputs, 1 gram and 3 low mic. inputs or 4 low mic. inputs.

200 WATT AMPLIFIER. Can deliver its full audio power at any frequency in the range of 30 c/s–20 Kc/s ±1 dB. Less than 0.2% distortion at 1 Kc/s. Can be used to drive mechanical devices for which power is over 120 watt on continuous sine wave. Input 1 mW 600 ohms. Output 100–120 V or 200–240 V. Additional matching transformers for other impedances are available.

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VORTEXION LIMITED, 257-263 The Broadway, Wimbledon, S.W.19
Telephone: 01-542 2814 and 01-542 6242/3/4 **Telegrams: "Vortexion, London S.W.19"**

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capacity 250 Watts

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New solid state variable voltage control
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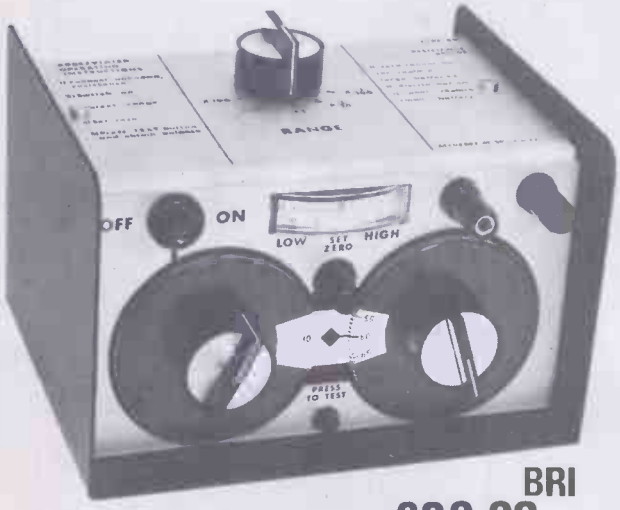

BRI

£29.90

This compact Resistance Bridge has many outstanding features not usually associated with a low priced instrument.

- An ELECTRONIC NULL DETECTOR with overload protection facilitates easy use with extremely high discrimination.
- The instrument incorporates FIVE RANGES giving measurements up to 1.1 M ohm from 0.1 ohm.
- The RATIO COILS are wound from low temperature coefficient minalpha wire which has been annealed and aged to give exceptionally good stability.
- The detector amplifier is powered by inexpensive internal batteries giving many months of use.
- An attractive leather carrying case can be supplied as an optional extra.

ALSO AVAILABLE—PORTABLE LABORATORY RESISTANCE BRIDGE WITH ACCURACIES OF 0.01% or 0.03% PRICES FROM £169.00

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10 Crystal controlled channels.

100kHz Calibrator.

Operation from standard AC supplies or powered directly from any 12V DC source.

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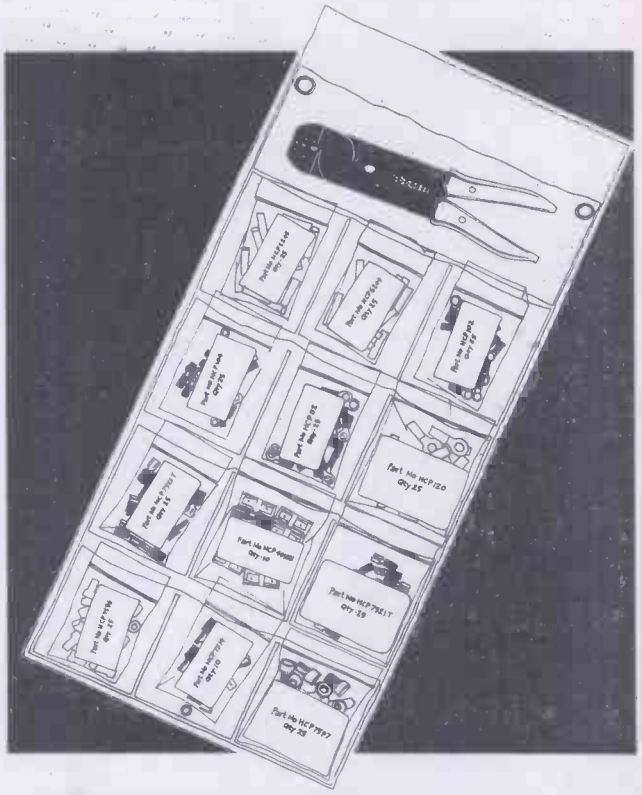
Use Hellermann-GKN Compression Terminal Kits. They're ideal for general maintenance work on electrical and electronic equipment — domestic or industrial — and one of the Kits is specially made for automobile electronics.

Take your pick from three different Kits, each one containing 12 of the most popular compression terminals. With or without a hand crimping tool. The terminal packets are re-sealable, and fit into the pockets of the plastic wallet that can either be hung on a wall or folded neatly into a tool bag.



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GKN

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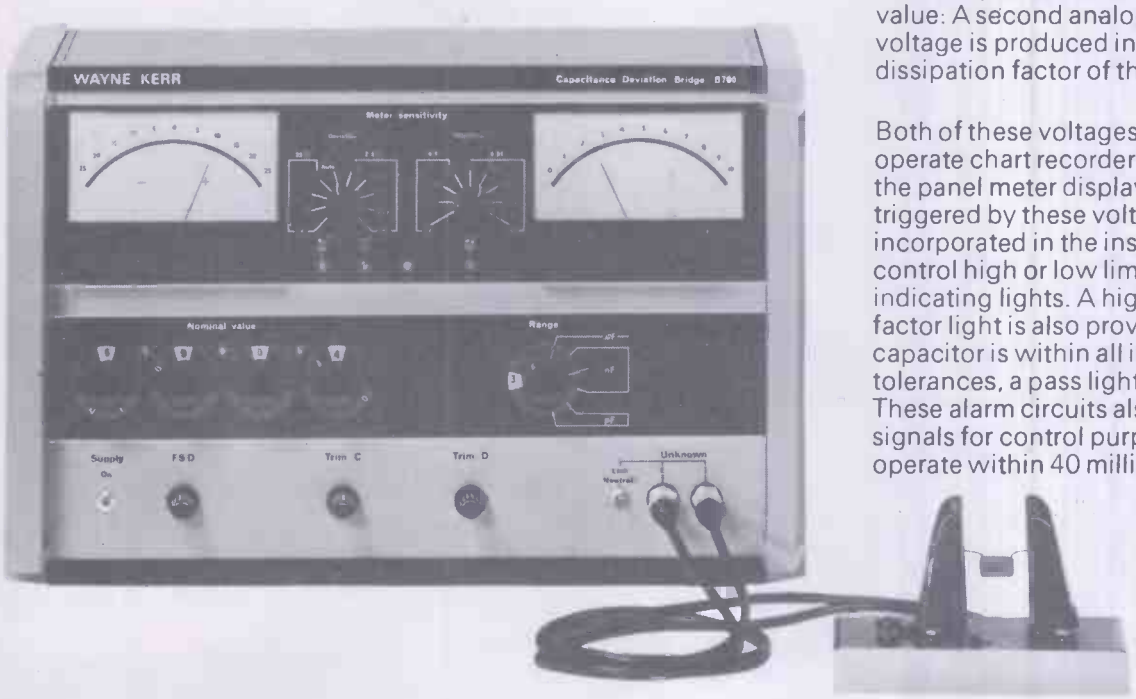
A production tool that balances itself— latest of Wayne Kerr's bridges

Capacitance Deviation Bridge B700



The B700 provides all the facilities required for checking capacitors during manufacture, quality control and batch selection to an accuracy of 0·1%. It can be adapted to control sorting, winding or cutting machines and is the latest in the WAYNE KERR series of transformer ratio-arm bridges.

This type of bridge circuit enables small values of capacitance to be accurately measured at the end of long lengths of screened cables, the measurement being unaffected by the capacitance of these cables. Also a very wide range of measurement is provided with the ability to set standard values digitally using only a few precise standard components.

This bridge balances itself automatically. It also produces a highly stable analogue output voltage in proportion to the percentage deviation of the component under test from the pre-set nominal capacitance value. A second analogue output voltage is produced in proportion to the dissipation factor of the capacitance.

Both of these voltages are available to operate chart recorders in addition to the panel meter display. Alarm circuits, triggered by these voltages, are also incorporated in the instrument and control high or low limit capacitance indicating lights. A high dissipation factor light is also provided. If the capacitor is within all its pre-set tolerances, a pass light is switched on. These alarm circuits also provide logic signals for control purposes and operate within 40 milliseconds.

Capacitance Range 10pF to 10μF in six decade ranges. Four digit Standard setting.
Accuracy ±0·1% of measured value of capacitance.
Deviation Range 0 to ±2·5%, 0 to ±25% of set capacitance.
Dissipation Range (tan δ) 0 to 0·01, 0 to 0·1.
Limit Settings ±0·2% to ±20% in seven steps of capacitance deviation with independent variable high and low limit controls. 0·001 to 0·1 in seven steps of dissipation factor with independent variable high limit control.
Bridge Frequency 1 kHz.

For more information, either call David O'Grady on 01-399 6751 or write to him at the address below:

WAYNE KERR

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Nombrex accuracy!

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Price £10.50

Every radio 'ham' needs one and at this low price you are buying a fully transistorised, high quality instrument.
Write for full technical leaflets.
Note a few of the specification details below:—

- **6 Ranges covering 1Ω to 100 MΩ**
  1 pF to 100μ F
- **Accuracy 2½% at centre to 5% near ends.**
- **Separate and clear R & C scales**
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- **Neon indication for capacitance leakage**
- **Battery operated or external supply**
- **Guaranteed for 12 months**

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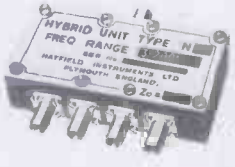
Hatfield get the signal right



Hatfield low-loss Passive Couplers pass a signal from one to a multiple of outlet ports. They can also be used to combine signals. Hybrid Types N.81 and N.82 cover a frequency from 3 MHz to 200 MHz.
For dividing a signal between two outputs while maintaining optimum VSWR and insertion loss characteristics, Hatfield can also supply an inexpensive VHF Signal Divider (765A) with a frequency range of d.c. to 1 GHz, through power to 1W maximum. Multicouplers for Antenna systems requiring up to 8 outputs are available to special order. *Send for full details of the full range of Hatfield Hybrid units and our Short Form Catalogue.*

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Hatfield Instruments (NZ) Ltd., P.O. Box 561, Napier, New Zealand.

WW—058 FOR FURTHER DETAILS

LINEAR RANGE OF

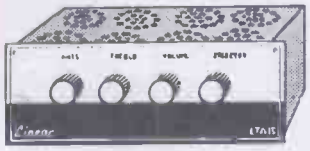
SOLID STATE A.C. MAINS AMPLIFIERS

employing only high grade components and transistors

LTA15 15 WATT AMPLIFIER

High Fidelity Output switched inputs for Gram, 'Mike', Tape and Radio.

Frequency Response 10-40,000cps—3dB.
Bass Control + 17dB to — 16dB at 40 cps.
Treble Control + 17dB to — 14dB at 14 Kcs.
Hum and Noise — 80dB.
Harmonic Distortion 0.2% at rated output.
Output for 3-8-15 ohm Loudspeakers.



Recommended Retail price £19
Size 9½x3¾x5¼ in. approx.

If required an attractive wood cabinet with veneer finish can be supplied for any model. Prices from £3·50

PTA30 HI-FI PUBLIC ADDRESS AMPLIFIER

A successor to our popular Conchord 30 watt unit.

Input Sensitivity 2 mv (max.)
Output 30 watts.
Output Sockets for Loudspeaker or combination of Speakers with total impedance between 3 ohms and 30 ohms.
Three individually controlled inputs for mixing purposes.
Housed in fully enclosed stove enamelled steel case.
Controls Vol (1) Vol (2) Vol (3) with mains switch, Treble 'lift' and 'cut.' Bass 'lift' and 'cut.'
AN IDEAL UNIT FOR VOCAL AND INSTRUMENTAL GROUPS SUITABLE FOR ANY KIND OF 'MIKE' AND INSTRUMENT PICK-UP, ALSO FOR RADIO, TAPE, OR GRAM.

Recommended Retail price £24
Size 12x3½x6 in. approx.

Available from your Local Hi-Fi Dealer

Please send a stamped addressed envelope for full descriptive details of above units.

Wholesale and Retail enquiries to: **LINEAR PRODUCTS LTD**
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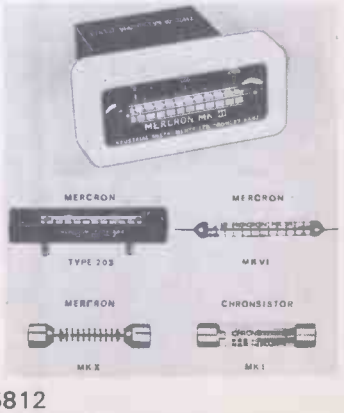
STATIC POWER CONVERSION EQUIPMENT



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FACTORY: PONSWOOD INDUSTRIAL ESTATE, HASTINGS, SUSSEX. TEL: HASTINGS 7344/5/6

WW—063 FOR FURTHER DETAILS

25 MHz Dual Trace Oscilloscope

The most remarkable feature of the new Telequipment D67 oscilloscope is the value for money it offers. Priced at £295, this dual trace scope offers a 25MHz bandwidth at 10mV/div sensitivity, delaying sweep, and 3% measuring accuracy.

Bright displays are obtained by using 10kV high voltage on the CRT which has a large 8 x 10cm viewing area.

A wide range of sweep rates from 2 sec/div to 200ns/div, and the delayed sweep feature, permit close examination of any part of a complex wave form and also allow for accurate measurement of the time jitter in the input wave form. Users who need to view television signals will also like the D67's ability to trigger at TV field and line rates.

In addition, the D67 has features not usually found in low-priced scopes—regulated power supplies, FET inputs to keep vertical trace drift to a minimum, and fully solid state design for added reliability. The price of £295 (U.K. only) is lower than that of any comparable scope on the market today.

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

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Wireless World

Electronics, Television, Radio, Audio

Sixty-first year of publication **September 1971** **Volume 77 Number 1431**

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 f.m. 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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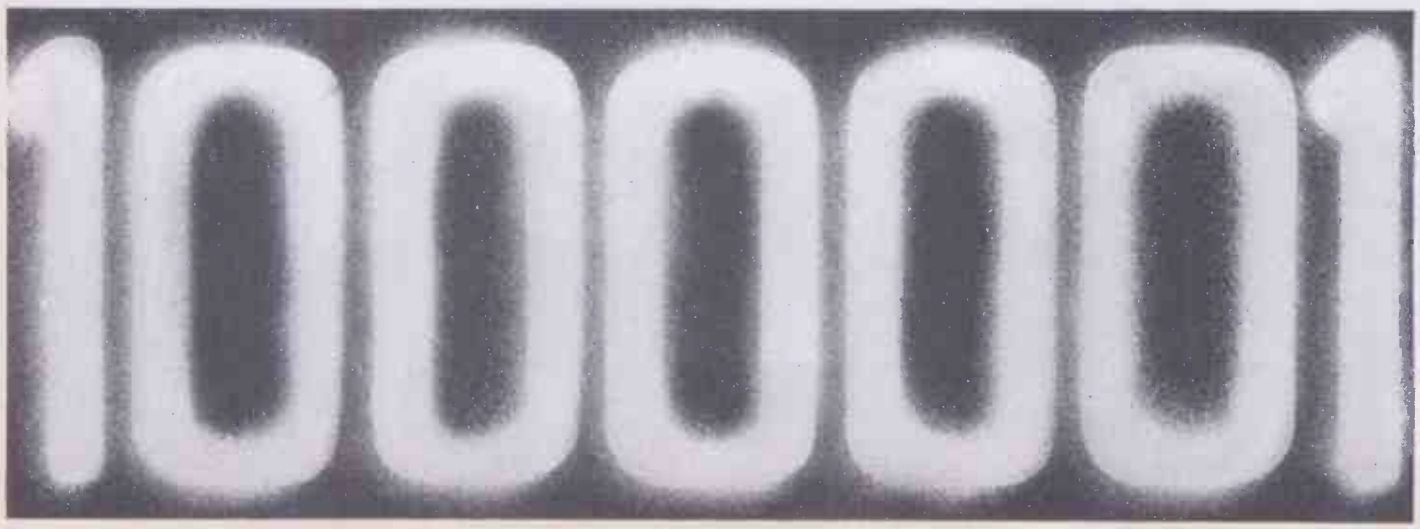
SE's Model SM 215 is the most accurate and linear digital volt meter in the world today. It's the one in a million DVM with unequalled performance: typical daily stability ± 1 part per million, coupled with linearity of ± 1 in a million, and annual stability of ± 10 parts per million. Four input ranges covering 0 – 1,000 V, full-scale 1,100,000 input current < 5 pA input impedance over 100,000 MΩ

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.

SE measures up to tomorrow's technology

SE Laboratories (Engineering) Ltd., North Feltham Trading Estate, Feltham, Middlesex. Telephone: 01-890 1166. Telex: 23995

Transducers, recorders, oscilloscopes, digital instrumentation, data systems, medical electronic equipment, etc.



WW—065 FOR FURTHER DETAILS

ANOTHER BREAKTHROUGH FROM AMPLIVOX

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 accoustic 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 accoustic 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.

AMPLIVOX COMMUNICATIONS LIMITED

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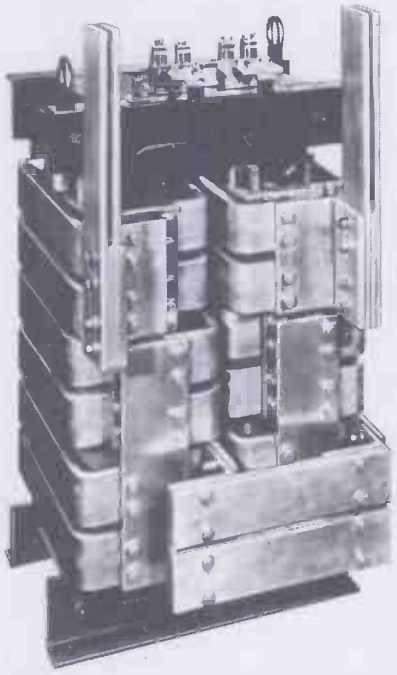
WW—066 FOR FURTHER DETAILS

Townley

Low voltage High current Transformers

better made at a more realistic price



Backed by 20 years experience, Harmsworth, Townley are making low voltage, high current transformers by methods which ensure reliability while keeping prices to the minimum.

We make the coils in cast aluminium, which has good mechanical and heat strength, and we use a modular form of construction which speeds and simplifies the work and reduces the cost to you.

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

HT1 rd

WW—067 FOR FURTHER DETAILS

RCA's five new IC arrays give you the design flexibility and cost-effectiveness of discrete devices

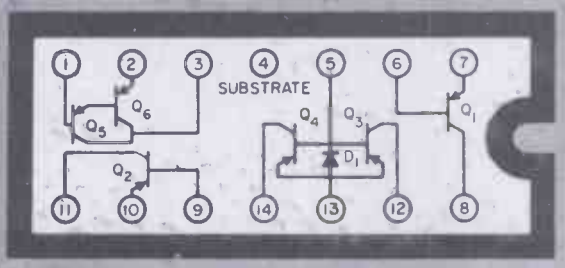
RCA linear IC arrays offer cost-conscious design engineers an ideal way to achieve new economies – they are priced as low as 6p (5p in volume) per transistor.

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.

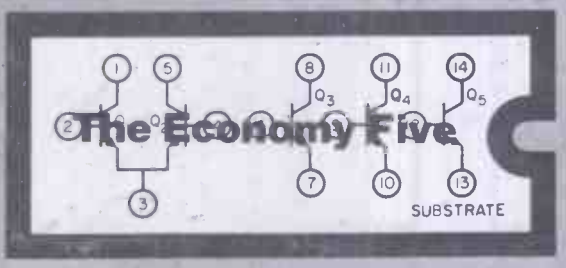
Check into the:

- 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.

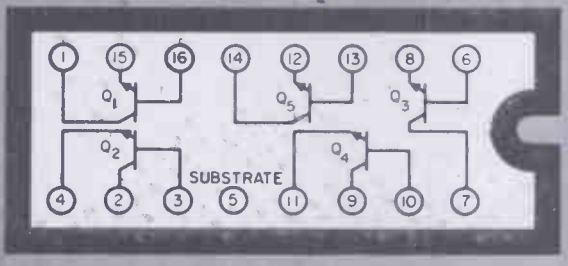
For further information on these devices and RCA's complete line of linear IC arrays, see your local RCA Representative or RCA Distributor. For a copy of RCA's Integrated Circuit Product Guide (or a specific technical bulletin by File No.) write to RCA Solid State, Europe, Sunbury-on-Thames, Middx.,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



CA3084



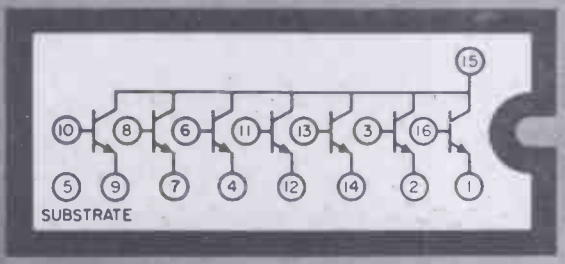
CA3086

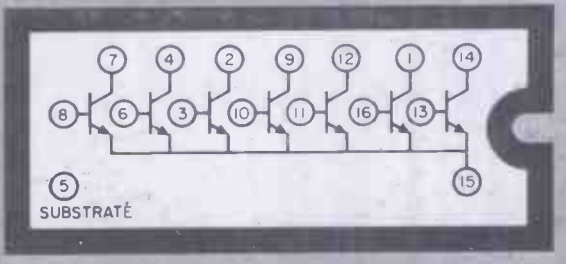


CA3083

Type	Package	Description	Technical Bulletin File No.	Price (1000-unit level)
CA3086	14-lead DIP	The economy five	483	£0·27
CA3084	14-lead DIP	P-n-p array	482	£0·97
CA3083	16-lead DIP	Five independent 100-mA n-p-n transistors, with V_{CEO} = 15 V (Q_1 and Q_2 are matched at low currents, i.e. 1 mA)	481	£0·92
CA3082	14-lead DIP	Seven 100-mA transistors with V_{CEO} = 16 V (common-collector array)	480	£1·00
CA3081	16-lead DIP	Seven 100-mA transistors with V_{CEO} = 16 V (common-emitter array)	480	£1·00

CA3082

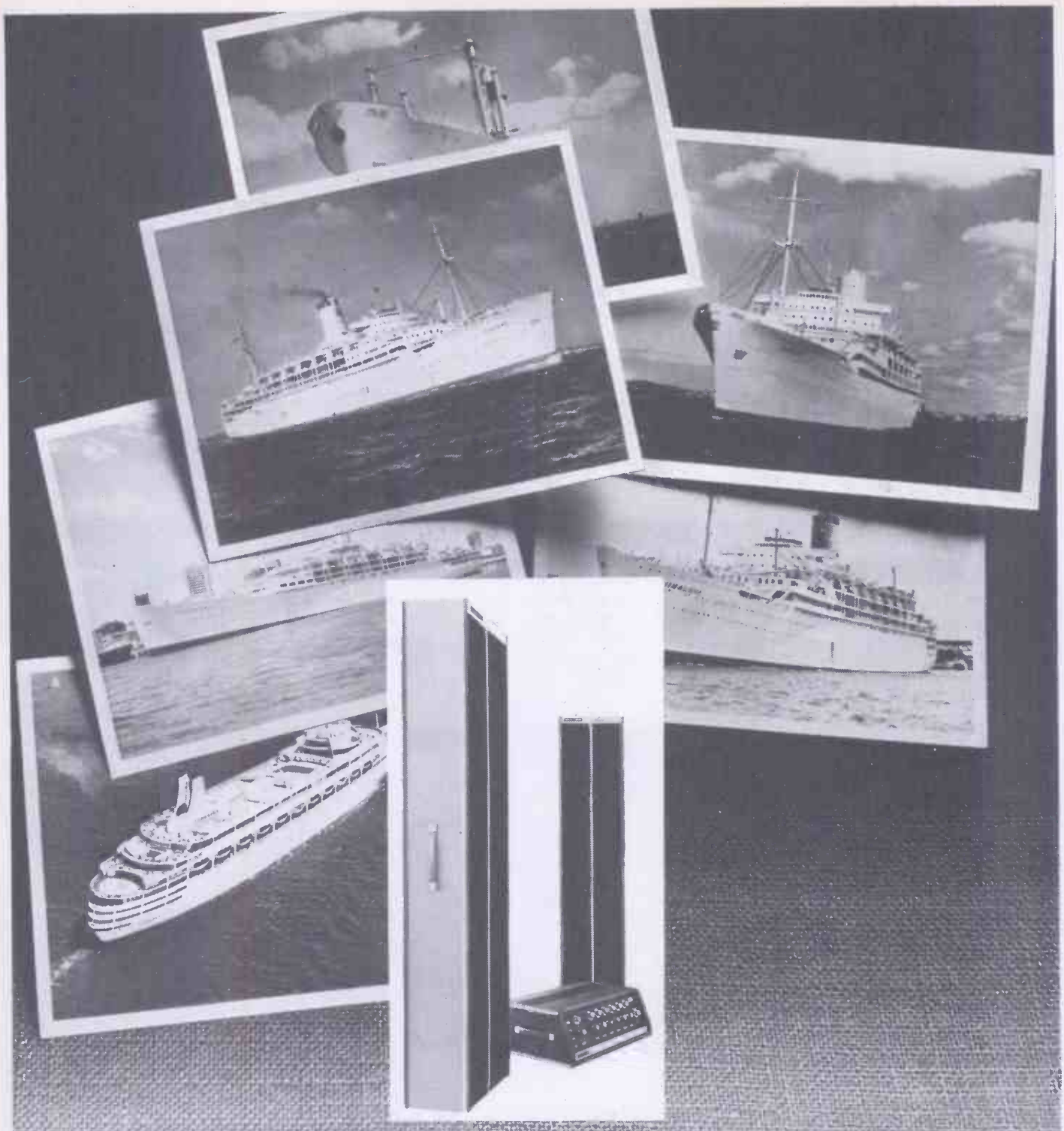




CA3081

RCA Solid State

WW—068 FOR FURTHER DETAILS



All sound and shipshape

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.

Please send me full information on the SHURE *Model VA302-E*

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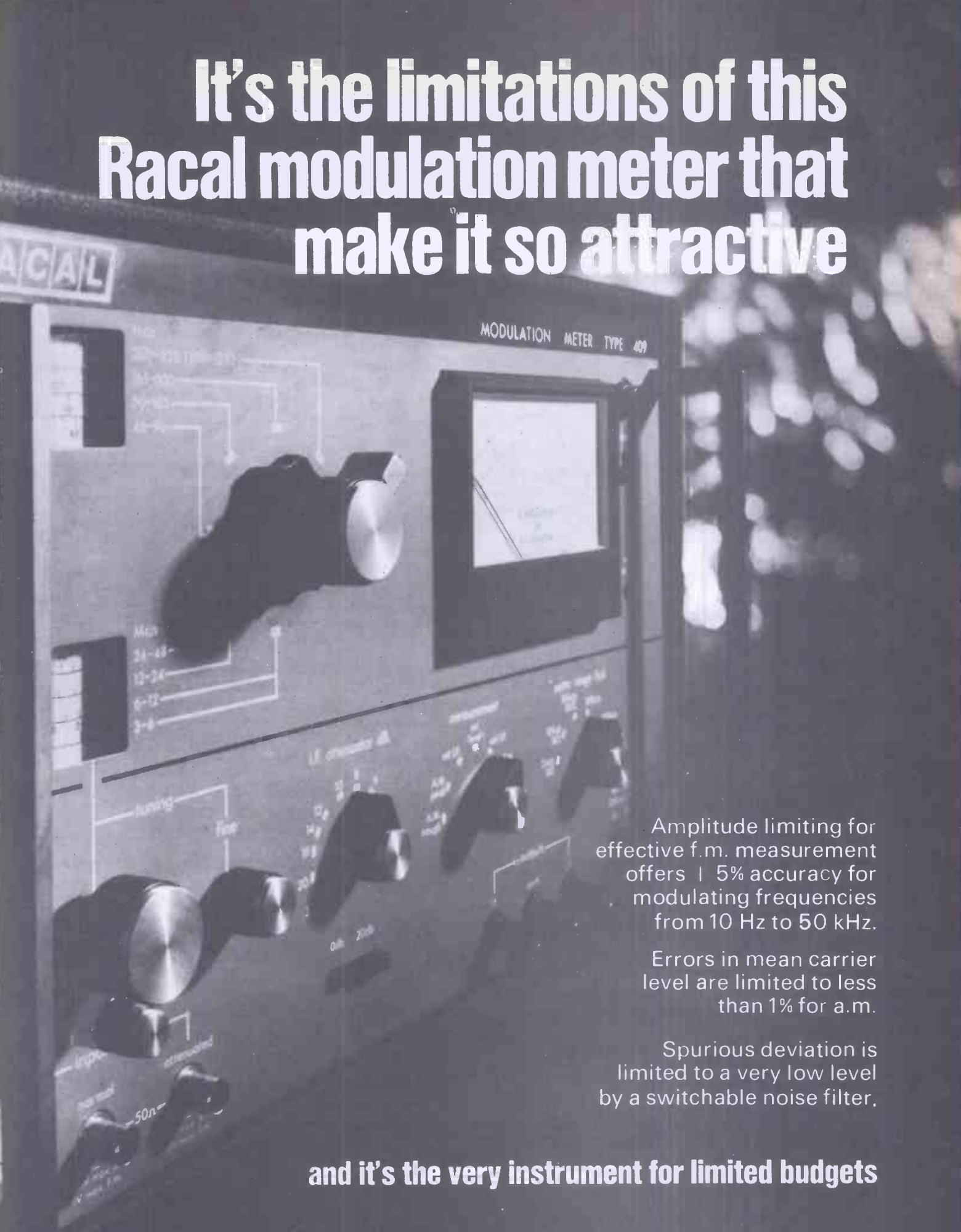
SHURE

WW 7

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

WW—069 FOR FURTHER DETAILS

It's the limitations of this Racal modulation meter that make it so attractive



Amplitude limiting for effective f.m. measurement offers ± 5% accuracy for modulating frequencies from 10 Hz to 50 kHz.

Errors in mean carrier level are limited to less than 1% for a.m.

Spurious deviation is limited to a very low level by a switchable noise filter.

and it's the very instrument for limited budgets

get full, unlimited details today from Racal Instruments

RACAL

RACAL INSTRUMENTS LIMITED
Duke Street, Windsor, Berkshire. Tel: Windsor 69811.
Telex: 847013 Cables Grams: Racal Windsor

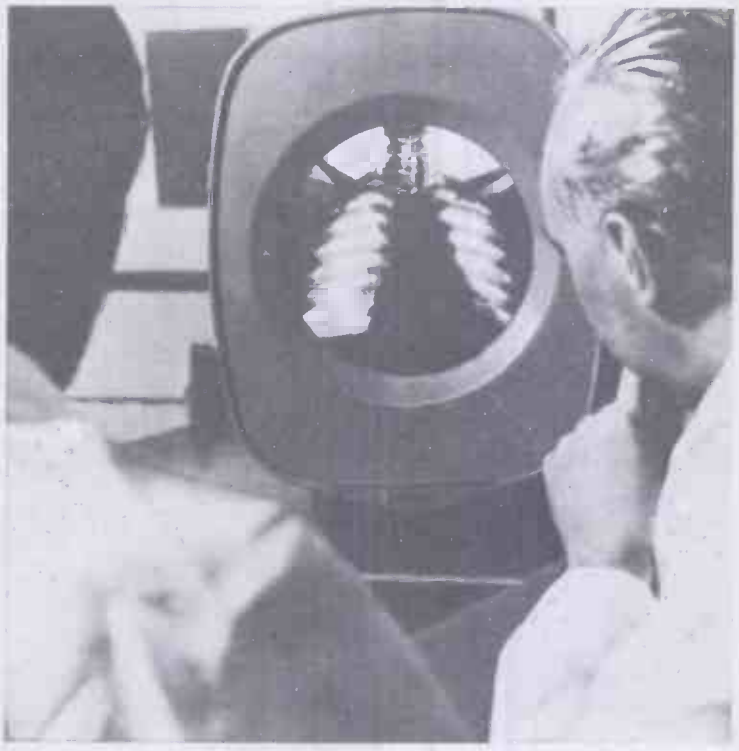
EEV knowhow helps you see

Some people still have the idea that TV cameras need good lighting conditions before they can work effectively. There is, of course, a wide range of vidicons for tungsten or daylight conditions, but until you know about our low light level tubes you haven't really seen anything.

You can, for example, see a black cat in a dark room, clearly, sharply, continuously – with light levels as low as 10^{-5} 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.

CRC 28

hings in a different light.



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 $\frac{1}{8}$ to $\frac{1}{2}$ second, 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.

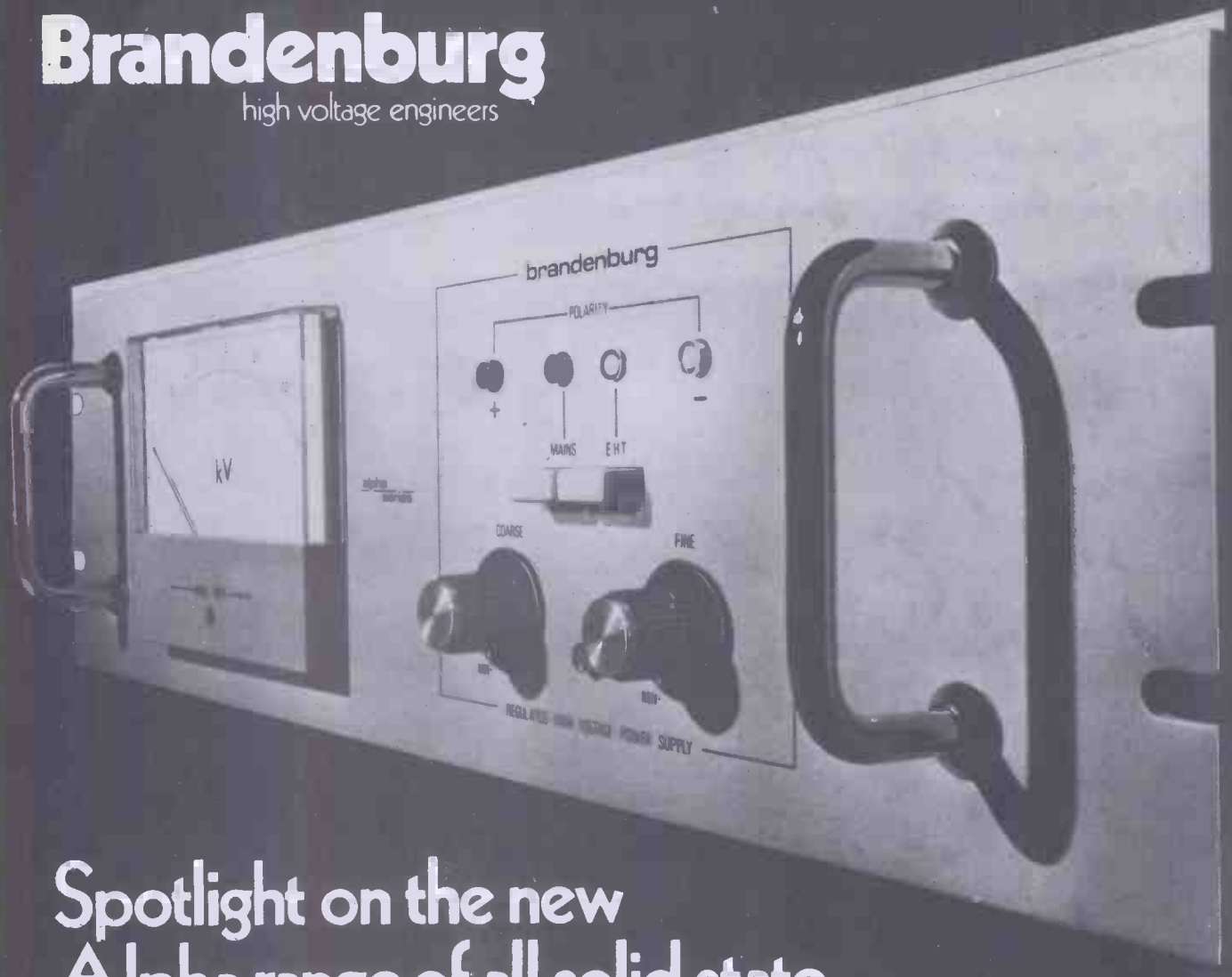
EEV know how.

ENGLISH ELECTRIC VALVE CO. LTD., Chelmsford, Essex, England, CM1 2QU. Tel: 0245 61777. Telex: 99103. Grams: Enelectico Chelmsford.

WW—071 FOR FURTHER DETAILS

Brandenburg

high voltage engineers



Spotlight on the new Alpha range of all solid state stabilised high voltage supplies – 500V to 60kV.

(40 parts per million for 15 minutes – guaranteed)

Alpha stabilised d.c. high voltage supplies have continuously variable outputs ranging from 500V to 60kV, from 0·4mA to 5mA. Polarity reversal is achieved within seconds. Solid state inverters, operating at high frequency into a ferrite cored transformer, provide the required voltage, which is rectified by a Cockcroft Walton multiplier. The Alpha range is light and compact, designed for rack mounting or bench use, and its performance meets the requirements of both industrial and laboratory duties.

Output Voltage Control	Continuously variable by coarse and fine potentiometers on front panel
Output Voltage Indication	4.5in scale length meter
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 ± 7½% mains change)
Drift	40 parts per million per 15 minutes

MODEL 507R (Reversible)
500V to 5kV, 5mA, d.c.
MODEL 707R (Reversible)
1.5kV to 15kV, 2mA, d.c.
MODEL 807R (Reversible)
3kV to 30kV, 1mA, d.c.
MODEL 907P (Positive*)
6kV to 60kV, 0.4mA, d.c.
MODEL 907N (Negative*)
6kV to 60kV, 0.4mA, d.c.

** with respect to ground*

For full details of Alpha (prices are very competitive) and the complete range of Brandenburg high voltage equipment send now to:

Brandenburg Limited

939 London Road, Thornton Heath, Surrey, CR4 6JE. England.
Tel: 01-689 0441 Telex 946149.

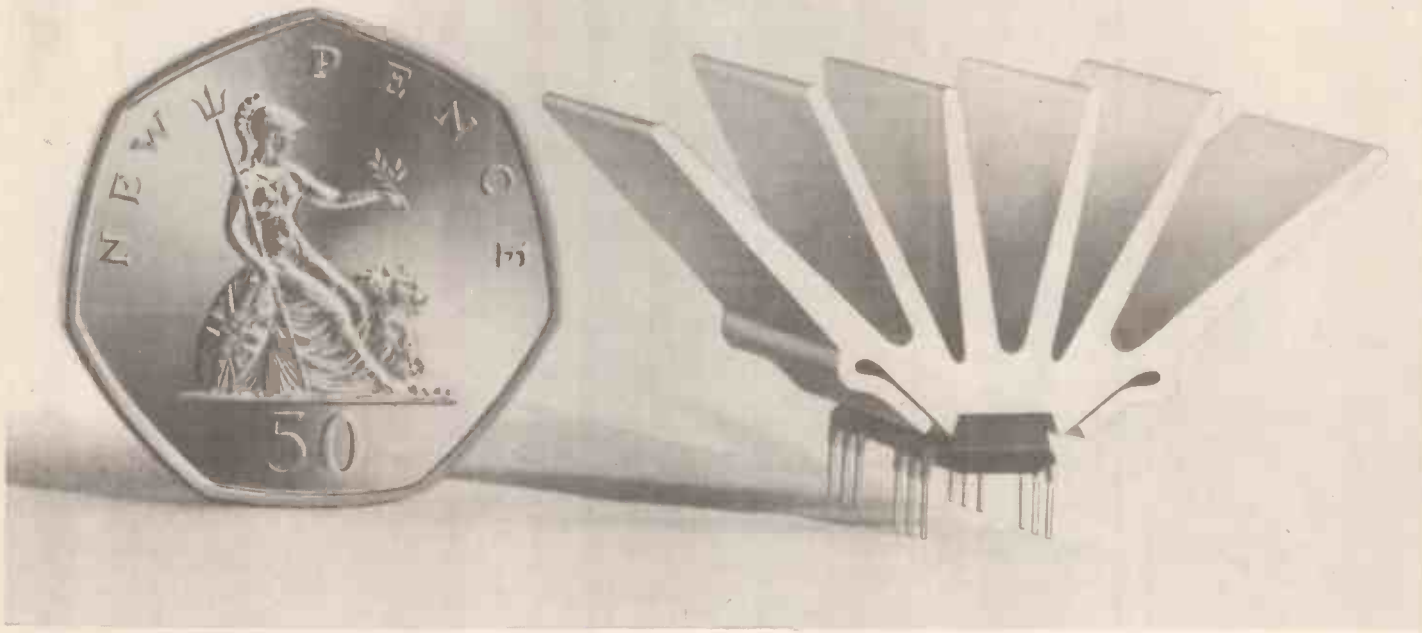
Switzerland: Fritz Weber, In der Rehweid 8, 8122 Pfaffhausen, Zurich. Telefon: 051-854444.

WW—072 FOR FURTHER DETAILS

P3630

new

Super IC-12



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. No other heat sink needed.
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

SINCLAIR GENERAL GUARANTEE

Should you not be completely satisfield with your purchase when you receive it from us, return the goods without delay and your money will be refunded in full, including cost of return postage, at once and without question. Full service facilities are available to all Sinclair customers.

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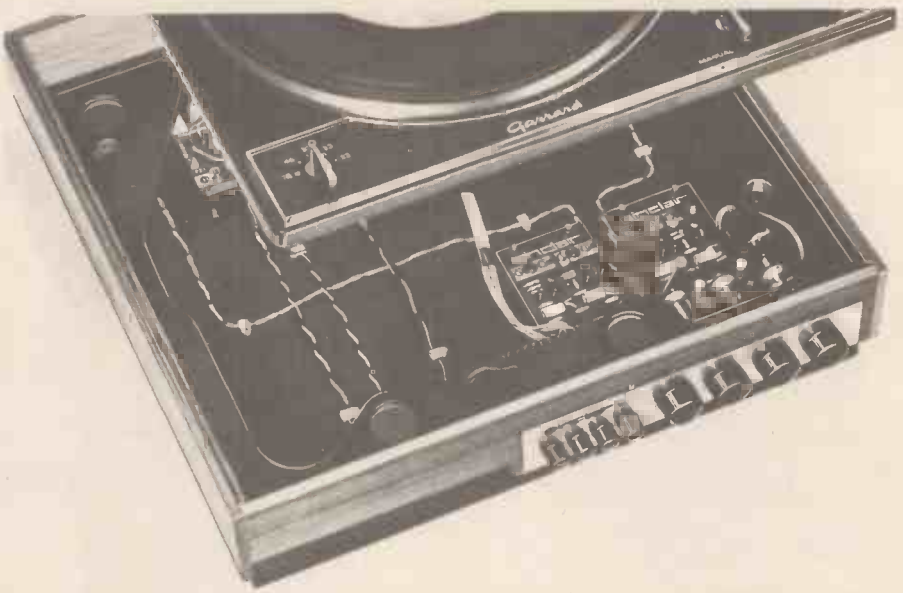
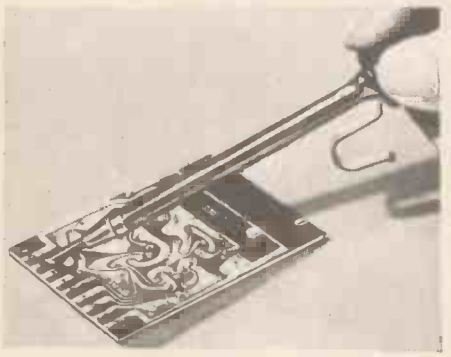
WW—073 FOR FURTHER DETAILS

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

System	The Units to use	together with	Cost of Units
Simple battery record player	**Z.30**	Crystal P.U., 12V battery volume control	**£4.48**
Mains powered record player	**Z.30, PZ.5**	Crystal or ceramic P.U. volume control etc.	**£9.45**
20 + 20 W. stereo amplifier for most needs	**2 x Z.30s, Stereo 60, PZ.5**	Crystal, ceramic or mag. P.U., F.M. Tuner, etc.	**£23.90**
20 + 20 W. stereo amplifier with high performance spkrs.	**2 x Z.30s, Stereo 60, PZ.6**	High quality ceramic or magnetic P.U., F.M. Tuner, Tape Deck, etc.	**£26.90**
40 + 40 W. R.M.S. de-luxe stereo amplifier	**2 x Z.50s, Stereo 60 PZ.8, mains trsfrmr**	As above	**£34.88**
Indoor P.A.	**Z.50, PZ.8, mains transformer**	Mic., guitar, speakers, etc., controls	**£19.43**

F.M. Stereo Tuner **(£25)** & A.F.U. Filter Unit **(£5.98)** may be added as required.

Sinclair Radionics Limited, London Road, St. Ives, Huntingdonshire PE17 4HJ.
Tel: St. Ives (048 06) 4311

sinclair

WW—074 FOR FURTHER DETAILS

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.50 units are interchangeable with Z.30s in all applications).***
Power Outputs
Z.30 15 watts R.M.S. into 8 ohms using 35 volts: 20 watts R.M.S. into 3 ohms using 30 volts.
Z.50 40 watts R.M.S. into 3 ohms using 40 volts: 30 watts R.M.S. into 8 ohms using 50 volts.
Frequency response: 30 to 300,000Hz±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

PZ.5

PZ.8

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 unstabilised* **£4.98**
PZ.6 *35 volts stabilised* **£7.98**
PZ.8 *45 volts stabilised (less mains transformer)* **£7.98**
PZ.8 *mains transformer* **£5.98**

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 thereafter. 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:** ±200 KHz. **Signal to noise ratio:** >65dB. **Audio frequency response:** 10 Hz – 15 KHz (±1dB). **Total harmonic distortion:** 0.15% 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 25,000 Hz. Ceramic p.u. – up to 3mV: Aux – up to 3mV. **Output:** 250mV. **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:** brushed aluminium with black knobs and controls. **Size:** 66 x 40 x 207mm. *Built tested and guaranteed.* **£9.98**

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

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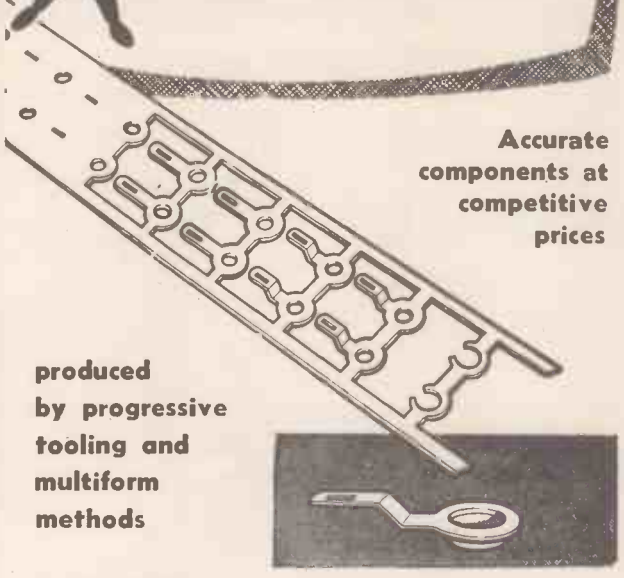

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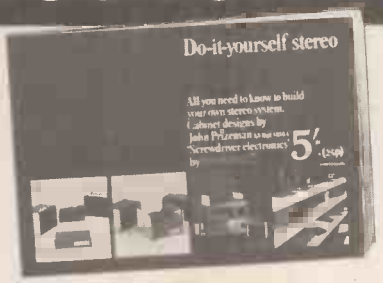

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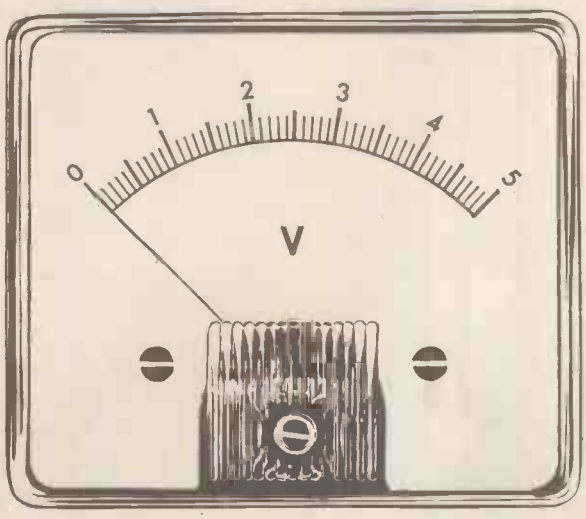

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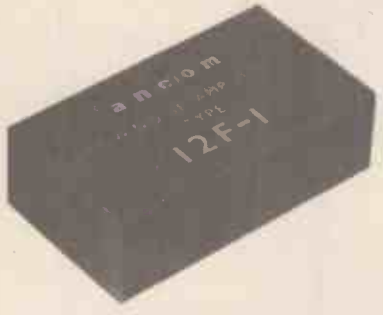

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61	100	5	12	10·2 × 8·9 × 8·3	2·28	52
62	250	12	4	9·5 × 12·7 × 11·4	5·05	67
63	500	27	0	17·1 × 11·4 × 15·9	9·74	*
92	1000	40	0	17·8 × 17·1 × 21·6	17·94	*
128	2000	63	0	24·1 × 21·6 × 15·2	29·66	*
129	3000	84	0	21·6 × 21·6 × 20·3	46·38	*
190	6000	178	0	31·1 × 35·6 × 17·1	76·11	*

AUTO SERIES (NOT ISOLATED)

Ref. No.	VA (Watts)	Weight lb	oz	Size cm.	Auto Taps	£	P & P Np
113	20		11	7·3 × 4·3 × 4·4	0-115-210-240	0·74	20
64	75	1	14	7·0 × 6·4 × 6·0	0-115-210-240	1·44	30
4	150	3	0	8·9 × 6·4 × 7·6	0-115-200-220-240	1·74	36
66	300	6	0	10·2 × 10·2 × 9·5	,, ,,	3·38	52
67	500	12	8	14·0 × 10·2 × 11·4	,, ,,	5·03	67
84	1000	16	0	11·4 × 14·0 × 14·0	,, ,,	9·12	82
93	1500	28	9	13·5 × 14·9 × 16·5	,, ,,	13·22	*
95	2000	40	0	17·8 × 16·5 × 21·6	,, ,,	17·26	*
73	3000	45	8	17·4 × 18·1 × 21·3	,, ,,	23·47	*

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213	1·0	0·5	1	0	8·3 × 5·1 × 5·1	0-12V at 0·5A × 2	0·88	22
71	2	1	1	0	7·0 × 6·4 × 5·7	0-12V at 1A × 2	1·16	22
18	4	2	2	4	8·3 × 7·0 × 7·0	0-12V at 2A × 2	1·62	36
70	6	3	3	12	10·2 × 7·6 × 8·6	0-12V at 3A × 2	1·95	42
72	10	5	6	3	7·9 × 10·8 × 10·2	0-12V at 5A × 2	2·56	52
17	16	8	7	8	12·1 × 9·5 × 10·2	0-12V at 8A × 2	3·95	52
115	20	10	11	13	12·1 × 11·4 × 10·2	0-12V at 10A × 2	5·03	67
187	30	15	16	12	13·3 × 12·1 × 12·1	0-12V at 15A × 2	9·28	82

30 VOLT RANGE

Ref. No.	Amps.	Weight lb	oz.	Size cm.	Secondary Taps	£	P & P Np
112	0·5	1	4	8·3 × 3·7 × 4·9	0-12-15-24-30V	0·88	22
79	1·0	2	0	7·0 × 6·4 × 6·0	,, ,,	1·18	36
3	2·0	3	2	8·9 × 7·0 × 7·6	,, ,,	1·75	36
20	3·0	4	6	10·2 × 8·9 × 8·6	,, ,,	2·16	42
21	4·0	6	0	10·2 × 9·5 × 8·6	,, ,,	2·56	52
117	6·0	7	8	12·1 × 9·5 × 10·2	,, ,,	3·79	52
89	10·0	12	2	14·0 × 10·2 × 11·4	,, ,,	6·21	67

50 VOLT RANGE

Ref. No.	Amps.	Weight lb	oz	Size cm.	Secondary Taps	£	P & P Np
102	0·5	1	11	7·0 × 7·0 × 5·7	0-19-25-33-40-50V	1·16	30
103	1·0	2	10	8·3 × 7·3 × 7·0	,, ,,	1·69	36
104	2·0	5	0	10·2 × 8·9 × 8·6	,, ,,	2·34	42
105	3·0	6	0	10·2 × 10·2 × 8·3	,, ,,	3·18	52
106	4·0	9	4	12·1 × 11·4 × 10·2	,, ,,	4·20	52
107	6·0	12	4	12·1 × 11·1 × 13·3	,, ,,	6·21	67
118	8·0	18	9	13·3 × 13·3 × 12·1	,, ,,	8·10	97
119	10·0	19	12	16·5 × 11·4 × 15·9	,, ,,	10·15	97

60 VOLT RANGE

Ref. No.	Amps.	Weight lb	oz	Size cm.		£	P & P Np
124	0·5	2	4	8·3 × 9·5 × 6·7	0-24-30-40-48-60V	1·18	36
126	1·0	3	0	8·9 × 7·6 × 7·6	,, ,,	1·64	36
127	2·0	5	6	10·2 × 8·9 × 8·6	,, ,,	2·56	42
123	4·0	10	6	11·4 × 9·5 × 11·4	,, ,,	5·03	67
120	6·0	16	12	13·3 × 12·1 × 12·1	,, ,,	7·28	82
122	10·0	23	2	16·5 × 12·7 × 16·5	,, ,,	12·05	*

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45	1·5	1	9	7·0 × 6·0 × 6·0	Please note, these units do not include rectifiers	1·17	30
5	4·0	3	11	10·2 × 7·0 × 8·3		1·77	42
86	6·0	5	12	10·2 × 8·9 × 8·3		2·67	52
146	8·0	6	4	8·9 × 10·2 × 10·2		3·04	52
50	12·5	11	14	13·3 × 10·8 × 12·1		4·52	67

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AC125	17p	AD161/		BC114	30p	BC180	20p	BF154	35p	BFX87	25p	MAT100	15p	OC204	25p	2N697	15p	2N2219	27p
AC126	17p	162(MP)	63p	BC115	30p	BC181	22p	BF157	45p	BFX88	22p	MAT101	17p	OC205	35p	2N698	24p	2N2220	22p
AC127	17p	ADT140	80p	BC116	35p	BC182	10p	BF158	25p	BFY50	20p	MAT120	15p	OC309	35p	2N699	55p	2N2221	22p
AC128	17p	AD2 11	£2.00	BC117	35p	BC182L	10p	BF159	30p	BFY51	20p	MAT121	17p	P346A	17p	2N706	7p	2N2222	27p
AC141K	17p	AD2 12	£2.10	BC118	25p	BC183	10p	BF160	30p	BFY52	20p	MPF102	43p	P397	45p	2N706A	8p	2N2368	17p
AC142K	17p	AF114	17p	BC119	45p	BC183L	10p	BF162	30p	BFY53	17p	MPF105	43p	QCP71	43p	2N708	12p	2N2369	15p
AC151	15p	AF115	17p	BC125	35p	BC184	13p	BF163	35p	BSX19	15p	OC19	30p	ORP12	43p	1N709	45p	2N2369A	15p
AC154	15p	AF116	17p	BC126	35p	BC184L	13p	BF164	35p	BSX20	15p	OC20	50p	ORP60	40p	2N711	40p	2N2411	50p
AC155	17p	AF117	17p	BC132	25p	BC186	27p	BF165	35p	BSY25	15p	OC22	30p	ORP61	40p	2N717	42p	2N2412	50p
AC156	17p	AF118	30p	BC134	30p	BC187	27p	BF167	22p	BSY26	15p	OC23	33p	ST140	12p	2N718	24p	2N2646	55p
AC157	17p	AF124	21p	BC135	30p	BC207	11p	BF173	22p	BSY27	15p	OC24	45p	ST141	17p	2N718A	50p	2N2711	22p
AC165	17p	AF125	20p	BC136	30p	BC208	11p	BF176	35p	BSY28	15p	OC25	25p	TIS43	40p	2N726	27p	2N2712	22p
AC166	17p	AF126	20p	BC137	35p	BC209	11p	BF177	35p	BSY29	15p	OC26	25p	UT46	27p	2N727	27p	2N2714	25p
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AC168	20p	AF139	33p	BC140	35p	BC213L	11p	BF179	50p	BSY39	15p	OC29	40p	V410A	45p	2N744	17p	2N2904A	30p
AC169	14p	AF178	50p	BC143	35p	BC214L	12p	BF180	30p	BSY40	30p	OC35	33p	2G301	19p	2N914	17p	2N2905	25p
AC176	23p	AF179	50p	BC142	45p	BC225	25p	BF181	30p	BSY41	35p	OC36	40p	2G302	19p	2N918	30p	2N2905A	30p
AC177	20p	AF180	50p	BC143	40p	BC226	35p	BF182	30p	BSY95	12p	OC41	20p	2G303	19p	2N929	22p	2N2906	25p
AC187	30p	AF181	50p	BC145	45p	BC317	12p	BF183	30p	BSY95A	12p	OC42	22p	2G304	20p	2N930	25p	2N2906A	27p
AC188	30p	AF186	45p	BC147	17p	BC318	12p	BF184	25p	Bu105	£3.90	OC44	15p	2G306	35p	2N1131	20p	2N2907	25p
ACY17	25p	AF239	37p	BC148	12p	BC319	12p	BF185	30p	CTITE	60p	OC45	12p	2G308	35p	2N1132	22p	2N2907A	30p
ACY18	20p	AF2 11	37p	BC149	17p	BCY30	20p	BF188	30p	C406	30p	OC70	15p	2G309	35p	2N1302	17p	2N2923	13p
ACY19	22p	AF2 12	45p	BC150	17p	BCY31	22p	BF194	23p	C407	25p	OC71	9p	2G339	17p	2N1303	17p	2N2924	13p
ACY20	20p	AL102	85p	BC151	20p	BCY32	25p	BF195	24p	C424	17p	OC72	12p	2G339A	15p	2N1304	20p	2N2925	13p
ACY21	20p	AL103	85p	BC152	17p	BCY33	17p	BF196	30p	C425	40p	OC74	12p	2G334	15p	2N1305	20p	2N2926(G)	12p
ACY22	19p	ASY26	25p	BC153	27p	BCY34	20p	BF197	35p	C426	30p	OC75	15p	2G345	15p	2N1306	22p	2N2926(Y)	11p
ACY27	18p	ASY27	30p	BC154	30p	BCY70	17p	BF200	45p	C428	20p	OC76	15p	2G371	13p	2N1307	22p	2N2926(O)	10p
ACY28	15p	ASY28	25p	BC157	20p	BCY71	30p	BF222	80p	C441	27p	OC77	25p	2G371B	10p	2N1308	27p	2N3010	80p
ACY29	30p	ASY29	25p	BC158	17p	BCY72	15p	BF257	35p	C442	35p	OC81	15p	2G374	17p	2N1309	27p	2N3011	20p
ACY30	25p	ASY50	25p	BC159	20p	BCZ11	20p	BF270	25p	C444	37p	OC81D	15p	2G377	27p	2N1613	17p	2N3053	20p
ACY31	25p	ASY51	25p	BC167	13p	BD121	85p	BF271	17p	C450	17p	OC82	15p	2G378	15p	2N1711	20p	2N3054	50p
ACY34	18p	ASY52	25p	BC168	13p	BD123	85p	BF272	60p	C720	12p	OC820	15p	2G382	15p	2N1899	35p	2N3055	63p
ACY35	18p	ASY54	25p	BC169	13p	BD124	75p	BF273	30p	C722	25p	OC83	20p	2G401	30p	2N1890	45p	2N3391	17p
ACY36	30p	ASY55	25p	BC170	12p	BD131	80p	BF274	30p	C740	25p	OC84	20p	2G414	30p	2N1893	37p	2N3391A	20p
ACY40	15p	ASY56	25p	BC171	13p	BD132	80p	BF308	35p	C742	17p	OC139	15p	2G417	25p	2N2160	60p	2N3392	17p
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AD140	40p	ASZ21	40p	BC174	13p	BF117	45p	BFW10	55p	C762	17p	OC171	15p	2N404	22p	2N2192	30p	2N3395	20p
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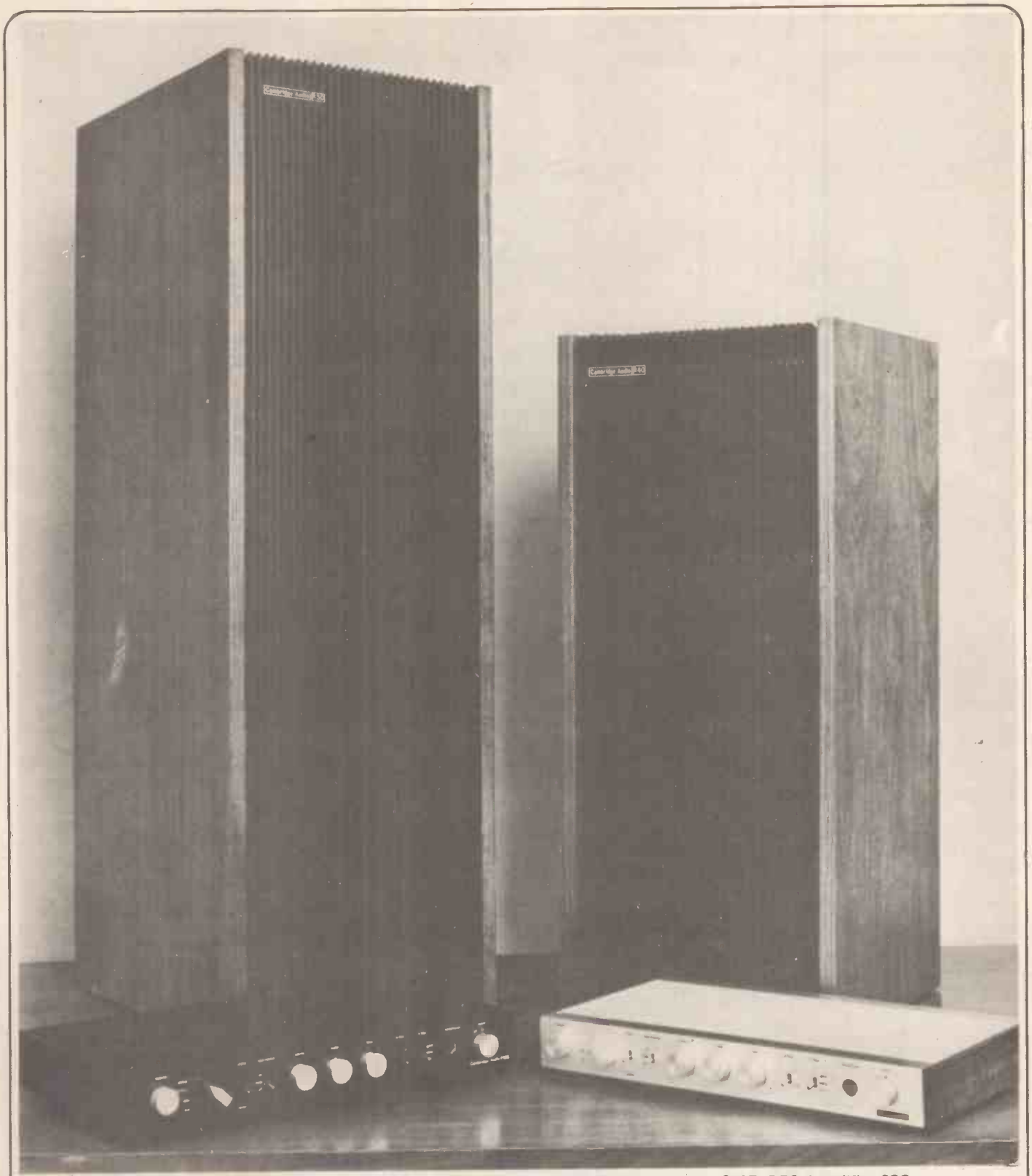

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SN7446	1·00	0·95	SN74160	1·80	1·75
SN7447	1·00	0·95	SN74161	2·60	2·55
SN7448	1·00	0·95	SN74162	4·26	4·10
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SN7450	0·20	0·18	SN74164	2·20	2·10
SN7451	0·20	0·18	SN74165	2·25	2·15
SN7453	0·20	0·18	SN74166	4·45	4·20
SN7454	0·20	0·18	SN74167	6·40	6·10
SN7460	0·20	0·18	SN74170	4·38	4·18
SN7470	0·40	0·38	SN74174	2·40	2·30
SN7472	0·32	0·30	SN74175	1·68	1·60
SN7473	0·43	0·41	SN74176	2·64	2·55
SN7474	0·43	0·41	SN74177	2·64	2·55
SN7475	0·45	0·44	SN74180	2·13	2·05
SN7476	0·45	0·44	SN74181	9·33	9·00
SN7480	0·70	0·65	SN74182	2·03	1·95
SN7481	1·40	1·38	SN74184	4·80	4·60
SN7482	0·87	0·82	SN74185	4·80	4·60
SN7483	0·87	0·82	SN74190	1·80	1·70
SN7484	2·00	1·85	SN74191	1·80	1·70
SN7485	3·62	3·40	SN74192	1·75	1·65
SN7486	0·33	0·30	SN74193	1·75	1·65
SN7490	0·87	0·84	SN74194	2·67	2·55
SN7491AN	1·21	1·10	SN74195	2·25	2·10
SN7492	0·87	0·84	SN74196	2·64	2·55
SN7493	0·87	0·84	SN74198	5·95	5·65
SN7494	0·87	0·84	SN74199	5·95	5·65
SN7495	0·87	0·84	9300	2·10	1·95
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2N404	0·22½	2N3439	1·30	40309	0·32½	BC159	0·12	BFY56A	0·57½	NKT240	0·27½
2N696	0·20	2N3440	0·97½	40310	0·45	BC160	0·62½	BFY75	0·30	NKT241	0·27½
2N697	0·17	2N3570	1·25	40311	0·35	BC167	0·11	BFY76	0·42½	NKT242	0·20
2N698	0·25	2N3572	0·97½	40312	0·47½	BC168B	0·10	BFY77	0·57½	NKT243	0·62½
2N699	0·30	2N3605	0·27½	40314	0·37½	BC168C	0·11	BFY90	0·67½	NKT244	0·17½
2N706	0·12½	2N3606	0·27½	40315	0·37½	BC169B	0·11	BFW58	0·27½	NKT245	0·20
2N706A	0·12½	2N3607	0·22½	40316	0·47½	BC169C	0·12	BFW59	0·25	NKT261	0·20
2N708	0·15	2N3702	0·11	40317	0·37½	BC170	0·12½	BFW60	0·25	NKT262	0·30
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2N1131	0·25	2N3773	2·40	40406	0·57½	BCY31	0·30	BSX77	0·27½	NKT452	0·62½
2N1132	0·25	2N3791	2·06	40407	0·40	BCY32	0·50	BSX78	0·27½	NKT453	0·47½
2N1302	0·17½	2N3819	0·35	40408	0·52½	BCY33	0·25	BSY10	0·27½	NKT603F	0·32½
2N1303	0·17½	2N3823	0·97½	40409	0·55	BCY34	0·30	BSY11	0·27½	NKT613F	0·32½
2N1304	0·22½	2N3854	0·27½	40410	0·62½	BCY38	0·40	BSY24	0·15	NKT674F	0·30
2N1305	0·22½	2N2754A	0·27½	40412	0·50	BCY39	0·60	BSY25	0·15	NKT677F	0·30
2N1306	0·25	2N3855	0·27½	40467A	0·57½	BCY40	0·50	BSY26	0·17½	NKT713	0·25
2N1307	0·25	2N3855A	0·30	40468A	0·35	BCY42	0·15	BSY27	0·17½	NKT717	0·42½
2N1308	0·30	2N3856	0·30	40528	0·72½	BCY43	0·15	BSY28	0·17½	NKT734	0·27½
2N1309	0·30	2N3856A	0·35	40600	0·57½	BCY54	0·32½	BSY29	0·17½	NKT736	0·35
2N1507	0·17½	2N3858	0·25	40673	0·85	BCY58	0·22½	BSY32	0·25	NKT773	0·25
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2N1631	0·35	2N3859	0·27½	AC126	0·20	BCY60	0·97½	BSY37	0·25	NKT10339	0·32½
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2N1671B	1·00	2N3877A	0·40	AC187	0·62½	BCZ11	0·42½	BSY52	0·32½	NKT20339	0·37½
2N1701	1·62½	2N3900	0·37½	AC188	0·37½	BDI16	1·12½	BSY53	0·37½	NKT80111	0·77½
2N1711	0·25	2N3900A	0·40	ACY17	0·27½	BDI21	0·65	BSY54	0·40	NKT80112	0·97½
2N1889	0·32½	2N3901	0·97½	ACY18	0·25	BDI23	0·82½	BSY56	0·90	NKT80113	1·12½
2N1893	0·37½	2N3903	0·35	ACY19	0·25	BDI24	0·60	BSY78	0·47½	NKT80211	0·92½
2N2147	0·82½	2N3904	0·35	ACY20	0·25	BDI31	0·75	BSY79	0·45	NKT80212	0·92½
2N2148	0·57½	2N3905	0·37½	ACY21	0·25	BDI32	0·85	BSY82	0·52½	NKT80213	0·92½
2N2160	0·57½	2N3906	0·37½	ACY22	0·20	BDY10	1·37½	BSY90	0·57½	NKT80214	0·92½
2N2193	0·40	2N4058	0·17	ACY28	0·20	BDY11	1·62½	BSY95A	0·12½	NKT80215	0·92½
2N2193A	0·42½	2N4059	0·10½	ACY40	0·20	BDY17	1·50	BSW41	0·42½	NKT80216	0·92½
2N2194A	0·30	2N4060	0·12½	ACY41	0·25	BDY18	1·75	BSW70	0·27½	OC20	0·75
2N2217	0·27½	2N4061	0·12½	ACY44	0·40	BDY19	1·97½	C111	0·75	OC22	0·50
2N2218	0·23	2N4062	0·12½	AD140	0·52½	BDY20	1·12½	C424	0·27½	OC23	0·60
2N2219	0·23	2N4244	0·47½	AD149	0·57½	BDY38	0·97½	C425	0·55	OC24	0·60
2N2220	0·25	2N4245	0·42½	AD150	0·62½	BDY60	1·25	C426	0·40	OC25	0·50
2N2221	0·25	2N4254	0·42½	AD161	0·37½	BDY61	1·25	C428	0·37½	OC26	0·27½
2N2222	0·30	2N4255	0·42½	AD162	0·37½	BDY62	1·00	C744	0·30	OC28	0·62½
2N2297	0·30	2N4284	0·17½	AF106	0·42½	BFI15	0·25	ME0402	0·25	OC29	0·62½
2N2368	0·17½	2N4285	0·17½	AF114	0·25	BFI17	0·47½	ME0411	0·22½	OC35	0·50
2N2369	0·17½	2N4286	0·17½	AF115	0·25	BFI63	0·37½	ME0412	0·25	OC36	0·62½
2N2369A	0·17½	2N4287	0·17½	AF116	0·25	BFI67	0·18	ME0413	0·22½	OC41	0·22½
2N2410	0·42½	2N4288	0·17½	AF117	0·25	BFI73	0·19	ME1120	0·25	OC42	0·25
2N2483	0·27½	2N4289	0·17½	AF118	0·62½	BFI77	0·30	ME4001	0·15	OC44	0·20
2N2484	0·32½	2N4290	0·17½	AF119	0·20	BFI78	0·30	ME4002	0·15	OC45	0·12½
2N2539	0·22½	2N4291	0·17½	AF124	0·22½	BFI79	0·30	ME4003	0·20	OC46	0·15
2N2540	0·22½	2N4292	0·12½	AF125	0·20	BFI80	0·35½	ME4101	0·15	OC70	0·15
2N2613	0·35	2N4303	0·47½	AF126	0·20	BFI81	0·32½	ME4102	0·17½	OC71	0·12½
2N2614	0·30	2N5027	0·52½	AF127	0·17½	BFI84	0·25	ME4103	0·15	OC72	0·12½
2N2646	0·52½	2N5028	0·57½	AF139	0·37½	BFI85	0·42½	ME6101	0·20	OC74	0·32½
2N2696	0·32½	2N5029	0·47½	AF178	0·42½	BFI94	0·17½	MJ400	1·07½	OC75	0·22½
2N2711	0·25	2N5030	0·42½	AF179	0·72½	BFI95	0·15	MJ420	1·12½	OC76	0·22½
2N2712	0·25	2N5172	0·12½	AF180	0·52½	BFI96	0·15	MJ421	1·12½	OC77	0·30
2N2713	0·27½	2N5174	0·52½	AF181	0·42½	BFI97	0·15	MJ430	1·02½	OC81	0·20
2N2714	0·30	2N5175	0·52½	AD239	0·42½	BFI98	0·15	MJ440	0·95	OC81D	0·22½
2N2865	0·62½	2N5176	0·45	AF279	0·47½	BF200	0·52½	MJ480	0·97½	OC83	0·25
2N2904	0·30	2N5232A	0·30	AF280	0·62½	BF224	0·14	MJ481	1·25	OC84	0·25
2N2904A	0·32½	2N5245	0·45	AF211	0·32½	BF225	0·19	MJ490	1·00	OC139	0·32½
2N2905	0·37½	2N5246	0·42½	ASY26	0·25	BF237	0·23	MJ491	1·37½	OC140	0·32½
2N2905A	0·40	2N5249	0·67½	ASY27	0·37½	BF238	0·23	MJ802	4·12	OC170	0·30
2N2906	0·25	2N5265	2·25	ASY28	0·27½	BF244	0·23	MJ4502	4·44	OC171	0·30
2N2906A	0·27½	2N5266	2·75	ASY29	0·27½	BFW61	0·47½	MJ1800	2·17½	OC200	0·40
2N2907	0·30	2N5267	2·62½	ASY26	0·25	BFX12	0·22½	MJE340	0·62½	OC201	0·60
2N2923	0·15	2N5305	0·37½	ASY50	0·25	BFX13	0·22½	MJE520	0·60	OC202	0·75
2N2924	0·15	2N5306	0·40	ASY51	0·32½	BFX29	0·30	MJE521	0·73	OC203	0·42½
2N2925	0·15	2N5307	0·37½	ASY53	0·25	BFX30	0·30	MJE2955	1·37½	OC204	0·42½
2N2926		2N5308	0·37½	ASY54	0·25	BFX43	0·37½	MJE3055	0·87½	OC205	0·90
Green	0·14	2N5309	0·62½	ASY62	0·25	BFX44	0·37½	MPF102	0·42½	OC207	0·75
Yellow	0·12½	2N5310	0·42½	ASY63	0·17½	BFX51	0·20	MPF103	0·37½	OCP71	0·42½
Orange	0·12½	2N5354	0·27½	ASY72	0·25	BFX68	0·67½	MPF104	0·37½	ORP12	0·62½
2N3011	0·30	2N5355	0·27½	ASY83	0·25	BFX84	0·25	MPF105	0·37½	ORP61	0·50½
2N3014	0·32½	2N5356	0·32½	ASY86	0·32½	BFX85	0·32½	MPS3638	0·32½	P346A	0·22½
2N3053	0·18	2N5365	0·47½	ASZ21	0·42½	BFX86	0·25	NKT0013	0·47½	TIS34	0·62½
2N3054	0·46	2N5366	0·32½	AU103	1·25	BFX87	0·27½	NKT124	0·42½	TIS43	0·27
2N3055	0·62	2N5367	0·57½	BC107	0·10	BFX88	0·25	NKT125	0·27½	TIS44	0·10
2N3133	0·30	2N5457	0·37½	BC108	0·10	BFX89	0·62½	NKT126	0·27½	TIS45	0·10
2N3134	0·30	2S005	0·75	BC109	0·10	BFX93A	0·70	NKT128	0·27½	TIS46	0·11
2N3135	0·25	2S020	2·00	BC113	0·15	BFY10	0·32½	NKT135	0·27½	TIS47	0·11
2N3136	0·25	2S102	0·50	BC114	0·15	BFY11	0·42½	NKT137	0·32½	TIP29A	0·50
2N3340	0·97½	2S103	0·25	BC115	0·15	BFY17	0·22½	NKT210	0·30	TIP30A	0·60
2N3349	1·30	2S104	0·25	BC116	0·15	BFY18	0·32½	NKT211	0·30	TIP31A	0·62½
2N3390	0·25	2S501	0·32½	BC116A	0·15	BFY19	0·32½	NKT212	0·30	TIP32A	0·75
2N3391	0·20	2S502	0·35	BC118	0·10	BFY20	1·60	NKT213	0·30	TIP33A	1·02½
2N3391A	0·30	2S503	0·27½	BC121	0·20	BFY21	0·42½	NKT214	0·22½	TIP34A	2·05
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100	,,	1·87½	500	,,	1·37½
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5" × 3"	0·75	Post and packing	0·15

PRESETS Carbon Miniature and Sub miniature. Vertical and Horizontal. 0·1 watt, 0·2 watt, all at 0·06 each. 0·3 watt 0·075.

CARBON POTENTIOMETERS £

Log. and Lin. Less switch .. .. 0·16
Log. and Lin. With switch .. .. 0·25
Wire-wound Pots (3 watts) .. .. 0·37½
Twin-Ganged Stereo Pots. (Log. and Lin.) Less Switch 0·40

HEAT SINKS £

4·8" × 4" × 1" Finned for Two TO-3 Trans. .. 0·47½
4·8" × 2" × 1" Finned for One TO-3 Trans. .. 0·32½
For SO-1 0·025 For TO-5 0·05 Finned
For TO-18 0·05 Finned For TO-1 0·05 Finned

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400 mW (from 3·3v to 33v) .. .. 0·15
1 Watt (from 2·7v to 200v) .. .. 0·37½
10 Watt (from 3·9v to 100v) .. .. 0·30
20 Watt BZY93 Series (from 7·5v to 75v) .. .. 0·52½

Antex 15W. Soldering Iron .. .. 1·62½
D.G. 30 W. Soldering Irons .. .. 1·10

POSTAGE AND PACKING CHARGES

U.K. .. .. 0·12½
EUROPE .. .. 0·25 (minimum)
COMMONWEALTH (AIR) .. .. .. 0·65 (minimum)

SILICON RECTIFIERS

PIV	50	100	200	400	600	800	1000	1200	1400
	£	£	£	£	£	£	£	£	£
1A	0·10	0·12½	0·15	0·16	0·17½	0·19	0·20	—	—
3A	0·15	0·17	0·20	0·22½	—	0·30	—	—	—
6A	—	—	0·25	0·30	0·32½	0·35	0·50	—	—
10A	—	0·52½	0·57½	0·65	0·77½	0·87½	0·97½	1·25	1·60
17A	—	0·57½	0·62½	0·77½	0·90	0·97½	1·20	1·57½	1·87½
35A	—	1·37½	1·60	1·97½	2·37½	2·70	3·10	3·50	4·50

1 amp and 3 amp are plastic encapsulation.

DIODES AND RECTIFIERS

IN914	0·07½	AAZ17	0·12½	BAY31	0·07½
IN916	0·07½	BA100	0·15	BAY38	0·25
IN4007	0·22½	BA102	0·22½	BY100	0·17½
IS44	0·10	BA110	0·32½	BY103	0·22½
IS113	0·15	BA115	0·07½	BY124	0·15
IS120	0·15	BA141	0·32½	BY126	0·15
IS121	0·17½	BA142	0·32½	BY127	0·17½
IS130	0·12½	BA144	0·12½	BY164	0·57½
IS131	0·12½	BA145	0·20	BYX10	0·22½
IS132	0·15	BA154	0·12½	BYZ10	0·35
IS940	0·07½	BA156	0·22½	BYZ11	0·32½
AAI19	0·10	BAX13	0·12½	BYZ12	0·30
AAI29	0·10	BAX16	0·12½	BYZ13	0·25
AAZI3	0·10	BAY18	0·17½	OA5	0·17½
AAZI5	0·12½				

OA10	0·22½		
OA9	0·10		
OA47	0·07½		
OA70	0·07½		
OA73	0·10		
OA79	0·09		
OA81	0·07½		
OA85	0·07½		
OA90	0·07½		
OA91	0·07½		
OA95	0·07½		
OA200	0·10		
OA202	0·10		
TIV307	0·50		

MAINS TRANSFORMERS £

1 amp Charger. Sec. 0-3-5-9-18v *Post and packing 0·22½* 0·97½
2 amp Charger. Sec. 0-3-5-9-18v *Post and packing 0·22½* 1·27½
1 amp (Douglas) MT103 Sec. tappings from 6v to 50v .. 1·70
2 amp (Douglas) MT104 Sec. tappings from 6v to 50v .. 2·20
Post and packing £0·28.
6 amp (Douglas) MT107 Sec. tappings from 6v to 50v .. 5·50
Post and packing 0·37½.
Various other Transformers ranging from ½A to 5A in stock.

TRIACS

SC35D	..	1·00	SC51D	..	1·95	DIACS	
SC36D	..	1·00	40430	..	0·97½	MPT20	.. 0·40
SC40D	..	1·25	40486	..	0·95	MPT28	.. 0·37½
SC41D	..	1·20	40528	..	0·72½	MPT32	.. 0·37½
SC45D	..	1·50	40430	..	1·30	MPT36	.. 0·37½
SC46D	..	1·42½	40432	..	1·37½	ST2	.. 0·21
SC50D	..	2·00	40512	..	1·45	40583	.. 0·27½

Economy Range Triacs

TC4/10 (Pressfit) 4 amp 100 PIV .. .. 0·65
TC4/20 (Pressfit) 4 amp 200 PIV .. .. 0·75
TC4/40 (Pressfit) 4 amp 400 PIV .. .. 0·87½

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THYRISTORS

PIV	50	100	200	300	400
1A	0·25	0·27½	0·37½	0·40	0·47½
4A	—	0·47½	0·55	0·57½	0·77½
5A	—	0·55	0·65	—	0·75
7A	—	0·55	0·65	—	0·97½

TIC47 0·6 amp. 200 PIV 0·55. TIC44 0·6 amp 50 PIV 0·47
Also 12 amp 100 PIV 0·75½ 2N3525 at £1·12½.

VEROBOARD

	·15 Matrix	·1 Matrix
2½" × 3½"	0·17½	0·20
2½" × 5"	0·21	0·24
3½" × 3½"	0·21	0·24
3½" × 5"	0·27½	0·27½
2½" × 17"	0·62½	—
3½" × 17"	0·80	1·07½
5" × 17"	—	1·32½
3½" × 17" (Plain)	—	0·57½
5" × 17" (Plain)	0·85	—
2½" × 17" (Plain)	0·47½	—

Vero Pins (Bag of 36) £0·20.
Vero Cutter £0·45. Pin Insertion Tools (·1 and ·15 matrix) at £0·55.

RESISTORS ¼ W & ½ W E24 Series.
Carbon Film ¼ W., 1W, 2W E12 Series.

¼ watt 5%	0·01½	1 watt 10%	0·02½
½ watt 5%	0·02		
2 watt 10%	0·06	½ watt 5%	0·01
1 watt M/oxide ..	0·09		

Wire Wound £

2½ watt 5% (up to 270 ohms only) .. .. 0·07½
5 watt 5% (up to 8·2k ohms only) .. .. 0·10
10 watt 5% (up to 25k ohms only) .. .. 0·12½

CAPACITORS. Polyester, ceramics, Polystyrene, silver mica, tantalum, trimmers etc. in stock, please enquire.

Electrolytics

MFD.	V.	£	MFD.	V.	£	MFD.	V.	£
1	18	0·07½	25	50	0·07½	400	16	0·14
1·6	25	0·07½	32	40	0·07½	500	25	0·19
2	350	0·10	32	450	0·27½	500	50	0·24
2·5	16	0·07½	40	16	0·07½	640	16	0·17½
4	10	0·07½	50	12	0·07½	1000	16	0·18
4	40	0·07½	50	25	0·07½	1000	25	0·25
4	350	0·11	50	50	0·10	2000	25	0·37½
5	18	0·07½	50	25	0·07½	2000	50	0·52½
5	50	0·07½	64	25	0·07½	2500	25	0·42½
6·4	6·4	0·07½	80	16	0·07½	2500	50	0·57½
8	40	0·07½	80	25	0·07½	2500	64	0·80
8	450	0·15	100	6·4	0·07½	3000	25	0·45
10	12	0·07½	100	12	0·07½	3600	100	1·70
10	25	0·07½	100	25	0·10	4000	40	0·80
12·5	25	0·07½	100	50	0·12½	4500	64	2·25
16	10	0·07½	125	10	0·07½	5000	25	0·57½
16	15	0·07½	200	10	0·07½	5000	50	0·97½
16	450	0·16	250	25	0·14	5000	85	1·75
25	6·4	0·07½	250	50	0·19			
25	10	0·07½	320	10	0·07½			
25	25	0·07½						

THERMISTORS (MULLARD)

R53 (STC) 1·27½	VA1010 0·12½	VA1039 0·15	VA1077 0·20
K151 (Siemens) IK 0·12½	VA1015 0·19	VA1040 0·12½	VA1091 0·22½
	VA1033 0·12½	VA1053 0·12½	VA1096 0·20
	VA1034 0·12½	VA1066 0·19	VA1097 0·20
VA1005 0·15	VA1037 0·12½	VA1074 0·12½	VA3705 0·87½
	VA1038 0·12½	VA1075 0·22½	

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Type N6428/1 THERMOCOUPLE TRIP AMPLIFIER..... £7·50

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Type N638A LOGARITHMIC AMPLIFIER..... £7·50

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Type AA621 DC AMPLIFIER..... £20·00

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DC AMPLIFIERS—solid stage plug-in units..... £7·50

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THREE-PHASE POWER AMPLIFIER..... £25·00

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Type JX612 SUBSONIC POWER AMPLIFIER..... £25·00

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Type 4202-972-108 ROTOR BALANCING AMPLIFIER £10·00 or offer

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Type TGA2 AMPLIFIER..... £10·00

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600 OHMS

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BOXES L.C. & R.

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Type D–801–D VOLTAGE DIVIDING RESISTANCE BOX. Range (voltage ratio): 1 : 0·0001 to unity in steps of 0·0001. Input resistance: 10KΩ. Accuracy: on DC ±0·1%; on AC accuracy is a function of frequency..... £20·00

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Type B901 VHF ADMITTANCE BRIDGE. Range: Admittance 0–100 Mohms; Capacitance 0–+75 pF and —75 pF. Accuracy: ±2%..... £95·00

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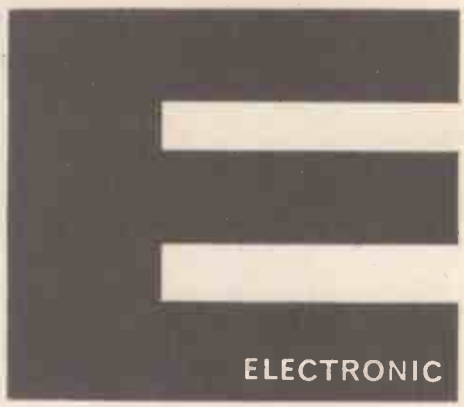

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110V DC..... £2·00

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12V DC 10 impulses/sec..... £5·25 (new)
12V DC 10 impulses/sec..... £1·50 (used)

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24V DC 25 impulses/sec..... £6·00

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B BROKERS

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3. ECKO
Type 1482A DECADE VOLTAGE & CURRENT GENERATOR This instrument is a self-contained unit for providing accurate voltages and currents which can be varied by small increments. Vnltage ranges: 0–1V in 0·0001V steps; 0–10V in 0·001V steps. Current ranges: On 1 volt range 10^{-3}; to 10^{-13}A; On 10 volt range 10^{-4} to 10^{-14}A. Voltage ranges: ±0·01%. Current series resistors: 10^5, 10^6 ohms ±0·1%; 10^7 ohms ±5%; 10^8, 10^9, 10^{10}, 10^{11}, 10^{12} ohms ±10% ..... £45·00

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4. WAYNE KERR
NOISE GENERATOR CT410. A portable instrument for measuring the noise factor of radio receiving equipment, metric radar receivers and radar wide-band i.f. amplifiers in the band 15kHz–160MHz ..... £75·00

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5. HATFIELD INSTRUMENTS
Type PUM16 400Hz GENERATOR. Provides 400Hz 1 ph and 3 ph power ..... £40·00

6. HATFIELD INSTRUMENTS
Type PUM 16/1 133Hz GENERATOR. Similar to above only 133Hz ..... £40·00

TEST GENERATORS

7. MARCONI
Type TF1167 TELEGRAPH TEST GENERATOR. This generator delivers high quality keyed RF signals at stable carrier frequencies of 3·1, 6·2, and 9·3MHz. On/off frequency-shift or frequency shift diplex (twinplex) keying can be selected, or the carrier can be sinewave amplitude modulation. Carrier Frequency: 3·1, 6·2, 9·3MHz. Frequency Stability: Better than ±0·001% for mains variation up to ±10% over an ambient temperature range of 20 to 50°C .... £65·00

PULSE GENERATORS

8. COSSOR
Type CG200 MICROSECOND PULSE GENERATOR ..... £15·00

9. FLEMMING RADIO
Type 1478A PULSE GENERATOR PRF 0·25 to 100K pps. Attenuator 1, 2, 4, 6, 10, 20, 40 db ..... £35·00

10. KASAMA ELECTRONICS
Type 301A PULSE GENERATOR PRF 0–100K pps. Pulse width and delay facility ..... £38·00

11. NAGARD
Type 5002 DOUBLE PULSE GENERATOR PRF 0·1–1M pps. Delay 0·2 sec. to 0·2 μsec. Pulse width: 0·2 sec. to 0·2μ sec. O/P 20mV–50V ..... £65·00

SIGNAL GENERATORS
Audio Frequency

12. AIRMEC
Type 257 SIGNAL GENERATOR. Provides four phase related outputs of identical frequency. A unique feature of this instrument is that one output is continuously variable in phase relative to a reference. Frequency range: 0·03Hz to 30Hz O/P level; 50V peak unbalanced to earth O/P impedance: 10Kohm normal. FULL SPECIFICATION AVAILABLE ON REQUEST ..... £95·00

13. ADVANCE
Type SG66 LF SIGNAL GENERATOR. Frequency range: 5Hz to 125kHz. Accuracy: ± (1% ±1Hz). O/P SINE WAVE: 0–30V rms into 600 ohms; 0–1W into 5 ohm. O/P SQUARE WAVE: 0–30V pk to pk; O/P impedance varies with O/P level. RISE & FALL TIMES: 0·75 μs max ..... £49·50

RF SIGNAL GENERATORS

14. ADVANCE
Type C2. Spot frequencies selected by 12 push buttons marked A to L. Each spot frequency is tunable. Frequency range: 200kHz to 15mHz ..... £15·00

15. SIGNAL GENERATOR
Type CT218. Frequency range: 85kHz–30MHz. Crystal calibrator at 200kHz and 2MHz ..... £55·00

16. AIRMEC
Type 201 STANDARD SIGNAL GENERATOR. This instrument will provide accurate, stable sinusoidal signals of pure waveform from 30kHz to 30MHz. Output levels, which are stabilised by an amplified AGC system can be varied from 1μV to 1·1V rms (or 2·2V roms unmodulated). A high output of 5V (10V unmodulated) is also provided from a 300 ohm source impedance. The attentuators are very accurately calibrated and have a constant 75 ohm output impedance. Frequency range: 30kHz–30MHz in 7 bands. CRYSTAL CALIBRATION: A 500kHz crystal oscillator provides between 20 and 50 check points on each band. FULL SPECIFICATION AVAILABLE ON REQUEST ..... £95·00

Tel: 01-837-7781/2
TELEX 267307

17. AIRMEC
Type 701 SIGNAL GENERATOR. Frequency range: 30kHz–30MHz in 7 bands ..... £95·00

18. COSSOR
Type CT202 SIGNAL GENERATOR. Frequency range: 7–70MHz. Band width: Swept 1–10MHz ..... £89·00

19. MARCONI
Type TF144H STANDARD SIGNAL GENERATOR. Frequency range: 10kHz–72MHz. Crystal check: 400kHz and 2MHz crystals. Stability: 0·002% in 10 minute interval. FULL SPECIFICATION AVAILABLE ON REQUEST ..... £165·00

20. MARCONI
Type TF144G STANDARD SIGNAL GENERATOR. Frequency range: 85kHz–25MHz. Output voltage: 1μV–1V continuously variable. Output impedance: 1μV to 100mV 10 ohms; 100μV to 1V 52·5 ohms. FULL SPECIFICATION AVAILABLE ON REQUEST ..... £85·00

21. MARCONI
Type TF517F/1 UHF SIGNAL GENERATOR. Frequency range: 0–300MHz Sine & Square wave ..... £45·00

22. ADVANCE
Type D1/D SIGNAL GENERATOR. Frequency range: 10MHz–300MHz. O/P voltage: 1μV–10mV ..... £45·00

23. ADVANCE
Type 71 SIGNAL GENERATOR. Frequency range: 0–320MHz ..... £25·00

24. AVO
Type CT378 SIGNAL GENERATOR. Frequency range: 2MHz–500MHz. O/P voltage: 1μV–25mV into 75 ohm. Internal modulation: 1kHz to 30%—sine or square ..... £45·00

25. MARCONI
Type TF801A SIGNAL GENEROTOR. Frequency range: 10MHz to 310MHz. O/P voltage: 0–100 db relative to 200 mV into 75 ohm; 1V CW O/P available. Internal modulation: 400Hz, 1kHz and 5kHz to 80% sine or square ..... £45·00

26. RCA
Type 710-A UHF SIGNAL GENERATOR. Frequency range: 370MHz –560MHz. Power supply: 117 volts 6Hz 50 Watts ..... £25·00

27. EX-SERVICES
No. 16 SIGNAL GENERATOR. Frequency range: 0–11cm ... £15·00

28. MARCONI
Type TF1343/1 'X' BAND SIGNAL GENERATOR ..... £65·00

29 .MARCONI
Type TF1343/2 'X' BAND SIGNAL GENERATOR ..... £65·00

30. SANDERS
Type SG480 'X' BAND SIGNAL GENERATOR. These high grade generators comprise a klystron oscillator in a coaxial cavity from a stable power source. Provision for applying sine wave or pulse modulation from either an internal or external source. Frequency range: 8–11·5kMHz ..... £275·00

31. SANDERS
Type SG478 'X' BAND SIGNAL GENERATOR. Frequency range: 1·3–4·2kMHz. Details as SG480 above ..... £275·00

INDICATORS

(See also CONTROLLERS)

1. MAKER NOT KNOWN
Type 248 INDICATOR UNIT. Range: 0–20,000MHz ..... £10·00

2. MAKER NOT KNOWN
Type CTR103 INDICATOR CRO. Range: 0–10MHz. TB Speed: 10,000–20,000MHz ..... £10·00

3. B.P.L.
Type LB320 BALANCE INDICATOR ..... £15·00

4. FOXBORO
Type M9600B MAGNETIC FLOW DYNALOG INDICATOR. Range: 0–40 Litres/min ..... £25·00

THERMOMETER INDICATORS

5. SANGAMO WESTON
Type 1T3–1 RATIOMETER INDICATOR. Range: 0–200°C .. £15·00

6. SANGAMO WESTON
Type 1T3–3 RATIOMETER INDICATOR. Range: —70°C to +30°C ..... £15·00

7. SANGAMO WESTON
Type 63/4 RATIOMETER INDICATOR. Range: 250°C–350°C ..... £15·00

8. SANGAMO WESTON
Type 863/5 RATIOMETER INDICATOR. Range: 50°C–350°C ..... £15·00

9. SANGAMO WESTON
Type 1T3/4 RATIOMETER INDICATOR. Range: 50°C–350°C ..... £15·00

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1. 500V 'WEE' MEGGER ..... £15·00
2. 100V 'WEE' MEGGER ..... £12·50
3. 100V 'WEE' MEGGER SERIES 3. Ranges: 0·02–20Mohm; 0–100 ohms ..... £16·50
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5. 100V EARTH TESTER SERIES 2. Range 0–50 ohms .. £10·50
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7. 500V BRIDGE MEGGER SERIES 2 Ranges: Bridge 0·01–999, 990 ohms. Insulation: 0–100Mohms ..... £29·50
8. 500V INSULATION TESTER SERIES 1. Range: 0–100Mohm–infinity ..... £20·00
9. 500V INSULATION TESTER SERIES °. Range: 0–100Mohms–infinity ..... £22·50
10. 1000V INSULATION TESTER SERIES 1. Range: 0–5000Mohm–infinity. Requires 1000V power supply ..... £12·50
11. 100V VARLEY LOOP TEST BRIDGE MEGGER ..... £25·00
12. 1000V BRIDGE MEGGER SERIES °. Ranges: Bridge 0·01–999, 990 ohms. Insulation: 0–200Mohms ..... £25·00
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14. METROHM BATTERY INSULATION TESTER. Ranges: 0–0·00 ohms, 0·1–infinity ohms ..... £15·00

INTEGRATORS

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INTEGRATOR 6 digit counter read-out ..... £25·00

2. NEW ELECTRONIC PRODUCTS
INTEGRATOR AND CAMERA CONTROL. For use with NEP camera recorder ..... £15·00

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RCA
The R.C.A. Speech Inverter is a device intended for use in radio-telephone installations where privacy is a prime consideration. The equipment when used in conjunction with the R.C.A. M1-7182 Hybrid Transformers enables parallel two-way conversations on a single telephone pair line at each terminal of the communications system. With inversion, speech fed into the transmitting inverter circuit will feed the radio transmitter with unintelligible signals. These signals will remain unintelligible until they pass through a receiving inverter circuit at the other end of the communication channel. (Used only under Licence in U.K.) ..... £12·50

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DYNAMCO SYSTEMS
TRANSMISSION MEASURING SET. Range: 0–15 db ..... £10·00

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Type 'A' 17½ × 6½ × 7 in. ..... £2·50
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METERS

MULTIMETERS

1. AVOMETERS
MODEL 7 ..... £17·00
MODEL 8 ..... £25·00

2. BRADLEY (GEC)
TRANSISTORISED MULTIMETER TYPE CT471B. Fully transistorized multi-range instrument for measurement of voltage up to 1000 MHz (1500 MHz with reduced accuracy) and current up 2 kHz and DC Resistance AC and DC voltage and current divided into 11 ranges. AC/DC Volts 12mV–1200V. AC/DC Current 12 micro A-1·2A. DC Resistance 5 ranges 0·1 ohm–1000 Mohm. R.F. Voltages 5 range 40mV to 4V. Battery powered. Offered in excellent condition. Tested before despatch. Complete with handbook ..... £49·50 Carriage 50p

3. E.I.L.
Type 44A PRECISION MULTI RANGE METER. An instrument of very high accuracy for use in laboratory, test-room, or factory. Ranges: Voltage: DC 0·2 to 1000V fsd. AC 1 to 1000V rms fsd. Current: DC/AC 1mA to 10 amp fsd. Resistance: 0·1Mohm in 3 ranges. Power: 0–4 watts. Sensitivity: 1000 ohms/volt ..... £15·00

OHMMETERS

4. W. G. PYE
Type 10B OHMMETER 500V ..... £9·50

5. E.I.L.
Type 47A MILLOHMMETER. Designed for measurement of low and very low resistance. It is a transportable direct reading instrument, with a clean linear scale and is very simple to use. Ranges: 1·2Mohms to 1200 ohms fsd in 7 ranges. Accuracy: better than ±2% of full scale. Mains powered ..... £35·00

Ph METERS

6. CAMBRIDGE INSTRUMENTS
Type L-134995 PL METER. Range: 0–12. Probes available from manufacturer at approx. £4·00 each. Complete with galvanometer ..... £12·50

7. INDUSTRIAL SCIENTIFIC INSTRUMENTS
Type 6A PL METER. Range: 0–14. In wooden box complete with electrode stand ..... £30·00

8. PYE
Type 11071 PL METER (PORTABLE) Range: 2–12 ..... £39·00

PHASEMETERS

9. MUIRHEAD
Type D729–BM PHASEMETER. Frequency range: 0–25Hz to 10kHz. Angle range: 0–360° ..... £15·00

10. SOUTHERN INSTRUMENTS
Type K159 PHASEMETER. Range: 0–100° ..... £25·00

PYROMETERS

11. INDUSTRIAL PYROMETER
INDUSTRIAL PYROMETER. Range: 0–110°C ..... £35·00
Range: 0-600°C ..... £30·00

RATEMETERS

12. FLEMING RADIO
Type 1171A LOGARITHMIC RATEMETER ..... £35·00

VIBRATION METERS

13. DAWE INSTRUMENTS
Type 1402C VIBRATION METER. Range: 2 to 10kHz. Complete with probe ..... £25·00

VOLTMETERS

14. DYNAMCO
Type 2006 DIGITAL VOLTMETER. Ranges: 100mV–1KV fsd. Scale: 4 digits. Sensitivity: 10μV. Supplied with D2 module and calibration certificate ..... £350·00

15. DYNAMCO
Type 2010 DIGITAL VOLTMETER. Ranges: 10 microvolts–1·1KV. Scale: 6 digit. Accuracy: 0·001% fsd. Complete with calibration certificate ..... £850·00

16. GLOSTER INSTRUMENTS
Type GE(B1E2123) DIGITAL VOLTMETER ..... £55·00

17. SOLARTRON
Type LM902·2 DIGITAL VOLTMETER. Ranges: 0·1V–1KV fsd 7 ranges. Scale: 4 digit. Accuracy: ±0·1% of fsd ..... £49·00

VALVE VOLTMETERS

18. E.I.L.
Type 22B (CT54) MICROVAC ELECTRONIC TESTMETER. A portable valve voltmeter of robust construction for use in the laboratory factory or by the field service engineer. Ranges: DC ±2·4V to ±2400V fsd NORMAL. DC 1·2–0–1·2 to 1200–0–1200 fsd BALANCED. Acor RF: 2·4 to 480V rms fsd. Resistance: 1000 ohms to 10Mohms fsd. Accuracy: ±3% of fsd up to 200MHz ..... £15·00

19. DAWES INSTRUMENTS
Type 612A TRUE RMS VALVE VOLTMETER. A sensitive electronic voltmeter for the measurement of true rms valves of complex wave forms. Range: 100 microvolt to 300V rms. Frequency: 5Hz–500kHz ..... £55·00

20. MARCONI
Type TF 428B VALVE MILLI VOLTMETER. Ranges: 0·15V, 0·5V, 2V fsd ..... £15·00

21. AVO
Type CT38 VALVE VOLTMETER ..... £15·50

22. EX-SERVICE
Type ZD00121 VALVE VOLTMETER. Ranges: DC 0–3V; L–10V. AC 0–1·5V; 0–5V; 0–15V ..... £10·00

METERS—continued

23. E.I.L.
Type 26 LABORATORY VALVE VOLTMETER. Ranges: AC/DC 0·2V to 250V fsd. Resistance: 500 ohms to 500 Mohms fsd. Frequency range: 30Hz to 200Hz..... £10·00

24. AVO
ELECTRONIC TESTMETER. Ranges: Voltage: DC 5mV–250V fsd; AC 0·1V–250V fsd. Current: DC 0·5 microamps–1A fsd. Frequency range: DC to 200MHz..... £18·00

25. E.L.
Type EL265 DC VALVE VOLTMETER. Ranges: DC Voltage 0–250V fsd in 10 ranges..... £9·50

26. G.E.C.
Type BW423 VALVE VOLTMETER. Ranges: AC/DC 1·5V, 5V, 15V, 50V and 150V fsd..... £11·50

27. G.E.C.
Type BW664 VALVE VOLTMETER. Details as BW423 above..... £11·50

28. WINSTON ELECTRONICS
Type M25 VALVE VOLTMETER. Ranges: AC/DC Voltage 2·5V to 750V in 12 ranges..... £15·00

WATTMETERS

29. MARCONI
Type TF938 AF ABSORPTION WATTMETER. Ranges: 200 microwatts–6 watts fsd in 10 ranges. Impedance: 2·5 ohms to 20kohms in 11 steps. Frequency: ±1 db from 100Hz to 10 kHz; ±2 db from 50Hz to 20kHz..... £20·00

30. SANGAMO WESTON
Type 567–1–367 AC/DC WATTMETER. Range: 0 to 450 Watts max..... £9·50

WAVEMETERS

31. EX-SERVICES
Type W1185/A WAVEMETER. Range: 20 to 100MHz..... £15·00

32. SULLIVAN & GRIFFITHS
Type 7088 WAVEMETER. Range: 10 to 30kHz..... £12·50

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1. KELVIN-HUGHES
DYNAMIC STRAIN MODULATOR UNIT. For use with K–H recorders..... £10·00

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Type D–652–A LF MODULATOR. For extending the range of the type D–489–G WAVE ANALYSER DOWN TO 2Hz..... £25·00

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1. LIVINGSTONE CONTROLS
Type LM091 PULSE SHAPER & REGISTER..... £35·00

2. LIVINGSTONE CONTROLS
Type LM092 PULSE SHAPER & RELAY..... £35·00

3. LIVINGSTONE CONTROLS
Type LM101 PULSE SHAPER & RELAY..... £35·00

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We have a wide range of oscilloscopes in stock including Telequipment, Tektronix, Solartron, etc. Our stock is constantly changing so please contact us with your requirements.

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Type ME1200 A8 12 CHANNEL OSCILLOGRAPH. Complete with camera..... £59·00

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OVEN..... £30·00

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Type 6467 VACUUM OVEN. Size Int.: 10½ in. DIAM. × 12 in. DEEP. Power: 200–250V 2·5A. Fitted simmerstat and vacuum gauge 0–30 in. Hg..... £49·00

OSCILLATORS

LF OSCILLATORS

1. EDISWAN
Type R666 LF OSCILLATOR. Range: 1·4Hz to 5·5kHz in 7 ranges..... £30·00

CRYSTAL OSCILLATORS

2. S.T.C.
Type 16–LXU–52A CRYSTAL OSCILLATOR. Range: 0–20MHz..... £95·00

SWEEP OSCILLATORS

3. PYE-LING
Type AC01 AUTOMATIC SWEEP LF OSCILLATOR. An automatic unit providing motorised sweep facilities and automatic changeover from displacement to acceleration characteristic. Applications Resonance Search and Endurance testing. 5 Hz·5 KHz 21 sweep speeds from 0·1–10 octaves/minute. Variable O/P up to 10V r.m.s. Mains I/P. Excellent condition. Carriage extra..... £95·00

DECADE OSCILLATORS

4. MUIRHEAD-WIGAN
Type D–638–A LF DECADE OSCILLATOR. Range: 0·1Hz to 212Hz. Power: 1W into 600 ohms on ×100 range 0·2W into 2·5Kohms on ×1 and ×0·1 range..... £40·00

5. SOLARTRON
Type OS 103·2A LOW FREQUENCY DECADE OSCILLATOR. Range: 0·01Hz to 11·1kHz sine and square. Accuracy: ±2%. V out: 10V rms. Power: 100mW into 1kohm..... £55·00

TUNING FORK OSCILLATORS

6. TINSLEY
Type 3086 TUNING FORK OSCILLATOR. Complete with frequency meter..... £25·00

GAUGE OSCILLATORS

7. SOUTHERN INSTRUMENTS
Type 700L GAUGE OSCILLATOR..... £25·00

HIGH DISCRIMINATION OSCILLATORS

8. MARCONI
Type TF1168 HIGH DISCRIMINATION OSCILLATOR. 2Hz discrimination at centre frequency continuously variable up to ±10kHz relative to centre frequency. Ranges: 0–±1kHz; 0–±10kHz; 0–±100kHz. Accuracy: ±1%..... £45·00

POWER OSCILLATORS

9. GOODMANS
Type 5VA POWER OSCILLATOR. Range: 5Hz to 50kHz in 4 ranges. O/P volts: 5 max..... £45·00

VIDEO OSCILLATORS

10. MARCONI
Type TF885 VIDIO OSCILLATOR. Frequency range: Sine 25Hz to 12MHz in 3 ranges. Square 50Hz to 150KHz in 2 ranges. Accuracy: ±2% ±2Hz..... £55·00

OSCILLOSCOPE CAMERAS

1. COSSOR
Type 1428 MK 11 Oscilloscope Camera. Single shot or continuous on 35 mm film or paper..... £45·00

2. LANGHAM THOMPSON
Type 200B Oscilloscope Camera. Single shot or continuous recording..... £65·00

3. SOUTHERN INSTRUMENTS
Type M732 Universal Oscilloscope Camera. Provides both drum and continuous feed recording using 35mm or 70mm film or paper. Drum speeds: 4–1200 in/sec C/F speeds: 0·4–100 in/sec Power supply: 12V DC..... £25·00

4. SOUTHERN INSTRUMENTS
Type 926 Continuous Feed Oscilloscope Camera C/F speeds: 0·4–100 in/sec 120mm film or paper in 200 ft. rolls. Complete with 4 cassettes..... £20·00

5. TELFORD PRODUCTS LTD.
Type 'A' Polaroid Oscilloscope Camera. This is a current instrument. A wide range of adaptors are available for most oscilloscopes. New..... £99·50

POWER SUPPLY UNITS

We specialise in all kinds of POWER SUPPLIES. Current stock includes the following Modular units. All have mains I/P.

Volts	*Current*	*Make*	*Type*	*Price*
6	½A	Roband	T.98	£10·00
6	2	Roband	T.98	£12·00
12	6			£15·00
15	5	Advance	P.M7	£15·00
17	6	Farnell	88U 17/6	£18·00
28	1	Roband	T109	£25·00
32	2	APT	10459/14	£25·00
150	200mA	Farnell	8PU 150	£14·00
55/60	1A	Roband		£22·00
7½–9U	10A	I.E.		£19·50
7½–9U	10A	Farnell		£25·00

Most of the above are adjustable within a limited range.

MULTI OUTPUT UNITS AND SPECIALS

O/PV	*A*	*I/PV*	*Make*	*Price*
335	½ unstabilised			
6·35 AC	2A (400Hz)	115 v. 400Hz	Farnell (PU.335)	£10·00
—12—0+12 +24	½	240	Livingstone (LM050)	£9·50
0–10 v. Unstabilised Variable	2A	240		£18·00
160–300 6·3 v. AC Variable (Voltmeter and Ammeter)	150mA 3A	240	I.E.	£35·00
30 AC 400 Hz adjustable	300mA	240		£36·00
175–260 Adjustable (Metered) 3·15–0–3·15 AC 3A	80mA	240	Smiths	£30·00
Universal Labpack HT & LT Supply Unstabilised adjustable			Radford	£20·00

EX-COMPUTER HIGHLY STABILISED TRANSISTORISED LOW VOLTAGE POWER SUPPLIES

These modular units incorporate, Overload protection on both INPUT and OUTPUT. LOAD regulation of 1% or better. Low Ripple and a fast response time. All units checked and O/H before despatch. I/P VOLTAGE 120–130 v. 50Hz available in the following types:

6 volt	8 amp	....	£12·00
6 volt	12 amp	....	£17·00
6 volt	16 amp	....	£20·00
12 volt	4 amp	....	£20·00
12 volt	12 amp	....	£22·00
12 volt	20 amp	....	£24·00
12 volt	26 amp	....	£25·00
20 volt	6 amp	....	£18·00
20 volt	15 amp	....	£24·00
30 volt	7 amp	....	£19·00
48 volt	6 amp	....	£20·00

These units are in great demand. ORDER NOW while stocks last.

BARGAIN—DC STABILISED POWER SUPPLY UNIT..... £9·50

Brand new solid state modular unit. I/P 110 v.–240 v. 50 Hz. O/P + 12v. DC–12 v. DC–24 v. DC w.r.t. common. All at 500 mA. I/P on/off switch. Fuse and warning light. Stabilisation 100/1 for + 10%–15% mains charge. Equivalent O/P resistance less than 50 M ohms. Ripple and noise less than 10 mV. Ambient Temp. Range 0–50°C. Dimensions: L. 9½ ins., H. 4¾ ins., D. 4½ ins. Wt. 8½ lb.

CONSTANT VOLTAGE TRANSFORMERS

Advance CVH 1500 A. Harmonic filtered. I/P 190–260 v. 50 Hz., 1 phase. O/P 230 v. 1500 w. Unity PF. £50·00. Carriage extra.

ADVANCE MT 285ZA

I/P 190–260 v. 50 Hz., 1 phase. O/P 230 v. 2 kW. Unity P.F. £35·00 Carriage extra.

ELECTRONIC POTENTIOMETERS

1. TINSLEY
Type 5205B PRECISION POTENTIOMETERS..... £55·00

2. PYE
Type 7565 UNIVERSAL PRECISION POTENTIOMETER. Range: 0–1·7500V. Each division of the slide wire equals 100 microvolts. Accuracy: 0·02% or ±1 slidewire division. Multipliers: 0·1 and 0·01 multipliers give slidewire divisions of 10 and 1 microvolt..... £95·00

3. TINSLEY
AC CO-ORDINATE POTENTIOMETER..... £79·00

4. DORAN
DC POTENTIOMETER..... £59·00

5. MUIRHEAD
Type D–72–A DC SLIDEWIRE POTENTIOMETER..... £45·00

6. CAMBRIDGE
Type L215558 SLIDEWIRE POTENTIOMETER..... £30·00

7 CAMBRIDGE
Type A544 SLIDEWIRE POTENTIOMETER. Range: 0–1·7500V..... £89·00

8. MUIRHEAD
Type A–Z–A SLIDEWIRE POTENTIOMETER. Range: 0·027–1·225 ohms..... £35·00

9. SULLIVAN
NON-REACTIVE SLIDEWIRE POTENTIOMETER..... £25·00

10. TINSLEY
Type 4524A SLIDEWIRE POTENTIOMETER. Range: 0·02–0·11 ohms..... £25·00

11. PYE
Type 7568 PRECISION VERNIER POTENTIOMETER. This instrument can be used as a laboratory standard and is suitable for submission to the National Physical Laboratory. Range: 10 microvolts to 1·90100V in 1 microvolt steps. Accuracy: ±0·002% or ±1 division of the lowest scale..... £95·00

12. TINSLEY
Type 4363 VERNIER POTENTIOMETER..... £65·00

13. CAMBRIDGE
Type L346145 VERNIER POTENTIOMETER..... £95·00

14. PYE
Type 2002 SINE COSINE POTENTIOMETER 47K. Precision component by Pye. Model 2002. Manufactured to rigid Ministry specification. The assembly consists of three units mounted in one frame, Each unit contains two sine and two cosine potentiometer sections the sliders being ganged together. Electrical connections, 2 end taps, slider and centre tap. Mechanical I/P: 30 r.p.m. Max torque: 3½ oz./in. Dimensions: W. 6¼ in., H. 5 in., D. 7⅛ in. Wt. 7¾ lb. Ex equipment. Good condition. £10·00 each. Carriage extra.

PRECISION POTENTIOMETERS

TEN TURN 3600° ROTATION BRAND NEW

Resl Ohms	*Linearity Per cent*	*Manufacturers*	*Model*	*Price*
100/100/100		Beckman	A	£8·00
100	0·5	Beckman	A.8	£3·00
200	0·5	Beckman	A	£3·00
500	0·1	Beckman	8	£3·50
500		Colvern	2501	£2·25
500		Foxes	PX4	£2·00
500		Colvern	2610	£2·50
500		Colvern	26/1000/11	£3·00
500	1·0	Relcon	HEL107-10	£2·25
1K		Relcon	HEL0710	£2·25
2K	0·5	Beckman	8A1101	£3·00
2K	0·25	Beckman	7216	£3·00
2K		Reliance	GPM15	£2·00
2K		General Controls	GPA15/4	£2·00
5K		Relcon	07-10	£2·50
5K		Colvern	CLR2503	£3·00
10K	0·5	Beckman	A	£3·00
10K	0·1	Beckman X	A	£3·50
10K	0·1	Colvern	CLR26/1001	£3·50
15K		Colvern	CLR2402	£3·00
18K		Beckman	A	£3·00
25K	0·5	Helipot	8A1337	£3·00
29K	0·05	Beckman	8A1244	£4·50
30K		Colvern	2402	£1·50
30K		Beckman	8A95C	£3·00
30K	0·1	Beckman	A.88	£3·50
30K	0·5	Beckman	8A1692	£3·00

ELECTRONIC BROKERS LTD.
49-53 Pancras Rd., London, N.W.1

B BROKERS

PRECISION POTENTIOMETERS— continued

30K	0·25	Beckman	8A1679	£3·25
30K	1·0	Colvern	2402/1	£1·50
50K		Reliance	07·10	£2·25
50K			07·5	£2·25
50K		Colvern	2503	£2·25
50K	X	Foxes	PX4	£2·25
50K	0·5	Beckman	A	£3·00
50K	0·1	Beckman	A	£3·50
100K/100K		Ford	A	£5·00
100K	0·1	Beckman	A	£3·50
100K	0·5	Beckman	A	£3·00
100K		Colvern	2501	£2·25
100K		Colvern	2610	£2·50
298K	0·1	Beckman	8A3902	£3·50
300K	0·1	Beckman	A	£3·50

THREE TURN 780° ROTATION

100/100	0·5	Beckman	C	£3·00
100/100		Beckman	Type C	£3·00
300		Beckman	9303	£2·25
1K		Fox	PX2/H3	£2·25
10K	0·5	Beckman	C.8s	£2·25
20K/20K	0·1	Beckman	C.8	£3·00
10K/10K	0·1	Beckman	C	£3·00
50K	0·5	Beckman	C.8	£1·75

FIVE-AND-A-HALF TURN

500		Colvern	2405	£2·00

TWENTY TURN 7200° ROTATION

1 Meg		General Controls	PXM130	£4·00
50K		Reliance		£2·00

FIFTEEN TURN 5400° ROTATION

25K/25K		Beckman B	10 watts	£6·50
46K/46K		Beckman B	10 watts	£6·50

TRIM POTENTIOMETERS (Ref. C7)

Manufacturer	*Value*	*Connection*	*Price*
PAIGNTON	5 ohms	P.C.	50p
AMPHENOL	5 ohms	P.C.	50p
PAIGNTON	10 ohms	P.C.	50p
AMPHENOL	20 ohms	—	50p
AMPHENOL	50 ohms	—	50p
AMPHENOL	70 ohms	T.C. Turret Lugs	50p
AMPHENOL	75 ohms	P.C.	50p
MICROPOT	100 ohms	—	50p
AMPHENOL	200 ohms	P.C.	50p
AMPHENOL	250 ohms	P.C.	50p
AMPHENOL	300 ohms	P.C.	50p
PAIGNTON	500 ohms	T.C.	50p
AMPHENOL	600 ohms	P.C.	50p
PAIGNTON	1 Kohms	P.C.	75p
AMPHENOL	2 Kohms	P.C.	75p
PAIGNTON	2·5 Kohms	P.C.	75p
AMPHENOL	2·5 Kohms	T.C.	75p
AMPHENOL	3 Kohms	T.C.	75p
BOURNES	5 Kohms	Stud Connection	75p
BOURNES	5 Kohms	Flying lead	75p
AMPHENOL	10 Kohms	P.C.	£1·00
AMPHENOL	25 Kohms	P.C.	£1·00
AMPHENOL	30 Kohms	T.C.	£1·00

RECORDERS

PEN RECORDERS

PEN RECORDERS. We have probably the largest stock of pen recorders in the UK. Listed below are some examples from this stock—if the recorder you require is not shown please contact us—we almost certainly can help you.

(R7)

(R4)

(R8) 2 PEN. DC MILLIAMMETER. 0-15mA. Chart width 8 in. Speed 6 in. and 12 in./hr. Mains supply..... Price £75·00

Tel: 01-837-7781/2

TELEX 267307

(R9) UNIVERSAL MULTIPOINT. 1-24 point suitable for quantities with slow rate of change. Chart width 12 in. Speed: 3 ranges, 6/1 ratio. Sensitivity 0·100°C based on 0-75mV FSD using Thermo-couple pick up..... Price £80·00

(R10) NEW MULTIPOINT RECORDER. 100-0-100mV. Chart width 6¼ in. Speed: 20 and 720 min./hr. Also available 0-100, 0-400°C using Thermocouple pick ups..... Price £79·50

(R12) MERSTED TEMPERATURE RECORDER. Two Pen 0-200°C c/w bulbs and capillary tubing. Mains supply. 24 hr. Chart dia. 10½ in..... Price £65·00

(R13) FIDDEN Mk. II SERVOGRAPH. Single point fitted with turret head to enable conversion to 4 point. Uses capacitive sensing input. Chart dia. 11 in. Speed: 1 rev./hr. Sensitivity 50 micro Amp. Resistance 1,950 ohms. Mains supply..... Price £95·00

SINGLE PEN RECORDER
By Record Electrical (R3)

3 in. chart, sensitivity 500 micro amps. Coil res. 1·53k. Fully interchangeable gears available to make a wide range of chart speeds. 200/250v Size: 8 x 11 x 6 in. Almost new—complete with chart and ink. List over £100.

Our price..... £52·50
0–1mA version..... £49·50

(R14) Kent Mk. II SINGLE POINT. Chart width 9½ in. Speeds: 1 in., 2 in., 3 in./hr. Sensitivity 10mV FSD. Various scales, k.e. 0-600°C, 0-1,000°C, —50 to —200°C, 0-100°C. Also available: multi-point. General purpose slow response suitable. Temperature, Humidity, etc. Response 33 secs. for FSD. Supply: 110V 50Hz. 230V Auto-transformer available..... Price £49·50

(R25) SINGLE PEN. DC MILLIAMETER. 0-1mA. Chart width 4½ in. Speed 3 in./hr. Mains supply..... Price £28·50

(R27) SINGLE PEN. DC MILLIAMMETER. 15-0-5mA. Oil damped movement. Chart width 7 in. Speed: 1 in./hr. Clockwork drive 8-day. Terminal resistance 100 ohms..... Price £29·00

(R39) SINGLE POINT. DC MILLIAMMETER. ½-0-½mA. Chart width 2 in. Speed: 6 in./hr. Uses typewriter ribbon marker. Mains supply. Terminal Resistance 240 ohms..... Price £25·00

(R52) PHILLIPS 0-10mA 6-CHANNEL DC. Chart width 5 in. Two-speed model. Mains supply..... Price £75·00

(R61/1) TWO PEN. DC MILLIAMMETER. 0-2mA. Chart width 8 in. Speed: 1 in./hr. Clockwork drive. Terminal Resistance 1,687 ohms..... Price £25·0

(R5) SINGLE PEN. SERVORITER MODEL FWS. Chart width 11 in. low sped. Response time 24 secs. for FSD. Suitable Temperature, Humidity, etc..... Price £75·00

(R7) PORTABLE SINGLE AND FOUR PEN. Suitable recording quantities with high rate of change. Speeds: Single pen 60 in./min. and 240 in./min.; Four pen ½, 1, 2, 4 and 16 cms./sec. Electric pens. Mains supply amplifiers to suit.
Price. Single pen c/w Amp. £99; Four pen c/w Amp..... £149

(R58) SINGLE PEN. DC MILLIAMMETER. 0-5mA. Chart width 8 in. Speed: 1 in./hr. Mains supply..... Price £30·00

(R57) SINGLE PEN. DC MILLIAMMETER. 0-0·5mA. Chart width 8 in. Speed: 1 in. and 6 in./hr. Terminal Resistance 4,500 ohms. Price £35·00

(58) SINGLE PEN. DC MILLIAMMETER. 0-2mA. Chart width 5 in. Speed: 1 in./hr. Mains supply..... Price £30·00

(R60/1) AC RECORDING WATTMETER MURDAY SYSTEM. 0-7kW. Chart width 4 in. Clockwork drive, 8-day movement. Maximum current: 38 amps..... Price £28·00

(R34) CAMBRIDGE SINGLE PEN STRIP CHART RECORDER COMPLETE WITH CONTROL UNIT. A general purpose potentiometric recorder for quantities such as temperature, moisture, etc. Specifications: Chart width 8 ins. Chart speed ½, ¾, 1½, 3, 6 in./min. Power supply 200/250V 50 Hz. Dimensions: Width 16½ in., height 31½ in., depth 10½ in..... Price £65·00

(R37) FOSTER STRIP CHART RECORDER TYPE 3490Y. Uses a six-colour half-inch ribbon and mechanical chopper principle to record data on to a 6 in. chart. Specifications: Chart width 6 in.; Chart speed 1½ cm./hr. Dimensions: Width 15½ in., Height 22 in., depth 13 in. Weight 60 lb..... Price £90·00

NEW 6-CHANNEL TIME & EVENT RECORDER

A self-contained instrument, specifically for recording events without the need for a combined recorder. There is a separate and independent paper drive, with a monitor lamp indicating when it is in operation. The pens are displaced 1/16 in., activated by a close contact system. Each of the 6 channels works independently of each other, with the pens writing at 72 hours per filling at a maximum speed of 10 pulses per second. £75·00. Send for leaflet.

EVERSHED & VIGNOLE

3-Channel Mk 1 Pen recorder with Amplifier Range F.S.D. ± 10V, with sensitivity control set to maximum. F.S.D. ± 51V Accuracy Response such as to provide a record of a 3·5 c/s signal with not more than 30 per cent less of amplitude as compared with a DC signal of value equal to the peak AC amplitude. Chart speed 12 in./min., chart width 12 in. 3½ in. per channel. Wt. 67½ lb. Size: 22 x 21 x 11 in.
Price £19·50

FACSIMILE RECORDERS (MUFAX)

D649 G/A 18 in. Chart Recorder. Helix speed: 60, 90, 120 rev./min. Transmission speed: 5/8th in. 15/16 in., 1¼ in. per min. Scanning rate 96 lines/in. Ref. C.3.

U-V RECORDERS

1. HONEYWELL
Type 1706 VISICORDER 6 channel

In almost new condition. This direct reading U/V Recorder can record up to 6 channels simultaneously from DC 5000 Hz at writing speed of 30000 mohs/sec.

Recording range:	DC—5000 Hz.
Paper width:	4¼ in. wide.
Optical Arm:	19 cm.
Paper Speeds:	Eight speeds from 0·25—32 in./sec. and 6—800 mm//sec.
Dimensions:	k. 10½ in., W. 12 in., Depth 14 in.

Complete with 4, 3Hz Galvos..... £400·00

X-Y PLOTTERS

1. ELECTRONIC ASSOCIATES
Type 1100E VARIPLOTTER

X-Y plotter, suitable for recording analogue information. Table size 15 in. × 10 in.; slow speed 20 in./sec., i/p sensitivity for F.S.D 0·05-20V in 9 ranges: Basic i/p sensitivity: Arm 10m V/in.; Pen 1 v/in. Fully overhauled, tested, guaranteed and in new condition.
PRICE..... £350·00

2. MOSELEY AUTOGRAPH Type 2A

Table size: 11 in. × 17 in. Dimensions: W. 24 in., H. 9 in., D. 16 in. Wt. 55 lb. Power I/P: 115V. 1 phase 100 w. Signal I/P: X Axis 0-7½. 15, 75, 150, 750 mV; 0-1½, 7½, 15, 75, 150V. Y Axis 0·5, 10, 50, 100, 500 mV; 0-1, 5, 10, 50, 100V. Sensitivity not less than 200 k ohms/V, Accuracy: 0·25% FS on all ranges. Response speeds: 1 sec. for full scale. Supplied complete with copy of handbook..... £310·00.

3. HOUSTON INSTRUMENTS Type HR 934

Table size: 8½ in. x 10½ in. Dimensions: W. 14 in., H. 8 in., D. 16 in., Wt. 30 lb. Power I/P; 115V. 1 phase. Signal I/P: "X" and "Y" Axis. 0-7, 7-8, 10, 19, 68 mV and 0-5 V. Switched Attenuators on both Axes. Response speeds: 2 sec. for full scale..... £250·00. Carriage extra.

TAPE RECORDERS DIGITAL

1. HONEYWELL
Model 6200 INCREMENTAL DIGITAL RECORDER

Records digital (binary) data on 7 track ½ in. tape in steps of 0·005 in. with a packing density of 200 bits/inch. Almost new and in excellent condition. This recorder offers excellent value for many applications involving date, logging. One only available. Price: £350·00.

2. Many decks by Potter, Ampex, etc. for ¼ in., ½ in. and 1 in. tape. Prices from £75·00.

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BRAND NEW COMPUTER TAPES AND EMPTY SPOOLS

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½ in. 2,400 ft. 800 b.p.i.	£8·50
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½ in. Highest grade 2,400 ft	£3·00
½ in. 10½ in. dia. speel and cassette	£1·50
½ in. 8½ in. dia. spool nd cassette	£1·50
1 in. metal 10½ in. dia. spool and cassette	£2·50
½ in. N.A.B. centres 10½ in. spool only	£1·00

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End Reading	*Quantity*	*Price each (less base)*
GR10M/U (Clear)	1-3	£1·40
	4-10	£1·35
	11-25	£1·30
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Bases 20p each

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XN3/FA 38 mm. lead (amber)		
XN3/F 38 mm. lead (red)	1-3	£1·15
XN3A/F 6 mm. lead (red)	4-10	£1·10
XN3A 6 mm. lead (clear)	11-25	£1·05
XN3A/F 6 mm lead (red)	4-10	£1·10
XN3A 6 mm lead (clear)	11-25	£1·05
XN11/F 38 mm. lead (red)	26-100	£0·95
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£6·65 P. & P. inclusive.

POWER SIGNAL GENERATOR

ROHDE & SCHWARZ Type SMLR (BN41091) POWER SIGNAL GENERATOR

100 KHz-30 MHz in 5 ranges. ±% O/P 1·7 v. MAX O/P volts 0-10 into 60 ohms and 1 micro volt—3 v. A.M. Modulation to 90%. This is a high quality laboratory instrument currently priced at £583. ELECTRONIC BROKERS PRICE £300. C/W Calibration certificate.

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LOW TORQUE HYSTERESIS MOTOR MA23

Ideal for instrument cha t drives. Extremely quiet, useful in areas where ambient noise levels are low. High starting, torque enable relative high inertia loads to be driven up to 6-oz in. Available in

the following speeds and ranges: 240V 50 Hz 1½ r.p.m., 1/5 r.p.m. 1/12 r.p.m., 1/20 r.p.m., 1/60 r.p.m. 120V 50 Hz 1/6 r.p.m., 1/51 r.p.m., 1/16 r.p.m., 1/24 r.p.m., 1/3 r.p.m., 1/240 r.p.m., 1/300 r.p.m., 1/720 r.p.m., 1 r.p.m. M.P.10 Induction Motor. 120V 50 Hz 20 r.p.m. £150 P. & P. inclusive.

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240V 50 Hz 1/12 r.p.m., 1/6 r.p.m. 1/3 r.p.m. 120V 50 Hz 1/12 r.p.m., 1/10 r.p.m., 1/6 r.p.m., 5/12 r.p.m., 4/11 r.p.m., 1 r.p.m., 2 r.p.m. 120V 60 Hz 1/5 r.p.m., 1 r.p.m. £1·50. P. & P. inclusive.

NEW LOW INERTIA INTEGRATING MOTORS

Electro-Methods Model. 901 and 906 PL. Permanent magnet D.C. Motor. High sensitivity. Ideal for instrument-type servo mechanisms, light loads driving mechanical counters performing integration, or as small power generators. Will operate directly off a photo-cell or thermo couple, etc. 6V. Nominal. Typical parameters. Starting voltage (no load) 15 mV at 0·375 mA. Full load speed 1845 r.p.m. (approx), Moment of Inertia of Armature 1·8 gr. cm—cm. Weight of Motor 300 gms. (approx.). £15·00.

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2N2646	50p	BC184L	15p	OA5	20p
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2N2904A	25p	BCY30	25p	OA10	25p
2N2905	25p	BCY31	30p	OA47	10p
2N2906	20p	BCY32	50p	OA70	10p
2N2906A	25p	BCY33	25p	OA73	10p
2N2907	23p	BCY34	30p	OA79	10p
2N2926	10p	BCY38	40p	OA81	10p
2N3011	25p	BCY39	85p	OA85	12p
2N3053	20p	BCY40	50p	OA90	10p
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2N3705	15p	BCZ10	35p	OC23	60p
2N3707	15p	BCZ11	45p	OC24	60p
2N3709	10p	BD112	50p	OC25	37p
2N3710	10p	BD121	65p	OC26	25p
2N3819	35p	BD123	80p	OC28	60p
2N3820	60p	BD124	75p	OC29	60p
2N4058	15p	BD125	50p	OC35	50p
2N4061	15p	BD131	75p	OC36	60p
2N5457	35p	BD132	85p	OC41	25p
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AAZ13	12p	BDY61		OC77	45p
AAZ17	10p		£1·25	OC81	25p
AC107	37p	BDY62		OC82	25p
AC126	25p		£1·00	OC83	25p
AC127	25p	BF115	25p	OC84	25p
AC128	25p	BF152	30p	OC139	25p
AC176	25p	BF154	40p	OC140	37p
AC187	30p	BF158	30p	OC141	62p
AC188	30p	BF159	60p	OC170	25p
ACY17	30p	BF167	25p	OC171	30p
ACY18	25p	BF170	35p	OC200	40p
ACY19	25p	BF173	30p	OC201	70p
ACY20	20p	BF177	40p	OC202	85p
ACY21	20p	BF178	25p	OC203	40p
ACY22	10p	BF179	40p	OC204	40p
ACY39	50p	BF180	35p	OC205	75p
ACY40	15p	BF181	35p	OC206	90p
AD140	50p	BF182	30p	OC207	90p
AD149	50p	BF184	20p	OCP71	97p
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AD162	37p	BF194	17p	ORP60	40p
AF114	25p	BF195	15p	ORP61	42p
AF115	25p	BF196	15p	TIP29A	50p
AF116	25p	BF197	15p	TIP30A	60p
AF117	25p	BF200	37p	TIP31A	62p
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AF181	42p	BFX88	20p	ZTX108	15p
AF186	40p	BFY18	30p	ZTX300	12p
AF239	40p	BFY50	22p	ZTX301	15p
ASY26	25p	BFY51	20p	ZTX302	20p
ASY27	32p	BFY52	22p	ZTX303	20p
ASY28	25p	BFY53	17p	ZTX304	25p
ASY29	30p	BFY90	65p	ZTX500	20p
ASY67	47p	BSX20	17p	ZTX501	25p
ASZ21	42p	BSX21	20p	ZTX502	25p
BA115	7p	BSX76	15p	ZTX503	20p
BA164	10p	BSY95	15p	ZTX504	40p
BAX13	6p	BSY95A	15p	ZTX531	30p
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7402	Quadruple 2-input Positive Nor Gates	23p	20p	15p	13p
7403	Quadruple 2-input Positive Nand Gates (with open collector output)	23p	20p	15p	13p
7404	Hex Inverters	23p	20p	15p	13p
7405	Hex Inverter with open collector	23p	20p	15p	13p
7410	Triple 3-input Positive Nand Gates	23p	20p	15p	13p
7413	Dual 4-input Schmitt Trigger	35p	32p	29p	25p
7420	Dual 4-Input Positive Nand Gates	23p	20p	15p	13p
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7460	Dual 4-input Expander	23p	20p	15p	13p
7470	Single-phase J-K Flip-Flop	35p	32p	29p	25p
7472	Master-slave J-K Flip-Flop	35p	32p	29p	25p
7473	Dual Master-slave J-K Flip-Flop	43p	40p	37p	33p
7474	Dual D type Flip-Flop	43p	40p	37p	33p
7475	Quad latch	47p	45p	43p	40p
7476	Dual J-K with pre-set and clear	47p	45p	43p	40p
7480	Gated Full Adders	87p	77p	67p	60p
7481	16-bit read/write memory	£1·35	£1·25	£1·15	£1·00
7482	2-bit Binary Full Adders	£1·30	£1·20	£1·00	85p
7483	Quad Full Adder	87p	77p	67p	60p
7486	Quad 2-input Exclusive Or Gates	80p	70p	60p	50p
7490	BCD decade counter	87p	77p	67p	60p
7491	8-bit Shift Registers	£1·21	£1·00	87p	75p
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7494	Dual entry 4-bit shift register	87p	77p	67p	60p
7495	4-bit up-down Shift Register	87p	77p	67p	60p
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74100	8-bit Bistable Latches	£1·75	£1·65	£1·55	£1·35
74118	Hex Set-Reset Latches	£1·30	£1·20	£1·00	85p
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74145	BCD-to-Decimal Decoder/Drivers	£1·80	£1·70	£1·60	£1·50
74151	8-bit Data Selectors (with Strobe)	£1·40	£1·30	£1·20	£1·05
74153	Dual 4-Line-to-1-Line Data Selectors/Multiplexers	£1·40	£1·30	£1·20	£1·05
74191	Binary Counter reversible	£3·50	£3·25	£3·00	£2·50

Devices may be mixed to qualify for quantity price.
Data available for above series in booklet form, price 10p. (Ref. No. 30.)
Larger quantity prices Extn. 4. Dual Inline 14 Pin Sockets 30p each; 16 Pin 35p each.

TRIACS

All stud mounting with accessories.

Larger quantity prices on application. Extn. 4.

Type	Volts	P.I. Cur-rent	1-49	50+	100+	500+
SC35A	100	3A	90p	75p	65p	60p
SC35B	200	3A	95p	80p	70p	65p
SC35D	400	3A	£1·00	85p	75p	70p
SC40A	100	6A	£1·00	85p	75p	70p
SC40B	200	6A	£1·20	£1·00	85p	80p
SC40D	400	6A	£1·25	£1·10	£1·00	90p
SC45A	100	10A	£1·25	£1·10	£1·00	90p
SC45B	200	10A	£1·35	£1·20	£1·10	£1·00
SC45D	400	10A	£1·50	£1·35	£1·20	£1·10
SC50A	100	15A	£1·65	£1·50	£1·35	£1·20
SC50B	200	15A	£1·75	£1·60	£1·45	£1·30
SC50D	400	15A	£2·00	£1·75	£1·60	£1·40
SC40E	500	6A	£1·50	£1·25	£1·10	£1·00
SC45E	500	10A	£1·75	£1·50	£1·35	£1·25
SC50E	500	15A	£2·25	£2·00	£1·75	£1·55
DIAC ST2 20p						

SILICON RECTIFIERS

1 AMP MINIATURE WIRE ENDED PLASTIC

Type	P.I.V.	1-49	50+	100+	500+	1000+
IN4001	50	8p	7p	6p	5p	4p
IN4002	100	9p	8p	7p	5½p	4½p
IN4003	200	10p	9p	7½p	6p	5p
IN4004	400	10p	9p	8p	7p	6p
IN4005	600	12p	10p	9p	7p	7p
IN4006	800	15p	14p	12p	11p	9p
IN4007	1000	20p	16p	13p	12p	10p

1·5 AMP MINIATURE WIRE ENDED PLASTIC

Type	P.I.V.	1-49	50+	100+	500+	1000+
PL4001	50	10p	9p	8p	7p	6p
PL4002	100	11p	10p	9p	8p	7p
PL4003	200	12p	11p	10p	9p	8p
PL4004	400	12p	11p	10p	9p	8p
PL4005	600	15p	13p	11p	10p	9p
PL4006	800	17p	15p	13p	12p	10p
PL4007	1000	20p	17p	15p	13p	11p

3 AMP PLASTIC WIRE ENDED RECTIFIERS

Type	P.I.V.	1-49	50+	100+	500+	1000+
PL7001	50	20p	18p	17p	16p	14p
PL7002	100	20p	19p	18p	17p	15p
PL7003	200	22p	20p	19p	18p	16p
PL7004	400	25p	23p	21p	20p	18p
PL7005	600	26p	24p	23p	22p	20p
PL7006	800	27p	25p	24p	23p	21p
PL7007	1000	30p	28p	26p	24p	22p

MINIATURE POTTED BRIDGE RECTIFIERS (Silicon) Size ⅜ in. × ½ in. × ⅜ in.

Type	P.I.V.	Cur-rent	1-49	50+	100+	500+
1002	100	2 amps	60p	55p	50p	45p
2002	200	2 amps	70p	65p	60p	55p
4002	400	2 amps	80p	75p	70p	65p
6002	600	2 amps	90p	80p	75p	70p
1004	100	4 amps	70p	60p	55p	50p
2004	200	4 amps	75p	70p	65p	60p
4004	400	4 amps	80p	75p	70p	65p
6004	600	4 amps	90p	80p	75p	70p
1006	100	6 amps	75p	70p	65p	60p
2006	200	6 amps	80p	75p	70p	65p
4006	400	6 amps	£1·10	£1·00	90p	80p
6006	600	6 amps	£1·25	£1·10	£1·00	90p

INTEGRATED CIRCUITS

MFC4000P	£1·12	MC1304	£2·75
I.C. 12	£2·75	MC724P	60p
PA246	£2·45	741c (T05)	85p
TAA263	75p	741c (DIL)	85p
TAD100	£1·97	709c (T05)	65p
TAD110	£1·97	709c (DIL)	65p
MC1303	£2·60	Toshiba 20w Amp	£4·47
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1000+ 6p
Any one type.

Zener Diodes ½ Watt 5% Wire Ends Metal Case
6·8 Volt all voltages to 100 Volts **25p each.**
25+ 22p
100+ 19p
500+ 17p
1000+ 15p
Any one type.

Zener Diodes 3 Watt Plastic Wire Ends 5%
All voltages 6·8 -100 Volts. **30p** each.
25+ 27p
100+ 25p
500+ 23p
1000+ 21p
Any one type.

Zener Diodes 10 Watt Stud Mounting 5%
All voltages 5·1-100 Volts. **40p** each.
25+ 37p
100+ 35p
Any one type.

POWER RECTIFIERS

Stud Mounting 6 amp Range

	P.I.V.	1-49	50+	100+
BYZ10	800	40p	35p	30p
BYZ11	600	35p	30p	25p
BYZ12	400	30p	25p	20p
BYZ13	200	25p	20p	17p

10 amp Rectifiers

	P.I.V.	1-49	50+	100+
SK103	100	45p	40p	37p
SK203	200	50p	45p	42p
SK403	400	55p	50p	45p
SK603	600	60p	55p	50p
SK803	800	75p	70p	65p

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1000 + 15p

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500 + 15p
1000 + 13p

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1000 + 13p

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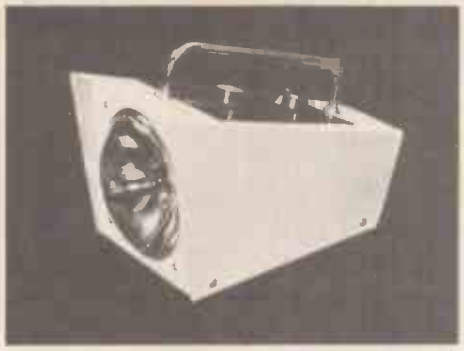

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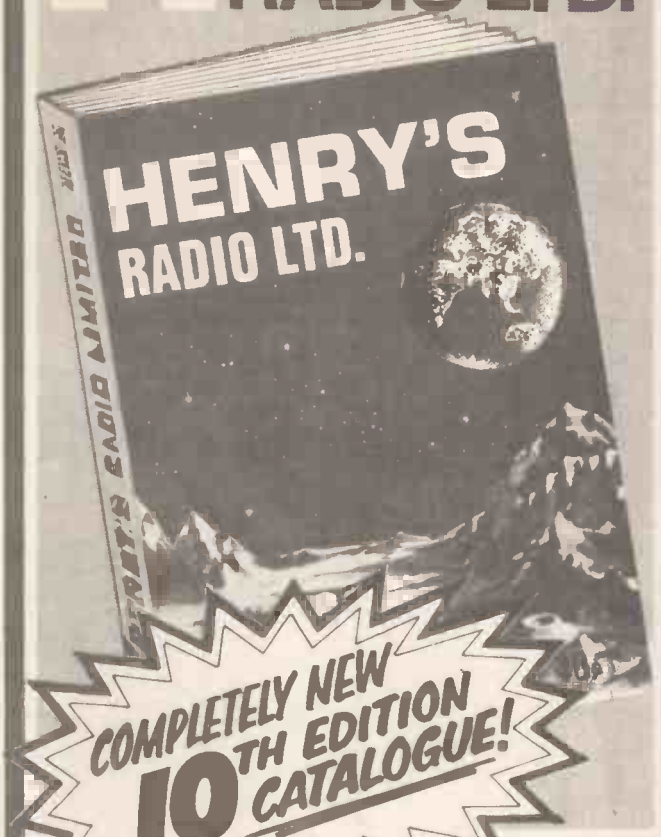

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1DF1	0·33	6C6	0·19	6SH7	0·53	12SQ7GT		50EH5	0·55	DH77	0·18	EF86	0·65	EY87/6	0·80	PCC89	0·45	QP21	0·50	U19	1·73		0·22	ASY29	0·50	GD14	0·50	OC36	0·43
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3D6	0·19	6EW6	0·55	7F8	0·88	25L6G	0·22	306	0·65	E88CC	0·60	EF37A	0·45	GZ34	0·48	PCL84	0·24	R52	0·35	U191	0·58	AC127	0·17	BC115	0·15	GET896	·23	OC78	0·15
3Q4	0·38	6F1	0·59	7H7	0·28	25Y5	0·38	807	0·59	E92CC	0·40	EF39	0·40	GZ37	0·67	PCL85	0·33	RGI/240A		U192	0·25	AC128	0·20	BC116	0·25	GET897	·23	OC78D	0·15
3Q5GT	0·35	6F6	0·63	7R7	0·65	25Y5G	0·43	956	0·10	E180F	0·90	EF40	0·50	HABC80		PCL88	0·85		1·98	U193	0·33	AC154	0·25	BC118	0·23	GET898	·23	OC79	0·40
3S4	0·27	6F6G	0·25	7V7	0·25	25Z4G	0·30	1821	0·53	E182CC		EF41	0·58		0·45	PCL801	0·59	RK34	0·38	U251	0·63	AC156	0·20	BC211	0·38	GEX13	0·18	OC81	0·11
3V4	0·32	6F12	0·17	7Z4	0·50	25Z5	0·40	5702	0·80		1·13	EF42	0·33	HL13C	0·20	PCL805/		SP13C	0·63	U281	0·40	AC157	0·25	BF154	0·25	GEX35	0·23	OC81D	0·11
5R4GY	0·53	6F13	0·33	9BW6	0·50	25Z6G	0·43	5763	0·50	E1148	0·53	EF54	0·98	HL23DD		PCL85		SP42	0·75	U282	0·40	AC165	0·25	BF158	0·29	GEX36	0·50	OC82	0·11
5V4G	0·35	6F14	0·43	9D7	0·78	30C1	0·28	6060	0·30	EA50	0·18	EF73	0·75		0·40	PD500	1·44	SP61	0·33	U291	0·50	AC166	0·25	BF159	0·25	GEX45	0·33	OC82D	0·11
5Y3GT	0·26	6F15	0·65	10C1	1·25	30C15	0·60	7193	0·53	EA76	0·88	EF80	0·22	HL41DD		PEN4DD	0·98	TH4B	0·50	U301	0·40	AC167	0·60	BF163	0·20	GEX55	0·75	OC83	0·20
5Z3	0·45	6F18	0·45	10C2	0·50	30C17	0·77	7475	0·70	EABC80		EF83	0·48	HL42DD		PEN45	0·35	TH233	0·98	U329	0·68	AC168	0·38	BF173	0·38	GT3	0·25	OC84	0·24
5Z4G	0·35	6F23	0·68	10C14	0·30	30C18	0·80	A1834	1·00		0·30	EF85	0·26		1·38	PEN45DD		TP2620	0·98	U381	0·25	AC169	0·33	BF180	0·30	M1	0·15	OC123	0·23
6/30L2	0·55	6F24	0·68	10D1	0·50	30F5	0·70	A2134	0·98	EAC91	0·38	EF86	0·30	HN309	1·40	PEN46	0·20	UABC80	·30	U403	0·33	AC176	0·55	BF181	0·40	M3	0·15	OC139	0·23
6A8G	0·33	6F25	0·58	10DE7	0·50	30FL1	0·60	A3042	0·75	EAF42	0·48	EF89	0·23	HVR2	0·53	PEN453DD		UAF42	0·49	U404	0·38	AC177	0·28	BF185	0·40	MAT100	·39	OC140	0·95
6AC7	0·15	6F26	0·26	10F9	0·45	30FL2	0·60	ACO44	1·16	EB34	0·20	EF91	0·17	HVR2A			0·98	UBC41	0·45	U801	0·93	ACY17	0·25	BF194	0·15	MAT101	·43	OC169	0·23
6AG5	0·25	6F28	0·70	10F18	0·35	30FL12	0·70	AC2PEN		EB91	0·11	EF92	0·35		0·53	PENA4	0·93	UBC81	0·40	U4020	0·38	ACY18	0·20	BFY50	0·23	MAT120	·39	OC172	0·35
6AK5	0·25	6F32	0·15	10LD11	0·53	30FL14	0·68		0·98	EBC41	0·48	EF97	0·55	1W3	0·38	PENDD	0·98	UBF80	0·29	VP2	0·53	ACY19	0·19	BFY51	0·19	MAT121	·43	OC200	0·22
6AK6	0·30	6G6G	0·25	10P13	0·54	30L1	0·29	AC2PENDD		EBC81	0·33	EF98	0·65	IW4/350			0·38	UBF89	0·30	VP13C	0·33	ACY20	0·18	BFY52	0·20	OA5	0·28	OC201	0·38
6AL5	0·11	6GH8A	0·50	10P14	1·10	30L15	0·58		0·98	EBC90	0·18	EF183	0·27	IW4/500		PENDD		UBL21	0·55	VP23	0·40	ACY21	0·19	BTX34/400		OA9	0·13	OC202	0·43
6AM4	0·83	6GU7	0·50	10P18	0·31	30L17	0·69	AC6/PEN		EBC91	0·30	EF184	0·29		0·38	/4020	0·88	UCC84	0·34	VP41	0·33	ACY22	0·15		2·00	OA10	0·43	OC203	0·30
6AM6	0·17	6H6GT	0·15	12A6	0·63	30P4MR			0·38	EBF80	0·30	EFP60	0·50	KT2	0·25	PL33	0·38	UCC85	0·34	VR105	0·33	ACY28	0·18	BY100	0·18	OA47	0·10	OC204	0·30
6AM8A	0·50	6J5G	0·19	12AC6	0·40		0·95	AC/PEN(7)		EBF83	0·38	EH90	0·38	KT8	1·75	PL36	0·47	UCF80	0·34	VR150	0·75	AD140	0·36	BY101	0·15	OA70	0·15	OC205	0·43
6AN8	0·49	6J5GT	0·29	12AD6	0·40	30P12	0·69		0·98	EBF89	0·27	EK90	0·21	KT41	0·98	PL81	0·44	UCH42	0·60	VT61A	0·35	AD149	0·50	BY105	0·18	OA73	0·15	OC206	0·50
6AQ5	0·22	6J6	0·18	12AE6	0·48	30P16	0·30	AC/TP	0·98	EBL21	0·60	EL32	0·18	KT44	1·00	PL81A	0·50	UCH81	0·30	VU120	0·60	AD161	0·45	BY114	0·18	OA79	0·09	OC812	0·40
6AR6	1·00	6J7G	0·24	12AT6	0·23	30P18	0·30	AL60	0·78	EC53	0·63	EL34	0·46	KT63	0·25	PL82	0·30	UCL82	0·33	VU120A	·60	AD162	0·45	BY126	0·15	OA81	0·09	OCP71	1·65
6AT6	0·81	6J7GT	0·38	12AT7	0·16	30P19/		ARP3	0·35	EC54	0·50	EL37	0·87	KT66	0·80	PL83	0·33	UCL83	0·43	VU133	0·35	ADT1400	0·63	BY127	0·18	OA85	0·08	ORP12	0·53
6AU6	0·20	6K7G	0·10	12AU6	0·21	30P4	0·58	ATP4	0·12	EC86	0·63	EL41	0·53	KT74	0·63	PL84	0·30	UF41	0·50	W76	0·34	AF102	0·90	BYY23	1·00	OA86	0·20	S6M1	0·25
6AV6	0·30	6K7GT	0·23	12AU7	0·19	30PL1	0·59	AZ1	0·40	EC88	0·60	EL42	0·53	KT76	0·63	PL302	0·58	UF42	0·60	W91M	0·63	AF114	0·25	BYZ10	0·25	OA90	0·13	8M1036	0·50
6AW8A	0·54	6K8G	0·16	12AV6	0·28	30PL12	0·32	AZ31	0·46	EC92	0·35	EL81	0·50	KT81	2·00	PL504/		UF80	0·35	W107	0·50	AF115	0·15	BYZ11	0·25	OA91	0·09	ST1276	0·50
6AX4	0·39	6L1	0·98	12AX7	0·22	30PL13	0·75	AZ41	0·53	EC332	1·50	EL83	0·38	KT88	1·70	PL508	0·83	UF85	0·34	W729	0·60	AF117	0·19	BYZ12	0·25	OA95	0·09	SX1/6	0·18
6B8G	0·13	6L6GT	0·39	12AY7	0·68	30PL14	0·65	B319	0·29	EC333	1·50	EL84	0·22	KTW61	·63	PL505	1·30	UF86	0·63	XE3	5·00	AF119	0·23	BYZ13	0·25	OA200	0·09	U14706	0·25
6BA6	0·20	6L7GT	0·63	12BA6	0·30	30PL15	0·87	C33	0·90	ECC40	0·60	EL85	0·40	KTW62	·63	PL508	0·90	UF89	0·27	XFY12	0·48	AF124	0·25	CG64H	0·20	OA202	0·10	XZ30	0·25
6BC8	0·50	6LI8	0·45	12BE6	0·30	35A3	0·50	CV6	0·53	ECC81	0·16	EL86	0·38	KTW63	·50	PL509	1·30	UL41	0·54	XH1-5	0·48	AF126	0·18	CG12E	0·20	OA210	0·48	Y543	0·18
6BE6	0·21	6L19	1·38	12BH7	0·27	35A5	0·75	CV988	0·10	ECC82	0·19	EL91	0·23	L63	0·19	PL801	0·69	UL46	0·88	X41	0·50	AF139	0·65	F8Y11A	·23	OA211	0·68	Y728	0·18
6BH6	0·43	6LD20	0·48	12E1	0·85	35D5	0·70	CY1C	0·53	ECC83	0·22	EL95	0·34	M8162	0·63	PL802	0·75	UL84	0·31	X65	0·50			F8Y28A	·23	OC22	0·38	ZE12V7	·09
6BJ6	0·39	6N7GT	0·40	12J7GT	0·33	35L6GT	·42	CY31	0·31	ECC84	0·28	ΣM80	0·38	ME1400	·74	PM84	0·35	UM80	0·33	X101	1·53								
6BQ5	0·22	6P28	0·59	12K5	0·50	35W4	0·23	D63	0·25	ECC85	0·25	EM81	0·39	PC86	0·48		0·33					MHL4	0·75	PX4	1·16	UR1C	0·53	Z329	0·70								
																						MHLD6	·75	PX25	1·16	UU5	0·33	Z749	0·68								
																						MU12/14		PY33/2	0·50	UU9	0·40										
																							0·33	PY80	0·33	UU12	0·22	Transistors									
																						N78	2·05	PY81	0·25	UY1N	0·50	and Diodes									
																						N108	1·40	PY82	0·25	UY21	0·55	1N1124A	·53								
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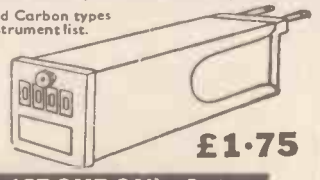

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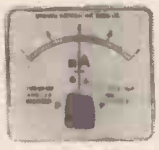

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1mA	£2·60	30 amp.	£2·60
1-0-1mA	£2·60	20V. D.C. ..	£2·60
5mA	£2·60	50V. D.C. ..	£2·60
		150V. D.C...	£2·60
		300V. D.C...	£2·60
		15V. A.C. ..	£2·60
		300V. A.C...	£2·60
		8 Meter 1mA	£2·87½
		VU Meter ..	£3·60
		1 amp. A.C.*	£2·60
		5 amp. A.C.*	£2·60
		10 amp. A.C.*	£2·60
		20 amp. A.C.*	£2·60
		30 amp. A.C.*	£2·60

Type MR.52P. 2½in. square fronts.

50μA	£3·10	10V. D.C. ..	£2·00
50-0-50μA ..	£2·60	20V. D.C. ..	£2·00
100μA	£2·60	50V. D.C. ..	£2·00
100-0-100μA	£2·37½	300V. D.C...	£2·00
500μA	£2·25	15V. A.C. ..	£2·00
1mA	£2·00	300V. A.C...	£2·00
5mA	£2·00	8 Meter 1mA	£2·10
10mA	£2·00	VU Meter ..	£3·10
50mA	£2·00	1 amp. A.C.*	£2·00
100mA	£2·00	5 amp. A.C.*	£2·00
500mA	£2·00	10 amp. A.C.*	£2·00
1 amp.	£2·00	20 amp. A.C.*	£2·00
5 amp.	£2·00	30 amp. A.C.*	£2·00

Type MR.65P. 3½in. × 3½in. fronts

50μA	£3·37½	10V. D.C. ..	£2·10
50-0-50μA ..	£2·75	20V. D.C. ..	£2·10
100μA	£2·75	50V. D.C. ..	£2·10
100-0-100μA	£2·60	150V. D.C...	£2·10
200μA	£2·60	100V. D.C...	£2·10
500μA	£2·37½	15V. A.C. ..	£2·10
500-0-500μA	£2·10	50V. A.C. ..	£2·10
1mA	£2·10	150V. A.C...	£2·10
5mA	£2·10	300V. A.C...	£2·10
10mA	£2·10	500V. A.C...	£2·10
50mA	£2·10	8 Meter 1mA	£2·37½
100mA	£2·10	VU Meter ..	£3·37½
500mA	£2·10	50mA A.C.‡	£2·10
1 amp.	£2·10	100mA A.C.*	£2·10
5 amp.	£2·10	200mA A.C.*	£2·10
10 amp.	£2·10	500mA A.C.*	£2·10
15 amp.	£2·10	1 amp. A.C.*	£2·10
20 amp.	£2·10	5 amp. A.C.*	£2·10
30 amp.	£2·10	10 amp. A.C.*	£2·10
50 amp.	£2·37½	20 amp. A.C.*	£2·10
5V. D.C.....	£2·10	30 amp. A.C.*	£2·10

Type MR.38P. 1 21/32in. square fronts.

50μA	£2·00	200mA	£1·37½
50-0-50μA ..	£1·87½	300mA	£1·37½
100μA	£1·87½	500mA	£1·37½
100-0-100μA	£1·75	750mA	£1·37½
200μA	£1·75	1 amp.	£1·37½
500μA	£1·50	2 amp.	£1·37½
500-0-500μA	£1·37½	5 amp.	£1·37½
1mA	£1·37½	10 amp.	£1·37½
1-0-1mA	£1·37½	3V. D.C....	£1·37½
2mA	£1·37½	10V. D.C. ..	£1·37½
5mA	£1·37½	15V. D.C. ..	£1·37½
10mA	£1·37½	20V. D.C. ..	£1·37½
20mA	£1·37½	100V. D.C...	£1·37½
50mA	£1·37½	150V. D.C...	£1·37½
100mA	£1·37½	300V. D.C...	£1·37½
150mA	£1·37½	500V. D.C...	£1·37½
		750V. D.C...	£1·37½
		15V. A.C. ..	£1·37½
		50V. A.C. ..	£1·37½
		150V. A.C...	£1·37½
		300V. A.C...	£1·37½
		500V. A.C...	£1·37½
		8 Meter 1mA	£1·60
		VU Meter ..	£2·10

Type MR.45P. 2in. square fronts.

50μA	£2·25	5 amp.	£1·50
50-0-50μA ..	£2·10	10V. D.C. ..	£1·50
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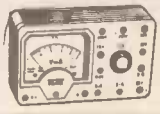

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Number of digits: 3 plus fourth overrange digit.
Overrange: 100% (up to 1·999)
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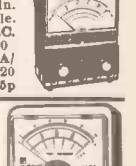

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2N3055	72p	2N5356	32p	BC119	35p	BFX93A	70p	NKT248	20p	ZTX502	20p
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2N3134	30p	2N5366	32p	BC122	20p	BFY18	25p	NKT250	20p	ZTX504	40p
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2N3136	25p	2N5457	34p	BC126	25p	BFY21	42p	NKT275	20p		
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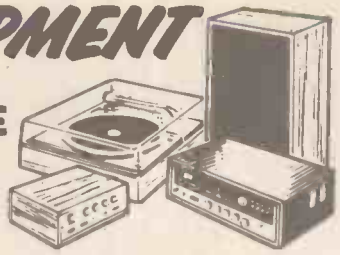

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MARCONI CT44 TF956 AF ABSORPTION WATTMETER

1 μ/watt to 6 watts £20. Carr. £1.

BELCO DA-20 SOLID STATE DECADE AUDIO OSCILLATOR

New high-quality portable instrument Sine 1 Hz to 100 KHz. Square 20 Hz to 20 KHz. Output max. +10 db (10 K ohms). Operation 220/240 v. A.C. Size 215 mm × 150 mm × 120 mm.

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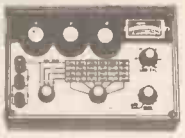
TE22 SINE SQUARE WAVE AUDIO GENERATORS

Sine: 20 cps to 200 kc/s. on 4 bands. Square 20 cps to 30 kc/s. Output impedance 5,000 ohms, 200/250 v. A.C. operation. Supplied brand new and guaranteed with instruction manual and leads. £16·50. Carr. 37½p.

TRANSISTORISED L.C.R. A.C MEASURING BRIDGE.



A new portable bridge offering excellent range and accuracy at low cost. Ranges: R. 1Ω—11.1 MEG Ω 6 Ranges ± 1%. L. 1μH—111 HENRIES. 6 Ranges — 2%. C. 10PF± 1110MFD. 6 Ranges ± 2%. TURNS RATIO 1:1/1000—1:11100. 6 Ranges ± 1%. Bridge voltage at 1,000 CPS. Operated from 9 volts. 100μA. Meter indication. Attractive 2 tone metal case. Size 7½" × 5" × 2" £20. P. & P. 25p.

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LAFAYETTE TE-46 RESISTANCE CAPACITY ANALYSER

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Our Price £5·97. P. & P. 25p.

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5 mc/s Pass Band. Separate Y1 and Y2 amplifiers. Rectangular 5 in. × 4 in. C.R.T. Calibrated triggered sweep from .2 μ/sec. to 100 milli-sec. per cm. Free running time base 50 c/s-1 mc/s. Built-in time base calibrator and amplitude calibrator. Supplied complete with all accessories and instruction manual. £87 Carr. paid.

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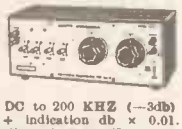

Variable range 0-111 db. Connections. Unbalanced T and Bridge T. Impedance 600 ohms. Range (0.1 db × 10) + (1 db × 10) + 10 + 20 + 30 + 40 db. Frequency: DC to 200 KHZ (—3db) Accuracy: 0.05 db. + indication db × 0.01. Maximum input less than 4 watts (50 volts). Built in 600 Ω load resistance with internal/external switch. Brand new £27·50 P. & P. 25p.

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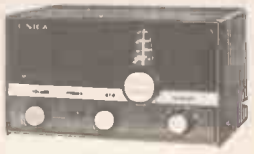

UNR 30 RECEIVER

4 Bands covering 550kc/s - 30mc/s. B.F.O. Built in Speaker 220/240v AC. Brand new with instructions. £15·75. Carr. 37½p.

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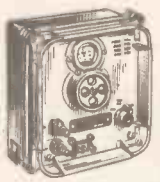

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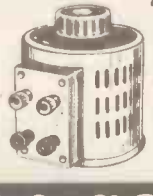

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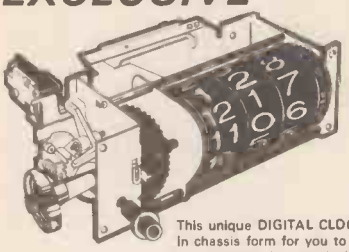

- Made especially for Lasky's by famous maker
- Mains operation
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- Shock and vibration proof
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This unique DIGITAL CLOCK is now available EXCLUSIVELY FROM LASKY'S in chassis form for you to mount in any housing that you choose. All settings are achieved by two dual-concentric controls at the front including: ON-OFF-AUTO and AUTO ALARM, "sleep" switch, 10 minute division "click" set alarm (up to 12 hour delay), time adjustment. Ultra simple mechanism and high quality manufacture guarantee reliable operation and long life.

The sleep switch will automatically turn off any appliance—radio, TV, light, etc., at any pre-set time up to 60 min. and in conjunction with the AUTO setting will switch on the appliance again next morning.

The clock measures 4¾W x 1¾H x 3¾D (overall from front of drum to back of switch). SPEC: 210/240V AC, 50Hz operation; switch rating 250V, 3A. Complete with instructions. HUNDREDS OF APPLICATIONS.

COMPLETE WITH SET OF CONTROL KNOBS

LASKY'S PRICE £6.95 P & P 18p.

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High precision, low-mass, counterbalanced pick-up arm, heavy balanced turntable, viscous cueing device, slide in cartridge, 4 pole motor.

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BSR McDonald units and packages

A. Chassis only. B. Complete with Lasky's plinth and cover. C. Complete with Lasky's plinth, cover and AD76K cart. D. comp. wired on BSR plinth with cover. E. As D plus AD76K cartridge.

Model	A	B	C	D	E
610	£15.45	£18.75	£22.50	£24.50	£28.50
510	£13.45	£16.95	£20.75	£22.00	£26.00
310	£9.95	£13.45	£17.25	£21.00	£23.50
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DENSHI KIT SR-1A

Kit comprises: Base board: tuner block, 4 resistors: choke coil; transformer; 28A transistor for RF, 2 diodes; 3 capacitors; battery block; morse key; antenna lead; crystal earphones; various bridge and connecting pieces. This kit permits the building of 16 basic circuits.

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Kit comprises of: 2 base boards, 50 component and accessory parts inc. 3 transistors and 2 diodes, vol. control, 2½in speaker in extension baffle housing, cadmium sulphide photo cell, crystal mic., earpiece, test probes, morse key, extension leads etc. Build at least 100 projects Comp. with batt.

DENSHI DR-7 (illustrated)

With this kit you can build various types of IF amplifiers and both audio and power amplifiers which can be used with external auxiliary equipment. Comprises 3in loudspeaker, personal earpiece, 7 transistors, diode, thermistor, volume control, capacitors, resistors, tuning capacitor, battery connectors, external project terminal blocks, shoulder carrying strap, battery, etc. PLUS 36 page manual of theory and schematics. High impact resistant case. Will house any of the radio receiver circuits thus making an excellent portable radio.

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121	Dual 4-input NAND gate	7420	20p	16p	14p
131	8-input NAND gate	7430	20p	16p	14p
141	Dual 4-input NAND buffer	7440	24p	20p	17p
151	Expandable dual 2-wide 2-input AND-OR-INVERT gate	7450	20p	16p	14p
161	Dual 2-wide 2-input AND-OR-INVERT gate	7451	20p	16p	14p
171	Expandable 4-wide 2-input AND-OR-INVERT gate	7453	20p	16p	14p
181	4-wide 2-input AND-OR-INVERT gate	7454	20p	16p	14p
191	Quadruple 2-input NOR gate	7402	20p	16p	14p
201	Quadruple 2-input NAND gate with with open collector output	7401	20p	16p	14p
211	Hex inverter	7404	25p	21p	18p
221	Gated full adder	7480	67p	56p	48p
231	2-bit binary full-adder	7482	87p	73p	62p
241	Four-bit binary full adder	7483	£1·32	£1·16	£1·00

Part No.	Description	Equal to	1-24	25-99	100 up
271	Hex inverter with open collector output	7405	25p	21p	18p
281	BCD to decimal decoder TTL output	7442	£1·16	94p	81p
291	Quadruple 2-input NAND gate with open collector output	7403	20p	16p	14p
341	Quadruple 2-input exclusive-OR element	7486	33p	27p	23p
351	Schmitt Trigger	7413	35p	29p	25p
361	Excess 3 to decimal decoder	7443	£1·45	£1·20	£1·08
371	Excess 3 gray to decimal decoder	7444	£1·45	£1·20	£1·08
381	Quad 2-input positive AND gate Totem pole output	7408	25p	21p	18p
391	Quad 2-input positive AND gate open collector	7409	25p	21p	18p
FLY101	Dual 4-input expander	7460	20p	16p	14p
FLJ 101	J-K flip flop	7470	45p	37p	32p
111	J-K master-slave flip-flop	7472	32p	27p	23p
121	Dual J-K master-slave flip-flop	7473	45p	40p	35p
131	Dual J-K master-slave flip-flop with preset and clear	7476	45p	40p	36p

Part No.	Description	Equal to	1-24	25-99	100 up
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151	Quad bistable latch	7475	45p	40p	37p
161	Decade counter	7490	80p	67p	57p
171	Divide-by-12 counter	7492	85p	71p	61p
181	4-bit binary counter	7493	80p	67p	57p
191	4-bit shift register	7495	87p	72p	62p
201	Synchronous up down 4-bit decade counter with one line mode control	74190	£1·80	£1·48	£1·27
211	Synchronous up down 4-bit binary counter with one line mode control	74191	£1·80	£1·48	£1·27
221	8-bit shift register	7491A	£1·28	£1·07	92p
231	4-bit shift register	7494	£1·13	94p	81p
241	Synchronous up down 4-bit decade counter	74192	£1·74	£1·45	£1·25
251	(As above)—binary counter	74193	£1·74	£1·45	£1·25
261	5-bit shift register	7496	£1·48	£1·22	£1·05
271	Dual J-K master-slave flip-flop with preset and clear	74107	52p	43p	36p
301	Dual quadruple bistable latch	74100	£1·64	£1·37	£1·17
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AC128	20p	C3V6	15p	NKT20329/ 0013	31p	2G302	19p
AC176	25p	C3V9	15p	NKT80111	67p	2G371	15p
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AC188	30p	C4V7	15p	NKT80113	£1·00	2N174	80p
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ACY18	20p	C5V6	15p	NKT80212	75p	2N404	23p
ACY19	20p	C6V2	15p	NKT80214	75p	2N696	15p
ACY20	19p	C6V8	15p	NKT80216	75p	2N697	17p
ACY21	19p	C7V5	15p	OA5	20p	2N698	30p
ACY22	19p	C8V2	15p	OA10	25p	2N706	10p
ACY40	15p	C9V1	15p	OA47	8p	2N706A	12p
ACY41	15p	C10	15p	OA70	8p	2N708	16p
AD140	55p	C11	15p	OA73	8p	2N711	37p
AD149	57p	C12	15p	OA79	8p	2N711A	37p
AD161	37p	C13	15p	OA81	8p	2N911	50p
AD162	37p	C15	15p	OA85	8p	2N914	20p
AF114	25p	C16	15p	OA90	8p	2N918	42p
AF115	25p	C18	15p	OA91	8p	2N1090	30p
AF116	25p	C20	15p	OA95	8p	2N1091	33p
AF117	25p	C22	15p	OA200	10p	2N1131	30p
AF118	44p	C24	15p	OA202	10p	2N1132	30p
AF124	25p	C27	15p	OC19	37p	2N1302	20p
AF126	17p	C30	15p	OC20	97p	2N1303	20p
AF139	37p	D13T1	45p	OC22	47p	2N1304	25p
AF186	40p	MJE520	75p	OC23	60p	2N1305	25p
AF239	37p	MJE521	75p	OC24	60p	2N1306	30p
ASY26	25p	MJ480	97p	OC25	37p	2N1307	30p
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BC109	12p	NKT125	40p	OC45	15p	2N2368	17p
BC147	15p	NKT126	37p	OC70	15p	2N2369	17p
BC148	15p	NKT128	25p	OC71	15p	2N2369A	20p
BC149	15p	NKT135	26p	OC72	23p	2N2646	50p
BC158	17p	NKT137	32p	OC75	23p	2N2904	44p
BC169C	19p	NKT210	25p	OC76	25p	2N2904A	49p
BC182	12p	NKT211	25p	OC77	40p	2N2905	65p
BC182L	10p	NKT212	25p	OC81	23p	2N2905A	75p
BC183	9p	NKT213	25p	OC81D	20p	2N2906	44p
BC183L	9p	NKT214	23p	OC81Z	55p	2N2906A	54p
BC184	15p	NKT215	21p	OC82	25p	2N2926 all colours	10p
BC184L	15p	NKT216	46p	OC82D	15p	2N3053	25p
BC212	17p	NKT217	50p	OC83	23p	2N3054	63p
BC212L	12p	NKT218	25p	OC84	25p	2N3055	75p
BCY30	25p	NKT219	25p	OC139	25p	2N3702	11p
BCY31	48p	NKT223	27p	OC140	35p	2N3703	10p
BCY32	50p	NKT224	25p	OC170	25p	2N3704	11p
BCY33	20p	NKT225	21p	OC171	30p	2N3705	10p
BCY34	25p	NKT229	29p	OC200	37p	2N3706	9p
BCY38	30p	NKT237	31p	OC201	47p	2N3707	11p
BCY70	19p	NKT238	19p	OC202	63p	2N3708	7p
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BF163	40p	NKT261	21p	ORP60	60p	2N4060	20p
BF167	25p	NKT262	19p	ORP61	40p	2N4061	20p
BF173	30p	NKT264	21p	P346A	19p	2N4062	20p
BF178	52p	NKT271	18p	ST140	15p	2N4284	15p
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Power Unit for above Modules: Type PU11/30, 30V, 500mA. 100W slave amplifier—100W into 4 ohm load 13¾in x 10½in x 7½in.

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2N1305	26p	2N3706	13p	AD142	50p	BC178	13p	NKT212	25p
2N1306	33p	2N3707	13p	AD149	58p	BC179	14p	NKT214	23p
2N1307	33p	2N3708	10p	AD161	33p	BC182L	11p	NKT274	18p
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2N1711	26p	2N3819	23p	AF117	22p	BC213L	16p	OC81	25p
2N1893	54p	2N3904	35p	AF124	33p	BC214L	16p	OC83	20p
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RESISTORS—10%, 5%, 2%

Code	Power	Tolerance	Range	Values available	to 9	10 to 99 (see note below).	100 up
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C	1/8W	5%	4·7Ω–470K Ω	E24	1	0·8	0·7
C	1/4W	10%	4·7Ω–10MΩ	E12	1	0·8	0·7
C	1/2W	5%	4·7Ω–10MΩ	E24	1·2	1	0·9
C	1W	10%	4·7Ω–10MΩ	E12	2·5	2	1·8
MO	1/2W	2%	10Ω–1MΩ	E24	4	3·5	3
WW	1W	10% ± 1/20Ω	0·22Ω–3·9Ω	E12	7	7	6
WW	3W	5%	12Ω–10KΩ	E12	7	7	6
WW	7W	5%	12Ω–10KΩ	E12	9	9	8

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WW = wire wound, Plessey.

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E12 denotes series: 10, 12, 15, 18, 22, 27, 33, 39, 47, 56, 68, 82 and their decades.
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BP 74 = 7474	Dual D Type Flip-Flop	37p	35p	32p
BP 75 = 7475	Quad Latch	47p	45p	42p
BP 76 = 7476	Dual J-K with Pre-Set & Clear	43p	40p	38p
BP 80 = 7480	Gated Full Adders	67p	64p	58p
BP 81 = 7481	16-Bit Read-Wright Memory	97p	94p	88p
BP 82 = 7482	2-Bit Binary Full Adders	97p	94p	88p
BP 83 = 7483	Quad Full Adder	£1·10	£1·05	95p
BP 86 = 7486	Quad 2-Input Excl. Nor Gates	32p	30p	28p
BP 90 = 7490	BCD Decader Counter	67p	64p	58p
BP 91 = 7491	8-Bit Shift Registers	87p	84p	78p
BP 92 = 7492	Divide-by-Twelve Counters	67p	64p	58p
BP 93 = 7493	4-Bit Binary Counters	67p	64p	58p
BP 94 = 7494	Dual Entry 4 Bit Shift Register	77p	74p	68p
BP 95 = 7495	4 Bit Up-Down Shift Register	77p	74p	68p
BP 96 = 7496	5 Bit Parallel in Parallel out Shift-Register	77p	74p	68p
BP100 = 74100	8-Bit Bistable Latches	£1·75	£1·65	£1·55
BP104 = 74104	Single J-K Flip-Flop equiv. 9000 Series	97p	94p	88p
BP105 = 74105	Single J-K Flip-Flop equiv. 9001	97p	94p	88p
BP107 = 74107	Dual Master Slave Flip-Flops	40p	38p	36p
BP110 = 74110	Gates Master-Slave FlipFlops	55p	53p	50p
BP111 = 74111	Dual Data Lock-out Flip-Flop	£1·25	£1·15	£1·00
BP118 = 74118	Hex Set-Reset Latches	£1·00	95p	90p
BP119 = 74119	Hex Set-Reset Latches 24 pin	£1·35	£1·25	£1·10
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BP154 = 74154	4 to 16 Line Decoder	£1·80	£1·70	£1·60
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BP161 = 74161	Sync. 4-Bit Binary Counter	£1·80	£1·70	£1·60
BP190 = 74190	Sync. Up-Down BCD Counter	£3·50	£3·25	£3·00
BP191 = 74191	Sync. Binary Up-Down Counter (single clock line)	£3·50	£3·50	£3·50
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UIC02 = 12 × 7402N	50p	UIC51 = 12 × 7451N	50p	UIC83 = 5 × 7483N	50p
UIC03 = 12 × 7403N	50p	UIC60 = 12 × 7460N	50p	UIC86 = 5 × 7486N	50p
UIC04 = 12 × 7404N	50p	UIC70 = 8 × 7470N	50p	UIC90 = 5 × 7490N	50p
UIC05 = 12 × 7495N	50p	UIC72 = 8 × 7472N	50p	UIC92 = 5 × 7492N	50p
UIC10 = 12 × 7410N	50p	UIC73 = 8 × 7473N	50p	UIC93 = 5 × 7493N	50p
UIC20 = 12 × 7420N	50p	UIC74 = 8 × 7474N	50p	UIC94 = 5 × 7494N	50p
UIC40 = 12 × 7440N	50p	UIC75 = 8 × 7475N	50p	UIC95 = 5 × 7495N	50p
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BP935	Expandable Hex Inverter	13p	12p	11p
BP936	Hex Inverter	13p	12p	11p
BP944	Dual 4-input NAND expandable buffer without pull-up	13p	12p	11p
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BP946	Quad, 2-input NAND	12p	11p	10p
BP948	Master-slave JK or RS	25p	24p	22p
BP951	Monostable	65p	60p	55p
BP962	Triple 3-input NAND	12p	11p	10p
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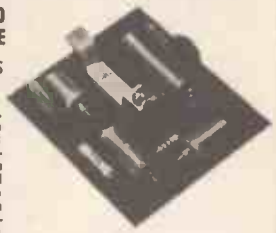

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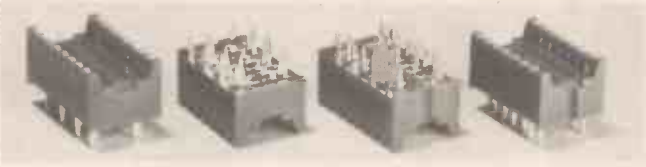

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Special offer of AMPEX professional tape heads, mu-metal shrouded. (Designed for model AG20). Full track record, or playback, **£3·00**. Erase head **£2·00**. Set of 3 with mounting bracket and cover **£7·50**. Half track record only, **£3·00** each. Carriage paid.

OXLEY P.T.F.E. BARB TERMINALS. Stand off ⅛" or ¼". **£2·75** box of 100.

HARWIN. Tapped (6 Ba) high voltage "stand off" insulators, length ¼", tapped (8 Ba) ⅜" long. **£2·00** per 100. Carriage Paid.

"BENSON BROS." 12v. D.C. HEAVY DUTY SOLENOID. Size: 3" overall × 1¼" × 1". Very powerful. Cont. rated. **£1·00** each. P. & P. 15p.

"DECCO" MAINS SOLENOID.— Compact and very powerful. 16 lb. pull. ⅜" travel which can be increased to 1" by removing captive-end-plate. Overall size 2"×2½"×2¾" high. **£1·50**. P. & P. 25p.

WEBBER MAINS SOLENOID. Robust and strong. On this item the plunger travel is 1¾". Performance: 6 lb. pull at 1½"; 8 lb. at 1"; 10 lb. at ½". The non-captive plunger has a fixing eye to take up to ¼" bolt. Size: 2⅜" high × 2" × 2". **£1·25** plus 25p P. & P.

MAINS SOLENOID BY MAGNETIC DEVICES LTD. A beautifully constructed solenoid at half normal price. A two-sided bracket is incorporated for vertical or horizontal mounting. Size: 2" × 1½" × 1½". Pull is approx. 2 lb., plunger travel 1½". Fixing eye takes up to ¼" bolt. Plunger non-captive. New in original makers boxes. **75p** each, plus 25p P. & P. Large number available, special price for quantity.

RELAYS

Perspex enclosed, plug in, with base. Size 1¼" × 1½" × 2¾"
MQ 308 600Ω 24v. 4 c/o. **60p** ea., **£5·00** per doz.
MQ 508 10,000Ω 100v. 4 c/o. **50p** ea., **£4·50** per doz.

S.T.C. Midget Field Relay type 4109EC. 12v. 40 mA 170Ω, single H.D. make. **53p** each.

"B. & R." 3 c/o. 10 amp. contacts (silver) operates on 2 volts D.C. Draws approx. 1 amp. Size: 2" × 1½" × 1⅜". **£1·00.**

"OMRON" OCTAL BASE. A.C. mains. 2 × 5 amp. C/O contacts. Perspex enclosed. **88p.**

A.E. Perspex enclosed, plug in, 50Ω 6v. 2 c/o. **63p** ea. 470Ω 12v. 4 c/o. **73p** ea. 2,780Ω 48v. 4 c/o. **73p** ea. 1,260Ω 48v. 6 c/o. **83p** ea.

E.R.G. 1,000Ω 6v. DC. 1 make encapsulated reed type. Size: ⅜" × 7/16" × 1⅞". 4 for **£1·00.**

NEW "F.I.R.E." PLUG-IN RELAY.—115v. Coil 50/60 c.p.s. 3 heavy duty silver change-over contacts. Very robust. **63p.**

NEW "ISKRA" 240v. A.C. RELAY.—3 × 6 amp Changeover contacts. **63p.**

SIEMENS HIGH SPEED RELAY, Type 89L. 1,700Ω + 1,700Ω coil. New **63p** each.

MINIATURE "LATCH-MASTER" RELAY 6, 12, or 24v. D.C. operation. One make one break, contacts rated 5 amps. at 30v. Once current is applied, relay remains latched until input polarity is reversed. Manufactured for high acceleration requirements by Sperry Gyroscope Co. Size: Length ⅜", dia. 7/16" (including mount). Please state vertical or horizontal mount and voltage. **£1·63** each.

VINKOR POT CORE ASS. TYPE LA.2103 (core LA.2100). Normal price £1·48. Our price **75p** each. Special quote for quantity.

UNISELECTORS. 8 Bank 25-way 24v. Double sweep. Brand new in maker's boxes. **£5·25.** P. & P. 25p.

ELECTROLYTIC CAPACITORS MULLARD. 900μF 100v. heavy ripple screw terminals 1⅞" dia. × 3½", **70p** eac., **£6·00** per doz. 1,600μF 64v. 1⅜" dia. × 3" **38p** ea., **£3·50** per doz. 10,000μF 10v. 1⅜" dia. × 3", **38p** ea., **£3·50** per doz. 1,250μF 25v. 1" dia. × 2". **50p** ea., **£4·50** per doz.

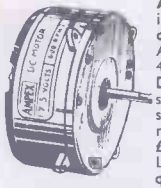
HUNTS 1,000μF 50v. 1⅜" dia. × 2", **25p** ea., 10,000μF 6v. 1⅜" dia. × 2", **30p** ea., **£3·00** per doz. 16μF 350v. ⅞" × 1¼" wire ends, **£2·00** per doz. 1,000μF 50v. 1" dia. × 3", **30p** ea., **£3·00** per doz. 32-32μF 275v. 1" dia. × 2", **38p** ea. 100μF 100v. 1" dia. × 2", **25p** ea.

ERIE. Ceramicon capacitor. Type CHV411P. 500 P.F. 30KV Size 1·5" dia. × 1·44" long. **50p** ea. Carriage paid.

HIGH CAPACITY ELECTROLYTICS. Cylinder. type with screw terminals on top. Average size 3" dia. × 4½" high. "Mallory" 20,000μF 30v. D.C. 45v. D.C. surge. "Mallory 25,000μF 25v. D.C., 40v. D.C. surge. Mallory 35,000μF 15v. D.C., 20v. D.C. surge. "Mallory" 40,000μF 10v. D.C., 12v. D.C. surge. "Sprague" 40,000μF 10v. D.C., 12v. D.C. surge. "General Electric" 46,500μF 25v. D.C., 30v. D.C. surge. "General Electric" 55,000μF 15v. D.C., 20v. D.C. surge. **50p** each. Minimum order **£1·00** on these items. P. & P. 10p each.

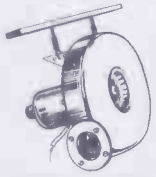
WHERE NO CARRIAGE CHARGE IS INDICATED PRICE IS INCLUSIVE. PERSONAL CALLERS WELCOME.

MOTORS



AMPEX 7.5v. D.C. MOTOR. This is an ultra-precision tape motor designed for use in the AMPEX model AG20 portable recorder. Torque 450GM/CM. Stall load at 500ma. Draws 60ma on run. 600 rpm ± 5% speed adjustment, internal AF/RF suppression. ¼" dia. × 1" spindle, motor 3" dia. × 1⅜". Original cost £16·50. **Our price £4·25.** P. & P. 25p. Large quantity available (special quotations). Mu-metal enclosure available **75p** each.

Brand New "DISCUS" Centrifugal Blower by Watkins & Watson. 240v. 50 Hz. Powered by A.E.I. continuous rating 2850 rpm motor. Cowl diameter 10". Outlet flange 2" I.D. Coupling flange supplied. These superb precision units are ideally suited for **Organ construction.** Offered at approx. half makers price **£12·50.** Carriage £1·50.



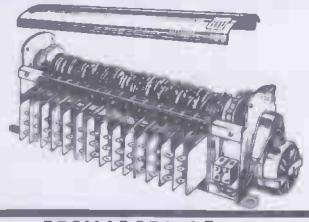
"PRECISION FAN CO." (Smiths Industries) DOUBLE ENTRY CENTRIFUGAL FAN/BLOWER.—This is a beautifully balanced, particularly quiet running, unit giving approx. 90 cubic ft./min. The motor is a 2 pole shaded pole Mycalex, drawing only 240ma on run. Weight 2¼ lb. Sizes: Case dia. 3·1 in., width (case only) 3·125 in., width overall (inc. motor) 5·25 in., aperture 3·125 in. by 1·85 in. Offered well below makers price at **£3·25.** P. & P. 25p.

SPECIAL SUMMER OFFER

LIMITED PERIOD ONLY FROM NOW UNTIL 31st AUG. 1971 A DISCOUNT OF 20% WILL BE DEDUCTED ON ALL ORDERS OF £7·50 AND OVER

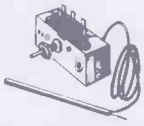
PROGRAMME TIMER BY HONEYWELL

A bank of 15 micro-switches are each independently operated by 15 pairs of cams which in turn are individually adjustable to give switching periods of zero to 12 seconds with infinitely variable combinations. A mains synchronous motor drives the cam shaft at 1 rev. per 12 seconds (5 R.P.M.). Designed originally for vending machines at a cost of £15·00 plus. Many applications where continuous sequence programmes are required, such as lighting effects etc. New in original makers cartons. First class value at £5·75 plus 25p P. & P.

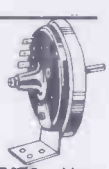


DEAC. RECHARGEABLE PERMA-SEAL Nickel-Cadmium Batteries Type 900D. 1·22v. at 900 mA (10-hr. rate). Size 90 mm. × 13·5 mm. Weight 40 gr. Unused **63p** ea. P. & P. 12p. **Stock now running low.**

"TEDDINGTON" CONTROLS THERMOSTAT.—Adjustable between 75° and 100°C. A further internal adjuster takes the maximum up to 120°C. Circuit cuts in again at 3° below cut-out setting. 42" capillary and sensor probe. The thermostat actuates a 15 amp. 250v. c/o switch. A second single pole on/off switch is incorporated in the adjustment mechanism. **88p.**



"GOYEN" PRESSURE SWITCH. —Incorporating differential adjustment between 2" and 12" water gauge (a max. of approx. ½ p.s.i.). A single pole change-over switch rated 15 amps. 250v. is actuated. Air inlet tube 7/16" dia. Projection 1¼". Overall size: dia. 3½", depth 2" plus 1¼" (air tube). **£1·25.**



HEAVY DUTY PORTABLE BATTERIES. New ex WD. 12v. 75 AH. Built in stout metal cases with carrying handles and nifam socket outlet. Size 15½" × 7½" × 10½" high, weight 73lb. **£8·75.** Carriage **£2.**

L.T. TRANSFORMERS. Prim. 0-110-240 v. Sec. 4·5 v.-0-4·5 v. at 1A. Size: 1⅞" × 1¼" × 1⅝". **60p.** P. & P. 15p. Prim. 220/240 v. Sec. 0-5-10-15-20 v. at 2 amps. **£1·25.** P. & P. 15p.

ADVANCE CONSTANT VOLTAGE TRANSFORMER. Type CVS 750A. Input 190-260 v. 50 Hz. Output 240 v. r.m.s. Load 750 watts. Size: 18 7/16" × 7 7/16" × 8⅜" high. Weight 68 lb. **£47·50.** Carriage **£2·50** (G.B. only).

GEARED MOTORS

"Parvalux" Reversible 100 RPM Geared Motor. Type S.D.14, 230/250v. A.C. 22 lb./in. ⅜" spindle. 1st class condition. **£7·50** each. P. & P. 50p. Also limited number only as above. **Brand New. £12·50** each P. & P. 50p.

ELECTRO CONTROL (CHICAGO). Shaded pole 240v. 50 Hz. 200 rpm 10 lb./in. **£2·50.** P. & P. 25p.

MYCALEX. Open frame, shaded pole motors. 240v. 50 Hz, 7 rpm. 28 lb./in. 80 rpm. 12 lb./in. **£2·25** each. P. & P. 25p.

"CROUZET" TYPE 965. 115/240v. 50 Hz. 47/68 watts. 50 rpm. Stoutly constructed. Size: 2½" dia. × 3½" long, plus spindle 1" × ¼" dia. Anti-clock. **£2·75.** P. & P. 25p.

TYPE 955. Same as above, but 3 rpm. **£3·00.** P. & P. 25p.

SYNCHRONOUS MOTORS. 220/380 v. 50/60 Hz. 250-300 rpm. **75p** each.

MYCALEX MAINS. Shaded pole, 1425 rpm. 3/16" spindle. 2 for **£1·25.** Carriage Paid.

MAINS INDUCTION MOTOR. Open frame, ¼" spindle, weight ¾ lb. Powerful. 88p each. P. & P. 12p

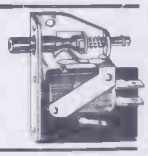
E.M.I. PROFESSIONAL TAPE MOTOR. 110/240 v. 50 Hz. 1500 rpm, reversible, silent running. 4¼" dia. × 4½" long. Spindle ⅜" × 2". Weight 6 lbs. **£3·50** each or **£6·00** per pair. P. & P. 50p each.

"FIBRE GLASS" COPPER CLAD. Top grade. One size only, 7½" × 4½" × 1/16". 3 panels **£1·00.** 12 panels **£3·50.** P. & P. 15p.

BELLING & LEE FUSEHOLDERS

TYPE LI382. Size 0. Rating 7A. Breakdown voltage (DC): > 10 kV. List price 71p. Our price **£2·00** per doz.
TYPE LI744. Size 0. Takes 1¼" × ¼" fuses. Connecting posts suitable for soldering or solderless snap-on connectors (¼" × 0·032"). Current rating 30A max. List price 30p. Our price **£1·50** per doz.

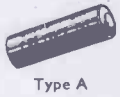
"HONEYWELL" TYPE 23AC-NE.—15 amp. change-over micro switch is fitted on angled metal mount with spring-loaded plastic rod operating cam. **50p** each.



PLUNGER SWITCHES. Spring return. 3 P.D.T. 1 amp. Single action. Size: ⅞" × 7/16" plus plunger. **£1·50** per doz. Carr. Paid.

SLIDER SWITCHES. 3 amp. type D.P.D.T. 1" × 9/16" × ¾" deep. 1 amp. type 3 P.D.T. ½" × 7/16" × 7/16" deep. **£1·25** per doz. Either type or mixed as required. Carr. Paid.

"MALLORY" LONG LIFE BATTERIES. Type A. RM12 cell 1·35v. 3,600 ma/H. CAP. 250/300 ma cont. current. Size: 2" × ⅞". 5 for **£1·00** or **£2·00** per doz. Carr. Paid. Type B. Comprises 8 × RM 625 cells. Nom. volts. 1·35 each 10·5v. Overall. 350 ma/H CAP. 20/25 ma cont. current. Size: 2¼" × ⅞" × ⅞". 3 for **£1·00** or **£3·00** per doz. Carr. Paid.



Type A

Type B

A.C./D.C. M/IRON AMMETERS. 0-5 amps or 0-8 amps (suitable battery chargers etc.). Perspex front. Size: 1⅝" × 1⅛". Any 2 for **£1·10.** Carr. Paid.

CURRENT FLOW INDICATOR. Ideal for all types of battery operated equipment (portable machines, tape recorders etc.). Four white segments appear when current flows. Coil is 600Ω 6/12v. Drawing only 8 ma on function. Neat in appearance. Size: dia. 1⅛" × 1⅛" deep. Fixing centres 1⅛". **£1·25** each. Carr. Paid.

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BSY26	13p	OC28	30p
BSY27	13p	OC35	25p
BSY28	13p	OC36	37p
BSY29	13p	AD149	30p
BSA95A	13p	2N3055	63p
OC41	13p	2SO34	25p
OC44	13p	Diodes	
OC45	13p	AAY42=OA5	10p
OC71	13p	OA91	9p
OC72	13p	OA79	9p
OC81	13p	OA81	9p
OC81D	13p	IN914	7p
OC139	13p		
OC140	17p		

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	1-10	10-50	50+
SL 403D Audio Amp.	2.00	1.95	1.80
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A.E.I. Fully marked & tested Gates	25p	22p	20p
A.E.I. Fully marked & tested Flipflops	50p	40p	30p
OC71/72. Fully tested, unmarked	5p	5p	4p
Matched Sets, 1-OC44, 2-OC45. Per set	25p	20p	15p
Matched Sets, OC45, 1st & 2nd I.F. Per set	15p	12p	10p
TIC45 Thyristors, 6A, 60V, Texas	15p	15p	12p
OA47 Gold bonded Diodes, marked & tested	3p	3p	2p
1W Zener Diodes: 6.8V, 7.5V, 24V, 27V, 30V & 43V	5p	4p	3p
10W Zener Diodes: 7.5V, 11V, 13V, 20V & 100V	20p	17p	15p
Micro Switches, S/P, C/O. Popular size	25p	20p	15p
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1 Amp Plastic Rectifiers: These are voltage, reverse Polarity and other rejects from the BY127 range. Ideal for low voltage Power Units etc. Price: £1 per 100.

COLOUR T.V. LINE OUTPUT TRANSFORMERS.

Designed to give 25 K.V. when used with PL509 and PY500 valves. As removed from colour receivers at the factory.

ONLY £1 each

post and packing 23p

BUMPER BUNDLES

These parcels contain all types of surplus electronic components, printed panels, switches, potentiometers, transistors and diodes, etc..

2 LBS IN WEIGHT FOR £1

Post and packing 25p

NEW TESTED & GUARANTEED PAKS

B2	4	Photo Cells, Sun Batteries .3 to .5 volt, .5 to 2 ma.	50p
H8	4	BY127 Silicon Recs. 1000 P.I.V. 1 amp. Plastic. Replaces the BY100.	50p
B79	4	1N4007 Sil. Rec. Diodes. 1,000 P.I.V. 1 amp. Plastic.	50p
B81	10	Reed Switches, mixed types, large and small.	50p
B99	200	Mixed Capacitors, Post and packing 13p Approx. Quantity counted by weight.	50p
H4	250	Mixed Resistors. Post and packing 10p. Approx. Quantity counted by weight.	50p
H7	40	Wirewound Resistors. Mixed Values. Postage 7p.	50p
H9	2	OCP71 Light Sensitive Photo Transistors.	50p
H12	20	NKT155/259 Germ diodes, brand new stock clearance.	50p
H18	10	OC71/75 uncoded black glass type PNP Germ.	50p
H19	10	OC81/81D uncoded white glass type PNP Germ.	50p
H28	20	OC200/1/2/3 PNP silicon uncoded To-5 Can	50p
H29	20	OA47 gold bonded diodes coded MCS2.	50p

OUR VERY POPULAR 3p TRANSISTORS

FULLY TESTED & GUARANTEED

TYPE "A"
PNP Silicon
alloy, metal TO-5 can.
2S300 type, direct replacement for the OC200/203 range

TYPE "B"
PNP Silicon
PLASTIC ENCAPSULATION,
low voltage but good gain, these are of the 2N3702/3 and 2N4059/62 range.

TYPE "F"
NPN Silicon
PLASTIC ENCAPSULATION
Low Noise Amplifier of the 2N3707/8/9/10/11 Series.

TYPE "E"
PNP Germanium
AF OR RF
please state on order. Fully marked and tested.

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.

1—10 = 30p each, 10—50 = 25p each, 50 + 20p each.

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**

BULK BUYING CORNER

NPN/PNP Silicon Planar Transistors, mixed untested, similar to 2N706/6A/8, BSY26-29, BSY95A, BCY70 etc.
£4.25 per 500. £8.00 per 1,000.

Silicon Planar NPN Plastic Transistors, untested, similar to 2N3707-11 etc.
£4.25 per 500. £8.00 per 1,000.

Silicon Planar Diodes, DO-7 Glass, similar to OA200/202, BAY31-36. £4.50 per 1,000.

NPN/PNP Silicon Planar Transistors, Plastic TO-18, similar to BC113/4, BC153/4, BF153/160 etc.
£4.25 per 500. £8.00 per 1,000.

OC44, OC45 Transistors, fully marked and tested.
500 plus @ 8p each. 1,000 plus @ 6p each.

OC71 Transistors, fully marked and tested.
500 plus @ 6p each. 1,000 plus @ 5p each.

3823E Field effect Transistors. This is the 2N3823 in plastic case.
500 plus @ 13p each. 1,000 plus @ 10p each.

1 Amp Miniature Plastic Diodes:
1N4001. 500 plus @ 3p each. 1,000 plus @ 3p each.
1N4004. 500 plus @ 5p each. 1,000 plus @ 4p each.
1N4006. 500 plus @ 6p each. 1,000 plus @ 5p each.
1N4007. 500 plus @ 8p each. 1,000 plus @ 7p each.

NEW UNMARKED UNTESTED PAKS

B80	8	Dual Trans. Matched O/P pairs NPN. Sil. in TO-5 can	50p
B83	200	Trans. manufacturer's rejects all types NPN, PNP, Sil. and Germ.	50p
B84	100	Silicon Diodes DO-7 glass equiv. to OA200, OA202	50p
B86	50	Sil. Diodes sub. min. IN914 and IN916 types	50p
B88	50	Sil. Trans. NPN, PNP, equiv. to OC200/1, 2N706A, BSY95A, etc.	50p
B60	10	7 watt Xener Diodes Mixed Voltages	50p
H6	40	250mW. Zener Diodes DO-7 Min. Glass Type	50p
H10	25	Mixed volts, 1½ watt Zeners. Top hat type	50p
B66	150	High quality Germ. Diodes. Min. glass type	50p
H15	30	Top Hat Silicon Rectifiers. 750mA. Mixed volts	50p
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Speakers, 2½in, 8 ohms	50p
Insulating Tape, ½in wide, 10 yard rolls	5p
Miniature Output Transformers	12p
Rotary Switches, 4 pole 3 way or 2 pole 6 way	15p
Switch cleaner, aerosol cans	50p

Electrolytic Capacitors

2,000 µf 25 volt Rev.	25p
1,000 µf 70 volt	35p
10,000 µf 35 volt	50p
10,000 µf 25 volt	35p
2,000 µf 18 volt	20p
60µf + 200µf 300 volt	30p
400 µf 275 volt	25p
10 µf 6 volt	2p
10 µf 25 volt	4p
16 µf 250 volt	8p
32 µf 275 volt	8p

Miniature type. Both wires same end.

5µf	10 volt
10µf	10 volt
30µf	10 volt
50µf	10 volt

all at 3p each.

Unrepeatable Offer ! ! ! !
Surplus VERO-BOARDS, 3¾" × 2½" × ·15"
Only 10p each or £1·00 per dozen

TRANSISTORS AND I.C.s
ALL BRAND-NEW WITH MANUFACTURERS MARKINGS

ASY22	10p	OC45	10p	2N709	50p	2N3703	13p
ASY29	25p	OC46	15p	2N1302	15p	2N3704	18p
ASZ17		OC141	22p	2N1309	23p	2N3707	15p
(OC35)	25p	OC139	22p	2N1613	25p	2N3877A	40p
BC167	15p	OC74	20p	2N1711	25p	7401	40p
BCY70	18p	OC204	25p	2N2646	58p	7410	40p
BFX12	20p	2G345	10p	2N2926	15p	7430	40p
OC41	20p	2G371	10p	2N3053	25p	7472	55p
OC42	23p	2G378	10p	2N3055	75p	7473	90p
OC43	20p			2N3702	18p	7475	£1·15
OC44	15p						

1,000,000 GERMANIUM TRANSISTORS
(OC71/OC75)

LOTS OF 100,000—£250
10,000—£30
1,000—£3·50
500—£2
100—50p

TANTALUM CAPACITORS. COMPARE THE PRICE—ONLY 10p EACH ! ! ! !

Sub-miniature types	*Miniature types*		*Standard*
·047µf 50 volts	·022µf 20 volts	5·6 µf 35 volts	
·056µf 50 volts	·033µf 20 volts	8·2 µf 10 volts	
·07 µf 20 volts	·047µf 20 volts	8·2 µf 35 volts	
·1 µf 20 volts	·068µf 35 volts	15 µf 35 volts	
·1 µf 50 volts	·12 µf 35 volts	18 µf 35 volts	
·18 µf 20 volts	·15 µf 35 volts	22 µf 15 volts	
·33 µf 35 volts	·22 µf 50 volts	27 µf 120 volts	
·47 µf 35 volts	·47 µf 50 volts	56 µf 15 volts	
·68 µf 20 volts	·68 µf 35 volts	56 µf 20 volts	
1·0 µf 15 volts	·68 µf 50 volts	150 µf 6 volts	
2·2 µf 3 volts	1·0 µf 35 volts		
2·7 µf 15 volts	1·0 µf 75 volts	6·8 µf 50 volts	
2·7 µf 35 volts	1·8 µf 20 volts	7·5 µf 20 volts	
3·0 µf 12 volts	2·2 µf 20 volts	8·2 µf 150 volts	
10·0 µf 1·5 volts	2·7 µf 50 volts	12 µf 35 volts	
	3 µf 12 volts	12 µf 50 volts	
	3·3 µf 15 volts	39 µf 20 volts	
	4 µf 20 volts	82 µf 20 volts	
	4·7 µf 35 volts	150 µf 15 volts	
	5·6 µf 6 volts	270 µf 6 volts	

VEROBOARD
2½in × 1in × 0·15in 6p
3¾in × 2½in × 0·15in 16p
3¾in × 3¾in × 0·15in 20p
5in × 2½in × 0·15in 20p
5in × 3¾in × 0·15in 28p
17in × 2½in × 0·15in 55p
17in × 3¾in × 0·15in 74p
3¾in × 3¾in × 0·1in 21p
3¾in × 3¾in × 0·1in 24p
5in × 2½in × 0·1in 23p
5in × 3¾in × 0·1in 28p
Spot Face Cutter 38p. Pin Insert Tool 48p. Terminal Pins (0·1 or 0·15) 36 for 18p. Special Offer Pack consisting of 5 2½in × 1in boards and a Spot Face Cutter—50p.

RECORD PLAYER CARTRIDGES. Well below normal prices!
G90 Magnetic Stereo Cartridges, Diamond Needle, 6mV output, £4. ACOS GP 67/2 (Mono, Crystal) 75p. ACOS GP 91/3 (Compatible, Crystal) £1. ACOS GP 93/1 (Stereo, Crystal, Sapphire) £1·25. ACOS GP 93/1D (Stereo, Crystal, Diamond) £1·63. ACOS GP 94/1 (Stereo, Ceramic, Sapphire) £1·50. ACOS GP 94/1D (Stereo, Ceramic, Diamond) £1·88. ACOS GP 95/1 (Stereo, Crystal with two L.P./Stereo needles) £1·25.

TRANSISTORISED FLUORESCENT LIGHTS, 12 volt. All with reverse polarity protection. 8 watt type with reflector, suitable for tents, etc., £3. Postage/Packing 25p. 15 watt type, batten fitting for caravans £4. Postage/Packing 25p. 13 watt type, batten with switch. 22in × 2in × 1in £5. Postage/Packing 25p. THESE CAN BE SENT ON APPROVAL AGAINST FULL PAYMENT.

MULLARD POLYESTER CONDENSERS
1,000pf, 1,200pf, 1,500pf, 1,800pf, 2,200pf, 15p per dozen (all 400V working). 0·15µf, 0·22µf, 0·27µf, 30p per dozen (all 160V working). 25% discount for lots of 100 of any one type.

RESISTORS
¼ and ½ watt Most values in stock. 50p per 100. 10p per dozen of any one value. WIRE WOUND MAINS DROPPERS. Hundreds of values from 0·7 ohm upwards. 1 watt to 50 watts. A large percentage of these are multi-tapped droppers for radio/television. Owing to the huge variety these can only be offered "assorted" at 50p per dozen.

SILVER MICA/CERAMIC/POLYSTYRENE CONDENSERS
Large range in stock, 75p per 100 of any one value. 15p per dozen.

RECORDING TAPE BARGAIN! The very best British Made low-noise high-quality Tape! 5in Standard 38p. Long-play 45p. 5½in Standard 45p. Long-play 60p. 7in Standard 60p. Long-play 82p. We are getting a fantastic number of repeat orders for this tape. Might we suggest that you order now whilst we still have a good stock at these low prices?

STOCKTAKING 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 condensers, controls, transistors, diodes etc., for a tiny fraction of normal price. It is emphasised that these are mixed parcels only—contents cannot be stipulated! Sold only by weight.
Gross weight 2 lb. .. .. .. £1 (postage 20p)
Gross weight 5 lb. .. .. .. £2 (postage 30p)

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** plus
Developer spray .. .. **50p** postage

SPECIAL 50p PACKS. ORDER 10 PACKS AND WE WILL INCLUDE AN EXTRA ONE FREE ! ! !

RESISTORS ¼/½ watt assorted	100	50p
Wire-wound 1 to 3 watt	20	50p
5 to 7 watt	15	50p
10 watts	10	50p
Multi-tapped	12	50p
PAPER CONDENSERS Tv types	50	50p
Miniature	100	50p
ELECTROLYTIC CONDENSERS Suitable for Mains Radio/Tv	10	50p
Transistor types	20	50p
Mixed (both types)	15	50p
POLYSTYRENE CONDENSERS	100	50p
MULLARD POLYESTER COND.	50	50p
SILVER MICA	100	50p
WIRE-WOUND 3-Watt SLIDERS	15	50p
VOLUME CONTROLS Assorted	5	50p
NUTS AND BOLTS. Mixed length/type 8 B.A.	100	50p
6 B.A.	100	50p
4 B.A.	100	50p
2 B.A.	100	50p
METAL SPEAKER GRILLES 7½in. × 3½in.	6	50p
EARPIECES, MAGNETIC No Plug	6	50p
2·5mm Plug	4	50p
3·5mm Plug	4	50p
500 MICRO-AMP LEVEL METERS	1	50p
VEROBOARD. TRIAL PACK 5 BOARDS + CUTTER		50p

TRANSISTORS		
P.N.P. Untested but mainly O.K.	50	50p
N.P.N. Untested but mainly O.K.	50	50p
OCP 71 equivalent	5	50p
Light-sensitive Diodes (*These produce up to 1ma from light*)	10	50p
OC44 Mullard 1st grade	4	50p
OC45 Mullard Boxed	5	50p
2G378 Output, Marked	5	50p
2G371 Driver, Marked	5	50p
ASY 22, Marked	5	50p
BY 127 Rectifiers	4	50p
IN4007 Rectifiers (1200V peak)	4	50p
STC 3/4 Rectifiers	6	50p
DIODES (OA 81 & OA 91)	40	50p
WIRE Solid Core. Insulated	100yds.	50p
Stranded ditto	50yds.	50p
SOLAR CELLS Large Selenium	2	50p
Small	3	50p
(6 cells will power a Micromatic radio)		
CO-AXIAL CABLE Semi Air-spaced	15yds.	50p
CRYSTAL TAPE RECORDER MIKES	1	50p
CRYSTAL EARPIECES 3·5mm Plug	2	50p
TRANSISTORISED Signal Injector Kit	1	50p
TRANSISTORISED Signal Tracer Kit	1	50p
TRANSISTORISED CAR REV. COUNTER KIT (Needs 1 ma. meter as indicator)	1	50p

G. F. MILWARD, Drayton Bassett, Tamworth, Staffs. Postage (minimum) per order 15p.

DRILL CONTROLLER

New 1kW model.

Electronically changes speed from approximately 10 revs. to maximum. Full power at all speeds by finger-tip control. Kit includes all parts, case, everything and full instructions £1·50, plus 13p post and insurance. Made up model also available £2·25 plus 13p p. & p.

MAINS MOTOR

Precision made—as used in record decks and tape recorders—ideal also for extractor fans, blower, heater, etc. New and perfect. Snip at 50p. Postage 15p for first one then 5p for each one ordered. 12 and over post free.

MAINS TRANSISTOR POWER PACK

Designed to operate transistor sets and amplifiers. Adjustable output 6v., 9v., 12 volts for up to 500mA (class B working). Takes the place of any of the following batteries: PP1, PP3, PP4, PP6, PP7, PP9, and others. Kit comprises: mains transformer rectifier, smoothing and load resistor, condensers and instructions. Real snip at only 83p, plus 18p postage.

NEED A SPECIAL SWITCH? DOUBLE LEAF CONTACT

Very slight pressure closes both contacts. 6p each. 60p doz. Plastic push-rod suitable for operating. 5p each, 45p doz.

MAINS OPERATED CONTACTOR

220/240v. 50 cycle solenoid with laminated core so very silent in operation. Closes 4 circuits each rated at 10 amps. Extremely well made by a German Electrical Company. Overall size 2½ × 2 × 2 in. £1 each.

AUTO—ELECTRIC CAR AERIAL

with dashboard control switch—fully extendable to 40in. or fully retractable. Suitable for 12v positive or negative earth. Supplied complete with fitting instructions and ready wired dashboard switch. £6 plus 25p post and ins.

TOGGLE SWITCH

3 amp 250v. with fixing ring. 7½p each 75p doz.

MICRO SWITCH

5 amp. changeover contacts, 9p each, £1·00 doz. 15 amp. on/off 10p each or £1·05 doz. 15 amp. changeover 15p, 10 for £1·35.

MINIATURE WAFER SWITCHES

2 pole, 2 way—4 pole, 2 way—2 pole, 3 way—4 pole, 3 way—2 pole, 4 way—3 pole, 4 way—2 pole, 6 way 1 pole, 12 way. All at 18p each, £1·80 dozen, your assortment.

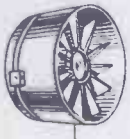
WATERPROOF HEATING ELEMENT

26 yards length 70W. Self-regulating temperature control. 50p post free.

PAPST MOTORS

Est. 1/20th h.p. Made for 110-120 volt working, but two of these work ideally together off our standard 240 volt mains. A really beautiful motor, extremely quiet running and reversible. £1·50 each. Postage one 23p, two 33p.

EXTRACTOR FAN

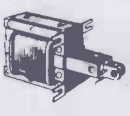


Cleans the air at the rate of 10,000 cubic ft. per hour. At the pull of a cord it extracts grease, grime and cooking smells before they dirty decorations. Suitable for kitchens, bathrooms, factories, changing rooms, etc., it's so quiet it can hardly be heard. Compact, 5½" casing with 5½" fan blades. Suitable wherever it is necessary to move air fast. Kit comprises motor, fan blades, sheet steel casing, pull switch, mains connector, and fixing brackets. £2 plus 36p post and ins.

HEARING AID AMPLIFIERS

(Ex behind ear deaf aids) 3 transistors on tiny P.C. board with volume control—whole thing only about half as big as Oxo cube. £1·75 or with sub-miniature microphone and L.S. attached £3·50.

MAINS OPERATED SOLENOIDS



Model 772—small but powerful 1" pull—approx. size 1½ × 1½ × 1½" 60p.
Model 400/1 ½" pull. Size 2½ × 2 × 1½" 75p.
Model TT16 1½" pull. Size 3 × 2½ × 2½" £1·80 plus 20p post and ins.

MAINS RELAY BARGAIN

Special this month are some single, double and treble pole changeover relays. Contacts rated at 15 amps. Operating coil wound for 240V. A.C. Good British Make. Unused. Size approx. 1½ × 1 ins. Open construction.

Single pole	25p each	10 for £2·25
Treble pole	35p each	10 for £3·15

CAR ELECTRIC PLUG

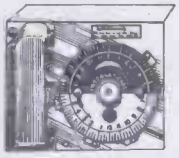
Fits in place of cigarette lighter. Useful method for making a quick connection into the car electrical system. 38p each or 10 for £3·42.

WAFER SWITCHES

Miniature, standard and instrument types. All available. See last month's advertisement.

HONEYWELL PROGRAMMER

This is a drum type timing device, the drum being calibrated in equal divisions for switch purposes with trips which are infinitely adjustable for position. They are also arranged to allow 2 operations per switch per rotation. There are 15 changeover micro switches each of 10 amp type operated by the trips thus 15 circuits may be changed per revolution. Drive motor is mains operated 5 revs. per min. Some of the many uses of this timer are Machinery control, Boiler firing, Dispensing and Vending machines, Display lighting animated signs, Signalling etc. Price from Makers probably over £10 each. Special snip price £5·75 plus 25p post and ins. Don't miss this terrific bargain.



ELECTRIC TIME SWITCH

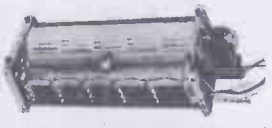
Made by Smiths these are A.C. mains operated. NOT CLOCKWORK. Ideal for mounting on rack or shelf or can be built into box with 13A socket. 2 completely adjustable time periods per 24 hours, 5 amp changeover contacts will switch circuit on or off during these periods. £2·50. post and ins. 23p. Additional time contacts 50p pair.

4 AMP VARIAC CONTROLLERS

With this you can vary the voltage applied to your circuit from zero to 270 volts without generating undue heat. One obvious application therefore is to dim lighting. Ex equipment but little used—as good as new offered at approx. half price—£5 plus 63p post and ins.

OUT OF SEASON BARGAIN

TANGENTIAL HEATERS



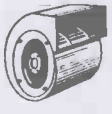
Once again we are able to make a special bargain offer of these very popular heating units. Tangential heaters although brought out a few years ago are still the latest and best type as nothing has yet been made which could be called an improvement on them. The Tangential unit is still the only one used in good quality heaters made by Hoover, G.E.C. and all the famous names. The unit comprises quiet running AC induction motor with special bearings, the tangential impeller and a 2 section heater element which allows switching half and full heat in the case of the 2kw and one-third-two-thirds and full heat in the case of the 3kw. These heaters are also fitted with a safety cut-out to cut the heaters should the impeller stop or the air flow be impeded. They are free standing and need only the simplest of cases, even a wooden cabinet is suitable (or the plinth of the kitchen cabinet). Lots of customers missed our special summer offer of these heaters last year so order early. 200/240 2kw model £2·50. 200/240 3kw model £3·50. Control switch heaters only 25p or two-heat, cold-blow and off 35p. Postage and insurance 33p on heaters.

BATTERY CONDITION TESTER

Made by Mallory but suitable for all batteries made by Ever Ready and others, most of which are zinc carbon types but also mercury manganese—nicad—silver oxide and alkaline batteries may be tested. The tester puts a dummy load on the battery and the meter scale indicates the condition depending upon which section the pointer rests. The section reads "replace" "weak" or "good." The tester is complete in its case, size 3½" × 6½" × 2" with leads and prods. Price £1·75 plus 20p postage.

THIS MONTH'S SNIP

CENTRIFUGAL FAN



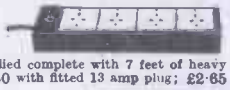
Mains operated, turbo blower type. Pressed steel housing contains motor and impeller. Motor is 1/10th h.p. giving considerable air flow but virtually no noise. Approx. dimensions 10½" wide × 12" dia. outlet into trunking 10½" × 4½".

£4·95 plus £1 post and insurance.

CAPACITOR DISCHARGE CAR IGNITION

This system which has proved to be amazingly efficient and reliable was first described in the *Wireless World* about a year ago. We can supply kit of parts for improved and even more efficient version. Price £4·95 plus 30p post. When ordering please state whether for positive or negative systems.

DISTRIBUTION PANELS



Just what you need for work bench or lab. 4 × 13 amp sockets in metal box to take standard 13 amp fused plugs and on/off switch with neon warning light. Supplied complete with 7 feet of heavy cable. Wired up ready to work. £2·25 less plug; £2·50 with fitted 13 amp plug; £2·65 with fitted 15 amp plug, plus 23p P. & P.

20 AMP ELECTRICAL PROGRAMMER

Learn in your sleep! Have Radio playing and kettle boiling as you awake—switch-on lights to ward off intruders—have warm house to come home to. All these and many other things you can do if you invest in an Electrical Programmer. Made by the famous Smiths Insrument Com pany. This is essentially a 230/240 volt mains operated Clock and a 20 amp Switch, the switch-off time of which can be delayed up to 12 hours (continuously variable not stepped). Similarly the switch-on time can be delayed. This is a beautiful unit, size 5½ × 3½ × 2½in. deep. Metal encased, glass fronted with chrome surround. Offered at £2·40 plus 23p postage and insurance.

INTEGRATED CIRCUITS

A parcel of integrated circuits made by the famous Plessey Company. A once in a lifetime offer of Micro-electronic devices well below cost of manufacture. The parcel contains 5 ICs all new and perfect, first grade device definitely not sub-standard or seconds. The ICs are all single silicon chip General Purpose Amplifiers. Regular price of which is well over £1 each. Full circuit details of the ICs are included and in addition you will receive a list of 50 different ICs available at bargain prices 25p upwards with circuits and technical data of each. Complete parcel only £1 post paid or List and all technical data.

FIRE ALARM BELL

Mains operated. Really loud ring 6" gong. Size approx. 12" × 6" × 4½", suitable outside or inside. Heavy cast case with ½" conduit entry. Made by A.F.A. Operates off 200-240V AC. £3·75 plus 60p.

AMPLIFIER MAINS TRANSFORMER

50V 1½ amp. Upright mounting with fixing brackets and metal shrouds to contain magnetic field, 50 c/s primary, tapped 110V, 117V, 210V, 230V and 250V. 2 secondaries, one 50V 1½ amp, other 6V 1 amp for pilot light, etc. £1·95. postage 30p.

BARGAIN OF THE YEAR

MICROSONIC RADIOS

7 transistor Key chain Radio in very pretty case, size 2½ × 2½ × 1½ in.—complete with soft leather zipped bag. Specification: Circuit: 7 transistor superheterodyne Frequency range: 530 to 1600 Kc/s. Sensitivity: 5 mv/m. Intermediate frequency: 465 Kc/s, or 455 Kc/s. Power output: 40mW. Antenna: ferrite rod. Loudspeaker: Permanent magnet type. In transit from the East, these sets suffered slight corrosion as the batteries were left in, but when this corrosion is cleared away they should work perfectly—offered without guarantee except that they are new, £1·25 plus 13p post and insurance. Less batteries. Six for £7, post free. Rechargeable batteries 43p per pair.

MULTI-SPEED MOTOR

Replacement in many well-known food mixers. Six speeds are available 500, 850 and 1,100 r.p.m. from either or both of the nylon sockets (where the beaters of the food mixers normally go) and 8,000, 12,000 & 15,500 r.p.m. (ideal polishing speeds) from the main drive shaft. This drive shaft is ¼ in. diameter and approximately 1 in. long. A further point about this motor is that being 230/240v. AC-DC series wound its speed may be further controlled with the use of our Thyrister controller. This is a very powerful and useful motor size approx. 2·in. dia. × 5 in. long, mains 230/240v. Price 88p plus 23p postage and insurance. 12 or more post free.

REED SWITCHES

Glass encased, switches operated by external magnet—gold welded contacts. We can now offer 3 types:
Miniature. 1" long × approximately ¼" diameter. Will make and break up to ½A up to 300V. Price 13p each. £1·20 dozen.
Standard. 2" long × ⅜" diameter. This will break currents of up to 1A, voltage up to 250V. Price 10p each, 90p per dozen.
Flat. Flat type, 2" long, just over ⅛" thick, flattened out, so that it can be fitted into a smaller space or a larger quantity may be packed into a square solenoid. Rating 1A 200V. Price 30p each, £3 per dozen.
Small ceramic magnets to operate these reed switches 9p each, 90p dozen.

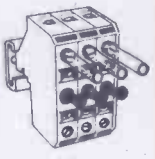
BALANCED ARMATURE UNITS

These Capsules are 1p in. diameter and ½ in. thick. They will operate as a microphone or loud speaker so can be used in intercome and similar circuits. 33p. Ten for £3.

12 VOLT 1½ AMP POWER PACK

This comprises double-wound 230" 240V mains transformer with full wave rectifier and 2000 m/f/d/ smoothing. Price £1·50.

MAINS CONNECTOR



A quick way to connect equipment to the mains safely and firmly—disconnection by plugs prevents accidental switching on; has sockets which allow insertion of meter without disconnection; cable inlets firmly hold one hair wire on up to four 7,029 cables. 85p each.

LIGHT DIMMER

For any lamp up to 200 watt. Mounted on switch plate to fit in place of standard switch. Virtually no radio interference. Price £1·99 plus 20p post and ins.

TELESCOPIC AERIAL

for portable, car radio or transmitter. Chrome plated—six sections, extends from 7½ to 47". Hole in bottom for 6BA screw. 38p KNUCKLED MODEL FOR F.M. 50p.

AC FAN

Small but very powerful mains motor with 5 in. blades. Ideal for cooling equipment or as extractor. Silent but very efficient. 90p, post 23p. Mounts from back or front with 4BA screws.

TREASURE TRACER

Complete Kit (except wooden battens) to make the metal detector as described editorially in Practical Wireless, August issue. £2·50 plus 20p post and insurance.

LIGHT CELL

Almost zero resistant in sunlight increases to 10 K. Ohms in dark or dull light, epoxy resin sealed. Size approx. 1in. dia. by ½in. thick. Rated at 500 MW. wire ended. 43p. Suit most circuits.

TRANSDUCER

Made by Acos, reference No. 1.D.1001. For measuring vibration, etc., to be used in conjunction with "G" Meter. Regular price £5. Our price £4. Brand new and unused.

Acos 'G' meters available ..	£12
Or with auto cut-out ..	£18

HIGH ACCURACY THERMOSTAT

Uses differential comparator I.C. with thermister as probe. Designer claims temperature control to within 1/7th of a degree. Complete kit with power pack £5·50.

MOTOR WITH GEARBOX

Very powerful 7 r.p.m., operates from standard A.C. mains. £1·50, plus 18p P. & P.

A New Service to Readers. A bulletin bringing news of new lines, special snips and "too few to advertise" lines will be posted to subscribers during first week of each month. The bulletin will be called "Advance Advert News" and the subscription is 60p per year. Subscribers will also receive our completed 1971 catalogue when this is published.

Where postage is not stated then orders over £5 are post free. Below £5 add 20p. S.A.E. with enquiries please.

J. BULL (ELECTRICAL) LTD.

Dept. W.W.7, Park Street, Croydon, CRO 1YD

VALVES

	£		£
B12H	1·75	ECH84	0·45
CY31	0·35	ECH200	0·62
DAF96	0·38	ECL80	0·45
DF96	0·37	ECL82	0·32
DK96	0·41	ECL83	0·65
DL92	0·32	ECL86	0·42
DL94	0·40	EF36	0·45
DL96	0·41	EF37A	0·45
DM70	0·30	EF39	0·40
DY86	0·30	EF40	0·50
DY87	0·32	EF41	0·62
DY802	0·48	EF80	0·25
E88CC/01	1·80	EF83	0·55
E180CC	0·42	EF85	0·32
E181CC	0·90	EF86	0·31
E182CC	1·05	EF89	0·26
EABC80	0·32	EFL200	0·75
EAF42	0·50	EF92	0·37
EB91	0·15	EF95	0·30
EBC33	0·50	EF183	0·32
EBC41	0·52	EF184	0·35
ECC81	0·30	EFL200	0·75
EBF80	0·42	EL34	0·52
EBF83	0·42	EL41	0·57
EBF89	0·30	EL42	0·53
ECC81	0·30	EL84	0·23
ECC82	0·28	EL85	0·40
ECC83	0·30	EL86	0·40
ECC84	0·30	EL90	0·35
ECC85	0·40	EL95	0·35
ECC86	0·50	EL500	0·85
ECC88	0·37	EM31	0·25
ECC189	0·52	EM80	0·40
ECF80	0·35	EM84	0·35
ECF82	0·35	EM87	0·55
ECF83	0·75	EY51	0·40
ECF801	0·62	EY86	0·35
ECF802	0·62	EY87	0·35
ECH35	0·60	EY88	0·40
ECH42	0·65	EZ41	0·42
ECH81	0·28	EZ80	0·25
ECH83	0·42	EZ81	0·27
		GZ34	0·52
		KT66	1·60

	£
KT88	1·15
N78	1·25
OA2	0·35
OB2	0·35
PABC80	0·37
PC97	0·40
PC900	0·47
PCC84	0·37
PCC89	0·45
PCC189	0·55
PCE800	0·75
PCF80	0·30
PCF82	0·33
PCF84	0·46
PCF86	0·57
PCF200	0·77
PCF201	0·77
PCF801	0·48
PCF802	0·48
PCF805	0·72
PCF806	0·65
PCF808	0·72
PCH200	0·70
PCL81	0·47
PCL82	0·37
PCL83	0·65
PCL84	0·42
PCL85	0·42
PCL86	0·42
PFL200	0·57
PL36	0·53
PL81	0·50
PL82	0·40
PL83	0·42
PL84	0·35
PL500	0·73
PL504	0·75
PY33	0·60
PY80	0·35
PY81	0·27
PY82	0·27
PY83	0·35
PY88	0·37
PY800	0·52
PY801	0·52
QQVO 3-10	1·25

	£
QQVO	
6·40A	5·25
R17	0·45
R19	0·37
STV	
280/40	3·00
STV	
280/80	9·00
TT21	2·75
U25	0·75
U26	0·75
U27	0·50
U191	0·70
U801	1·00
UABC80	0·35
UAF42	0·50

	£
UBC41	0·47
UBF80	0·35
UBF89	0·35
UCC85	0·40
UCF80	0·55
UCH42	0·70
UCH81	0·35
UCL82	0·35
UCL83	0·60
UV41	0·50
UF80	0·36
UF89	0·35
UL41	0·60
UL84	0·30
UU5	0·55
UY41	0·45
UY85	0·30
VR105/30	0·35

	£
VR150/30	0·35
Z759	1·65
Z801U	1·50
Z803A	1·25
Z900T	0·75
1L4	0·15
1R5	0·35
184	0·25
185	0·24
1T4	0·22
1X2A	0·40
1X2B	0·40
3A4	0·30
3D6	0·15
3Q4	0·37
384	0·35
3V4	0·45

	£
5B254M	2·20
5B/255M	1·75
5R4GY	0·60
5U4G	0·32
5V4G	0·40
5Y4G	0·40
5Y3GT	0·35
5Z4	0·75
5Z4GT	0·40
6AB7	0·30
6AC7	0·15
6AH6	0·50
6AK5	0·30
6AK8	0·32
6AL5	0·15
6AL5W	0·40
6AM6	0·30
6AN8	0·50

	£
6AQ5	0·35
6AQ5W	0·50
6AS6	0·37
6AS7G	0·80
6AT6	0·30
6AU6	0·25
6AX4GT	0·40
6AX5GT	0·65
6B7	0·40
6BK7	0·40
6BA6	0·25
6BE6	0·30
6BG6G	0·55
6BJ6	0·45
6BQ7A	0·35
6BR7	0·80
6BW6	0·80
6BW7	0·70

	£
6C4	0·30
6C6	0·25
6CH6	0·55
6CL6	0·49
6D6	0·20
6EA8	0·55
6F23	0·75
6F33	1·50
6H6M	0·20
6J4WA	0·75
6J5	0·40
6J5GT	0·25
6J6	0·20
6J7G	0·35
6J7M	0·40
6K6GT	0·56
6K7	0·32

	£
6K7G	0·20
6K8GT	0·45
6K25	0·70
6BA7	0·40
6BA7GT	0·32
6SC7GT	0·25
6SG7	0·35
6SJ7	0·37
6SJ7GT	0·32
6SK7	0·35
6SL7GT	0·32
6SN7GT	0·35
6SQ7	0·39
6SQ7GT	0·35
6V6G	0·17
6V6GT	0·35
6X4	0·27
6X5G	0·25
6X5GT	0·32
6Y6G	0·60
6-30L2	0·70
6Z4	0·32
7B7	0·45
7C5	0·85
7C6	0·40
7-7	0·32
7Y4	0·60
9D6	0·37
11E2	2·50
12AT6	0·30
12AT7	0·30
12AU7	0·29
12AV6	0·30
12AX7	0·30
12BA6	0·35
12BE6	0·35
12BH7	0·27
12C8	0·32
12E1	1·25
12K5	0·55
12K7GT	0·40
12K8GT	0·45
12Q7GT	0·30
128G7	0·35
1487	0·75
19AQ5	0·40
19G3	4·25
19G6	1·50
19H4	5·00
20P4	1·00

	£
25L6GT	0·40
30C15	0·75
30C17	0·80
30C18	0·75
30F5	0·84
30FL1	0·70
30FL12	0·92
30FL13	0·50
30FL14	0·75
30L15	0·85
30L17	0·80
30P12	0·80
30P19	0·80
30PL1	0·70
30PL13	0·92
30PL14	0·85
35L6GT	0·50
35W4	0·30
35Z4GT	0·45
42	0·45
50C5	0·40
50CD6G	1·60
50EH5	0·60
75	0·40
76	0·40
78	0·40
80	0·45
803	3·25
805	8·00
807	0·50
813	3·75
832A	0·40
866A	0·75
954	0·40
955	0·25
956	0·20
957	0·30
991	0·40
1622	1·00
2051	0·55
5933	1·12

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749 3542

MARCONI VHF OSCILLATOR TYPE TF 924/1. Complete with power unit Type TM 4230. Frequency range 2,100 MHz to 3,750 MHz, output power 10 to 50mW, Klystron Osc with automatic tracking. Facilities for reflection modulation. **£125.** Carriage £2.

MARCONI VHF ALIGNMENT OSCILLOSCOPE TF 1104. Combined sweep generator and CRO for VHF, IF and VF analysis. RF ranges 41-216kHz. IF range 10-40MHz. VF range 5kHz to 10MHz. Output 10μV to 250MV continuous at 50 ohms. Sweep 500kHz to 10MHz. **£89·50.** Carr. £1.

MARCONI R/C OSCILLATOR TYPE TF 1101. Frequency range 20Hz to 200kHz. Accuracy ± 1%; distortion less than 0·5%. Stabilised Oscillator, no zero setting required. **£72·50.** Carriage £1·50.

VALVE VOLTMETER TYPE TF 958 Measures AC 100mV; 20 c/s to 100 mc/s, DC 50mV to 100V, multiplier extends ac range to 1.5kV. Balanced input and centre-zero scale for DC. AC up to 100MHz. **£32·50.**

MARCONI SIGNAL GENERATOR TYPE TF 801B/3/S
Frequency range 12-485 Mc/s in five ranges. Directly calibrated frequency dial. Output waveform: C.W., sinewave A.M., pulse A.M. (from ext. source only). Internal modulation frequency 1,000 c/s. Output: a, normal—continuously variable directly calibrated from 0·1μv.—0.5v. b, high; up to 1 v. modulated for 2 v. unmodulated, output impedance 50 ohms. Fine frequency tuning control carrier, on/off switch, built-in crystal calibration for 2 Mc/s and 10 Mc/s. Stabilised voltage supply. In excellent "as new" condition. Laboratory checked and guaranteed. Including necessary connectors, plugs and instruction manual. Price on application.

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MANY OTHERS IN STOCK

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CA 3005 wide band R.F. Ampl. 300mW diss ..... £1·20
CA 3012 wide band ampl. 150mW diss ..... £0·90
CA 3020 Audio power ampl. ..... £1·37
CA 3036 Audio pre-ampl. ..... £0·90

General Electric
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Mullard
TAA 300 £1·75; TAA 320 £0·73.

REDIFON
Twinplex combiner type AFS 13 **£65**
Twinplex converter type AFS 12 with P.S.W. **£85**
F.S.K. unit type GK185A **£58·50.**

SPECIAL OFFER O9J TUBE £1·75

TRANSISTORS, ZENER DIODES

	£
OA5	0·20
OA10	0·25
OA70	0·10
OA71	0·10
OA73	0·10
OA74	0·10
OA79 (6D15)	0·10
OA81	0·10
OA91	0·07
OA200	0·07
OA202	0·10
OA210	0·25
OA211	0·37
OAZ200	0·55
OAZ201	0·50
OAZ202 to OAZ207	0·47
OAZ208 to OAZ213	0·32
OAZ223 to OAZ225	0·50
OC16	0·50
OC22	0·50
OC25	0·37
OC26	0·25
OC28	0·62

	£
OC29	0·62
OC35	0·50
OC38	0·42
OC44	0·17
OC45	0·15
OC70	0·12
OC71	0·15
OC72	0·25
OC73	0·30
OC75	0·25
OC76	0·25
OC81	0·25
OC81D	0·20
OC81DM	0·20
OC82	0·25
OC82DM	0·30
OC83	0·25
OC83B	0·15
OC84	0·25
OC122	0·50
OC139	0·25
OC140	0·37
OC170	0·25
OC171	0·30
OC172	0·37
OC200	0·40
OC201	0·60
OC206	0·90

	£
IN21	0·17
1N21B	0·25
1N25	0·60
1N43	0·10
1N70	0·07
1N702-725	0·36
1N823A	1·30
IN4785	0·50
1ZMT5	0·35
1ZMT10	0·33
1ZT5	0·67
1ZT10	0·63
2G385	0·51
2G403	0·51
2N918	0·37
2N1304	0·25
2N1306	0·25
2N1307	0·25
2N2147	0·75
2N2904A	0·32
2N3053	0·25
2N3054	0·50
2N3055	0·75
2N3730	0·50
2N3731	2·75

	£
2N5109	2·05
40362	0·62
82303	0·50
3F100	0·62
3FR5	0·32
3N128	0·87
3N139	1·75
3N140	0·97
3N154	0·95
3N159	1·45
6FR5	0·45
12FR60	0·73
10D1	0·16
40954	1·37
40595	1·37
40636	1·45
40668	1·35
40669	1·45
AC126	0·25
AC127	0·25
AC128	0·25
AC176	0·25
ACY17	0·30
ACY28	0·17
AD149	0·50
AD161	0·37
AD162	0·37
AF118	0·62

	£
AF127	0·17
AF139	0·30
AF178	0·48
AF186	0·40
AFY19	0·13
ASY26	0·25
ASY28	0·25
ASY67	0·48
BAW19	0·28
BC107	0·12
BC108	0·12
BC113	0·25
BC118	0·38
BCY72	0·15
BF115	0·25
BF173	0·30
BFY51	0·20
BFY52	0·23
BSO5	0·38
B8	0·45
B82	0·47
B8Y29	0·25
BU100	1·80
BYZ13	0·25
BYZ16	0·63
CR81/10	0·25
CR81/20	0·38

	£
CR81/30	0·40
CR81/35	0·43
CR81/40	0·48
CR83/05	0·30
CR83/20	0·38
CR83/30	0·43
CR825/025	0·75
CR83/40	0·50
GET103	0·23
GET115	0·45
GET116	0·50
GEX66	1·00
NKT222	0·20
NKT304	0·50
8D918	0·28
8D928	0·31
8D938	0·32
8D94	0·21
8D988	0·46
V405A	0·40

ZENER DIODES

All preferred voltage

¼W	0·17
1W	0·37
1·5W	0·25
7W	0·40

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	£
6057	0·50
6060	0·50
6064	0·45
6065	0·65
6080	1·37
6146	1·50
8020	2·25
9001	0·20
9002	0·25
9003	0·50
9004	0·15
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CR. Tubes	
VCR97	4·50
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88D	9·00
88J	9·00
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6097C	17·50
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JP9/7D	37·50
K301	5·00
K305	12·00
K308	16·00
K337	16·00
KRN2A	3·50
WL417A	1·50
3J/92/E	37·50
5C22	18·00
714AY	4·00
725A	16·00

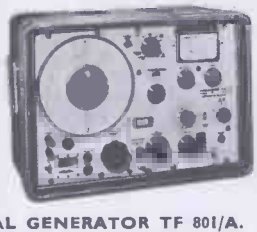
PLEASE NOTE Unless offered as "as seen" ALL EQUIPMENT ordered from us is completely overhauled mechanically and electrically in our own laboratories

MARCONI TEST EQUIPMENT

TF144G SIGNAL GENERATOR. To clear. In very good "as seen" condition. Complete with mains and battery cables, etc. **£15.**

TF1041C VTVM A.C. voltage range 300 MV to 300V in 7 ranges. 20 Hz-1500 MHz. D.C. voltage ranges 300 MV-1000V in 8 ranges. D.C. resistance 50 ohms to 500 Mohms. Price **£62·50.**

TF144H SIGNAL GEN. Freq. range 10 KHz-72 MHz. R.F. output 2uV to 2V at 50 ohms 400 and 1000 Hz internal mod. Limited qty. only available. Full spec and price on request.



SIGNAL GENERATOR TF 801/A. 10-300 Mc/s. in 4 bands. Internal at 400 c/s. 1 kc/s. External 50 c/s to 10 kc/s. Output 0-100 db below 200 mV from 75 ohms source. **£85.** DITTO but **801/A/1** with additional high level output. **£89.** Both P. & P. £1, including necessary connectors, plugs, and instruction manual.

AM/FM SIGNAL GENERATOR TF 937 (CT 218) Frequency range 85kHz-30mHz. 8 bands. Main dial total 56 foot. Built in crystal calibrator 200kHz and 2mHz. RF output ·1μV to ·1V. Four internal mod. freq. FM deviation up to 9kHz. **£115.** Carriage £1/5/0.

F.M. DEVIATION METER TYPE TF934. Frequency range 2.5-100MHz. Can be used up to 500MHz. Deviation range 0-75kHz **£67·50.** Carriage £1·50.

HEWLITT PACKARD AUDIO SIGNAL GENERATOR MODEL 206A £89·50. Carriage £1·50. Full specification for S.A.E.

REMSCOPE TYPE 741 STORAGE OSCILLOSCOPE. On trolley, complete with plug-in trace shifter and two plug-in Y amplifiers. Price on application.

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1½in. DIA. PANEL METERS. 7½-15v —ideal for "Battery Condition" indicators for cars **£0·77.**

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BRADLEY PORTABLE ELECTRONIC MULTIMETER TYPE CT471B. This instrument operates from three 1½V cells, is fully transistorised and measures A.C. and D.C. current, A.C. and D.C. voltage and D.C. resistance. Built-in battery check and calibration check. Full spec. and price on request.
As above but MODEL CT 471A manufactured by AVO, full spec and price on request.
4, 5 and 8 bank 25 way uniselectors, 24V, guaranteed perfect, £3·75; £4·50; £6·87 respectively.
AR88 SPARES. We hold the largest stock in U.K. Write for list.

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Originally made to work with Hallicrafters BC 610E transmitters. 2mc to 18mc, for output up to 450 watts. Brand new **£8·50.** Carriage £1.

PRECISION VHF FREQUENCY METER TYPE 183. 20-300 Mc/s with accuracy 0.03% and 300-1,000 Mc/s with accuracy 0.3.%. Additional band on harmonics 5.0-6.25 Mc/s with accuracy + —2×10⁻⁴. Incorporating calibrating quartz 100 kc/s + —5× 10⁻⁵ 120/220 v. A.C. mains. **£85.** Carriage £2.

MUIRHEAD-WIGAN DECADE OSCILLATORS. TYPE 650A 9650B. Frequency range 1 to 111,100 Hz. Accuracy ± 0.2%. Power supply 100-250 v. D.C. **£65** and **£75** respectively. carr. £1·75.

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CD 711S.2. Double beam, DC to 7MHz 'scope, **£85.** Carriage £1·50.

HARNESS "A" & "B" control units, junction boxes, headphones, microphones, etc.

29/41FT. AERIALS each consisting of ten 3ft., ⅞in. dia. tubular screw-in sections. 11ft. (6-section) whip aerial with adaptor to fit the 7in. rod, insulated base, stay plate and stay assemblies, pegs, reamer, hammer, etc. Absolutely brand new and complete ready to erect, in canvas bag, **£4.** P. & P. £0·50.

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53 TRANSMITTERS. All spares available. COLLINS TCS. Complete installations and spare parts.
COLLINS TYPE 231D 5KW TRANSMITTERS. 10 channel, autotune and manual tuning. Complete with very comprehensive spares. Full specification and price on application. Complete installations and all spares. No. 19 WIRELESS SETS. H.P. SETS and all spares R.210 RECEIVERS with all necessary accessories.
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RSC MK III SUPER 30 HI-FI STEREO AMPLIFIER

A COMPLETELY NEW DESIGN FURTHER IMPROVED IN BOTH APPEARANCE and PERFORMANCE. REPRESENTING VALUE FAR HIGHER THAN THE PRICES SUGGEST.

Only high grade components by leading manufacturers. **£25** Carr. 65p

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Or **FACTORY BUILT** with 12 months guarantee Dep. £5·75 and 9 monthly payments £3·50 (Total £37·25) **£33·75**

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PRINTED CIRCUITRY, TWENTY SILICON TRANSISTORS. FOUR DIODES, FOUR RECTIFIERS.

TECHNICAL DETAILS (Applying to each channel where appropriate).

CONTROLS: PUSH-BUTTON SELECTOR (1) Disc (2) Radio (3) Tape (4) Mono L (5) Mono R (6) SPEAKER DIS. (7) Mains on/off. Bass, Treble, and Balance Plus Ceramic Mag. P.U. Switch.

★ SATIN SILVER METAL FACIA with black lettering. Black edged knobs with bright silver centres.
★ PUSH-BUTTON SELECTOR SWITCHING
★ NEON INDICATOR
★ JACK SOCKET FOR HEADPHONE
★ CABINETED MODEL VENEERED IN SATIN TEAK. SUITABLE FOR ANY MODERN PICK-UP CARTRIDGE CERAMIC or MAGNETIC, REGARDLESS OF PRICE.

WE RECOMMEND USE WITH THE REST ANCILLARY EQUIPMENT THAT CAN BE AFFORDED.

OUTPUT: 15 watts R.M.S. (Continuous) into 8 ohms. 10 watts R.M.S. (Continuous) into 15 ohms.
HUM & NOISE —75dB Min. Vol. —65dB Full Vol.
HARMONIC DISTORTION 0·1% at 1000 Hz 10 Watts
FREQUENCY RESPONSE: —3dB 7Hz to 70KHz
TREBLE CONTROL: +16dB to —12dB at 14KHz
BASS CONTROL: +17dB to —16dB at 40Hz CROSS TALK —58dB
SENSITIVITIES: Disc Mag. 2·5mV. Ceramic 35mV. Radio 120mV. Tape 120mV.

REAR PANEL SOCKETS ARE FOR 3 PAIRS OF INPUTS (1) P.U. (2) Radio (3) Tape Amp. Plus pair for tape recorder signal take off and 2 pairs for speaker connections.

FANE 807 HIGH FIDELITY LOUDSPEAKER

A full range 8in. 10 watt Unit for excellent sound quality in suitable enclosure. Roll P.V.C. cone surround and long throw voice coil to achieve very low fundamental resonance at 30 c.p.s. Tweeter cone is fitted to extend high note response. Frequency range 25 Hz to 15 KHz. Impedance 3 Ω or 8-15 Ω. Cast Chassis. REMARKABLE VALUE AT ONLY **£3·50**

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Heavy construction. Latest high efficiency ceramic magnets. Treated Cone surround or "L" indicates Roll Rubber surround. "D" indicates Tweeter Cone providing extended frequency range up to 15,000 c.p.s. Exceptional performance at low cost. Impedance 3 or 8-15 ohms.

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HF 102D	10" 10W	£3·40	HF 126	12" 15W	£5·50
HF 120	12" 15W	£4·25	HF 126D	12" 15W	£5·90

FANE ULTRA HIGH POWER LOUDSPEAKERS

All power ratings are R.M.S. continuous. 2 years' guarantee. High flux ceramic magnets. Heavy cast chassis. ALL CARRIAGE FREE.

'POP' 100	'POP' 60	'POP' 50
18in. 100 watt 14,000 gauss 8/15 ohms	15in. 60 watt 14,000 gauss 8/15 ohms	12in. 50 watt 13,000 gauss 15 ohms
£22·05	£12·90	£10·50
Dep.: £6 and 9 monthly payments £2·10 (Total £24·90).	Dep.: £3·30 and 9 monthly payments £1·30 (Total £15).	Dep.: £2 and 9 monthly payments £1·15 (Total £12·35).
FOR BASS GUITAR OR ELECTRONIC ORGAN, ETC.		PAIR SUITABLE ALL PURPOSES.

AUDIOTRINE HI-FI SPEAKER SYSTEMS

Consisting of matched 12in. 11,000 line 15 watt 15 ohm high quality speaker, cross-over unit and tweeter. Smooth response and extended frequency range ensure surprisingly realistic reproduction. Carr. 30p.
Or SENIOR 15 WATT inc. HF126 15,000 line Speaker £6·75. Carr. 35p. **£5·75**

HI-FI LOUDSPEAKER ENCLOSURES

Teak or Afrormosia veneer finish. Modern design. Acoustically lined. All sizes approx. Carr 25p extra.
JE8 Size 16×11×9in. Pressurised. Gives pleasing results with any 8in. Hi-Fi speaker. **£5·35**
SE8 For optimum performance with any 8in. Hi-Fi 'speaker. 22×15×9in. Ported **£6·47**
SE10 For outstanding results with Hi-Fi 10in. speaker. 24×15×10in. Ported **£6·74**
SE12 For high performance with 12in. Hi-Fi speaker and Tweeter. Size 25×16×10½in. Pressurised. **£7·87**

TA12 MK III 6·5+6·5WATT STEREO AMPLIFIER

FULLY TRANSISTORISED, SOLID STATE CONSTRUCTION HIGH FIDELITY OUTPUT OF 6.5 WATTS PER CHANNEL

Designed for optimum performance with any crystal or ceramic Gram P.U. cartridge, Radio tuner, Tape recorder, 'Mike' etc. ★ 3 separate switched input sockets on each channel ★ Separate Bass and Treble controls ★ Slide Switch for mono use ★ Speaker Output 3-15 ohms ★ For 200-250 v. A.C. mains ★ Frequency Response 20-20,000c.p.s. —2dB ★ Harmonic Distortion 0.3% at 1000c.p.s. Hum and noise —70dB ★ Sensitivities (1) 50 mV (2) 400 mV (3) 100 mV ★ Handsome finish Facia Plate and Knobs. Output rating I.H.F.M. Complete kit of parts with full wiring diagrams and instructions. Carr. 40p. **£15·50**
FACTORY BUILT WITH 12 MTH GNTEE. £19·50. Or dep. £3 and 9 mnthly pymts. £2·15 (Total £22·35). Or in Teak veneer housing. £23. Or Dep. £3 and 9 mthly. pymts £2·55 (Total £25·95).

SELENIUM RECTIFIERS F.W. Bridged 6/12v. D.C. Output Input Max. 18v. A.C. 1a., 25p; 2a., 35p; 3a., 50p; 4a., 65p; 6a., 80p.

R.S.C. G66 6+6 WATT HIGH QUALITY STEREO AMPLIFIER

Individual Ganged controls: Bass, Treble, Volume and Balance. Printed circuit construction employing 10 Transistors plus Diodes. Output rating I.H.F.M. Suitable for Crystal Pick-ups etc., and for loudspeaker output impedances of 3 to 15 ohms. For standard 200-250 v A.C. mains operation. Attractive silver finished metal facia plate and matching control knobs. Complete KIT OF PARTS INCLUDING FULLY WIRED PRINTED CIRCUIT and comprehensive wiring diagram and instructions. Or FACTORY BUILT in Teak veneered cabinet as illustrated £12·99.

£9·99 Carr. 40p. Or Deposit £2·50 and 9 monthly payments of £1.45 (Total £15·55).

INTEREST CHARGES REFUNDED ON CREDIT SALES SETTLED IN 3 MONTHS

R.S.C. MAINS TRANSFORMERS

FULLY GUARANTEED. Interleaved and Impregnated. Primaries 200-250v. 50c/s. Screened

MIDGET CLAMPED TYPE 2½×2½×2¼m.

250v., 60mA, 6.3v. 2a.	99p
250-0-250v., 60mA, 6.3v., 2a.	£1·05

FULLY SHROUDED UPRIGHT MOUNTING

250-0-250v. 60mA., 6.3v. 2a., 0-5-6.3v. 2a...	£1·40
250-0-250v. 100mA, 6.3v. 4a., 0-5-6.3v. 3a..	£2·20
300-0-300v. 100mA, 6.3v. 4a., 0-5-6.3v. 3a..	£2·20
300-0-300v. 130mA, 6.3v. 4a., c.t., 6.3v 1a. For Mullard 510 Amplifier	£2·45
350-0-350v. 100mA., 6.3v. 4a., 0-5-6.3v. 3a.	£2·20
350-0-350v. 150mA. 6.3v. 4a., 0-5-6.3v. 3a.	£2·65
425-0-425v. 200mA, 6.3v. 4a. c.t., 5v. 3a...	£4·95
425-0-425v. 200mA, 6.3v. 4a., 6.3v. 3a, 5v. 3a	£5·10
450-0-450v. 250mA. 6.3v, 4a., c.t., 5v. 3a...	£5·50

TOP SHROUDED DROP-THROUGH TYPE

250-0-250v 70mA, 6.3v. 2a., 0-5-6.3v. 2a...	£1·35
250-0-250v. 100mA, 6.3v. 3.5a.	£1·55
250-0-250v. 100mA, 6.3v. 2a., 6.3v. 1a.	£1·60
350-0-350v. 80mA, 6.3v. 2a., 0-5-6.3v. 2a...	£1·65
250-0-250v. 100mA, 6.3v. 4a., 0-5-6.3v. 3a.	£2·20
300-0-300v. 100mA, 6.3v. 4a., 0-5-6.3v. 3a.	£2·20
300-0-300v. 130mA, 6.3v. 4a., 0-5-6.3v. 1a. Suitable for Mullard 510 Amplifier	£2·60
350-0350v. 100mA., 6.3v. 4a., 0-5-6.3v. 3a.	£2·20
350-350v. 150mA, 6.3v. 4a., 0-5-6.3v. 3a.	£2·60

FILAMENT or TRANSISTOR POWER PACK Types 6.3v. 1.5a. 49p; 6.3v. 2a. 54p; 6.3v. 3a. 76p; 6.3v. 6a. £1·30; 12v. 1a. 55p; 0-9-18v. 1½a. £1·10; 0-12-25-42v. 2a. £1·75; 12v. 3a. or 24v. 1.5a. £1·35;

CHARGER TRANSFORMERS 0-9-15v. 1½a. 99p; 2½a. £1·10; 3a. £1·25; 5a. £1·45; 6a. £1·65; 8a. £2·00.

AUTO (Step UP/Step DOWN) Transformers
0-110/120v., 200-230-250v. 50-80 watts.... £1·10
150 watts, £1·90; 250 watts, £2·75; 500 watts, £5·75.

OUTPUT TRANSFORMERS

Standard Pentode 5,000Ω to 7,000Ω to 3Ω	50p
Push-Pull 8 watts EL84 to 3Ω or 15Ω	83p
Push-Pull 10 watts 6V6 ECL86 to 3, 5, 8 or 15Ω	£1·37
Push-Pull EL84 to 3 or 15Ω 10-12 watts..	£1·35
Push-Pull Ultra Linear for Mullard 510, etc.	£2·20
Push-Pull 15-18 watts, sectionally wound 6L6 KT66, etc., for 3 or 15Ω	£1·99
Push-Pull 20 watt high quality sectionally wound EL34, 6L6, KT66, etc. to 3 or 15Ω	£3·30

SMOOTHING CHOKES
150mA, 7-10H. 250Ω 70p; 100mA. 10H. 200Ω 60p; 80mA. 10H. 350Ω. 50p; 60mA. 10H. 400Ω 25p.

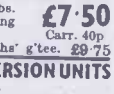
FANE LOUDSPEAKERS 'POP'25/2

Dual cone 15Ω (for uses other than Bass Guitar or Electronic Organ. Carr. free. Or dep.: £1 and 9 monthly payments 75p (Total £7·75). 12in. 25watt **£6·75**

R.S.C. TA6 6 Watt High Fidelity Solid State Amplifier

200-250v. A.C. mains operated Frequency Response 30-20,000 c.p.s. —2dB. Harmonic Distortion 0.3% at 1,000 c.p.s. Separate Bass and Treble 'lift' and 'cut' controls. 3 input sockets for Mike, Gram, Radio or Tape. Input selector switch. Output for 3-15 ohm speakers. Max. sensitivity 5mV. Output rating I.H.F.M. In fully enclosed enamelled case, approx. 9½ × 2½ × 5½in. Attractive brushed silver finish facia plate 10½ × 3½in. and matching knobs. Complete kit of parts with full wiring diagrams and instructions. **£7·50** Carr. 40p
OR FACTORY BUILT with 12 months' g'tee. £9·75

R.S.C. BATTERY/MAINS CONVERSION UNITS



Type BM1. An all-dry battery eliminator. Size 5½ × 4½ × 2in. approx. Completely replaces batteries supplying 1.5 v. and 90 v. where A.C. mains 200/250 v. 50 c/s. is available.
COMPLETE KIT WITH DIAGRAM £3 or READY FOR USE £3·50.

HIGH QUALITY LOUDSPEAKERS

In teak or afrormosia veneered cabinets.

L13 3 or 15 ohms. 13 × 8in. 8-10 Watt Model Gauss 10,000 lines. Carr. 40p **£5·25**

L12 12in. 20 Watt Model. Gauss 11,000 lines. Size 18 × 18 × 10 in. approx. 15Ω. Carr. 45p. **£10·50.** Or dep £3 and 9 mthly pymts £1. (Total £12).

R.S.C. COLUMN SPEAKERS

Covered in Rexine and Vynair, ideal for vocalists and Public Address. 15 ohm matching. TYPE C4SS, 30 watts. Fitted four 8in. high flux 8w. speakers. Or dep. £3 and 9 mthly pmts £2 (Total £21). Carr. 50p.

TYPE C4125, 50 watts. Fitted four 12in. 11,000 lines 15 watt Speakers. Or dep. £4 and 9 mthly. pymts. of £3 (Total £31). **£17·75** **£27·50** Carr. 75p

R.S.C. A10 30 WATT ULTRA LINEAR HI-FI AMPLIFIER

Highly sensitive. Push-Pull high output, with Pre-amp./Tone Control Stages. Hum level —70dB. Frequency response ±3dB 30-20,000 c/s. All high grade components. Valves EF86, EF86, ECC83, 807 .807, GZ34. Separate Bass and Treble Controls. Sensitivity 36 millivolts. Suitable for High Impedance mic. or pick-ups. Designed for Clubs, Schools, Theatres, Dance Halls or Outdoor Functions, etc. For use with Electronic Organ, Guitar, String Bass, etc. Gram, Radio or Tape. Reserve L.T. and H.T. for Radio Tuner. Two Inputs with associated volume controls so that two separate inputs such as Gram and "Mike" can be mixed. 200-250 v., A.C. For 3 & 15Ω speakers. COMPLETE KIT PARTS, WIRING DIAGRAMS, INSTRUCTIONS. Twin-handled perforated cover £1·75. Or factory built with EL34 output valves and 12 months' guarantee for £19·75. Tech. figs. apply to factory built units. Carr. 65p.
£15·75
TERMS: Deposit £4 and 9 monthly payments of £2·10 (Total £22·90). Send S.A.E. for leaflet.

RSC BASS-REGENT 50 WATT AMPLIFIER

A powerful high quality, all purpose unit. For lead, rhythm, bass guitar, vocalists, gram., radio, tape. Peak output rating. Employing current valves and reliable components. FOUR JACK INPUTS and TWO VOLUME CONTROLS for simultaneous use of up to 4 pick-ups or 'mikes'. SEPARATE BASS AND TREBLE CONTROLS. OR SUPPLIED COMPLETE with matched twin loudspeaker unit as illustrated for £60. Carr. £1·50. Terms: Dep. £16 and 9 monthly payments £5·75 (Total £67·75). **£30·50** Carr. 90p

THE 'YORK' HIGH FIDELITY 3 SPEAKER SYSTEM

Moderate size (approx. 25×14×10 in.). Range 30-20,000 c.p.s. KIT COMPLETE Impedance 15 ohms. Performance comparable with units costing considerably more. Consists of (1) 12in. 15 watt Bass unit with cast chassis. Roll rubber cone surround for ultra low resonance, and ceramic magnet. (2) 3-way quarter section series cross-over system. (3) 8 × 5in. high flux middle range speaker. (4) High efficiency tweeter. (5) Appropriate quantity acoustic damping material. (6) Teak veneered cabinet. (7) Circuit and full instructions. **£22** Carr. 63p
REMARKABLE VALUE HEAR IT AT ANY BRANCH

AUDIOTRINE A55 HIGH QUALITY STEREO SYSTEM

5 + 5 WATT OUTPUT

Garrard 5200 Changer with low mass pick-up arm and Stereo Cartridge. Controls: TREBLE, BASS, VOLUME, STEREO, BALANCE.

Operation on 200-250 v. A.C. mains. Output rating I.H.F.M.

Luxurious Teak Veneer Finished Cabinets. Transparent plastic (tinted) cover included for main unit. Silver finished facia plate and matching control knobs.

PAIR OF LOUDSPEAKER UNITS

Incorporating high flux 8 in. × 5 in. speaker. Size approx. 13 × 7½ × 8½ ins.

PRICE COMPLETE ONLY £42

Carr. £1·25

Terms: Deposit £5·50 and 9 monthly payments £4·50 (Total £46).

A REALLY SURPRISING STANDARD OF QUALITY IS OBTAINED FROM THIS COMPACT LOW PRICED SYSTEM

BRADFORD 10 North Parade (Half-day Wed.). Tel. 25349
BLACKPOOL (Agent) O & C Electronics 227 Church St.
BIRMINGHAM 30/31 Gt. Western Arcade. Tel.: 021-236 1279. Half-day Wed.
DERBY 26 Osmaston Rd. The Spot (Half-day Wed.). Tel. 41361
DARLINGTON 18 Priestgate (Half-day Wed.). Tel. 68043
EDINBURGH 133 Leith St. (Half-day Wed.). Tel. 556 5766
GLASGOW 326 Argyle St. (Half-day Tues.). Tel. 248 4158
HULL 91 Paragon Street (Half-day Thurs.). Tel. 20505

R·S·C HI-FI CENTRES LTD.

MAIL ORDERS to: 106 Henconner Lane, Leeds 13 Terms C.W.O. or C.O.D. Postage 25p extra under £2. 30p extra over £2, or as stated. Trade supplied. S.A.E. with enquiries. EXPORT ENQUIRIES welcomed.
Branches open ALL DAY Sats
MAIL ORDERS MUST NOT BE SENT TO SHOPS.

LEICESTER 32 High Street (Half-day Thurs.). Tel. 56420
LEEDS 5-7 County (Mecca) Arcade, Briggate (Half-day Wed.) Tel. 28252
LIVERPOOL 73 Dale St. (Half-day Wed.). Tel. 236 3573
LONDON 238 Edgware Road, W.2 (Half-day Thurs.). Tel. 723 1629
MANCHESTER 60A Oldham Street (Half-day Wed.) Tel. 236 2778
MIDDLESBROUGH 106 Newport Rd. (Half-day Wed.). Tel. 47096
NEWCASTLE UPON 41 Blackett Street (opp. Fenwicks TYNE Store) (Half-day Wed.). Tel. 21469
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SPECIAL HI-FI OFFERS

All Carriage Paid. Mail Order Only.

WHARFEDALE/F.A.L. 1 Pr. Wharfedale Super Linton Speakers, 1 F.A.L. Phase 32 15+15 Watt Stereo Amplifier. Total Rec. Retail Price **£87·70** Package Price **£66·50**
Above brand new goods. Following have been unpacked for display purposes only.
LEAK MINI SANDWICH (Teak finish) £18
ROGERS RAVENSBROOK STEREO AMP. £39
TANDBERG 62X Tape Recorder (Stereo) **£88**
GOLDRING GL68 Transcription Turntable and P.U. **£14·50**
GOODMANS AUDIOM 91 18" speaker **£19·95**

28watts, r.m.s. 40Hz to 40kHz ±3dB

Viscount III Audio Suite complete £49

PRICES SYSTEM 1

Viscount III R101 amplifier	£22.00 + 90p p&p
2 x Duo Type II speakers.	£14.00 + £2 p&p
Garrard SP25 Mk. III with MAG. cartridge, plinth and cover	£23.00 + £1.50 p&p
Total	£59.00

Available complete for only £52.00 + £3.50 p&p

SPECIFICATION (R100/101)

14 watts per channel into 3 to 4 ohms. Total distortion @ 10W @ 1kHz 0.1%. *P.U.1* (for ceramic cartridges) 150mV into 3 Meg. *P.U.2* (for magnetic cartridges) 4mV @ 1kHz into 47K, equalised within ± 1dB R.I.A.A. *Radio* 150mV into 220K. (Sensitivities given at full power.) Tape out facilities; headphone socket, power out 250mW per channel. *Tone controls and filter characteristics.* Bass: + 12dB to − 17dB @ 60HZ. Bass filter: 6dB per octave cut. Treble control: treble + 12dB to − 12dB @ 15kHz. Treble filter: 12dB per octave. *Signal to noise ratio:* (all controls at max) RT101—P.U.1 & radio—65dB. P.U.2—58dB. **R100** same as RT101 but P.U.2 (for crystal cartridges) 450mV into 3 Meg. *Cross talk* better than −35dB on all inputs. *Overload characteristics* better than 26dB on all inputs.

Size 13¾" x 9" x 3¾".

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

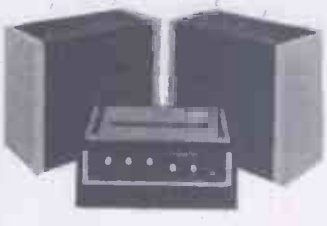
Viscount III Amplifier R100	£17.00 + 90p p&p
2 x Duo Type II speakers, pair	£14.00 + £2 p&p
Garrard SP25 Mk. III with CER. diamond cartridge, plinth and cover	£21.00 + £1.50 p&p
Total	£52.00

Available complete for only £49.00 + £3.50 p&p

SPEAKERS Duo Type II

Size 17" x 10¾" x 6¾". Drive unit 13" x 8" with parasitic 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. Teak veneer cabinet. **£32 pair** + £3 p&p.

SOUND 50 50 WATT AMPLIFIER & SPEAKER SYSTEM



Output Power. 45 watts R.M.S. (Sine wave drive). *Frequency response:* −3 db points 30 Hz at 18 KHz. *Total distortion:* less than 2% at rated output. *Signal to noise ratio:* better than 60 db. *Speaker Impedance:* 3, 8 or 15 ohms. *Bass Control Range:* ±13 db at 60 Hz. *Treble Control Range:* ±12 db at 10 KHz. *Inputs:* 4 inputs at 5 mV into 470 K. Each pair of inputs controlled by separate volume control. 2 inputs at 200 mV into 470K. To protect the output valves, the incorporated fail safe circuit will enable the amplifier to be used at half power. *SPEAKERS:* Size 20" x 20" x 10" incorporating 12" heavy duty 25 watt high flux, quality loudspeaker with cast frame. Cabinets attractively finished in two tone colour scheme—Black and grey.

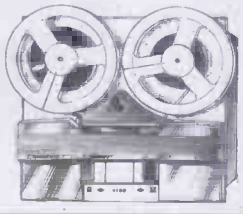
COMPLETE SYSTEM £50 Sound 50 amp and 2 speakers

Plus £6 P. & P.

or available separately
Amplifier: £28.50 plus £1.50 P. & P.
Speaker: £12.50 each plus £2.25 P. & P.

CONTINENTAL 4-TRACK, 3-SPEED TAPE DECK

with high impedance heads



R.C.74 tape deck. Three speeds—7½, 3¾ and 1⅞ ips. 4-track record/playback head. Plus 4-track erase head. Positive pressure pad system. Takes any tape spool up to and including 7". The R.C.74 is driven by a powerful 200/250V 50-cycle A.C. motor. A heavy, accurately balanced, flywheel brings wow and flutter levels down to approx. 0.3% total at 3¾ and 7½ ips. Fast rewind in both directions.

Controls couldn't be simpler! Just five push buttons that interlock to cut out accidental tape damage. Efficient servo-action type braking. Easy drop-in tape loading.

The R.C.74 comes with an attractive moulded deck cover, which has positions for tone and volume controls. The unit is built into a rigid die-cast frame, and overall size of the whole unit is 12⅞ x 11⅞ x 6 inches. Every single deck fully tested before dispatch. Spools not supplied

Price complete **£15.00.** Plus 75p p. & p.

TOURIST MARK 3 ALL TRANSISTOR CAR RADIO

Beautifully designed to blend with the interiors of all cars. Permeability tuning and long wave loading coils ensures excellent tracking, sensitivity and selectivity on both wave bands. R.F. sensitivity at 1 MHz is better than 8 micro volts. Power output into 3 ohm speaker is 3 watts. Pre-aligned I.F. module and tuner together with comprehensive instructions guarantees success first time. 12 volts negative or positive earth. Size 7" x 2" x 4½" deep.

Circuit diagram 13p Free with parts. Speaker, baffle and fixing kit £1.25 extra plus 20p P. & P. Speaker postage free when ordered with parts.

SET OF PARTS **£6.30** Plus 50p P. & P

R+TV

RADIO & TV COMPONENTS (Acton) LTD
21a High Street, Acton, London, W.3. 6.NG

Also 323 Edgware Road, London, W.2. ALL ORDERS BY POST to Acton

Goods not dispatched outside U.K. Terms C.W.O. All enquiries S.A.E.

SERVICE TRADING CO

Postage and Carriage shown below are inland only. For Overseas please ask for quotation. We do not issue a catalogue or list.

VARIABLE VOLTAGE TRANSFORMERS

INPUT 230 v. A.C. 50/60
OUTPUT VARIABLE 0/260 v. A.C.

50 AMP

1 AMP

BRAND NEW. Keenest prices in the country. All types (and spares) from ½ to 50 amp. available from stock.

0-260 v. at 1 amp.	£5·50
0-260 v. at 2·5 amps	£6·75
0-260 v. at 5 amps.	£9·75
0-260 v. at 10 amps.	£18·50
0-260 v. at 15 amps.	£25·00
0-260 v. at 20 amps.	£37·00
0-260 v. at 25 amps.	£49·00
0-260 v. at 37·5 amps.	£72·00
0-260 v. at 50 amps.	£92·00

carriage extra.

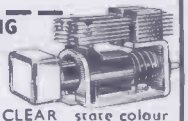
OPEN TYPE (Panel mounting). ½ amp. £3·93
1 amp £5·50. 2½ amp. £6·63. P. & P. 40p.

VAN DE GRAAF ELECTROSTATIC GENERATOR,

fitted with motor drive for 230 v. A.C. giving a potential of approx. 50,000 volts. Supplied absolutely complete including accessories for carrying out a number of interesting experiments, and full instructions. This instrument is completely safe, and ideally suited for School demonstrations. Price £7·50, plus 60p P. & P. £'t on req.

T.M.C. ILLUMINATED LOCKING PUSH BUTTON KEY SWITCH

NO 5528857 6 co



Complete with mounting bracket, Push Knob and Lenses (GREEN, AMBER, RED or CLEAR state colour preference). Price 88p each excluding bulb. Post Paid. Discount for quantities of 200 or over.

ALARM BELL

Manufactured by GENTS. 6 inch bell, 3/6 volt D.C. operation. As NEW. Only £1·50 plus 45p P. & P.

12-28 VOLT D.C. BLOWER UNIT

Powerful, smooth running, precision made Blower Unit. 5,000 RPM, ·54 amps. Size 3" diameter × 3¾" long over all. Price £2·00 post paid.

LIGHT SOURCE AND PHOTO CELL MOUNTING

Precision engineered light source with adjustable lens assembly and ventilated lamp housing to take MBC bulb. Separate photo cell mounting assembly for ORP.12 or similar cell with optic window. Both units are single hole fixing. Price per pair £2·75 p & p 18p.

LIGHT SENSITIVE SWITCHES

Kit of parts including ORP.12 Cadmium Sulphide Photocell. Relay Transistor and Circuit. Now supplied with new Siemens High Speed Relay for 6 or 12 volt operations. Price £1·25, plus 12p P. & P. ORP. 12 and Circuit 63p post paid.

220/240 A.C. MAINS MODEL

Incorporates mains transformer rectifier and special relay with 1 make, 1 break, H.D. contacts. Price inc. circuit £2·38, plus 20p P. & P.

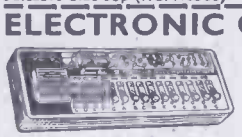
200-250 v. A.C. NEON INDICATOR

Available in RED or AMBER at 20p each, or in GREEN at 32p. Min. order 3 units. P. & P. 5p.

MOTOROLA MAC11/6 PLASTIC TRIAC 400 PIV 8 AMP

Now available EX STOCK supplied complete with full data and applications sheet. Price £1·05 plus 7p P. & P. Suitable diac 30p (RCA40583)

ELECTRONIC ORGAN KIT



Easy to build, solid state. Two full octaves (less sharps and flats). Fitted hardwood case, powered by two penlite 1½v. batteries.

Complete set of parts including speaker, etc., together with full instructions and 10 tunes. £3·00. P. & P. 25p.

50 in 1 ELECTRONIC PROJECT KIT

50 easy to build Projects. No soldering, no special tools required. The Kit includes Speaker, meter, Relay, Transformer, plus a host of other components and a 56-page instruction leaflet. Some examples of the 50 possible Projects are: Sound level Meter, 2 Transistor Radio, Amplifier etc., etc. Price £7·75. P. & P. 30p.

CRYSTAL RADIO KIT

Complete set of parts including: crystal diode, ferrite aerial, drilled chassis and personal ear-piece. No soldering, easy to build, full step-by-step instructions. £1·75 inc. post.

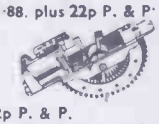
POWER RHEOSTATS

(NEW) Ceramic construction, winding embedded in Vitreous Enamel, heavy duty brush assembly designed for continuous duty. **AVAILABLE FROM STOCK IN THE FOLLOWING 11 VALUES: 100 WATT 1 ohm 10a., 5 ohm 4.7a., 10 ohm 3a., 25 ohm 2a., 50 ohm 1.4a., 100 ohm 1a., 250 ohm ·7a., 500 ohm ·45a., 1k ohm 280mA., 1·5k ohm 230mA., 2·5k ohm ·2a., 5k ohm 140mA.,** Diameter 3¼in. Shaft length ⅜in. dia. ¼ in., £1·50. P. & P. 15p. **50 WATT** 1·12/10/25/50/100/250/500/1K/1·5K/2·5K/5K ohm. All at £1·12, P. & P. 11p. **25 WATT** 10/25/50/100/250/500/1K/1·5K/2·5K/3·5K ohm. All at 78p, P. & P. 5p.

Black Silver Skirted knob calibrated in Nos. 1-9. 1½ in. dia. brass bush. Ideal for above Rheostats, 18p ea.

UNISELECTOR SWITCHES—NEW

4 BANK 25 WAY FULL WIPER
25 ohm coil, 24 v. D.C. operation £5·88. plus 22p P. & P.



6 BANK 25 WAY FULL WIPER
25 ohm coil, 24 v. D.C. operation. £6·50, plus 22p P. & P.

8 BANK 25 WAY FULL WIPER
24 v. D.C. operation. £7·63, plus 22p P. & P.

MINIATURE UNISELECTOR

3 banks of 11 positions, plus homing bank. 40 ohm coil. 24-36v. D.C. operation. Carefully removed from equipment and tested: £1·13, plus 13p P. & P.

VERY SPECIAL OFFER

Cannot be repeated. 500 v. 50 Meg Record Insulation testers. Excellent condition, fully tested. Complete with leather carrying case. £12. P. & P. 50p.

STROBE! STROBE! STROBE!

- THREE EASY TO BUILD KITS USING XENON WHITE LIGHT FLASH TUBES. SOLID STATE TIMING + TRIGGERING CIRCUITS. PROVISION FOR EXTERNAL TRIGGERING. 230-250v. A.C. OPERATION.
- The Strobe is one of the most useful and interesting instruments in the laboratory or workshop. It is invaluable for the study of movement and checking of speeds. Many uses can be found in the psychiatric and photographic fields, also in the entertainment business. It is used a great deal in the motor industry and is a real tool as well as an interesting scientific device.
- **EXPERIMENTERS "ECONOMY" KIT**
  Adjustable 1 to 36 Flash per sec. All electronic components including Veroboard S.C.R. Uniiunction Xenon Tube + instructions £6·30 plus 25p P. & P.
- **NEW INDUSTRIAL KIT**
  Ideally suitable for schools, laboratories etc. Roller tin printed circuit. New trigger coil, plastic thyristor Adjustable 1-80 f.p.s. Price £10·50. 50p P. & P.
- **HY-LYGHT STROBE**
  This strobe has been designed for use in large rooms, halls and the photographic field, and utilizes a silica tube for longer life expectancy, printed circuit for easy assembly, also a special trigger coil and output capacitor. Speed adjustable 1-30 f.p.s. Light output approx. 4 ioules. Price £12·00. P. & P. 50p.

AND NOW!

- **THE 'SUPER' HY-LYGHT KIT**
- Approx. 4 times the light output of our well proven Hy-Lyght strobe.
- Incorporating, Heavy duty power supply.
- Variable speed from 1-23 flash per sec.
- Fantastic Octal based tube with massive electrodes.
- Reactor control circuit producing an intense white light.
- The brilliant light output of the 'SUPER' HY-LYGHT gives fabulous effects with colour filters.
- **Never before a Strobe Kit with so HIGH an output at so LOW a price. ONLY £20·00 plus 75p P. & P.**
- **7-INCH POLISHED REFLECTOR.** Ideally suited for above Strobe Kits. Price 53p and 13p P. & P. or post paid with kits.

RUNNING HOUR METER. 240 volt, 50 cycle, 2·2 watt. Calibrated in minutes. Six figure. PRICE; £3·00 including Post & Packing.

VENNER ELECTRIC TIME SWITCH

200/250 volt. Ex-GPO. Tested, perfect condition. Two ON, two OFF, every 24 hrs. at any manually pre-set time. Price: 10amp. £2·75. 15amp. £3·25. 20amp. £3·75. P. & P. 20p. Also available with Solar Dial ON at dusk, OFF at dawn. Prices as above.

INSULATED TERMINALS

Available in black, red, white, yellow, blue and green. New 10p each. Post paid.

SEMI-AUTOMATIC "BUG" SUPER SPEED MORSE KEY

7 adjustments, precision tooled speed adjustable 10 w.p.m. to as high as desired. Weight 2½lb. £4·63 post paid.

RELAYS NEW SIEMENS PLESSEY, etc.

MINIATURE RELAYS AT COMPETITIVE PRICES.

1	2	3	4	1	2	3	4
45	6-9	2 HD M	50p	700	12-24	2 c/o	63p*
185	6-12	4 c/o	73p*	700	15-35	2 c/o HD	73p*
230	9-18	2 c/o HD	63p*	700	16-24	6 M	63p*
230	9-12	4 c/o	78p*	1250	24-36	4 c/o	63p*
280	9-12	2 c/o	73p*	2500	36-45	6 M	63p*
600	18-32	4 c/o	78p*	5800	40-48	4 c/o	50p
700	16-24	4 M 2 B	63p*	2400	30-48	4 c/o	63p*
700	16-24	4 c/o	78p*	9000	40-70	2 c/o	63p*
				15k	85-110	6 M	50p*

(1) Coil ohms; (2) Working d.c. volts; (3) Contacts; (4) Price HD = Heavy Duty. All Post Paid. *including Base.

MAINS RELAY
230 v. A.C. coil 3 c/o, 10 amp. A.C. contacts. 50p + 8p p. & p. Similar to above illustration.

COMPLETE NI. CAD. BATTERY OUTFIT (EX W.D.)

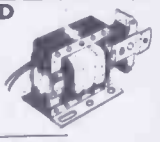
2 metal carrying cases each containing 10 × 1·2 volt 7 AH (12v.) batteries, also 10 × 1·2v. 22 AH (12v.) batteries (40 batteries in all). 1 Dual voltage, dual meter, thyristor controlled charging unit. Designed for charging the 7AH and 22AH batteries simultaneously. Input voltage can be adjusted between 100-250v. A.C. Built to ministry specification. Ideal power supply for field work. Offered at fraction of makers price. 2 sets of batteries, 1 charging unit. The set £45·00, c. & p. £1·50.

NICKEL CADMIUM BATTERY

1.2 v. 35 AH. Size 80 high × 3 × 10. £1·50 each, plus 20p P. & P.

Sintered Cadmium Type 1.2 v. 7AH. Size: height 3½ in., width 2¼in. × 1 1/16in. Weight: approx. 13 ozs. Ex-R.A.F. Tested 63p. P. & P. 15p.

230 VOLT AC SOLENOID

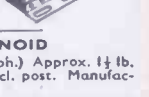


EXTREMELY POWERFUL SOLENOID with approximately 14lb. pull, 1 inch travel. Fitted with mounting feet. Size 4 inches long, 2⅜ inches wide and 3 inches high. Price £2·00 including post & pkg.

230-250 VOLT A.C. SOLENOID

(Similar in appearance to above Illustration.) Approx. 1½ lb. pull. Size of feet 1⅜ × 1 1/16. Price 85p incl. post. Manufactured by Westool Ltd.

36 volt 30 amp. A.C. or D.C. Variable L.T. Supply Unit



Input 220/240 v. A.C., Output Continuously variable 0-36 v. A.C./D.C. Fully isolated. Fitted in robust metal case with Voltmeter, Ammeter, Panel Indicator and chrome handles. Input and Output fully fused. Ideally suited for Lab. or Industrial use. £58 plus £2 p. & c.

230V/240V COMPACT SYNCHRONOUS GEARED MOTORS

Manufactured by either Sangamo, Haydon or Smith. Built-in gearbox.

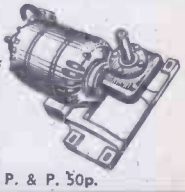
1 rev. per hour.	Clockwise rotation.
1 rev. per hour.	Anti-clockwise rotation.
2 revs. per hour.	Clockwise rotation.
3 revs. per hour.	Anti-clockwise rotation.
5 revs. per hour.	Anti-clockwise rotation.
15 revs. per hour.	Anti-clockwise rotation.
60 revs. per hour.	1 rev per minute clockwise

Fraction of makers' price. All at 75p incl. P. & P.

12 VOLT DC MOTOR

Powerful 12 volt 1 amp REVERSIBLE motor. Speed 3,750 rpm. Complete with external gear train (removable) giving final speed of 125 RPM. Size 4½in. × 2½in. dia. Price inc. post 95p.

PARVALUX TYPES DI9 230/250 VOLT AC REVERSIBLE GEARED MOTORS



30 r.p.m. 40 lb. ins. Position of drive spindle adjustable to 3 different angles. Mounted on substantial cast aluminium base. Ex-equipment. Tested and in first-class running order. A really powerful motor offered at a fraction of maker's price. £6·30, P. & P. 50p.

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SPECIAL OFFER RADIO SPARES MULTI-TAPPED L.T. TRANSFORMERS
Pri. 200, 220, 240v. Sec. provides all voltages from 1-40v., 90 watts. Separate taps are as follows: 1v. 9a., 2v. 9a., 2v. 9a., 5v. 9a., 10v. 4·5a., 10v. 3a., 10v. 3a. Fully enclosed. Table top connections. Size 4¼ × 4¼ × 3¼ ins. £4·50. P. & P. 25p.

GARDNERS HEAVY V DUTY HT TRANSFORMERS
Pri. 110-220-240v. Sec. 255-0-6a. Conservatively rated. 'C' core Table top connections. Size 10 × 8 × 7 in. £12·75. Carr. £1·50.

T.E.C. 240-110v. ISOLATION TRANSFORMERS
Pri Tapped 10. 0. 200. 220. 240v. sec. Tapped 110-112·5-115v. Conservatively rated at 9 amps. Tropicalised open frame type. Terminal Board connections. Size 9 × 9 × 7 ins. Weight 60 lbs. £15·00. Carr. 90p.

Gardners Pri 200-220 240v. ES Sec. tapped 100-110-120v. Conservatively rated at 2·8 amps. "C" core. £7·75. Carr. 75p.

HEAVY DUTY LT TRANSFORMERS
By famous maker. Fully Tropicalised. Pri tapped 100, 110, 120, 200, 220, 240v. E.S. Three Separate Secondaries 27v. 9a., 9v. 9a., 3v. 9a. Plus 17-0-17v. 0·25a and 17v. 0·25a. Table Top Connections. £4·00. Carr. 50p.

PARMEKO "C" CORE TRANSFORMERS
Pri. tapped 110-200-240v. Sec. 1 250v. 197 m/a. Sec. 2 161v. 110 m/a. Sec. 3 152v. 76 m/a. Sec. 4 124v. 25 m/a. Sec. 5 28v. 0·4a. Sec. 6 6·4v. 6·2a. 6·3v. 3·25a. 6·3v. 1·4a. Table top connections. Size 5 × 4 × 4 ins. Brand new boxed. £1·75. P. & P. 45p.

REDCLIFFE 'C' CORE TRANSFORMERS
All Primaries tapped 200-220-240v. Table top connections. Sec. 130v., 450 m/a. Three times. £4·25. P. & P. 40p. 11-0-11v., 176 m/a. 75p. P. & P. 20p. 22v., 0·9a. and 21v., 60 m/a. 75p. P. & P. 25p. 370-390-410v., 6 m/a. 50p. P. & P. 20p. 28-8-0-28-8v., 150 m/a. 90p. P. & P. 25p. 128-0-128v., 20 m/a. 90p. P. & P. 25p. 45v. 25 m/a. and 1v., 0·5a. 50p. P. & P. 20p. 23·5v., 0·1a. twice. 75p. P. & P. 20p. 6·3v., 10·6a. Conservatively rated. £1·75. P. & P. 25p. 20-24-28-32-36-40v., 250 m/a. Twice. £1·50. P. & P. 30p. 90-0-90v., 100 m/a. 75p. P. & P. 20p.

GRESHAM HEAVY DUTY HT CHOKES
10H 300m/a DC. Conservatively rated. DC Res 50Ω. Size H 7¼ × 5¼ × 5¼ ins. Weight 18¼ lbs. Open type. Table top connections, £3·50. Carr. 75p. Oil-filled potted types. 15H 300 m/a. 60Ω. £3·75. Carr. 75p. 15H 180 m/a. 200Ω. £2·25. P. & P. 50p. 10H 180 m/a. 130Ω. £1·50. P. & P. 40p. 10H m/a, £1·25. P. & P. 40p.

GRESHAM HT TRANSFORMERS
Pri. 200-240v. Sec. 250-0-250v. 100 m/a. 6·3v. 3a., 6·3v. 3a., 5v. 3a. Potted type, £2·50. P. & P. 40p. Pri. 200-240v. Sec. 495v. 83 m/a. 6·3v. 4·35a., 6·3v. 1·8a., 6·3v. 1·6a., 6·3v. 0·9a., 6·3v. 0·5a., 5v. 2·8a., 5v. 2·8a. Oil-filled, £3·00. P. & P. 50p.

PARMEKO E.H.T. TRANSFORMERS
Pri. 110, 220, 230, 250v. Sec. 1000-0-1000v. 122 m/a. Potted type, £3·75. P. & P. 50p. Ignition transformers. Pri. 240v. Sec. 10,000v. 20m/a. Cont. mid point of sec. Earthed to case. Enclosed in metal case. Size 5 × 4¼ × 4¼ ins. Weight 11 lbs. £4·50. P. & P. 75p.

Samson's
(ELECTRONICS) LTD.

9 & 10 CHAPEL ST., LONDON, N.W.1
01-723-7851 01-262-5125

CURRENT RANGE OF BRAND NEW L.T. TRANSFORMERS. FULLY SHROUDED (*excepted) TERMINAL BLOCK CONNECTIONS. ALL PRIMARIES 220/240v

No.	Sec. Taps	Amps	Price	Carr.
1A	25–33–40–50	15	£10·50	65p
1B	25–33–40–50	10	£7·75	50p
1C	25–33–40–50	6	£6·75	50p
1D	25–33–40–50	3	£4·00	40p
2A	4–16–24–32	12	£7·25	45p
2B	4–16–24–32	8	£5·50	45p
2C	4–16–24–32	4	£3·75	40p
2D	4–16–24–32	2	£2·50	30p
3A*	25–30–35	40	£16·50	75p
3B*	25–30–35	20	£10·25	65p
3C	25–30–35	10	£7·25	60p
3D	25–30–35	5	£4·25	45p
3E	25–30–35	2	£3·25	45p
4A*	12–20–24	30	£13·00	75p
4B	12–20–24	20	£8·25	50p
4C	12–20–24	10	£4·50	50p
4D	12–20–24	5	£3·75	45p
5A	3–12–18..	30	£9·75	45p
5B	3–12–18..	20	£7·25	50p
5C	3–12–18..	10	£4·50	45p
5D	3–12–18..	5	£3·00	40p
6A	48–56–60	2	£3·75	40p
6B	48–56–60	1	£2·75	35p
7A*	6–12	50	£10·50	55p
7B	6–12	20	£6·25	45p
7C	6–12	10	£3·75	35p
7D	6–12	5	£2·75	35p
8A	12–24	1	£1·75	35p
9A	17–32	8	£6·25	35p
10A*	9–15	2	£1·50	35p
11A	6·3	15	£2·50	35p
12A	30–25–0–25–30	2	£3·75	35p
13A	36	45	£16·50	75p

Note: By using the intermediate taps many other voltages can be obtained.
Example: No. 1 .. 7–8–10–15–17–25–33–40–50v.
No. 2 .. 4–8–12–16–20–24–32v.
No. 5 .. 3–6–9–12–15–18v.

AUTO TRANSFORMERS
240v.-110v. or 100v. Completely Shrouded fitted with Two-pin American Sockets or terminal blocks. Please state which type required.

Type	Watts	Approx. Weight	Price	Carr.
1	80	2¼ lb.	£2·00	30p
2	150	4 lb.	£2·75	35p
3	300	6¼ lb.	£3·75	35p
4	500	8¾ lb.	£5·25	45p
5	1000	15 lb.	£7·25	50p
6	1500	25 lb.	£9·75	55p
7*	1750	28 lb.	£14·75	75p
8*	2250	30 lb.	£17·85	75p

* Completely enclosed in beautifully finished metal case fitted with two 2-pin American sockets, neon indicator, on/off switch, and carrying handle.

EXIDE GLASS ACCUMULATORS
10 Volt. 5 A.H. Size: Height 5 × 7 × 2½ ins. Supplied brand new with charging instructions. Ideal for Emergency Lighting Alarm Systems, etc. £1·75 for Two, packed in original maker's cartons. P. & P. 65p. One £1·00 P. & P. 40p.

AMERICAN WILLARD
Miniature accumulators 6v. 1·2 A.H. Size ¾ × 1¼ × 4 in. Wt. 5½ oz. These batteries were designed for meteorological balloon transmitters. Easily filled with a hypodermic syringe. Self sealing. 37p. P. & P. 10p.

SCOTCH MAGNETIC TAPE
Type 3M 459 ¼ in. 3,600 feet. Supplied new in makers cartons. Fraction of makers price. £3·75. P. & P. 40p.

HAYDON SYNCHRONOUS MOTORS
1 r.p.m. AC. 240v. 5 watts. Clockwise direction spindle. Length ⅞ in. × ¼ in. diameter. Overall size 2½ × 2 × 1⅛ ins. 87½p. P. & P. 12½p.

NEWMARK SYNCHRONOUS MOTORS
220-240v. 50 cycles, 3 watts 8 r.p.m. Overall size 2 × 2 × 2 in. 50p. P.P. 10p.,

VENNER SYNCHRONOUS BIO-DIRECTIONAL MOTORS
220-240v. 50 cycles 40 r.p.m. automatically reverses wherever spindle stop is placed. Overall size 2½ x 2 x 1 in. Spindle length ½ in. dia. 1/16th. An ideal motor for display, giving a forward and reverse motion. 60p. P.P. 15p.

LOW TENSION SMOOTHING CHOKES
By Redcliffe. 100MH. 2 amps. £2·50. P. & P. 45p. Swinging Types. 10MH. 6·5 amp-50MH. 2 amps. £2·25. P. & P. 45p. Both types less than ½ ohm res. Hermetically sealed. Oil filled. Brand new. In makers cartons. Parmeko 0·13H. 1·15amps. Less than ½ ohm. Res. £1·25. P. & P. 25p.

ADVANCED COMPONENTS CONSTANT VOLTAGE TRANSFORMERS
Input 190-260v. Output 230v. 75 watts. Type CV 75J. £6·50. P. & P. 50p. Type CV 45/95. Input 95-130v., 190-260v. Output 4v. rms-+ or —1%. 3 watts. Open frame type. £1·25. P. & P. 25p.

GARDNERS CHOKES
100H. 20 m/a., 50p. P.P. 20p. 20H. 80 m/a., 50p. P.P. 20p. 20H. 40 m/a., 37½p. P.P. 15p. 10H. 75 m/a., 37½p. P.P. 15p. PARMEKO. Neptune Series. 10H. 130 m/a., £1. P.P. 40p. 15H. 75 m/a., 50p. P.P. 20p. 0·7H. 450 m/a., 75p. P.P. 40p. 5H. 50 m/a., 50p. P.P. 20p. 50H. 25 m/a., 50p. P.P. 20p. 12H. 200 m/a., £1·75. P.P. 45p. PARTRIDGE. 5H. 250 m/a., £1·25. P.P. 40p. SWINGING TYPE CHOKES. 34H. 60 m/a.-70H. 35 m/a., 2·5Kv. D.C. wk g., £1·25. P.P. 40p.

GARDNERS AUTO TRANSFORMERS
Tapped 0·200, 210, 220, 230, 240, 250v. 600 watts. Open frame type table top connections. £2. P. & P. 00p.

MARCONI SIGNAL GENERATOR TYPE TF-144G: Freq. 85 Kc/s-25Mc/s in 8 ranges. Incremental: ± 1% at 1Mc/s. Output: continuously variable 1 microvolt to 1 volt. Output Impedance: 1 microvolt to 100 millivolts, 10 ohms 100mV - 1 volt - 52.5 ohms. Internal Modulation: 400c/s sinewave 75% depth. External Modulation: Direct or via internal amplifier. A.C. mains 200/250V, 40-100c/s. Consumption approx. 40 watts. Measurements 29 × 12¼ × 10 in. New condition. **£45** each, Second hand condition £27·50 each, Carr. £1·50.

MARCONI SIGNAL GENERATOR TYPE TF-144H/S: Frequency Range 10Kc/s-72Mc/s. RF Output 2μV-2V at 50Ω. Int. Mod. 400 and 1000c/s. Excellent condition with Manuals. £200·00 each. Carr. £2.

MARCONI UNIVERSAL BRIDGE TF-866A and TF-868: £75·00 each, Carr. £2.

TELEPRINTER CREED TYPE 7B: "as new" condition, in original packing case, **£25·00** each. Second-hand condition (excellent order), no parts broken, **£15·00** each. Carriage both types £2.

FOR EXPORT ONLY

BRITISH & AMERICAN COMMUNICATION EQUIPMENT

VRC.19X Trans-ceiver, 150-170Mc/s, 2 Channel, 20 Watts, Output 12/24V d.c. operation. General Electric Transmitter, 410-419Mc/s, thin line tropo scatter system, with antennae. W.S. Type 88, Crystal controlled, 40-48 Mc/s. W.S. Type HF-156, Mk. II, Crystal controlled, 2.5-7.5 Mc/s. W.S. Type 62, tunable, 1.5-12 Mc/s. C.44, Mk. II, Radio Telephone, Single Channel, 70-85 Mc/s, 50 watts, output, 230V. a.c. input. G.E.C. Progress Line Tx Type DO36, 144-174 Mc/s, 50 watt, narrow band width. A.C. input 115V. BC-640 Tx, 100-156 Mc/s, 50 watt output, 110V or 230V input. STC Tx/Rx Type 9X, TR1985; RT1986; TR1987 and TR1998, 100-156 Mc/s. TRC-1 Tx/Rx, Types T.14 and R.19; FM 60-90 Mc/s. With associated equipment available. Redifon GR410 Tx/Rx, SSB, 1.5-20 Mc/s. Sun-Air Tx/Rx Type T-10-R. Collins Tx/Rx/Type 18S4A. Collins Tx/Rx Type ARC-27, 200-400 Mc/s, 28V d.c. With associated equipment available. ARC-5; ARC-3; and ARC-2 Tx/Rx. BC-375; 433G; 348; 718; 458; 455 Tx/Rx. Directional Finding Equipment CRD.6 and FRD.2 complete Sets available and spares. Complete system with full set of Manuals.

FREQUENCY METER BC-221: 125-20,000 Kc/s, complete with original calibration charts. Checked out, working order **£18·50** + £1 carr.; OR BC-221 (as received from Ministry), good condition, less charts, £8·50 + £1 Carr.

RACK CABINETS: (totally enclosed) for Std. 19 in. Panels. Size 6 ft. high × 21 in. wide × 16 in. deep, with rear door. **£12** each, £2·50 Carr. OR 4 ft. high × 23 in. wide × 19 in. deep, with rear door. **£8·50** each, £2 Carr.

RECEIVER BC-348: Operates from 24V d.c. Freq. Range 200-500 Kc/s, 1·5-18Mc/s. Secondhand **£20** each, £1 Carr.

APR-9 SEARCH RECEIVER: Complete with two Tuning Units TN128, 1000-2600Mc/s, and TN129 2300-4450Mc/s. **£250·00** each.

APR-5 UHF RECEIVER: 1000-6000Mc/s, 115V a.c. Circuit. Oscillator, 6 IF Stages, Detector, Video Amplifier and Audio Amplifier. **£120·00** each, Carr. £2.

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USM-24C OSCILLOSCOPE: 3 in. oscilloscope with 2c/s to 10Mc/s vertical response, and 8c/s to 800Kc/s horizontal response. Sensitivity 50 mv. rms/inch. Triggered sweep, built-in trigger pulses and markers. Mains input 115V, 50c/s. Complete with all leads, probes and circuit diagram. **£42·50** each, carr. £2.

OS-46/U OSCILLOSCOPE: A general purpose oscilloscope suitable for measuring signals from 0-1000V d.c. to over 50,000 c.p.s. (Further details on request, S.A.E.) **£35** each, carr. £1·50.

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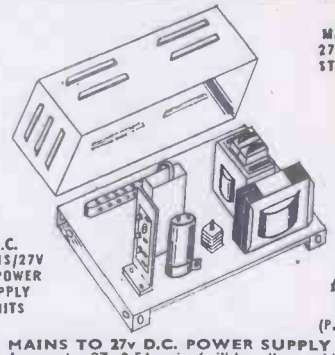

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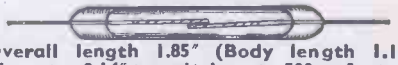

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E88CC	40p	EF89	40p	EZ882	27½p	PCL85	52½p	U50	30p	5U4G	30p	6BX6	25p	6J4	47½p	10F9	50p	25C5	45p	807	47½p
EL30L	£4·50	EF91	42½p	EZ40	45p	PCL86	51p	U52	30p	5U4GB	37½p	6BZ6	32½p	6J5GT	30p	10F18	40p	25L6GT	37½p	811A	£1·50
E180F	95p	EF92	50p	EZ41	45p	PD500	£1·52½	U76	25p	5V4G	40p	6C4	30p	6J7	42½p	10L1	40p	2524G	30p	812A	£3·25
EABC80	52½p	EF93	47½p	EZ80	27½p	PFL200	74p	U78	25p	5Y3GT	30p	6C5GT	35p	6K6GT	50p	10LD11	55p	25Z6GT	50p	813	£3·75
EBC41	47½p	EF183	56p	GS10C	£5·00	PL36	64p	U191	75p	5Z3	45p	6CD6G	£1·40	6K7	32½p	10P13	55p	30A5	40p	866A	70p
EBC81	32½p	EF184	35p	GY501	80p	PL38	90p	U193	41p	524GT	40p	6CA4	27½p	6K8G	30p	10P14	£1·00	30AE3	40p	5642	80p
EBC90	47½p	E280F	£2·10	GZ30	37½p	PL81	51p	U201	35p	6/30L2	75p	6CA7	52½p	6K23	50p	12AB5	50p	30C15	75p	6080	£1·37½
EBF80	40p	EF800	£1·00	GZ31	30p	PL81A	62½p	U281	40p	6AB4	32½p	6CBC	27½p	6K25	75p	12AC6	37½p	30C17	80p	6146	£1·50
EBF83	40p	EF804	£1·00	GZ32	47½p	PL82	36p	U282	40p	6AF4A	47½p	6CD6GA	£1·15	646GT	45p	12AD6	37½p	30C18	75p	6146B	£2·37½
EBF89	40p	EF811	75p	GZ33	37½p	PL83	51p	U403	50p	6AG7	37½p	6CG7	45p	6L7	32½p	12AE5	40p	30F5	85p	6267	32½p
EB91	26p	EL34	52½p	GZ34	55p	PL504	85p	U404	37½p	6AH6	50p	6CH6	55p	6L18	30p	12AQ5	40p	30FL1	75p	6360	£1·25
EC53	50p	EL36	47½p	HK90	32½p	PL505	£1·45	U801	£1·00	6AJ8	29p	6CL6	50p	6LD20	32½p	12AT6	25p	30FL2	92½p	6939	£2·10
EC86	60p	EL41	55p	HL92	35p	PL508	£1·00	UABC80	52½p	6AK5	30p	6CW4	62½p	6N7GT	35p	12AU6	75p	30FL13	50p	7199	75p
EC88	60p	EL42	57½p	HL94	40p	PL509	£1·54	UBF89	40p	6AK6	57½p	6CY5	40p	6P1	60p	12AV6	30p	30FL14	77½p	7360	£1·80
EC90	30p	EL81	50p	KT66	£1·37½	PL802	86p	UBC41	49p	6AL3	42½p	6CY7	60p	6P25	£1·05	12AV7	45p	30L1	45p	7586	£1·25
EC92	32½p	EL83	41p	KT88	£1·66	PL805	86p	UCC85	46p	6AL5	16p	6D3	40p	6P28	61½p	12AX7	30p	30L15	85p	9002	32½p
EC93	47½p	EL85	42½p	N78	£1·05	PY33	62½p	UCH42	69p	6AM5	25p	6DC6	67½p	6Q7	37½p	12AY7	67½p	30L17	85p	9003	50p
ECC81	40p	EL86	42½p	PABC80	40p	PY80	32½p	UCH81	54p	6AM6	22½p	6DQ6B	60p	6S4	40p	12BA6	32½p	30P12	80p		
ECC82/3	42½p	EL90	32½p	PC86/8	51p	PY81	41p	UCL82	51p	6AQ5	32½p	6D84	75p	6S4A	55p	12BA7	32½p	30P18	35p		
ECC82/3	42½p	EL91	25p	PC95	36p	PY800	41p	UCL83	61p	6AT6	32½p	6EA8	55p	6S7	37½p	12BE6	32½p	30P19	75p		
ECC84/5	42½p	EL95	35p	PC97	41p	PY801	41p	UF41/2	55p	6AU6	32½p	6EH7	32½p	6S8G7	32½p	12BH7	32½p	30PL1	77½p		
ECC88	55p	EL360	£1·15	PCC84	46p	PY82	35p	UF80/5	37½p	6AU8	55p	6EJ7	35p	6S8J7	37½p	12BY7	50p	30PL13	90p		
								UF89	41p	6AB5	32½p			6S8K7	32½p	12K5	50p	30PL14	85p		
																		35A3	50p		

CATHODE RAY TUBES

New and Budget tubes made by the leading manufacturers. Guaranteed for 2 years. In the event of failure under guarantee, replacement is made without the usual time wasting forms.

Type		New £	Budget £
MW36—20			£4·50
MW36—21			£4·50
MW43—69Z	CRM171		
	CRM172	£6·60	£4·62½
MW43—80Z	CRM173	£6·60	£4·62½
AW43—80Z	CME1702	£6·60	£4·62½
	CME1703	£6·60	£4·62½
	CME1706	£6·60	£4·62½
	C17AA	£6·60	£4·62½
	C17AF	£6·60	£4·62½
AW43—88	CME1705	£6·60	£4·62½
AW47—90			
AW47—91	A47 14W	£5·95	£4·87
A47 14W	CME1901	£5·95	£4·87
	CME1902	£5·95	£4·87
	CME1903	£5·95	£4·87
	C19AH	£5·95	£4·87
A47—11W	CME1905	£8·86½	£7·00
A47—13W	CME1906	£10·27½	£8·50
A47—26W	CME1905	£8·86½	£7·75
A47—26W/R	CME1913R	£9·33½	

Type		New £	Budget £
A50—120W/R	CME2013	£10·85	
AW53—80		£8·93½	£6·25
AW53—88	CME2101	£8·93½	£6·25
AW59—90			
AW59—91	CME2303	£9·58½	£7·20
A59—15W	CME2301		
	CME2303		
	CME2303	£9·58½	£7·20
A59—11W	CME2305		
A59—13W	CME2306	£13·65	£10·97½
A59—16W	CME2306	£13·65	£10·97½
A59—23W	CME2305	£12·60	£10·50
A59—23W/R		£12·60	£10·50
A61—120W/R	CME2413	£13·50	£11·50
A65—11W	CME2501	£16·50	£14·50

COLOUR TUBES

A49—191X	19 inch	£52·50
A56—120X	22 inch	£57·50
A63—11X	25 inch	£62·50

PORTABLE SET TUBES

T8D217	£11·50	
T8D282	£11·50	
A28—14W	£9·16½	
		Not supplied
CME1601	£7·75	
CME1602	£8·00	

TRANSISTORISED UHF TUNER UNITS NEW AND GUARANTEED FOR 3 MONTHS

Complete with Aerial Socket and wires for Radio and Allied TV sets but can be used for most makes.
Continuous Tuning, £4·50; Push Button, £5·00.

SERVICE AIDS

Switch Cleaner, 55p; Switch Cleaner with Lubricant, 55p; Freeza 62½p. P. & P. 7½p per item.

PLUGS

Jack Plugs and Sockets		Co-Axial Plugs	
Standard Plugs	19p	Belling Lee (or similar type)	6½p
Standard Sockets	12½p	Add 2p per doz. p. & p.	

LINE OUTPUT TRANSFORMERS

G.E.C.	BT454	£4·75	G.E.C.	2028	£4·75
G.E.C.	BT456	£4·75	G.E.C.	2041	£4·75
G.E.C.	2010	£4·75	G.E.C.	2000 Series	
G.E.C.	2013	£4·75	Philips	19TG	£4·75
G.E.C.	2014	£4·75	Pye	Mod. 36	£4·75
G.E.C.	2018	£4·75	Pye	Mod. 40	£4·75
G.E.C.	2043	£4·75	Thorn	800—850	£4·75
G.E.C.	2048	£4·75			

STYLII—BRITISH MANUFACTURED

All types in stock.			
Single Tip "S"	13p	Double Tip "S"	33p
Single Tip "D"	37p	Double Tip "D"	47p
"S" = Sapphire		"D" = Diamond	

A discount of 10% is also given for the purchase of 3 or more tubes at any one time. All types of tubes in stock. Carriage and insurance 75p anywhere in Britain.

SEMICONDUCTORS BRAND NEW MANUFACTURERS MARKINGS NO REMARKED DEVICES

2N388A	62½p	R.C.A.		AF106	42½p	BC142	30p	BF224	30p		
2N614	30p	40253	P.A.	AF114	25p	BC143	P.A.	BF225	30p		
2N697	20p	40398	P.A.	AF115	30p	BC147	17½p	BF257	47½p		
2N698	25p	40458	P.A.	AF116	25p	BC148	15p	BFX84	30p		
2N706	12½p	2N4061	22½p	AF117	25p	BC149	17½p	BFY19	33p		
2N706A	12½p	2N4062	22½p	AF118	60p	BC152	17½p	BFY50	22½p		
2N930	27½p	2N4286	17½p	AF119	20p	BC157	20p	BFY51	22½p		
2N1192	32½p	2N4291	17½p	AF124	22½p	BC158	17½p	BFY52	25½p		
2N1303	17½p	AC107	30p	AF125	20p	BC169B	14p	BSX21	37½p		
2N1305	22½p	AC117	60p	AF126	20p	BC169C	15p	OC25	50p		
2N1306	25p	AC126	20p	AF127	17½p	BC171	17½p	OC26	32½p		
2N1307	25p	AC127	25p	AF139	37½p	BC175	27½p	OC28	62½p		
2N1711	25p	AC128	20p	AF178	45p	BC183	22½p	OC29	75p		
2N2147	72½p	AC154	22½p	AF179	45p	BC184	22½p	OC35	40p		
2N2160	57½p	AC176	25p	AF180	52½p	BC187	28½p	OC36	62½p		
2N2614	30p	AC187	62½p	AF181	42½p	BC213L	26½p	OC42	25p		
2N2646	57½p	AC188	37½p	AF186	66½p	BCY32	37½p	OC44	20p		
2N2905	40p	ACY17	27½p	AF239	42½p	BCY58	22½p	OC45	12½p		
2N2926		ACY18	25p	ASY28	28p	BCY70	20p	OC46	15p		
Green	14p	ACY19	25p	BC107	15p	BD115	78p	OC70	15p		
Yellow	12½p	ACY20	25p	BC108	15p	BD121	65p	OC71	12½p		
Orange	12½p	ACY21	25p	BC109	15p	BD123	82½p	OC72	12½p		
2N3053	27½p	ACY22	20p	BC113	27½p	BD124	62½p	OC74	32½p		
2N3055	75p	ACY28	20p	BC114	37½p	BD131	97½p	OC75	22½p		
2N3391	20p	ACY40	20p	BC115	32½p	BD132	97½p	OC76	22½p		
2N3392	20p	ACY41	25p	BC116	82½p	BF115	25p	OC77	27½p		
2N3702	17½p	ACY44	40p	BC116A	37½p	BF117	47½p	OC78	25p		
2N3704	22½p	AD140	40p	BC117	39p	BF160	P.A.	OC81	20p		
2N3705	20p	AD142	58p	BC118	32½p	BF162	P.A.	OC81D	20p		
2N3711	20p	AD149	57½p	BC134	57½p	BF163	35p	OC83	25p		
2N3819	35p	AD150	62½p	BC135	P.A.	BF167	25p	OC84	25p		
2N3826	30p	AD161	37½p	BC136	P.A.	BF173	32½p	OC139	32½p		
2N3905	37p	AD162	37½p	BC137	P.A.	BF178	35p	OC140	32½p		
2N3914	P.A.	AF102	58p	BC138	P.A.	BF179	72½p	OC170	30p		
						BF180	35p	OC171	30p		
						BF181	32½p	OC200	32½p		
						BF184	25p	OC202	47½p		
						BF194	22½p	OCP71	42½p		
						BF195	27½p	P346A	25p		
						BF196	42½p	T1843	40p		
						BF197	31½p				
						BF198	42½p	P.A. Price on application			
						BF200	36½p				

DIODES & RECTIFIERS

IN914	7½p	BZY88		OA91	7½p
AA119	10p	(Series)	32½p	OA202	10p
BA102	22½p	OA5	12½p	BA144	12½p
BA115	7½p	OA47	7½p	BA145	20p
BA114	12½p	OA70	7½p	BA148	23p
BY100	22½p	OA79	9p	BA155	P.A.
BY126	20p	OA81	7½p	BA156	P.A.
BY127	22½p	OA90	7½p		

CARTRIDGES

	Inc. P. T. each
ACOS	
GP79	63p
GP91—18c	£1·05
GP91—28c	£1·05
GP91—38c (TC8) ..	£1·05
GP92	£1·32
GP93—1	£1·24
GP94—1	£1·55
GP94—5	£1·80
GP95	£1·24
GP96	£1·57
Acos 104 1—10 ..	£2·09
B.S.R.	
X3M .. 8/8	£1·39
X3H .. 8/8	£1·39
X5M .. 8/8	£1·39
X5H .. 8/8	£1·39
8X5M .. 8/8	£1·81
8X5H .. 8/8	£1·81
8X5M .. D/8	£2·00

	Inc. P.T. each
8X5H .. D/8	£2·00
X4N .. D/8	£1·36
GOLDRING	
850	£5·25
G800	£7·35
G800E	£15·00
G800 Super E	£19·50
RONETTE	
105 .. 8/8 ..	99p
106 .. 8/8 ..	99p
DC400 .. 8/8 ..	70p
DC4008C .. 8/8 ..	70p
105 .. D/8 ..	£1·12
106 .. D/8 ..	£1·12
DC400 .. D/8 ..	84p
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8TA .. D/8 ..	£1·25
9TA .. D/8 ..	£1·79
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600ft	5	50p
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Long Play		
210ft	3	27p
450ft	4	43p

POLYESTER Length	Spool Size in.	Price
900ft	5	70p
1200ft	5½	85p
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1200ft	5	87p
1800ft	5½	£1·10
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3in 7p
4in 9p
5in 11p
5½in 13p
7in 13p

CASSETTES
Boxed in Plastic Library Packs
C60 .. .. 53p
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P. & P. 7p on all orders.

ADD 3p PER ITEM FOR POST AND PACKING FOR ORDERS UNDER 24 PIECES.

TERMS, CASH WITH ORDER ONLY. POST AND PACKING PAYABLE ON ORDERS UP TO £6, AFTER THAT, FREE EXCEPT C.R.T.'s.

Modern **TELEPHONES** type 706. Two-tone grey and two-tone green. **£3·50** ea. P. & P. 25p ea. Brand new **£6** ea. P. & P. 25p ea.

STANDARD GPO DIAL TELEPHONES (black with internal bell. **87p.** P. & P. 25p. Two for **£1·50**) P. & P. 37p.

PHOTOMULTIPLIERS. EMI 6097X at **£8·50** ea. 6097B—**£5** ea. Type 931A—**£2·25** ea.

SPECIAL OFFER
5 in. Photomultiplier type, PDP84G by 20th Century. **£3** ea. P. & P. 30p.

TRANSISTOR OSCILLATOR. Variable frequency 40 c/s to 5 kc/s. 5 volt square wave o/p, for 6 to 12v DC input. Size 1¾ × 1¼ × 1¼in. Not encapsulated. Brand new. Boxed. **57p** ea.

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G.E.C. Sealed Relays High Speed 24V. 2m 2b—**23p** ea S.T.C. sealed 2 pole c/o, 2,500 ohms. (okay 24v) **13p** ea; 12v **35p** ea.
CARPENTERS polarised Single pole c/o 20 and 65 ohm coil as new, complete with base **37p** ea.
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Varley VP4 Plastic covers 4 pole c/o 5K—**30p** ea. 15K—**33p** ea.

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COLVERN 3 watt. Brand new. 5; 10; 25; 50; 100; 250; 500 ohms; 1; 2·5; 5; 10; 25; 50k all at **13p** ea.
MORGANITE Special Brand new. 2·5; 10; 100; 250; 500K; 2·5 meg. 1 in. sealed. **17p** ea.
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BOURNE TRIM POTS. 10; 20; 50; 100; 200; 250; 500 ohms; 1; 2.5; 5; 25K at **35p** ea.
ALMA precision resistors 100K; 400K; 497K; 998K; 1 meg—0·1% **27p** ea.; 3·25k, 13K—0·1% **20p** ea.
SILVER ZINC Non-spill. Brand new. Single cell 1.5V 4AH size 1⅛ × ⅞ × 3¼. 4oz. weight **£1** ea.

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MULLARD ELECTROLYTICS
2200MFD 100v
10A (50°C)
75p each
BRAND NEW BOXED

LARGE REDUCTION FOR QUANTITY

ERIE feed through ceramicons 2200 pf—**4p** ea.
Sub-min. **TRIMMER** ¼ square. 8, 5pf. Brand new **13p** ea.
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E.H.T. 2mfd 5KV. Brand new. **£1·50** ea.

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Size 1 × 2¼ ins.			Size 1¼ × 5¼ ins.		
0.05mfd	2·5kV	50p ea.	0·01mfd	10kV	50p ea.
0.001mfd	5kV	40p ea.	0·002mfd	18kV	65p ea.
0·001mfd	10kV	50p ea.	0·05mfd	15kV	80p ea.
			0·01mfd	15kV	80p ea.
			0·0005mfd	20kV	60p ea.
Size 2¼ × 6¼ ins.			0·1mfd	7kV	40p ea.
0·05mfd	8kV	50p ea.	0·1mfd	5kV	35p ea.

Brand new 0.25mfd 5 KV. Dubilier **50p** ea. P. & P. 15p. Rapid discharge 1mfd 5.6KV **£1** ea. P. & P. 15p.
DUBILIER. Brand new. 1 mfd 15 KVW 30KVT.. **£7** ea. Carr. **£1.**

E.H.T. TRANSFORMERS & POWER UNITS
Complete Assembly 0 to 130KV DC. Variac Controlled. **£245.**
As above, but 26KV DC 3·5KVA. **£135.**
Choice of capacitors and chokes, e.g., 400H 25MA 60KV Insulation.
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DECADE DIAL UP SWITCHES. Finger-tip. Engraved 0/9. Gold plated contacts. Size 2¼" high, 2¼" deep, ¾" wide. **75p** ea. Bank of 4 with escutcheon plates, etc., 2¼" high, 2¼" deep, 2¼" wide. **£2·50.**
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MARCONI TF888 SIGNAL GENERATOR.
Freq. 70 kc/s-70 mc/s in 8 ranges Directly read. 500 kc/s-5 mc/s Crystal Calibrator. 1 kc/s Internal modulation available on terminals as external audio. Built-in power meter 3 to 600 ohms and 10 mw to 1 watt. Large rectangular meter scaled for RF and Power. 50 ohm, 80 ohm and high level OP sufficient for lining, etc., available on termination unit. Attenuator calibrated to 0·5 micro volt. Size 14 × 10 × 5½ ins. Mains or battery operated. Supplied Brand New in original crates at **£30** each. Carriage £1·50.

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All carefully checked and tested. Carriage £1·50 extra.

MARCONI
Noise gen. TF1301, **£40.** Carr. £1·50.
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Stabilised P.U. SRS 151A. **£15.** Carr. £1·50.
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AVO
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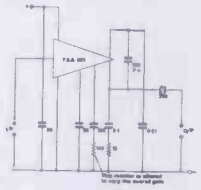

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1R5	0·35	6AN8	0·50	6DQ6B	0·63	6SR7	0·40	12BA6	0·35	30PL1	0·70	833A	17·00	DAF96	0·42	EBC81	0·30	EF86	0·30	EY86	0·40	MH4	0·50
1S4	0·27	6AQ5	0·35	6DS4	0·75	6S87	0·20	12BA7	0·35	30PL13	0·93	837	0·85	DC90	0·45	EBC90	0·30	EF89	0·28	EY87	0·43	ML4	0·45
1S5	0·25	6AQ6	0·55	6E5	0·55	6T8	0·35	12BE6	0·35	30PL14	0·90	866A	0·75	DF91	0·25	EBC91	0·30	EF91	0·33	EY88	0·43	ML6	0·40
1T4	0·25	6AR5	0·35	6EA8	0·58	6U4GT	0·60	12BH7	0·40	35B5	0·65	872A	3·00	DF92	0·20	EBF80	0·40	EF92	0·40	EZ35	0·35	MSPEN/T	
1T5GT	0·45	6AR6	0·40	6EH7	0·30	6U8A	0·40	12BY7	0·55	35C5	0·40	884	0·60	DF96	0·42	EBF83	0·40	EF93	0·25	EZ40	0·45		0·50
1U4	0·27	6AR11	1·25	6EJ7	0·35	6V6GT	0·38	12C8	0·35	35D5	0·70	927	3·00	DH76	0·35	EBF89	0·30	EF94	0·25	EZ41	0·45	MT17	4·50
1U5	0·50	6AS5	0·35	6F5	0·50	6X4	0·30	12E1	1·35	35L6GT	0·50			DH81	0·60	EBL1	0·75	EF95	0·30	EZ80	0·25	MU12/14	
1V2	0·45	6AS6	0·37	6F6G	0·30	6X5GT	0·35	12E14	3·57	35W4	0·30	931A	3·50	DH101	0·55	FBL31	1·50	EF96	0·22	EZ81	0·28		0·60
1X2B	0·40	6AS7G	0·80	6F11	0·38	6X8	0·55	12H6	0·30	35Z3	0·60	955	0·25	DK40	0·55	EC53	0·50	EF97	0·65	EZ90	0·30	N78	1·45
2AP1	2·25	6AT6	0·30	6F13	0·38	6Y6G	0·65	12J5GT	0·25	35Z4G	0·30	4378	1·40	DK91	0·35	EC86	0·60	EF98	0·65	FG17	4·50	N8P1	3·50
2C26A	0·50	6AU5GTA		6F14	0·65	6Z4	0·35	12J7GT	0·45	35Z5GT	0·40	4687	1·75	DK92	0·50	EC88	0·60	EF183	0·30	FW4/500		NSP2	4·00
2C40	3·50		1·15	6F15	0·65	7B5	0·75	12K5	0·55	42	0·50	5544	6·50	DL66	1·25	EC90	0·33	EF184	0·35		0·75	PABC80	
2C51	0·45	6AU6	0·25	6F17	0·50	7B6	0·70	12K7GT		50A5	0·70	5551A	18·00	DL68	0·65	EC92	0·35	EF800	1·00	FW4/800			0·40
2CW4	0·65	6AV5GTA		6F18	0·45	7B7	0·45		0·35	50B5	0·45	5553A	40·00	DL69	1·75	EC93	0·50	EF804	1·25		0·75	PC86	0·60
2D21	0·35		0·70	6F22	0·30	7F8W	0·85	12K8	0·50	50C5	0·40	5654	0·40	DL91	0·27	EC8010	2·25	EF811	0·75	GC10B	3·75	PC88	0·60
2E24	2·55	6AV6	0·30	6F23	0·80	7S7	1.25	50CD6G		5670	0·50	DL92	0·35	ECC34	0·40	EF812	0·80	GN4	1·50	PC900	0·48
2K25	8·00	6AW8A	0·55	6F24	0·75	7Y4	0·60	12Q7G	0·30		1·65	5751	0·60	DL93	0·35	ECC40	0·60	EF814	0·75	GR10M	1·50	PC84	0·40
2X2	0·37	6AX4GTB		6F25	0·75	7Z4	0·50	12SC7	0·35	50EH5	0·60	5763	0·70	DL94	0·45	ECC70	0·85	EH90	0·40	GS10C	5·00	PC85	0·40
3A4	0·35		0·45	6F28	0·60	9BW6	0·50	12SG7	0·35	50L6GT	0·50	5796	14·00	DL95	0·40	ECC81	0·33	EK32	0·45	GS10D	5·75	PC88	0·55
3B28	2·15	6AX5GT		6GK6	0·60	10C2	0·50	12SH7	0·30	52KU	0·40	5814A	0·50	DL96	0·42	ECC82	0·30	EK90	0·30	GS10E	3·10	PCC89	0·50
3BP1	2·75		0·65	6H6	0·23	10D1	0·50	12SJ7	0·30	53KU	0·70	5894	5·50	DY86	0·38	ECC83	0·30	EL5	0·55	GS10F	7·00	PCC189	0·55
3D6	0·20	6B4G	1·00	6J4	0·50	10D2	0·40	12SK7	0·45	75B1	0·50	6072	0·85	DY87	0·35	ECC84	0·30	EL33	1·25	GS12D	7·00	PCC805	0·85
3D21A	2·00	6B7	0·40	6J5GT	0·30	10F1	0·90	12SQ7	0·50	75C1	0·45	6080	1·50	DY802	0·50	ECC85	0·40	EL34	0·50	GS47X	3·00	PCC806	0·80
3Q4	0·40	6B8G	0·20	6J6	0·20	10F9	0·50	12SR7	0·35	80	0·50	6146	1·50	E35L	2·75	ECC88	0·40	EL36	0·50	GU50	1·75	PCE800	0·70
3Q5GT	0·45	6BA6	0·25	6J7	0·45	10F18	0·45	12SW7	0·35	83	1·10	6146A	2·00	E80CC	1·10	ECC89	0·50	GY501	0·80	GZ30	0·40	PCF80	0·30
3S4	0·35	6BE6	0·30	6K6GT	0·55	10L1	0·45	12X4	0·45	85A2	0·40	6146B	2·50	E80CF	1·50	ECC91	0·20	EL41	0·55	GZ31	0·33	PCF82	0·35
3V4	0·45	6BF5	0·80	6K7	0·35	10LD11	0·60	14S7	0·80	85A3	0·50	6293	3·25	E80L	0·95	ECC189	0·60	EL42	0·58	GZ32	0·48	PCF84	0·50
4-250A		6BH6	0·45	6K8G	0·35	10P13	0·55	20CV	3·15	90AG	2·40	6360	1·25	E81L	1·15	ECC807	1·20	EL81	0·55	GZ33	0·70	PCF86	0·60
	13·00	6BJ6	0·45	6K8GT	0·50	10P14	1·10	20D1	0·45	90AV	2·50	6939	2·15	E83F	1·10	ECF80	0·35	EL83	0·42	GZ34	0·60	PCF87	0·85
4-400A		6BK4B	1·20	6K23	0·55	11D3	0·45	20L1	1·10	90CM	0·60	7199	0·75	E84L	0·50	ECF82	0·35	EL84	0·25	HABC80		PCF800	0·80
	16·00	6BK7A	0·55	6L7	0·40	11D5	0·45	20P1	0·50	90CG	1·25	7586	1·25	E86C	0·90	ECF86	0·65	EL85	0·43		0·45	PCF801	0·50
4B32	4·00	6BL6	18·00	6L18	0·45	11E2	2·50	20P3	0·60	90CV	1·25	7591A	1·00	E88C	1·15	ECF804	1·50	EL86	0·40	HBC90	0·30	PCF802	0·50
4HA5	0·48	6BK7A	0·55	6L7GTA		11E3	4·00	20P4	1·10	108C1	0·35	7895	1·25	E88CC	0·65	ECH42	0·70	EL90	0·35	HBC91	0·33	PCF805	0·75
4THA	0·45	6BL6	18·00	6LD20	0·40	12AB5	0·60	20P5	1·20	150B2	0·60	9002	0·35	E88CC/01		ECH81	0·30	EL91	0·32	HF93	0·35	PCF806	0·70
5AR4	0·60	6BL7GTA		6N7GT	0·40	12AC6	0·40	25L6GT	0·45	150B3	0·60	9003	0·50		1·90	ECH83	0·40	EL95	0·35	HF94	0·30	PCF808	0·75
5B/254M			0·65	6P1	0·60	12AD6	0·55	25Z4G	0·30	150C4	0·60	A1834	0·80	E90CC	0·45	ECH84	0·45	EL821	0·55	HK90	0·35	PCH200	
	2·25	6BN6	0·40	6P28	0·65	12AE6	0·45	25Z6GT	0·65	305	0·65	A2293	1·35	E91H	0·60	ECL80	0·40	EL822	0·90	HL23	0·40		0·70
5CP1	5·00	6BQ5	0·25	6Q7	0·40	12AH7GT		30A5	0·45	310A	1·50	AC/HL/DD		E182CC	1·20	E180F	0·95	EL83	0·45	HL23DD		PCL81	0·50
5D21	5·00	6BQ6GTB		6R7G	0·45		0·30	30AE3	0·40	311A	2·00	AC/TH1		E186F	1·25	E188CC	0·90	EL84	0·45		0·40	PCL82	0·35
5R4GY	0·60		0·65	6R8G	0·40	12AL5	0·45	30C1	0·80	328A	2·00		0·45	E280F	2·10	E810F	2·90	EL84	0·55	HL92	0·40	PCL83	0·65
5U4G	0·33	6BQ7A	0·40	6S2	0·40	12AQ5	0·43	30C15	0·80	329	1·15	AX50	2·25	EA50	0·20	ECL85	0·55	EM84	0·35	HL94	0·45	PCL84	0·45
5V4G	0·42	6BR7	0·85	6S4A	0·60	12AT6	0·30	30C17	0·85	329A	1·90	AZ31	0·55					EM85	1·00			PCL85	0·40
5W4GT	0·40	6BR8	0·65	6S7A	0·40																	PCL86	0·45

	£		£		£
PCL88	0·90	QY4-400A		UF43	0·60
PCL800	0·93		16·00	UF80	0·35
PCL801	0·70	R10	1·00	UF85	0·40
PCL805	0·50	R18	0·55	UF89	0·35
PD500	1·50	RG3-250A		UL41	0·65
PEN4DD			0·75	UL84	0·30
	0·50	RL18	0·50	UM4	0·40
PEN36C		S130	1·75	UM84	0·20
	0·70	S130P	1·75	UU5	0·60
PEN45	0·40	SP2	0·50	UU8	0·60
PEN45DD		SP4	0·50	UY1N	0·50
	0·75	SP41	0·45	UY11	0·65
PEN46	0·40	SP61	0·55	UY41	0·45
PEN383		TP22	0·60	UY82	0·50
	0·55	TP25	0·40	UY85	0·30
PEN384		TT21	2·65	VL8631	1·90
	0·60	TT22	2·80	VP41	0·75
PEN453DD		TY2-125		VP133	1·00
	0·60		10·00	VR75/30	
PF86	0·60	U17	0·75		0·45
PF818	0·85	U18/20	0·75	VR105/30	
PFL200	0·70	U19	2·80		0·38
PL33	0·35	U20	0·75	VR150/30	
PL36	0·55	U25	0·75		0·35
PL81	0·50	U26	0·75	VU33	0·60
PL82	0·45	U31	0·45	VU39A	0·60
PL83	0·45	U37	1·50	VU111	0·60
PL84	0·40	U50	0·32	VU120	0·80
PL302	0·80	U52	0·33	VU133	0·60
PL504	0·80	U76	0·30	VU139	0·60
PL508	0·90	U78	0·30	W107	0·50
PL509	1·30	U191	0·75	W729	0·60
PL801	0·80	U201	0·35	X65	0·55
PL802	0·75	U281	0·40	X66	0·55
PLL80	0·55	U282	0·40	X76M	0·50
PM84	0·50	U301	0·40	XC11	0·75
PX25	2·00	U403	0·50	XC12	0·35
PY31	0·30	U404	0·40	XC12T	0·40
PY33	0·63	U801	1·00	XC15	0·25
PY80	0·35	UABC80		XC15T	0·40
PY81	0·30		0·35	XC16	0·50
PY82	0·30	UAF41	0·50	XC23	0·90
PY83	0·38	UAF42	0·55	XC25	0·35
PY88	0·40	UB41	0·60	XR1-1600	
PY500	1·00	UBC41	0·50		14·00
PY800	0·50	UBC81	0·40	XR1-3200	
PY801	0·50	UBF80	0·40		6·50
PZ30	0·35	UBF89	0·35	Z329	0·85
QQV02-6		UBL1	0·50	Z700U	0·40
	2·15	UBL21	0·60	Z700W	0·75
QQV03-10		UC92	0·35	Z719	0·25
	1·25	UCC85	0·40	Z729	0·30
QQV03-20A		UCF80	0·55	Z749	0·80
	5·25	UCH21	0·60	Z759	1·85
QQV06-40A		UCH42	0·70	Z800U	1·75
	5·50	UCH43	0·75	Z801U	1·75
Q883/3	0·40	UCH81	0·35	Z900T	0·75
QU37	2·00	UCL81	0·60		
QV03-12		UCL82	0·35		
	0·70	UCL83	0·60		
QY3-125		UF9	0·60		
	9·00	UF11	0·50		
QY4-250A		UF41	0·60		
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Apply, naming two referaes, to the Head of Department.

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Experienced Test Engineers are invited to write to Redifon with regard to vacancies in our Test Department at Wandsworth.

The salary range for these positions is £1,248–£1,749 plus. The Company is engaged in the design and manufacture of a wide range of radio communications and allied equipment from military pack-set to broadcast transmitter, including communications receivers, M.F. beacons, teleprinter terminals, complete radio office installations for the Merchant Marine and mobile H.F. S.S.B. stations. Our Test Engineers have sound technical knowledge coupled with good practical experience in the alignment and test of H.F. and V.H.F. Communications equipment.

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1174

ELECTRONIC ENGINEERS

required

for new Technical Service Centre to be established at Hemel Hempstead by British Manufacturers and Servicing Group of a wide range of Business Equipment Products. Ideally suited for engineers experienced in Radio/T.V. H.M. Forces, Industrial electronics.

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Control Systems Ltd.,
Technical Services Centre,
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1284

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If you are British born and resident in the United Kingdom, under 35 years of age (40 for exceptionally well qualified candidates), write NOW for full details and an application form from:—

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(Telephone: Cheltenham 21491, Ext. 2270).

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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:

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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.

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radio technicians

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The positions are permanent and pensionable and offer attractive conditions of employment plus opportunities for air travel concessions.

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BEA

BEA, Hatton Cross Restaurant, Engineering Base, Heathrow Airport - London, Hounslow, Middlesex.

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Fly high with Fairey Surveys

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Write with full personal and career details to the Personnel Manager.

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Here's Variety, Interest and Technical Challenge

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I meet the requirements, please tell me more about the work of a Radio Technician.

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(C/WW/28)

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NATS

National Air Traffic Services

1355

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.

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.

Write giving brief details of your qualifications and experience, quoting reference HM/I/WW, to: The Personnel Manager, EVR Processing Station Christopher Martin Road, Basildon, Essex.

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 Telecommications 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

Pye Telecommunications Ltd

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 electronics design and fabrication. *Salary range £1,728 to £2,592.* Apply to Professor P. A. Sheppard at above address.

1321

AIRTECH

ELECTRONICS INSPECTOR

A vacancy exists in our quality assurance department to cover the testing and inspection of electronic assemblies and systems. Preferably O.N.C. or equivalent. Would suit ex-Service personnel.
Free works transport from approximately 15 miles radius.

Apply: Personnel Officer,
AIRTECH LIMITED,
Haddenham, near Aylesbury, Bucks
Telephone: Haddenham 422

1317

COVENTRY HOSPITAL MANAGEMENT COMMITTEE

ELECTRONICS TECHNICIAN WALSGRAVE HOSPITAL

Technician required for the Electronics Department dealing with 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 of Light Current Engineering, or the Final City and Guilds Tele-Communications Engineering Certificate. General experience in the electronic field is necessary and experience of Hospital Equipment an advantage. Salary scale: £1,356-£1,764, plus overtime if worked.

Applications, stating age, qualifications and experience, together with two referees to: Group Engineer, Coventry Hospital Management Committee, The Birches Annexe, Tamworth Road, Keresley, Coventry CV7 8NN. 1357

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 House, Whitechapel High Street, London E1 7PF. 1360

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 a Radiocommunication Operator's General Certificate issued by 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 Inspector of Wireless Telegraphy,
I.M.T.R.
Wireless Telegraph Section (L. 6.)
Union House,
St. Martins-le-Grand,
London,
EC1A 1AR.

Post Office
Telecommunications

93

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**
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*** 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.

Equipment. Modern low and medium power H.F., S.S.B. and V.H.F. equipment including multiplex links. Knowledge of maintenance of teleprinters, diesel and petrol generators preferred.

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.M2Z/61274/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.M2Z/690315/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 and maintenance of the Analogue Computer Laboratory in the Department of Computer Studies 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 (T.3)—£1,089-£1,272. Additions of £30 or £51 for appropriate City and Guilds of National Certificate qualifications.

Further details and application forms (to be returned by 1 September, 1971) from Central Personnel Office, Bristol Polytechnic, Ashley Down, Bristol, BS7 9BU. Please quote post reference number T41/113 in all communications. 1362

SITUATIONS VACANT

A FULL-TIME technical experienced salesman required for retail sales; write giving details of age, previous experience, salary required to—The Manager, Henry's Radio, Ltd., 303 Edgware Rd., London, W.2. [67

DRAUGHTSMEN. Mechanical and Electrical required by expanding electronics company specialising in lighting control and audio visual products. This position is salaried and gives ample opportunity for advancement. Please apply Electrosonics Ltd., 47 Old Woolwich Road, Greenwich, London, S.E.10. Tel. 858 4784. [22

ELECTRONICS maintenance and development engineer is required to take complete responsibility for technical equipment in studio and dubbing complex. He will also be in charge of specialist audio hire equipment. H.N.C. or degree in an appropriate subject essential. Salary will be in the range £1,750-£2,000 depending on experience in this field.—Aply in writing to: Theatre Projects Sound Limited, 10 Long Acre, London, W.C.2. [1337

SERVICE ENGINEER. Additional Service Engineer required for busy, growing, Audio and Colour TV retailer. Full range of modern test equipment in use. First-class working conditions in modern centrally heated single storey premises. Good prospects for future advancement. Substantial salary, re-settlement grant, company car provided (not a van). Good life insurance and pension scheme. Please apply to Merrow Sound Ltd., 205 Epsom Road, Guildford, Surrey. [1342

Careers in Electronics

EMI

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 pneumatics 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. Company benefits include free Life Assurance and a 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.

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BRICO ENGINEERING LIMITED

HOLBROOK LANE, COVENTRY Telephone No. 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.'

Oscilloscopes	*Qty.*	*Price*
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Domain	3 off	£12 each
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Coutant ASB.1000	1 off	£50
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Resistance Boxes	*Qty.*	*Price*
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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.

1352

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.

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0·022 µF.	250V.	Paper	,,	5p
0·47 µF.	160V.	Paper	,,	10p
1 µF.	160V.	Paper	,,	15p
2 µF.	35V.	Electrolytic	Hunts Printilyt I.	7·5p
3·3 µF.	100V.	Polycarbonate	S.T.C. PMA 3·3K100	25p
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5 µF.	25V.	Electrolytic	,, Printilyt I.	7·5p
8·2 µF.	20V.	Tantalum		70p
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68	2	ELECTROSIL TR5	
82	2	ELECTROSIL TR5	
91	2	ELECTROSIL TR5	
100	2	ELECTROSIL TR5	
150	2	ELECTROSIL TR5	
180	2	ELECTROSIL TR5	
220	2	ELECTROSIL TR5	
270	2	ELECTROSIL TR5	
330	2	ELECTROSIL TR5	
360	2	ELECTROSIL TR5	
390	2	ELECTROSIL TR5	
470	2	ELECTROSIL TR5	
560	2	ELECTROSIL TR5	
680	2	ELECTROSIL TR5	
820	2	ELECTROSIL TR5	
910	2	ELECTROSIL TR5	
1K	2	ELECTROSIL TR5	
1K2	2	ELECTROSIL TR5	133p
1K5	2	ELECTROSIL TR5	
1K8	2	ELECTROSIL TR5	
2K	2	ELECTROSIL TR5	
2K2	2	ELECTROSIL TR5	
2K4	2	ELECTROSIL TR5	
3K3	2	ELECTROSIL TR5	
4K5	2	ELECTROSIL TR5	
4K7	2	ELECTROSIL TR5	
5K1	2	ELECTROSIL TR5	
5K6	2	ELECTROSIL TR5	
6K2	2	ELECTROSIL TR5	
6K8	2	ELECTROSIL TR5	
8K2	2	ELECTROSIL TR5	
9K1	2	ELECTROSIL TR5	
13K	2	ELECTROSIL TR5	
15K	2	ELECTROSIL TR5	
27K	2	ELECTROSIL TR5	
33K	2	ELECTROSIL TR5	
82	5	ISKRA UPM	
150	5	ISKRA UPM	
180	5	ISKRA UPM	
820	5	ISKRA UPM	
8K2	5	ISKRA UPM	
10K	5	ISKRA UPM	
22K	5	ISKRA UPM	46p
1M2	5	ISKRA UPM	
1M5	5	ISKRA UPM	
2M7	5	ISKRA UPM	
3M3	5	ISKRA UPM	
3M9	5	ISKRA UPM	
4M7	5	ISKRA UPM	

* Prices per 100 in quantities of 100-10,000

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47	5	ISKRA UPM	
120	5	ISKRA UPM	
150	5	ISKRA UPM	
220	5	ISKRA UPM	
270	5	ISKRA UPM	
330	5	ISKRA UPM	46p
390	5	ISKRA UPM	
470	5	ISKRA UPM	
680	5	ISKRA UPM	
820	5	ISKRA UPM	
1K	5	ISKRA UPM	
1K2	5	ISKRA UPM	
3K3	5	ISKRA UPM	
3K9	10	MORGANITE	
10K	5	ISKRA UPM	
18K	5	ISKRA UPM	
22K	5	ISKRA UPM	
220K	5	ISKRA UPM	
820K	5	ISKRA UPM	
1M5	10	ISKRA UPM	46p
1M8	10	ISKRA UPM	
2M2	10	ISKRA UPM	
2M7	5	ISKRA UPM	
4M7	5	ISKRA UPM	
5M6	5	ISKRA UPM	
6M8	10	ISKRA UPM	
1K	2	ELECTROSIL TR4	
1K2	2	ELECTROSIL TR4	
1K5	2	ELECTROSIL TR4	
2K2	2	ELECTROSIL TR4	133p
2K7	2	ELECTROSIL TR4	
12K	2	ELECTROSIL TR4	
18K	2	ELECTROSIL TR4	

* Price per 100 in quantities 100-10,000

½ WATT RESISTORS

Value Ohms	*Tol ±%*	*Supplier & Ref.*	*Price/100*
150	5	Mullard B803104NB	
220	5	Mullard B803104NB	
330	5	Mullard B803104NB	
820	5	Mullard B803104NB	
1K	5	Mullard B803104NB	
1K2	5	Mullard B803104NB	
1K3	2	ELECTROSIL TR4	
1K5	5	Mullard B803104NB	
1K8	5	Mullard B803104NB	
2K2	5	Mullard B803104NB	
2K7	5	Mullard B803104NB	
3K3	5	Mullard B803104NB	
3K9	5	Mullard B803104NB	
4K7	5	Mullard B803104NB	
5K6	5	Mullard B803104NB	
6K2	5	Mullard B803104NB	
6K8	5	Mullard B803104NB	
8K2	5	Mullard B803104NB	
10K	5	Mullard B803104NB	
11K	5	Mullard B803104NB	
12K	5	Mullard B803104NB	
15K	5	Mullard B803104NB	
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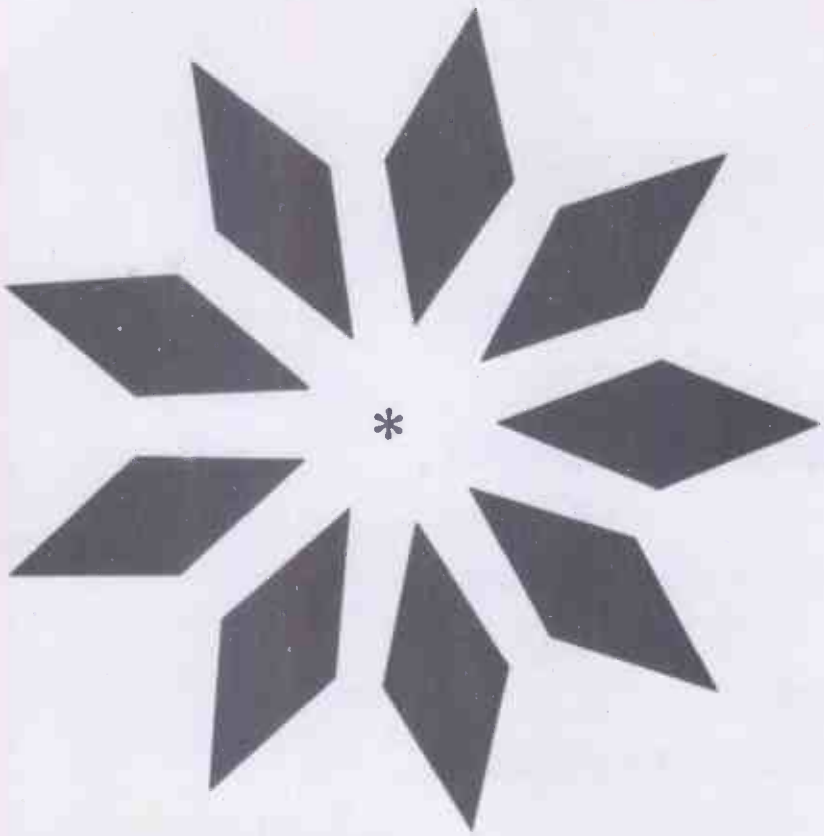

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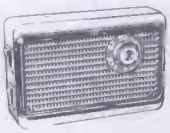

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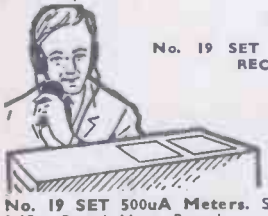

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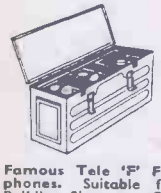

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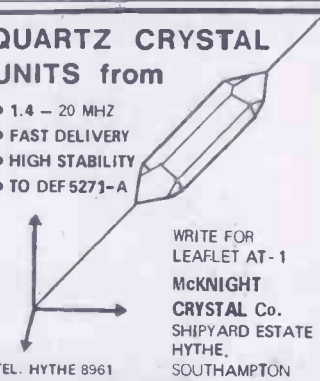

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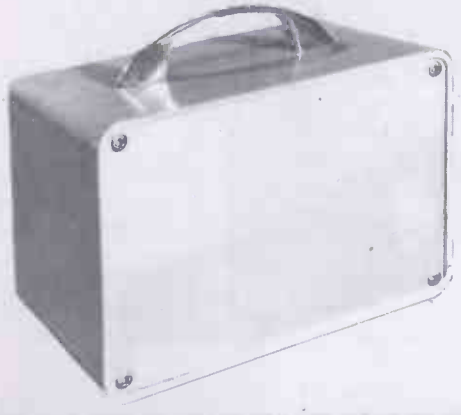

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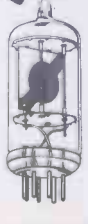

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