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APRIL 1974 20p

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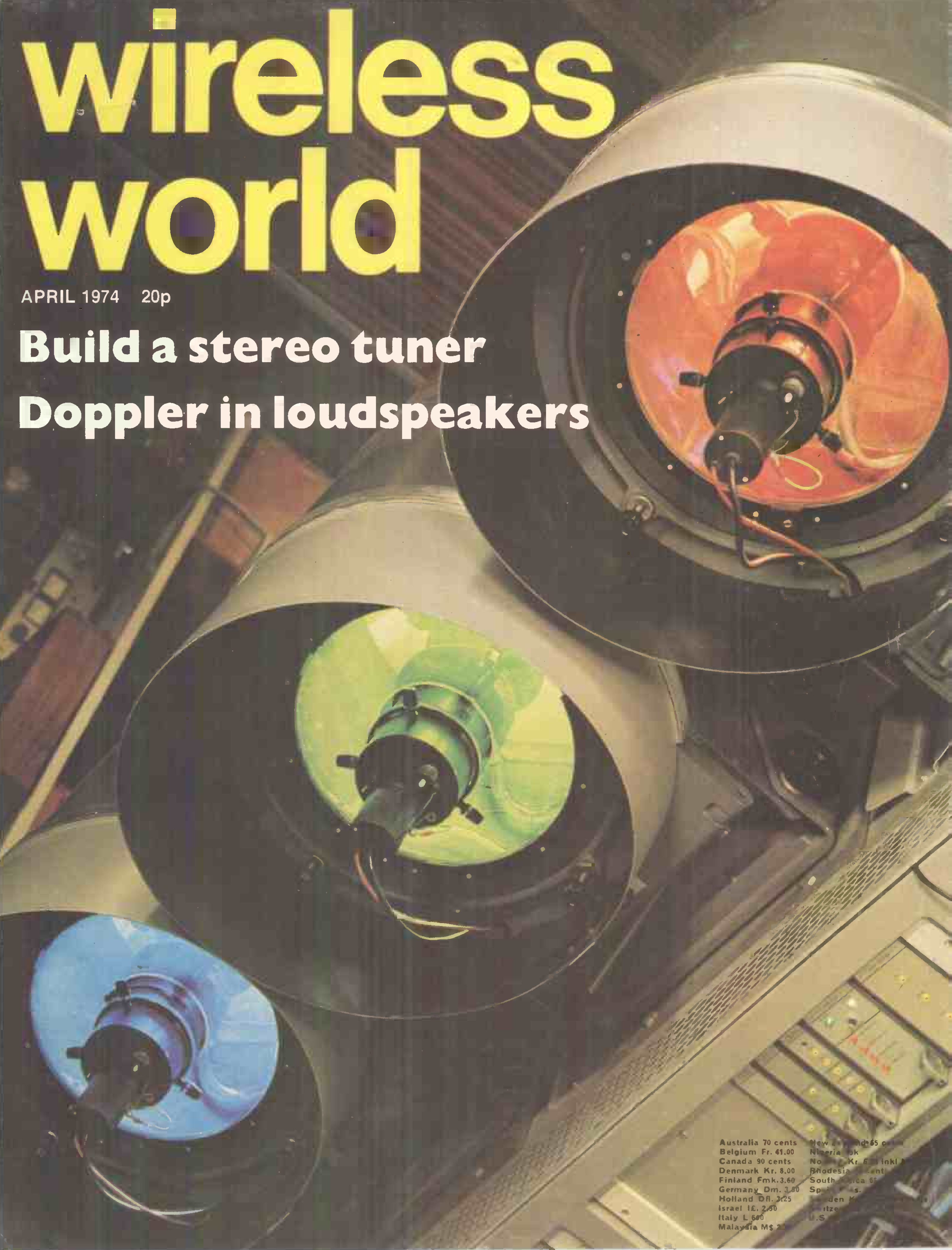

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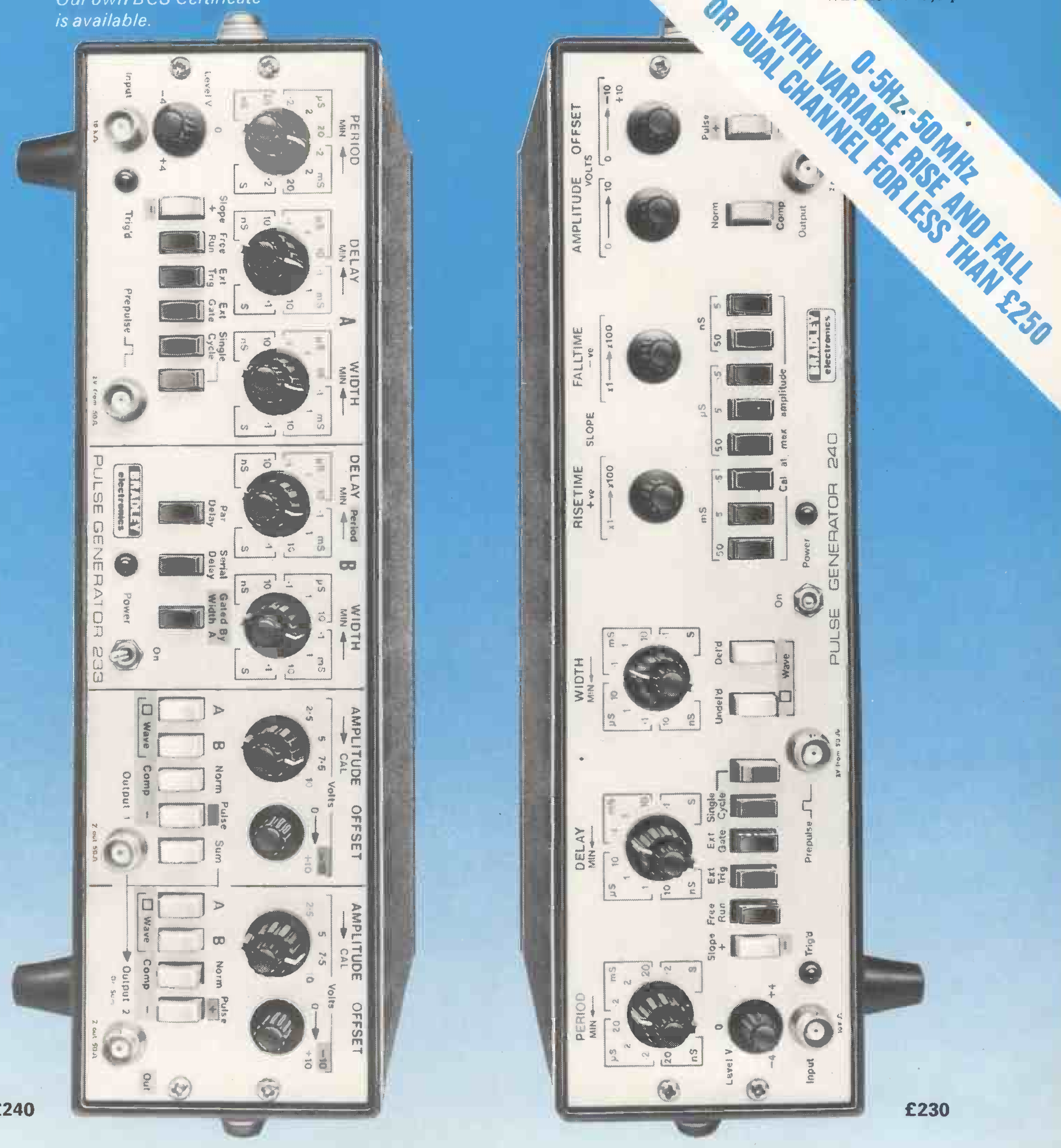

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wireless world

Electronics, Television, Radio, Audio

APRIL 1974 Vol 80 No 1460

SIXTY-FOURTH YEAR OF PUBLICATION

This month's cover picture shows the red, green and blue triple optical head of a colour television projection equipment made by Pye TVT.
(Photographer Paul Brierley)

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IN OUR NEXT ISSUE
(published May 22)

Radar for cars. Clutter-free system for avoiding road collisions.

Colour-sound system. Compact equipment for controlling light hue and brightness by audio signal frequency and amplitude.

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Electronic piano. Part 3: assembly of the electronics and the cabinet.

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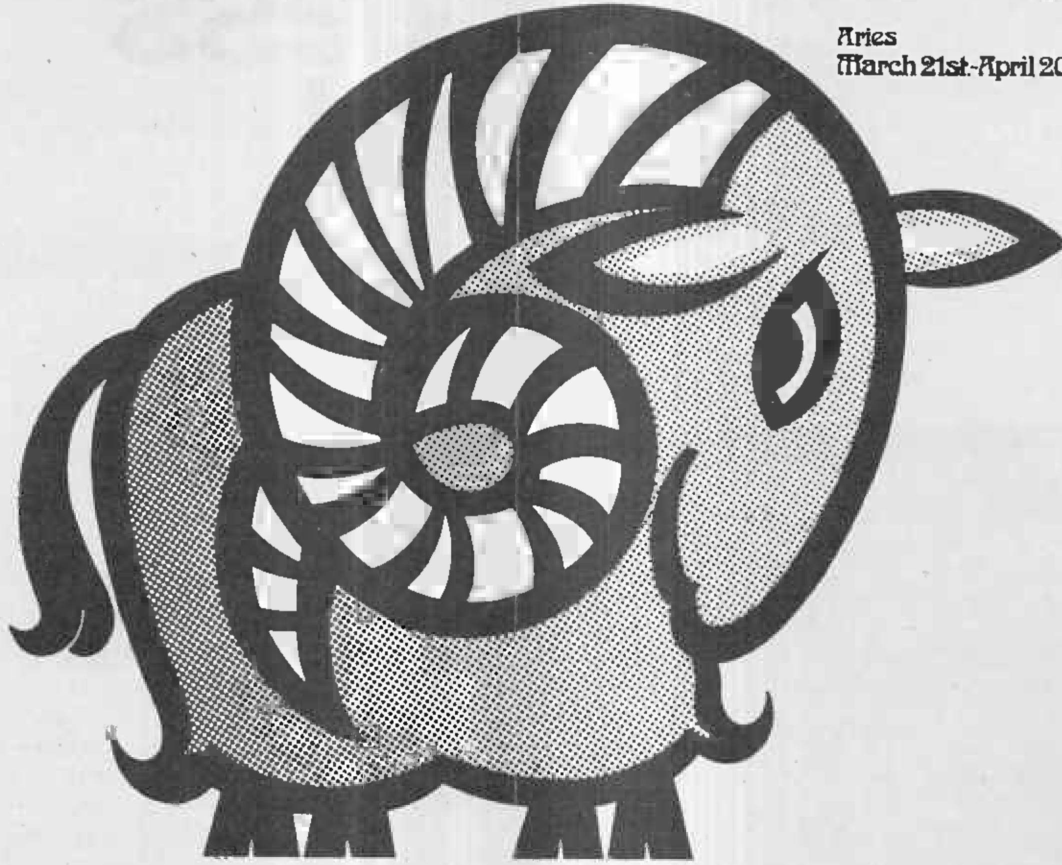

Astrologically speaking...

. . . the best and most promising times of the year are May, June and December, however if you are careful and do not attempt anything too rash, the remainder of the year should not present you with too many problems.

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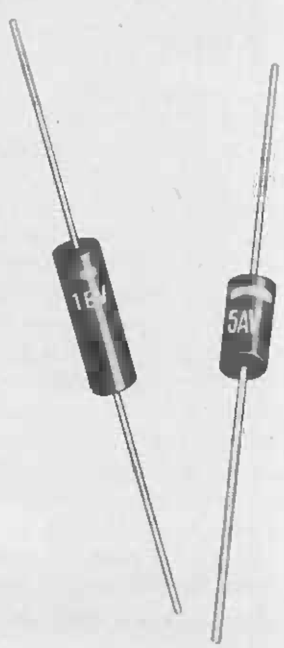

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What is an engineer worth?

The short answer to the question What is an engineer worth? is: what he can get. This may seem cynical to those who have certain ideas about the intrinsic worth of an engineer—in terms of his education, qualifications and so on—but because this intrinsic worth cannot be evaluated in money there can be no other answer. In practice the engineer has to accept a prospective employer's evaluation of his worth, perhaps after the two of them have bargained about it. In private industry the settlement may be a capricious one, very much dependent on market forces and therefore seemingly unfair in relation to other workers. At the time of writing there are bricklayers and carpenters earning £4,000–£5,000 p.a. in the London area. How many engineers can command this level of salary? It may seem that in state-run organizations such as the Civil Service things are better because they are more regularized and predictable. As a result the engineer may be more ready to accept without question the employer's evaluation of his worth: it seems to be based on the accumulated wisdom of the state and the will of the people.

Of course there have been plenty of studies, reports and recommendations made on behalf of the engineer. Last year, for example, we had the fourth CEI survey of professional engineers and the IEEE manpower report. Such investigations are mainly intended to let the engineer see where he stands and what are his prospects: they don't hope to change anything. One of the most forthright statements was in the famous "Brain Drain" report, which said there was clear evidence "that industry undervalues its engineers, technologists and scientists" and recommended that industry should be prepared to "promote within its own salary structure the pay of qualified engineers, technologists and scientists". More recently the United Kingdom Association of Professional Engineers has been campaigning against engineering employers' "apparent willingness" to classify professional engineers "alongside the mass of technicians and manual employees" in concluding pay agreements.

Much of the agitation for improved pay rests on the assumption of a superior order of intellectual ability in the professional engineer relative to other engineering workers—an ability to analyse and conceptualize, to see clearly the fundamentals of problems—which has been brought to a high level by three or more years' education and given the stamp of an official qualification. This is the core of the engineers' claim. It is a strong case and nobody disputes it. Why, then, do not engineers have the courage of their convictions and organize themselves to deploy this advantage in a more effective way? Mere recognition is not enough. The CEI is a toothless watchdog. The reluctance of engineers to organize themselves into pressure groups or unions is partly because, like many creative people, they are individualistic by nature, and partly because the word "professional" for them has an image that is aloof from the cloth-cap image of the trade union. They therefore turn their backs on collective bargaining in a world which operates on collective principles. If only they were able to recognize fully the significance of their own strength they would find the will to use it.

Novel stereo f.m. tuner

1 —Circuits and operation

by J. A. Skingley and N. C. Thompson

Plessey Components Ltd, Swindon

Using a ready-made front-end, integrated circuits and only one inductor, this tuner design is simple to operate, construct and set up. It includes novel circuitry to give inter-station muting, a.f.c. restricted to less than station spacing, a single-lamp tuning indicator, temperature-compensated varicap tuning allowing stations to be preset, and a linear-scale frequency meter. A simple stereo decoder circuit (part 2) uses active filters to eliminate "birdies" and remove subcarrier harmonics. Printed circuit wiring diagrams, assembly instructions and setting up procedure will appear in part 2.

The designer of technical equipment for the domestic market faces a problem. On the one hand the technical operating requirements can dictate a multiplicity of controls and demand a detailed knowledge of their use. On the other hand the operation must be simple and easily understood by people of all walks of life and professions. This design had to cater for non-technical people and children.

The first requirement then was that the system used should mask the technicalities and present the user with the simplest possible mode of operation, relying at most on traditional skills learned from more conventional a.m. receivers, without sacrificing the advantages to be had from a modern f.m. tuner.

The second requirement was to provide a tuner which was at least as good as the best commercial unit on all technical parameters. The total design objectives were therefore

requirement 1—ease of operation:
(a) provision for push-button tuning
(b) no undesirable outputs
(c) powerful a.f.c.
(d) sensitive, unambiguous tuning indication

requirement 2—good performance:
(a) 2μV for 30-dB signal-to-noise ratio
(b) 3-dB limiting 0.5μV
(c) image rejection 40dB
(d) i.f. rejection 65dB
(e) capture ratio 2dB
(f) a.m. rejection 60dB
(g) a.f. response ±1dB, 20Hz to 15kHz.

The combination of these objectives led to a system which to our knowledge is unique (Fig. 1).

The core of an f.m. system is its i.f. strip, and in this design it was decided to use a block filter and integrated-circuit limiting amplifier. The distribution of selectivity and gain has conflicting requirements. From the point of view of noise selectivity should come after gain; from the view point of intermodulation effects gain should come after selectivity. The ideal choice is one where the gain and selectivity are uniformly distributed throughout the system, and this was more nearly achieved in traditional i.f. amplifiers using discrete components. The use of integrated circuits however precludes the use of this system because selectivity cannot be integrated.

There are however a number of advantages to the use of block filters over distributed systems. They can be designed as a single entity, providing a shaped response via the controlled interaction between sections to give a complex pole system, and avoiding the need for delicate stagger tuning of discrete sections. Termination conditions are easily allowed for, the filter as a whole is less sensitive to variations in transistor parameters. The filter used in this receiver is the Murata SFG-10.7 MA, which has excellent bandwidth and selectivity (Fig. 2).

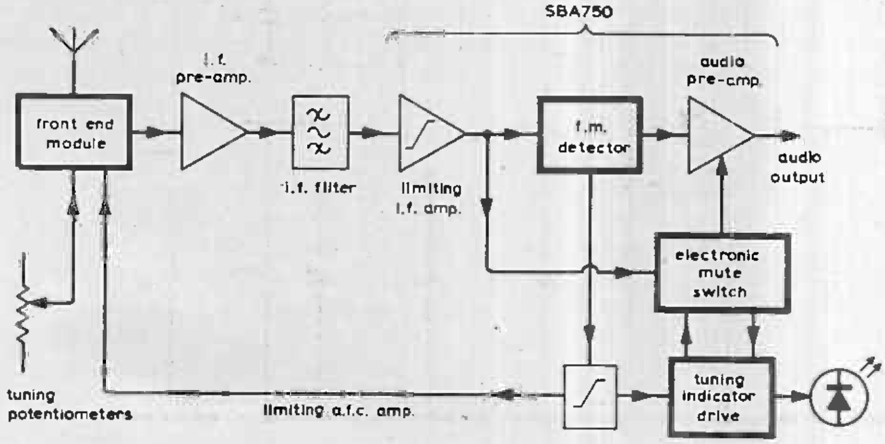

Fig. 1. In this tuner design limiting and demodulation is provided in a five-stage amplifier and a balanced demodulator, both in the SBA750A i.c., additional gain being provided by a two-stage discrete-component preamplifier. Integrated muting circuit eliminates inter-station noise and the novel one-lamp indicator makes tuning simple.

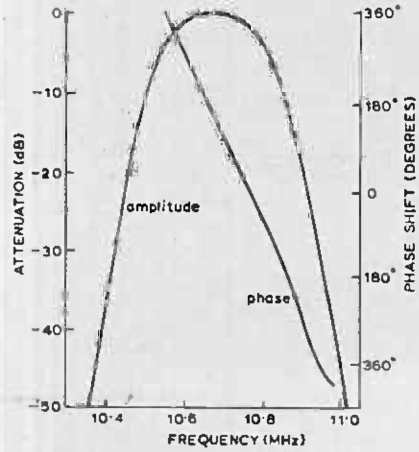

Fig. 2. Filter characteristic is maintained by making filter "see" 330 ohms at source and load.

The integrated amplifier must have excellent limiting characteristics to provide a good a.m. rejection, and the device chosen achieves this by the use of a five-stage limiting amplifier and a balanced demodulator. This is the Plessey SBA750A which has 45dB rejection at 200µV and 60dB at 2mV input. These figures correspond to 2µV volts and 20µV respectively at the input in this design. This device also features a mutable a.f. amplifier which is used in the mute circuit to be described later.

It is interesting to reflect here that, at the present stage of integrated circuit development, the system designer has a wide choice of such building blocks, and, being relieved of the detailed design of these, has far more scope for originality than he used to have. This would seem in contrast to the gloomy forecast once made that all design would be done by the i.c. manufacturer, leaving the system designer the simple task of plugging in devices. In fact it is this new freedom which brings to light the need for new building blocks, and in turn produces more advanced systems.

Objective 1(a), is met by using a varicap-tuned front end. The performance of commercially-available units, although capable of improvement, is equal to our design objectives and presents the simplest solution. The unit chosen was the Mullard LP1186, which can be conveniently mounted on a printed circuit board.

To achieve objective 2(a) more gain is required than that given by the above items. This extra gain is provided by a two-stage feedback amplifier as shown in Fig. 3. The first stage acts as a transconductance amplifier, its gain being defined by the 100-ohm emitter resistor. The second stage then functions as a transresistance amplifier or current-to-voltage converter. The combination therefore has a gain defined by the 100-Ω resistor and the 2-kΩ feedback resistor, and has a value of 26dB. The output impedance of this stage is around 90 ohms,

Features of this simple-to-operate stereo tuner include a muting circuit to prevent unwanted signals being heard (e.g. weak stations, signals affected by flutter, and mistuned stations), a single-lamp tuning indicator and a linear frequency meter.

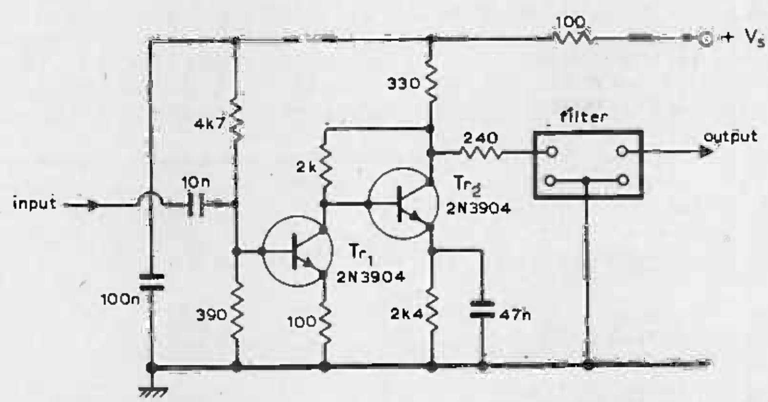

Fig. 3. Feedback amplifier consisting of voltage-to-current converter followed by a current-to-voltage converter has 26dB gain, defined by 100-ohm and 2k-ohm resistors. Output impedance of 90 ohms is made up to 330 ohms to correctly feed the filter.

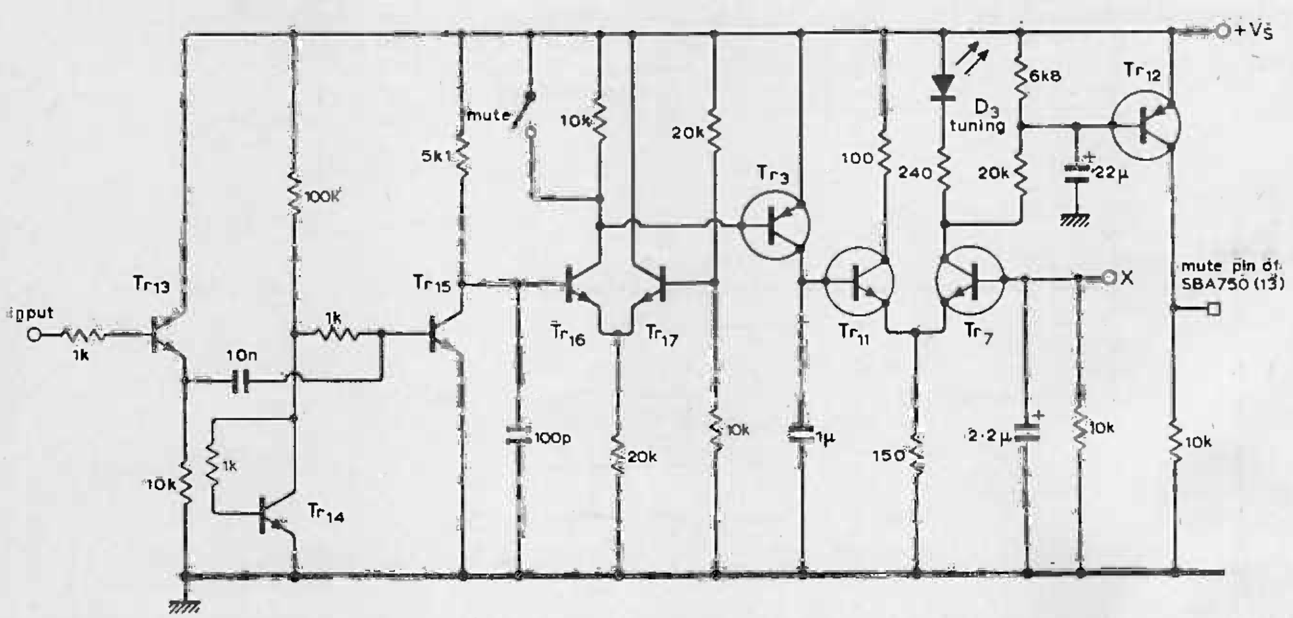

Fig. 4. Mute circuit, operated by the amount of amplitude modulation in the i.f. output, has the advantage of suppressing unwanted outputs due to detection on the non-linear regions of the S-shaped demodulation curve. Point X, fed from the demodulator via Fig. 5, feeds the tuning indicator, which is held off by Tr_{11} in the presence of noise. An output from this circuit unmutes the stereo output from SBA750 i.c. First five transistors are contained in SL3045 i.c.

and so a buffer resistance of 240 ohms is used to present the filter with its required source impedance of 330 ohms. This introduces a slight loss of gain, but ensures that the correct filter characteristic is obtained.

Muting circuit

The system so far described provides an audio output from an aerial input and could therefore be used as a tuner as it stands. However, this is really where our story begins. If the above system is used, the first thing soon realized is that the interstation noise is highly objectionable. In fact it corresponds to a fully modulated signal over the entire audio band, since the input stage noise is sufficient to achieve limiting in the last i.f. stage, with a bandwidth equal to the i.f. filter pass-band.

In addition to this ear shattering blast, as a station is tuned a highly distorted version of the station programme is received before the correct tuning point is reached, also at a high volume. This is of course due to detection via the "S" curve of the detector, and will be produced at equal intervals either side of the correct tuning point. The net result of all this is design objective 1(b), the suppression of all unwanted outputs. Put the other way round, the only sounds heard should be correctly tuned stations.

Audio muting is achieved by using the remote gain control facility of the SBA750. This is a pin connection usually taken to a remote potentiometer carrying d.c. only. For our use the potentiometer is replaced by a p-n-p transistor (Tr_{12}, Fig. 4) which is controlled from a number of sources.

Because the noise level is sufficient to produce a fully limited signal from the i.f. amplifier, the magnitude of this cannot be used to detect the presence of the station to un-mute the system, and this presents a problem. The solution is simple in concept.

What is required is a measure of the degree of limiting taking place within the i.f. amplifier, and this is easily monitored by detecting the amount of amplitude modulation present in the i.f. output. This has the advantage of detecting the spurious responses mentioned earlier, as these are in fact caused by the high-slope edges of the i.f. filter response converting the frequency modulation into amplitude modulation which is then detected by the quadrature detector.

The first device in Fig. 4 acts as a buffer to the i.f. amplifier output, which is very sensitive to capacitance loading. The next two devices form the amplitude detector. Transistor Tr_{14} is diode-connected and fed with a small current from the supply. As the five devices Tr_{13} to Tr_{17} are contained on one chip of silicon (SL3045), they have well matched base-emitter voltages, and this causes Tr_{15} to conduct the same current as Tr_{14}. The 1-kΩ resistors in Tr_{14} and Tr_{15} bases provide a higher input impedance for the signal while preserving the voltage match, since the base currents are also equal.

The collector of Tr_{15} would sit at a relatively high voltage due to its smaller load resistance, but application of the i.f. signal (noise or "clean" 10.7MHz), which is about 400mV pk-pk, causes this stage to rectify bringing its collector down to a low voltage. The collector time constant is chosen so that the 10.7-MHz signal is filtered out but allowing amplitude modulation up to about 100kHz to be followed. This modulation can only be negative, as the i.f. is amplitude limited, and this produces positive-going signals, when present, at Tr_{15} collector.

The following transistor pair is biased with Tr_{17} normally on, so that this positive-going signal turns on Tr_{16} and hence Tr_3, both of which are normally non-conducting. In the presence of noise therefore the capacitor in Tr_3 collector is charged rapidly taking the base of Tr_{11} positive. This will happen in the presence of any form of a.m. noise or spurious signals, and may be used to mute the receiver.

Single-lamp tuning indicator

There are many ways of meeting objective 1(d). However there is a need to provide an indication which is readily understood by all, without the need for instruction, which

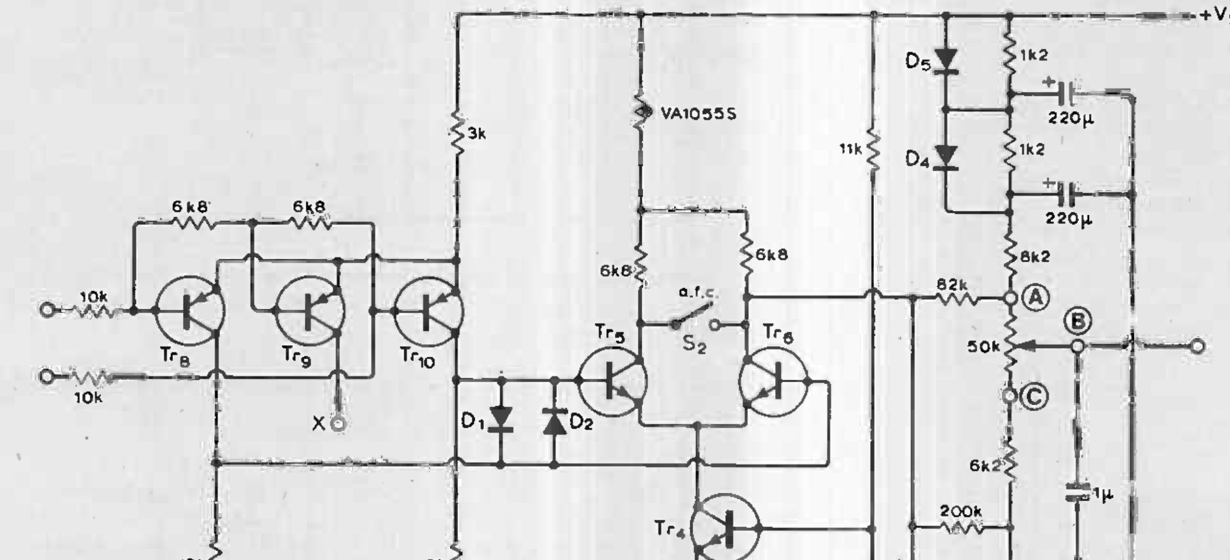

Fig. 5. A.F.C. amplifier has its voltage swing limited to restrict a.f.c. action to less than station spacing. Using a computer programme, the tuning potentiometer network was optimized to provide uniform lock-in range over the tuned band and correct temperature compensation of the front-end. Diodes in potentiometer smoothing circuit allow quick charging of capacitors and keep settling time after switch-on short.

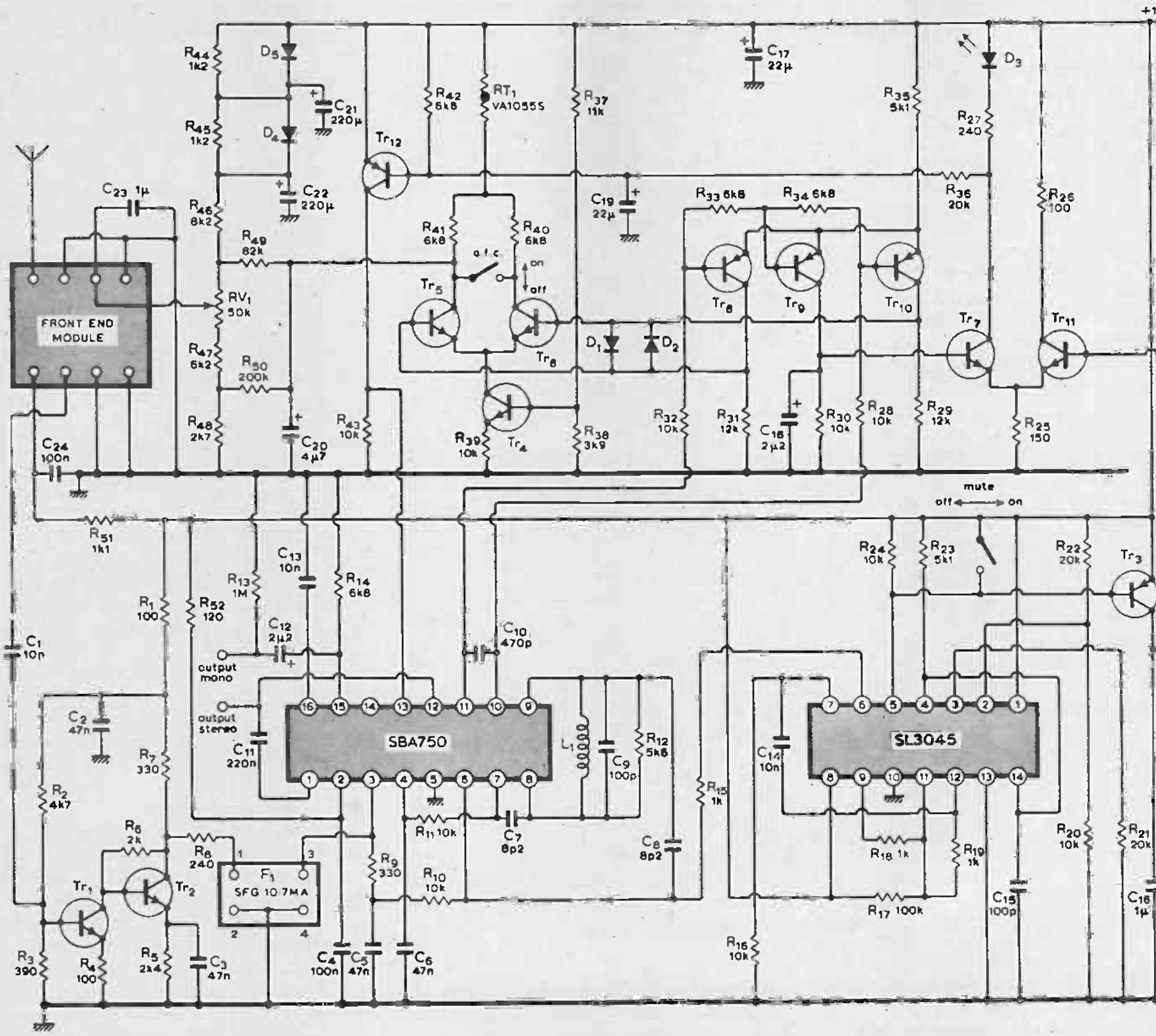

Fig. 6. Circuit of f.m. receive section of tuner with a.f.c., muting and tuning indicator circuits. Frequency is displayed on a moving-coil meter (circuit in part 2). Resistors in this circuit should be 2% tolerance.

ruled out several of the recently-used types. These include the centre-zero meter and the two-lamp system, as neither of these provide a maximum response at the correct tuning point, which is the conventional mode of adjustment. This topic is to be covered in another article and the final design is shown in Fig. 5.

Inputs are taken from the balanced demodulator output via 10kΩ resistors and fed to a long-tailed pair with the addition of a third transistor. This device is connected so that it conducts a maximum current (one third of the tail current) when the inputs are balanced. The collector of this (point X) is connected to the base of Tr_7 (Fig. 4), the d.c. conditions being arranged so that at balance, and assuming Tr_{11} is off, Tr_7 conducts 20mA into the single l.e.d. indicator, D_3. This then has a maximum brilliance at the correct tuning point.

The Tr_{11} tuning indicator is extinguished in the presence of noise, since Tr_{11} conducts away the current supply to it when its base is made positive by the action described earlier.

Objective 1(b) can now be easily obtained. We only require the audio signal to be unmuted when there is a correctly tuned station being received, that is, when the tuning indicator is fully lit. The voltage-current characteristics of a l.e.d. are similar to those of a zener diode; therefore a 240-ohm resistor is placed in series to give a voltage-varying point, and this is used to operate the mute transistor Tr_{12} (Fig. 4). The system will only pass a correctly tuned signal of significant signal-to-noise ratio. Very weak stations, stations suffering from gross interference or aircraft flutter, spurious responses, and even strong stations which are mis-tuned by more than a few tens of kHz will be completely muted.

A.F.C. circuit

There now only remains the objective 1(c), the provision of a.f.c. This function received a lot of thought and discussion before the system described was finalized. A high degree of loop gain was required to reduce the tuning error to negligible proportions, but when this was tried, however, several disadvantages came to light.

Firstly it was found impossible to tune the receiver with a.f.c. applied. One station would be captured and the tuning control rotated past several others on the dial before the original station was lost, and then it was not known which station had been recaptured. The tuning was completely ambiguous, in opposition to the main requirements and objective 1(d) in particular. There are several expensive commercial tuners having this fault.

The solution to this problem is simple in hindsight. What is needed is indeed high gain, but the frequency range should be restricted to less than the typical station spacing. This is easily achieved by limiting the swing voltage available from the a.f.c. amplifier. One requirement for the above system to be successful is that the tuner

Components (main board)

Filter Murata SFG 10.7MA
Front-end module Mullard LP1186
Mains transformer
RS Components (634 Trans)
Push buttons
RS Components (Press 2P)
Pre-set pots
RS Components (Lin Cerm 50k)
Multi-turn pots
RS Components (Multi pot 50k)
Regulator
RS Components (MVR 15)
Rectifier
RS Components (REC 70)
Meter RS Components (MR 42A)

Semiconductor devices

IC_1	SBA750A
IC_2	SL3045
Tr_1, Tr_2	2N3904
Tr_3, Tr_8 to Tr_{10}	BC179
Tr_4 to Tr_7, Tr_{11}, Tr_{12}	BC109
D_1, D_2	1N4148
D_3	5082–4403 (l.e.d.)
D_4, D_5	1N4001

Capacitors

C_1, C_{14}	10nF (disc ceramic)
C_2, C_3, C_5, C_7	47nF (disc ceramic)
C_4, C_{24}	0.1µF (disc ceramic)
C_7, C_8	8.2pF (min. plate ceramic)
C_9, C_{15}	100pF (min. plate ceramic)
C_{10}	470pF (disc ceramic)
C_{11}	0.22µF (stack foil polycarbonate)
C_{12}, C_{18}	2.2µF (63V electrolytic)
C_{13}	10nF (stack foil polycarbonate)
C_{16}, C_{23}	1µF (stack foil polycarbonate)
C_{17}, C_{19}	22µF (25V electrolytic)
C_{20}	4.7µF (63V electrolytic)
C_{21}, C_{22}	220µF (16V electrolytic)

Resistors (all Electrosil TR5 2% except thermistor)

R_1, R_4, R_{26}	100Ω
R_2	4.7kΩ
R_3	390Ω
R_5	2.4kΩ
R_6	2kΩ
R_7, R_9	330Ω
R_8, R_{27}	240Ω
R_{10}, R_{11}, R_{16}, R_{24}, R_{28}, R_{30}, R_{32}, R_{39}, R_{43}	10kΩ
R_{12}	5.6kΩ
R_{13}	1MΩ
R_{14}, R_{33}, R_{34}, R_{40} to R_{42}	6.8kΩ
R_{15}, R_{18}, R_{19}	1kΩ
R_{17}	100kΩ
R_{21}, R_{22}, R_{36}	20kΩ
R_{23}	5.1kΩ
R_{25}	150Ω
R_{29}, R_{31}	12kΩ
R_{35}	5.1kΩ
R_{37}	11kΩ
R_{44}, R_{45}	1.2kΩ
R_{46}	8.2kΩ
R_{47}	6.2kΩ
R_{48}	2.7kΩ
R_{49}	82kΩ
R_{50}	200kΩ
R_{51}	1.1kΩ
R_{52}	120Ω
RT_1	VA10555 thermistor

should not have a temperature drift greater than the hold-in range of the a.f.c. This would anyway render the tuning calibration unreliable. In this design the a.f.c. amplifier is used to provide temperature compensation independently of the hold-in range. The circuitry used is shown in Fig. 5.

The differential output from the tuning indicator triple is further amplified by Tr_5 and Tr_6. Due to the action of the triple there is a common-mode signal present in its output, and this is rejected by Tr_5 and Tr_6 by providing them with a constant-current tail from Tr_4. Also under extreme mistuning it would be possible for Tr_5 or Tr_6 to bottom, causing a spurious output voltage and incorrect a.f.c. action. Diodes D_1 and D_2 are included to prevent this from happening. They limit the swing available by clamping Tr_8 and Tr_{10} collectors together at a maximum of 0.6 volts difference.

The a.f.c. can easily be cancelled by closing switch S_2, thus removing differential gain. The output voltage is now determined by the current from Tr_4, which is fixed, and the total load resistance in the common mode. This includes the thermistor common to both collectors which is selected to provide the correct compensation of the front end, via the following network.

This network was optimized by a computer programme to provide a shift of the end voltages of the tuning potentiometer by amounts representing equal frequency shifts. This results in a uniform lock-in range over the tuned band, and also correct temperature compensation. A possible method of switching and tuning potentiometers is shown; alternatively these may be connected in parallel provided that the total resistance remains at 50kΩ.

The positive end of the tuning potentiometer, point A, is connected via a total of 10.6kΩ to the positive supply, and any residual mains ripple at this point will modulate the tuning and produce a hum at the output. Less than 0.1mV ripple is required to produce a hum level at least 60dB down on full signal. Therefore, the resistance is split and two 220µF capacitors inserted as shown. This has the desired effect, but produces a slow sweep across the tuning range as these capacitors charge up after switch-on. This is annoying as several stations are captured by the a.f.c. in passing, before the wanted station is reached.

To overcome this defect, it is arranged that D_4 and D_5 diodes rapidly charge the capacitors, by-passing the 1.2-kΩ resistors.

When fully charged, the voltage drop across these is insufficient to keep the diodes forward biased and they cease to conduct, allowing the full time constant to become effective. By this means the switch-on settling time is greatly reduced. These diodes can be seen in Fig. 6 which shows the discrete components and their inter-connection with the integrated circuit and front-end module.

The tuner circuit described provides the optimum performance with regard to the needs of all users. Operation is simplicity itself. The set is silent while tuning between stations and the tuning indicator is un-lit. When a station is encountered the tuning indicator lights fully and the set un-mutes. The tuning control is now left untouched in the knowledge that no further adjustment is required. If an adjacent station exists, the control may be turned further and the tuning lamp will blink off then on again and the new station will be heard; again no further adjustment will be required. This action is similar to turning a rotary switch. If this new station is further away, the set will remain silent until it is reached; mis-tuned stations cannot be received. If the a.f.c. is disabled, for instance when hunting up-band for foreign stations, the tuning indicator allows a sensitive fine adjustment to be made. The mute facility may also be removed under these conditions to allow weak stations of less than 5 to 10µV to be received.

The design has been sufficiently thorough to ensure that the performance can be guaranteed, provided that the components specified are used and the layout of the p.c. board is as recommended. Setting up can be done with nothing more than a trimming tool, for the single tuned circuit, and a pair of eyes.

Performance

Sensitivity	1.8µV for 30dB s/n (mono, see graph in part 2 for stereo)
3-dB limiting	0.7µV
image rejection	42dB
i.f. rejection	60dB
capture ratio	1.8dB
a.m. rejection	60dB (see graph)
mute level	3 to 5µV
output level	180mV stereo 1.7V mono
harmonic distortion	0.5% for 75kHz dev.

Part two will include details of an improved stereo decoder, assembly instructions, and setting up procedure.

Paris components exhibition

As semiconductors have been a marker, for many years, of the state of development, we thought we would have a look and see what was happening here. Trends are towards larger-scale integration of almost everything, from computers to car radios, and the number of stands on which displays for meters, calculators, clocks, watches and any parameter not previously thought of makes one wonder whether liquid crystals, light-emitting diodes, neons, or some device yet to see the light of day will be the standard in ten years' time.

Semiconductors

To get down to details, an example of l.s.i. was shown by Motorola, who had the MC6800 set of ion-implanted, n-channel integrated circuits, which together form a microcomputer. (Will the next step be a nano-computer, one wonders?) The set consists of an 8-bit central processor, an 8k ROM, a 1k RAM, an interface for peripherals and an asynchronous line interface. The processor, in a 40-pin pack, handles decimal or binary and accommodates 72 instructions, with provision for up to 64 bytes of external memory—in any form.

Also by Motorola is the set of three i.cs for a PAL decoder, giving final R, G and B tube drive from the composite video signal. One of the set is the MC1327 colour demodulator, which is already known, together with the TBA 395 (chrominance) and TBA 396 (luminance) modules. The last two contain a gain-controlled chrominance amplifier, a gated burst amplifier, p.l.l. reference oscillator, chrominance amplifier a.g.c. generator (this is usually known as a.c.c. —automatic chrominance control) and colour killer, together with black-level clamps, beam current limiting and tracked control of saturation and contrast.

Chips for calculators continue to evolve, and General Instrument Microelectronics showed two new ones. The 8-digit C595 possesses automatic constant on all four functions, and percentage. It has one memory, but four separate keys allow the memory to be updated, information stored, cleared or read. All functions are in the one chip, including display and clock. The C150 is a 14-digit unit for office or scientific work, which offers the facility of storing and operating upon two numbers simultaneously, for example, in the solution of quadratic equations. C151 is a version for general use, with a direct square root key.

SGS-Ates showed a range of seven integrated circuits—in various stages of development—which together make up a virtually complete colour receiver. The planning is such that three of the i.cs are concerned with the colour section of receivers, the remaining four being usable in monochrome sets. One remarkable chip, the TDA1170, contains the entire vertical deflection circuitry, providing 1·6A peak-to-peak to the deflection coils. A voltage stabilizer is built in to provide immunity to supply variations.

SGS-Ates also had their TDA2020, a 15W audio amplifier on one chip, claiming high-fidelity performance at a t.h.d. figure of 1% at 15W. It requires ± 18V supplies, and has a power-limiting circuit with thermal shut-down. The two-rail supply enables direct coupling of the loudspeaker. The amplifier is also available in industrial guise as the LO68, to be used as a servo driver and error amplifier combined.

An automotive i.c. by ITT Semiconductors, the SAJ280, is intended to ensure that seat belts are worn. The unit is named "Interlock" and creates all manner of visual and aural commotion if the belts are unfastened either before or after ignition, which it also prevents in such circumstances. It will refrain from such behaviour if the vehicle is moving when the belts become unfastened.

"Old-fashioned" semiconductors—transistors—are acquiring a very humdrum connotation lately, but nevertheless development continues in all the important parameters. Motorola had the range of high-power Darlingtons which are intended as replacements for the 2N3055, 2N6253 and 2N625 single types. The new pairs offer h_{FE} between 500 and 5000, with V_{CEO} of 45 to 80V. Shunt diodes across the output transistor are built in. RTC were also showing power Darlingtons, in p.n.p. and n.p.n. configurations, offering h_{FE} of 3000 typical at collector currents of 1·5A to 10A. Collector voltage ratings are between 60 and 100V and, again, the shunt diodes are built in.

Transistors and diodes for high frequencies, shown by RTC, include the BFT50 low-noise type (less than 2dB at 500MHz); the BFT51, a 1W, 12V type with an f_T of 2500MHz at 140mA; the BLX38 linear class A wide-band amplifier, delivering 700mW at -60dB intermodulation in Bands IV and V; two Gunn oscillators for 3cm work and some gallium arsenide avalanche diodes for use as X-band oscillators, producing 4W.

Pentawatt is the name given by SGS-Ates to the new 5-lead package with an integral bolt-down heat sink, claimed to be usable up to 50W.

Instruments

While we were not primarily looking for new instrumentation, it was there in abundance, and must be mentioned at least.

Marconi Instruments TF2370 spectrum analyser displays the spectrum of the signal in a completely new way. The information normally presented in analogue form—the spectrum—is stored in a memory which is organized as a 256×512-point matrix. The 512-point axis corresponds to the x axis, or frequency base of the display, and the memory is addressed as the sweep progresses, so that at the end of a sweep, the point of the spectrum at each frequency increment is stored at one of 256 (vertical) addresses or one of the 512 (horizontal) lines. At the end of the sweep, the memory is read at a rate of 76Hz, modulating the brightness of 512 vertical lines to produce a representation of the spectrum. The system has the advantage that the spectra of non-repetitive signals can be displayed without loss of brightness or the use of storage tubes. It also permits two images to be displayed, for example a reference trace and the signal from a circuit under test. Resolution is 5Hz and 0.1dB, a 100dB dynamic range is provided and a 9-digit frequency meter is incorporated.

New equipment from Philips includes the PM3260, a dual-trace 120MHz oscilloscope with 5mV sensitivity. An extremely high e.h.t. of 20kV enables the observation of the "two nanoseconds every other Thursday" type of phenomena. Time-base speed is 5ns/cm and y rise time is 3ns. The PM3010 is a dual-trace instrument measuring only $86 \times 153 \times 190$mm and weighing 1·8kg, but providing a y bandwidth of 5MHz with sensitivity of 30mV/div. The battery pack is rechargeable.

From Iskra, the Digimer 1 is a 3-digit multimeter for a.c. and d.c. volts and current, and resistance. Resolution is from 0.1mV, 0.01mA and 0.1Ω. The unit is of unusual form, being somewhat like a tiny petrol pump in appearance, the readout being where the gallons normally appear. Each function is selected by a separate unit, which is plugged into the base to form a foot.

Research Notes

Yoga and electronics versus stress disease

A medical use of a closed-loop feedback system has been reported in the *Lancet*. The patient is part of the loop and the feedback is used to change of the state of his body.

High blood pressure is often the result of psychological stress. A possible treatment is to relieve the stress by Yoga exercises, which can relax both the mind and the body. An Indian-born doctor, Mrs Chandra Patel, now working in London, has reported encouraging results. She uses a simple measurement (skin resistance) as an indicator of tension. The patient's skin resistance is made to control the frequency of an audio oscillation. By monitoring the pitch the patient can "hear himself relaxing" and this helps him to improve his performance of the relaxation exercises. Some of Dr Patel's patients have been able to reduce or even abandon the use of drugs to relieve blood pressure.

The *Lancet*, 73.11.09

Neutron radiography

If a metal-and-plastic clock is X-rayed, only the metal parts show up clearly. If neutrons are used instead of X-rays only the plastic parts appear. This useful property makes neutron radiography complementary to X-radiography.

The physical basis of neutron radiography is the way in which neutrons interact with matter. A neutron has about the same mass as a proton, and this makes it interact more strongly with single protons than with heavier nuclei. (It merely "bounces off" a heavy nucleus, with little loss of energy—an elastic collision.)

In nature, single protons occur in hydrogen atoms, so the substances which stop neutrons most effectively are hydrogen compounds such as water and plastics. Living tissue, which contains both water and organic compounds, is also revealed.

A difficulty in neutron radiography is that the silver compounds in photographic film do not interact strongly with neutrons, so ordinary photographic film cannot be used to register neutron pictures. At the Nuclear Research Centre at Karlsruhe in West Germany, where neutron radiography is used to take pictures of the insides of fuel elements, much work has been done to find ways of facilitating photography. What is required is some means of image conversion which can change the emergent neutron beams into some form of radiation which affects a photographic emulsion. The required conversion can be accomplished by allowing the neutrons to pass through thin films of metals such as dysprosium, gold, indium and gadolinium. The neutrons activate the metal atoms and make them emit various kinds of radioactive rays which follow the same density pattern as the neutron beams.

Exposure of the film can either be direct, with the film and foil in contact during neutron bombardment, or indirect. The indirect method makes use of the fact that the neutron bombardment leaves the metals slightly radioactive. The foil therefore serves as a storage device, and a photograph can be made by laying it over a film and leaving it there until the "remembered" radiation pattern has exposed the film sufficiently.

The exposure times required for neutron radiography are short, compared with X-radiography, and the technique has possible medical uses.

Black holes and naked singularities?

Astronomers are beginning to search for "black holes", strange dead stars. Since they emit no light or radiation of any kind the search is difficult, and may well require the aid of electronics for success.

The notion of a black hole is quite simple, and goes back to the 18th century. Laplace pointed out that, according to Newtonian physics, the "escape velocity" which a moving object has to reach in order to leave a star increases as the gravity at the star's surface increases. In a very large star, with the same density as the earth, gravitation could be so intense that the escape velocity would exceed the velocity of light. So nothing, not even light, could leave the star, which must appear black to an outside observer.

Stars of the required size do not exist, but there is good reason for believing that the necessary gravitational strength can be obtained in another way, namely the packing of all the mass of a normal-sized star into a very small space. What governs density is energy. Thermal energy keeps atoms and molecules apart. The energy inside the atom keeps the electrons away from the nucleus. It is theoretically possible for this energy to be lost as radiation, giving rise to an unimaginably dense body made up of closely packed atomic nuclei. If such a collapsed star has a mass greater than about 1.3 times the mass of the sun then the gravitation can be large enough to prevent light, radio waves, X-rays and all other forms of radiation from leaving. The star is black. But the process doesn't stop there. The gravitation is by now so strong that the matter of the star continues to be crushed. The star becomes even smaller and denser, until perhaps it shrinks away to nothing. But so long as its gravitation remains it appears from the outside as a black hole of a size which depends on the mass; in other words, the "black hole" begins where gravitation reaches the required intensity and does not depend on the size of the lump of matter inside.

How do you detect a black hole without going close to it and so running the risk of being sucked in and destroyed? One possibility is to find a black hole which is one partner of a double star, that is, two stars orbiting about one another. To an observer, the pair would appear as a single visible star which exhibited peculiar motions. Another possibility involves a possible amplification effect on passing electromagnetic waves. A wave passing near the star could split into two parts, one being sucked into the black hole and the other continuing outside. These two waves could in theory interact in such a way that the internal wave reinforced the external wave. The effect is small, but it is possible that a positive feedback mechanism might exist which would allow the external wave to reach a large amplitude before leaving the sphere of influence of the black hole.

An even stranger possibility is the "naked singularity", which is a completely collapsed star *not* contained in a black hole and therefore capable of being communicated with. It may seem impossible to communicate with a speck of nothingness made of energy-less matter, but the prospect is not necessarily as bleak as that. If the collapsing star is spinning, as many stars are, then it still has angular momentum, and this prevents it from collapsing into nothing. There may, therefore, be very small, dense, spinning bodies which can reveal their presence in some way, such as exciting nearby gas into states which produce radiation.

It all sounds rather abstract, but black holes and singularities are of such great interest to physicists and cosmologists that the search for them is bound to continue over the years.

"Horn loudspeaker design"

We apologize that it has been necessary to postpone the publication of the second part of J. Dinsdale's article "Horn loudspeaker design". This second part will now appear in the May issue.

Doppler distortion in loudspeakers

Simple techniques for the separation, measurement and assessment of intermodulation distortion due to the Doppler effect

by James Moir, F.I.E.E.

James Moir & Associates

The significance of the Doppler distortion produced by loudspeakers has been the subject of discussion for many years, opinions ranging all the way from "there isn't any such distortion", to the very opposite view that it is "the main source of distortion in loudspeaker reproduction". Such wide differences of opinion generally arise when there is no well founded body of measured data on the extent of the distortion, but in this instance, the issue has been clouded by the different methods of expressing the scanty data that is available. It should assist our understanding if the origin of Doppler distortion is clarified.

Frequency intermodulation distortion

Consider a loudspeaker reproducing two tones having frequencies f_1 and f_2, with a frequency ratio of twenty to one, then while the loudspeaker cone is moving towards the listener to reproduce one half cycle of the lower frequency, f_1, it will simultaneously reproduce ten complete cycles of the higher frequency, f_2. On the reverse half cycle of the lower frequency, while the cone is moving away from the listener, it will reproduce the second ten cycles of the higher frequency. This is a classical Doppler situation, the pitch of the higher frequency as heard by the listener, being increased as the source moves towards the listener, and decreased as the source moves away from the listener.

An observer listening to a signal frequency, f_2, from a source moving towards him with a velocity, v, hears the resultant note with a frequency, f_2', where,

$$f_2' = f_2(c+v)/c$$

where c = velocity of sound in air. When the source is moving away from him he hears the note as having a frequency,

$$f_2'' = f_2(c-v)/c$$

The velocity of sound in air is around 1125ft/s and the velocity of the cone generally below 10ft/s but dependent, of course, on the frequency and amplitude of the lower frequency. Thus the maximum change in pitch (frequency) due to the Doppler effect is in the region below 1%.

When the moving source is a loudspeaker diaphragm executing a sinusoidal motion, the note as heard by the listener will swing cyclically between the two limit frequencies quoted above at the frequency of modulation, f_1, a simple example of frequency modulation. The mathematics of this are well understood, the known result being the appearance of two sidebands, symmetrically disposed about the carrier frequency at frequencies $(f_2 \pm f_1)$ and having amplitudes that are an indication of the extent of the Doppler distortion. It is necessary to differentiate between the value of the carrier frequency shift Δf_2 measured in hertz and the frequency at which the sidebands due to this shift appear. The carrier shift is an indication of the extent of the Doppler distortion and it is at its acceptable limit when it is only 20–30Hz. The sidebands are always spaced from the carrier at the frequency of the modulation, f_1, because the carrier frequency deviation is cyclic at this modulating frequency.

The amplitude of the two sidebands can be predicted by some mathematical manipulation of the basic equation for a frequency modulated wave.

$$v = V_0 \sin(2\pi f_1 t + M \sin 2\pi f_2 t) \quad (1)$$

where

$$M = \frac{\text{carrier frequency deviation}}{\text{modulating frequency}} = \frac{\Delta f_2}{f_1}$$

Quantity M is the modulation index, familiar to the engineer interested in frequency modulation broadcasting. With the standards adopted for f.m. broadcasting a transmitter fully modulated to a deviation of 75kHz by a 15kHz signal, has a modulation index of 75/15 = 5 but as will be seen in the later discussion the frequency deviation in any audio application is at its very worst, only a few tens of herz and the resultant index, M, is almost invariably much less than unity.

The amplitude of the two sidebands that are generated can be obtained by expanding Equation 1 in Bessel form. It has been shown that this results in the series,

$$\begin{aligned} e = {} & EJ_0(M)\sin 2\pi f_2 t \\ & + J_1(M)\sin(2\pi f_2 t + 2\pi f_1)t \\ & + \sin(2\pi f_2 - 2\pi f_1 t)t \\ & - J_2 \ldots \end{aligned} \quad (2)$$

where J_0: Bessel function of order 0
J_1: Bessel function of order 1
J_2: Bessel function of order 2.

Values of $J_0(M)$, $J_1(M)$, $J_2(M)$ can be obtained from standard mathematical tables but examination of the data indicates that if the analysis is confined to the frequency deviation range that is of real interest in Doppler distortion problems, then M is always below 1 and the sideband amplitude is then simply $M/2 \times$ the amplitude of the carrier frequency.

If it is assumed that the lower frequency signal applied to the loudspeaker is 100Hz then for $M = 0.1$, $M/2 = 0.05$ and the two sidebands have amplitudes that are 5% of the amplitude of the carrier frequency f_2. The deviation $\Delta f_2 = 0.1 \times 100 = 10$Hz. This is the frequency deviation Δf_2 of carrier f_2 and if this has the standard test frequency of 3kHz the flutter amounts to 10/3000 = 0.3%.

Amplitude intermodulation distortion

Distortion sidebands of a very similar type appear when a two frequency signal is applied to any device that has a non-linear input/output characteristic[1]. If two sinusoidal voltages $V_1 = V\sin(2\pi f_1 t)$ and $V_2 = \sin(\pi f_2 t)$ are simultaneously applied to a device having a transfer characteristic represented by the power series,

$$V_0 = a_1 V + a_2 V^2 + a_3 V^3 + a_4 V^4 \quad (3)$$

the output will include in addition to the harmonics of f_1 and f_2 two sidebands having frequencies of (f_2+f_1) and (f_2-f_1) with amplitudes proportional to the coefficients a_2 and a_4 in Equation 3. It will be seen that the frequencies of these two sidebands are identical to those produced by frequency intermodulation but the amplitude of the two sidebands is determined by an entirely different factor, the degree of amplitude non-linearity in the device. The extent of this non-linearity is indicated by the value of the coefficients a_2 and a_4 in the power series of Equation 3. The sidebands produced by this amplitude dependent intermodulation are subsequently referred to as the a.i. sidebands. These a.i. sidebands are produced in loudspeakers by non-linearities in the suspension, non-uniform distribution of the magnetic field in the gap and at higher frequencies by non-linearities in the cone material.

The distortion spectrum that results from applying two separate test frequencies is in the simplest example like that shown in Fig. 1. The two sidebands $f_2 \pm f_1$ are the sum of the Doppler and amplitude modulation components whereas the $f_2 \pm 2f_1$ are almost invariably due to amplitude intermodulation. The remaining two distortion components are the first two harmonics of the two test frequencies f_1 and f_2.

It should be remembered that the presence of the amplitude intermodulation sidebands implies the simultaneous presence of harmonic distortion components having frequencies of $2f_1$, $3f_1$, $2f_2$, $3f_2$, etc. These have no equivalent in the frequency intermodulation case. With the same amount of distortion *power* in both the f.i. and a.i. sidebands, the total distortion power due to the amplitude dependent distortions will usually be the greater proportion of the total distortion. The first order intermodulation sidebands whether due to Doppler or amplitude intermodulation are seen to form only a small part of the total distortion. It is thus unlikely that their presence will be easily detected.

It has generally been considered that the amplitude dependent distortions were the prime cause of much of the residual distortion in loudspeakers. Perhaps it should be remembered that it has never been conclusively demonstrated that the addition of the lower order harmonics alone results in any significant loss in sound quality. Thus violins, all of unquestionable tonal quality, differ markedly in their harmonic structure. The quality deterioration that is evident when harmonic distortion is present is generally assumed to be due to the sidebands components $(f_2 \pm f_1)$, $(f_2 \pm 2f_1)$ etc., that inevitably accompany harmonic distortion, but do not accompany the harmonics in musical instruments.

Measurement technique

Separate determination of the amplitude of the a.i. and f.i. sidebands has evidently proved difficult if judged by the complexity of some of the techniques used. The technique to be described provides a simple method of not only separating the two sets of sidebands from each other but allows the f.i. sidebands to be separated from the music being reproduced by the loudspeaker.

Our technique is to insert an amplitude limiter and f.m. discriminator designed for a carrier frequency of 3kHz into the measuring system. This particular carrier frequency was chosen as it allows data obtained to be compared with that obtained by other investigators[2] when assessing the subjective effect of wow and flutter, a very similar form of frequency intermodulation distortion.

The arrangement of the test equipment is shown in the block diagram of Fig. 2. Test signals are provided by two Bruel and Kjaer type 1014 signal generators, adequately decoupled and fed via a Quad type 303, 50 watt amplifier to the loudspeaker under test mounted in the open air. The output signal from the loudspeaker is picked up by a Bruel & Kjaer type 4131 microphone mounted on the axis of the speaker at a distance of 1 metre, amplified and then fed in parallel to the 3kHz limiter and discriminator and to a Marconi type 2330 narrow band analyser. Meter M_1, checks the amplitude of the two separate input signal components f_1 and f_2 and the total amplitude of the combined signals, meter M_2 reads the f.m. distortion components only, while meter M_3 indicates the amplitude of each of the individual components of the speaker output signal spectrum. The reading of M_2 is proportional to the frequency deviation of the carrier f_2. This is related to the modulation index, M, by the simple relation,

$$M = (\Delta f_2 \times f_2)/f_1$$

Beers and Belar[3] derived an equation for the f.m. distortion components. This is,

$$\text{distortion factor} = 2900\frac{f_2 \times \sqrt{P_1}}{f_2^{\,2} \times d^2} \quad (4)$$

where P_1 is the power at frequency f_1 and d is the cone diameter.

This equation provides a guide to the relations that should exist among the data collected.

It will be seen that the distortion should be proportional to the frequency f_2 and to the amplitude of f_1 (i.e. $\sqrt{P_1}$), be independent of the amplitude of f_2 but inversely proportional to the square of the cone diameter. A measuring system intended to obtain data on the amplitude of frequency modulation sidebands should meet the following requirements. (1) The limiter and discriminator should not respond to an amplitude modulated signal. (2) No frequency intermodulation components should be measurable at the amplifier output terminals when the two-frequency test signal is applied.

As used, the measuring system provided loudspeaker distortion values that were independent of the amplitude of f_2 over a range of at least 10:1 and they were directly proportional to the amplitude of f_1 up to a power output at least ten times the power applied to any of the loudspeakers during testing. The requirements of (1) and (2) were met with a large factor of safety.

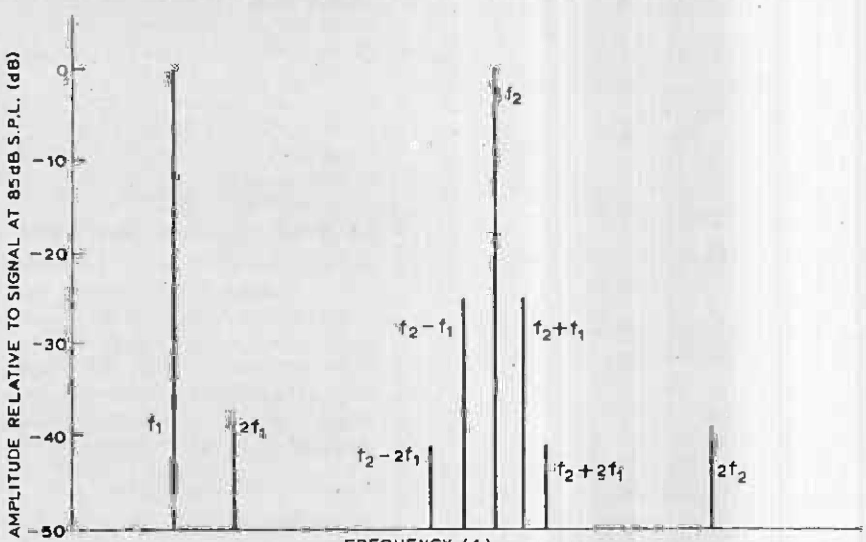

Fig. 1. Distortion spectrum of a 7in loudspeaker unit.

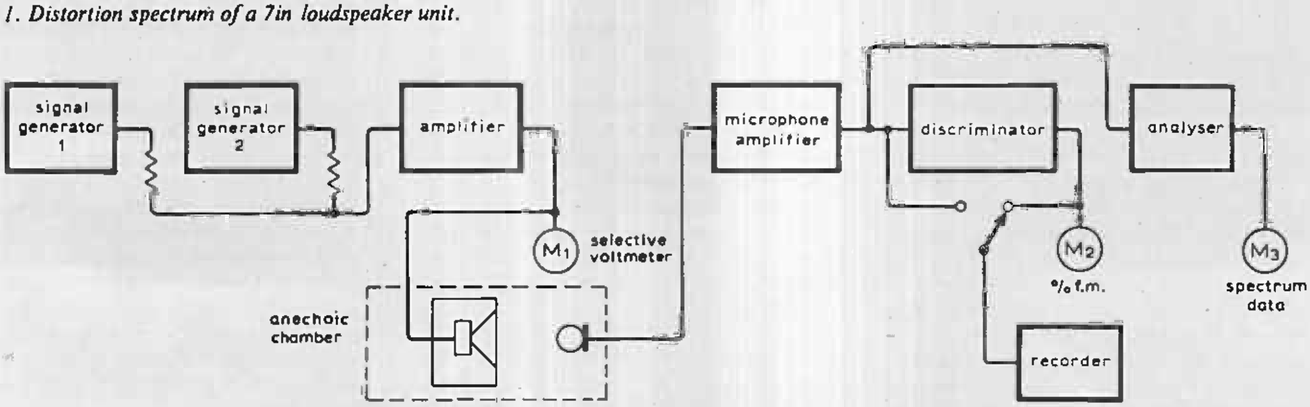

Fig. 2. Block diagram of the test equipment.

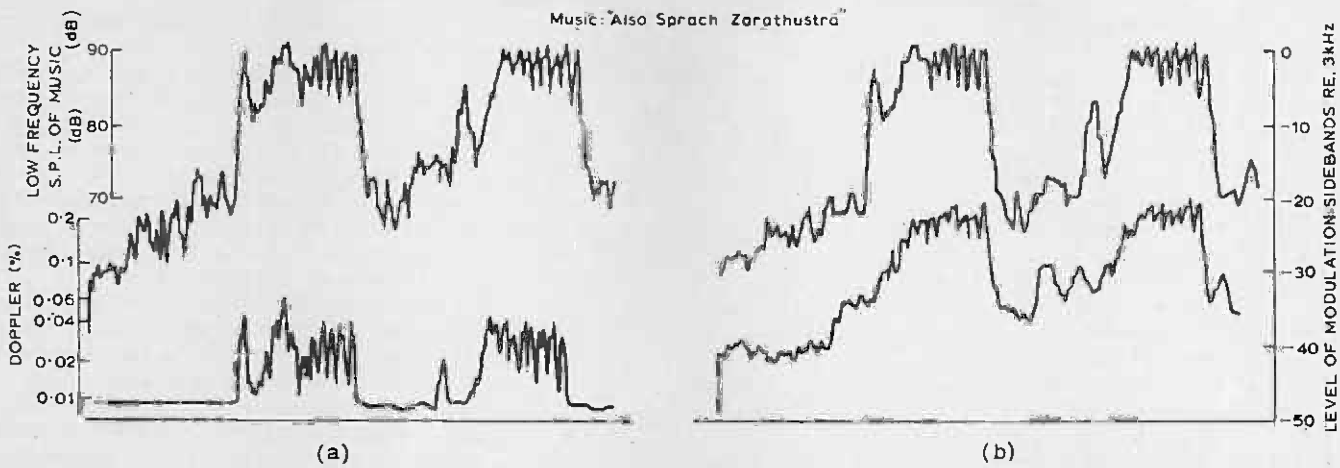

Fig. 3. Level of Doppler distortion. See text for further explanation (a) 12in (30.4cm) diameter loudspeaker (b) 4in (10.1cm) diameter loudspeaker.

Amplitude intermodulation measurement

While the test system as shown in Fig. 2 measures the frequency intermodulation components alone, and ignores the amplitude intermodulation components, it appeared desirable to be able to separately measure these amplitude intermodulation sidebands. To do this advantage was taken of the absence of any frequency term in Equation 3. Thus when none of the coefficients of V in Equation 3 are frequency dependent, the amplitude intermodulation distortions produced are independent of the test frequencies, provided only that the amplitudes of the test signals are held constant. A choice of two frequencies such as 4kHz and 900Hz eliminates almost all the components due to frequency intermodulation, leaving only the intermodulation components due to amplitude interactions.

Experimentally, this is found to result in a modulating frequency of about 200Hz. Below this, the coefficients become frequency sensitive. To obtain data in this region, advantage is taken of the dependence of the a.m. components and the independence of the f.m. components on the amplitude of f_2. Experience, subsequent to the development of the technique, has shown that there is little advantage in using it for measuring the amplitude of the a.m. sidebands, values of adequate accuracy being obtained by subtracting the measured value of the f.m. sideband amplitudes from the measured value of the total sideband amplitude. There is some phase ambiguity in this but it does not appear to be significant in typical loudspeakers. We now have a test system in which the amplitude intermodulation and frequency intermodulation components can be separately measured.

Measurement of frequency intermodulation distortion is generally carried out with the lower frequency f_1, somewhere around 70 to 90Hz. A loudspeaker having a frequency response limited by a high cone-surround-enclosure resonance frequency will not reproduce at constant level frequencies below this resonance frequency because of the restriction to cone motion. In consequence, it will minimize Doppler distortion. Conversely a loudspeaker having a prominent bass resonance in that portion of the frequency band containing high levels of bass signal, will introduce considerable f.i. distortion.

Test samples

The data obtained on three of the speakers is typical of the results obtained on many other units. They are fairly representative of the products available on the market but the choice was biased towards demonstrating the effect of radiator size on the frequency intermodulation distortions.

The first unit tested was a 12in (30.4cm) cone speaker covering the full audio range mounted in a ported enclosure having a volume of 3,200 cu. in. The second was an enclosure of 1498 cu. in using a single 7in (17.7cm) diameter unit to cover the full range. The third was a 4in (10.1cm) diameter unit in an enclosure of 400 cu. in.

All three systems were operated at an on-axis sound pressure level of 85dB at the carrier frequency of 3kHz. It is appreciated that this may be a little below the sound level at which the hi-fi enthusiast may operate his system but it enabled the performance of the three systems to be compared without grossly overloading the smaller units. In all cases the level of the lower frequency, f_1, was varied over a range sufficient to confirm the expected relation between sound pressure level and distortion.

Test data

The first result was the finding that the amplitude of the f.i. sidebands as calculated from Equation 2, for the two smaller speakers, agreed almost exactly with the measured values. This suggested that substantially *all* the distortion sidebands ($f_2 \pm f_1$) introduced by these speakers were due to frequency intermodulation, the amplitude intermodulation sidebands being at least 20dB below the frequency intermodulation sidebands at the same frequencies. This was confirmed by further analysis of the 12in unit where the a.i. distortion just about equalled the f.i. distortion. Typical test data is quoted in the following table, the results applying to a sound pressure level of the f_1 component of 85dB at a frequency of 80Hz.

It is interesting to note that the amplitude

Intermodulation distortions in typical speaker systems

Cone diameter (in)	Amplitude (dB)	Frequency (dB)
4	−40	−16
8	−41	−25
12	−43	−41

intermodulation components showed little dependence on cone diameter, not only in the three units used for the tests quoted above, but in a large number of other units tested. This rather suggests that this residual distortion is a basic property of the diaphragm material, but no further work has been carried out on this aspect of speaker performance.

Distortion on programme

In practice, frequency intermodulation takes place between all the components of a complex music signal rather than between one high frequency and one low frequency signal. Music has an extremely complex and continuously varying frequency spectrum so another technique was devised to show the amount of frequency intermodulation distortion developed during the playing of an ordinary programme. This technique takes advantage of the lack of dependence of the frequency intermodulation distortion on the level of the higher frequency carrier signal, f_2.

A notch filter tuned to 3kHz is inserted at a convenient point in the amplifier system to remove the 3kHz components of the music, but at a later point in the chain, a 3kHz signal from a signal generator is inserted and adjusted to about 50% of the programme level.

A filter in the microphone pre-amplifier circuit removes this inserted signal and the 3kHz band from the reproduced signal and channels it through the limiter and discriminator and into a high speed chart recorder. With the filter and the limiter and discriminator out of circuit a chart record of the signal at the microphone output is obtained. The chart is then re-wound, the filter inserted, the record replayed and the

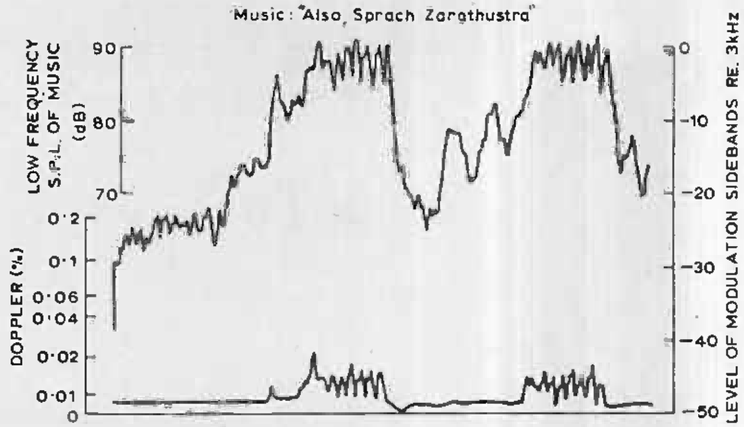

Fig. 4. Level of Doppler distortion for a well-known electrostatic loudspeaker.

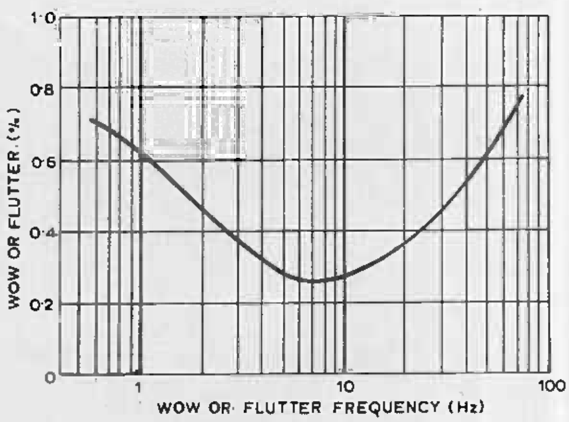

Fig. 5. Subjective thresholds for sinusoidal modulation of piano music.

output of the discriminator recorded below the upper music curve. Thus we obtain two curves showing music and f.i. distortions on the same chart. This arrangement has the subtle advantage that it also eliminates all the wow and flutter modulation present in the recordings where these were used as test material.

Typical results obtained on two speaker systems are shown in Fig. 3 as confirmation that the test system is not a limiting factor. Fig. 4 illustrates the results obtained on a well-known electrostatic loudspeaker. This particular unit has lower f.i. distortions than any other type so far tested.

Significance of Doppler

We now come to the significance of the Doppler distortions, a more contentious subject, ignoring the suggestion that it does not exist. The next line of defence is usually that the Doppler distortion cannot be heard and therefore is of no consequence. This is a sterile line even if it were well founded. Progress towards the perfect reproduction can only be achieved if each distortion is removed as it is identified. If we find a way to remove an inaudible distortion, it should be removed to help bring into prominence the remaining distortions and allow those to be deat with. As each distortion is removed those remaining become more obvious and at a later stage in the development, the distortion that was inaudible becomes of prime concern.

How should we assess the importance of Doppler? The existence of several schools of thought has led to much misunderstanding. If in a particular loudspeaker the sidebands due to Doppler are of greater amplitude than the sidebands at the same frequency due to amplitude modulation, it is almost certain that the Doppler sidebands are subjectively more significant. The amplitude of the Doppler sidebands as a percentage of the carrier can then be compared with the amplitude of the a.m. sidebands at the same frequency expressed in the same way. This is the technique we use to indicate the relative importance of the a.m. and f.m. sidebands. On this interpretation virtually all the sidebands are due to Doppler when using single loudspeakers having cone diameters below twelve inches. At this diameter the a.m. and f.m. sidebands are about equal, but in speakers having cone diameters above this value the a.m. distortions predominate.

We have earlier noted that the sidebands whether due to Doppler or amplitude intermodulation are only a small part of the total distortion spectrum and if judged on this basis it is possible to show that their presence is of no significance. There is, however, little evidence to suggest that the lower harmonics themselves are subjectively annoying, largely because they are harmonically related. This simple harmonic relation does not hold for any of the sum and difference components so they may be expected to be more annoying per per cent, than the harmonics. For these reasons it would seem unreasonable to expect the subjectively judged distortion to be indicated by comparing the power in the Doppler sidebands to the total distortion power.

Yet other approaches are to express the amplitude of the f.m. sidebands as a percentage of the amplitude of the carrier frequency f_2 or to compare the total power in the two f.m. sidebands to the power in the carrier frequency f_2. We feel that neither of these are as realistic as comparing the amplitude of the a.m. sidebands and Doppler sidebands at the same frequency.

An alternative way of assessing the importance is to compare the values of flutter that result from the Doppler process with the known data on the significance of flutter. The most comprehensive data is that due to Stott and Axon.[2] In a well conducted experiment they found that the "just audible" amount of flutter was around 1%, when reproducing piano music. Their data is reproduced in Fig. 5. On this basis all the loudspeakers used in our music recording tests would be adequate. I personally would reject this view, feeling that even a moderately experienced observer is about ten times more sensitive to flutter than Stott and Axon suggest. Thus on balance, I feel that comparing the amplitude of the f.m. and a.m. sidebands gives a true picture of the relative importance of the f.m. and a.m. sidebands.

Listening tests

Obtaining a decision by listening tests is unlikely to be a simple matter. Not only is the distortion power in the sidebands a small part of the total distortion but the f.m. and a.m. sidebands vary in different ways when the amplitude of the high frequency signal, changes. The Doppler component is not dependent upon the amplitude of the high frequencies being reproduced, whereas the amplitude intermodulation distortion is directly proportional to the amplitude of the higher frequencies. Thus the proportion of the f.m. and a.m. sidebands to the total sideband distortion power varies continuously as the music spectrum changes.

We have attempted to assess the importance by experiment but only with a small listening crew. The Doppler sidebands in the 3kHz region were removed by suitable filters and tape recorded. The a.m. sidebands were similarly obtained by filtering from the signal spectrum in a slightly overloaded amplifier and these were also tape recorded. The two sets of sidebands were then compared when reproduced at the same level. Both observers were agreed that the Doppler sidebands were subjectively more annoying than an equal percentage of the a.m. sidebands.

As a second check the performance of three loudspeakers having very similar frequency response and amplitude distortion figures but very different Doppler distortion figures were subjectively compared and again both observers decided that the speakers with the higher Doppler distortion values sounded rougher than the speaker with low Doppler distortion values. The result is more convincing because the decision about the sound quality was made before either of the observers knew that one of the speakers had much lower Doppler distortion values than the other two units.

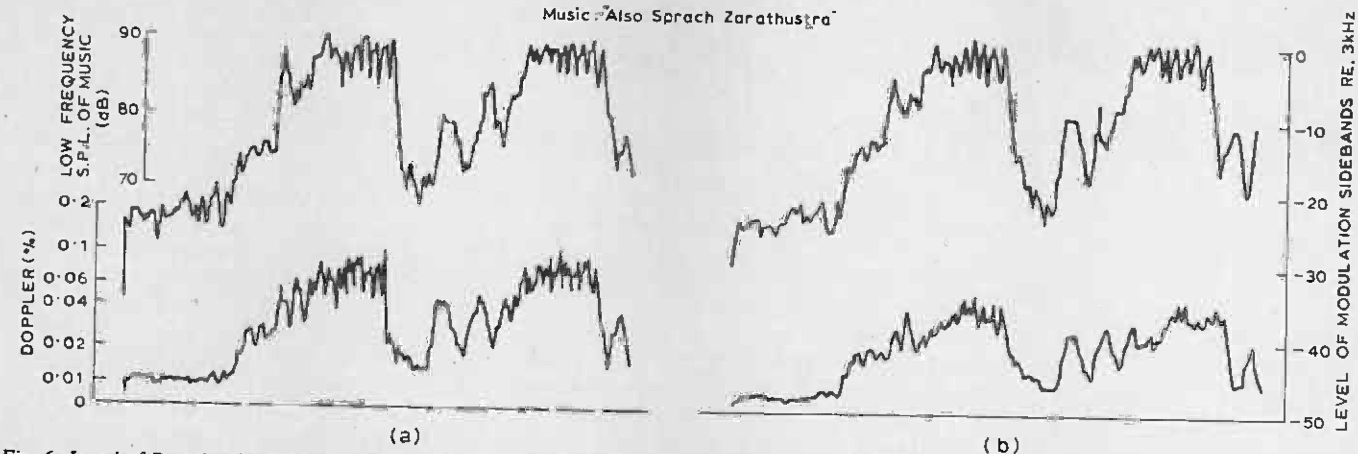

Fig. 6. Level of Doppler distortion (a) three unit monitor with 3kHz cross-over frequency (b) three unit monitor with 2kHz crossover frequency.

Reduction of Doppler

On the basis of the test data presented earlier it appears necessary to have a bass radiator area not less than about 120–150 square inches in any single wide band loudspeaker.

It is often thought that the use of a two unit system is a complete solution but this is highly unlikely when changeover frequencies in the kHz region are used, a practice that is almost universal because of the extension of the frequency range that results. All the signal components below the changeover frequency are then Doppler modulated. If two separate units are used, each dealing with a fraction of the total spectrum the crossover must be in the 300–500Hz region to remove the relatively large low frequency signals from the high frequency unit.

This aspect is well illustrated by the charts in Fig. 6 representing two high quality (and high priced) speaker systems. In respect of Doppler distortion, it will be seen that neither system is significantly different to the single 12 inch unit. On comparing these results with those quoted earlier for the electrostatic speaker, the electrostatic unit distortions are about five times lower than the speaker system using a 3kHz cross-over.

Simple cross-over networks are of little value. A series capacitor achieved very little, for the current in the speaker unit is then directly proportional to frequency below the cross-over frequency and the h.f. unit tends to operate as a constant velocity device up to the changeover frequency. Any cross-over network must have an attenuation of at least 12dB/octave below cross-over to effectively eliminate low frequency modulation of the high frequency speaker.

A three unit system can be a further step in the right direction if the lower changeover frequency is below about 500Hz but it is not automatically so. The acoustic impedance facing the middle range and high frequency unit diaphragm is modulated by the low frequencies reproduced by the larger low frequency speaker and in some systems this results in appreciable Doppler distortion.

As another alternative, horn loaded designs, can be adopted. The mouth area of the horn is then the effective area of the low frequency radiator. This is generally several hundred square inches and thus Doppler distortion is almost invariably very much lower than from any other type of speaker. This is one reason and possibly the major reason why horn loaded loudspeakers usually have a "cleaner sound" than any open diaphragm speaker system though this may be accompanied by a more restricted bass response. It is suggested that the achievement of low distortion is much more important in obtaining good sound quality than any extension of the frequency range below 70–100Hz.

Acknowledgement

I have to thank Mr W. R. Stevens of our laboratory who produced practically the whole of the experimental data.

This article is the essence of a paper read at the September 1973 meeting of the Audio Engineering Society of America in New York.

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2. Stott & Axon, "The Subjective Discrimination of Pitch and Amplitude Changes", *Proc. Inst. Elec. Engs*, Vol. 102B, No. 4, 1949, pp. 643–656.
3. Beers & Belar, "Frequency Modulation Distortion in Loudspeakers", *Proc. I.R.E.*, Vol. 31, No. 4, April 1943.

Communications 74

Brighton June 4 to 7

Users of radio and line communications systems will find the very latest techniques and equipment described and demonstrated at "Communications 74", a four-day conference and exhibition to be held at the Metropole Convention Centre, Brighton, Sussex, from June 4 to 7. Over 100 exhibitors will take part and 56 papers will be read. Some papers and exhibits will be of interest to communications equipment designers. Full details will be given next month but here is some advance information:

Exhibition. The 100 or more exhibitors will include many of the best-known names in the UK electronics industry, together with organizations such as Cable & Wireless, the Post Office, the MPT, the Ministry of Defence and the Home Office. The event is supported by the Department of Trade and Industry and the Electronic Engineering Association, and will cover the fields of data communications, civil mobile radio communications, fixed radio communications, defence communications, recording systems, test equipment and ancillary devices and equipment. For free exhibition tickets contact the organizers: ETV Cybernetics Ltd, BETA, 109 Kingsway, London WC2 6PU (telephone, 01-405 6233; cables, BUSQUIP LONDON WC2).

Conference. The 56 papers are to be presented by speakers from well-known companies, colleges, Government departments and other organizations in the field of communications. Overseas speakers will come from Canada, Denmark, Germany, Japan, Sweden and the USA. Organized by *Electronics Weekly* and *Wireless World*, the conference will be divided into four broad subject areas: June 4, data communications day; June 5, mobile communications day; June 6, fixed communications day; June 7, defence communications day. While the emphasis of the conference is on uses of communication systems, there will be four equipment design papers presented on each day, run in a separate morning session. For further information contact: Roger Woolnough, IPC Electrical-Electronic Press, Dorset House, Stamford Street, London SE1 9LU (telephone, 01-261 8590).

News of the Month

Anglo-French digital telecommunications pact

France and Britain are to collaborate in the development, manufacture and marketing of a digital telecommunications switching system. It will be based on a combination of the existing E10 digital switch, developed by the French company CIT-Alcatel and at present operated in the French public telephone network, and the system 250 stored programme control processor, developed by Plessey.

The importance of the digital switch is its use in the pulse code modulation system of digital transmission which has already been adopted by the British and French Post Offices as their future standard and which administrations all over the world are expected to turn to in the 1980s.

Development costs could be 5 to 10 million pounds, and the partners claim that the world market for their sort of product in the early 1980s will be around £500m a year—excluding the US, Japan and Germany. The system is code-named Felicite and the partners should be ready to take orders by the end of 1976.

Sonex versus Hi-Fidelity '74

Competition for the annual Sonex audio exhibition held this year at the Post House Hotel, Heathrow will have given the organizers food for thought. Thirty companies exhibited their products at the nearby well-organized Hi-Fidelity '74 exhibition in the Heathrow Hotel, as opposed to 35 at Sonex. Both exhibitions ran during the same period from March 27 to 31. The need for a new exhibition arose, according to the organizers, Pyser Britex (Swift) Ltd, through increasing annoyance expressed by manufacturers and distributors at the conditions under which they have been obliged to display their products at recent exhibitions—"It is impossible to mount a worth-while hi-fi exhibition where most of the products have to be displayed in small hotel bedrooms".

Attendance at Sonex was similar to that at the Hi-Fidelity '74 exhibition. Information on new products introduced at both shows will be presented in the next issue of *Wireless World*.

17% UK semiconductor growth predicted 40% for m.o.s. circuits

In predicting the growth of the UK semiconductor industry for 1974 at a "conservative" 17%, J. D. Hurley who is general manager of ITT Semiconductors said his forecast had been tempered because of recent increases in the price of gold (gold content can account for as much as 25% of device prices) and other raw materials. Despite the shortage of silicon wafers, due to the "lead" time of capital investment of two to three years following the 1971 recession, device prices had been held firm. Mr Hurley said in reviewing the semiconductor industry for 1973.

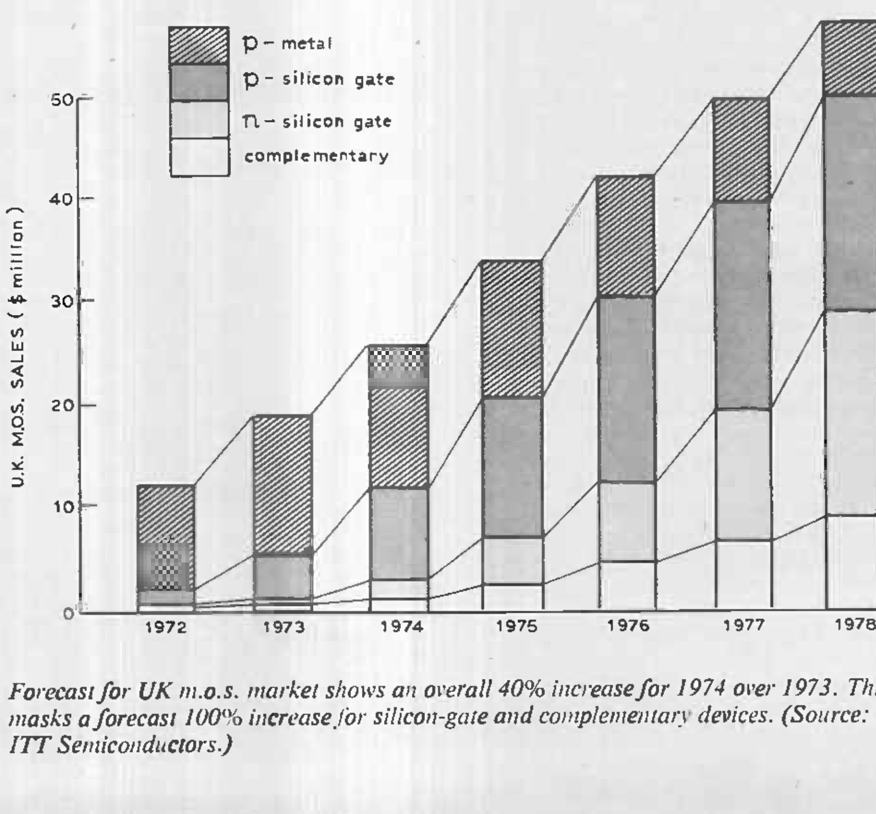
During that year there was a sharp growth in custom circuits (up by 100%), and a general semiconductor growth (28%) that exceeded ITT expectations (16%). A trend to m.o.s. and complex i.cs was confirmed, and "forward integration"—the semiconductor industry making complete calculators, watches, microcomputers and electronic cash registers—became fact. EEC legislation came into operation, one effect of which is that duty must be paid on equipment if the majority of devices used are not European.

For ITT Semiconductors it was a year of record export growth, and of 55 new products, contributing to a 25-fold increase in m.o.s., television and custom bipolar i.cs and an overall sales increase of 60% (against a predicted 30%). It also marked record capital investment for ITT—in new diffusion and design areas and in new equipment, both for mask-making and automated assembly. Three-inch silicon wafers can now be handled.

Other UK electronics industry predictions for 1974 include a 15% increase in value of semiconductor device usage in colour receivers, a 20% increase in telecommunications equipment and a 17% increase in the computer and industrial sectors. In the semiconductor industry, exports are expected to be up and imports down. A 40% growth in m.o.s. devices is anticipated with a doubling for silicon-gate and complementary devices—see histogram on this page. For themselves, ITT Foots Cray expect another year of high capital expenditure and a 47% sales increase, maintaining their capability in both m.o.s. and bipolar devices, and in both digital and analogue areas. Current m.o.s. involvement includes automotive products, "white" goods controls, industrial controls, telephone devices, display drivers for electronic voltmeters, cash registers, cipher machines, computers and calculators, as well as unspecified military systems.

Universal telephone microcircuit

A new m.o.s. l.s.i. microcircuit can provide the electronics for a line-powered, push-button telephone incorporating both access pause and re-dial facilities. It can be programmed to suit the impulse dialling speed, the mark-to-space ratio and the inter-digit pause of any national telephone system employing impulse dialling principles.



Forecast for UK m.o.s. market shows an overall 40% increase for 1974 over 1973. This masks a forecast 100% increase for silicon-gate and complementary devices. (Source: ITT Semiconductors.)

The microcircuit, AY-5-1100 series, was developed by General Instrument Microelectronics at their Glenrothes, Scotland design centre and has a 20-digit capacity to provide adequate storage for future intercontinental STD numbers. A re-dialling facility is provided in two of the versions. If a number is engaged, the caller merely presses the retain-button and replaces the receiver. Then when he picks up the phone, if the line is free, the number is set up ready to be re-dialled with one button depression. The microcircuit has been designed to work with a store-and-control chip to form a short number or "repertory" dialler.

The complete microcircuit sub-system, providing re-dialling facilities is available in an 18-lead d.i.l. package. Control pins are provided for externally adjusting the impulse rate, inter-digit pause and mark-space ratio.

In the 12-lead TO8 version, impulse rate, inter-digit pause and mark-to-space ratio are all mask programmed to the customers's specification, and the access pause and re-dial facilities are omitted. This circuit arrangement provides the optimum packaging solution for applications where single number repertory dialling is not required. Versions with 14 and 16 leads complete the options open to the manufacturer.

Error-free underwater communication

What is believed to be the first telegraph error detection and correction equipment designed specifically to provide teleprinter to teleprinter communication under water has just been completed. The equipment, called Sonar 2010 by the Royal Navy, was designed by Marconi Communication Systems Ltd, in collaboration with the Admiralty Underwater Weapons Establishment for Royal Navy underwater tactical communications.

The programme to produce the type 2010 equipment started in 1967 with a series of studies in which research equipment was taken to sea on vessels of the Royal Navy to determine the techniques that could be best employed to overcome the many difficulties that face the underwater communicator. The problem is particularly acute in data transmission, which has to cope with the effects of fades, multipath, noise bursts and doppler shifts caused by the relative motion between communicating vessels.

From the early research trials, a combination of techniques was involved, and this was followed by the design and manufacture of prototype production equipment. A further series of sea trials took place and the equipment was evaluated under a variety of propagation conditions chosen to represent those found in service use.

The trials were highly successful and beat the target of 98 per cent error free copy under a wide range of propagation conditions from shallow water, deep sea and rough sea to calm tropical conditions. It was also shown that the 2010 can pass traffic at a greater transmission rate than can be achieved by speech.

Production is scheduled to start this year and will cover a shipfitting programme of existing and new RN vessels over a period of years. Interest has also been expressed by NATO and Commonwealth countries.

These watches don't tick. Even so, 180 million were sold in 1972 and RCA expect the total to reach 300 million by 1980.

Sensitive solid-state TV camera

A very sensitive solid-state television camera, capable of taking pictures by the glow of a candle has just been developed. The new television camera is wallet-sized and weighs less than a pound. Developed by General Electric in the United States, it can be adapted for use with an ordinary television set to produce exceptionally crisp images even when light levels are extremely low.

The camera light sensor is a charge-injection solid state device—a quarter-inch-square m.o.s. chip which performs the same job as the camera tube in conventional TV cameras. Since the miniature device can be fabricated with current solid-state manufacturing techniques, it could be manufactured for a fraction of the cost of a conventional television camera.

Each pair of 20.000 capacitors on the imager-chip functions as an individual light-sensing device. As light strikes the chip, each capacitor-pair collects a charge proportional to the light striking it. To process the electrical charge into a television picture, each pair of capacitors is individually addressed by scanning circuits to release its charge, "injecting" it into the base of the chip. The imager can be scanned at speeds compatible with ordinary television sets. If a pair of capacitors should fail, the result is only one minute dark spot on the screen.

Circards award

The Circards idea has won recognition as the best innovation in IPC Business Press journals during 1973; *Wireless World* entered the scheme on behalf of the compilers—Jack Carruthers, John Evans, Joe Kinsler and Peter Williams, all of Paisley College of Technology—with the conviction that Circards was a unique innovation in electronics information publishing.

As well as providing performance graphs and data on tested circuits, both new and standard, Circards describe circuit operation, effects of component changes, how to modify circuits to extend performance, and give component values and suggestions for further reading. Articles published in the journal alert and introduce readers to the chosen topic. Format is chosen for ease of handling "at the bench".

Circards are available in sets of ten or 12 cards, at £1 per set (see p.100).

Optical reader captures data

A system based on an optical page reader has been developed by the Communications Branch of British Airways for use as an input device to their worldwide telegraph network. The airline is marketing the equipment in the UK under the name BARDATA.

An electric typewriter produces both the clearly human readable character and, immediately beneath it, a miniature bar code. By separating the need for the machine to read from a complicated character-comparison technique and allowing it to simply scan the bar code, it has been possible to produce an economic desk-top optical reader.

The technique, using a page reader by the Datatype Corporation of Miami, USA, was originally designed to provide an effective means of converting typed script into typeset for the newspaper industry. It can also be used as a computer input system and has application in the field of order entry and stock control.

Arthur Bulgin

A well-known personality in the British electronics industry, Arthur F. Bulgin, chairman of A. F. Bulgin & Co. Ltd, died at Westcliff, Essex, on March 29, aged 75 years. He was one of the founders in 1932 of the Radio & Electronic Component Manufacturers' Federation. His passing marks the end of 51 years in the industry.

Letters to the Editor

Sound radio compression

I realize that m.f. broadcasting is, by and large, a passé subject in this swinging quadraphonic era. Nevertheless, there must still be a lot of people about who, like myself, live in poor reception areas for v.h.f., listen to reasonable quality car radios, and have perforce to use m.f. when, as is becoming increasingly common, the complementary v.h.f. channels are devoted to different programmes.

In general I have no complaints about the quantity of signal received or of interference. What does get my goat is the apparently unnecessary and deliberate degradation of programme quality which results from the application of excessive degrees of audio compression at some transmitters.

Until a year or so ago the local prize for wooden sound was firmly held by the Brookmans Park Radio 4 transmitter but it has now passed to the most effective audio mangler I've heard for a long time, the Radio London transmitter at the same location. To hear the compressor of this one attacking the individual syllables of the words of slow speakers and rendering them almost unintelligible is an experience to forego.

I wonder if your erudite readership could provide me with a rationale for the practice and perhaps persuade me that, as a manifestation of "progress", it improves my listening lot.

C. Higham,
Olney,
Bucks.

Plug-in p.c. boards

As large users of professional audio equipment we have become increasingly concerned about one particular aspect of reliability. It has been our experience that a high proportion of faults are due to contact failure in switches, connectors, etc. Switches have improved considerably in recent years with the use of better contact material, but one area of persistent trouble is the plug-in printed circuit board.

This all seems to stem from the very widespread practice, with most manufacturers, of not fitting a male connector to the board. It is almost standard to form contact "fingers" on the edge of the board which are then "hard gold plated", and this then mates with various forms of edge connector. Without exception, we have had contact trouble with this type of board from every manufacturer whose products we use. In contrast to this we have been using p.c.bs in equipment that we have built ourselves, for about seven years, and each board is fitted with a male connector, usually the ISEP type made by ITT. To the best of our knowledge we have never had a failure using this system. The cost of a typical 25-way male connector is about 90p, and we consider this a small price to pay for reliability. The cost of a fault occurring on a recording session, with a studio full of musicians, can be very high. It is still worse if the fault is not a complete break and is not noticed until after the session. One further disadvantage of the board with integral connector is that, if you have the misfortune to drop a board on its connection edge, this can easily be broken. The whole board is then a write-off.

So manufacturers please note, you are indulging in dangerously false economy. Some of the p.c.bs can cost as much as £300 for a spare, and still they won't spend £1 or less on a male connector. One manufacturer of tape recorders even multiplies the madness by plugging one board into another which is itself plugged into a third board!

R. N. Goodman,
The Decca Record Company Ltd,
London, N.W.6.

The costs of engineering

Your editorial in the December 1973 issue on the "Costs of Engineering" calls for some comment. In the first place, the cost estimates made at the start of large engineering projects are usually made by engineers themselves and not, as you imply, imposed from without by authorities deficient in engineering competence. However, it is not my purpose to discuss this aspect of the problem in detail.

A more important matter which I wish to raise is to question the justification for basing policy in engineering project work so strictly on a purely "cost" basis as we have tended to do in the last two decades. To the accountancy minded managers by whom we have come to be dominated, "cost" has come to mean cost in the short term. Since accountants rarely look more than five years ahead, if as far, the cost of a project tends to be based entirely on the estimate of present-day costs or at best an extrapolation of these for a year or two ahead. It takes no account whatever of the real cost to the community as a whole over a much longer period extending often to several decades. An example which is currently only too obvious is the readiness with which we turned to oil for electricity generation and away from coal only ten or so years ago just because oil was then so much cheaper. Nor do the cost-accountants pay very much attention to the hidden or secondary costs of projects such as costs which may be attributable to polution of the environment.

It seems to me to be imperative to cease to regard short-term costs as so overwhelmingly important and instead to attempt to use value to the community in the longer term as the criterion by which to judge whether new engineering projects should go ahead or not. I accept that it is extremely difficult to arrive at credible estimates of value to the community but this is no excuse for not trying.

William Ross,
Malvern,
Worcs.

Model railway control system

I would like to reply to Mr Ganderton's criticisms (March, Letters) about my article "Model railway control system" published in the November 1973 issue.

Armature inertia after power is removed permits coasting for a few milliseconds as shown "typically" in Fig.1 of the article. The mechanism used does not affect the control system function; gear or worm and wheel mechanisms are both successful. The addition of a large flywheel increases the starting load of the motor and makes smooth "start from rest" more difficult than without a flywheel.

The "armature slot" (after removal of the armature) of some Hornby, now Hornby/Wrenn, mainframes can be sawn and filed out to take a ring field magnet and still retain the original bearings. A suitable magnet is obtainable from a "Monoperm" motor sold by Radio Control Supplies Ltd, 581 London Road, Isleworth, Middlesex. A 2-6-4 tank has been succesfully modified.

I agree that anyone lacking confidence in their skills with saw and file and electronics "should leave well alone".

Criticisms regarding Hornby ring field motors are best directed to Hornby & Co. Motors taking 2A under stalled conditions are quite suitable for the control system. The "about 6-watt" dissipation quoted in my article is for an eight-coach train traversing 3ft radius curves on a typical gradient (1:200) at full speed. Apparently, Mr Ganderton has overlooked the fact that it should not be necessary to apply full power to start a heavy train. On the train detailed above a 25% duty cycle was necessary, thus even under a 2A stall condition and with coach illumination the dissipation in Tr_{28} or Tr_{31} is typically $(24.5-12)2 \times 0.25 = 6.25$ watts, using Trix 'Scotsman with Milliperm motor.

3.05A in Fig.2 relates to the peak on-demand current at 29.5 volts expected of the power supply and is equal to a nine-coach train pulling away from stop with lights and whistle on, i.e. full load for this controller. The Peco Streamline track used to run the system on has given no trouble during 12 months of service. Track current carrying capacity has been found adequate at 0.1 volts drop/yd/amp. Every possible track type has not been tried and tested; however, the track used by Mr Ganderton will probably be adequate provided sufficient connection points are used. Mr Ganderton's figure of 2.5A for 1.5^2mm c.s.a. copper conductor is surely incorrect; the IEE Regulations for Electrical Equipment, page 126, rate 1.5^2mm c.s.a. copper conductor at 13A. Current collection limitations of the brush system and contact pressure of the wheels are a more likely source of trouble; however, no trouble has been experienced so far, standard brush gear being used.

Electronics for coach lighting fits inside the toilet or parcels compartment of most coaches, other coaches having room under the seats. The original coaches modified had ample room to house the electronics and still retain the original seats and passengers etc. A photo depicting the above, and another showing electronics for whistle and locomotive etc in a Trix 'Scotsman, was supplied with my article but not published.

I am well aware of the scales used by Trix and that I have accepted a compromise. However, eventually this is true of most modelling in my opinion, e.g. full size track is not nickel plated, nor do railway companies require 15 locos to handle 35 coaches!

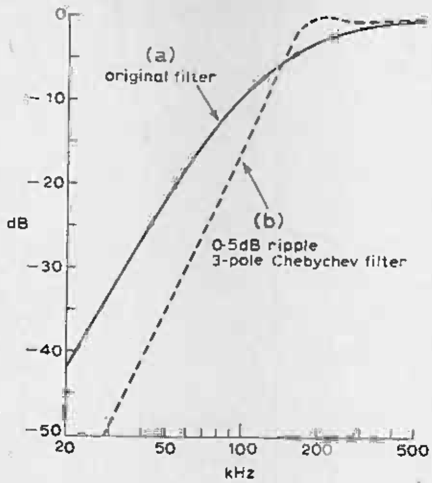
The first* loco cost £3·50 to modify, the whistle a further £4 and each coach about £1·25. A controller cost about £12 to build, since a controller has to be provided anyway. The real extras are only the locomotive and coach costs, which, considering the extra realism derived from train operation, is, I feel, cheap. The system has been fitted without interfering with cab fittings or crew.

Mr Ganderton states that the system is "not a viable proposition" and that the same or better results can be obtained at lower cost by other electronic circuits. In the absence of such circuits I can only conclude that Mr Ganderton is doing a little pointless huffing and puffing.

P. Cowan.

*Not including motor modifications which may cost a further 50p–£1.

Modified automatic noise limiter



Having tried out most of the modifications to the Nelson-Jones tuner suggested in your columns during the past two years, I was most interested in the automatic noise limiter described by P. Hinch (November 1973 issue) as his circuit offered a simple, add-on method of muting the high inter-station noise characteristic of these tuners.

I built and installed a noise limiter. It worked well except when the sensitivity of the noise sensing circuit was increased (by R_{19} on Mr Hinch's Fig.1) to remove all but the signals from the local transmitter. When a programme with high stereo content was being received, the limiter would intermittently mute on loud passages. Apparently some of the multiplexed stereo signal (up to 53kHz) was getting past the 3-pole high-pass filter used to separate broad-band noise from the broadcast signal.

The filter used by Mr Hinch is equivalent to three 100kHz single-pole filter sections cascaded, and has a rather gentle roll-off, as can be seen in curve (a) in the accompanying graph. By tolerating some pass-band ripple, this filter can be replaced by a Chebychev filter having a much sharper cut-off. Curve (b) shows the response of a 0.5dB ripple, 3-pole, Chebychev, having a similar (150kHz) −3dB frequency to Mr Hinch's design, but with the attenuation at 50kHz increased from 21dB to 35dB. This filter response can be obtained, using the tables given by M. Bronzite (*W.W.* March 1970, p.117), without changing the design of Mr Hinch's circuit, by making the following component value changes (referring to his Fig.1):

C_1 33 pF silver mica or polystyrene.
R_2 27kΩ
R_3 33kΩ
R_6 1.8kΩ
R_7 33kΩ
R_8 82kΩ All 5% carbon film.

I have also added a 22nF disc ceramic decoupling capacitor between +V and earth, close to Tr_1. As C_1 has been halved, these modifications also reduce the loading on the tuner output in the 0–53kHz frequency range.

Using a noise limiter with these modifications, I have been able to cut off all but the local transmitter, and, even with R_{19} set for maximum sensitivity, there is no muting due to strong stereo signals.

M. L. G. Oldfield,
Department of Engineering Science,
Oxford University.

TV picture interference

I have read with interest D. C. Cooper's letter published in December concerning moving dots on his TV picture.

I, too, have noticed the appearance of similar dots on my monochrome u.h.f. set, first on BBC2 and then, a few months later, on BBC1. The ITV picture is, so far, unaffected. Unlike Mr Cooper's, though, my dots appear in a single line, slightly above the field test pulses, i.e. outside the picture area.

I cannot explain these dots, except that I think they cannot be anything to do with cable distribution systems as suggested by Mr Wood of the BBC, as my reception is direct from the Mendip transmitter.

George Cavarra,
Bristol.

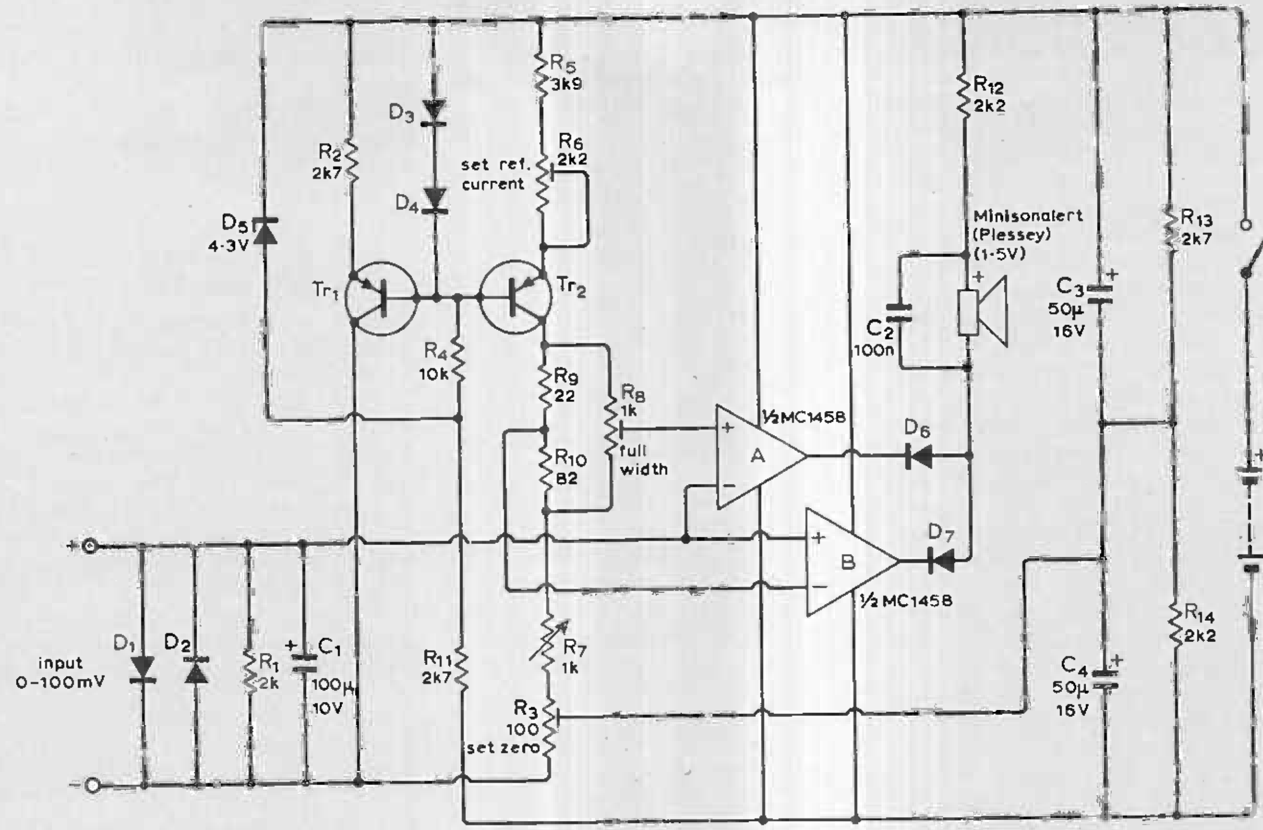
I, too, have observed the moving pattern of dots on a television screen and supposed that they were connected with the BBC data transmission experiments. Unlike Mr Cooper's (December 1973 issue) observations, mine occurred on a monochrome receiver (BBC2 transmission) but at the extreme top of the picture. They are, I assume, only seen because the frame amplitude has deteriorated—the set is some ten years old. I have not observed it on a new colour set operating from the same aerial. Like Mr Cooper, I live in the Guildford area.

J. G. Steel,
Guildford,
Surrey.

Multimeters for blind students

Readers may be interested to hear of two d.c. multimeters for blind students built recently for schools in Sydney. The circuitry of the instruments, as shown, owes much to that of the aural-tactual meter described by Dr R. S. Maddever (*Wireless World*, January 1973).

As in Dr Maddever's circuit, Tr_2 drives a constant current of 0.1mA through R_7 which thus produces a variable reference voltage between 0 and 100mV. Now, if the reference voltage is appreciably greater than an applied input voltage, the output of amplifier A is positive and that of amplifier B is negative. Conversely, if the reference voltage is appreciably less than that applied to the input, the amplifier output polarities are reversed. Thus in both cases, either amplifier A or B in conjunction with



Circuit of multimeter for blind students (G. P. Roberts). Tr_1 and Tr_2 are silicon p-n-p types, e.g. BC177, BC187. D_5 is a 400mW, 4.3V zener diode, e.g. BZX79/C4V3, and other diodes are small signal silicon types, e.g. BA100, IN914A.

diodes. D_6 or D_7 is able to sink the 3mA required to operate the "minisonalert" which produces an audible signal at 3500Hz. However, the network consisting of R_8, R_9 and R_{10} is arranged so that for values of reference voltage very nearly equal to the input voltage, the outputs of both amplifiers go positive, producing an audible null. The width of the null—a compromise between accuracy and ease of setting of R_7—is adjusted by means of R_8. In practice, the high open loop gain of the Motorola 1458 dual op-amp ensures that the "edges" of the null are quite sharply defined, allowing the null width to be made as small as 0.2mV.

Where an attenuator raises the source impedance as seen by the input, the capacitor C_1 allows the instrument to be used to measure d.c. quantities containing moderate amounts of a.c. ripple. Although slowing the response time, this facility is useful when poorly regulated mains supplies are involved. The zener diode D_5 is included to further stabilize the current sources Tr_1 and Tr_2 against changes in battery voltage.

The instruments were built in diecast aluminium boxes measuring 8¼in × 5¼in × 2in. A simple in-built attenuator provides push-button selection of three voltage ranges (1V, 10V and 100V) and three current ranges (10mA, 100mA and 1A). A standard linear wirewound potentiometer was used for R_7 and this, in conjunction with a large pointer and embossed scale of 2.2in radius, was found to be easily read to accuracies of within 2% of full scale. Front panels were made from plastic laminate board. Braille dots were made by pushing ordinary dress-making pins through tight fitting holes drilled in the board, and cutting off their stems flush with the other side. The panel was also engraved for the benefit of sighted teachers.

The materials and metalwork were provided by the School of Mathematics and Physics, Macquarie University, with help particularly from Mr Ingram Paterson.

G. P. Roberts,
Cheltenham,
N.S.W., Australia

Buying groups

May I through the courtesy of your columns bring to the attention of component retailers the way we are attempting to deal with an urgent problem which affects all of us—I refer to the shortage of electronic components.

There are many buying groups operating successfully in commodities ranging from groceries to television sets, but we believe we are the first (and perhaps the only one) dealing in electronic components. We are the poor relation of this industry and it is the manufacturer who can buy bigger quantity who comes first. "Group One" has been functioning for about three years, during which time it has prevented the total disappearance of many vital components by large purchases. To give us more buying power we would like to recruit more members. Would any electronic component retailer who is interested, please contact me at the address below.

A. Sproxton,
Home Radio (Components) Ltd,
234–240 London Road,
Mitcham,
Surrey CR4 3HD.

Licences

I would like to point out for the Ministry of Posts and Telecommunications that the installation and use of wireless telegraphy apparatus in the UK is an offence contrary to the Wireless Telegraphy Act 1949 except under and in accordance with the terms of a licence issued by the Ministry. Furthermore it is an offence to manufacture and import apparatus for wireless telegraphy capable of operating on frequencies between 26.1–29.7MHz and 88–108MHz. Any enquiries should be sent direct to the Ministry of Posts and Telecommunications, Waterloo Bridge House, Waterloo Bridge Road, London SE1 8UA.

B. Griffin,
Ministry of Posts and Telecommunications,
London, S.E.1.

Electronic piano design

Part 2—assembling circuits and case

by G. Cowie, B.Sc.

Most electronic keyboard instruments are insensitive to touch, the keys operating on/off switches. The touch-sensitive feature of string pianos is retained in this design, while still being simple and inexpensive to construct. It is small, portable and, with headphones, is ideal as a practice instrument. Basic design points and detailed circuits were given in part 1 (vol. 80 no. 1459 pages 8–13). This article gives constructional details of a case, together with guidance on component layout, assembly and wiring. Part 3 will describe how to test and tune the instrument, suggest an alternative tone generator using an m.o.s. master oscillator, and give some other optional circuit refinements.

The piano is designed so that the 33-in key-board will just fit inside its case. There is a metal projection at the low end of the key-board that must be sawn off flush with low C for the keyboard to fit. The keyboard base plate is used as a chassis for the keying circuitry, and the remaining circuitry is mounted in the upper rear of the case.

Before starting work, you should consider the finish for the case. As described, the case is suitable for finishing with paint, leatherette, or, like the prototype, with Formica. If a Formica-type finish is wanted then a lot of time can be saved by using a plastics-surfaced board for parts 2, 3, 5, 7 and possibly 11 (Fig. 9). Some dimensional changes will be necessary, and parts 4, 5 and 6 must be shortened to 33.1in. Exposed wood edges may be painted. Wood parts are fastened together by glueing and dowelling or nailing.

Start by cutting the wood parts to shape, using a rasp if necessary to trim them to exact size. Parts 2 have notches cut in them to fit parts 4 and 6. Parts 2 should be identical, and this can be checked by clamping them together. It is important that the internal width from front to back is a fraction over 33in (say 33.1in) otherwise the keyboard will not fit. This dimension is identical to the length of part 3.

The case is deeper from front to back than strictly necessary, and if you do not intend to put anything other than the circuitry described inside the case, you can reduce the front-back dimension by up to three inches. This involves shortening parts 1, 2 and 7.

Case assembly

Begin assembly by gluing and panel-pinning part 1 to part 4. Add parts 2, and dowel part 4 to parts 2. Next attach part 6 with glue and dowels. (Dowelling should be done by drilling one of the parts to be joined and then, holding the parts in their final position, passing the drill through the hole already drilled to drill the mating part to about an inch deep. Spread glue on the dowel and the mating surfaces, place the parts together and knock the dowel fully in.)

Part 3 rests on top of part 1 and is fixed to parts 2 by dowelling. Tack parts 3 and 1 together with a few panel pins and fill up the crack with glue and strips of wood. Part 3 has one edge planed off at 45°, and the opposing edge is also planed at 45° to fit against part 1.

Part 5, the back panel, should be left slightly oversize until fixed in place. It is more convenient to drill the holes, with a bit and brace, before fixing. Three holes of $\frac{3}{8}$-in dia. and two holes for a mains connector and fuse are required, their positions not being critical. Apply glue to mating surfaces and secure the part 5 with panel pins.

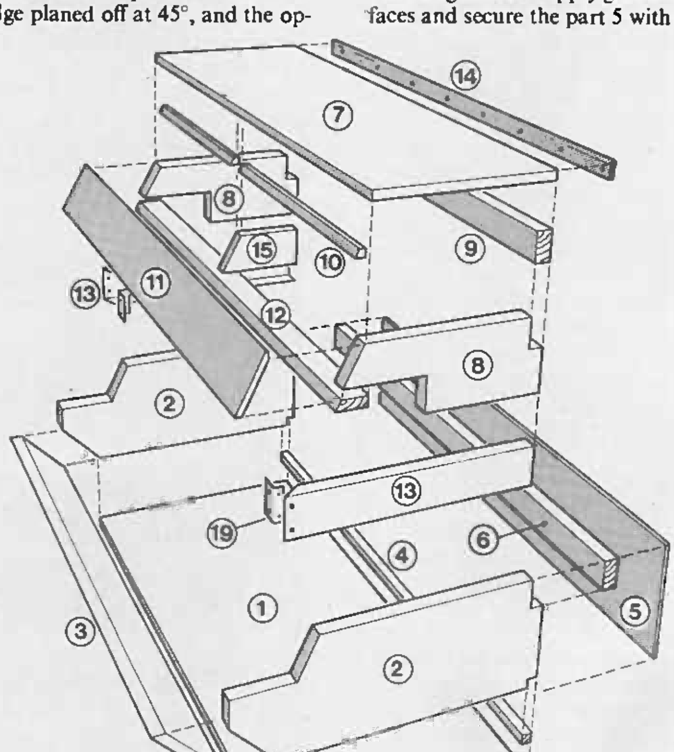


Fig. 9. Top part of the case, comprising nine wood parts and a front panel, carries the keyboard—bolted to parts 13 with angle brackets—and lifts to expose wiring about hinge (14). Parts 16, 17 & 18 are shown in Fig. 10. Dimensions given in parts list.

Notes on components

The pieces of Veroboard for the key circuits boards are 17 x 5in, as advertised by various suppliers, but which does not appear in Vero's current lists. If the board specified cannot be obtained, a slightly longer and narrower board could be used instead.

The resistors used on the keying boards are $\frac{1}{8}$-watt because larger resistors would be more difficult to fit in the space available. Similarly the diodes should not be bigger than the Do–7 size, which is about 0.3-in long excluding leads. "Untested" silicon signal diodes were used in the prototype, and proved to be satisfactory. They are very cheap, but it is necessary to test them with an ohmmeter, both to weed out a few faulty diodes from the batch and also to determine the polarity of each diode. The ohmmeter will give a reading characteristic of a silicon junction when its red lead is applied to the cathode (+) end the diode and its black lead to the other end.

"Untested" transistors may be used to save money but in my experience they are less satisfactory than cheap diodes. It is to be expected that nearly all the batch will be usable for something, but that half will be leaky with a tendency to deteriorate. They should be tested as thoroughly as possible to ensure that the transistors used have a gain of greater than 40 at 100mA and a leakage of less than a microamp or so. The transistors specified are a medium-power type, and low-power transistors should not be substituted in the key circuits. The dividers and op-amps must be good devices, not rejects. They can be bought nowadays for little more than 55p and 25p each, respectively. In the remainder of the circuitry the choice of semiconductor devices is not critical.

Capacitance values for the key circuit capacitors C_1, C_2 should be adhered to as closely as possible. Voltage ratings are low to minimize bulk and cost, but are not critical provided that C_1 is 10V or more and C_2 is 6V or more. Tantalum capacitors are preferred as the tolerance on capacitance values is closer. On the other hand it is not known what effect the better power factor of the tantalum capacitors (without series resistors) will have on the life of contacts S_1 and the tantalum capacitors are more expensive. Aluminium electrolytic capacitors performed adequately in practice. Essentially the question is one of initial cost versus reliability.

The operational amplifier used for the summing preamplifier should be a 741 as this type is internally compensated. As no compensation is needed for the oscillator op-amps the slightly cheaper 709 type can be used instead. Lead connections for several packages were given in part 1.

At each step in the assembly check that the parts are squared up. If a rear panel of plastics-coated board is used, cut out a neat aperture about 3 x 4in before assembly. Subsequently the aperture can be closed by a connector panel fixed to the inner surface of part 5. When the lower case assembly is completed set it aside for the glue to harden.

The keyboard is bolted to two metal channel sections 13, which in turn are screwed to the hinged upper half of the case. In their normal position, parts 13 rest on part 1, touching parts 2, so that they fix the height of the keyboard and its position; ideally 0.5in clear of parts 2.

Parts 13 are fixed to the vertical front part of the keyboard chassis by two brackets of $\frac{3}{4}$-in angle, $1\frac{1}{4}$-in long. For each fixing, drill two holes in the keyboard chassis and two in parts 13, the last-mentioned being countersunk. A section of flange of each part 13 must be cut away over a length of three inches to clear the top and bottom C actuator slots and the keyswitch mounting area behind. (To do this with an ordinary hacksaw cut and file away a portion of the flange so that the hacksaw blade can be got into position to cut away the remaining scrap section with a longitudinal cut.) Bolt the parts 13 in place, with the nuts inside, and place the whole assembly on a flat surface. Make sure that parts 13 are square to the keyboard, and drill at each end of the keyboard, near the springs, a 6BA-clearance hole so that the chassis plate can be bolted to part 13 flange.

Place the assembly inside the lower case to check that it fits without jamming, and decide on the precise position of the keyboard with respect to part 3. If the keyboard is to be well forward, as in the prototype, then the edge of part 3 must be relieved so that the white keys do not strike it. (It is a good idea to put small packing pieces underneath parts 13 as then it will not matter so much if swarf and shavings collect there.)

On looking at the top of the keyboard, there is an obvious transition between the seen and unseen parts of the black eyes. It is important to know the exact horizontal distance (about 11in) between this point and part 6. This dimension, less 0.05-in clearance, less the hinge thickness, less the thickness of any laminate finish on part 11, is the front-to-back depth of the upper case assembly. If a mistake is made then either the black keys will strike on part 11 or there will be an unsightly gap.

Lay the parts of the upper case, 7–12, together to check that they form a structure of the right size when fitted together. Parts 8 rest on parts 13, and part 7 placed on top should be flush with the top of the lower case. Make sure the gap between pieces 12 and 13 is sufficient to clear the keyboard.

Glue and nail parts 7 and 9 together, and add parts 8, dowelling it to part 9 and dowelling or nailing them to part 7. Plane the front edge of part 12 to a 30° angle and fix it to parts 8 with dowels. Add part 15 with dowels to give some central support to piece 12. Leave this assembly to dry. Check that the upper case assembly fits into the lower case without jamming or leaving an excessive gap at the sides.

Part 11 is thin so that the mains on/off switch and any extra controls can be mounted on it. Fit it by relieving the front of part 7 at 30° or by relieving part 11, leaving some gap to be filled or concealed; the lower edge of part 11 should be relieved at 30° on the inner side. Use glasspaper or a sanding disc to smooth down the mating surfaces for part 11. Attach part 11 with glue and a few panel pins. Use the parts 10, suitably shaped, and some glue to fill and strengthen the join between parts 7 and 11. Put the assembly aside to dry upside-down so that parts 10 will stay in place. (At this stage the upper and lower case halves may be painted on the inner surfaces.)

Attach two lengths of $\frac{1}{2}$-in or $\frac{5}{8}$-in square wood (parts 16 and 17, Fig. 10) to the keyboard chassis plate to act as bearers for the key circuit boards, which are to be $\frac{7}{8}$ to 1in

Footswitch for sustain action is simply a push-button switch embedded in a wood block.

below the main plate. Fix part 16 by woodscrews to the front vertical plate, which must be drilled for four fixing holes. Secure part 17 by woodscrews at its ends to parts 13; a countersunk hole is required in each part 13. Drill the main plate in two places by the springs, about one-third and two-thirds of the length of the board, so that packing pieces can be fixed in place to stiffen part 17. The keys scratch easily so protect them during drilling.

The desired surface finish is most conveniently applied to the outside of the upper and lower case at this stage. In the prototype all visible surfaces are white Formica except for the inner surfaces of parts 2 and the top edge of part 3, which are black.

Various accessories are next fitted to the case. Fit the three jack sockets, the mains connector socket, and the mains fuseholder to the rear panel. Next fit the mains switch and indicator lamp to the front panel. Attach the piano hinge to the upper case, with the axis rod above the top surface. Arrange the upper case in the fully open position, supported on a block, and screw the hinge to the lower case. This is trickier than it seems and it is best to put in two small screws first so that the assembly can be closed to check whether it is all lined up and fits properly. If all is well then the hinge may be securely fastened by $\frac{1}{2}$-in countersunk-head brass screws.

Screw parts 13 to parts 8, thereby fixing the keyboard into the upper part of the case. Screw an eyelet into each side of the case, inside, next to part 3, and provide a similar fixing on the keyboard chassis. Permanently attach two restraining cords to hold the upper case open in a suitable position for working inside. Check that the assembly still closes. Fit the case carrying handle and add metal ties between parts 3 and 1 at the handle location. Two large self-tapping screws are used to hold the case closed. Turn the case upside-down and drill two holes near the front of the case in such a position that they pass through the flange of part 13. These holes must be of the root diameter of the self-tapping screw. Next drill the wood to the clearance diameter, grease the screws and screw them into place by repeatedly making one turn in and half a turn out.

Circuit assembly

In one sense the assembly work is very simple as there are only five major circuits involved, none of which has more than a dozen components. There is, on the other hand, a great deal of work to be done, and very boring and repetitious work at that. To give some idea of the time involved, fitting 60 components on boards will take $1\frac{1}{4}$ to $1\frac{1}{2}$ hours from unpacking to checking the soldered joints, and putting in the 183 key wires will take at least a day. Clean soldering and general neatness are very important, greatly increasing the chances that the circuitry will work as intended.

Make up the power supply, oscillators, and amplifiers first, so they can then be used to test the key circuits.

No detailed assembly is shown for the power supply as it is a simple wired unit and the original was made from junk. For safety it is best to make the power supply on a metal baseplate and completely enclose it in an earthed metal case. Mount the +5-V regulator on a small heatsink of $\frac{1}{16}$-in thick aluminium forming the lid of the case. As the case of the regulator forms its 0–V connection it should be isolated from the heatsink with the standard kit of mica washer etc, so that the 0–V line can be floated or grounded as necessary. Make sure that no live terminal is within $\frac{1}{4}$-in of anything on the low-voltage side. Earth any metal parts of the on/off switch showing on the front panel, as well as the metal case of the power supply. Mount the unit in the lower left-hand part of the case.

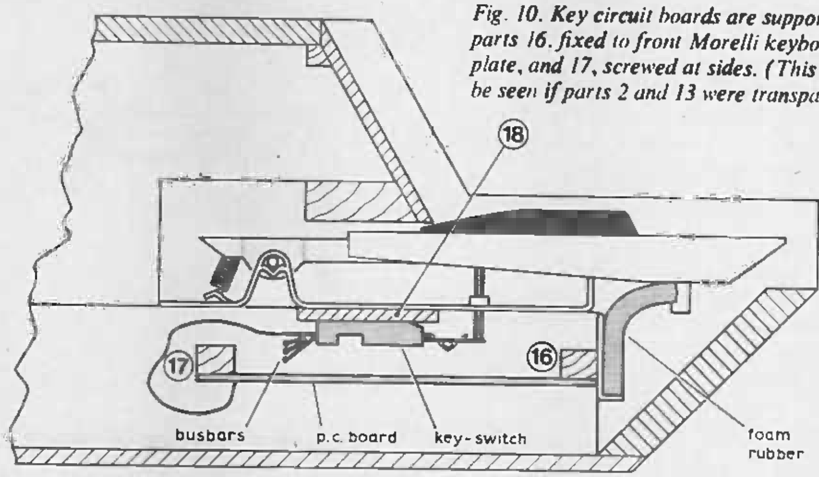


Fig. 10. Key circuit boards are supported by parts 16, fixed to front Morelli keyboard plate, and 17, screwed at sides. (This would be seen if parts 2 and 13 were transparent.)

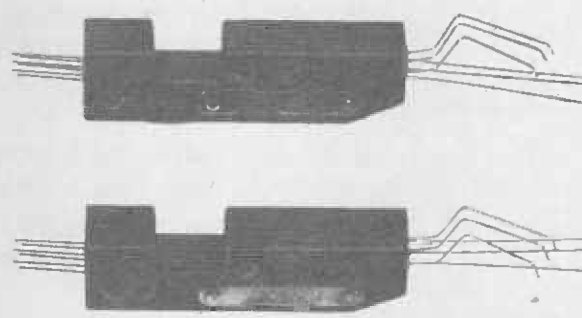


Fig. 11. Keyswitch as bought is normally-open (top) and is simply modified to normally-closed (bottom).

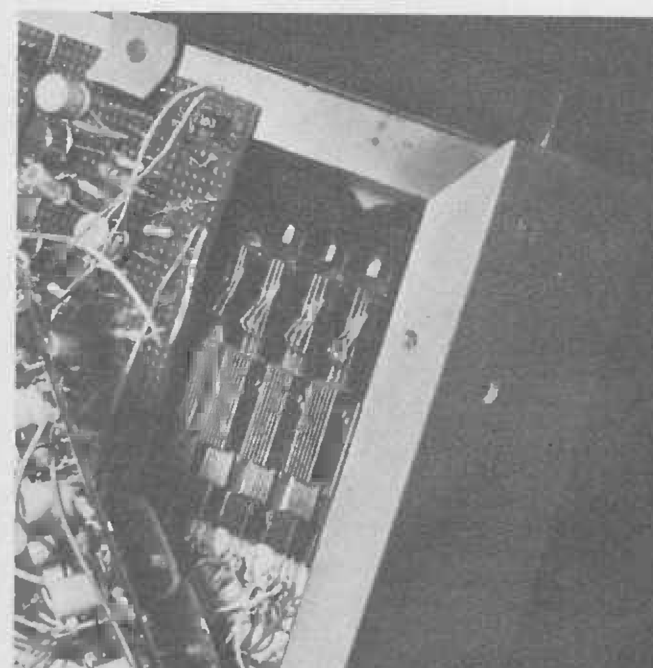


Fig. 12. View of underside of keyboard (with lid raised) shows key circuit boards with dividers and, beneath, keyswitches and actuators.

Keyswitch modification

The keyswitches as bought are of the triple normally-open type, not normally-closed as required. This is of no consequence as it is a simple matter to hook the bent wire of each pair around the straight wire, so that the switch becomes normally-closed (Fig. 11). It is less easy to arrange for the contacts to open in the correct sequence. In the prototype this was done by mounting the keyswitches and then bending both wires of all three pairs until the desired result was achieved. As the differential between S_1 and S_2 opening is fairly critical, and there are 366 wires in all, this was tedious. I therefore devised a procedure which is not only less laborious but should give more satisfactory results.

Under each key is a plastics actuator rod capped by a rubber boot which is designed to push the straight key switch wires (see Figs 12 & 13). A notch 0.1-in deep must be effectively produced at one side of each pusher, and the simplest way of achieving this seems to be to stick a tiny square of plastics sheet, not to the rubber boot, but to the two wires that must move first (Fig. 13). This should be 0.10-in (2.5-mm) thick, and about 0.15-in (4-mm) square. One side of the keyswitches has a large rectangular notch which exposes the wires. This is the visible side, and the opposite side is the mounting side. The plastics squares of course go on the mounting side of the wires.

Simplest way to attach them is to apply a little glue with a matchstick to the ends of the two wires, touch them on the square to pick it up, adjust it carefully for position, and leave the assembly upside-down to set. Contact adhesive should stick most materials: alternatively a solvent adhesive or Araldite could be used.

The keyswitches must be mounted on a spacing piece (part 18, Fig. 10) stuck to the main plate of the keyboard chassis. The thickness of the spacer must be determined before the keyswitches are mounted. Find a piece of packing which will support one of the keyswitches in an operating position so that the rubber actuator is almost touching the plastics pad. This should ensure that when the key is pressed, the actuator opens first two contacts almost together, and the third before reaching the end of the travel (the differential is 0.10in). A piece or pieces of packing, preferably of plastics, two inches wide and in all 33-in long are stuck down with contact adhesive, and the keyswitches are stuck to this with contact adhesive. They should be as far back as possible consistent with correct operation; and they can be placed with sufficient accuracy by hand.

Oscillator assembly

The twelve oscillators (Fig. 14) are identical except for the tuning resistors (see Table 3 in part 1). The frequencies used depend on whether a C–C or F–F keyboard is chosen: 2093 to 1108Hz and 1397 to 739.8Hz respectively.

The layout shown in Fig. 15 is designed to enable six oscillators and six buffer transistors to be assembled on a $2\frac{1}{2} \times 5 \times 0.1$in pitch Veroboard. In the prototype two of these were mounted on plug-in carriers so that the oscillators could be removed easily for tuning and repairs, but to make things as simple as possible I recommend that all twelve oscillators and the buffer transistors be mounted on a piece of Veroboard of at least $5 \times 5\frac{1}{2}$in which is wired for plugging into a suitable edge connector with a minimum of 16 ways (that is twelve outputs, three power lines, and a space for a polarizing/locating key).

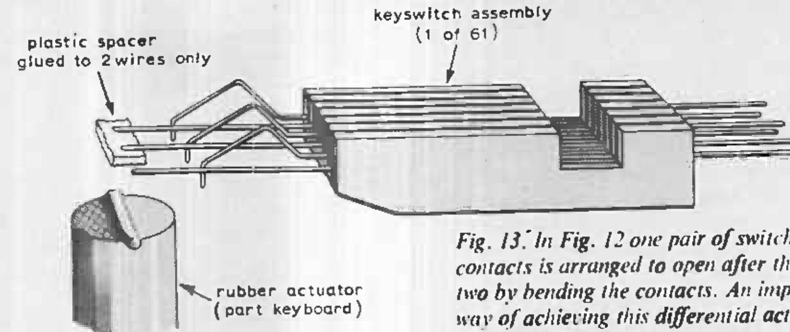


Fig. 13. In Fig. 12 one pair of switch contacts is arranged to open after the other two by bending the contacts. An improved way of achieving this differential action is to glue pads to contacts as shown.

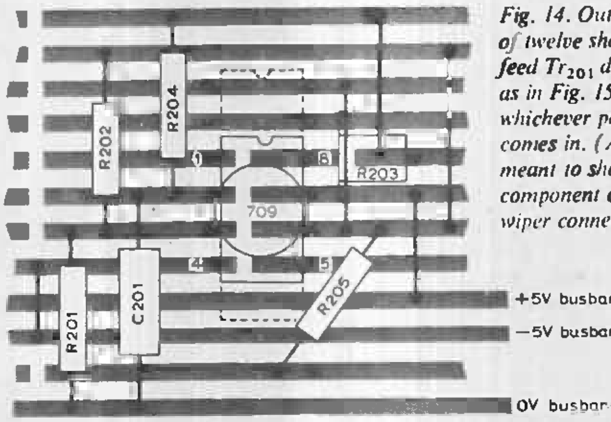


Fig. 14. Output from the oscillators (one of twelve shown) is taken from R_{205} to feed Tr_{201} drivers, which can be arranged as in Fig. 15. Board wiring is the same whichever package the 709 or 741 i.c. comes in. (Arrangement of R_{203} is meant to show the outer leads of the component connected together, with the wiper connected to track 5.)

Use the layout given, placing the oscillators in four rows of three. The order is not important, but it is helpful if they are arranged on the board in strict alphabetical order. Break the copper tracks where shown with a Vero spot face cutter or drill. All tracks should be broken between oscillators except the three power lines, and the four tracks under the i.c. must also be broken. Wire resistor R_{205} to the buffer transistor.

The integrated circuits may be either the 709 or the 741; see part 1 for pin connections. Note that the twelfth or eighth pin is not connected in the 741 but is internally connected in the 709 and so no connection must be made to it. Either skeleton or button-type preset pots may be used, the skeleton type being easier to mount. Resistors R_{201} to R_{204} should be 2%, $\frac{1}{2}$-watt types, and the capacitors polystyrene or polyester. The component leads may be left a little long to stand them off the board. The presets form a small part only of the tuning resistance so their stability is less important.

Mount the edge-connector of the oscillators in the upper right part of the case, and arrange a clip to hold the free end of the oscillator board.

Amplifier assembly

The summing preamplifier and headphone amplifier (Figs 16 & 17) can both be assembled on a $2\frac{1}{2} \times 5$in piece of Veroboard, of 0.1-in pitch, and arranged to plug into a suitable edge-connector. An internal connection must be made between R_{404} and the input of the headphone amplifier, and the external connections are the three power lines, two inputs, low level output, and headphone output. A 741 op-amp must be used in this circuit.

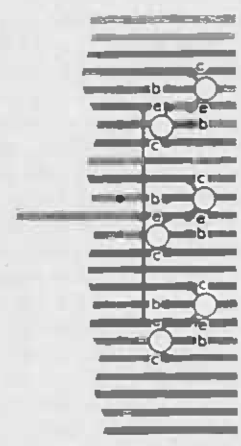


Fig. 15. Twelve top-octave driver transistors (Tr_{201}, six shown) can be arranged to enable six oscillators and drivers to be accommodated on $2\frac{1}{2} \times 5$in Veroboard or, preferably, all twelve on a 5×5in board.

Mount the edge-connector for this board in the upper right part of the case, together with a 12-way tagstrip.

Wire the three power lines to the tagstrip, using fairly thick stranded wire (24/0.2mm). Connect a lead for the +8-V line from the power supply to the tagstrip, and check that none of the wires can be trapped when the case is closed. Mount the dropper resistors R_{506} and R_{507} on the tagstrip. Mount the components R_{501-3}, D_{501}, $Tr_{501/2}$ on the tagstrip, making connections to the power lines. Two of the tags are also terminals for the bias and damper lines. Wire the amplifier edge-connector to the two output sockets. The low-level socket should be wired conventionally, but the headphone socket should be a three-way socket with the 0-V line wired to the middle contact and the signal to the inner contact, so that normal connection is made to a two-way jack, but the coils of stereo headphones are connected in series. Wire the sustain pedal connection from the tagstrip to the sustain pedal socket. Connect power lines to the oscillator and amplifier edge-connectors from the tagstrip. If the power supply uses a 9-volt transformer then R_{507} must be about 18 ohms to drop the raw direct voltage to the 8V required for the switch busbar, and for a 6.3-volt transformer it must be about 3 ohms.

Key circuit assembly

The key circuits are assembled on two large pieces of 0.1-in pitch Veroboard, one 5×15in, the other, containing the odd key circuit, $5 \times 16\frac{1}{2}$in. The overall length is calculated to be just less than the distance between parts 13 flanges. The 12 groups of key circuits are identical, and the 61 key circuits are themselves identical save for the connections of diode D_1. The assembly details are given in Fig. 18 which shows the divider and the top key circuit. The whole group should be exactly five inches long, the pitch of the key circuits being 0.9in.

Mark each circuit board with two rows of three $2\frac{1}{2} \times 5$in rectangles, using a scriber. Mark within these the areas occupied by the key circuits. Each occupies a width of eight holes, the boundaries between key circuits falling on the ninth rows of holes where several tracks must be cut to electrically isolate the circuits. Fit the divider i.cs in their correct positions, at the top of each rectangle and one hole from the left-hand edge. Use Veroboard pins or some cheaper equivalent to attach the key wires, three to each key circuit.

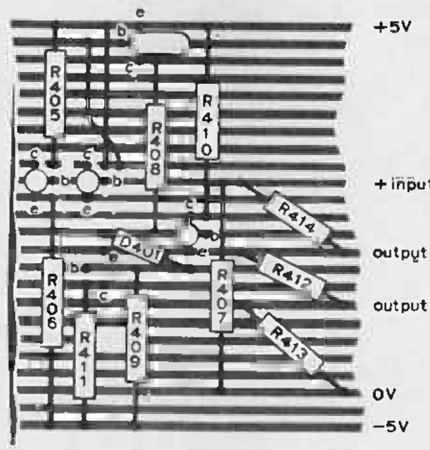
At the assembly is quite a large operation, much time will be saved if it is approached methodically, for instance by taking 61 components (e.g. R_3), bending all the leads, fitting to the board, bending the leads flush with the tracking, clipping the leads to 0.1in from hole, and then soldering.

Each group of key circuits must be assigned to a letter, C, A etc. and the resistors R_4 fitted, following Table 3. The lowest values go with the highest pitch notes, and so the key circuit nearest the divider will have R_4 of 1k, 1.2k or 1.5kΩ. The positions of diodes D_1 vary; in the no. 1 key circuit the cathode goes to track 1 (pin 14 of i.c.); in no. 2 to track 3 (pin 12); in no. 3 to track 6 (pin 9); in no. 4 to track 7 (pin 8) and in no. 5 to track 4 (pin 11).

The lowest pitch key circuit takes the form of a small 13th letter-group, in physical arrangement. It fits on the extra $1\frac{1}{2}$-in of board next to the C letter-group. The divider could be almost any t.t.l. flip-flop but I recommend a 7493, mounted on a dual in-line socket so that it can be changed easily. The connections are easily deduced: pin 14 is wired to track 4 of preceding stage, D_1 cathode goes to track 3.

Lines for +5-V, 0-V, output, and collector busbars run the length of each board. Three tracks should be commoned for the ground busbar to reduce the resistance.

Fig. 16. Summing preamplifier and headphone amplifier (Fig. 17) can be included on the same board.



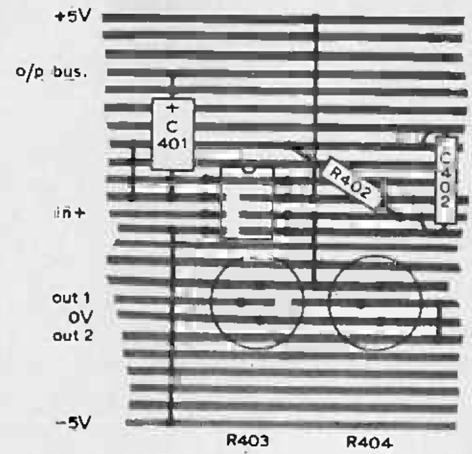
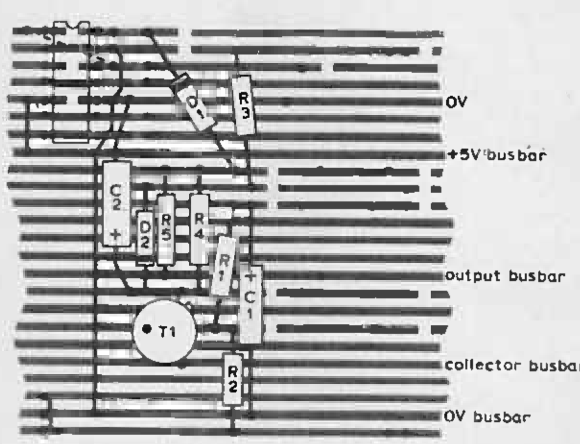


Fig. 17. Headphone amplifier, together with R_{404}, could be omitted if an external amplifier is used.

Fig. 18. Layout of one divider and key circuit. Outputs from divider feed four similar (except for D_1 position) key circuits alongside that shown. (Thirteenth divider feeds only one key circuit). Two large boards bear 61 key circuits and 13 dividers. In the five key circuits related to any one divider, uppermost wire of D_1 connects to different i.c. terminals or tracks (see text). A minor modification to this board is suggested in part 3.



Parts list

1 Plywood $34\frac{1}{2} \times 16 \times \frac{1}{4}$in
2 Plywood* $18 \times 6 \times \frac{3}{4}$in (two)
3 Ply or hardwood* $33 \times 3\frac{1}{4} \times \frac{3}{4}$in
4 Deal $34\frac{1}{2} \times \frac{1}{2} \times \frac{1}{2}$in
5 Ply or hardboard* $34\frac{1}{2} \times 6\frac{1}{2} \times \frac{3}{16}$in
6 Ply or hardwood $34\frac{1}{2} \times 1\frac{1}{4} \times \frac{3}{4}$in
7 Plywood* $33 \times 9\frac{1}{2} \times \frac{3}{8}$in
8 Plywood or deal $10 \times 3\frac{1}{2} \times \frac{3}{4}$in (two)
9 Deal $33 \times 1\frac{1}{2} \times \frac{3}{4}$in
10 Deal $15 \times \frac{3}{8} \times \frac{3}{8}$in (two)
11 Ply or hardboard $33 \times 3 \times \frac{3}{16}$in
12 Deal $33 \times 1\frac{1}{2} \times 1\frac{1}{2}$in
13 Aluminium or steel channel $13 \times 2 \times \frac{5}{8}$in (two)
14 Piano hinge 33in
15 Plywood or deal $4 \times 1\frac{3}{4} \times \frac{1}{2}$in
16 Deal $31 \times \frac{1}{2} \times \frac{1}{2}$in (or $\frac{5}{8} \times \frac{5}{8}$in)
17 Deal $33 \times \frac{1}{2} \times \frac{1}{2}$in
18 Plastics spacer 33×2in (see "keyswitch modification")
Dowel rod 2m $\times \frac{1}{4}$in
Aluminium angle bracket $2\frac{1}{2} \times \frac{3}{4}$in
Deal block to house sustain switch $6\frac{1}{2} \times 5\frac{1}{2} \times 1\frac{1}{4}$in
Perspex 4 sq in × 0.1in thick
Carrying handle and bolts
Aluminium plate $\frac{1}{16}$-in for heatsink
TO–3 insulator kit
Metal box for power supply
Deal for stand: $26 \times 1\frac{1}{2} \times 1\frac{1}{2}$in (four)
$16 \times 6 \times \frac{1}{2}$in (two)
$34 \times 5 \times \frac{1}{2}$in
*Parts 2, 3, 5 & 7 could alternatively be Contiboard

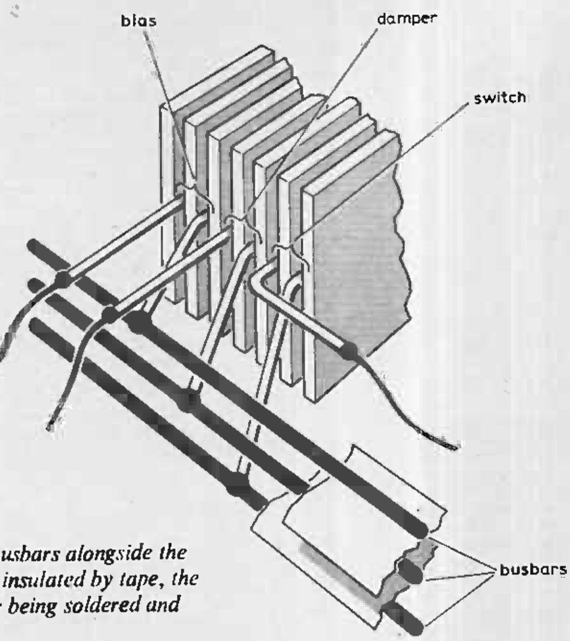


Fig. 19. Three busbars alongside the keyswitches are insulated by tape, the "switch" busbar being soldered and insulated first.

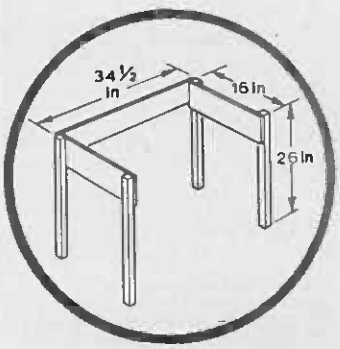


Fig. 20. Simple stand for the piano can be made from deal.

Key wiring

Six wires about ½-in long extend from the back of each keyswitch (Fig. 19). Bend down the extreme right-hand wire of each switch (looking from the rear), and solder to them a bare tinned-copper wire of about 22 s.w.g. Inspect this work and cover the wire (switch busbar) with a length of adhesive tape. Do the same for the third wire from the right (left, as shown), and cover the damper busbar with tape. The third, bias, busbar should be of slightly thicker wire, and is soldered to the gold wires as shown. The bias contacts are the pair that open last. Bend the remaining gold wires upwards and outwards to make it easier to connect the flex wires.

To mount the two key circuit boards, use six small nails, bent over at 45°, in part 17, on which the boards rest. To hold the boards while the case is closed, drill four holes in part 16 to take retaining screws with large washers, which overlap the boards.

Key wiring must be done with miniature stranded flex wire. Connect a wire to the switch contact, top C. Pass the wire through the gap between part 17 and the keyboard plate and lead it along part 17, then up through a right angle towards the connecting point—the pin on track 11 of the top C key circuit. Similarly, connect the damper wire to the pin on track 2, and the bias wire to the pin on track 18. Place cable ties at intervals along part 17 to hold the wires and tie wires together to the board in groups of six where they pass up over the lower edge of the boards.

When several keys have been wired up check whether the system works. Wire the bias, switch, and damper busbars to the tagstrip, and connect the ground 0-V line to each key circuit board. Check that the power supply delivers the correct voltages and connect the +5-V and collector busbar lines to both boards. Connect oscillator signal lines for the letter-groups in use, plug in headphones, connect the output busbar to the amplifiers, temporarily ground the positive input of the summing preamplifier, plug in the oscillators and amplifiers, and switch on. If the wired keys do not work look for faults as detailed later (part 3).

The remaining key wires may be put in when you are satisfied that the system is more or less in working order. The wires should be cut a little long, leaving about two inches of slack.

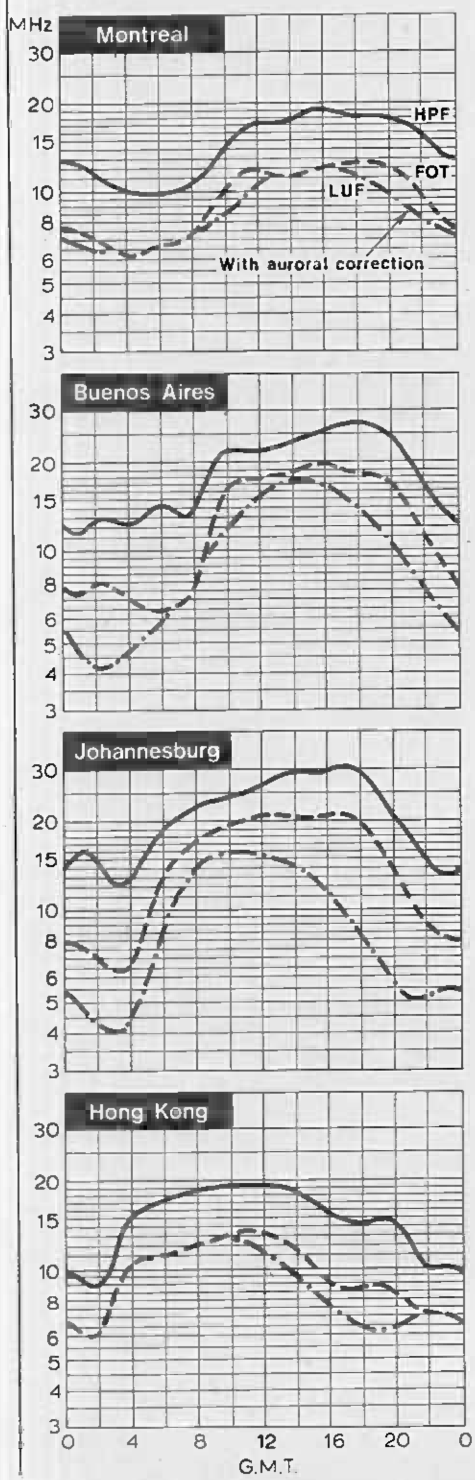
Tuning details together with some optional circuits will be given in the third and final article.

H. F. Predictions

April

Seasonal trend and low solar activity combine to produce FOTs and LUFs which give a restricted choice of time and frequency for reliable day to day communication. The charts show that the restriction is severe when both ends of a circuit are in the northern hemisphere.

A magnetic disturbance observed at the end of February is almost certain to recur at about 27-day intervals over the next six months. April 16 to 26 is the next expected appearance.



Guglielmo Marconi

An appraisal, on the centenary of his birth

by W. J. Baker

Guglielmo Marconi, who was born on April 25, 100 years ago, was a many-sided genius who, in his lifetime, probably achieved more honours, including the Nobel Peace Prize, than any man before or since. For all that, there was a curious thread which ran through his life; it was rather as if some daemon, while providing him with pre-eminence, always contrived to give it a bitter-sweet quality; a denial of the full satisfaction that was his goal.

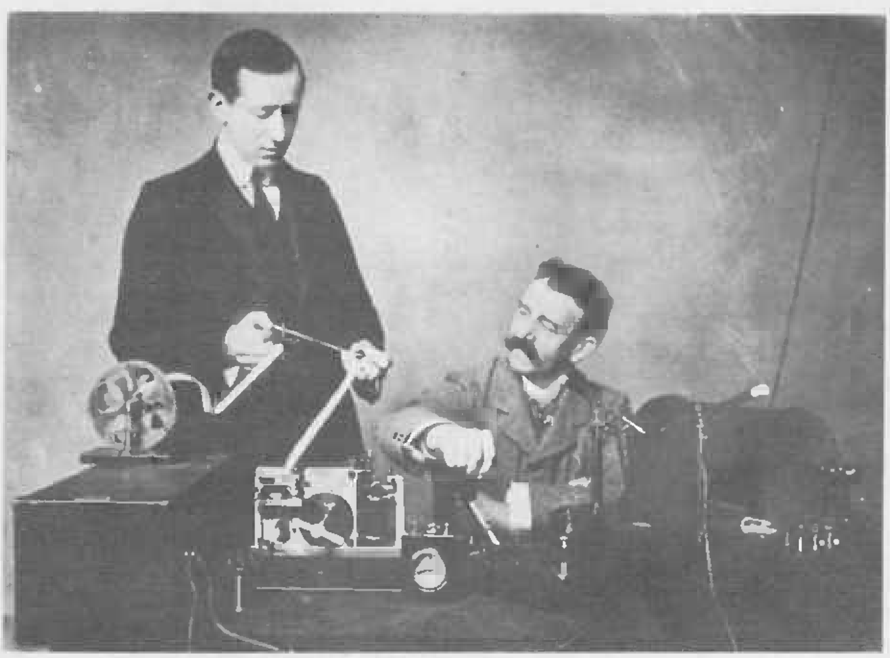
If genius is a matter of acquiring the right genes, then Marconi collected his by a circuitous route. The story of his birth has all the ingredients of a romantic novel[1]. It begins when one Andrew Jameson, together with his brothers, emigrated from Scotland to Ireland, where Andrew founded a distillery (even tee-total readers will have heard of Jameson's Irish whiskey). Concurrently he founded a family of four daughters, the ménage being a moated manor, Daphne Castle of Enniscorthy. One of these girls, Annie Jameson, was not only beautiful but possessed a singing voice of a quality which brought her an offer to appear at the Royal Opera House, Covent Garden.

At this juncture papa put his foot firmly down. No daughter of his was going to appear on the stage; however, by way of recompense he offered Annie the prospect of going to Italy, to stay with some banker friends of the family in Bologna, where she might study *bel canto*. So, half a loaf being better than nothing, Annie went.

Andrew Jameson's attempt at family diplomacy boomeranged with painful accuracy. For his Italian friends had a son-in-law; a widower with one child. Annie was still a minor; the widower was seventeen years her senior, but they fell in love and Annie returned to Ireland to ask permission to marry. This time papa jumped with both feet. Allow his daughter, a mere child, to marry an unknown Italian, almost old enough to be her father, and of a different religious persuasion? Unthinkable! Annie was kept at home and forbidden to communicate with this foreigner. But somehow she did and as soon as she became legally of age she fled via England to France, where at Boulogne she was met by her suitor. On April 16, 1864, Annie Jameson was married to Giuseppe Marconi, whereupon the pair returned to Bologna. A year later their first child, Alfonso, was born. Almost as if reluctant to enter the scene, a further nine years elapsed before their second child arrived, on April 25, 1874. So, Guglielmo Marconi's maternal grandfather was a Scot and I am rather surprised that they have not made more of this north of the border.

In spite of the foregoing, this is not a biography of Marconi. Those readers who are sufficiently interested will already have read at least one of the several which are around[1,2]. Those who regard history as bunk would only be bored by a potted account of what he accomplished. All I propose to do is to select one or two of the bitter-sweet episodes referred to earlier, by way of illustration of what I meant. So no more of the boyhood of Marconi, except to say that his father was a well-to-do landowner who was intent that his sons should eventually manage his estates; to this end his younger son's interest in physics was ruthlessly discouraged and the electrical apparatus he constructed was destroyed whenever it was discovered. It is a miracle that Marconi survived this antagonism and that he did is due to his obdurate refusal to give in and to the secret encouragement and devotion of his mother, Annie Jameson Marconi. Nor must we forget Alfonso, nine years older than his brother, but helping him whenever possible; Alfonso was Marconi's first assistant, the hewer of wood and the drawer of water; never making the headlines, just staying quietly in the background and, after father Giuseppe's death, looking after their mother while Guglielmo was pursuing his endless quest for improvements to wireless telegraphy. Both Annie Marconi and Alfonso are buried in Highgate cemetery, Guglielmo in Italy.

Throughout his life Guglielmo Marconi was a loyal Italian, and his first act, after bringing his wireless telegraphy system to a workable state, was to offer it, unprotected by patents, to the Italian P. and T. Understandably, they were not particularly interested, for what had this odd contraption, with its slow speed and mere mile or so of range, got to offer against their inland telegraph system? It was a mistake; had it been offered to the Italian Navy the reaction would doubtless have been different, for at sea wireless telegraphy had no competitor. But, stung by the P. and T's indifference, the Marconi family



Marconi (left) and his assistant Kemp with apparatus

(Giuseppe had grudgingly come around by this time) decided that England, where they had influential relatives, was the place to send Guglielmo. Britain, too, had the most powerful navy and the greatest mercantile fleet in the world—both potentially valuable customers.

So, Marconi, at the age of 21, came to London accompanied by his mother. They arrived in February 1896 and until recently it has always been assumed that he made his first patent application on June 2 of that year. Recently however, it has been discovered that the initial application was on March 5, 1896 (Application No. 5028/96). Provisional protection was granted on March 19—almost three months earlier than supposed and soon after his arrival in England.

Who was the first to "invent" wireless telegraphy? The controversy, over the years, has unfortunately become political rather than technical, involving rival ideologies in terms of prestige and doing nothing to enhance the prestige of either Prof. A. S. Popov or Guglielmo Marconi. It is futile for many reasons. One is that, prior to the critical year 1895, about 20 "inventions" for signalling through space without wires had been made, at least two of which employed Hertzian waves. Another is that, had neither man ever lived, wireless telegraphy would have come almost as quickly. It is also futile because the partisans adopt differing rules and standards and because certain acts of faith are called for.

Prof. Oliver Lodge was the first man to demonstrate publicly that the tube of metal filings that he christened the coherer could be actuated by Hertzian waves. The coherer consisted in essentials of a glass tube containing two metal contacts between which metal filings were loosely packed to give a high resistance. It had been known for years that when a Leyden jar (capacitor) was discharged in the vicinity of the tube the filings cohered and formed virtually a short-circuit, but it was generally accepted (except perhaps by Prof. E. Branly of France, who did much useful experimental work) that it was the light of the spark discharge that operated the device.

Lodge, in two lectures given in 1894, showed otherwise and presented to the world a much more sensitive means of detecting the presence of Hertzian waves than had been known before. But the Branly type of coherer, as used by Lodge, needed to be tapped to restore it to the high-resistance state after the advent of every wavetrain and it could never be relied upon to return to the same resistance value after successive taps. As a consequence its sensitivity varied pro rata: thus, although, when carefully adjusted in the laboratory, it would unerringly trigger on the first half-cycle of a wavetrain and thus detect its presence, the subsequent decohering tap might well restore it to a comparatively insensitive state. It follows therefore that when used to receive telegraphy it would miss a large proportion of the dots and dashes.

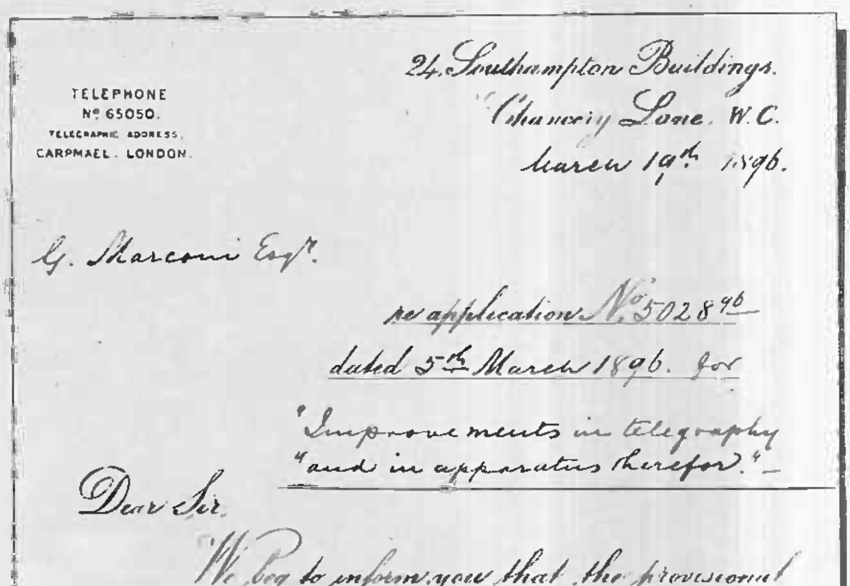
Between the mere initial registration of the presence of Hertzian waves and the faithful following of telegraphy signals there was a great gulf fixed, as both Marconi and Popov were to find out. Both constructed apparatus deriving from Lodge's demonstration equipment, including the electric bell type of tapper, and both ran into trouble. We know that Marconi had to produce several designs of coherer and experimented with 300–400 different types of metallic filings mixtures, as well as introducing important modifications to the electrical circuits of the tapper before a recognizable message could be received. Popov, too, had the same trouble apparently for he, too, completely redesigned the Branly coherer and modified the tapper.

Back now to Popov versus Marconi. As far as can be gathered the Russian claim is *not* that on May 7, 1895 Popov actually demonstrated wireless telegraphy but that the apparatus he used for a lecture on that occasion was capable of sending and receiving telegraphic signals had he so wished. During the lecture he did, in fact, show how the coherer could be used as a detector of thunderstorms but as electrical storms do not occur to order even for eminent scientists he used a Hertzian transmitter to simulate natural disturbances. A short antenna was used at the coherer receiver.

That Popov had telegraphy in mind around this date is shown by a newspaper report a week later, which stated that the importance of his experiments lay in their theoretical application to signalling over distances without wires. His own description of his apparatus was published in January 1896 and this also expresses the hope that "when further perfected" the apparatus might be used for signalling over a distance.

Undeniably, Popov was the first to demonstrate in public a practical use for the coherer. Undeniably, he was the first to publish an account of his apparatus. Undeniably, *on paper*, the equipment had an inherent capability for achieving short-range wireless telegraphy. The critical question is—was Popov's coherer sufficiently good to follow every dot and dash of a Morse message? We do not know, neither are we ever likely to now. The only clues are that the minutes of the meeting make no mention of telegraphy and both the newspaper and Popov's own published article refer to it in the future tense.

One point that further confuses the issue is that Popov was a civilian scientist in the employ of the Russian Navy and therefore subject to security restrictions. It is not impossible therefore that even before May 7, 1895 Popov had demonstrated telegraphy to Russian Navy officials in the privacy of his laboratory and was restrained from doing more than hint at its possiblity in print. But this is pure speculation, unsupported, as far as I am aware, by any shred of evidence.


TELEPHONE
No 65050.
TELEGRAPHIC ADDRESS,
CARPMAEL. LONDON.

24, Southampton Buildings.
Chancery Lane. W.C.
March 19th 1896.

G. Marconi Esqr.

re application No 5028/96
dated 5th March 1896. for
"Improvements in telegraphy
"and in apparatus therefor".—

Dear Sir,

We beg to inform you that the provisional Specification lodged with the above application has been accepted by the Comptroller of Patents and provisional

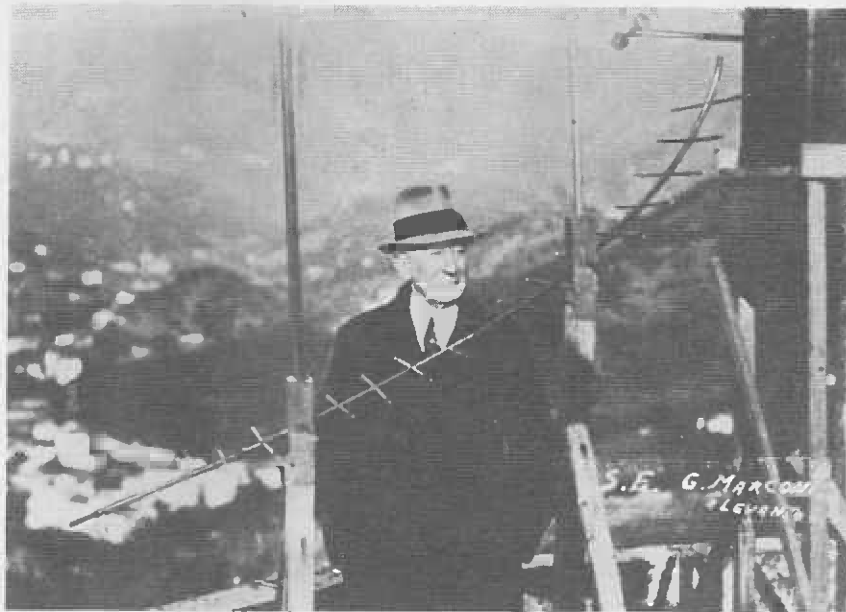
Part of a letter from Marconi's patent agents, dated March 5, 1896, informing him of the acceptance of the provisional specification for "Improvements in telegraphy and apparatus therefor".

All that can be said is that if military security robbed Popov of his rightful credit then it did so in vain, for in the Russo-Japanese war of 1904 the Russian Navy was using German wireless equipment while Marconi stations were installed on land.

As for Marconi, his early work was done in secrecy because he had no patent protection. We have his own unsupported statement that he first had the idea of wireless telegraphy "in the fall of 1894 or possibly early in 1895" and that he began his experiments in the early summer of 1895. By September of that year he was demonstrating ranges of one to two miles to close friends (including a Mr William Miller of Dublin). The first official document is the patent application of March 5, 1896, and this was followed by the complete specification on June 2. In that month Marconi was giving demonstrations to William Preece, Engineer-in-Chief of the British Post Office and to War Office officials, all of whom were impressed. Preece gave a public lecture on the demonstrations in September, 1896 and a more complete account at Toynbee Hall, London in December. Technical details of Marconi's apparatus were not published until some time after, for obvious reasons of commercial security. What is certain is that Marconi registered the world's first patent for wireless telegraphy; that he formed the world's first radio company (1897) and the world's first radio factory (1898). As to whether Popov or Marconi sent the first experimental wireless message—well, the partisans will probably always go out by the same door which they came in. There are indications that neither of them was the first, but as the other candidates also demand acts of faith as a condition of acceptance, perhaps we had better leave them alone.

Another bitter-sweet triumph for Marconi was the famous transatlantic experiment of 1901. The details of this episode are well known, so suffice it to say that Marconi claimed that on December 12 and 13, 1901, he and his assistant, G. S. Kemp, operating a temporary receiving station on a cliff-top at St. John's Newfoundland, received signals in the form of the three dots of the letter S in Morse code, sent by pre-arangement from Marconi's new high power transmitter at Poldhu, Cornwall.

It would be idle to pretend that this news did not provoke controversy at the time and indeed there is an informed school of thought today that maintains that the signals did not get across. It is not difficult to see why, quite apart from the facts that no witnesses were present and that no further listening watches were possible because of the intervention of the Anglo-American Telegraph Company, which had the message-carrying monopoly in the area. The transmitter at Poldhu was experiencing teething troubles; it was



Marconi demonstrated his ultra-short-wave radio telephone system in Italy between Santa Margherita Ligore and Levanto, a distance of 25 miles, on November 19, 1931.

feeding an antenna which had been built in one week (to replace the original, destroyed in a gale). The radiated frequency according to Marconi himself was about 800kHz (366 metres) and therefore quite unsuitable for daylight operation over long distances, although no one was aware of this at the time. The radiated power is not known with certainty but figures lying between 3kW and 12kW have been given.

At the receiving end the antenna consisted of 400ft of wire, elevated at one end by a kite, which was flapping madly up and down in an Atlantic gale. The receiver itself consisted of what was subsequently known as an Italian Navy self-restoring coherer with a telephone earpiece and a Leclanché cell in circuit with it, the whole being connected between the antenna and earth, either directly or via a jigger or h.f. transformer (it is not known which particular approach was in use at the times the signals were stated to have been heard). No tuned circuits were employed and no amplification was possible.

The self-restoring "coherer" consisted in essentials of a glass tube with threaded rod inserted from either end. One rod terminated in a small cylindrical block of iron, the other in a similar block of carbon. The two were screwed into close proximity and a tiny blob of mercury inserted between them. For many years I have maintained a belief that this was not a coherer at all, but a solid-state rectifier with an oxide film on the mercury's surface providing the rectifying agency. One of these devices has recently been examined by Dr G. L. Grisdale of the Marconi Research Laboratories who has confirmed that this is so. The specimen on test was shown to have a rectifying performance (at best) of about 7dB below that of a modern germanium point-contact rectifier.

It has frequently been said that a couple of months later Marconi vindicated his claim by his tests aboard the liner *Philadelphia*. For these he used an antenna slung between two 150ft masts and connected to one of his new tuned receivers which embodied a Marconi coherer and a Morse inker. Sailing westward he received messages at a distance of 1551 miles from Poldhu, and isolated Morse letters at 2099 miles. This however is not a vindication of actual reception of signals at St. John's, for the ranges quoted were obtained at night. Daylight reception ceased at 700 miles (roughly one-third of the Poldhu–St. John's distance). The Italian Navy device was also tried on the *Philadelphia* but the range obtained was never better than 700 miles. What the *Philadelphia* experiment did do was to prove conclusively that Marconi was right in his basic belief that signals could cross the Atlantic, albeit (at the frequency employed) only over a night path. (It has always seemed to me to be curious that this was the first time the "night effect" had been noted, considering the number of stations which were by then in operation.) On this occasion Marconi made no mistake; the messages and signals were automatically recorded on paper tape and duly witnessed by ship's officers.

So, to return to the Newfoundland experiment, it will be seen that the doubting Thomas school of thought has a strong case. Let us now consider the other side of the coin. Marconi would have been insane to have pretended that he heard the signals, as exposure would inevitably follow. Furthermore, for him to have done so would have been completely out of character, for he was always meticulous in his public statements.

Various suggestions have been made in attempts to account for the mystery. Some have believed that he genuinely mistook static discharges for the three dots of the letter S. This is hardly likely;

both Marconi and Kemp were far too experienced to have been thus deceived, particularly as the Poldhu signals were machine-sent and precisely timed. Others have theorized that in all good faith he imagined he heard what he so badly wanted to hear—a common human experience. Others have invoked earth currents in order to explain the matter. Another suggestion has been that he heard faint signals but that these emanated from nearer at hand than Poldhu, and it is true that one or two transatlantic liners were by this time wireless-equipped (the *Lucania* for one was within feasible range). There were also a few shore stations in the USA and Canada and at least one amateur.

Now, after over 70 years of speculation comes a startling theory, namely that Marconi did, after all, receive the Poldhu signals; not, as he believed, on the fundamental frequency, but via a harmonic at h.f. This is a theory which, to my knowledge, has been privately expounded for some years by Mr G. R. M. Garratt, formerly of the Science Museum and a well-known authority on telecommunications history. I believe that detailed calculations are being made and that there is some reason to suppose that these will vindicate Mr Garratt's ingenious and far-seeing suggestions. I understand that the matter has been discussed in a paper at the joint IEE/IERE colloquium "The Marconi Heritage" on April 25.

The bitter-sweet transatlantic episode had at least one major effect on Guglielmo Marconi. His summary treatment by the cable company turned him into an implacable foe of all such organizations and with obsessive energy he flung himself into the problems of providing a commercially viable transatlantic service, often working a sixteen-hour day and pouring money into his projects at a rate which alarmed his fellow directors. Initial failure gave way to limited success. Invention followed invention, the magnetic detector, the directional antenna and the rotary disc discharger being only three of many. Not until 1907 was a fully reliable day and night two-way transatlantic service possible, by which time the wavelength used had gone from 366 metres to 6000 metres and the power from the original 3–12kW to 300kW. For this purpose a giant station had been built at Clifden, Ireland and was communicating with the refurbished Glace Bay station in Canada[3].

Even then Marconi was denied complete satisfaction, for the bulk of the traffic was between London and New York. The messages were transferred across the Atlantic quickly enough but the link between Glace Bay and New York was 800 miles of landline which was permanently overloaded, occasioning up to 12 hours' delay. Not until 1914 when Caernarvon (transmitting) and Towyn (receiving) stations were built in Wales and equivalent stations at Tuckerton and New Brunswick in New Jersey State in the USA could the wireless service compete on equal terms with the cables. Triumph at last for Marconi? Not so. Almost immediately, war broke out and the two British stations came under the control, first, of the Post Office and then of the Admiralty.

For some years prior to this, Marconi had enlarged his anti-cable horizons to the whole world. His ambition now was to own and operate a chain of high-power stations that would link the major areas of the (then) mighty British Empire. Time after time the prospects brightened in this respect, only to cloud over again by reason of Government prevarication or change. Not until 1924 did anything definite emerge and even then it was only half a loaf. An Empire Chain was decided upon, but a Government Committee decided that the Post Office should own and operate all stations in Britain which communicated with the Empire (with a partial exception in the case of Canada) while private enterprise should be free to develop communication between Britain and foreign countries. This by no means was what Marconi had worked for through the years, but at least he already held contracts for building giant long-wave high power stations in Australia and South Africa, with more in prospect in other countries.

Behind the scenes the Marconi-Franklin h.f. beam system was being developed, with promise that world communication could be achieved at a fraction of the size, power and cost of the mighty long-wave stations. The system was not, however, fully engineered and had not been tried on a long-term basis. Should it be kept secret and the long-wave stations proceeded with? Or should Marconi inform everyone concerned and give them the choice? It was a difficult decision, but in the event the customers were told and elected for the untried beam system. So, for once, Marconi got something approximating to his desire. He built all the beam stations in Britain and throughout the world: they were successful beyond all expectations and, to Marconi's intense satisfaction, cast gloom over the world's cable interests. It seemed that at last Marconi had achieved total success.

But no. His daemon intervened again in the form of the British and Dominion governments, who, as a belt-and-braces insurance in the event of war, wanted to retain the cables. Pressure was brought to bear to bring about a merger between the various cable interests and the Marconi Company. In this, Marconi's seemed to hold all the aces, because by 1927 the cable companies had already lost half of their traffic to the beam system. Incredibly, in view of this, a merger was agreed in which the Cable Group held 56.25% of the voting power and the Marconi Company 43.75%.

Thus in April 1929 Cable and Wireless Ltd came into being; the Marconi Company ceased to be directly involved in message-carrying as a source of revenue and thereafter was limited to the areas of research, invention, development and manufacture. The lifelong ambition of Guglielmo Marconi, which began on the cliff-top in Newfoundland, was over almost as soon as he had achieved it.

A lesser man would have retired from the scene but Marconi went on to pioneer microwave communications and, towards the end of his life, despite recurring heart attacks, was feverishly working on marine navigation by microwaves and investigations into what eventually became known as radar.

Marconi was from first to last a patriotic Italian subject. He was a member of the Senate and, admiring the way in which Mussolini had so successfully raised the standard of living in Italy in his early years of office, had become a member of the Fascist party in 1923, although never a politically active one. On the other hand, he had a deep affection for England, which had given him his opportunity and where much of his work was done.

Then, at last, the daemon relented. On July 20, 1937, yet another heart attack occurred, this time fatal. At least he had been spared the mental crucifixion which his divided loyalties would inevitably have brought when Italy and Britain went to war.

A strange man; almost, one would think, unknowable. Those who were his chosen assistants served him with fanatical loyalty, yet he was always "Mr Marconi". He could be ruthless; he could be extremely kind, but always aloof. In his later years he seemed to be in some fear of his life; at Marconi House, London, he would never share the lift with someone he did not know personally. He seldom was without an innocent-looking walking stick which concealed a rapier. This, however, might have some justification. Mentally deranged people not infrequently wrote to him complaining that "his" radio waves were the cause of their disturbance.

He sincerely believed that the true role of radio communication was to save lives; although he spoke little of it there can be no doubt that the steadily increasing part that the technology was playing in weapons of destruction brought periods of self-examination, as for instance on the occasion when he was elected Lord Rector of St. Andrew's University, he remarked to the Principal "Have I done the world good or have I added a menace?"

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Colour TV tube developments

New types recently on the market

The Trinitron tube developed by Sony was the first colour television receiver tube to break away substantially from the established design technique of the shadow-mask tube which came out in the 1950s (see *WW*, December 1971, pp. 589–592). It was characterized by cathodes arranged in a horizontal line instead of in triangular or "delta" formation, a single electron gun instead of three separate guns, and an "aperture grille" and vertically striped colour phosphors instead of the circular-hole shadow-mask and dot pattern of colour phosphors. Since then a variety of new tubes, all using horizontal "in-line" cathodes, vertically slotted masks and vertical phosphor strips, have been put on the market, and several have already appeared in television receivers.

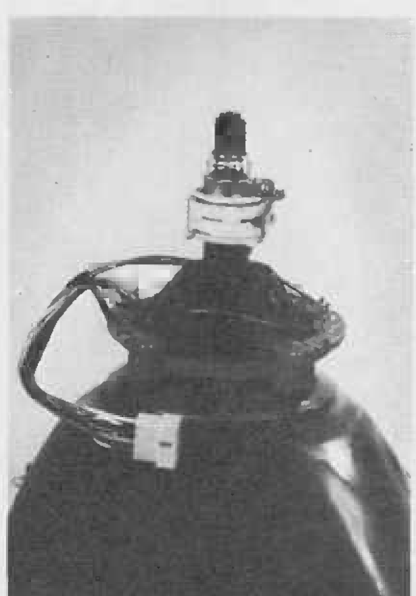
One of the first in this category was the RCA "Precision in line" tube mentioned in our 1972 review of sets (*WW*, October 1972, pp. 466–467). The aim of this development has been a colour tube display system, for small receivers, which can operate without any dynamic convergence correction circuitry. The absence of this circuitry, plus the absence of convergence coils on the tube neck and the fact that there is no need for lengthy adjustments by the set manufacturers or service technicians, has made this tube very attractive to set makers. It is a thin-necked type with a 90° deflection angle, available initially in a 20-in size. A 110° angle would have reduced the depth of receivers but the convergence simplification could only be achieved with a 90° tube. However, shorter electron guns and the omission of convergence coils has enabled the neck to be shortened by 46mm relative to that of a conventional 90° colour tube.

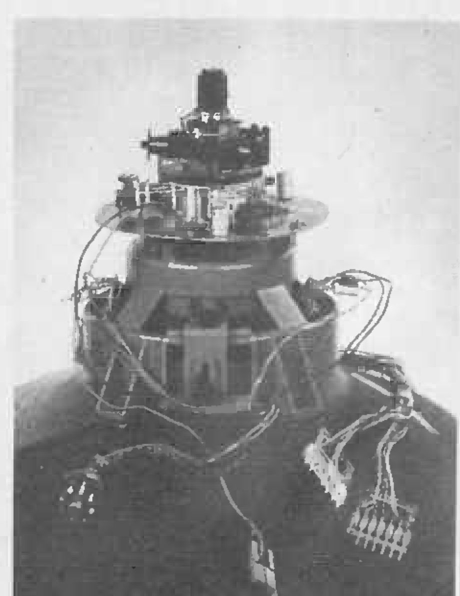
In the electron gun structure of the RCA tube all three grids are provided by a common component and this makes for a small beam-to-beam spacing of 5mm. For static convergence correction four small ferrite magnets act on the outer two beams with respect to the middle one. The red beam is placed in the uncritical middle position, the idea being that red errors have the greatest visual effect in the picture. The shadow mask does not have continuous vertical slots like the Trinitron but each slot has horizontal bridges across it to give mechanical stability to the mask. Overall this design has the advantages that the screen can be filled with more phosphor material than is possible with the conventional dot structure; it avoids the loss of brightness at picture corners that has to be traded in the shadow-mask tube for correction of geometry distortion; and the effect of external magnetic fields, such as the Earth's, is greatly reduced.

Example of the 110° Toshiba tube, showing the neck components fitted.

Dynamic convergence corrections are provided by the deflection coils themselves, by virtue of the geometry of their windings and the way these are laid on the tube envelope relative to the electron beams. The deflection yoke, known as a "precision static toroid", is formed by wires laid into grooves in plastic rings cemented to a toroidal core and this, in turn, is cemented permanently to the glass envelope by the tube manufacturers to provide an integrated tube and deflection assembly. Convergence adjustments are made by the manufacturers before cementing, the yoke being moved horizontally and vertically to cause the blue and green rasters to converge with the red raster.

This RCA tube is made under licence by a number of European television tube manufacturers.

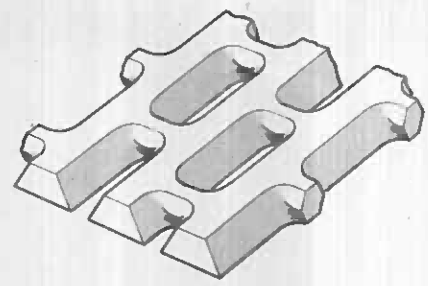




Comparison of the neck components required for a 27-inch conventional shadow-mask tube (right) and for an RCA "Precision in line" tube (left).

The latest European developed tube in the new category is a 26-inch 110° type, one of a family designated 20AX, which has been recently announced by the Philips group—in the UK by Mullard Ltd. This has horizontal in-line electron guns, a vertical-stripe screen and a shadow-mask with staggered vertical slots. This slotted mask has about the same transparency to the electron beams as the conventional round-hole shadow mask. The electron gun is reduced in length and allows the tube neck to be about 2cm shorter than that of the 110° conventional "delta" gun tubes so far released by Mullard. The 20AX family has an internal magnetic shield, a 6·3V, 0·75A heater and a "quick vision" cathode by which a picture appears on the receiver screen only 5 seconds after switching on the set (normally there is a 15-second wait).

The tube design is described as "self-converging", which means that part of the dynamic convergence is performed by the geometry of the deflection coils and part by an additional small winding on the deflection yoke through which suitable currents are paseed. There is no pre-alignment of the yoke and tube by the manufacturer, as with the RCA tube, the tube and yoke being supplied as separate components. Electronic circuitry required is reduced from the normal dynamic convergence correction printed-circuit board to a small p.c. board on which the tolerances of the convergence correction are adjusted by seven independent variable components. The maximum tolerance adjustment required in this system amounts to a 2mm shift on the screen. Mullard have demonstrated a receiver using the system,



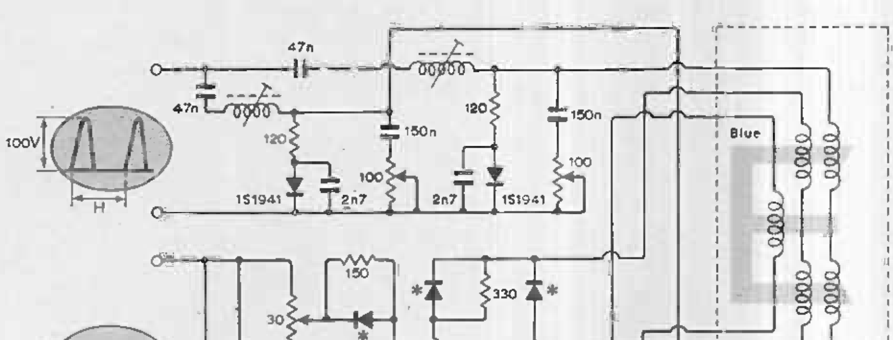
Structure of the slotted mask of the Toshiba colour tubes. Note the hexagonal cross-section of the horizontal bridges between slots.

which, they claim, eliminates 70–100 dynamic convergence components and nine related adjustments. It is expected that the 26-inch tube will appear in "luxury" sets in Germany during 1975 while a smaller version will be available in 1976.

Just before the Mullard announcement the Japanese manufacturer Toshiba showed in London a whole range of tubes with in-line guns and vertically structured masks and screens as described above: 14-inch and 16-inch tubes with 90° deflection angles; and 16-inch, 18-inch, 20-inch and 22-inch tubes with 110° deflection angles.

These tubes use a slotted mask (see diagram of structure) and the screen has vertical stripes of red, green and blue phosphors with black stripes between them. The electron beam landing on the screen is wider than the phosphor stripe of each colour (in the horizontal direction) and, of course, is shorter than the stripe in the vertical direction. This provides what the makers call a "hybrid landing system" and is claimed to give superior uniformity of white on the screen and insensitivity of the beam to registration with the phosphor in the vertical direction. These characteristics allow greater freedom in the design of the deflection yoke than is possible with the conventional shadow-mask tube and allow a simplification in the dynamic convergence adjustment procedure. In the 90° tubes the number of controls required for dynamic convergence adjustment is only two. Convergence circuitry for a 110° tube used in a PAL receiver is shown in the diagram. The mask and screen structure of the Toshiba tube is claimed to give a 60% increase in brightness and 10% increase in contrast relative to a conventional shadow-mask tube with a tinted faceplate. It is also claimed to give higher resolution—about 50% more information than is possible with a conventional shadow-mask tube.

Incidentally, Sony introduced a 114° version of their Trinitron last year and this is used in an 18-inch colour television set, KV1810UB, put on the British market early in 1974 by Sony (UK) Ltd. The extra wide angle design is claimed to improve picture quality by giving sharper electron beam focusing and more accurate beam landing on the phosphors.



Dynamic convergence correction circuitry for a 110° Toshiba tube used in a PAL television receiver. Neck components are shown on the right.

Sixty Years Ago

Radio-navigation

The use of radio signals as an aid to navigation was brought to public prominence by the development of equipment such as GEE and OBOE during World War II. Aircraft and ships were equipped with navigational radio long before this, of course, but it may come as rather a surprise to read the following extract, taken from our issue of April, 1913. The Government referred to is presumably the French one.

"Wireless lighthouses are being established by the Government along the French coast, the first two being located on islands near the approach to the port of Brest. Two more are planned for the port of Havre. The lighthouses will operate by a system almost exactly like that of ordinary lighthouses, except that, instead of light waves, wireless waves will give the information to approaching ships. The great advantage of such lighthouses is that fog will not hinder their efficiency. When a ship approaches Brest, and is within thirty miles of the islands, wireless signals will be picked up. If the ship has an instrument to detect the direction from which the signals come it will be easy to apply the information; but even if it does not have such an instrument the receipt of any signals at all will be of assistance, for the exact positions of the two lighthouses are known, and a comparison of the strength of the signals from each will help in estimating the ship's position. Each station, like an ordinary lighthouse, will send out flashes every few seconds, together with special signals to indicate which station is sending. The sending apparatus is automatic, and is constructed so that it will run for thirty hours without any attention."

Photographic development timer

Multiple unit giving elapsed-time indication and an audible warning

by R. G. Wicker

A multiple timer is described which has been built as an aid to photographic paper development. Six independent timers are used which may be started at random intervals as each sheet of exposed paper is placed in the developer. A "time elapsed" meter is included which indicates the state of the timer which will next reach its terminal condition. An audible signal is given each time a timer reaches the end of its period and an indicator light is included which shows when all six timers are simultaneously in use.

When printing on photograpic paper from a negative the paper is first exposed to the light in an enlarger or contact printer for a period of the order of seconds. Several timers have been described, using both analogue and digital techniques[1,2] which indicate or control this time to a degree of accuracy which is more than adequate for the required purpose. (Errors of up to 10% are difficult to detect in the final print.)

After exposure the paper is then placed in a developer where it must remain for approximately two minutes—the normal time for black and white prints with developer at 20°C. Various clockwork clocks are available to time this period but these suffer from a number of drawbacks. The clock not only needs starting but has to be stopped and reset manually. The face, although luminous, is not always easy to see in the near darkness of the darkroom. When several prints are produced from one negative they become available at 15 or 20sec intervals and the operator must then remember the time intervals at which prints are introduced into the dish to know when to remove them. It is obviously less time-consuming to develop several prints concurrently than to develop them individually.

It was to overcome these limitations of clockwork timers that the unit was developed and constructed. The timer has proved useful and accurate and the maximum capacity of six simultaneous prints has been found to be just about right. When working alone it is unusual to use more than four timers at a time; with an assistant one does occasionally get up to six. To date the need for a greater number has not been felt.

Circuit operation

Both digital and analogue timers were considered. Whilst it is fully realised that greater accuracy can be achieved by digital methods using, for example, the 50Hz mains as a master clock, the complexity needed to realise a multiple timer using these techniques, the cost involved in the digital timers and a suitable elapsed time indicator led one to adopt an analogue technique, shown in block form in Fig. 1. Using a ramp generator as the basic timer circuit means that a simple meter indicator, which gives a continuous and ergonomically satisfactory elapsed time indicator, can be used, although integrated logic circuits are used in the control section of the unit.

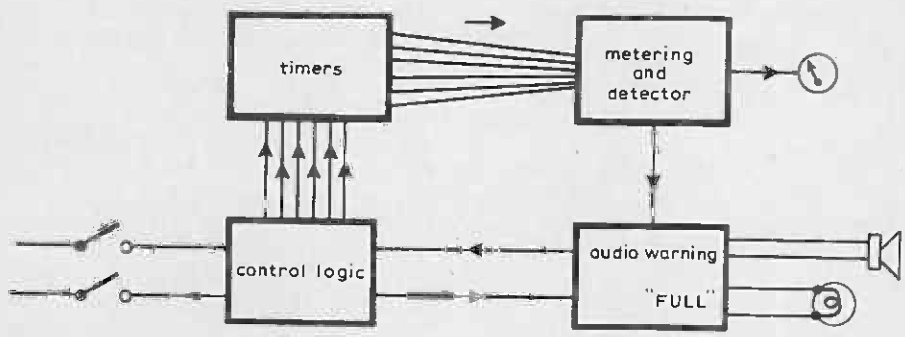


Fig. 1. Block diagram of the timer.

An input switch is used to start each timer in turn, the input signal being steered to the appropriate timer. An "end of time" detector produces a reset pulse which resets each timer to zero in turn. The reset pulse is applied to a multivibrator via a pulse lengthener to produce an audible "bleep" and warn the operator should he not be paying attention to the meter at that particular time.

Timer. As mentioned, a ramp generator is used as the basic timer circuit, shown in more detail in Fig 2.

The basic requirements of the timer were considered to be

(a) to produce a time delay of 2min ± 5sec,

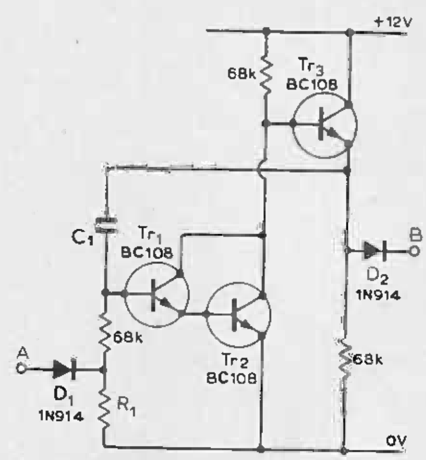


Fig. 2. Ramp generator circuit diagram. C_1 is $1\mu F$ and R_1 $11M\Omega$ in the instrument described, which runs up in 2min.

(b) to "run" or "standby" in accordance with the state of a logic input,

(c) to provide a linear output at suitably low impedance to drive a 1mA meter, and

(d) to be simple and economical to build. Economics in terms of home construction tend to be affected to some extent by availability of components through retail channels.

A Miller type circuit was chosen for the ramp generator and a "Darlington pair" followed by an emitter follower using three high gain transistors gave the desired result. The timing capacitor C_1 should be of low leakage and should be a paper or polycarbonate type. Including the emitter follower in the feedback loop helps to linearize the circuit. Field effect transistors, with their high input impedance, are an attractive proposition where long time constants are required but their higher cost is not warranted in this case.

The circuit, as shown, yields a linear ramp with an amplitude of at least 90% of the supply voltage with a run up time of 2min. having a $C_1.R_1$ product of some 10farad.ohms. One microfarad capacitors were used in the prototype but larger values could be used to advantage especially if longer periods are required, for example in some colour processes, where 4min development is needed. R_1 was adjusted for each timer to give the required period. The accuracy with which R_1 is adjusted is a matter of choice but the prototype was adjusted to give an accuracy of $\pm$ 2secs and this has been maintained over a period of several months. No temperature cycling has been attempted as the timer is used in the near constant temperature environment of a darkroom.

When a logic "1" is applied to the anode of D_1, Tr_1 and Tr_2 are switched hard on and Tr_3 is consequently switched off, the output voltage at the cathode of D_2 being 0V.

When a logic "0" is applied to the input, C_1 charges through R_1, the charge being slowed down and linearized by Miller effect. After a period of time the output voltage reaches approximately rail voltage, Tr_1 and Tr_2 being cut off and Tr_3 hard on. The input diode D_1 prevents C_1 charging via the low output impedance of the controlling logic whilst D_2 is used to combine the output of all the ramp generators to the metering circuit input. The meter will thus only "see" the ramp generator output with the highest voltage, i.e. the one with the least time to run.

Meter and detector. The metering circuit consists simply of a suitable meter and multiplier adjusted to read 10V f.s.d. (if a 12V supply rail is used). The scale would ideally be calibrated in minutes and seconds but in practice a linear scale reading 0 to 1 or 0 to 100 is quite acceptable, as percentage of time rather than absolute time is a satisfactory indication. The sensitivity of the meter is only of secondary importance as long as the output of the ramp generators is not loaded to the point of reducing the voltage gain of the generators and thus affecting the ramp time. A 1mA meter is suitable as of course would be any meter of greater sensitivity.

The detector consists of a Schmitt trigger circuit driving a reset pulse generator. As the slew rate at the input to the detector is only of the order of 80mV per second a ramp amplifier has to be introduced to improve the accuracy of the detector. The bias of this amplifier is adjusted so that only the positive end of the ramp is amplified and adjustment of this bias is a convenient point at which the firing point of the trigger circuit may be set. The hysteresis of the Schmitt is kept small to enable the circuit to differentiate between two nearly equal voltages as may occur when two timers have been started within a few seconds of each other.

The slew rate at the input to the trigger may be further increased by including a suitable zener diode in the feed to the amplifier base but in practice this has not proved necessary.

The reset pulse generator is coupled to the trigger circuit via a small value capacitor and produces the necessary short, t.t.l.-compatible reset pulse for the control logic. Fig. 3 shows the circuit of this part of the system.

Control logic. To control the ramp generators in the required manner the control logic must produce six independent outputs, all at logic "1" (+ 3.4V). Means must be provided for each logic output, in turn, to be switched to a logic "0" (0.4V) on command from a unique input switch. The outputs must, similarly, revert to their standby condition (logic "1") in the correct order at the command of the reset pulses.

Three dual *JK* flip-flops are used to provide the necessary outputs and two-input NAND gates and inverters are used to steer the reset pulses, as in Fig. 4. One pair of two-input NAND gates are used to produce fully compatible input pulses from the input switch control. This circuit not only produces a pulse with correct levels, rise time and fall time, but also ensures that contact bounce does not cause spurious starting of several timers simultaneously.

All the flip-flops have their *K* inputs grounded and their *J* inputs connected to the *Q* output of the previous flip-flop except for the first flip-flop in the chain which has its *J* input connected to + 5V. Initially, with all the timers in "standby", all the flip-flops are in the reset state with the *Q* outputs at "O" and the $\overline{Q}$ outputs to the timers at "1".

The first operation of the switch will set the first flip-flop as only this one has a "1" on its *J* input. On release of the switch the "1" is transferred to the output of the flip-flop thus enabling timer No.1 to start its run up and changing the *J* input of flip-flop No.2 from "0" to "1". Each subsequent operation of the input switch will set the next flip-flop allowing the associated timer to run up and presetting the following flip-flop. When the sixth and last flip-flop is set, its *Q* output, now at "1", switches on the indicator transistor and lights up the "FULL" indicator lamp.

The first requirement of the control logic is thus satisfied. Resetting of the flip-flops in sequence presents a more complex problem when using a single reset pulse generator for all the timers. Whereas the output of a *JK* flip-flop changes at the end of a clock pulse it is reset at the start of a pulse applied to the reset terminal. Thus a reset pulse of any duration long enough to ensure resetting under the most adverse conditions would be gated through to subsequent flip-flops and thus reset more than one flip-flop at a time. Gates can be delayed by including a suitable *CR* network in either the input or output terminal but under these conditions they may become unstable at the transition point and produce what amounts to a train of pulses at the output; an undesirable state of affairs, which can be prevented by using an inverter as the delay element.

The reset pulse is therefore applied directly to the first flip-flop (which will always be the first to be reset) and via gates to all the following flip-flops. The gates are controlled by the state of the preceding flip-flop via inverters which act to delay this "enabling input" to the gates until after the termination of the reset pulse. In this way the gate which drives the reset input of flip-flop "*n*" will not be enabled by the changing output of flip-flop "*n*-1" until several microseconds after this change has occurred, by which time the reset pulse which reset flip-flop "*n*-1" has finished.

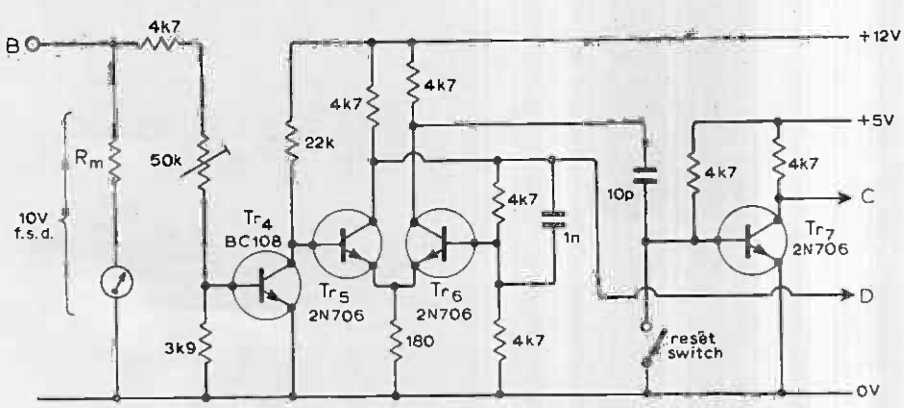


Fig. 3. Meter and trigger circuit. Meter can be 1mA or less.

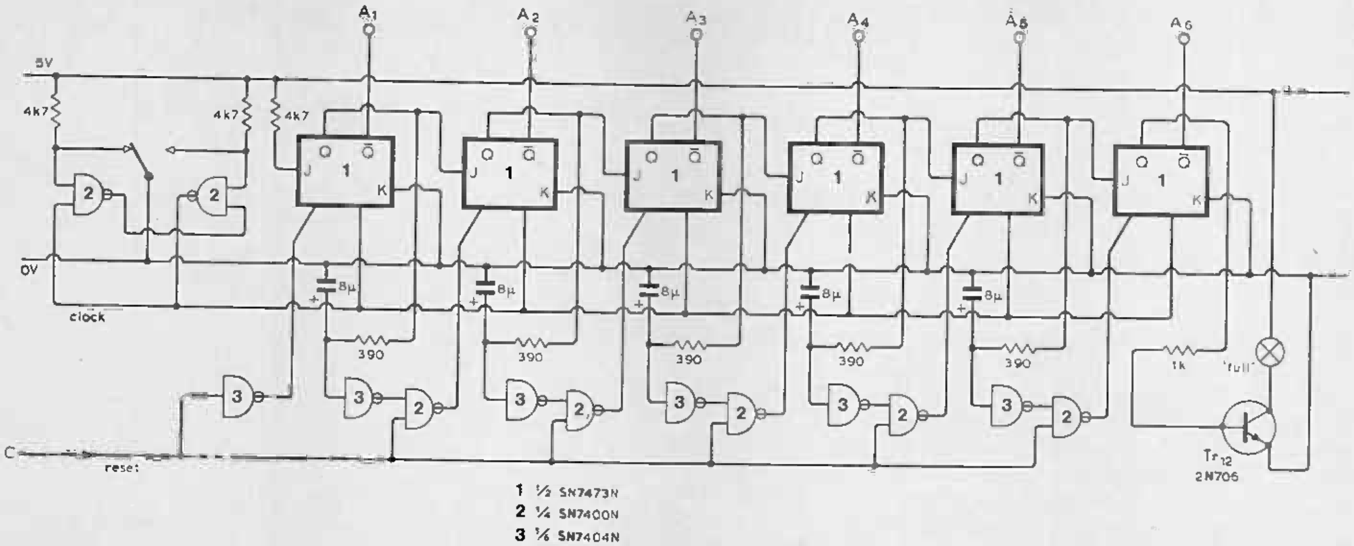


Fig. 4. The control logic circuit.

Thus each flip-flop and its associated timer is reset in turn in the same order as they were set by the input switch.

Audible warning. At the time when the Schmitt trigger changes state, when a timer has reached its terminal point before being reset, the collector of Tr_5 in Fig. 3 switches from near 0V to approximately +6V. This voltage is applied to the base of Tr_9 in Fig. 5, which in turn switches on to charge C_4. The charge thus stored then discharges as base current for Tr_{10}, one half of a multivibrator operating at a few kHz. Tr_9 and C_4 thus lengthen the short reset pulse so that the audible warning multivibrator may oscillate long enough for the signal to be heard. A short "bleep" is thus produced by the device each time a timer has reached its final time and is reset.

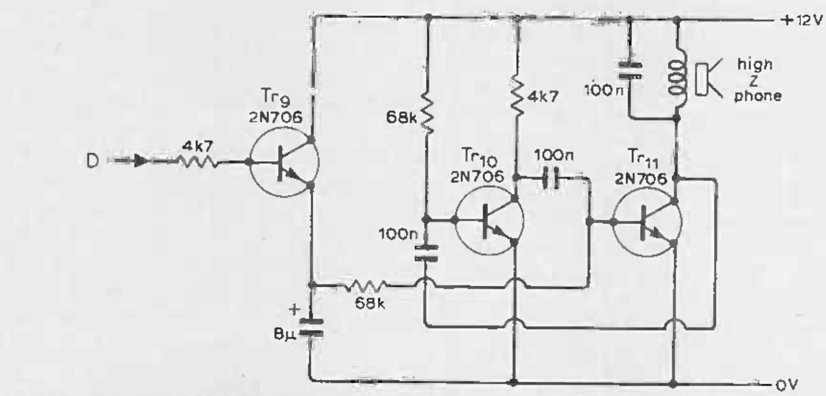


Fig. 5. Circuit to give audible warning of a timer reaching its preset condition.

Construction and setting up

No particular precautions are necessary in construction other than those appertaining to the use of integrated circuits. The lead lengths around the ramp generators should be kept as short as possible as there is considerable power gain between the input and output terminals of this part of the unit. No parasitic oscillations were experienced using this circuit configuration but some of the early stages of development showed that this particular problem should be kept in mind. The prototype was constructed on two boards, one with the timers and the other all the other parts of the system. The power supply should provide 12V at about 5mA and 5V at about 300mA for the logic circuits. No supply stabilisation has been found necessary, the only precaution being to ensure that the supply line to the t.t.l. circuits does not exceed the manufacturers' recommendations. Fig. 6 shows a suitable circuit.

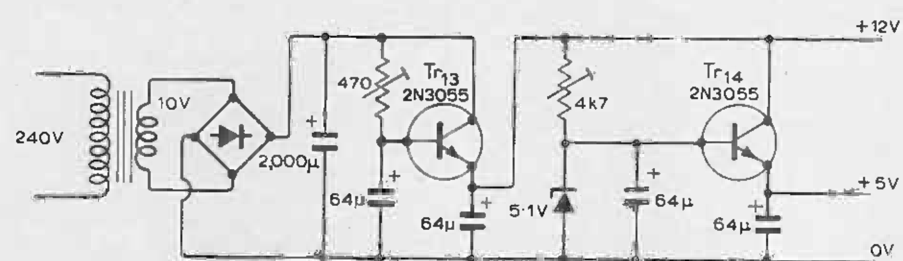


Fig. 6. Power supply.

On the author's unit a small yellow plastic box, of a type well known to most photographers, was mounted in front of and below the meter face. The inside of this box was lined with chrome-plated adhesive tape and two 6V, 40 mA bulbs were mounted within the box. These bulbs are connected in parallel across the 5V supply line, thus illuminating the meter face and incidentally providing sufficient light to obviate the use of a separate darkroom lamp.

For setting up purposes R_1, the timing resistor, should be replaced or shunted by a resistor of about 220kΩ—a wait of 2min each time one wishes to check the operation of the reset or logic soon becomes tedious. Next, each timer should be checked individually to see that the output voltage reaches at least 11V (reset generator not connected). With the meter multiplier adjusted so that the meter reads 10V full scale the Schmitt threshold should now be adjusted until the reset pulse is generated just as the meter reaches full scale. When, and only when, one is satisfied that all is in order does one begin to adjust R_1 to give the correct time. With the threshold set as above it was found that R_1 was typically 11MΩ (C_1 = 1μF) and the value was made up of suitable resistors until the desired degree of accuracy was reached.

A reset button is useful during the setting up and testing period and if desired can be fitted permanently. Its main use in operation is to reset all the timers to "standby" when the unit is first switched on but it can be considered as an optional extra. Similarly the "FULL" indicator can be omitted as one rarely loses count of the number of prints which have been passed through the enlarger on to development.

Possible modifications

Often some photographic processes require longer or shorter periods than the 2min for which this unit was designed. Using larger values of C_1, time periods of several tens of minutes can certainly be achieved with no great difficulty. One facility which might be considered for certain applications is the ability to switch from one time to another as required. This can readily be achieved by switching in various values for VR_1, the threshold control, and simultaneously switching the meter multiplier so that the meter always reads full scale for full time. Should this technique be adopted a more sensitive meter should be used, as in the shortest time position a full scale reading may be required from a ramp voltage of only 1 or 5V. A maximum to minimum time ratio of at least five-to-one is readily achievable and ten-to-one can be obtained if one can tolerate a certain degree of non-linearity in the elapsed time indicator. This non-linearity is mainly due to the knee voltage of the ramp output diode, D_2, which, while insignificant in a 10V ramp, ceases to be so when the ramp is reduced to 1V. The use of gold bonded germanium diodes could well be considered in this position to improve linearity of the indicator should this be thought sufficiently important.

The unit may be extended beyond the six timers of the present system but care should be taken that the loading of the input switch gates is not exceeded. A gate or inverter can be included to increase the available fanout. Although the present unit does go beyond the recommended fanout for the input gate (just), no trouble has been experienced as a result of this.

A simple multiple timer such as the one described can find numerous applications in industry. The timing C or R could be switched to give a range of times.

A continuously variable control of C or R is hardly a practical proposition due to the number of ramp generators which need to be ganged. Should this facility be required the timing can be continuously varied by means of a potentiometer at the input to the Schmitt trigger circuit to alter its firing point. A ganged control must be included in the meter circuit so that f.s.d. always corresponds to the ramp terminal voltage. A combination of both techniques could be used with a switched C to give, for example, 1, 4 or 16min whilst the threshold control would give a calibrated range of 25% to 100% of the set time.

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Acknowledgment
The author wishes to thank Dr R. C. V. Macario for help in the preparation of this article

Colour separation overlay

Generation of television picture "insets"

by Gwilym Dann

An everyday use of colour separation overlay is seen in news broadcasts where a framed area behind the newsreader is filled with picture material which can be changed with each different news item. A conductor may be seen surrounded by close-up shots of various musicians, or dancers can be given a background which may range from street scenes to pictures of faraway places either in the form of stills, or from film or video tape.

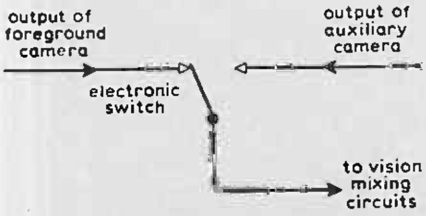

Fig. 1. Basic requirements for an overlay system.

Fundamentally, all that is required to achieve effects of this nature is a high-speed switch which will change-over the signal from a camera looking at the foreground figure to one from a video source providing the new background material. Fig. 1 shows the basic requirements. As distinct from the cuts between video sources performed as a manual operation, this switch must change-over as the scanning beam passes the image boundaries between figure and background or vice versa.

We must now consider how the switch may be given information so that it will change-over at these boundaries. Before the advent of colour television, overlay was attempted by arranging a brightness or contrast distinction between the foreground figure and its background. The sudden change in the camera signal as the scanning beam passed over the figure/background boundary was used to initiate a pulse which controlled the electronic switch, as indicated in Fig. 2.

From a practical point of view this system required that the figure should be overall light in tone against a background that was as evenly dark as possible. Only the simplest of effects could be achieved in this way and the results were unsatisfactory mainly because the lighting of the foreground figure had to be very flat in order to avoid shadows. Shadows, after all, might have the same tone as the background and this could result in the inserted background appearing in quite the wrong places. Worse still, an open mouth would be a shadow area and it was practically impossible to avoid the new background being seen therein.

The next step was to make use of colour distinction between the foreground figure and the background, albeit with monochrome cameras. The figure was lit with yellow light and the background with blue. Two cameras were then set up so that they received an identical image by means of an optical beam splitter. By fitting one camera with a yellow filter and the other with a blue, it was possible to derive a much more precise switching signal and a much more successful overlay resulted. This ingenious system was, however, operationally clumsy and difficulties in setting it up made it an unattractive production adjunct.

The introduction of colour television naturally re-opened the possibility of making use of colour discrimination between the foreground figure and its background, especially as the colour camera had the built-in ability to provide accurately registered images of red, green and blue components of the scene being viewed. It was fortunate also that in the colour television system there exist signals which embrace parameters of both colour and brightness, namely the colour difference signals, $B-Y$, $R-Y$ and $G-Y$. The choice of one of these signals for use in an overlay system is dictated by other than purely electronic considerations. The foreground figure will inevitably exhibit flesh colouring and we must choose a colour which is completely different for his or her background. A little thought will show that blue would be a suitable choice of colour which is remote from that of normal flesh. Additionally of course, we must forbid to the artiste any dress material or accessories which are blue in colour. From this it follows that the chosen colour difference signal will be $B-Y$ and it is interesting to consider the values of this signal for the whole range of colours which may be seen by the foreground camera.

The $B-Y$ values of signal voltage for each colour of the standard colour bars and those for white, black and grey are shown in Table 1. If these values are plotted as shown in Fig. 3, it will be seen that a datum may be drawn for which the value of blue is on one side and the values for the other colours, including white, black and grey, are on the other. Applying the $B-Y$ signal to a suitable voltage discriminator will therefore result in a keying signal which can be used to control the electronic switch of an overlay system.

The basic requirements of an overlay system utilizing the principle of colour separation have now been described. It will be apparent that no great electronic complexity is involved. The necessary hardware is a comparatively small addition to the circuitry of a television studio. In a practical situation however, comprehensive switching facilities have to be provided to gain access to a number of different video sources together with means of controlling the operating level of the voltage discriminator.

It may perhaps be mentioned that considerable care has to be taken in installation to ensure very exact coincidence in timing the arrival of signals on each side of the electronic switch. Errors in this connection could result in displacement of the foreground figure image with respect to the "hole" which has been "punched" in the inserted background.

It is of course necessary for the blue backing behind the foreground figure to have certain requirements as regards hue, saturation and luminance. Stated simply the hue should approximate to the peak response of the system's blue channel. Paint manufacturers can be asked to provide a paint with specific I.E.C. co-ordinates but a certain amount of trial and error is involved. The final hue and saturation may depend on the material to which the paint is applied and also on the need to introduce fire-resisting additives.

Studio lighting must provide sufficient luminance in the blue backing so that a satisfactory signal-to-noise ratio is provided in the blue channel. However, care must be taken to ensure that the lighting level on the backing is not excessive because reflected light tends to creep round the profile of the foreground figure. This effect is known as "rimming" and if severe, can be quite unpleasant in the final result. Furthermore this blue outline can make determination of the correct switching level somewhat difficult and because of the poor definition of outline an aberration known as "tearing" can occur. A certain amount of blue rimming is usually accepted as an inevitable feature of colour separation overlay. It may be reduced to a satisfactory degree by increasing the physical separation between the backing and the foreground figure, but it is unfortunate that studio-floor conditions do not always allow the necessary degree of separation to be achieved.

As described so far, the requirement has been one where the foreground figure occupies an appreciable portion of the television frame as in the case of news broadcasts. Where trick shots are involved such as a dancer seen floating over rooftops, she has to be small in the frame and this means that her blue backing has to be correspondingly large in area. In addition it will be necessary for an appreciable area of floor to be given blue treatment. Under these conditions, reflected blue light will tend to suffuse the figure of the dancer and it is extremely difficult to avoid a somewhat unnatural effect. Fortunately however, motion of the figure and perhaps the background tends to reduce the subjective awareness of this blemish.

Picture material intended for use as a background in colour separation overlay has fixed dimensions with respect to the television frame. There is no simple or direct way in which it may be changed in size or offset so that it appears in only a portion of the final composite picture as seen by the viewer. In news broadcasts, for example, the required material is provided by slide transparencies and it is necessary for the reduction in size and offset to be obtained optically, in the transparency scanner.

In other programmes the requirement may be for a full-size picture of a remote interviewee to be seen as if on a large-scale monitor beside the interviewer. To achieve this the incoming material is displayed on a "behind-the-scenes" monitor. An auxiliary camera is then trained on this monitor and the shot is adjusted so that the incoming picture fits the overlay blue area beside the inter-

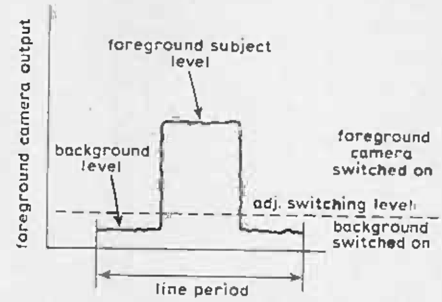

Fig. 2. Principle of contrast discrimination.

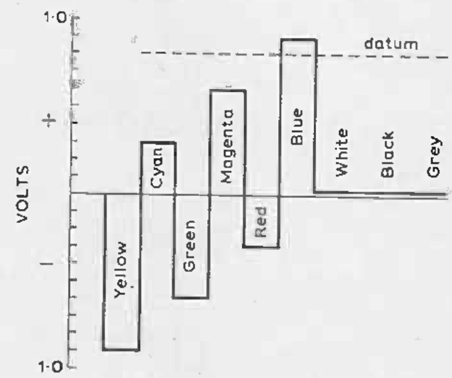

Fig. 3. B-Y values from Table 1 showing discriminating datum.

Table 1. Values of R, G, B and Y with corresponding values of B-Y.

	R	G	B	Y	B−Y
Yellow	1·0	1·0	0	0·89	−0·89
Cyan	0	1·0	1·0	0·7	0·3
Green	0	1·0	0	0·59	−0·59
Magenta	1·0	0	1·0	0·41	0·59
Red	1·0	0	0	0·3	−0·3
Blue	0	0	1·0	0·11	0·89
White	1·0	1·0	1·0	1·0	0
Black	0	0	0	0	0
Grey	0·5	0·5	0·5	0·5	0

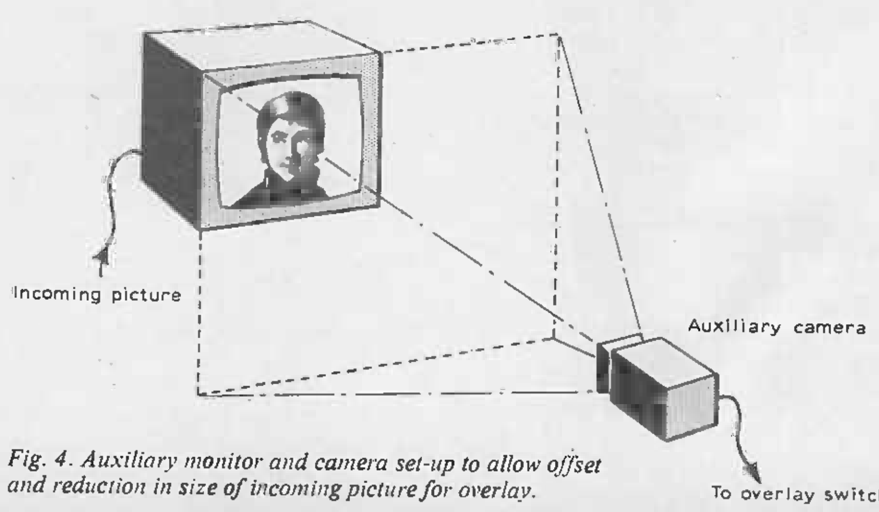

Fig. 4. Auxiliary monitor and camera set-up to allow offset and reduction in size of incoming picture for overlay.

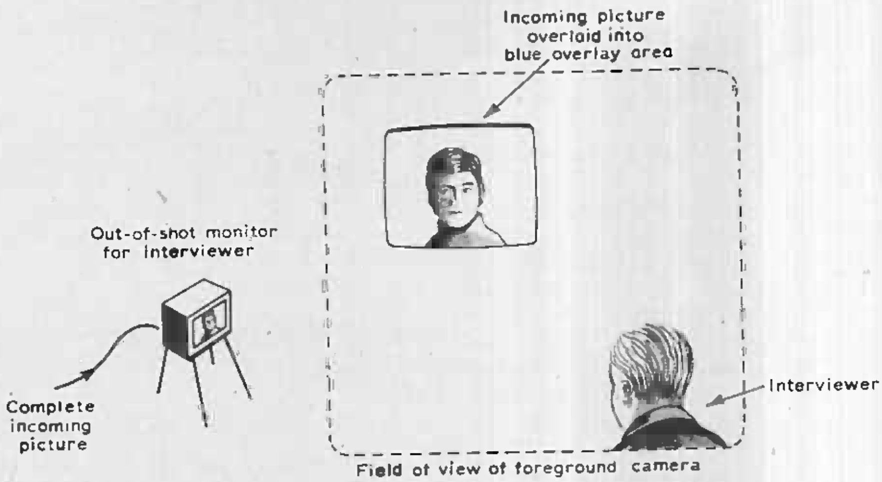

Fig. 5. Studio arrangement for overlay of full-size picture into part of frame.

viewer. This is illustrated in Fig. 4. The signal from the auxiliary camera is now the one which is fed to the overlay equipment for insertion as a background. Since the overlay blue area is all that is visible to the interviewer the illusion that he is addressing the distant speaker is completed by affording him a suitably disposed monitor out of shot of the main or foreground camera. The set-up as shown in Fig. 5 and Fig. 6 schematically shows the signal paths to the overlay switch.

Earlier in this article, good reasons were given for the choice of blue as the colour of the backing in colour separation overlay. This is because blue does not appear in normal flesh tones. However, reference to Fig. 3 will show that an equally satisfactory switching datum can be drawn with respect to the colour yellow. While it can be shown that yellow in this connection has a measure of discrimination against caucasian flesh tones, it would not be a satisfactory colour for the backing if the foreground figure had blond hair. The availability of a $B-Y$ signal in the television system is another reason why the colour blue is almost universally adopted for use in colour separation overlay.

In some types of television production it is not always required to use overlay continually and it may not be desirable or artistically pleasing for other cameras to show viewers the rather vivid blue backing. This difficulty can be avoided by using a neutral backing which can be given the required blue colour by lighting methods. This may be by means of suitably filtered projectors from the front or alternatively by rear projection on to some translucent material. When overlay is not required, the backing may be illuminated by light of another colour. Rearward illumination of a translucent backing with blue light results in considerably less blue rimming of the foreground subject. Future developments in the process may make increasing use of this method when studio conditions allow.

Although colour separation overlay as a process has been available to the broadcaster for many years, its full capabilities have never been fully explored and it may be interesting to consider why this is so. Day-to-day use of the system in news broadcasts involves minor additions to existing production routines; anything beyond this can involve a great deal of preparation and planning. Moreover it is by no means certain that the results will be satisfactory and there may be a good deal of time-consuming rehearsal before success is achieved. In an industry where, as elsewhere, time is money, uncertainties are anathema and there is a preference for old and well-tried methods where success is more assured.

One of the criteria involved is whether the effect is required to deceive or merely to produce a dramatic or spectacular result. In the former, success will only be achieved if the viewer is unaware of trickery and this means that a natural effect must be obtained. In the latter case however, naturalness is not essential and it will not matter if the viewer recognizes the effect as an intended gimmick.

An example of the unexplored possibilities of colour separation overlay is its use in providing a substitute for conventional scenery. An actor can be made to appear in a variety of settings obtained from still photographs or moving film which would pass for the real thing. The producer however, is unlikely to be satisfied with the single viewpoint or size of shot which is forced on him by this arrangement. For example, he would be unable to cut to another camera with a different view of his actor because, unless the scenery is very distant, it too ought to change its appearance or perspective. There would be other difficulties from a production point of view but these are beyond the scope of this article.

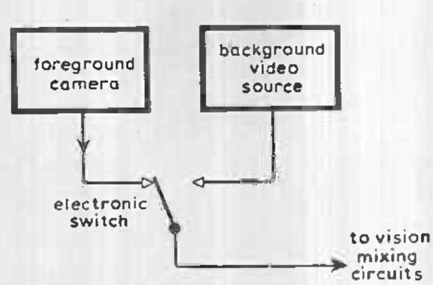

Fig. 6. Signal paths for overlaying full-size picture in part of frame.

Colour separation overlay can be successfully used to take the place of back-projection methods where a moving background must appear behind actors who are seen riding in a train or motor-car. Once again there is a difficulty in that we expect to see such a background out of focus compared with the foreground actors. This is achieved almost automatically with back projection of film due to the rearward spacing of the b-p screen. With overlay, the moving background would, unless special methods are employed, be as sharply in focus as the foreground actors and the effect would not be completely natural.

Colour separation overlay has been more successfully employed in the field of light entertainment. It can easily provide a flying-carpet illusion, an artiste appearing with his "other self" or the turning of a magazine page to disclose a new and moving scene.

It will now have been made clear that successful use of colour separation overlay depends on a large number of factors outside the field of electronics. It is a further example of the engineer's dilemma in that, having produced a clever device he not only looks for someone to use it, but to see it achieve its full potential.

Binding WW volumes

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Instruments Electronics Automation

Exhibitors, exhibition details and new products

The 10th International IEA exhibition is to be held at Olympia, London from May 13 to 17 and this year has approximately 600 exhibitors represented by over 300 companies. Opening time is from 9.30 a.m. to 6 p.m. and admission is free. The organizers of the show, Industrial Exhibitions Ltd, state that increased stand size, keen overseas interest and heavy bookings stimulate confidence that the UK's domestic troubles will not disrupt one of the electronic industry's major international events. A list of manufacturers and distributors at the exhibition is shown below. In addition to these there will be several publishers, banks and ancillary services to the electronics industry present.

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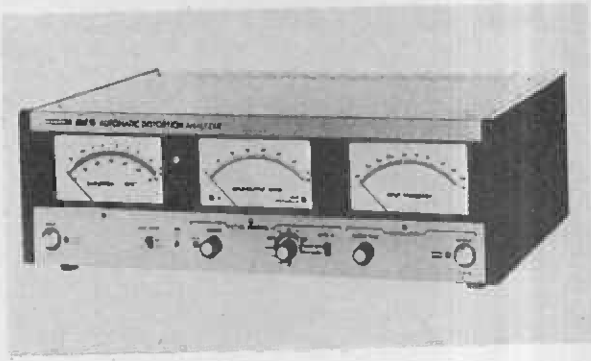

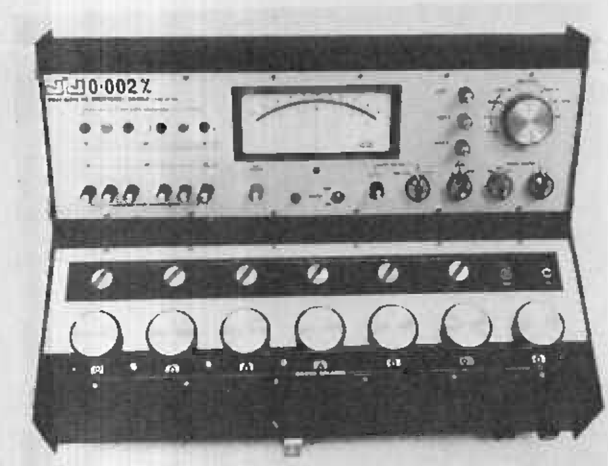

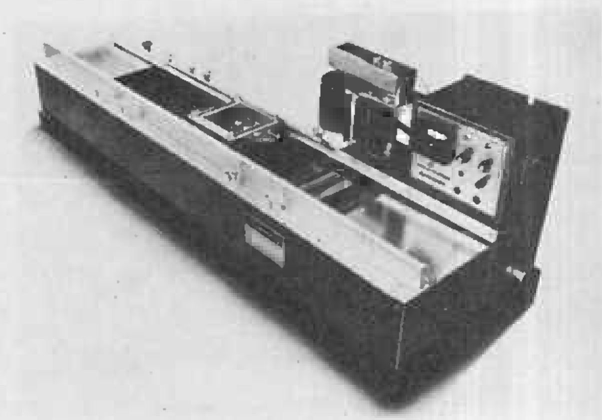

International Instruments will be showing the new Radiometer type BKF10 distortion analyzer. Designed as an integrated test system for audio equipment, its readouts include percentage distortion, frequency and signal-to-noise ratio. A self-contained sweep system allows amplitude response to be plotted (top left).

Allied International are expected to have the Electrovert "Minipak" automatic wave-soldering machine on view (bottom left).

Type BR100 d.c. resistance bridge from J. J. Lloyd Instruments will grade resistors into pre-set bands with 20 p.p.m. accuracy (above).

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Traffic information broadcasting in West Germany

by R. C. V. Macario, B.Sc., Ph.D., M.I.E.E.
University College of Swansea

The use of v.h.f. car radios with tone decoders will provide varying degrees of automatic traffic information reception. The system illustrates the use of digital techniques within the accepted type of analogue modulation.

The *Wireless World* a few months ago[1] surveyed some of the possibilities of broadcasting traffic information to the motorist and outlined the principal factors which lay behind various proposals. Since that time tests by the European Broadcasting Union have led to the recommendation of the ARI[2] (auto-motive radio information) system conceived by Blaupunkt in W. Germany. This system has been undergoing steady development over the last few years so that tests of the system are at a very advanced stage and not confined to small areas or a single town, but indeed cover the whole of W. Germany.

The writer had the opportunity to try the system quite independently with a current v.h.f. car radio and a fully developed ARI adaptor—which will be described—fitted as a normal car radio installation. The unit was used across part of Europe and listening tests were favourable, as indeed the EBU's must have been.

The techniques[3] behind the system are of special interest as the system makes use of digital techniques within an essentially analogue system. This move towards digital techniques in domestic systems will doubtless show a marked increase in the near future.

The system

The aim of the Blaupunkt v.h.f. radio system is to make use of the existing network of v.h.f. transmitters and appropriate car radios in the country wishing to introduce an ARI system. When an existing v.h.f. transmitter is adapted for the system, it is called a *traffic information station*. Because there is usually more than one programme in any regional area of a country, not every transmitter need be allocated, and in West Germany the allocation is about one in three. Short regional traffic information messages are then broadcast by these stations, as the need arises. The station is also identified by its transmission of the third harmonic of the 19kHz v.h.f.–f.m. stereo pilot tone, namely 57kHz (see Fig. 1) which can also be amplitude modulated in the manner described below. The additional tone does not cause interference with stereo transmissions. This identifying signal enables the traffic information station decoder attached to a v.h.f. car radio to recognize such stations. We then have the following choices:

1. At home, no changes to the programmes are apparent, except that one knows one's local traffic information station, and can receive so-called strategic traffic information.
2. In the car, with a "decoder", one can recognize traffic information stations in all regions, but has still a free choice of listening.
3. The additional transmitter identifying signal enables automatic functions to be introduced for the motorist, some of which will be referred to.

A great deal of discussion on all the possibilities of this scheme is possible, but probably sufficient has been said so far to give at least the general idea on the system aims.

Transmitter modifications

The principal modifications to the existing v.h.f. transmitter which is to be marked as a traffic information station are sketched in Fig. 2 and are:

- The 57kHz pilot tone.
- Additional l.f. amplitude-modulation tones, obtained by division of the 19kHz pilot tone.
- A traffic information desk microphone which switches on the l.f. tones when it is in circuit.

The tones, A, B, C, D, are called "regional tones". Although four are shown, there could be more or less. A transmitter in region A would use the A tone, marked as 23.75kHz, a transmitter in region B would use the B tone, etc. The additional tone, marked DK (125Hz) from the German *Durchsagekennung* which has been translated as "message only marking", is an additional identifying signal from the transmitter which enables the car radio decoder to do more than just listen. The DK tone modulation depth is kept to half that of the principal regional tone, which allows a 57kHz modulation depth of up to 60% without the likelihood of over modulation. The DK tone cannot interfere with the programmes, as it only appears during a traffic information broadcast.

Vehicle decoder

This is an optional extra to the car radio, but is of course the extra which provides the service the system is designed for. The following levels of sophistication exist, in ascending order:

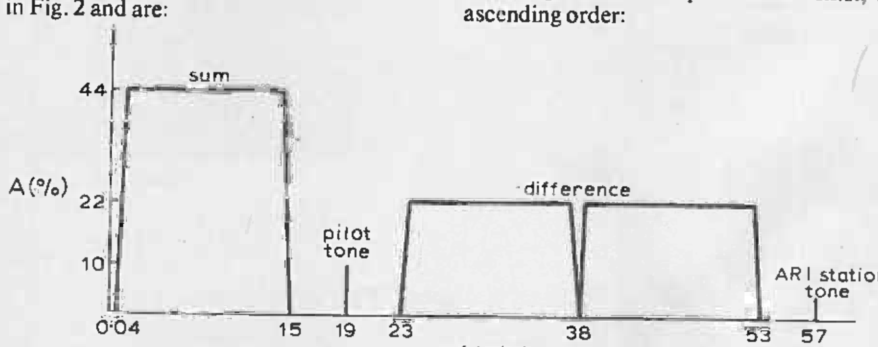

Fig. 1. Modulation spectrum of v.h.f.–f.m. stereo transmitter with traffic information pilot tone.

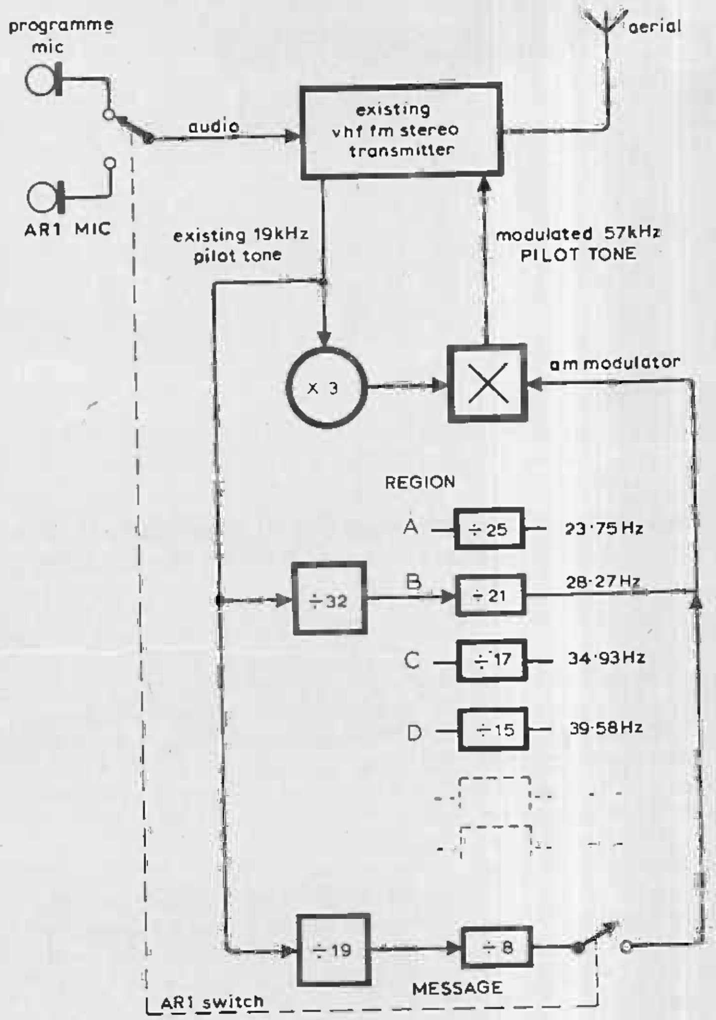

Fig. 2. Traffic information station transmitter showing additional circuits.

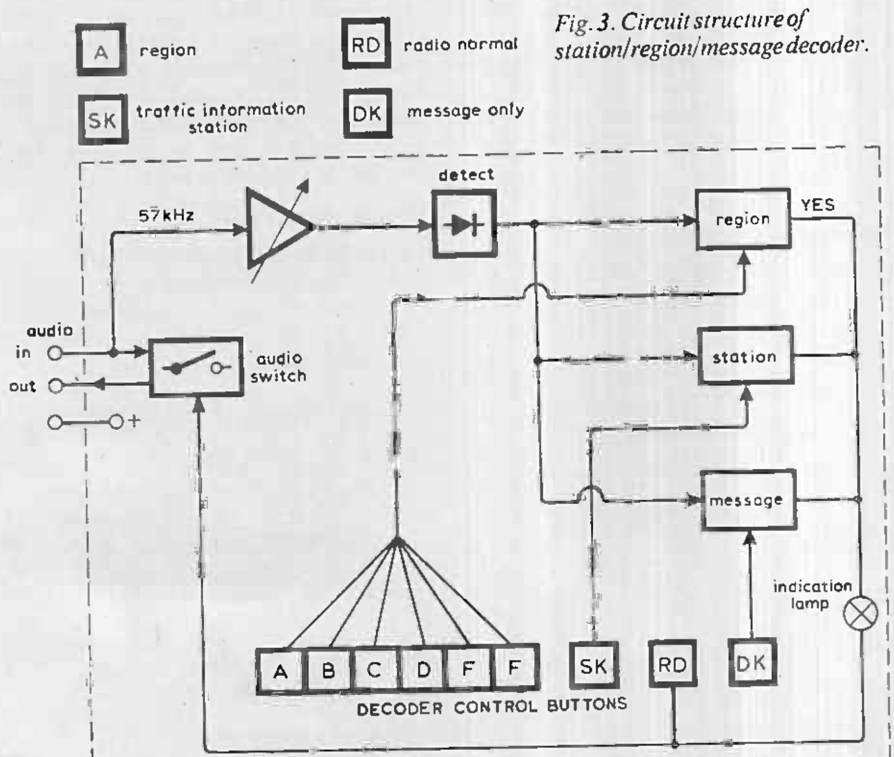

Fig. 3. Circuit structure of station/region/message decoder.

1. Station indication only. The decoder indicates which stations being received are traffic information stations by recognizing the 57kHz identifying signal.
2. Regional station indication. The decoder will recognize only stations on a regional basis, by recognizing the 57kHz signal and the regional modulation tone.
3. Regional indication and message only. In addition to recognizing stations the decoder controls the audio output of the existing radio so that only traffic messages are heard.
4. Automatic set tuning, regional station recognition and message handling. In addition to all the recognizing, etc., automatic returning of the receiver for the purpose of the message is possible.

The first three levels are operated by the available demodulated f.m. signal (audio prior to de-multiplexing). The last system with automatic retuning of the receiver requires "access to the set", and is somewhat beyond the principle of an adaptation of an existing receiver, but does illustrate the sophistication which can now be offered to the driver of a vehicle.

Decoder electronics. The electronics used in the system is interesting in the fact that the decoder needs to recognize low frequency tones fairly rapidly. and reliably. We shall consider a specific decoder which is particularly illustrative. namely the station/region/message type; system 3. A photograph of such a decoder is shown as Fig. 5. The general structure of the decoder circuit is shown in Fig. 3, and this demonstrates the action the unit provides.

For example, by means of a tape recording outlet, the existing audio in the receiver is diverted through the decoder and the audio switch (the unit marked in Fig. 3). Depressing switch "RD" of the push buttons keeps the switch on and the radio works normally. Depressing the switch "SK" (traffic information station), means that the receiver only operates when a traffic information station is received (because of the 57kHz).

Depressing instead a regional button, "A" for example, means the switch only operates when the selected regional station is tuned in. In other words the receiver is muted except when the driver tunes into an appropriate station. This action requires the rapid response action just mentioned, because the audio needs to come "alive" as the set is tuned. The indicating lamp on the decoder also helps here, and also a.f.c. on the receiver is assumed. On the other hand the system acts as a tuning aid to the driver, especially in a congested v.h.f. spectrum.

The final sophistication in this system is when button DK is depressed. This holds off the audio, even in the presence of the 57kHz and the regional tone, until the 125Hz message tone appears. The car radio will then only apparently turn on during a traffic information message.

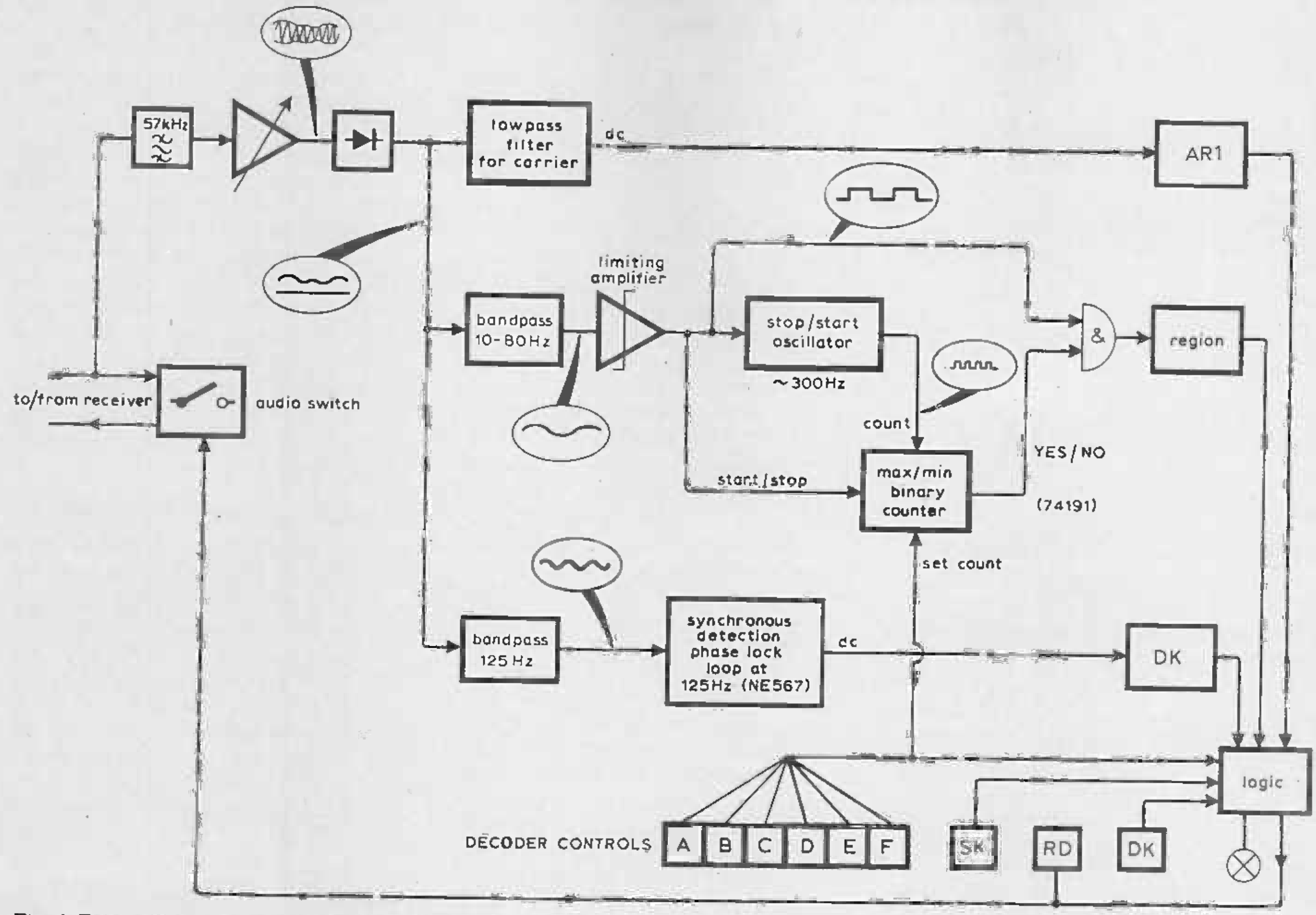

Fig. 4. Functional organization of the decoder circuits.

A more detailed diagram of the arrangement for this type of decoder at the present time is shown as Fig. 4. Apart from the logical connections, three main paths are evident, which clearly look for the three main indication signals from the traffic information transmitter, namely (i) the 57kHz pilot tone, (ii) the regional modulation tone in the range 20–60Hz, and (iii) the message tone of 125Hz.

The 57kHz tone is conventionally filtered and envelope detected, and will light the indicator lamp with either the **RD**, or the SK button depressed. The modulation tones are also obtained from the envelope.

The regional tone signal, if selected with a normal active tuned circuit or with a narrow band phase-lock loop, would have a response time which would be too long to enable the tune-in feature described above to be used. For instance, the response time in the worst case could be of the order of 0.5s. which is far too long. To overcome this problem a digital technique is used, as indicated in Fig. 4 which can be explained as follows. The regional modulation tone is pre-selected in an active bandpass filter covering the possible regional frequencies which are in the band 23.75 to 53.98Hz in the existing West German scheme. The resulting sine wave is then sharply limited to form a square wave at the tone frequency. The positive going edge, say, is then used to start a square wave oscillator running at some six to ten times faster than the input tone. The number of oscillations within half a regional tone period are counted. This count is at the same time compared to a preset count set by the regional button, A, B, . . . , etc. If the two counts are equal at the end of one half period a "yes" is registered, by which means the frequencies can be discriminated. In other words the system acts as a frequency discriminator with a response time of the order of one wave period of the frequency being selected, in this case a few tens of milliseconds, which of course is very much shorter than the fractions of a second referred to earlier. Since the modulation tones and the transmitter pilot tones are exactly synchronous, it is possible, by using techniques similar to that just described, to signal a very large number of tones with equally rapid unambiguous recognition.

The selection of the message tone of 125Hz uses a synchronous detecting phase-lock loop. This gives a better performance with regard to signal-to-noise ratio at the expense of slower acquisition. For instance, the message tone only appears during a message, and not during a tuning operation; also it is at a lower level of modulation and is the most likely tone to be subject to intermodulation by the message speech.

The unit shown as "logic" carries out the operation of turning the "ARI" light on at the right time, and operating the audio switch according to the control button positions.

Fig. 5. Station/region/message ARI decoder connected to v.h.f. stereo receiver.

References
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2. Sandell, R. S. "The Broadcasting of Traffic Information to Road Vehicles", I.E.E.Elec.Div. Lecture, November 16, 1973.
3. Information made available by the management of Blaupunkt-Werke GmbH, Hildesheim, W. Germany, and the Institut für Rundfunktechnik, Hamburg.

World of Amateur Radio

V.h.f./u.h.f. notes and news

The remarkable tropospheric ducting conditions on January 19–21 brought "wide-open" band conditions for many amateurs using v.h.f. and u.h.f. bands and resulted in what was probably the first contact with this mode between England and Austria at a frequency above 1GHz when G4BEL and OE2OML made contact on the 23-cm band over a distance of 640 miles. Other examples were the exchange of slow-scan television pictures between several British and West German amateurs on 144MHz at distances up to about 550 miles; there were many 144MHz contacts southwards to Spain and eastwards to Poland. An analysis published by Professor Walter Dieminger, DL6DS of the Max-Planck-Institut für Aeronomie, of atmospheric conditions over Berlin shows a pronounced inversion at heights of about 3km on the 19th, dropping to about 1km on the 20th and 21st and then gradually rising again. British amateurs must envy the frequent tropo ducting conditions that exist in such areas as the eastern Mediterranean providing excellent paths, for example, between Cyprus and Israel.

On the 13-cm band (2304MHz) two Czechoslovakian stations (OK1WFE and OK1KIR) have made contact over a distance of 243km; OK1WFE uses a 0.8-watt transmitter, a receiver with Schottky diode mixer and a 1.8-m parabolic dish aerial.

The GB3VHF beacon station at Wrotham, Kent has changed frequency to 144.15MHz in accordance with the new band plan.

Sic transit gloria DX?

Activity on h.f. bands recently underlines the steady reduction in m.u.f. as we approach another sunspot minimum. 14MHz has been closing early and on many days 21MHz opens only for north-south paths.

Recently Katashi Nose, KH6IJ of Hawaii has written nostalgically in *CQ* of long-distance working on the h.f. bands in the thirties: "Time was when skill, know-how, luck and patience were the hallmarks of a DXer. Today I'm afraid it is who you know and how much you can buy. Organized DXing (expeditions, special schedules etc) as we know it today is a postwar phenomenon only 25 years old. The 'golden age of DX' was 1934 to 1939—AC4YN from Lhasa, Tibet, ON4CSL 'the voice of the Belgian Congo'—such things as 11-year cycles had not yet been conceived. ZS2A was S9 on 7MHz. There was no pressure, stations were there for the digging —none of the pettiness and snarling, characteristic of the phone bands today. If someone stole your DX from under you, you admired his skill, but then most of the serious DXing was done by c.w."

He continues: "I remember August 31, 1939 very well. I worked Europeans never before possible from Hawaii. DX was never the same after that. After the war—the day of the manufactured contact and the Master of Ceremonies had arrived."

Most active h.f. amateurs, even though they may not agree that pleasant DXing died as early as 1939, will understand the sentiments of KH6IJ. Perhaps one of the reasons was the introduction after the war of "single-channel" working where everyone knew the frequency on which the distant station would be listening—a very effective system when there is no great competition to work a particular station but leading to anarchy when a rare call-sign appears.

Top band activity

Despite the general belief that low sunspot activity always means good conditions on 1.8 and 3.5MHz, Stewart Perry, W1BB does not rate the 1973/74 Top Band season as good as the year before and reports very variable conditions. Nevertheless by January 31 he had worked 32 countries compared with 30 the year before. In his "Bulletin" he reports that Phil Ashton, G3XAP has now completed his "worked all continents" but contacting VK6HD after two years of effort with 9 watts input: now he intends trying to do it all again but this time with 5 watts. Many amateurs must have envied the aerial system at W2WLN/2 during ARRL 1.8MHz tests: a $\frac{1}{4}$-wave insulated vertical with 300-ft radials every 3 degrees (120 radials) and two Beverage aerials 1000ft long towards Europe and terminated in a 120-radial earth. Apparently this is a United States Coastguard centre used to test Loran-A transmitters. F. J. ("Dud") Charman, G6CJ has an interesting theory that at the critical sunset/sunrise periods, ionospheric tilts can produce conditions where signals arrive at significantly higher angles than at other times and that when this happens dipole type aerials can be more effective than long-wire aerials designed for low-angle reception. He believes this applies to most h.f. bands but that these periods of "focusing" with the ionosphere tilted from a lower (day) height to the higher (night) height are quite short.

Marconi centenary

Guglielmo Marconi is on record as saying: "You know I have always considered myself an 'amateur'" and once wrote in *Wireless World* "I consider the existence of a body of independent and often enthusiastic amateurs constitutes a valuable asset towards the further development of wireless telegraphy". To mark the centenary of his birth a special amateur station, GB2MT, operated from April 25 to 28 from the house at 71 Hereford Road, Bayswater, London, where Marconi lived from 1896 to 1897; it used 3.5, 14 and 21 MHz s.s.b. Italian amateurs have been operating a centenary station, II4FGM, from near Bologna, Italy where Marconi was born on April 25, 1874.

Amateur growth continues

Amateur radio licences in the UK at the end of 1973 totalled 23,779, representing an increase of 1,692 during the year. Since most of the mobile licences are held by amateurs also holding a fixed station licence the total number of British amateurs was about 19,500. The Class B licences (v.h.f./u.h.f. telephony only) continue to increase more rapidly than the long-established Class A licences, although the rate of increase was a little less in 1973 than in 1972.

	end-1971	end-1972	end-1973
Class A	14,065	14,462	14,930
Class B	3,012	3,718	4,328
Class A/mobile	2,666	2,854	3,081
Class B/mobile	545	826	1,176
Amateur television	214	227	254

It would be interesting to know the age distribution of people taking out a licence for the first time: there is a general belief that the hobby is attracting fewer youngsters. One indication is that although RSGB membership has remained roughly the same during the 1970s (about 16,500), associate membership (mostly youngsters) has dropped from about 1,500 to just over 1,000.

In brief

The annual convention of the Northern Radio Societies' Association is being held this year on Sunday, May 12 at the Belle Vue Pleasure Centre, Manchester . . . Other mobile rallies during May include: May 5 Spalding Tulip-time rally at Surfleet; May 12 South Leicestershire at the Westfield Activity Centre, Hinckley; May 19 Northern mobile rally at Victoria Park Hall, Keighley; May 26 Hull mobile rally at Bishops Burton . . . The annual reunion of RAOTA (Radio Amateur Old Timers' Association) is on May 17 at the Bonnington Hotel, Southampton Row, London WC1 . . . GB2ITU will operate May 9 to 19 from Tonbridge School . . . The third convention of the British Amateur Radio Teleprinter Group is on Saturday, May 18 at the Village Hall, Meopham, Kent . . .

PAT HAWKER, G3VA

Alarm circuits

Sensing, processing and indicating

by J. Carruthers, J. H. Evans, J. Kinsler and P. Williams

Paisley College of Technology

As well as introducing series 13 of Circards this article touches on the concept of data domains

In this topic the viewpoint changes. Previously in Circards, circuits have been described as separate entities, with the articles laying a foundation, and the cards showing the practical alternatives. The dilemma is that the title used here, though commonly applied to the topic, can be misleading. This is because so many "alarm circuits" have several identifiable sub-sections each of which can be readily classified under headings such as those of previous series e.g. Schmitt trigger and astable circuits. Even heading this article "Alarm systems" might confuse since it could convey the idea of a conglomeration of alarms.

A typical alarm arrangment is shown in block diagram form in Fig. 1. An alarm signal is required from some output transducer when the signal from an input transducer indicates a particular fault condition. The intervening blocks are required to process the signal representing the fault condition, to detect a particular voltage/current level which is an analogue of the input parameter, and to deliver power to the output transducer. Before considering each of these sub-sections individually, there is a general principle which can be very helpful in considering such systems—the concept of data domains.

Data domains

Information on physical systems is obtainable in the form of physical quantities such as force, distance, energy. The required information may often have to be obtained by monitoring some more complex property involving a function of the more common parameters. In few cases is the information in such a form that it can be conveyed and displayed directly. It has to be transmitted through some medium or series of media first. To the practising engineer the medium is not the message but rather the barrier that hinders the appearance of that message.

In passing through these media the information takes on new forms or dimensions. For each new set of dimensions we may postulate a domain in which the data exists. Within that domain there may take place further conversions without going outside the domain. Thus the first main division is between inter-domain and intra-domain conversions. The division is arbitrary since the selection of domain interfaces is arbitary. One possible division is discussed below but readers may have their own ideas on this.*

For the purpose of this article, the domains are determined by the following considerations: is the data (a) continuous or discontinuous and (b) instantaneous or not. These conditions applied to electrical phenomena provide us with four domains. In addition there is the much larger physical domain (P) containing all non-electrical data. For other disciplines it is this domain that would be sub-divided into more convenient packages, as for example the heat/light/sound divisions of physics. The electrical domains are thus

	Instantaneous	Non-instantaneous
Continuous	A	t
Discontinuous	D_p	D_s

An A or amplitude function e.g. voltage/current/resistance. is an electrical signal precisely and continuously related to some other function which may or may not be within the A domain itself. It has an instantaneous value which is a measure of some property of the unknown. An example is the electrical resistance thermometer where the resistance (A domain) is a continuously variable function of the instantaneous temperature (P domain) i.e. a P-A domain conversion occurs.

A t function is also continuously variable, but to represent the data a finite time must elapse i.e. it is not instantaneous. This property should not be confused with the finite delays imposed by the physical limitations of systems, which prevent the instantaneous change in an A function. A t function will have corresponding delays in responding to changes in the data, but even with a fixed input requires a finite time to complete the conversion. An example is an oscillator whose frequency is proportional to a voltage. To determine that frequency at least one period must elapse (often many) and the data conversion is non-instantaneous. Such a voltage-controlled oscillator is performing an A-t conversion, the amplitude of the output waveform being irrelevant as all the data resides in the time-function.

Conversions may take place through more than one domain, and the shortest route in a system is not necessarily the best. If we wish, for example, to convert from temperature to frequency (a P-t conversion) we can do so by constructing an oscillator whose frequency is temperature dependent†, or we can use a thermocouple to generate a direct voltage that, amplified, controls a v.c.o. The latter can be considered as a P-A-A-t conversion with the voltage amplifier being an A-A converter i.e. input and output both existing in the amplitude or A domain. Better linearity of frequency against temperature could be achieved in this second approach.

Where the data is required in digital i.e. discontinuous form, a similar distinction can be made as to whether the data appears simultaneously at input and output (within the delay constraints mentioned above) or whether a finite time is required for the data conversion. The two categories resulting are the parallel and series modes respectively (D_p and D_s). They may also be thought of as a spatial and temporal ordering of the data—a pulse train representing the data in serial form conveys that information correctly regardless of the frequency if the order pattern is correct. In a digital voltmeter the data might be converted into serial form following an initial voltage-to-

*This approach was prompted by the excellent book "Digital Electronics for Scientists" by Malmstadt & Enke (Benjamin) which proposed a slightly different division.

†This can also be considered as a hidden form of P-A-t conversion since the temperature affects some A parameter such as R, C etc.

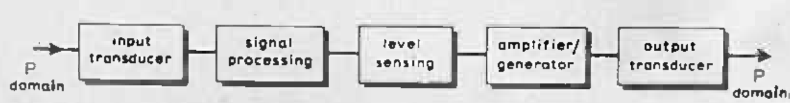


Fig. 1. Typical alarm circuit with input and output transducers.

frequency/time conversion, while it would be stored and displayed in parallel form. The data domain conversion pattern would then be A-t-D_s-D_p.

Within each domain, there may be a great variety of possible forms for the data, and multiple conversions can and do take place. Even a "simple" amplifier may have individual stages best viewed as V-I and I-V converters, while a voltage amplifier can be regarded as a V-V converter.

Transducers

These are the interfaces between the physical (P) and electrical domains (A, t, D_p, D_s). The range and variety is too large to cover in such an article as this, but some obvious examples are worth discussing. If an electrical conductor is subject to temperature variations its conductivity will vary. For metallic conductors the temperature coefficient of resistance is normally positive and the characteristic is sufficiently well-defined to allow precision thermometers to be based on it (platinum resistance thermometers). For semiconductors the coefficient may be negative or positive and of much greater magnitude though generally less well defined. This makes devices such as thermistors, which depend on this property, particularly useful in alarm circuits as a relatively sharp transition takes place in the resistance value and switching of a load is simplified.

If such a resistance which depends on a physical parameter is incorporated in a bridge circuit (Fig. 2) then by suitable selection of the other resistors the critical resistance value of the transducers may be made to correspond to the bridge balance point. Any high gain differential input amplifier may be used to detect this change of polarity about the balance point, providing a large output swing. Addition of positive feedback provides hysteresis, minimizing the output switching that would occur from noise or other stray input signals, when close-to-balance comparators or general-purpose operational amplifiers may be satisfactory in such applications.

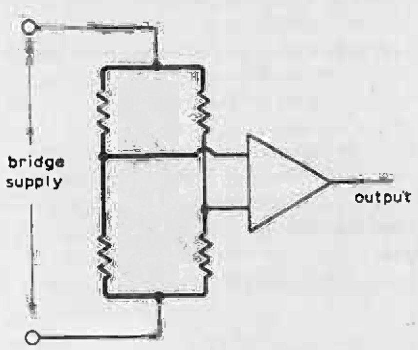


Fig. 2. Bridge circuit for including a sensing resistor.

Other physical parameters may affect the resistance of particular conductors and semiconductors. For example a polycrystalline film of cadmium sulphide in darkness has a very high resistance (>1MΩ), while exposure to sunlight may drop that resistance to a few hundred ohms. Where the changes are as extreme as this, the variable resistance could simply be placed in series with a supply voltage and the load to provide a direct if somewhat imprecise alarm.

Other semiconductors when exposed to particular gaseous impurities show similar large variations in resistance and are now used in gas and smoke detectors, though they require a separate power source to raise their operating temperature. Even the basic resistance thermometer mentioned above can be adapted to detect other physical parameters; for example the flow of air or other fluid across a heated filament removes the heat more rapidly causing the resistance to fall. Thus detection of fluid velocity is a possibility.

Other transducers give a voltage or current that is a function of a physical parameter; the e.m.f. of a thermocouple and the current flow in a reverse-biased photodiode are examples. Yet others may involve the variation of electrical parameters such as capacitance or inductance, coupling between coils, etc. In such cases a common alternative to the bridge technique, still viable with the substitution of a.c. drive to the bridge, is to make the frequency of an oscillator depend on the variation of the reactance used, and follow the oscillator by some form of frequency-sensitive switch.

Following the input transducer the signal may need to be amplified, filtered or modified (domain conversion of some form) in some signal-processing stage prior to being fed to a level-sensing stage. In some cases the two functions can be combined, as operational amplifiers having very high gain can suffice. If the output of the level-sensing device is insufficient in magnitude to drive the required load then a further power stage may have to be substituted (Fig. 1).

Additionally it may be required to cause this output signal to be an audible tone or an interrupted voltage for flashing a lamp. Either case could require an astable oscillator or similar form of generator (Fig. 3). A monostable circuit may be interposed to delay the onset of the alarm output for some period after the appearance of the fault signal and logic gating would be added in more complex systems to generate alarm outputs that depend on a particular combination of input parameters.

Thus most alarm systems can be broken down into simpler blocks and the block diagram of a burglar alarm could be identical with that for a circuit intended to sense icy conditions on a road. By appreciating and making use of this principle, it is often possible to make very economical designs of alarm circuits by adapting the best individual blocks from previously published alarm circuits. The major design problem is then that of making the blocks compatible in respect of supply voltage load requirements and the like.

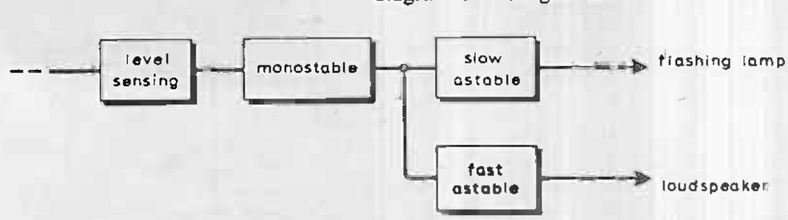


Fig. 3. Arrangement for operating a lamp and/or loudspeaker.

Titles of cards in Series 13 are

Flame, smoke and gas detectors
Bridge circuits
Time delay and generator circuits
Level sensing and load driving
Application of 555 timer
Frequency sensing alarm
Digital alarm annunciators
Filament lamps and relays
Signal domain conversion
Pressure, temperature and moisture-sensitive alarms
Security, water level and automobile alarms
Electromechanical alarms

An f.e.t. curve tracer

Concluding part of a sixth-form project

by L. G. Cuthbert

Queen Mary College, University of London

It is usually easier to build and test an electronic system as a series of blocks. Each can then be built, connected to the previous one and tested before the following one is added. Furthermore, the use of such blocks does illustrate the concept of the curve tracer as an electronic system.

Circuit description

Ramp generator. The basic ramp is obtained by forming a relaxation oscillator (Fig. 7), with R_3, C_1 and unijunction Tr_1. As explained in the system considerations, it does not matter that the ramp is an exponential rather than a linear function of time, but excessive non-linearity does mean that some parts of the trace would be much brighter than others. The potential divider R_1, R_2 is therefore used to reduce the voltage on base 2 of the unijunction, thus reducing the firing voltage.

The IC_1 is used to separate those parts of the ramp above and below zero thus producing the triggering and clipped-ramp waveforms at the two outputs. A small amount of gain is used on this amplifier to keep the voltage swing to about 12V and the amount of clipping is controlled by preset resistor R_{13} which shifts the signal, before separation, by a variable amount. Since the amplifier is used in its inverting mode a second inverting stage IC_2 is used to reinvert and produce a positive going ramp. Similarly, the common-emitter stage (R_7 and Tr_2) is used to reinvert the triggering part of the waveform. Since a fairly low-value base resistor (R_7) is used, the transistor is easily saturated and a fairly square pulse is produced.

Switch S_1 enables the drain voltage to be held at a constant value of about 11–12V so that the current amplifier can be calibrated. This is explained later.

Current sense amplifier. Drain current passing through the 100Ω resistor R_{14} (Fig. 8) develops a small voltage across it, proportional to the current. This is amplified by a difference amplifier to give the *y* output (drain current) for the oscilloscope. Preset resistor R_{19} enables the output voltage to be conveniently related

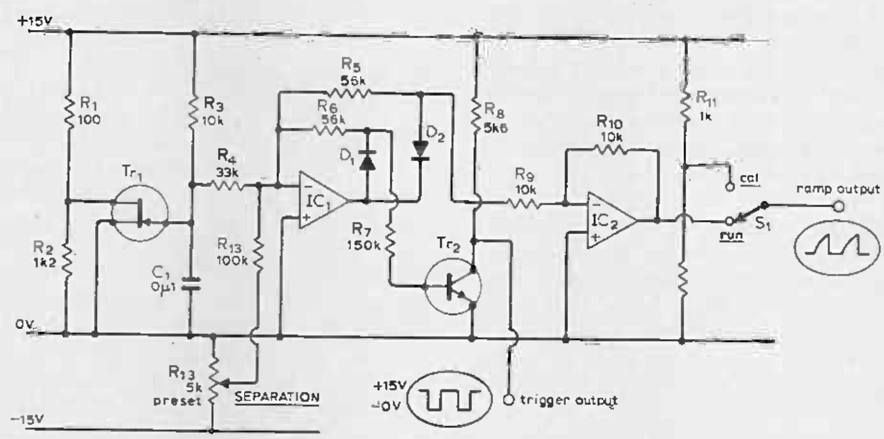


Fig. 7. Circuit diagram of the ramp generator.

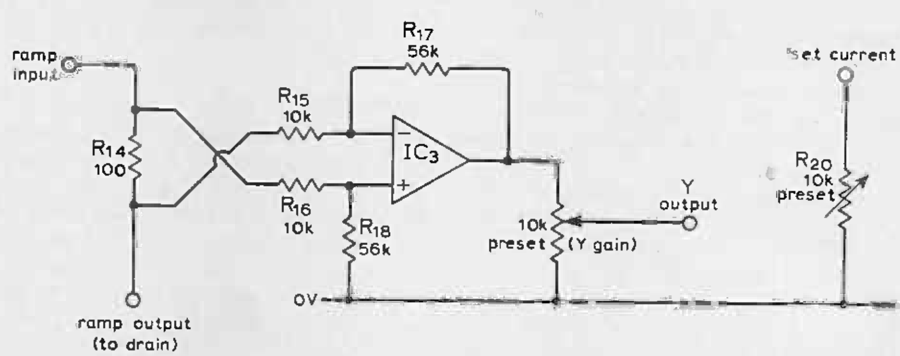


Fig. 8. Current sense amplifier.

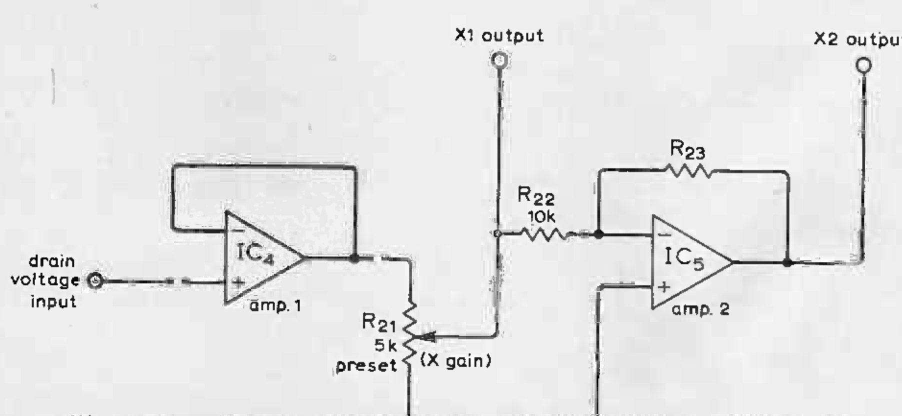


Fig. 9. X-voltage amplifier.

to the drain current. A value of 200mV/mA is quite suitable.

To calibrate this output, the switch on the ramp generator is set to the "cal" position and its output connected to the input side of the series resistor (R_{14}). The other side (drain terminal) is connected through a milliammeter to R_{20} which is varied until a current of about 5mA is obtained. Adjustment of R_{19} until the output voltage is 1V will give a calibration of 200mV/mA.

X-output amplifier. The x-axis of the display is the drain voltage so this circuit (Fig. 9) is simply a non-inverting buffer amplifier (to take negligible current) connected to the drain terminal. Preset resistor R_{21} is used to enable a suitable calibration of the x scale to be obtained.

Unfortunately, while a positive voltage applied to the x input of many oscilloscopes produces a trace movement from left to right, as expected, on others the reverse happens. A unity gain inverter is therefore provided for such cases.

Staircase generator. This is a standard transistor pump circuit driven by a differentiating and squaring circuit. Using a differentiating input has the advantage that the staircase "block" is triggered by a negative edge rather than by a pulse and therefore it can be used in applications where only an edge is available—for instance the resetting edge of a normal sawtooth.

A transistor pump rather than a simple diode circuit is used as this ensures that each step is of equal magnitude. As capacitor C_4 is loaded only by the unijunction and a high-impedance buffer amplifier, negligible current is drawn from this capacitor and therefore the steps do not droop.

Variable resistor R_{21} is used to alter the voltage on base 2 of Tr_6 so that the voltage at which the unijunction fires can be varied, thus changing the number of steps before the staircase is reset.

Gate drive circuit. The output of the staircase generator is a series of steps starting at 0V and rising in equal positive increments. However, the f.e.t. requires that the gate voltage should be negative and therefore an inverting amplifier with variable gain is used to invert the staircase. Since the unijunction transistor (in the staircase "block") does not reset the capacitor quite to zero, a variable offset control (R_{28}) is provided so that the whole staircase can be shifted, thus enabling a zero step to be achieved. The gate voltage must never be positive but there is enough range on this "zero step" control to shift the waveform across zero producing a positive voltage at the output of the inverter. Clamping diodes are therefore used in the feedback loop to clip the output to zero.

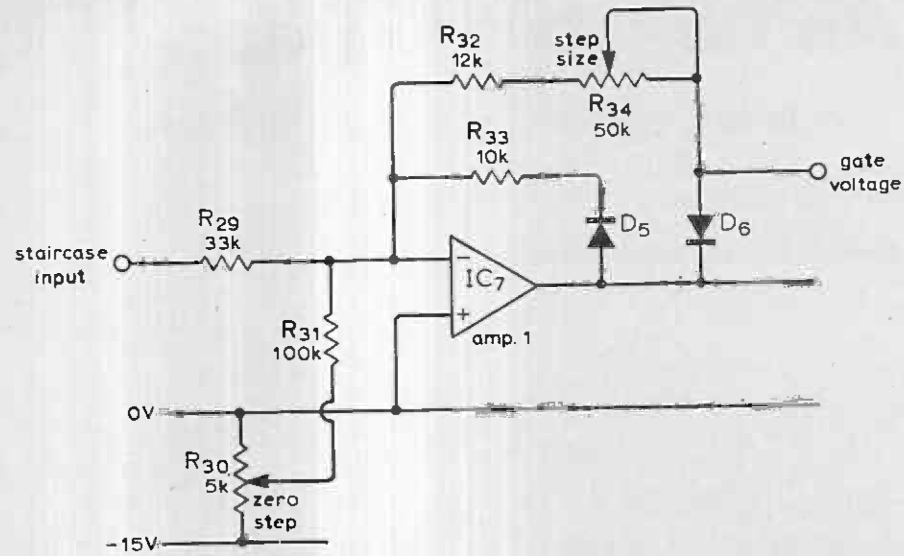


Fig. 11. Gate drive circuit.

Operation

The curve tracer has been designed to work with any oscilloscope with an external x input but on some of the cheaper dual-trace ones where the chopped-beam technique is used the display will have a mottled appearance. This is because the electron beam is rapidly switched between the two traces and, as only one is being used for this display, there will be blank parts when the beam is being used for the other trace. This can be avoided by carefully setting the gain of both y inputs to be identical, connecting both inputs together and shifting both traces until they are superimposed on top of each other.

The separate triggering pulse should eliminate flyback problems. However, on most oscilloscopes there is a slight phase difference between x and y inputs so that, even though the flyback should follow the main trace, a small Lissajous figure is in fact created and the flyback will depart slightly from the main trace.

Several variable resistors are provided and these fall into two groups: those which are used only to calibrate the curve tracer; those which are used to set up the required gate conditions for the f.e.t. being tested.

Calibration

The variable controls in this category are
separation (ramp generator)
set current and y gain (current sense amplifier)
x gain (drain voltage amplifier)
and a suitable calibration procedure is as follows:

(a) Calibrate the oscilloscope: use the y input in the d.c. mode. Remove the f.e.t.

(b) Use the oscilloscope on its internal timebase. Connect the y input to the gate terminal and adjust the separation control until a staircase just appears.

(c) Connect the x output to the external x input of the oscilloscope and the drain current output of the curve tracer to the y input and switch the oscilloscope to the external timebase. Set the y range to 200mV/div and put switch S_1 of the ramp generator block to the "cal" position. Connect a milliammeter between the drain terminal and the set current terminal of the terminal current amplifier. Adjust the set current control until the milliammeter reads 5mA and then vary the y gain resistor of the current sense amplifier until the oscilloscope trace is deflected 5 divisions. The y output is now calibrated as 200mV/mA drain current.

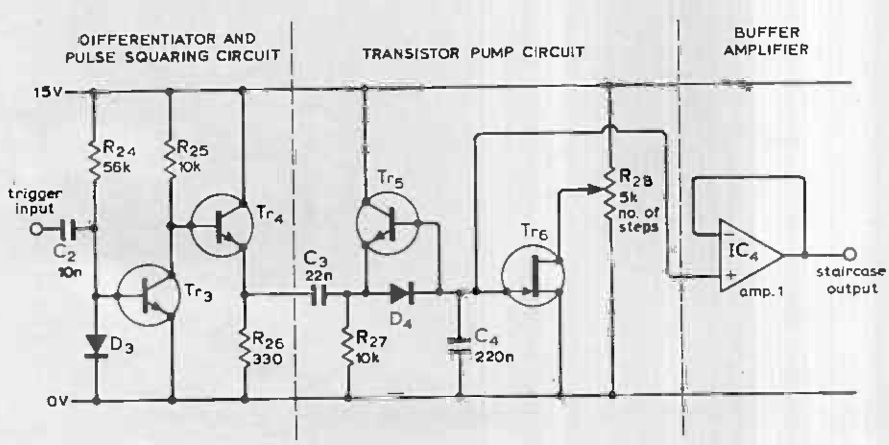


Fig. 10. Staircase generator.

(d) Put S_1 in the "run" position. Use the y trace of the oscilloscope to measure the magnitude of the drain voltage at the drain terminal. Adjust the x gain control (R_{21} on the x amplifier block) until a suitable deflection is obtained on the x axis of the oscilloscope display.

Gate voltage conditions

A suggested setting-up procedure is:

(a) Connect the gate terminal to the y input of an oscilloscope.

(b) Adjust the step size resistor until the required step size is obtained.

(c) Adjust the number of steps control to get the required number of steps.

(d) Use the zero step potentiometer to shift the whole staircase until the top (least negative) step just reaches zero. It is important not to raise it any more as the clamp holds the top step at zero but the rest would still move up, thus reducing the step size between the top two steps.

Once adjusted, characteristics of different f.e.ts can be obtained simply by plugging the device into the transistor socket.

Appendix

If any teachers have any difficulty with building the curve tracer or require further information, please do not hesitate to contact me: L. G. Cuthbert, Schools Liaison Tutor, Department of Electrical and Electronic Engineering, Queen Mary College, Mile End Road, London E1 4NS. Telephone 01-980, 4811, ext. 719 or 561 (departmental office).

Suggested semiconductor devices

Many different semiconductor components are suitable for this project, but the following types are those used in the prototype at Queen Mary College. Type numbers are those of Texas Instruments Ltd, but this does not imply that this manufacturer is particularly recommended. Most manufacturers make equivalent or similar components.

Bipolar transistor	BC182L
Unijunction transistor	TIS 43
F.e.t.	2N3819
Operational amplifier	SN72558P (2 in a package)
	SN72741P (1 in a package)
Diode	1S44

Printed circuit boards and components are available from: E. Tomlinson. 33 Manchuria Road, London SW11.

Literature Received

ACTIVE DEVICES

A short-form catalogue giving data on the range of TAG silicon controlled rectifiers distributed by Jermyn is now available. This range is low cost and available ex-stock from Jermyn Industries, Vestry Estate, Sevenoaks, Kent WW401

A publication called C.M.O.S. Integrated Circuit Data Book has information on the Solid State Scientific Inc. range of digital i.cs which incorporates the SCL4000A, SCL4400A and SCL4500A series. Transworld Scientific Ltd, Short Street, High Wycombe, Bucks HP11 2QH WW402

The 1974 EEV/M-OV Abridged Data Book describing the European range of professional electron tubes and devices is available from the GEC Electronic Tube Company Ltd, Chelmsford, Essex WW403

A Motorola publication called Phase Lock Loop Data Library gives information on phase detection, oscillators, mixers, counters and related devices as well as application notes. Available from GDS Sales Ltd, Michaelmas House, Salt Hill, Bath Road, Slough, Bucks WW404

A condensed data catalogue by Silec Semi-Conductors gives information on their range of components, most of which are readily available through S.S.C. distributors. Transworld Scientific Ltd, Short Street, High Wycombe, Bucks HP11 2QH WW405

A data book entitled "Schottky & Emitter-Coupled Logic" is available from Signetics International Corporation, Yeoman House, 63 Croydon Road, Penge, London SE20 .... Price £1

Motorola Inc have just published the first 1974 edition of their technical journal "Semiconductors". The journal, available only to senior engineers, is published in four languages for distribution throughout Europe. Motorola Semiconductors Ltd, York House, Empire Way, Wembley, Middlesex WW408

Available from Signetics is a data book entitled "Memory and Interface Handbook", which gives information on m.o.s., t.t.l. and e.c.l. Signetics International Corporation, Yeoman House, 63 Croydon Road, Penge, London SE20 ..... Price £1

PASSIVE DEVICES

A revised price list of Erie products is now available. The new prices are applicable to all shipments made on and after February 4, 1974. Erie Electronics Ltd, South Denes, Great Yarmouth, Norfolk WW409

A range of film legends and film symbols are now available for use with the range of illuminated push-button switches and signal lights manufactured by Highland Electronics Ltd, 33–41 Dallington Street, London EC1V 0BD WW411

Radio Resistor have published a new catalogue giving full specifications, diagrams, photographs and prices of over 7,000 stock items available by return of post. Both active and passive components are listed as well as the full range of Sasse switches (sole UK distributor). Radio Resistor Company Ltd, 5 Platina Street, London EC2 .... WW412

APPLICATION NOTES

Two application notes on the use of a new Norbit 2 solid-state control module GLD60 are available. The first is entitled "Grounded-load Driver Module" Ref. TP1397; the second is "Self-checking Solid-state Control System" Ref. TP1398. Requests for copies on company-headed paper to Computer Electronics Division, Mullard Ltd, Mullard House, Torrington Place, London WC1E 7HD WW415

Mullard have recently published a 22-page application note on "RF Power Modules" providing information on the BGY22, BGY23 and BGY24 u.h.f. amplifier modules for mobile communications. Mullard Ltd, Mullard House, Torrington Place, London WC1E 7HD WW416

An application note from Sivers Lab describes measurements ideal for the Y.I.G.-tuned crystal video analyzer 1-18GHz. The booklet gives examples of measurements on oscillators, amplifiers, mixers, passive components antennae and noise. Sivers Lab, Box 42018 S-126 12 Stockholm 42, Sweden WW417

Two new application notes are now available from Siliconix Incorporated. The first, entitled "An Introduction to FETs", provides brief but concise information on the nature of f.e.ts. Terminology, characteristics, test parameters and applications are all dealt with in the 20-page brochure. The second paper, called "L144 Programmable Micro-Power Triple Op Amp", deals with features and applications of the device. Siliconix Incorporated, 2201 Laurelwood Road, Santa Clara, California 95054, USA WW419

EQUIPMENT

We have received a brochure describing the Farnell FG1 Function Generator. It provides sine, square, triangular and ramp waveforms, sweep and burst facilities and offers programmable frequency control. Farnell Instruments Ltd, Sandbeck Way, Wetherby, Yorks LS22 4DH WW420

A new catalogue giving detailed information on the Maxon range of low inertia d.c. micromotors is available from Trident Engineering Ltd, Shute End, Wokingham, Berks RG11 1BH WW422

A four-page brochure is available from Oxford Instruments describing their Microlog-Environmental Data Acquisition System. This data logging system, claimed to be the smallest in the world, weighs about 0.5kg and incorporates its own power supply and input amplifiers. Oxford Instruments, Osney Mead, Oxford OX2 0DX WW424

The latest Linson celloscope manufactured by A. B. Lars Ljungberg & Co of Sweden, is now available in the UK through D. A. Pitman Ltd. A brochure describes the model 421 celloscope which is a solid-state particle counter for haematological parameters. D. A. Pitman Ltd, Jessamy Road, Weybridge, Surrey WW426

The first of a series of system reports on the use of mobile radio for communication and data transmission is now available from Storno Ltd. Each report will combine a straightforward description together with a section of technical details. Storno Ltd, Frimley Road, Camberley, Surrey ... WW428

We have received the 1974 "Tektronix Products" catalogue and revised UK price list. Tektronix UK Ltd, Beaverton House, P.O. Box 69, Harpenden, Herts WW429

GENERAL INFORMATION

Farnell have issued their latest short-form catalogue describing instruments, power supplies and industrial control. More detailed information can also be obtained from Farnell Instruments Ltd, Sandbeck Way, Wetherby, Yorkshire LS22 4DH WW432

A new short-form catalogue issued by Arrow-Hart gives information on the availability of Arrow switches and controls. The publication also lists the complete European and world-wide distribution network. Arrow-Hart Ltd, Plymbridge Road, Estover, Plymouth, PL6 7PN WW433

The latest Heathkit catalogue contains several new items including a 4 channel a.m./f.m. receiver, pocket calculator and a 15MHz oscilloscope. Heath Ltd, Gloucester GL2 6EE WW434

New Products

Pulse generator

The model 4300 general-purpose pulse generator covers the repetition frequency range of 3Hz to 30MHz in seven ranges. The pulse width is variable between 20ns and 100ms and the delay when the triggering facility is used can be adjusted from less than 50ns to 100ms. Transition times are less than 5ns and jitter on rising and falling edges is less than 0.1% of the repetition interval. The output can be either ±10V into a high impedance or ±5V into 50Ω, an adjustable base-line offset being provided in both cases. Single-shot and double-pulse modes are made available and the repetition rate may be derived from an external oscillator. The price is £279. Solartron-Schlumberger, Farnborough, Hants.
WW301 for further details

Car radar aerial

Aerials for use with car collision-avoidance radar have been introduced by EMI-Varian. Working at 35GHz, the printed-circuit flat pair configuration provides sufficient cross-coupling for direct pickup between transmit and receive aerials to function as the local oscillator signal, when doppler or f.m. modes are in use. The −3dB aerial beamwidth is 5° × 5°, the bandwidth being 34.5 to 35GHz. EMI-Varian Ltd, 248 Blyth Road, Hayes, Middlesex.
WW302 for further details

Printed-circuit miller

This small milling machine is intended for use in design offices and similar situations wherein single printed-circuit boards or small proving quantities are needed quickly. It is an adaptation of the conventional engraving machine, in which a stylus follows a sketch or master and controls the movement of a milling cutter on the material. The control of cutter movement is manual, and a power unit is available to drive the 12V motor. A selection of cutters is provided, and the machine may be used to drill the component holes in the finished board. The miller costs £160 and is available from West Hyde Developments Ltd, Ryefield Crescent, Northwood, Middx.
WW303 for further details

Signal generator synchronizer

Designed for use with the TF2015 signal generator, the synchronizer enables the output frequency to be set and maintained within 2 parts in 10^7, by means of a phase-lock loop. An auxiliary output is taken from the TF2015 to the synchronizer, where its phase is compared with that of a reference frequency. A control voltage resulting from the comparison is applied to an external f.m. connection on the generator, thereby adjusting the frequency of the generator until it is in coincidence with the reference. The reference frequency in the TF2171 is set up on switches, whereupon the signal generator is tuned until the acquisition of lock is indicated. Amplitude and frequency modulation of the signal generator can be used while the synchronizer is in control. Marconi Instruments Ltd, Longacres, St. Albans, Herts.
WW304 for further details

Stroboscope

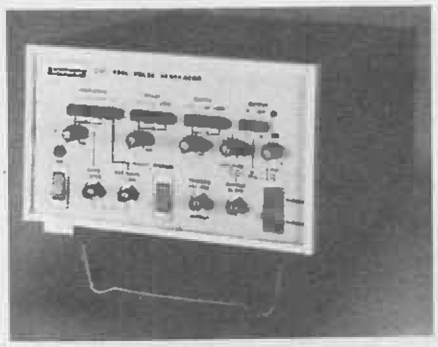
Type 1222A Strobotorch from Dawe can be controlled from either its internal oscillator or from an external pickup at rates between 300 and 36,000 flashes per minute. Non-contacting pickups of various types producing 200mV r.m.s. or more will trigger the unit, although the trigger input circuit prevents spurious signals when mechanical contacts are used. The 5–10μs flashes are produced by a 12W xenon tube, the repetition rate being indicated by meter. A pulse is emitted for use with a digital frequency meter. Dawe Instruments Ltd, Concord Road, Western Avenue, London W3.
WW305 for further details

Turns-counting dial

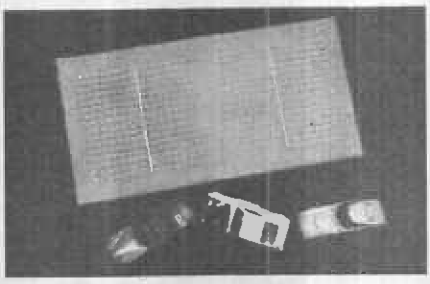
Radiatron have produced a turns-counting dial to match the Elma range of collet-fixing knobs and dials. The 025 dial is calibrated and can be adjusted to one hundredth of a turn, complete turns, 0–14, being indicated in a window. The three standard Elma colours of grey, grey-black or red-grey are used in the dial and caps are available in a variety of colours. The unit can be obtained to fit spindles of 0.25in, 3mm, 4mm and 6mm. GDS (Sales) Ltd, Michaelmas House, Salt Hill, Bath Road, Slough, Bucks.
WW306 for further details

dBm meter and graphic equalizer

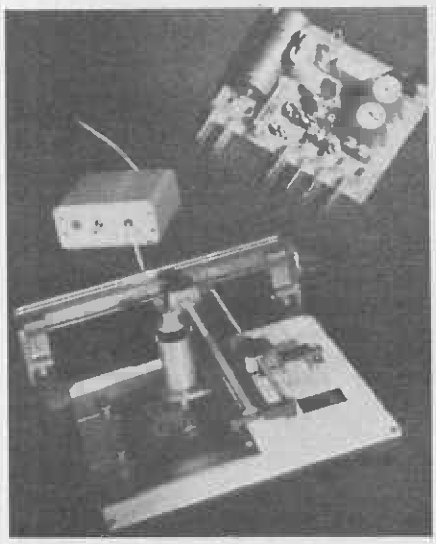
Two American products recently intro-



WW301



WW302



WW303

duced by the British agency Scenic Sounds Equipment are a dBm meter model 81 and an eight-centre-frequency graphic equalizer.

The dBm meter, manufactured by DBX, is battery operated and provides measurement from −70 to +10dBm on a single scale which has a true r.m.s. response, the result of a patented sensing circuit. The meter is also available with a 50dBm range. Accuracy is ±1dB at 0dBm to ±2.5dB at −70dBm. Response from −40 to +10dBm is 20Hz to 20kHz and at −70dB is 20Hz to 7.5kHz. Size of the unit is 4 × 4 × 7½in and it weighs 3lb. Price is £92.

The Aengus graphic equalizer uses *RC* networks throughout and is primarily designed for professional recording studio use as it can be easily slotted into the appropriate point of a mixing desk input channel. Eight centre frequencies can be treated simultaneously and are located at 50Hz, 100Hz, 220Hz, 500Hz, 1kHz, 2.2kHz, 5kHz and 10kHz. Eight lever-operated switches provide boost or cut at each frequency in twelve steps: +15, +12, +9, +6, +4, +2, 0, −2, −4, −6, −9 and −12dB. Input impedance is 9.5kΩ (high level) and 5kΩ (low level) and output impedance is 100Ω balanced. Normal operating level is +4dB, 0VU. At high level, insertion loss is zero. Low level provides 6dB of gain. Unequalized frequency response is ±0.2dB, 20Hz to 20kHz, measured at +4dBm. Equivalent input noise is −86dBm unequalized and −84dBm equalized. Distortion from 20Hz to 2kHz is stated at 0.1% t.h.d. at 4dBm. Power requirements are ±15V, 75mA (maximum output) and the dimensions of the module are 1½ × 5¼in face, and 5¾in depth. One other feature is a push-button which can switch the equalizer in or out of the signal path. The module can be mounted in a 19in rack system. Price is £147.

Both units are available from Scenic Sounds Equipment, 28 Bryanston Street, London W1H 7LS.
WW307 for further details (model 81 dBm meter)
WW308 for further details (Aengus graphic equalizer)

Choppers

Field-effect transistors are used as the switches in three types of chopper intended as plug-in replacements for the mechanical variety used in Controle Bailey, Leeds and Northrup and Cambridge amplifiers and recorders. MTL208, 210 and 211 are claimed to exhibit voltage and current offset drifts of less than 0.1μV/°C and 0.03nA/°C and are said to operate safely at 75°C. The MTL208 and 211 possess an "on" resistance of 250 ohms and revert to 10^9 ohms in the "off" state. The drive to the f.e.t. switches is obtained from the 50/60Hz supply, via a transformer which is double-screened to minimize coupling between the supply and the input. Measurement Technology Ltd, 26–30 John Street, Luton, Beds.
WW309 for further details

Very-low-frequency counter

Digital measurements of very low frequencies normally take several minutes to achieve a sensible resolution (about 17 minutes at 1Hz to 0.1%). The type 207 by Time Electronics neatly surmounts this obstacle by determining the time of one cycle of the unknown frequency, during which a higher crystal-derived measuring frequency is counted. The reciprocal of this result is then obtained and displayed as frequency—the instrument is also scaled to display revolutions per minute. The range of frequencies acceptable are 0.001Hz to 100kHz or 0.1 r.p.m. to 10^6 r.p.m., the ranges being automatically selected. Digital and analogue outputs are provided and a printer unit is available. Time Electronics Ltd, Botany Industrial Estate, Tonbridge, Kent.
WW310 for further details

Servo driver

The EM100 servo drive systems are control units for 12–24V d.c. motors and incorporate power supplies. Almost any type of motor up to 1/6 h.p. can be used, including basket-wound and printed-circuit types. Control input amplifiers are 741 op-amps, which confer flexibility on the type and level of control permissible. Stall current is rendered innocuous by a protection circuit. The system will operate in velocity, positional or velocity/positional modes, in which overshoot is greatly reduced. McLennan Engineering Ltd, King's Road, Crowthorne, Berks.
WW311 for further details

Thick-film power controller

Proportional control is a feature of the ZC1/250-15 zero-switching controller, a new unit in the Hyreg range from Westinghouse. It is intended mainly for use in temperature-control applications and will control resistive loads of 3.75kW at 25–250V r.m.s. The module includes the protected power triac and control circuitry, the only additional components necessary being the thermistor sensor, three resistors and a potentiometer. Engineering publication ZC1 provides a complete specification. Westinghouse Brake & Signal Company Ltd, Semiconductor Division, Chippenham, Wilts.
WW312 for further details

Printed-board switch

A novel configuration is adopted by NSF for their Type FL switch, which is a ball-index rotary type intended for direct contact to a printed-circuit board. Five

WW305

WW307

WW309

wafers can be used on each mechanism, each wafer having 12 positions, and 1, 2, 3, 4 or 6 poles can be accommodated on each wafer, subject to a maximum of 16 per switch. Shorting or non-shorting 5VA contacts of gold-plated copper can be used, switching up to 0.2A. N.S.F. Ltd, Keighley, Yorks.
WW313 for further details

Frequency synthesizer

With an output of 0.1Hz to 9.99MHz, the Syntest SI-60 digital frequency synthesizer produces a t.t.l. compatible square-wave at an accuracy of $\pm$ 10 p.p.m. Frequency is set either by front-panel edge switches or by an external b.c.d. signal to a resolution of three figures, with four or five digit versions available. Settling time to within 10% of the desired frequency is 1ms. Price is £270. Lyons Instruments Ltd, Hoddesdon, Hertfordshire.
WW314 for further details

Drum printer

The "Mini-Kit" printer is a system of units which may be assembled by the user to fit his own requirements. The basic unit is the 18 column, 3 lines per second printing head, which is complemented by a parallel-entry logic-compatible drive unit accepting 4-bit b.c.d. inputs, a power supply and wiring harness. The head, which uses red/black ribbon, prints "on the fly", the paper being ejected either vertically or horizontally with the characters in the correct orientation for easy reading in both cases. The printer costs about £230. Electrographic Peripherals Ltd, Printinghouse Lane, Hayes, Middx.
WW315 for further details

Sound emitter

A new range of high-power sound emitters, working in the range 200–300W is announced by Gearing & Watson. They have used their experience in the design of large vibration generators to enable them to ensure reliability in the new units. A series of horns is available to derive a variety of radiation patterns from the basic drive units, which are designed for operation from the company's power amplifiers. The drive units are capable of producing a pressure level of 130dB at 1m using the correct horn for the application. Gearing & Watson (Electronics) Ltd, Birch Close, Eastbourne, Sussex.
WW316 for further details

Trimmer capacitor

The Trimline is tubular in form, with a constant length of 18mm. Adjustment is by means of a screwdriver slot at one end, and the elimination of the conventional moving piston has improved the linearity of the law to within 2%. The capacitance range exceeds 0.5pF to 5pF in ten turns of the adjuster. Air is used as the dielectric, a coaxial sleeve being the moving element, which is precisely guided by a glass outer sleeve to maintain linearity. A slipping clutch is provided. Jackson Brothers (London) Ltd, Kingsway, Waddon, Croydon, Surrey.
WW317 for further details

Servo amplifiers

Two high performance servo amplifier modules, conservatively rated as 250 and 600 watt linear d.c. power amplifiers, are being marketed by the Cranfield Unit for Precision Engineering. They are manufactured to quasi-military standards of ruggedness, and are claimed to provide high reliability and ease of use and maintenance under adverse conditions.

Designated the CUPE 2501 and CUPE 6001, the amplifiers are housed in 488.60mm (19in) rack mounting chassis or free-standing cabinets. They have high open loop gain (10^7), wide bandwidth, low drift and distortion, adjustable current limiting and are said to be short-circuit proof. A removable front sub-panel gives *in-situ* access to the multiple summing functions, compensation networks, zero balance and current limit controls. Power stages are protected against load-induced voltage, current transients and thermal overload.

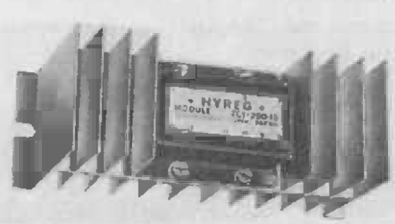
A high-gain f.e.t. input operational preamplifier, with high input impedance and low drift (10μV/°C) drives a low-gain, high-power output stage equipped with bi-directional current limiting circuitry. Internal feedback loops make the amplifiers unconditionally stable over a wide range of load and environmental conditions, while anti-saturation networks prevent lock-up and phase reversal under severe input overload conditions.

The pre-amplifier module is mounted on a p.c. card which also accommodates the summing network and additional feed-forward and feedback compensation networks as required. Power stage is single-ended, consisting of a complementary pair of silicon power transistors operating in class B. Adjustable current limit controls permit setting the maximum output current between 10% and 100% of peak current.

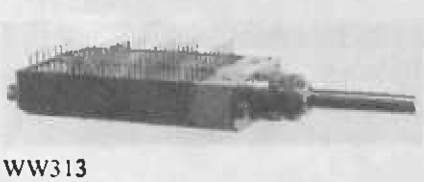
Current limiting is bi-directional with independent adjustment for each polarity. Rapid response prevents demagnetisation of all electrodynamic loads and devices. A fail-safe automatic load disconnect is provided to prevent damage due to motor back EMF in the event of mains failure or removal. Cranfield Unit for Precision Engineering, Cranfield Institute of Technology, Cranfield, Berks.
WW318 for further details

Racks and cases

Lektrokit Ltd, formerly part of A.P.T. Electronics, have launched a range of enclosures and hardware for the electronics industry. In addition to the company's range of British products they are offering the Motek range which is available in the UK exclusively from Lektrokit. Motek products, which include 19in racking systems, chassis modules, ventilation units and instrument cases, are offered ex-stock. The racking systems are available in an industrial finish or with anodised-aluminium front sections. There are five basic chassis modules for use in the racking system, each available in five different heights and three depths. The instrument cases are available in three models, also offered in five heights and three depths. Lektrokit Ltd, Trafford Road, Reading, Berks RG1 8JR.
WW319 for further details



WW312



WW313

WW314

WW319

Solid State Devices

The names of suppliers of devices in this section are given in abbreviation after each section and in full at the end of the section.

Field-effect switches

Two high-speed f.e.t. switches, the SD210 and SD211 by Signetics, are intended as digital or analogue switches in applications where switching times in the order of 0.7ns are required. Both are n-channel enhancement devices with permissible input signals of ±10V (SD210) and ±5V and "on" resistances of 30 ohms. The SD211 has a gate/source protection diode.

WW330 for further details Signetics

Power-control circuits

A range of TO-3 encapsulated integrated circuits for power control, including half and fully controlled thyristor bridges and switches for heating and lighting applications. The PH400 range is available in 120V or 240V versions and will handle up to 90A peak surges.

WW331 for further details International Rectifier

Voltage regulators

Series 843 dual-tracking regulators produce ±12V or ±15V outputs, the negative line tracking the positive output within ±10 parts per million over the range −55° to 125°C. Stabilization and regulation are both 0.005% with a load of 300mA maximum. The devices are TO-8 packaged.

WW332 for further details Beckman

Dual timer

NE556 by Signetics is a dual version of the established 555 timer, used as a modulator, clock generator, switch and many other applications. The 556 is available in versions in the temperature ranges 0–70°C (NE556), −55 to 125°C (SE556 and SE556C), all versions being contained in dual-in-line packages.

WW333 for further details SDS

CCD image sensor

CCD110 is a 128/256 element charge-coupled linear sensor, intended primarily for optical character recognition. It is a two phase device which can be clocked by t.t.l. clocks at rates in excess of 10MHz. A preamplifier and compensation amplifier are on the same chip, and the dynamic range is 200:1. The circuit is t.t.l. compatible and is contained in an 18-pin d.i.p.

WW334 for further details Fairchild

Matched dual transistor

A closely-matched transistor pair by Precision Monolithics Inc, the mono-Mat-01 is made by a silicon nitride "triple passivation" process, which is claimed to afford extreme stability of critical parameters. The device exhibits voltage offset matching of 40–100μV and h_{FE} matching of 0.7 to 3%. Voltage offset drift is 0.15 to 0.5μV/°C and h_{FE} at 10nA collector current is around 590. Over the range 0.1 to 10Hz, noise is 0.23μV peak to peak. The device is in a 6-pin TO-99 case.

WW335 for further details Bourns

Colour TV i.c.

Mullard announce the TCA300, an integrated circuit consisting of synchronous detector, matrix and clamps to determine black level. Subcarrier filter capacitors are included. A complete decoder can be assembled using this unit, TB540 and a TBA560.

WW336 for further details Mullard

Crystal oscillator

MC12060 is a 16-pin d.i.p. circuit from Motorola, which incorporates a crystal oscillator and buffer stage, together with sine-to-e.c.l. and sine-to-t.t.l. converters. The series-mode crystal is external to the package, as are by-pass capacitors and fine-tuning circuit, if required. Stability is around 8 in 10^8 per degree centigrade. Fundamental crystals from 100kHz to 2MHz can be resonated and above this frequency the MC12061 can be used up to 20MHz, providing a stability of about 16 in 10^8.

WW337 for further details Motorola

Power Darlingtons

Complementary Darlington pairs from Motorola exhibit current gain of 1000 at 10A. The MJ2500 and MJ3000 (p-n-p and n-p-n respectively) comprise driver and power transistors and emitter/base resistors in a single TO-3 pack. Power dissipation is 150W at a case temperature of 25°C, the units having a collector rating of 80V. In a complementary-symmetry audio output stage, a pair of these devices will put out 60W into an eight-ohm load.

WW338 for further details GDS

Audio amplifier

A 5W audio amplifier from RS Components incorporates both preamplifier and output stage. Total harmonic distortion is 5% at 5W r.m.s. (0.3% at 1W, 400Hz) and noise is −75dB. The sensitivity and input impedance is suitable for crystal/ceramic pickups, and the −3dB amplitude/frequency response is 20Hz–30kHz. Information provided with the amplifiers covers the incorporation of the unit into a stereo amplifier with tone controls.

WW339 for further details RS

Audio amplifier

The MFC4000B is a simple, integrated-circuit audio-amplifier, designed for small radio receivers. Supply voltages up to 12V are acceptable, and the device will produce 250mW in 16 ohms. At 9V supply and 200mW, total harmonic distortion is around 2%, an input signal of 240mV giving full output. Current drain is about 3mA when quiescent.

WW340 for further details Motorola

Variable capacitance diode

The 574BAY is a silicon diode intended for use in v.h.f. television tuner band-switching and as a transmit-receive switch in small transceivers. Maximum reverse voltage is 35V, maximum forward current being 100mA. Typical capacitance is 0.8pF and resistance 0.5 ohms.

WW341 for further details Mullard

Suppliers

Signetics International Corporation, Yeoman House, 63 Croydon Road, London SE20.

Mullard Ltd, Mullard House, Torrington Place, London WC1E 7HD.

Motorola Semiconductors Ltd, York House, Empire Way, Wembley, Middlesex.

R.S. Components Ltd, 13–17 Epworth Street, London EC2.

GDS (Sales) Ltd, Michaelmas House, Salt Hill, Bath Road, Slough, Bucks.

Bourns (Trimpot) Ltd, Hodford House, 17/27 High Street, Hounslow, Middx. TW3 1TE.

SDS Components Ltd, Hilsea Trading Estate, Portsmouth, Hants. PO3 5JW.

Fairchild Semiconductor Ltd, Kingmaker House, Station Road, New Barnet, Herts.

International Rectifier Co, Hurst Green, Oxted, Surrey.

Beckman Instruments Ltd, Queensgate, Glenrothes, Fife.

Real and Imaginary

by "Vector"

"A VOICE CRYING IN THE WILDERNESS . . ."

Professor M. W. Thring, head of the department of mechanical engineering at Queen Mary College, London, is probably best-known to the general public as "the man who designs robots"; a tag which, although justified, is only a part of his story, as most engineers will know and the professor's service on many national committees will testify.

He is, for instance, deeply concerned about the role of the engineer in society. Now, most of us, I imagine, are too pre-occupied with the problems of meeting the next mortgage payment to bother ourselves overmuch about the suicide course along which the world is accelerating. Naturally, we brood a bit at times over such matters as world over-population, arms escalation, pollution, damage to the environment, the impending exhaustion of minerals, the steady deterioration in the quality of life and the growth of violence, drug-taking, suicides, alcoholism and stress illnesses. "It's a deplorable state of affairs," we say in effect "and it's high time the politicians got down to doing something about it."

"Wrong!" says Professor Thring in a paper* published a few months ago. "It's you, the engineer, who has to get down to it." And he proceeds to tell us why, in no uncertain terms. His point is that we live in a technology-orientated world in which, ever since the industrial revolution, the engineer has been the key factor. Out of that revolution came much that was good and much that was evil, with the engineer solving every problem presented to him by his masters without regard for the consequences for the world at large. It's high time, argues Professor Thring, that we concerned ourselves with the morality of our work instead of blindly carrying out orders. In his view, we can no more shrug off responsibility for what we're doing than could the commandant of Belsen.

The parallel he draws is unpalatable, but apt. For we're blueprinting a future which, by comparison, may well make Belsen seem a Sunday-school picnic. Merely by conforming to the system we're squandering irreplaceable resources at such a rate that within a few lifetimes there won't merely be shortages: there just won't be anything left; and let's not delude ourselves that magic new minerals will arrive to take the place of the vanished ones, because they won't.

Just consider this at a personal level. No matter what plans we're making for that baby in his cot, it's certain that as an adult he won't enjoy the same quality of life that you take for granted; at best he will live in an ant-like society in which everything that isn't compulsory is forbidden. Your grandchildren will be condemned to misery and squalor, not entirely because of the shortages themselves but because inevitably law and order will collapse as the "have-nots" struggle against the "haves". The legacy we are leaving to later generations—by then probably nuclear-doped mutants—is one of savagery and (as like as not) cannibalism. Time is against us: you, in your lifetime, will see a significant deterioration.

As Professor Thring says, one of the main obstacles is that we just don't want to know. Some of us look on the future as hopeless and trust that we'll be dead before the crunch comes; the more optimistic try to convince themselves that the present system will somehow cope, and, with a bit of patching here and there and a little further effort by engineers and scientists, it will all come right in the end. It won't. Neither will it suffice to content ourselves with theorizing about the situation. Either we get down to the nitty-gritty or we end up by crucifying our own flesh and blood.

The villain of the piece, asserts the Professor, is the profit motive. To serve this god, vast quantities of precious, irreplaceable materials are squandered day and night in the manufacture of non-essential commodities; it produces evil by-products and dumps them in the cheapest possible way, in callous indifference to the damage done to the environment. With certain miniscule exceptions, we're all thoroughly conditioned to the concept that the acquisition of money and possessions is the yardstick of success; it's the norm; the accepted way of life. In spite of such manifest lunacies as Centre Point, we seldom question whether or not there's a better way of doing things.

If I read him correctly, the Professor's argument is that only by breaking free from the profit motive, with its cardinal tenet that "if there's a percentage in it, go ahead and make it", can we clear decks for action in the matter of conserving our resources. We've got to decide what we really need, as distinct from what the persuaders tell us we should have (and "we" in this context means everybody of course).

In a survival situation, human needs are simple; food, drink and some means of maintaining a reasonable body temperature are the basics. Provision of these is top priority. Beyond them, all other items are, in degree, luxuries and parasitic upon the staples. Now, Professor Thring isn't suggesting that we must adopt such a Spartan existence as that, but merely that we should abandon sufficient fripperies to halt our lemming-like march to destruction. We must hold an objective stock-taking and, as the Professor puts it, jettison many of our cherished luxuries. The amount we're prepared to discard is the measure of our concern for the future. Every ounce of metal or other material must be accounted for and only used if absolutely necessary. Every possible scrap must be recycled. Every gallon of fuel must transport the maximum load to an essential destination.

Of course, the conditioned reply to anyone who dares to attack the profit motive is to yell "Yah, boo! Dirty communist!" I've no idea what Professor Thring's political views are, but I would point out that the Communist bloc is as firmly wedded to the profit motive as we are, as anyone who has had dealings with an Iron Curtain trade delegation will testify. There's an interesting point here, though. We tend to sneer at the lack of variety in consumer goods available in Communist countries; but could it be that they're consciously playing the ant to our grasshopper, conserving their resources against the day when we'll have to go begging?

But it's one thing to accept Professor Thring's diagnosis in principle; how does he suggest that we go about applying his remedy? This is a world crisis, not a national one. We've got to have global control of all resources, with equitable shares for all. We've got to provide the present famine-prone areas with an assured standard of living. And we've got to achieve a zero population growth in every area of the world—all this, not at some nebulous future date, but within 15 years, says the Professor. It seems to me that this calls for a super-powerful United Nations organization with one or two miracles, like a mass change of heart, thrown in. Perhaps Professor Thring will give us the nuts and bolts in his book.

What part could electronics play in the new order? We're a relatively clean industry in the sense that in the main we don't use tons of raw materials in our devices. But when we come to a stock-taking of how many of our products are really necessary, then our hands begin to look mucky. Do we, for instance, need such a multiplicity of sound and vision stations operating all day and half the night, churning out (for the most part) escapist rubbish, forgotten by next day when it's time for our next "fix"? But I'll have more to say on this topic in my next article.

* "Towards a Creative Society." *Electronics and Power*, Nov 29, 1973. Based on a forthcoming book, "Machines—Master or Slaves of Man?" (Peter Peregrinus Ltd.)

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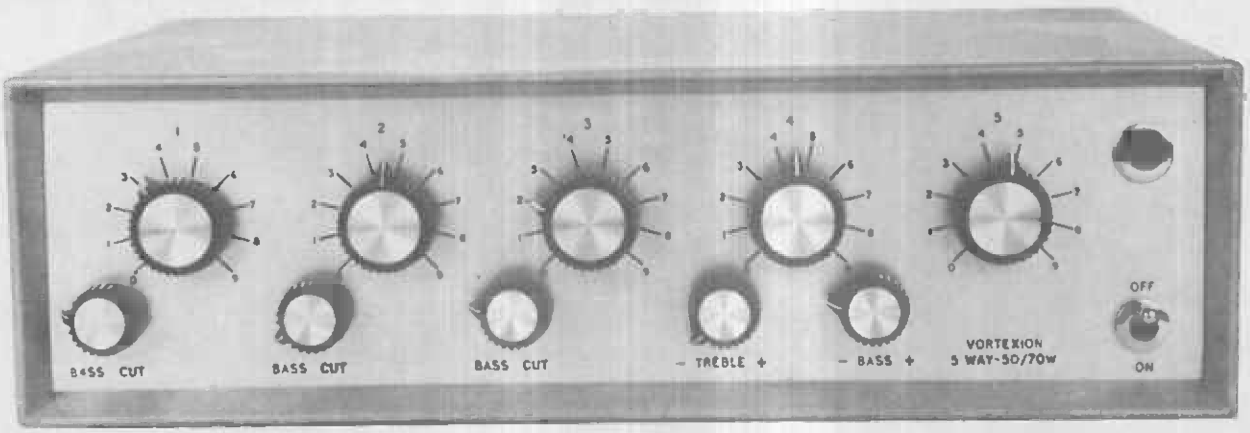

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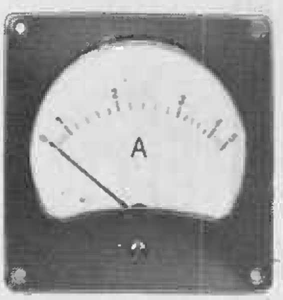
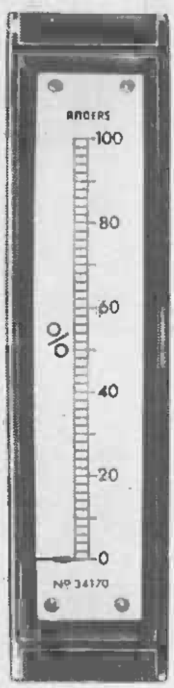
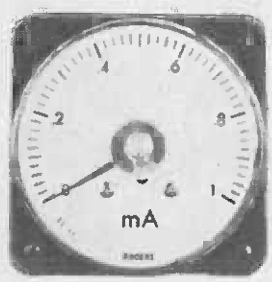
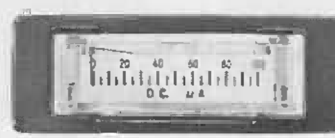


Vulcan Moving Iron. 4 models, 1·5", 1·8", 2·7", 3·7" scales. Voltmeters, ammeters and motor starting meters.

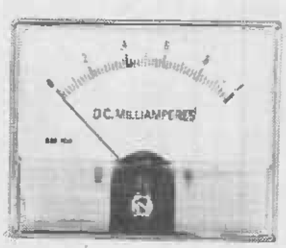




Oxford Long Scale 240°. 2 models, 5·5", 8" scales. DC moving coil and AC moving coil rectified.



Profile Miniature Edgewise Meters. 3 models, 1", 1.2", 2" scales. DC moving coil and AC moving coil rectified.



Kestrel Clear Front. 7 models, 1·3"—5·25" scales. DC moving coil. AC moving coil rectified; AC moving iron.

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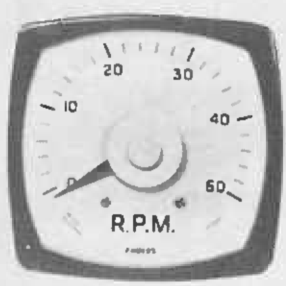
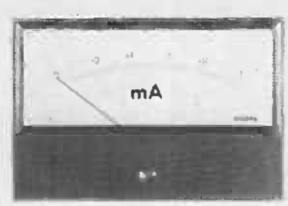


Stafford Long Scale 240° 6 models, 3·5"—11·5" scales. DC moving coil, AC moving coil rectified, AC moving iron. Also 98° scale.



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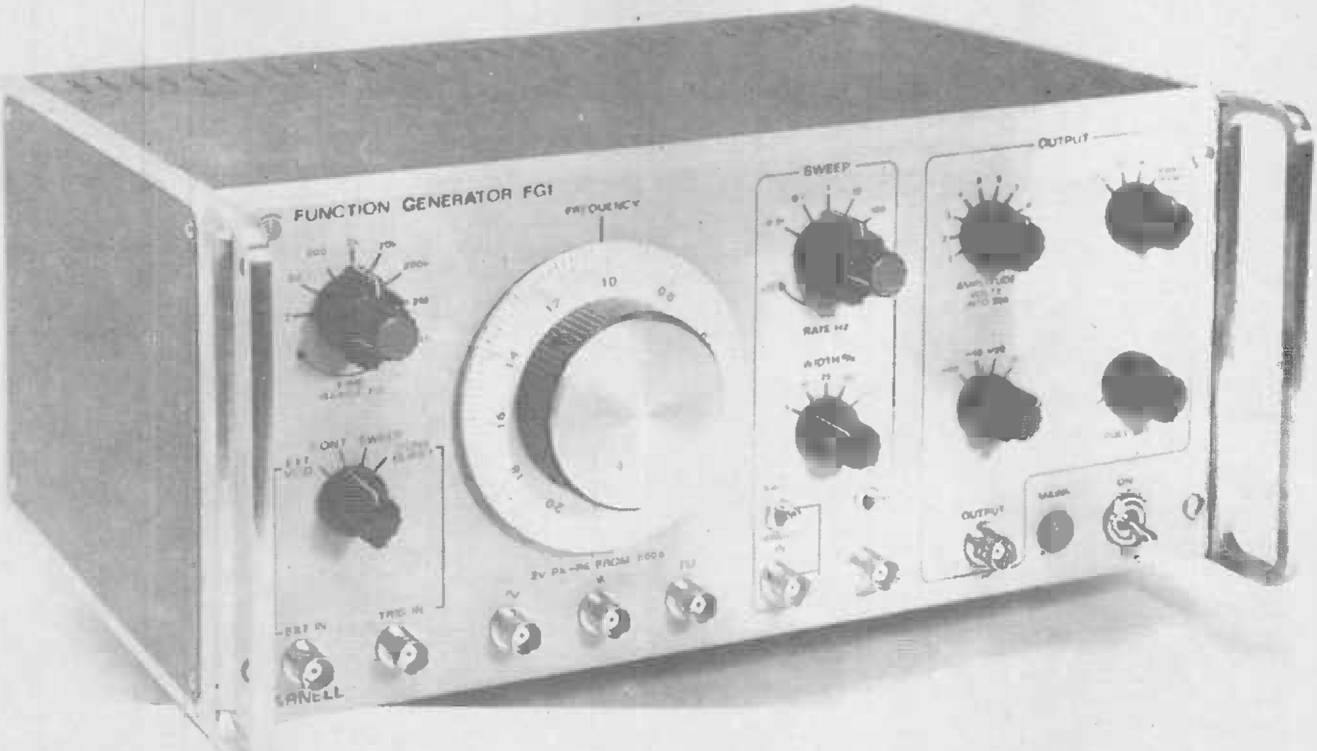

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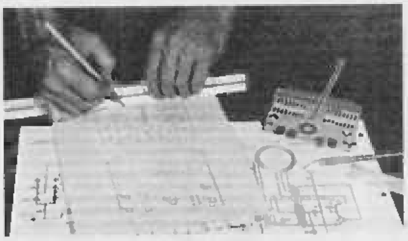
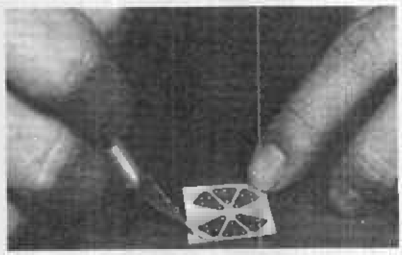
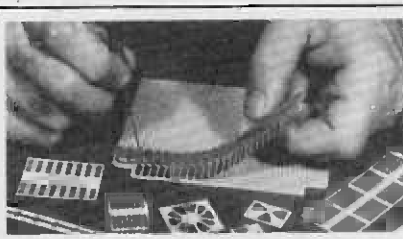


1. SKETCH YOUR BOARD
Be sure all components are included and placed in the best position for easy copper tape interconnections.



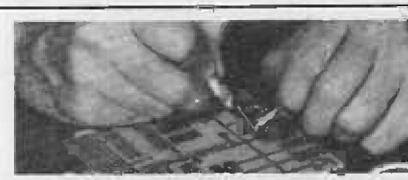
2. CUT PULL TAB
Cut a corner through first layer to make a pull tab.

3. REMOVE QUIK-RELEASE ADHESIVE LINER
Remove polyolefin liner to expose pressure sensitive adhesive.



4. ALIGN SUBELEMENT
Align pre-drilled holes in subelements to matching holes in the pre-drilled board. Backlighting or guide pins allow easy registration.

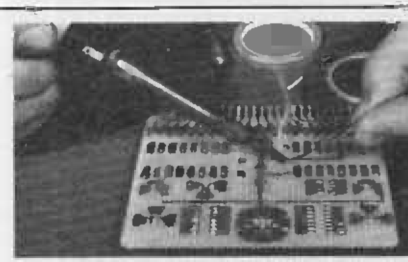
5. PRESS IN PLACE
Press firmly in place. The pressure sensitive adhesive holds the subelements firmly in place, yet they may be repositioned if necessary. After the adhesive has cured, 48 hours or speeded by heat, the bond strength doubles. The subelement may still be removed but not reused.



6. INTERCONNECT SUBELEMENTS
Interconnect subelements using copper tape or jumpers.
- Overlap copper tape approx. $\frac{1}{16}$ inch.
- Press firmly in place with fingers.
- Do not overstress copper by burnishing onto board as it may tend to lift when soldered.

7. INSULATE CROSSOVERS
Use insulating mylar tape between copper tape when making crossovers.

8. INSERT COMPONENTS
Insert electronic components through the pre-drilled holes from the opposite side of the board. Bend leads over against circuit so that they are firmly held in place, then cut off ends.



9. SOLDER BOARD
Clean surfaces solder best. For best results, use a 47 watt iron with a 600°F slender tip and very thin, high quality rosin core solder. Excessively dirty surfaces may be cleaned with a rubber eraser or alcohol just prior to soldering. Use only a SMALL amount of solder. Circuit-Stik subelements have a G-10 Epoxy-Glass substrate and may be soldered many times. Copper tape and donut pads do not have an epoxy-glass substrate to act as a thermal barrier during soldering. Therefore, the adhesive will soften and care must be taken to prevent the copper from sliding or lifting. Best results are obtained when the soldering iron tip is held on the lower layer of each overlap joint. The adhesive regains full strength upon cooling.

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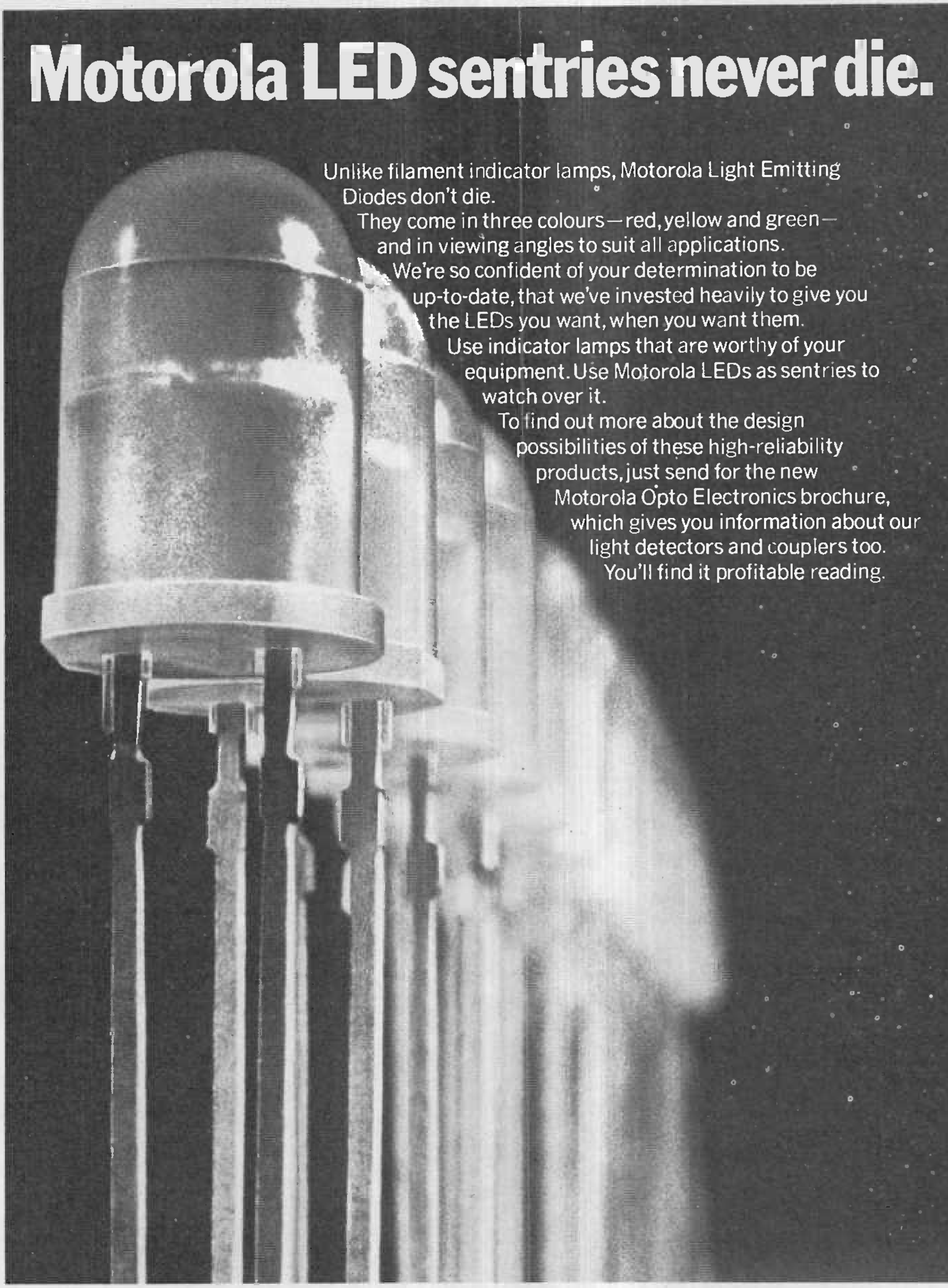
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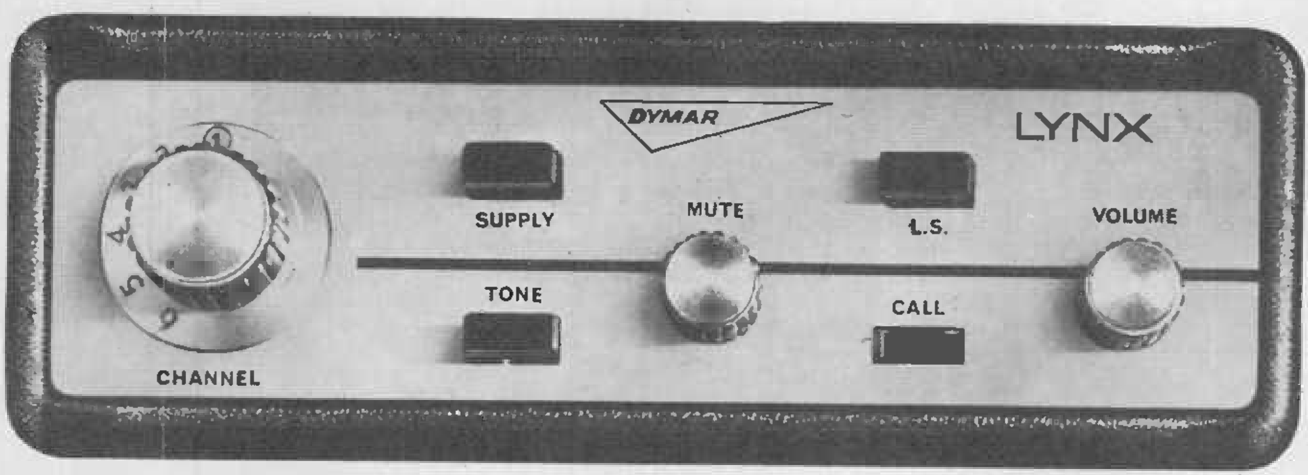

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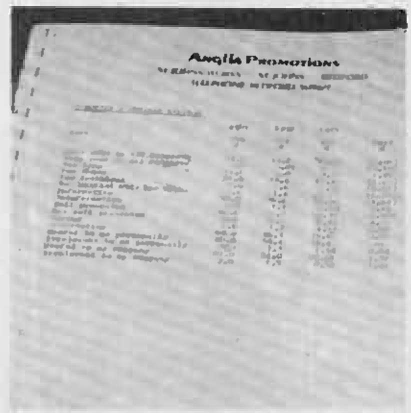

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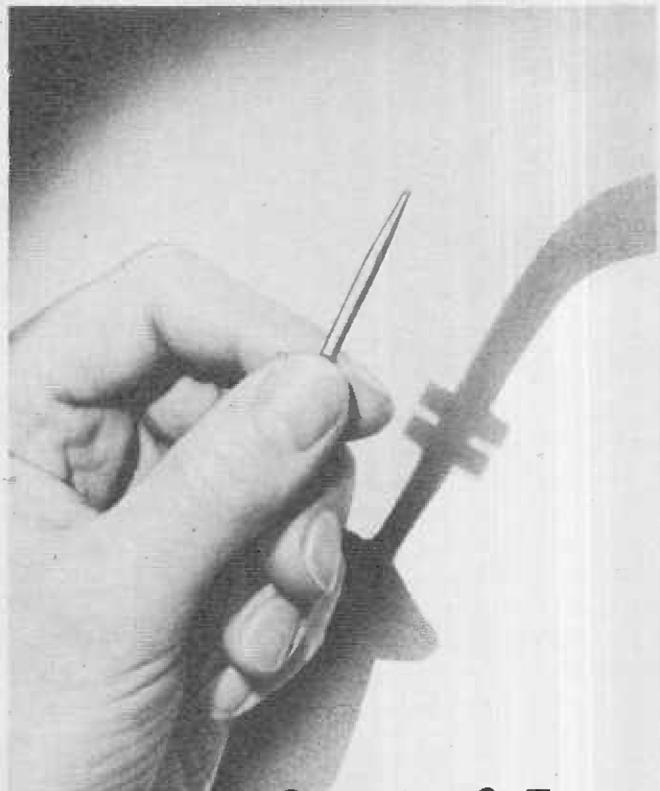

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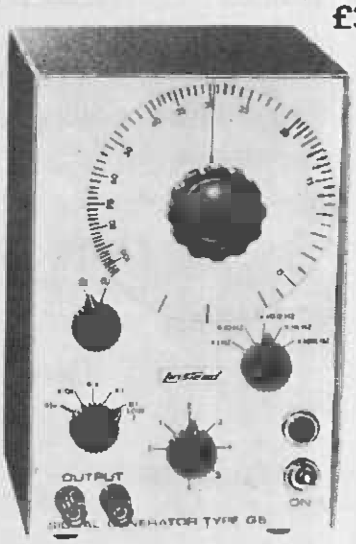

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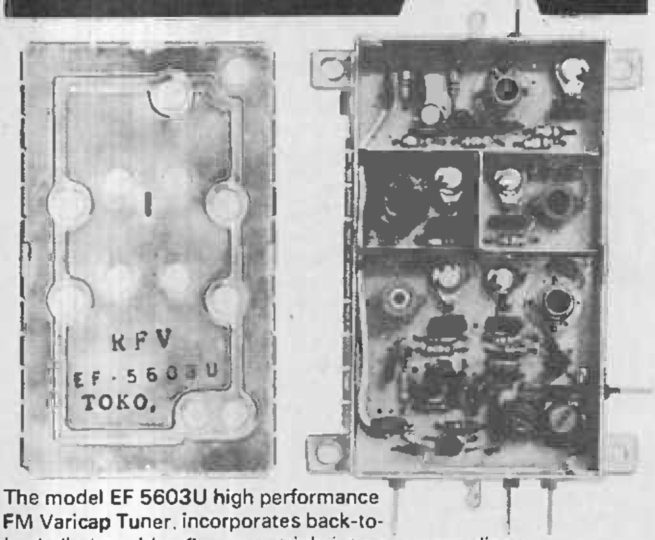
WW—033 FOR FURTHER DETAILS

High Performance varicap tuner



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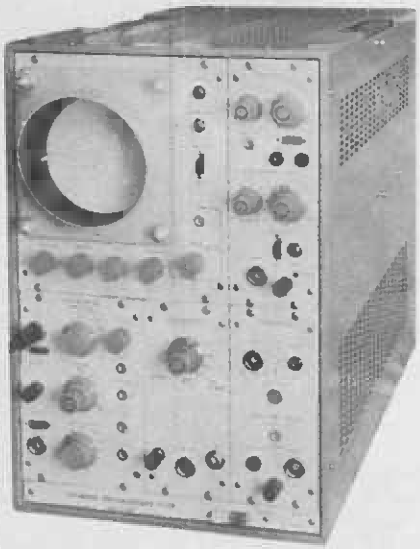

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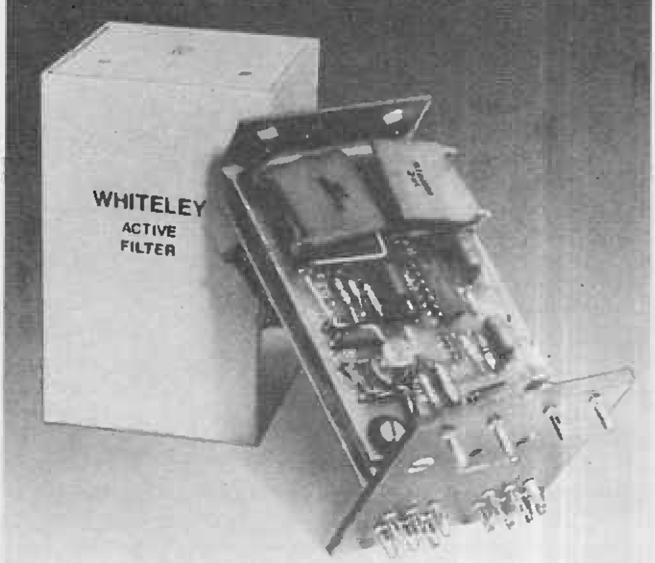
New active filter takes over from passive networks



These active filters are designed to take over the functions of passive filter networks in audio telecommunications systems. They offer several advantages, in space—saving, economy and reliability.

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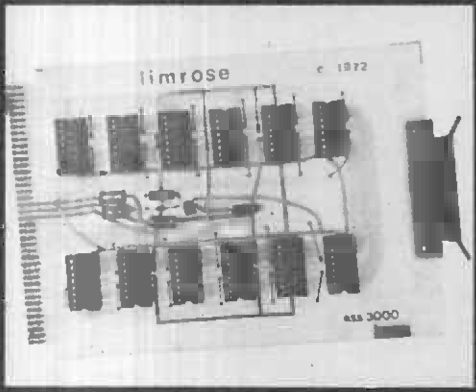
low cost memory card is easy to interface....



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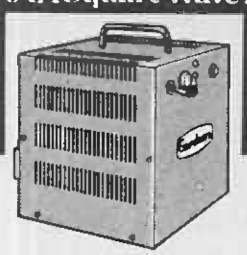

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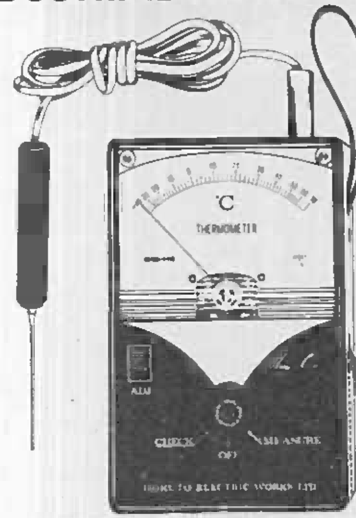

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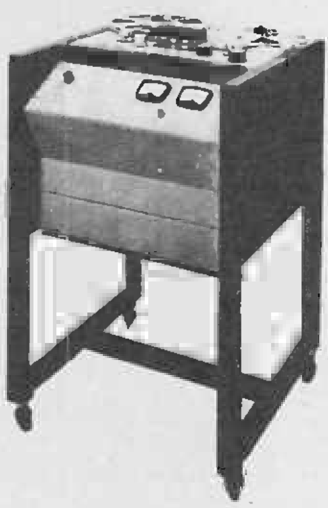

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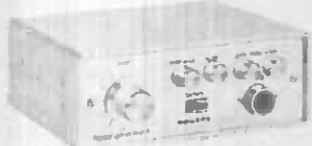

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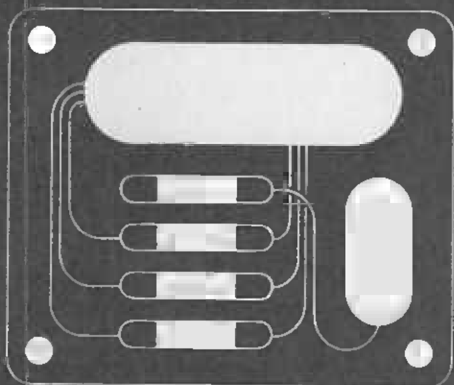

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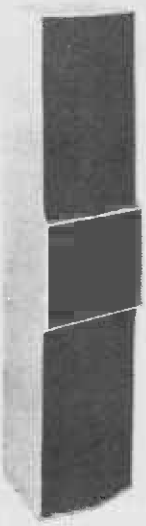

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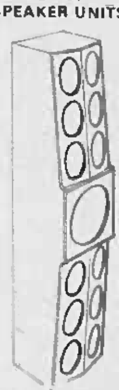

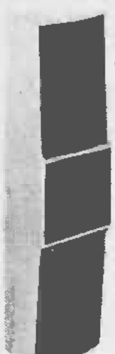

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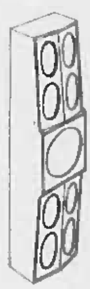

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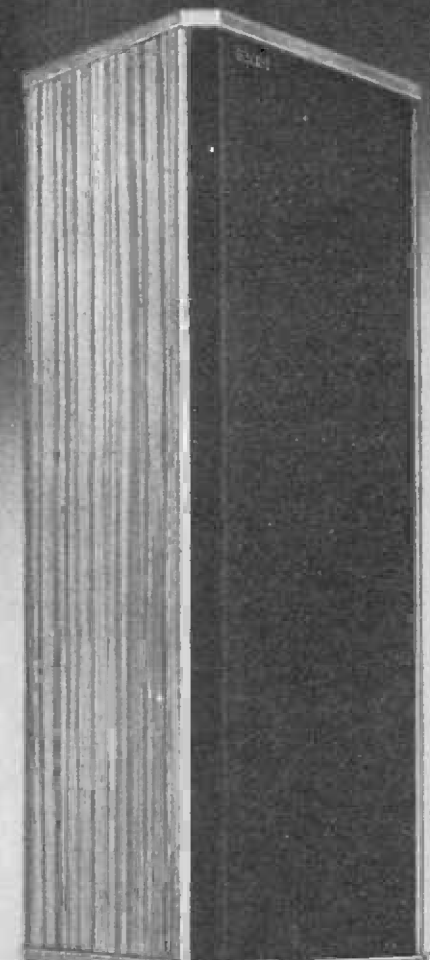

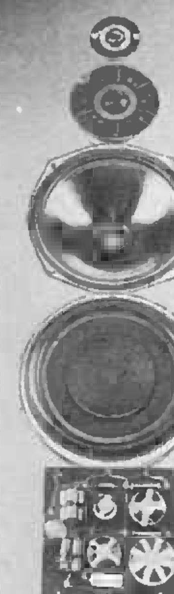

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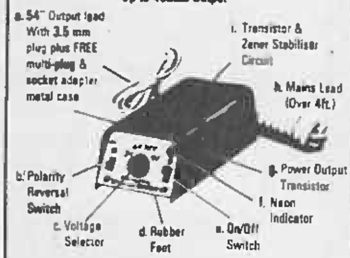

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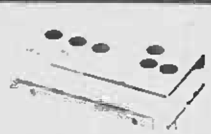

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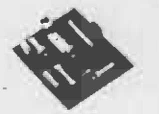

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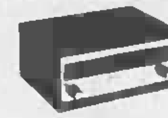

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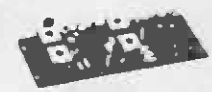

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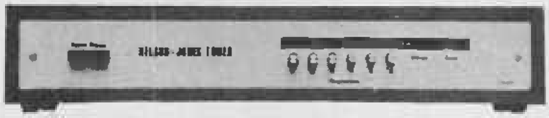
THE NEW NELSON-JONES FM TUNER



PUSH-BUTTON VARICAP DIODE TUNING
(6 Position) ('WW' JUNE '73)

Exclusive Designer Approved Kits

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Our low cost **alignment service** is available to customers without access to a signal generator. Please send large SAE for our latest price lists which detail all of the many options and special low prices for complete kits. All our other products remain available.
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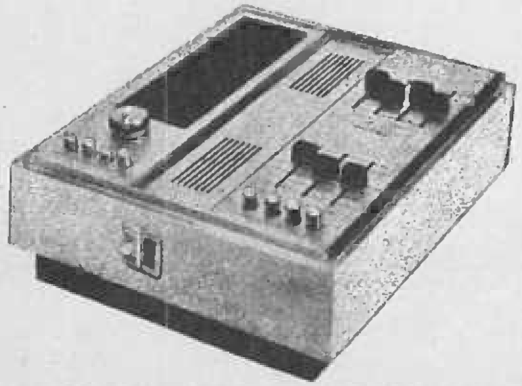

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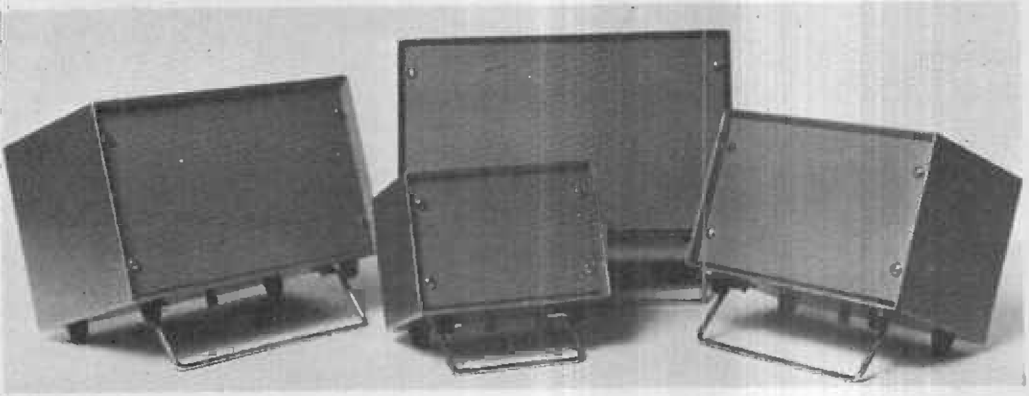

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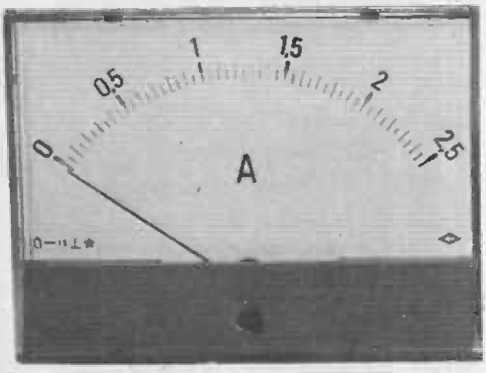

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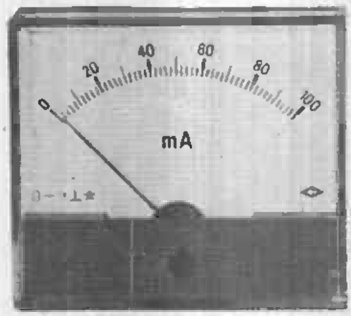

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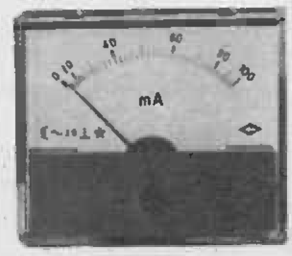

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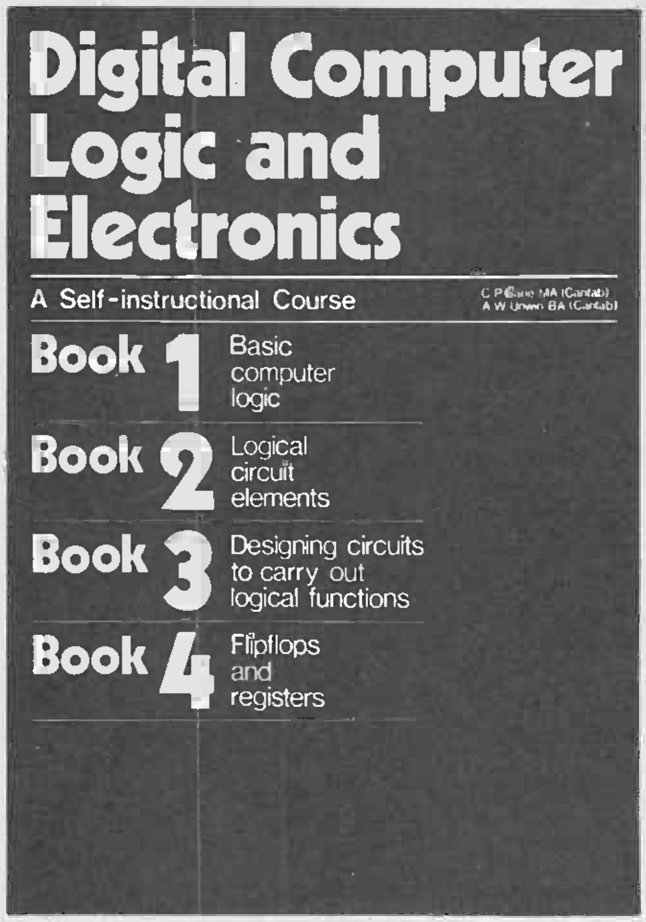

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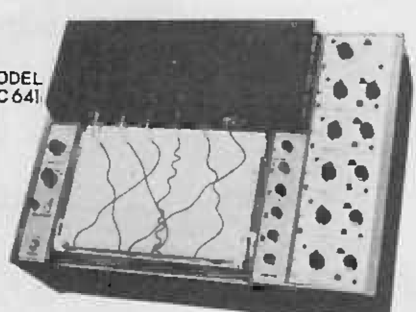

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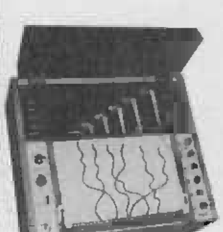

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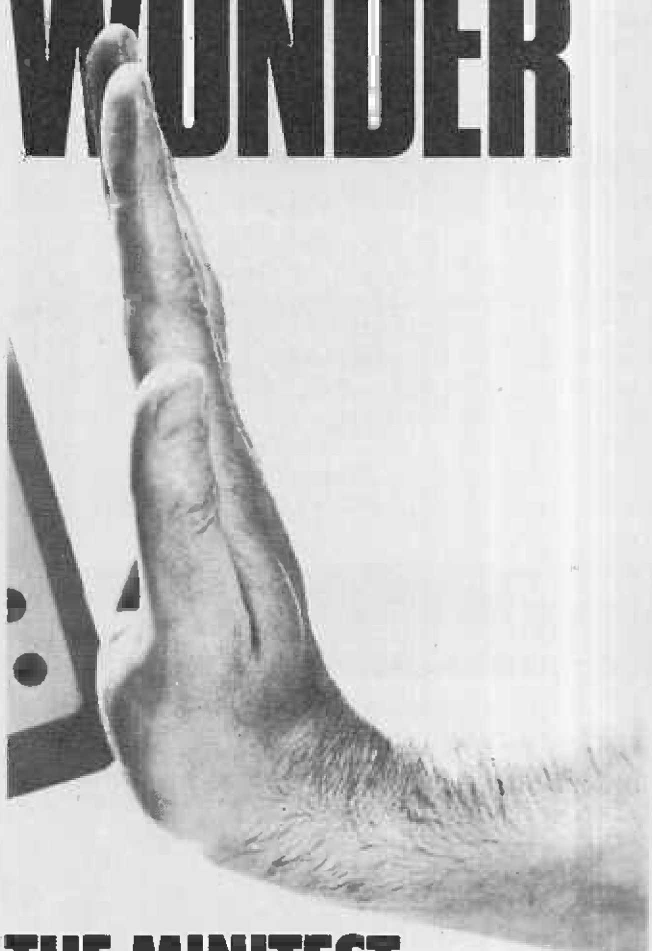

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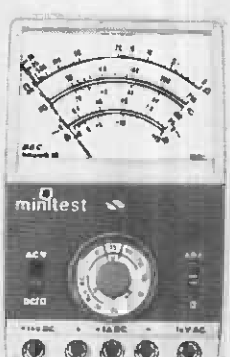

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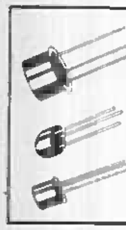

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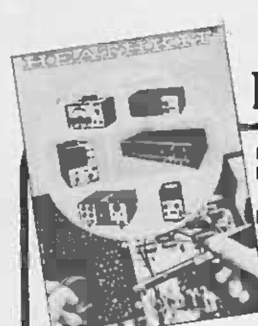

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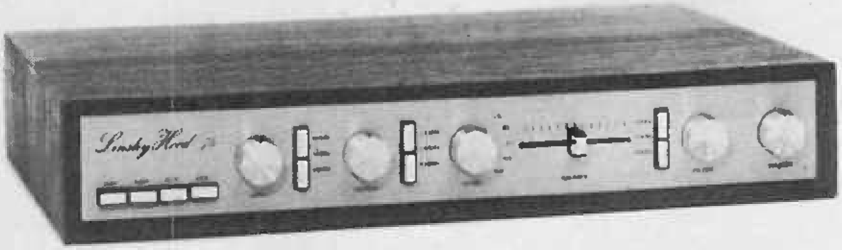

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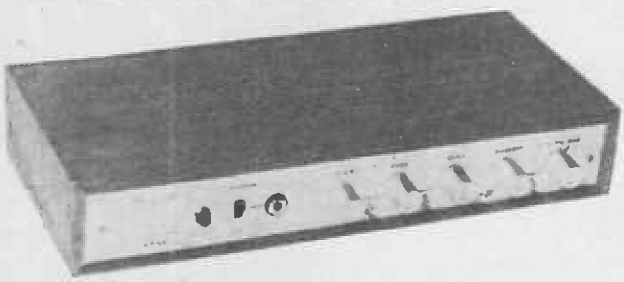

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wireless world

Electronics, Television, Radio, Audio

APRIL 1974 Vol 80 No 1460

SIXTY-FOURTH YEAR OF PUBLICATION

This month's cover picture shows the red, green and blue triple optical head of a colour television projection equipment made by Pye TVT.
(Photographer Paul Brierley)

IN OUR NEXT ISSUE
(published May 22)

Radar for cars. Clutter-free system for avoiding road collisions.

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Novel stereo f.m. tuner. Part 2: decoder; assembly; setting-up; and a frequency meter.

Electronic piano. Part 3: assembly of the electronics and the cabinet.

Contents

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Aries
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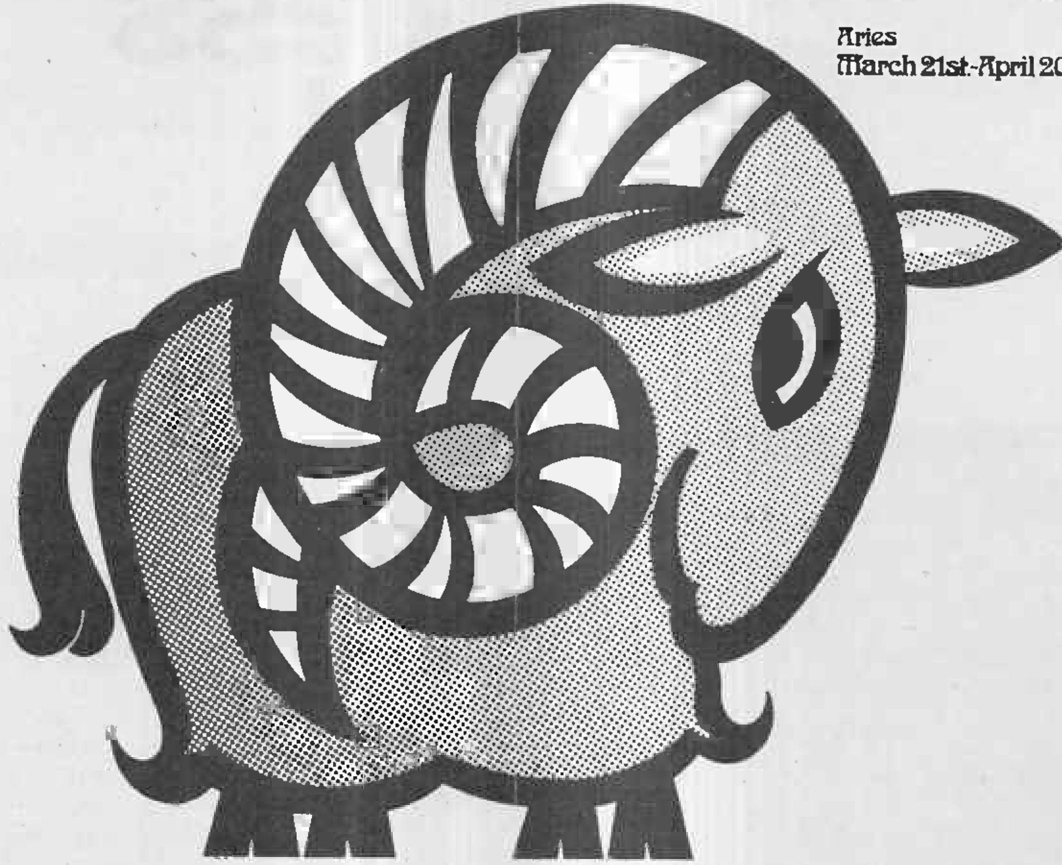
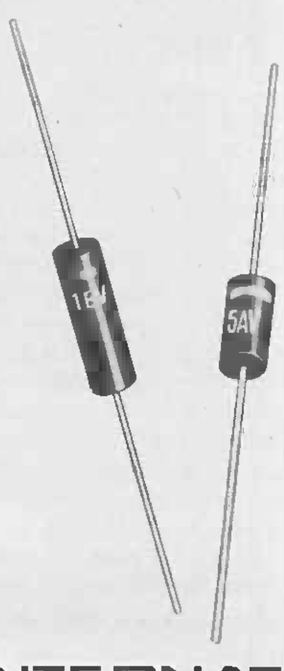


Astrologically speaking...

. . . the best and most promising times of the year are May, June and December, however if you are careful and do not attempt anything too rash, the remainder of the year should not present you with too many problems.

All in all a productive future is forseen in your horoscope.

...now discover our scope!



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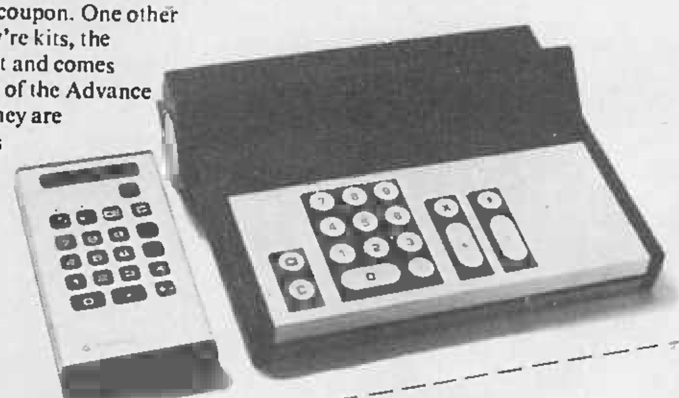

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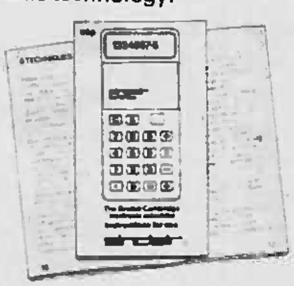

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WW/4/74

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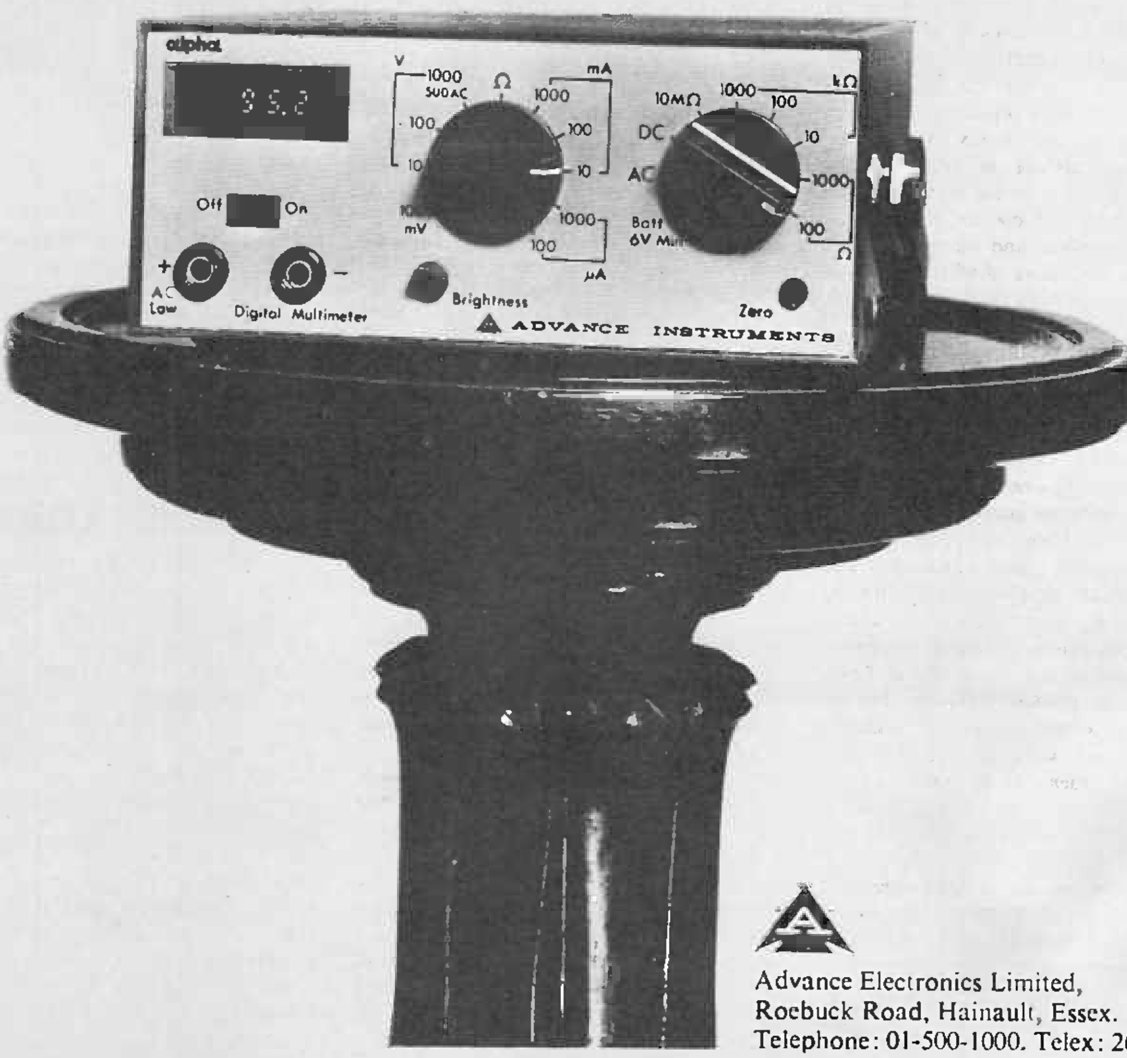

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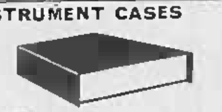
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BA6	3"	×	2"	×	1"	84p
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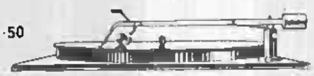

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PS 27	Jack ¼" Plastic	0·24
PS 28	Jack ¼" Screened	0·28
PS 29	Jack Stereo Plastic	0·22
PS 30	Jack Stereo Screened	0·32
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SN7405	0·18	0·17	0·16
SN7406	0·39	0·34	0·31
SN7407	0·39	0·34	0·31
SN7408	0·20	0·19	0·18
SN7409	0·20	0·19	0·18
SN7410	0·18	9·17	0·16
SN7411	0·28	0·27	0·26
SN7412	0·39	0·34	0·31
SN7413	0·32	0·31	0·30
SN7416	0·48	0·44	0·42
SN7417	0·48	0·44	0·42
SN7420	0·18	0·17	0·16
SN7422	0·55	0·53	0·50
SN7423	0·55	0·53	0·50
SN7425	0·55	0·53	0·50
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SN7432	0·50	0·46	0·44
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SN7454	0·18	0·17	0·16
SN7460	0·18	0·17	0·16
SN7470	0·32	0·29	0·27
SN7472	0·32	0·29	0·27
SN7473	0·41	0·39	0·35
SN7474	0·41	0·39	0·35
SN7475	0·50	0·48	0·46
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SN74198	£5·00	£4·75	£4·50
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Devices may be mixed to qualify for quantity price. (TTL 74 Series only) data is available for the above series of I.C.'s in book form. Price 35p

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The NEW AL60 Hi-Fi Audio Amplifier FOR ONLY £3.95

- Max Heat Sink temp. 90°C.
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- Supply voltage 10-35 volts
- Thermal Feedback
- Latest Design Improvements
- Load—3, 4, 8 or 16 ohms
- Signal to noise ratio 80dB
- Overall size 63mm × 105mm × 13mm

Especially designed to a strict specification. Only the finest components have been used and the latest solid state circuitry incorporated in this powerful little amplifier which should satisfy the most critical A.F. enthusiast.

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AP80 is especially designed to power 2 of the AL50 Amplifiers, up to 15 watt (r.m.s.) per channel simultaneously. This module embodies the latest components and circuit techniques incorporating complete short circuit protection. With the addition of the Mains Transformer MT80, the unit will provide outputs of up to 1·5 amps at 35 volts. Size: 63 mm × 105 mm × 20 mm. These units enable you to build Audio Systems of the highest quality at a hitherto unobtainable price. Also ideal for many other applications including: Disco Systems, Public Address, Intercom Units, etc. Handbook available, 10p.

TRANSFORMER BMT80 £2·15 p. & p. 25p

INTEGRATED CIRCUIT PAKS

Manufacturers "Fall Outs" which include Functional and Part-Functional Units. These are classed as 'out-of-spec' from the maker's very rigid specifications, but are ideal for learning about I.C's and experimental work.

Pak No. Contents	Price
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UIC07=8×7407	0·55
UIC10=12×7410	0·55
UIC20=12×7420	0·55
UIC30=12×7430	0·55
UIC40=12×7440	0·55
UIC41=5×7441	0·55
UIC42=5×7442	0·55
UIC43=5×7443	0·55
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UIC46=5×7446	0·55
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UIC50=12×7450	0·55
UIC51=12×7451	0·55
UIC53=12×7453	0·55
UIC54=12×7454	0·55
UIC60=12×7460	0·55
UIC70=8×7470	0·55
UIC72=8×7472	0·55
UIC73=8×7473	0·55
UIC74=8×7474	0·55
UIC76=8×7476	0·55
UIC80=5×7480	0·55
UIC81=5×7481	0·55
UIC82=5×7482	0·55
UIC83=5×7483	0·55
UIC86=5×7486	0·55

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UIC90=5×7490	0·55
UIC91=5×7491	0·55
UIC92=5×7492	0·55
UIC93=5×7493	0·55
UIC94=5×7494	0·55
UIC95=5×7495	0·55
UIC96=5×7496	0·55
UIC100=5×74100	0·55
UIC121=5×74121	0·55
UIC141=5×74141	0·55
UIC151=5×74151	0·55
UIC154=5×74154	0·55
UIC193=5×74193	0·55
UIC199=5×74199	0·55
UICX1=25 Assorted 74's	1·55

Packs cannot be split, but 25 assorted pieces (our mix) is available as PAK UIC X1.

STEREO PRE-AMPLIFIER TYPE PA100

Built to a specification and NOT a price, and yet still the greatest value on the market, the PA100 stereo pre-amplifier has been conceived from the latest circuit techniques. Designed for use with the AL50 power amplifier system, this quality made unit incorporates no less than eight silicon planar transistors, two of these are specially selected low noise NPN devices for use in the input stages.
Three switched stereo inputs, and rumble and scratch filters are features of the PA100, which also has a STEREO/MONO switch, volume, balance and continuously variable bass and treble controls.

SPECIFICATION:

Frequency response	20Hz—20kHz ±1dB	Bass control	±15dB at 20Hz
Harmonic distortion	better than 0·1%	Treble control	±15dB at 20kHz
Inputs: 1. Tape head	1·25mV into 50KΩ	Filters: Rumble (high pass)	100 Hz
2. Radio, Tuner	35mV into 50KΩ	Scratch (low pass)	8kHz
3. Magnetic P.U.	1·5mV into 50KΩ	Signal/noise ratio	better than +65dB
		Input overload	+26dB
		Supply	+35 volts at 20mA
		Dimensions	292×82×35 mm

All input voltages are for an output of 250mV.
Tape and P.U. inputs equalised to RIAA curve within ±1dB from 20Hz to 20kHz.

SPECIAL COMPLETE KIT COMPRISING 2 AL50's, 1 SPM80, 1 BMT80 & 1 PA100 ONLY £25.30 FREE p.&p

only £13·15

LINEAR I.C.'s—FULL SPEC.

Type No.	Case		1	25	100+
72702	DIL	14	0·50	0·48	0·45
72709	DIL	14	0·35	0·33	0·30
72710	DIL	14	0·45	0·43	0·40
72741	DIL	14	0·40	0·38	0·35
72741C	TO-5	8	0·45	0·43	0·40
72741P	DIL	8	0·38	0·36	0·34
72748P	DIL	8	0·38	0·36	0·34
SL201C	TO-5	8	0·50	0·45	0·40
SL701C	TO-5	8	0·50	0·45	0·40
SL702C	TO-5	8	0·50	0·45	0·40
TAA263	TO-72	4	0·80	0·70	0·60
TAA293	TO-74	10	£1·00	0·95	0·90
TAA350A	TO-5	10	£1·85	£1·80	£1·70
μA703C	TO-5	8	0·28	0·26	0·24
μA709C	TO-5	8	0·35	0·33	0·30
μA711	TO-5	10	0·45	0·43	0·40
ZN414	TO-18	4	£1·20	—	—

DTL 930 SERIES LOGIC I.C's

Type	1	25	100+
BP930	0·15	0·14	0·13
BP932	0·16	0·15	0·14
BP933	0·16	0·15	0·14
BP935	0·16	0·15	0·14
BP936	0·16	0·15	0·14
BP944	0·16	0·15	0·14
BP945	0·30	0·28	0·25
BP946	0·15	0·14	0·13
BP948	0·30	0·28	0·25
BP951	0·70	0·65	0·60
BP962	0·15	0·14	0·13
BP9093	0·45	0·43	0·40
BP9094	0·45	0·43	0·40
BP9097	0·45	0·43	0·40
BP9099	0·45	0·43	0·40

DUAL-IN-LINE SOCKETS

14 & 16 Lead Sockets for use with DUAL-IN-LINE I.C's. TWO Ranges PROFESSIONAL & NEW LOW COST.

PROF. TYPE No.	1-24	25-99	100up
TSO 14 pin type	33p	30p	27p
TSO 16 ,, ,,	38p	35p	32p
TSO 24 pin type	75p	70p	65p
BPS 8 pin type	15p	13p	11p
LOW COST No.			
BPS 14 ,, ,,	16p	14p	12p
BPS 16 ,, ,,	17p	15p	13p

NUMERICAL INDICATOR TUBES

Type	Description	
3015F	Minitron 7 Segment Indicator	£1·50
MAN 3M	L.E.D. 7 Segment Display 0.127" High Characters	£1·90
CD 66	Side Viewing 'Nixie Type' Tube 16 mm.	£1·87
GR 116	Side Viewing 'Nixie Type' Tube 13 mm.	£1·70

3 TERMINAL POSITIVE VOLTAGE REGULATORS

To3 Plastic Encapsulation O/P 1.5 Amps.
μA7805 5V (Equiv. to MVR5V) £1·76
μA7812 12V (Equiv. to MVR12V) £1·76

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AL10/AL20/AL30 AUDIO AMPLIFIER MODULES

The AL10, AL20 and AL30 units are similar in their appearance and in their general specification. However, careful selection of the plastic power device has resulted in a range of output powers from 3 to 10 watts R.M.S.
The versatility of their design makes them ideal for use in record players, tape recorders, stereo amplifiers and cassette and cartridge tape players in the car and at home.

Parameter	Conditions	Performance
HARMONIC DISTORTION	Po=3 WATTS f=1KHz	0·25%
LOAD IMPEDANCE	—	8–16Ω
INPUT IMPEDANCE	f=1KHz	100 kΩ
FREQUENCY RESPONSE ± 3dB	Po=2 WATTS	50 Hz-25KHz
SENSITIVITY for RATED O/P	Vs=25V. Rl=8Ω f=1KHz	75mV. RMS
DIMENSIONS	—	3"×2½"×1"

The above table relates to the AL10, AL20 and AL30 modules. The following table outlines the differences in their working conditions.

Parameter	AL10	AL20	AL30
Maximum Supply Voltage	25	30	30
Power output for 2% T.H.D. (RL=8Ω f=1 KHz)	3 watts RMS Min.	5 watts RMS Min.	10 watts RMS Min.
PRICE	£2·20	£2·50	£3·3

TEAK VENEERED CABINETS for:
STEREO 20
TC 20. £3.95 p&p 30p
MK 50 KIT
TC 100. £6.50 p&p 30p

E.M.I. LEK 350 Loudspeaker System Enclosure kit in teak veneer, including speakers. Rec. retail price £45.50 per pr. OUR SPECIAL PRICE £35.50 per pair P. & P. £1. ONLY WHILE STOCKS LAST!

The STEREO 20

The 'Stereo 20' amplifier is mounted, ready wired and tested on a one-piece chassis measuring 20 cm. × 14 cm. × 5·5 cm. This compact unit comes complete with on/off switch volume control, balance, bass and treble controls, Transformer, Power supply and Power amps. Attractively printed front panel and matching control knobs. The 'Stereo 20 has been designed to fit into most turntable plinths without interfering with the mechanism or, alternatively, into a separate cabinet. Output power 20w peak. Input 1 (Cer.) 300mV into 1M. Freq. res. 25Hz-25kHz. Input 2 (Aux.) 4mV into 30K. Harmonic distortion. Bass control ±12dB at 60Hz typically 0·25% at 1 watt. Treble con. ±14dB at 14kHz.

£14·45

FRONT PANEL, 4 knobs, Headphone Socket, on/off switch and neon for PA100/MK50. FPK100 £2.95.

TRANSFORMERS

T461 (Use with AL10) £1 88 P. & P. 15p.
T538 (Use with AL20) £1 93 P. & P. 15p.
BMT80 (Use with AL30 & AL50) £2·15 P. & P. 25p

POWER SUPPLIES

PS 12. (Use with AL10 & AL20) 88p
SPM 80. (Use with also AL30 & AL50) £3 25

PA 12. PRE-AMPLIFIER SPECIFICATION

The PA 12 pre-amplifier has been designed to match into most budget stereo systems. It is compatible with the AL 10, AL 20 and AL 30 audio power amplifiers and it can be supplied from their associated power supplies. There are two stereo inputs, one has been designed for use with *Ceramic cartridge while the auxiliary input will suit most †Magnetic cartridges. Full details are given in the specification table. The four controls are, from left to right: Volume and on/off switch, balance, bass and treble. Size 152mm × 84mm × 35mm

PRICE £4.35

Frequency response—
20Hz-50KHz (—3dB
Bass control—
± 12dB at 60H
Treble control—
±14dB at 14KHz
*Input 1. Impedance
1 Meg. ohm
Sensitivity 300mV
†Input 2. Impedance
30 K ohms
Sensitivity 4mV

FRONT PANELS FP12 with knobs £1·20

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7401	20p	18p	7448	£1·98	£1·81	74141	£1·10	99p
7402	20p	18p	7450	20p	18p	74145	£1·65	£1·48
7403	20p	18p	7451	20p	18p	74150	£3·30	£2·75
7404	21p	19p	7453	20p	19p	74151	£1·21	£1·15
7405	21p	19p	7454	20p	18p	74153	£1·32	£1·15
7406	54p	49p	7460	20p	18p	74154	£2·20	£1·87
7407	54p	48p	7470	33p	27p	74155	£1·65	£1·21
7408	29p	24p	7472	33p	30p	74156	£1·65	£1·21
7409	29p	24p	7473	46p	42p	74157	£1·54	£1·43
7410	20p	18p	7474	44p	40p	74160	£2·18	£2·05
7411	23p	21p	7475	63p	57p	74161	£2·18	£2·05
7412	40p	33p	7476	55p	51p	74162	£4·84	£4·54
7413	31p	29p	7480	£1·10	99p	74163	£4·84	£4·54
7416	49p	47p	7481	£1·37	£1·26	74164	£2·73	£2·63
7417	57p	53p	7482	£1·10	99p	74165	£2·73	£2·63
7420	20p	18p	7483	£1·32	£1·29	74166	£4·28	£3·94
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7430	20p	18p	7493	82p	66p	74182	£2·18	£2·02
7432	42p	33p	7494	£1·04	93p	74184	£2·69	£2·42
7433	97p	91p	7495	£1·14	£1·03	74190	£3·08	£2·69
7437	77p	74p	7496	£1·25	£1·15	74191	£2·30	£2·24
7438	77p	74p	74100	£2·75	£2·58	74192	£2·53	£2·30
7440	20p	18p	74104	£1·18	£1·14	74193	£2·53	£2·30
7441	81p	78p	17405	£1·18	£1·14	74194	£3·27	£3·15
7442	80p	78p	74107	48p	46p	74195	£2·42	£2·30
7443	£1·40	£1·32	74110	67p	65p	74196	£2·18	£2·06
7444	£1·57	£1·52	74111	£1·52	£1·40	74197	£2·18	£2·06
7445	£2·31	£2·18	74118	£1·10	80p	74198	£6·65	£6·05
7446	£2·31	£2·18	74119	£1·64	£1·54	74199	£6·65	£6·05
			74121	47p	42p	74200	£28·40	£21·12
			74122	£1·70	£1·59			

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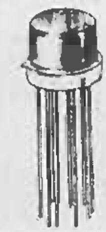
301 DIL	50p
301 TO99	55p
301 8 Pin DIL	46p
301A DIL	69p
301A TO99	69p
301A 8 Pin DIL	66p
308 TO99	£6·55
308A TO99	£6·40
709C DIL	38p
709C TO99	36p
723A DIL	89p
723P TO99	88p
741C 8 Pin DIL	36p
741C 14 Pin DIL	38p
741C TO99	38p
747C DIL	46p
748C DIL	39p
748C TO99	41p



Electrolytic Capacitors

4 VOLT		16 VOLT		40 VOLT	
47µF	6½p	15µF	6½p	47µF	6½p
100µF	6½p	33µF	6½p	100µF	9p
220µF	6½p	150µF	6½p	68µF	10p
330µF	6½p	150µF	8p	220µF	11p
1000µF	13p	220µF	9p	470µF	19p
4700µF	29p	680µF	17p	680µF	25p
		1000µF	17p	1000µF	25p
		1500µF	25p	2200µF	44p
		2000µF	43p		

6·3 VOLT		25 VOLT		63 VOLT	
33µF	6½p	10µF	6½p	1µF	6½p
68µF	6½p	22µF	6½p	2·2µF	6½p
150µF	6½p	47µF	6½p	4·7µF	6½p
470µF	11p	100µF	8p	6·8µF	6½p
680µF	13p	150µF	8p	10µF	6½p
1500µF	18p	220µF	10p	22µF	6½p
2200µF	18p	470µF	13p	68µF	10p
3300µF	26p	680µF	20p	100µF	11p
		1000µF	22p	150µF	13p
		2200µF	39p	220µF	19p
		5000µF	68p	330µF	22p
				470µF	26p
				1000µF	44p

10 VOLT		40 VOLT	
22µF	6½p	6·8µF	6½p
47µF	6½p	15µF	6½p
1000µF	6½p	33µF	6½p
220µF	8p		
330µF	10p		
470µF	10p		
1000µF	11p		
1500µF	20p		
2200µF	24p		

Resistors

¼ watt 5% carbon.	1p
½ watt 5% carbon..	1p
1 watt 10% carbon	2½p
Range 10 ohms to 4·7 megohms.	
½ watt m/o 2%	4p
Range 10 ohms to 1 megohms.	

Vereoboard

	0·15 matrix	0·1 matrix
2½ × 3¾	17p	22p
2½ × 5	22p	24p
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2½ × 17	60p	79p
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Pack of 36 pins	42p	42p
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AC127	15p
AC128	15p
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AC187	18p
AC188k	26p
AC188	16p
AD140	49p
AD149	49p
AD161	42p
AD162	42p
AF114	16p
AF115	16p
AF116	16p
AF117	16p
BC107	12p
BC108	12p
BC109	13p
BC147	12p
BC148	12p
BC149	13p
BF194	16p
BF195	18p
BFY50	19p
BFY51	20p
BFY52	20p
OC25	40p
OC28	55p
OC35	48p
OC36	54p
OC71	15p
2N3053	26p
2N3054	55p
2N3055	49p
2N3819	28p
40636	66p

DIODES

1N4001	5p
1N4002	5p
1N4003	6p
1N4148	4p
OA90	6p
OA91	8p

THYRISTORS

1 amp	
50v	28p
100v	30p
400v	38p
3 amp	
50v	44p
100v	50p
400v	66p

Mullard Polyester Capacitors

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250V P.C. mounting: 0·01µF, 0·015, 0·022 3½p. 0·033, 0·047, 0·068 4p. 0·1 4½p. 0·15, 0·22 5½p. 0·33 7p. 0·47 9½p. 0·68 12p. 1µF 14p. 1·5µF 22p. 2·2µF 27p.

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160V: 0·01µF, 0·015, 0·022, 0·033, 0·047, 0·068 3½p. 0·1 4p. 0·15 4p. 0·1 4½p. 0·15, 0·22 5½p. 0·33 7p. 0·47 9½p. 0·68 12p. 1µF 14½p. 1·5µF 22p. 2·2µF 24p.

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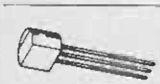

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B1	50	Germanium Transistors PNP, AF and RF.	55p
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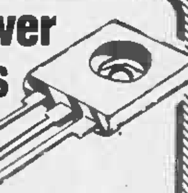

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RANGE 1 VCE. Min. 15 HFE. Min. 15			
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90 Watt	26½p	24½p	22p
RANGE 2VCE. Min. 40			
RANGE 2VCE. Min. 40 HFE. Min. 40			
40 Watt	33p	31p	29p
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This latest addition to our range will be in production late March '74. It is designed to offer the best possible performance allied to the ease of operation given by push button varicap tuning. We have taken great care to look after the constructors' point of view and there are no coils to wind, no RF circuits to wire and no alignment is required. In fact the whole unit can be easily completed and working in an evening as there are only 3 transistors, one IC and two ready built and aligned modules comprising the active components. We have abandoned the concept of having a tuner as large as the amplifier and this new unit has a frontal size of only 1¾ in. × 4 in. It can be mounted on the side of our Bailey amplifier metalwork thus turning it into a tuner/amplifier whilst only increasing its width by 1¾ in.
Cost of tuner chassis (no case) is £22 for mono, £25·45 for stereo. Metal case £2·55. An extended wooden case to fit tuner and amplifier will be offered shortly.

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The best engineered kit available of the combined best of three pre-amp designs. This is the kit with no wiring to the controls, switches or inputs. A complete and sophisticated 5 input signal processing stage for any power amplifier requiring up to 1½v input for only £20·50. Front end only £10·44. Tone control only £11·41.

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METALWORK, FRONT PLATES, WOODEN CASES
These are the things that convert your hobby into cost saving professional equipment. Remember if the finished job looks decent the wife won't worry about the money you spend. Complete metalwork for Stereo Bailey 30's, preamp and power supply £5·40. Metal cover £1·60. Wooden case £4·85. Front plate £1·37.

DIGITAL MULTIMETER
Our first venture into instruments and by the way it's selling it won't be long before we're offering others. It is of course unique as it measures DC and AC volts, resistance, capacitance, period, time and frequency. Not bad for £65's worth of parts.

STUART TAPE CIRCUITS
Our printed circuits and components offer the easy way to convert any suitable quality deck into a very high quality Stereo Tape unit. Input and output levels suit Bailey pre amp.
Total cost varies but around £35 is all you need. We can offer tape heads as well if you want new ones.
All above kits have fibreglass PCB's. Prices exclude VAT but P&P is included.
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30.	2N2906. Motorola	35p
25.	MJ480. Motorola	88p
30.	2N388. Sesco	25p
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800.	1W W/W 22Ω. Plessey	06p
28.	Trimpot 1k. MEC	60p
Capacitors		
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400.	C426AR/F80. 80/25. Mullard	22p
60.	2500µf 70v. CCL	60p
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300.	79/840. 3way Phono soc. Carr	05p
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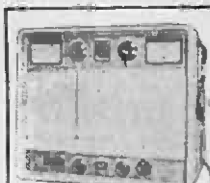

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Range: 15KHz to 30MHz. Output 0.4µV to 4V at 13 or 75 ohms. Impedance with termination (supplied). Built in crystal check facility with handbook. £138

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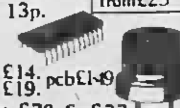

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Tests PNP or NPN transistors. Audio indication. Operates on two 1.5V batteries. Complete with instructions etc.
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Top value 1,000 opv pocket multimeter. Ranges: – 0/10/50/250/1,000 volt AC and DC. DC current 0-1mA/100mA. Resistance: 0/150k ohms. Decibels: –10 to +22dB. Size 90 x 60 x 28mm. Complete with test leads.
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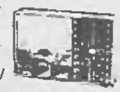
U4323 MULTIMETER

20,000opv. Simple unit with audio/IF oscillator. Suitable for general receiver tuning. Ranges: 0.5/2.5/10/50/250/500/1000V DC. 2.5/10/15/250/500/1000V AC. 0.05/0.5/5/50/500mA DC. Resistance: 5/50/500 ohms/5/10/100k ohms/1Meg. Battery operated. Size: 160 x 97 x 40mm. Supplied in carrying case complete with test leads.
OUR PRICE £7.00 P&P 20p

U4312 MULTIMETER

extremely sturdy instrument for general electrical use. 667opv. 0/0.3/1.5/7.5/30/60/150/300/600/900V DC & 75mV. 0/0.3/1.5/7.5/30/60/150/300/600/900V AC. 0/300uA/1.5/6/15/150/60/600mA/1/1.5/6A DC. 0/1.5/6/15/60/150/600mA/1.5/6A AC. 0/200/3k/30k ohms. DC accuracy 1%. AC 1.5%. Knife edge pointer, mirror scale. Complete with sturdy metal carrying case, leads and instructions.
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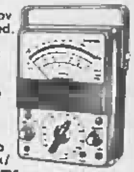
High sensitivity tester. 200,000 opv. Overload protected. Mirror scale. Ranges: –0/.06/.3 3/30/120/600/1200V DC. 0/3 12/60/300/11200 V AC. 0/6uA/1.2mA/120mA/600mA/12A DC 0/12A AC. –20 to +63dB. 0/2k/200k/2 Meg/200 Megohms.
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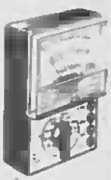
U4341 Multimeter & Transistor Tester

27 ranges. 16,700opv. Overload protected. Ranges: 0.3/1.5/6/30/60/150/300/900V DC. 1.5/7.5/30/150/300/750V AC. Current: 0.06/0.6/6/60/600mA DC. 0.3/3/30/300mA AC. Resistance: 0.06/0.6/2/6/20/60/200k ohms/2 Mohms. Battery operated. Supplied complete with probes, leads and steel carrying case. Size: 115 x 215 x 90mm.
OUR PRICE £10.50 P&P 20p

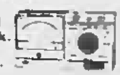
AUDIOTRONIC Model ATM5

Jewel movement, attractively moulded case with edgwise ohms adjustment. Ranges: 0-3/15/150/300/1200V AC, (2500 opv). 0-6/30/300/600V DC, (5000 opv). 0-300 uA/0-300mA DC. Resistance: x 10 & x 100. –10 to +16dB. Supplied with battery test leads and data booklet. Size: 121 x 73 x 29mm.
OUR PRICE £3.50 P&P 15p

MODEL HIOKI 730X

30,000 opv. Overload protection. 6/30/60/300/600/1200V DC. 12/60/120/600/1200V AC. 60/μA/30mA/300mA. 2K/200K/2 Meg Ohm. –10 to +63 dB.
OUR PRICE £7.50 P&P 15p.

MODEL 500

30,000 opv with overload protection. Mirror scale. 0/0.5/2.5/10/25/100/250/500/1000V DC. 0/2.5/10/25/100/250/500/1000V AC. 0/50uA/5/50/500mA. 12A DC. 0/60k/6 meg/60 megohms.
OUR PRICE £13.95 Carr. paid
Leather case for above £1.75

U4317 MULTIMETER

High sensitivity instrument for field and laboratory work. Knife edge pointer, 86mm. mirror scale. Ranges: 100mV/0.5/2.5/10/25/50/100/250/500/1000 V DC. 0.5/2.5/10/25/50/100/250/500/1000V AC. Current: 50uA/0.5/1/5/10/50/250mA/1/5A DC. 0.25/0.5/1/5/10/50/250mA/1/5A AC. Resistance: 0.5/10/100/200 ohms/1/3/30/300k ohms. Decibels: –5 to +10dB Battery operated. Size: 210 x 115 x 90mm. Supplied in carrying case complete with leads.
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Features 5,000 opv jewel movement and a good selection of range functions. Edgwise ohms adjustment. Ranges: – 0–3/15/150/300/1,200V AC (2,500 opv). 0–6/30/300/600 V DC (5,000 opv). DC current. 0–300uA/300mA. Resistance: R x 10. R x 1,000. –10 to +16dB. Complete with battery, test leads and data booklet. Size: 120 x 73 x 28mm.
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MODEL TE300

30,000opv. Mirror scale. Overload protection. 0/0.6/3/15/60/300/1200V DC. 0/6/30/120/600/1200V AC. 0/30uA/6mA/60mA/300mA/600mA. 0/8k/80k/800k/8 Meg ohms. –20 to +63dB.
OUR PRICE £7.50 P&P 15p

HIOKI 750X VOLT-OHM-MILLIAMETER

43 ranges: 0–0.3/0.6/1.5/3/6/12/30/60/150/300/600/1,200V DC. 0–3/6/15/30/60/120/300/600/1,200V AC. Current: 0–30/60uA/1.5/3/15/30/150/300 mA/6/12A. Resistance: 0–3/300k/3/30Mohms. Decibels: –10 to +17dB. Output: – 0–3/6/15/30/60/120/300V. Accuracy ± 3% DC, ± 4% AC. Sensitivity: 50,000 opv DC, 5,000 opv AC. 4 inch meter. Built in protection. Size: 57 x 102 x 153mm.
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100,000opv. 6½" scale. Buzzer short circuit check. Sensitivity 100,000 opv DC. 5k/V AC DC Volts: 0.5/2.5/10/50/250/1000V AC, 3/10/50/250/500/1000V DC. current 10/100uA/10/10/100/500mA/2.5/10A. Resistence: 1k/10k/100k/10 Meg/100 Meg ohms. Decibels: –10 to +49dB. Plastic case with carrying handle. Size: 190 x 172 x 99mm.
OUR PRICE £19.95 P&P 25p

S100TR MULTIMETER TRANSISTOR TESTER

100,000opv. Mirror scale. Overload protection. 0/0.12/0.6/3/12/30/120/600V DC. 0/6/30/120/600V AC. 0/12/600uA/12/300mA/6/12A DC 0/10k/1 Meg/100 Meg. –20 to +50dB. 0.01–0.2 MFD Transistor tester measures Alpha, Beta and ICO. Complete with instructions, batteries and leads.
OUR PRICE £15.95 P&P 25p

MODEL U437 MULTIMETER

10,000opv. A first class, instrument manufactured in USSR to the highest standards. Ranges: 2.5/10/50/250/500/1000V DC. 2.5/10/50/250/500/1000V AC. DC current 100uA/1/10/100mA/1A. Resistence 300 ohms/3/30/300k/3 Meg. ohms. Complete with batteries, test leads, instructions and a sturdy steel carrying case.
OUR PRICE £4.95 P&P 25p

U4324 MULTIMETER

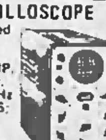
High sensitivity, overload protected. 20,000opv. Ranges: 0.6/1.2/3/12/30/60/120/600/1200V DC. 3/6/15/60/150/300/600/900V AC. Current: 0.06/0.6/6/60/600mA/3A DC. 0.3/3/30/300mA/3A AC. Resistence: 25/500 ohms/0.5/5/50/500k ohms/5 Mohms. Decibels: –10 to +12dB. Size 167 x 98 x 63mm. Supplied complate with test leads, spare diode and instructions.
OUR PRICE £8.00 P&P 20p

HIOKI MODEL 700X

100,000opv. Overload protection. Mirror scale. 0.3/0.6/1.2/1.5/3/6/12/30/60/120/300/600/1200V DC. 1.5/3/6/12/30/60/150/300/600/1200V AC. 15/30uA/3/6/30/60/150/500mA/6/12A DC. 2k/200k/2M/20MOhms. –20 to +63dB.
OUR PRICE £14.95 P&P 20p

MODEL U4311 Sub-standard Multi-range Volt-Ammeter

Sensitivity 330 Ohms/Volt AC and DC. Accuracy 0.5% DC, 1% AC. Scale length: 165mm. 0/300/750uA/1.5/3/7.5/15/30/75/150/300/750mA/1.5/3/7.5A DC. 0/3/7.5/15/30/75/150/300/750mA/1.5/3/7.5A AC. 0/75/150/300/750mV/1.5/3/7.5/15/30/75/150/300/750V DC. 0/750mV/1.5/3/7.5/15/30/75/150/300/750V AC. Automatic cut out device. Supplied complete with test leads, manual and test certificates.
OUR PRICE £49.00 P&P 50p

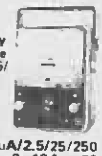
C15 PULSE OSCILLOSCOPE

For display of pulsed and periodic waveforms in electronic circuits. VERT. AMP. Bandwidth: 10MHz. Sensitivity at 100kHz VRMS/mm: 0.1–25; HOR. AMP. Band width: 500kHz. Sensitivity ay 100kHz VRMS/mm: 0.3–25 Preset triggered sweep 1–3000usec. Free running 20–200 kHz in nine ranges. Calibrator pips. 220 x 360 x 430mm. 115–230V AC.
OUR PRICE £39.00 Carr. paid

MODEL TH12

20,000 opv. Overload protection. Slide switch selector. 0/0.25/2.5/10/50/150/1000V DC. 0/10/50/250/1000V AC. 0/50uA/25/250mA DC. 0/3k/30k/300k/3 Megohms. –20 to +50dB.
OUR PRICE £5.95 P&P 15p

TMK MODEL TW50K

46 ranges, mirror scale. 50k/V DC 50k/V AC. DC Volts: 0.125/0.25/1.25/2.5/5/10/25/50/125/250/500/1000. AC Volts 1.5/3/5/10/25/50/125/250/500/1000. DC current 25/50uA/2.5/5/25/50/250/500mA/5/10A. Resistence: 10k/100k/1 Meg/10 Meg ohms. –20 to +81.5dB.
OUR PRICE £8.50 P&P 17p

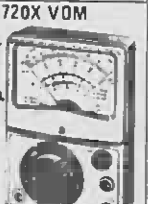
Model HT 10084 MULTIMETER

Overload protected, shock proof circuits. 9.5uA Meter with mirror scale. Sensitivity 100kV. Polarity change switch. Ranges: 0.5/2.5/1-/50/250/500/1,000 Volts DC. 2.5/10/50/250/1,000 Volts AC. DC resistence 0–20/200k/2/20 Meg. ohms. DC current: – 10/250uA/2.5/25/250 mA/10A. AC current: –0–10A. –20 to +62dB. Operates from 2 x 1.5V batteries. Size: 180 x 134 x 79mm.
OUR PRICE £15.00 P&P 40p

TE40 HIGH SENSITIVITY AC VOLTMETER

10 Meg input. 10 ranges: 0.001/0.03/0.1/0.3/1/3/11/30/100/300V RMS. 5cps–1.2MHz. –40 to +50dB supplied complete with leads and instructions.
OUR PRICE £17.50 P&P 25p

RUSSIAN CI16 Double Beam OSCILLOSCOPE

5 MHz pass band. Separate Y1 and Y2 amplifiers. Rectangular 5" x 4" CRT. Calibrated triggered sweep from 0.2usec. to 100 milli-sec/cm. Free running time base, 50Hz–1MHz. Built-in time base Calibrator and amplitude Calibrator. Supplied complete with all accessories and instruction manual.
OUR PRICE £87.00 Carr. paid

HIOKI Model 720X VOM

A versatile, accurate measuring instrument. 20,000 opv. 0/5/25/100/500/1000V DC. 0/10. 50/250/1000V AC. 0–50uA/250mA. 0–20k/2 Megohms.
OUR PRICE £5.97 P&P 20p

U435 MULTIMETER

20,000opv. Overload protected. Ranges: 75mV/2.5/10/25/100/250/500/1000V DC. 2.5/10/25/100/250/500/1000V AC. Current: 50uA/1/5/25/100mA/0.5/2.5A DC. 5/25/100mA/0.5/2.5A AC. Resistance: 0.3/3/30/300k ohms. Size: 205 x 110 x 84mm. Supplied complete with leads, crocodile clips and steel carrying case.
OUR PRICE £8.75 P&P 20p

MODEL AS.100D VOM

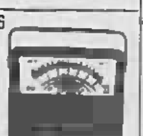
100,000 opv. Mirror scale. Built-in meter protection. 0/3/12/60/120/300/600/1200V DC. 0/6/30/120/300/600V AC. 0/10μA/6/60/300mA/12 Amp. 0/2K/200K/2M/200 Meg Ohm. –20 to +17 dB.
OUR PRICE £17.50 P&P 20p.

TE65 VALVE VOLTMETER

28 ranges. DC volts 1.5–1500V. AC volts 1.5–1500V. Resistance up to 1000 Megohms. 200/240V AC operation. Complete with probe and instructions.
OUR PRICE £17.50 P&P 30p
Additional probes available: RF £2.12, HV £2.50

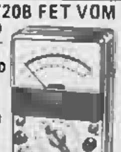
MODEL TE15 GRID DIP METER

Transistorised. Operates as Grid Dip, Oscilator, Absorbtion Wave Meter and Oscillating Detector. Frequency range 440kHz–280MHz in six coils. 500uA meter. 9V battery operation. Size: 180 x 80 x 40mm.
OUR PRICE £19.95 P&P 20p

MODEL PL436

20,000 opv DC. 8000 opv AC. Mirror scale ·6/3/12/30/120/600V DC. 3/30/120/600V DC. 50/600μA/60/600mA. 10/100K/1 Meg/10 Meg Ohm. –20 to +46 dB.
OUR PRICE £6.97 P&P 15p.

U91 Clamp VOLT AMMETER

For measuring AC voltage and current without breaking circuit. Ranges: 300/600V AC. Current 10/25/100/250/500A. Accuracy 4%. Size 283 x 94 x 36mm. Complete with carrying case, leads and fuses.
OUR PRICE £10.50 P&P 20p

KAMODEN HM7208 FET VOM

Input impedance 10 Megohms. Ranges: – 0/.25/1/2.5/10/50/1000V DC. 0/2.5/10 50/250/1000V AC. 0/25uA/2.5/25/250 mA DC. 0/5k/50k/500k/5 M 500 Megohms
OUR PRICE £21.00 P&P 30p

LB3 TRANSISTOR TESTER

Tests ICO and B. PNP/NPN. Operates from 9V battery. Instructions supplied.
OUR PRICE £3.95 P&P 20p

Also see following pages

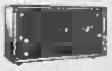
ALL PRICES EXCLUDE VAT

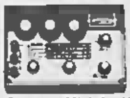
LASKYS

Also see previous page

SWR METER Model SWR3

Handy SWR meter for transmitter antenna alignment, with built-in field strength meter. Accuracy 5%. Impedence 52' Indicator 100uA DC. Full scale 5 section collapsible antenna. Size 145 x 50 x 60mm.
OUR PRICE £4.25 P&P 25p

AT201 Decade ATTENUATOR

Frequency range 0–200kHz. Attenuator 0–111dB, 0.1dB steps. Impedence 600 ohms. Input power maximum 30dBm. Size: 180 x 90 x 56mm.
OUR PRICE £12.50 P&P 37p

TRANSISTORISED L.C.R. A.C. BR/8 MEASURING BRIDGE

A new portable bridge offering excellent range and accuracy at low cost. Ranges: R 1 11.1 meg 6 Ranges ±1% L 1 H — 111 HENRY 6 Ranges 2 × % C.10pF 1110mFd 6 Ranges ± 2% TURNS RATIO 1 : 1/1000—1 : 1/100. 6 Ranges ± 1%. Bridge voltage at 1,000 cps. Operated from 9 volts. 100 A Meter indication. Attractive 2 tone metal case. Size 7¼ x 5 x 2in.
OUR PRICE £25.00 P&P 25p

TE16A TRANSISTORISED SIGNAL GENERATOR

5 ranges, 400kHz to 30 MHz. An inexpensive instrument for the handy-man. Operates on 9V battery. Wide easy to read scale. 800kHz modulation. Size: 149 x 149 x 92mm. Complete with instructions and leads.
OUR PRICE £8.97 P&P 25p

MODEL TE20 RF SIGNAL GENERATOR

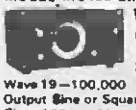
Six bands, 120kHz–260MHz. Dual output RF terminals. Separate variable audio output. Accuracy ± 2%. Audio output to 8V. Power requirements: 105–125V, 220–240V AC. Size: 193 x 265 x 150mm. Complete with test leads etc.
OUR PRICE £17.50 P&P 40p

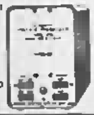
TE-200 RF SIGNAL GENERATOR

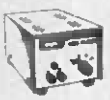
Accurate wide range signal generator covering 120 kHz-500 MHz on 6 bands. Directly calibrated. Variable R.F. attenuator audio output. Xtal socket for calibration. 220/240V a.c. Brand new with instructions. Size 140mm x 215mm x 170mm.
OUR PRICE £17.50 P&P 30p

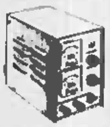
ARF 300 AF/RF SIGNAL GENERATOR

All transistorised compact fully portable. AF sine wave 18Hz to 220 kHz. AF square wave 18Hz to 100k Hz. Output Square/Sine wave 10V. P-P RF 100kHz to 200MHz. Output 1V maximum. 220/240V AC operation. Complete with Instructions and leads.
OUR PRICE £29.95 P&P 50p

MODEL MG100 SINE SQUARE WAVE AUDIO GENERATOR

Range 19-220,000Hz Sine Wave 19–100,000 Hz Square Wave. Output Sine or Square wave 10v. P. to P. Size 180 x 90 x 90mm. Operation 220/240v. A.C.
OUR PRICE £19.95 P&P 37p.

MCA220 Automatic Voltage Stabiliser

Input 88–125V AC or 176–250V AC. Output 120V AC or 240V AC. 200V/A rating. P&P 50p
OUR PRICE £11.97

PS100B Regulated POWER SUPPLY UNIT

Solid state. Output 6, 9 or 12V DC up to 3 Amp. Meter to monitor current. Input 220/240V AC. Size: 100 x 82 x 159mm.
OUR PRICE £11.97 P&P 25p

PS200 Regulated POWER SUPPLY UNIT

Solid state. Variable output 5–20V DC up to 2 Amp. Independent meters to monitor voltage and current. Output 220/240V AC. Size: 190 x 136 x 98mm.
OUR PRICE £19.95 P&P25p

POWER RHEOSTATS

High quality ceramic construction. Windings embedded in vitreous enamel. Heavy duty brush wiper. Continuous rating. Wide range available ex-stock. Single hole fixing. ¼" diameter shafts. Bulk quantities available.

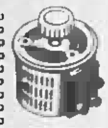
25 WATT 10/25/50/100/250/500/1000/2500 Ohms **£1.15** P&P 10p
50 WATT 10/25/50/100/250/500/1000/2500/5000 Ohms. **£1.62** P&P 10p
100 WATT 1/5/10/25/50/100/250/500/1000/2500 Ohms **£2.34** P&P 15p

AUTO TRANSFORMERS
0/115/250V. Step up or step down. Fully shrouded.

80 WATTS	£2.75	P&P 18p
150 WATTS	£3.50	P&P 18p
300 WATTS	£4.50	P&P 23p
500 WATTS	£6.95	P&P 33p
1000 WATTS	£9.50	P&P 38p
1500 WATTS	£12.50	P&P 43p
2250 WATTS	£20.95	P&P 50p
5000 WATTS	£44.95	P&P £1

CP110 CHASSIS PUNCH SET

Carefully machined top grade steel. Contains 1/2", 5/8", 3/4", 1" and 1 1/8" punches complete with gripper and accessories.
OUR PRICE £3.00 P&P 40p

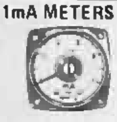
YAMABISHI VARIABLE VOLTAGE TRANSFORMERS

Excellent quality at low cost. Input: 230V 50/60Hz. Output 0–260V.

MODEL S260 BENCH MOUNTING

		P&P
1A	£10.50	30p
2.6A	£12.00	35p
5A	£17.50	37p
8A	£30.35	50p
10A	£33.75	75p
12A	£29.50	75p
20A	£85.00	125p
25A	£95.00	130p
40A	£120.00	150p

MODEL S260B PANEL MOUNTING

1A	£10.00	30p
2.5A	£12.00	35p

240° Wide Angle 1mA METERS

MW 1–6 60x60mm
£6.50 P&P 15p
MW 1–8 80x80mm
£6.90 P&P 15p

BV05 Vernier TUNING DIAL

App. 7/1 ratio planetary drive vernier dial. Log scale 0–180 degrees. Blank scales 1–5. Dial size 128 x 76mm. Overall size 190 x 117 x 41mm, deep including knob and coupling. ¼" diam. shaft
OUR PRICE £1.62 P&P 15p

WALKIE TALKIES

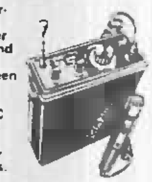
SKYFON 100mW
OUR PRICE £24.95 per pair
P302 Two Channel 300mW
OUR PRICE £52.50 per pair
P1003 Three Channel 1 Watt
OUR PRICE £71.25 per pair
P&P 50p per pair
NB. Licence required for use in UK

RUH6 Reflex Horn Speaker

Built-in driver unit. Impedence 16 ohms. Power rating 10W. Response 380–7000Hz. Size app. 6" x 6". Weather and shock protected.
OUR PRICE £4.97 P&P 30p

TRIO 9R59DS RECEIVER

Four bands covering 650kHz to 30 MHz continuous and electrical band spread on 10, 15, 20, 40, and 80 mtrs. 8 valve plus 7 diode circuit. 4 to 8 ohm output and phone jack. SSB–CW, ANL, variable BFO. S Meter and separate band spread dial. IF frequency 445kHz, audio output 1½ watt. Variable RF and AF gain controls. 115/250V AC, with instructions.
Our Price £42.50 CARR. PAID

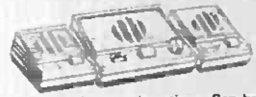
TRIO TR2200 TRANSCEIVER

Fully transistorised portable VHF transceiver Will transmit and receive on six channels between 144–146MHz. 1 watt transmitter. 12V DC internal or external supply. Built-in charger for Ni-Cad cells. Power/volume switch, squalch control, channel selector, mic. socket, earphone/external speaker socket. Complete with microphone and 144.48, 144.72 & 145.32 crystals. Size: 134 x 58 x 180mm.
OUR PRICE £79.50 Carr.paid

BELTEK W5400 CAR TRANSCEIVER

Solid state mobile transceiver for 12 volt DC neg. Transmits and receives on any 12 of 28 channels between 144 and 146MHz. Power output 10W and 1W switchable. Controls: On/off/volume, squelch and channel selector. Internal 3" speaker. Complete with dynamic mic. PTT switch, three sets of crystals for 144.48, 144.6 and 145MHz, mounting bracket and instructions. Size: 150 x 70 x 220mm.
OUR PRICE £75.00 P&P 50p

DT55G DIGITAL CLOCK MECHANISM

Features 24 hour alarm setting, on/off and auto alarm 'sleep' switch. Illuminated rotary dial with hours, minutes and seconds. Automatically turns off radio, TV, light etc. and with auto-switching will turn on again when required. 240V AC operation. Switch rating 250V–3 Amp.
OUR PRICE £5.95 P&P 30p

KE630 3 Station INTERCOM

Master and two sub-stations. Can be used on desk or wall mounted. Complete with cable and batteries
OUR PRICE £5.25 P&P 50p

LH02S STEREO HEADPHONES

Light weight headphones with padded ear pieces. 4/16 ohms 20–20,000Hz. Complete with 5' lead and plug.
OUR PRICE £1.97 P&P 30p

TE1018 Deluxe Mono High Impedence Headset.

Sensitive magnetic headset with soft ear pads. Impedence 2,600 ohms (600 ohms DC). Frequency response: 200–4,000Hz.
OUR PRICE £2.25 P&P 30p

DH02S STEREO HEADPHONES

Wonderful value and excellent performance combined. Adjustable head band. Impedence 8 ohms. 20–12,000Hz. Complete with lead and plug.
OUR PRICE £2.50 P&P 30p

TE1035 Stereo HEADPHONES

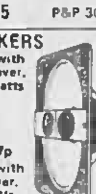
Low cost with excellent response. Foam rubber earcups. Adjustable headband. 8 ohms impedence. Frequency response 25Hz–18kHz. Complete with cable and stereo jack plug.
OUR PRICE £2.60 P&P 30p

SH80V MONO/STEREO HEADPHONES

Volume control for each channel. 4/16 ohms impedence. Frequency response 20Hz–18kHz. Complete with 10ft. coiled lead and jack plug.
OUR PRICE £4.97 P&P 30p

BH001 HEADSET and Boom Microphone

Moving coil. Ideal for language teaching, communications etc. Headphone impedence 16 ohms. Microphone impedence 200 ohms.
OUR PRICE £5.95 P&P 30p

EMI LOUDSPEAKERS

Model 350 13 x 8" with single tweeter/crossover. 20–20,000Hz. 15 watts RMS. Available 8 or 15 ohms.
OUR PRICE £7.25 each P&P 37p
Model 450 13 x 8" with twin tweeter/crossover. 55–13,000Hz. 8 watts RMS. Available 8 or 15 ohms
OUR PRICE £3.62 each P&P 25p

HIGH QUALITY CONSTRUCTION KITS
JOSTY KIT
WE ARE APPOINTED STOCKISTS AT ALL BRANCHES

All kits are complete with comprehensive easy to follow instructions and covered by full guarantee.
Post and Packing 15p per kit.

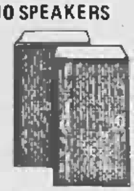
AF20 Mono amplifier	£4.80
AF25 Mixer	£3.60
AF30 Mono pre-amplifier	£2.61
AF35 Emitter amplifier	£2.27
AF80 0.5W mic. amplifier	£4.22
AF305 Intercom	£9.52
AF310 Mono amplifier	£5.91
AT5 Automatic light control	£2.58
AT25 Window wiper robot	£5.82
AT30 Photo cell switch unit	£5.70
AT50 400W triac light dimmer/speed control	£4.80
AT56 2,200W triac light dimmer/speed control	£6.90
AT60 1 channel light control	£7.80
AT65 3 channel light control	£14.55
GP304 Circuit board	£4.94
GP310 Stereo pre-amplifier for use with 2 x AF310	£21.27
GP312 Circuit board	£11.45
GU330 Tremolo unit	£7.50
HF61 Diode detector	£3.32
HF65 FM transmitter	£2.70
HF75 FM receiver	£2.87
HF310 FM tuner	£15.81
HF325 Deluxe FM tuner	£24.12
HF330 Decoder (HF310/325)	£9.96
HF380 lw/vhf aerial amplifier	£4.94
HF395 broadband aerial amp.	£1.77
LF380 Quadraphonic device	£11.36
M160 Multi-vibrator	£1.71
M191 VU Meter	£4.55
M192 Stereo balance meter	£4.97
M1302 Transistor tester	£8.45
NT10 Stabilised power supply 100mA, 9V	£6.15
NT300 Stabilised p. supply	£12.51
NT305 Voltage converter	£4.50
NT315 Power supply 240V AC to4,5/15V DC, 500mA	£9.67

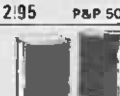
Amateur Electronics by Josty-Kit, the professional book for the amateur —covers the subject from basic principals to advanced electronic techniques. Complete with circuit board for AE1 to AE10.
OUR PRICE £3.30 (No VAT)
P&P 25p plus VAT.

AE1 100mW output stage	£1.65
AE2 Pre-amplifier	£1.26
AE3 Diode receiver	£2.00
AE4 Flasher	£1.09
AE5 Astable multi-vibrator	£1.05
AE6 Monostable multi-vibrator	£1.02
AE7 RC generator	£1.06
AE8 Bass filter	99p
AE9 Treble filter	99p
AE10 CCIR filter	99p

2 TRANSISTOR RADIO KIT

No Soldering required. All connect made with spring clips. Kit includes all parts and wire including ear-piece. Will receive all normal broadcasts on Medium Wave 535–1605kHz. Operates from standard 9V battery or Solar Cell included.
OUR PRICE £1.30 P&P 30p

SPECIAL BARGAIN !! STEREOSOUND SPEAKERS

Matched pair of stereo bookshelf speakers. Deluxe teak veneered finish. Size: 368 x 229 x 190mm. 8 ohms. 8 watts RMS, 16 watts peak. Complete with Din lead.
OUR PRICE £12.95 P&P 50p

SPECIAL BARGAIN! FERGUSON 3406 HI-FI SPEAKERS

High quality 2 way speaker systems. 25 Watts. 4–8 ohms. 40Hz–18kHz. Size: 560 x 340 x 255mm. approx. Wood grain finish with black fronts.
OUR PRICE £26.95 PR. P&P £1

Model A1018 FM TUNER

6 transistor high quality unit— 3 IF stages and double tuned discriminator. For use with most amplifiers. Covers 88–108MHz. Powered by 9V battery.
OUR PRICE £13.50 P&P 30p
Stereo multiplex adapter £6.95 extra.

ALL PRICES EXCLUDE VAT

LEMANIA AIRCREW CHRONOGRAPHS. Stainless Steel case with screw back; luminous hands and markings. One fifth sec. sweep hand controlled independently of main movement by press to start, stop and return to zero button. 15 jewel movement. Many of these watches are as new but all have been cleaned and checked. Fitted strap. White face £18·55, Black face £19·50 inc. P.&P. Inspection against remittance

GS WATCHES all with brushed stainless steel case with screw back and black faces. Manufactured by CYMA, VERTEX, TIMOR, GRANA, IWC, RECORD, SMITHS etc. to a common specification. We will try to meet your requirements for specific manufacturer and quantity orders will be of one manufacturer's production. All cleaned and checked. Fitted Strap. £8·95 inc. P. & P.
We also have limited quantities of these watches by OMEGA, LONGINES, BUREN, JAEGER LE COULTRE at £15·50 inc. P. & P.

GAS CHROMATOGRAPHY RESEARCH OVEN PV4051/4056
A large capacity oven of low thermal mass for use between 35 and 350°C. Provides a forced air circulating system yielding 1000 changes of air per min. The oven has forced air cooled outer surfaces when the internal temperature is high. 210-250V, 50Hz, 2·6KW, £28·60. (C.Pd. England and Wales).

MIL SYNCHROS AVAILABLE EX-STOCK
In sizes 08, 11, 15, 16, 18 and 23 for 50, 60 and 400 Hz operation.
Synchro Control Transformers
Synchro Control Transmitters
Synchro Control Differential Transmitters
Synchro Torque Transmitters and Receivers
Synchro Resolvers

IONISATION AMPLIFIER PV4075
A modern high grade low noise solid state amplifier to feed a potentiometer recorder. 18 input ranges from 10^{-12} to 5×10^{-7} A with 5 outputs of 1mV to 100mV. Linearity 0·1% f.s. Noise less than 0·5% f.s. at max. sensitivity. Back off facility. Dimensions 28 × 10 × 43 cm deep. With operating information £27·50. (C.Pd. U.K.)
Details of these three and other gas chromatography items are available—price 25p (C.W.O. only) Handbooks (complete) Available.

ALL PRICES INCLUDE 10% V.A.T.

AERIAL DIRECTION INDICATING KIT
This set comprises a pair of Magslips to provide remote indication of aerial azimuth and comprises a transmitter and receiver. The transmitter is directly coupled to the remote aerial and the receiver can be mounted at the control point, to provide immediate and continuous indication of aerial position. Supply voltage required is 50v 50Hz and the price £7·75 (P. Pd.) including a pointer for the receiver. The suggested use of these items would include a mains operated, geared motor to drive the aerial, controlled from the position to which is fed back position information by the magslip link. Transformers to provide 50v 50Hz from 240v A.C. £3·25 each. (P. Pd.)

PLESSEY GROUND BASED U.H.F. GROUND/AIR TX/RX FOR EXPORT ONLY OR SALE TO LICENSED USERS.
This equipment comprises:
Single Channel Receiver 5820-99-932-5694.
Single Channel Transmitter 5820-99-932-5698.
Single Channel Amplifier 5820-99-932-5701.
Power Unit for Amplifier 5820-99-932-5700.
Cooler Unit 5820-99-932-3995.
These assemble into a free standing rack unit providing U.H.F. communications over 225·0 to 399·9MHz, the TX/Amplifier unit giving 100 Watts R.F. output into 50 Ohms. We have sufficient of these units to form 12 complete installations with a number of spare sub-units. All are guaranteed new and unused. Full details on request.

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(ELECTROSIL & WELWYN)

Tantalum Capacitors
(KEMET, ITT, PLESSEY, ETC.)

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Electronic Test Instruments
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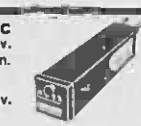

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SN7403AN	0·38	0·38	0·33
SN7404N	0·24	0·21	0·18
SN7405N	0·20	0·18	0·16
SN7405AN	0·44	0·44	0·38
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SN7407N	0·40	0·38	0·35
SN7408N	0·25	0·22	0·19
SN7409N	0·33	0·33	0·28
SN7409AN	0·44	0·44	0·38
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SN7411N	0·25	0·23	0·21
SN7412N	0·28	0·28	0·25
SN7412AN	0·38	0·38	0·33
SN7413N	0·30	0·27	0·25
SN7414N	0·72	0·72	0·63
SN7416N	0·30	0·27	0·25
SN7417N	0·30	0·27	0·25
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SN7422AN	0·38	0·38	0·33
SN7423N	0·37	0·34	0·32
SN7425N	0·37	0·37	0·32
SN7427N	0·37	0·37	0·32
SN7428N	0·43	0·43	0·37
SN7430N	0·20	0·18	0·16
SN7432N	0·37	0·37	0·32
SN7433N	0·43	0·43	0·38
SN7433AN	0·57	0·57	0·50
SN7437N	0·43	0·43	0·37
SN7438N	0·43	0·43	0·37
SN7438AN	0·57	0·57	0·50
SN7440N	0·20	0·18	0·16
SN7441AN	0·85	0·79	0·73
SN7442N	0·85	0·79	0·73
SN7443N	1·50	1·27	1·13
SN7444N	1·50	1·27	1·13
SN7445N	2·16	2·16	1·89
SN7446N	2·16	2·16	1·89
SN7447AN	1·80	1·80	1·57
SN7448N	1·50	1·27	1·13
SN7450N	0·20	0·18	0·16
SN7451N	0·20	0·18	0·16
SN7453N	0·20	0·18	0·16
SN7454N	0·20	0·18	0·16
SN7460N	0·20	0·18	0·16
SN7470N	0·33	0·30	0·27
SN7472N	0·38	0·38	0·34
SN7473N	0·44	0·41	0·37
SN7474N	0·48	0·48	0·42
SN7475N	0·59	0·55	0·51
SN7476N	0·45	0·38	0·32
SN7480N	0·80	0·70	0·50
SN7481N	1·25	1·10	0·95
SN7482N	0·87	0·80	0·72
SN7483N	1·20	1·10	1·00
SN7485N	1·87	1·87	1·63
SN7486N	0·50	0·50	0·44
SN7489N	4·32	4·32	3·78
SN7490N	0·75	0·70	0·63
SN7491AN	1·10	1·00	0·90
SN7492N	0·75	0·70	0·63
SN7493N	0·75	0·70	0·63
SN7494N	0·85	0·80	0·75
SN7495N	0·85	0·80	0·75
SN7496N	1·00	0·90	0·83
SN74100N	2·16	1·89	1·89
SN74104N	0·60	0·53	0·45
SN74105N	0·60	0·53	0·45
SN74107N	0·51	0·51	0·45
SN74110N	0·57	0·57	0·50
SN74111N	0·86	0·86	0·75
SN74116N	2·16	2·16	1·89
SN74118N	1·00	0·90	0·83
SN74119N	1·82	1·82	1·58
SN74120N	1·05	1·05	0·92
SN74121N	0·57	0·57	0·50
SN74122N	0·80	0·80	0·70
SN74123N	1·44	1·44	1·28
SN74125N	0·69	0·69	0·60
SN74126N	0·69	0·69	0·60
SN74132N	0·72	0·72	0·63
SN74136N	0·83	0·63	0·55
SN74141N	1·00	0·90	0·80
SN74142N	2·88	2·88	2·52
SN74145N	1·44	1·44	1·26
SN74147N	2·30	2·30	1·83
SN74148N	2·01	2·01	1·83
SN74150N	2·30	2·30	2·01
SN74151N	1·15	1·15	1·00
SN74153N	1·09	1·09	0·95
SN74154N	2·30	2·30	2·01
SN74155N	1·15	1·15	1·00
SN74156N	1·09	1·09	1·00
SN74157N	1·09	1·09	0·95
SN74159N	2·44	2·44	2·14
SN74160N	1·58	1·58	1·38
SN74161N	1·58	1·58	1·38
SN74162N	1·58	1·58	1·38
SN74163N	1·58	1·58	1·38
SN74164N	2·01	2·01	1·78
SN74165N	2·01	2·01	1·76
SN74166N	2·16	2·16	1·89
SN74167N	4·10	4·10	3·59
SN74170N	2·88	2·88	2·52
SN74172N	5·74	5·76	5·04
SN74173N	1·66	1·66	1·45
SN74174N	1·80	1·80	1·57
SN74175N	1·29	1·29	1·13
SN74176N	1·44	1·44	1·26
SN74177N	1·44	1·44	1·26
SN74180N	1·44	1·44	1·24
SN74181N	5·18	5·18	4·53
SN74182N	1·44	1·44	1·26
SN74184N	2·16	2·16	1·89
SN74185AN	2·16	2·16	1·89
SN74188N	6·48	6·48	5·67
SN74190N	2·30	2·30	2·01
SN74191N	2·30	2·30	2·01
SN74192N	2·30	2·30	2·01
SN74193N	2·30	2·30	2·01
SN74194N	1·72	1·72	1·51
SN74195N	1·44	1·44	1·26
SN74196N	1·58	1·58	1·38
SN74197N	1·58	1·58	1·38
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AC128	20p	BCY39	1·00	GET111	55p	OC45	18p	ZTX302	18p	2N3773	2·25
AC187	20p	BCY55	2·50	GET115	75p	OC71	15p	ZTX500	15p	2N3790	2·25
ACY17	35p	BCY70	15p	GET880	55p	OC72	25p	2G301	40p	2N3819	35p
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AD161	39p	BD124	80p	MJE340	50p	OC83	25p	2N930	20p	2N4002	14p
AD162	39p	BD131	45p	MJE520	65p	OC140	65p	2N987	45p	2N4126	15p
AF117	20p	BF115	22p	MJE3055	75p	OC170	25p	2N1132	25p	2N4871	35p
AF118	50p	BF180	33p	MPF105	48p	OC200	55p	2N1304	22p	2N5457	36p
AF139	33p	BF194	13p	NKT217	45p	OC202	90p	2N1613	20p	2S001	3·00
AF186	40p	BFX13	25p	NKT404	60p	OCP71	1·00	2N1671	1·00	2S026	8·90
AF239	44p	BFX34	55p	OA5	60p	ORP12	55p	2N2147	75p	2S303	70p
ASY27	30p	BFX88	22p	OA81	10p	ORP60	45p	2N2160	59p	40250	45p
BA115	10p	BFY50	20p	OA200	8p	P346A	20p	2N2926	10p	40361	45p
BAX13	5p	BFY51	20p	OA202	10p	TIL209	25p	2N3053	20p	40362	40p
BC107	15p	BFY64	45p	OC16	85p	TIP29A	49p	2N3054	45p	40408	50p
BC108	15p	BFY90	75p	OC20	1·25	TIP30A	58p	2N3055	45p	40485	75p
BC109	15p	BLY36	6·25	OC28	65p	TIP31A	61p	2N3440	50p	40636	1·00
BC109C	14p	BSX20	15p	OC35	55p	TIP41A	74p	2N3442	1·10	40430	85p
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TRIACS Stnd. mounting with accessories

3 AMP RANGE

Type	P.I.V.	1-11 Price Each
SC35A	100v	80p
SC35B	200v	85p
SC35D	400v	90p
SC35E	500v	£1·20

6 AMP RANGE

SC40A	100v	90p
SC40B	200v	95p
SC40D	400v	£1·20
SC40E	500v	£1·50

10 AMP RANGE

SC45A	100v	£1·05
SC45B	200v	£1·15
SC45D	400v	£1·45
SC45E	500v	£1·85

15 AMP RANGE

SC50A	100v	£1·45
SC50B	200v	£1·65
SC50D	400v	£1·95
SC50E	500v	£2·25

TRIACS Additional Types

40430 TRIAC (T066)	85p
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3 Amp T048 — 15 Amp T048

SILICON CONTROLLED RECTIFIERS

Type	P.I.V.	1-11
ONE AMP (T05)		
CRS 1/05AF	50v	30p
CRS 1/10AF	100v	30p
CRS 1/20AF	200v	35p
CRS 1/40AF	400v	45p
CRS 1/60AF	600v	55p
THREE AMP (T048)		
CRS 3/05AF	50v	40p
CRS 3/10AF	100v	40p
CRS 3/20AF	200v	45p
CRS 3/40AF	400v	55p
CRS 3/60AF	600v	65p
FIVE AMP		
CRS 5/400	400v	60p
SEVEN AMP (T048)		
CRS 7/100	100v	60p
CRS 7/200	200v	67p
CRS 7/400	400v	85p
CRS 7/600	600v	95p
SIXTEEN AMP (T043)		
CRS 16/100	100v	70p
CRS 16/200	200v	75p
CRS 16/400	400v	85p
CRS 16/600	600v	£1·10

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120	12 watt amplifier	4·70
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130	Mono control unit	3·60
605	Power supply for 115	4·55
610	Power supply for 120	4·55
615	Power supply for 2 x 120	5·73
230	AM/FM aerial amplifier	2·93
240	Auto packing light	5·90
275	Mic. preamplifier	6·08
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575	Sq. wave generator 20Hz-20Khz	14·60
590	SWR meter	12·85
620	Ni-CAD Charger 1·2-12v	8·00
630	STAB Power supply 6-12v 0·25-0·1A	8·15
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835	Guitar preamp.	4·25
840	Delay car alarm	6·15
675	CAP. Discharge Ignition for car engine (-Ve Earth)	13·15
80	Scope Calibrator	2·25
255	Level Indicator	9·15
525	120-160mHz VHF tuner	11·30
715	Photo cell switch	7·70
795	Electronic continuity tester	4·30
860	Photo timer	13·25
371	Slide projector auto. feed control	7·15
235	Acoustic Alarm for driver	7·60
465	Quartz XTAL checker	8·75
220	Signal Injector	2·30
390	Vox	15·50
432	Testakit	19·30
670	Buffer Battery Charger	6·55
885	Capacitive Contact Alarm	6·25
850	Electronic Keyer	18·75
820	Electronic Digital Clock	58·50

ALL KITS OFFERED SUBJECT TO STOCK AVAILABILITY
Prices correct at time of preparation. Subject to change without notice.

EXCLUSIVE—SPECIAL OFFERS!

MW/LW CAR RADIO + or — Earth with speakers and fixings. £8·50 carr/packg 30p.
8 TRACK CAR STEREO (— Earth) with speakers. In pods and fixings £12·50 carr/packg 40p.
PORTABLE BATTERY CASSETTE TAPE PLAYER £7·25
CAR LIGHTER PLUG and ADAPTOR for all cassette and radio 6/7½/9 volt output (state width) £1·95 each.
ROTEL STEREOPHONES RH630 £4·50; RH700 £6·75; RH430 £3·30. **ROTAL RA310** 15+15watt Stereo Amplifier (List £52·00) £34·52
AKAI GXC40
Stereo cassette recorder £59·95 carr/packg 50p.
Pair Akai ADM microphones £6·95 carr/packg 20p
WEIN W500 BATTERY/MAINS CASSETTE RECORDER £12·75
PORTABLE CASSETTE TAPE
Player—for car or carry around. £7·25 carr/packg 20p.
HANIMAX POCKET CALCULATOR WITH KEY £33·50.
HANIMAX BC811M Memory Version £37·50
MAINS UNIT for BC808, BC811M £2·85 (state model)
Hanimax H101 **STEREO COMPACT RECORD PLAYER** 2x7 watts. Complete with speakers (List £54·50) Price £39·95 Plus free pair of stereo phones.

NEW RANGES

BRIDGE RECTIFIERS

FEATURES SMALL SIZE AND LOW COST. Sizes are approximate.

250M/A QUARTER AMP

B025/05	50 PIV	16p
B025/10	100 PIV	18p

⅜ x ⅜ x ⅛" dia.

½ AMP 1-11 Pricing

Type	P.I.V.	Price ea.
B05/05	50v	20p
B05/10	100v	22p
B05/20	200v	23p
B05/40	400v	25p
B05/60	600v	27p

¼H x ⅜L x $\frac{3}{16}$" dia.

1 AMP P.I.V.

B1/05	50v	25p
B1/10	100v	25p
B1/20	200v	28p
B1/60	600v	30p

½H x ½L x $\frac{3}{16}$" dia.

1 AMP P.I.V.

W005	50v	29p
W01	100v	30p
W02	200v	32p
W06	600v	35p

⅜ x ⅜" Tubular

2 AMPS P.I.V.

B2/05	50v	35p
B2/10	100v	40p
B2/20	200v	45p
B2/60	600v	50p
B2/100	1000v	55p

⅜H x ⅜L x $\frac{3}{16}$" dia.

4 AMPS P.I.V.

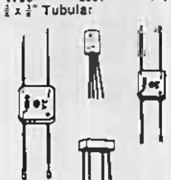
B4/100	100v	55p
B4/200	200v	59p
B4/400	400v	45p
B4/600	600v	75p
B4/800	800v	£1·00

⅜H x ⅜L x $\frac{3}{16}$" dia.

6 AMPS P.I.V.

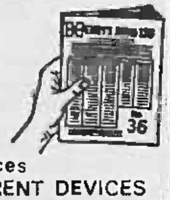
B6/05	50v	65p
B6/10	100v	70p
B6/20	200v	80p
B6/40	400v	90p
B6/6x0	600v	£1·00

⅜H x ⅜L x $\frac{3}{16}$" dia.



All prices correct at time of press 10% VAT to be added to all orders (UK only) Export & UK Manufacturers/ Colleges supplied. E.&O.E.

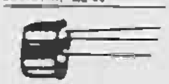
FREE BOOKLET



All types of Transistors
Rectifiers – Bridges
SCR's – Triacs
Integrated Circuits
F.E.T. — Light Devices
OVER 1500 DIFFERENT DEVICES
ENTIRELY NEW 1973 EDITION
More Devices ★ New Prices
★ New Ranges ★
This is a must for all Semi-conductor Users. (Ask for booklet No. 36.)
SEND FOR YOUR FREE COPY TODAY

TBA800 5 WATT IC
Suitable alternative to SL403D 5/30 volt operated. 8/16 OHM 5 watt output. With circuits and data £1·50. Complete with printed circuit boards and components £2·75.

Sinclair IC12
with circuits and data. 6 watt IC with printed circuit board. 28 volt. operated. £2·00



ZN414 IC
Integrated circuit radio as featured by many magazines (PW Jan. 73 Reprint Ref. No. 19 for 10p). £1·20.

STROBE TUBE
ZFT4A. Suitable for Dec. '73 Pract.Electronics £3·00

ST2 (D32) DIAC	25p
CRS1/40 SCR	45p
ZFT4	£3·00
ZFT8	£3·50
ZFT12	£4·50

Ultrasonic Transducers
Operate at 40Khz up to 100 yds. Ideal remote switching and signalling. Complete with data transmitter and receiver new I.C circuits. Per pair £5·90.
TA960 with socket £1·80

3015F 7 SEG.
I.C. size complete with data price £1·70 each (digital clock circuits ref. No. 31, 15p).

TIL209 LED 24p ea. 22p ea. per 10

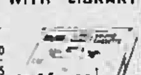
BUILD YOURSELF A POCKET CALCULATOR

A complete kit, packaged in a polystyrene container and taking about 3 hours to assemble—that's the Sinclair Cambridge pocket calculator from Henry's. Some of the many features include interface chip, thick-film resistor pack, printed circuit board, electronic components pack. Size 4⅜" long x 2" wide x $\frac{11}{16}$" deep.
Free of charge with the kit for the more advanced technologist is a 32-page booklet explaining how to calculate Logs, Tangents, Sines etc.

Price £19·95 + VAT Also available assembled ready to use £22·50 + VAT.

LIVING SOUND LOW NOISE TOP QUALITY CASSETTES MADE BY EMI TAPES LTD TO INTERNATIONAL STANDARDS ESPECIALLY FOR HENRY'S. ALL POST PAID LESS THAN ⅓ REC. PRICES. COMPLETE WITH LIBRARY CASES.

	3 for	6 for	10 for	25 for
C 60	£1·10	£1·98	£3·00	£7·40
C 90	£1·46	£2·80	£4·60	£11·25
C 120	£1·80	£3·45	£5·50	£13·45



Quantity and trade enquiries invited.

LEARN A LANGUAGE—complete with phrase book. German—French—Spanish—Italian £1·36 per course. £5 for any 4.

A SELECTION OF INTERESTING ITEMS

3025	Compact transistor tester	£6·95 p & p 15p
O4002	Photoelectric system	£13·70
E1310	Stereo mag. cart. preamp.	£4·80 p & p 25p
Easiphone	O1201 telephone amplifier	£7·50 p & p 25p
D1203	Teleamp. with PU coil	£4·85 p & p 20p
LL1	Door intercomm. and chime	£8·40 p & p 25p
US50 Ultrasonic Switch transmitter/receiver		£12·75
1 Kw Dimmer/controller		£3·00 p & p 10p
9" Twin spring unit	For	£3·30 p & p 15p
16" Twin spring unit	Reverbs	£6·85 p & p 25p
VHF 105 Aircraft Band Convertor		£4·50 p & p 15p
B2005 4 Ch. mic. mixer		£4·20 p & p 15p
B2004 2 ch. Stereo mixer		£6·75 p & p 15p
PK3 kit. Etch your own printed circuits		£1·95 p & p 20p.
C3041	1-250 MHz	£4·25
C3043	50H 1-300 MHz	£5·75

Henry's RADIO LIMITED
EDGWARE ROAD, W2

ELECTRONICS FOR EVERY PURPOSE
See facing page for addresses

ZENER DIODES
400 m/w BZY88/BZX83. From 3·3 volt—33 volts 10p each.
1·3 watts 5% Miniature Tubulars IN4700 series. From 3·3 volt—33 volt 18p each.
10 watts. Stnd. Mounting. ZS series 6·8 volts—100 volts 5% 40p each.

SILICON RECTIFIERS
1 amp series IN4001 to IN4007. From 6p ea
1·5 amp PL4001 to PL4007 from 8p ea
3 amp PL7001/IN5400 From 14p ea
Send for full list 36.

YATES ELECTRONICS

(FLITWICK) LTD.
DEPT. WW ELSTOW STORAGE DEPOT
KEMPSTON HARDWICK
BEDFORD

C.W.O PLEASE. POST AND PACKING PLEASE ADD 10p TO ORDERS UNDER £2.

Catalogue which contains data sheets for most of the components listed will be sent free on request. 10p stamp appreciated.

CALLERS WELCOME
MON.-SAT. 9 a.m.-5 p.m.

PLEASE ADD 10% V.A.T.

RESISTORS

¼W Iskra high stability carbon film—very low noise—capless construction. ½W Mullard CR25 carbon film—very small body size 7·5 x 2·5 mm. ⅓W 2% ELECTROSIL TR5.

Power watts	Tolerance	Range	Values available	Price 1–99	Price 100+
¼	5%	4·7Ω–2·2MΩ	E24	1p	0·8p
¼	10%	3·3MΩ–10MΩ	E12	1p	0·8p
⅓	2%	10Ω–1MΩ	E24	3·5p	3p
½	10%	1Ω–3·9Ω	E12	1p	0·8p
½	5%	4·7Ω–1MΩ	E12	1p	0·8p
4	10%	1Ω–10Ω	E12	6p	5·5p

Quantity price applies for any selection. Ignore fractions on total order.

DEVELOPMENT PACK

0·5 watt 5% Iskra resistors 5 off each value 4·7Ω to 1MΩ.
E12 pack 325 resistors £2·40. E24 pack 650 resistors £4·70.

POTENTIOMETERS

Carbon track 5kΩ to 2MΩ, log or linear (log ¼W, lin ½W).
Single, 12p. Dual gang (stereo), 40p. Single D.P. switch, 24p.

SKELETON PRESET POTENTIOMETERS

Linear: 100, 250, 500Ω and decades to 5MΩ. Horizontal or vertical P.C. mounting (0·1 matrix).
Sub-miniature 0·1W, 5p each. Miniature 0·25W, 7p each.

TRANSISTORS

AC107	15p	AF126	20p	BF115	25p	OC42	12p	2N3707	12p
AC126	12p	AF139	32p	BF173	20p	OC44	12p	2N3708	10p
AC127	15p	AF178	32p	BF177	28p	OC45	12p	2N3709	11p
AC128	15p	AF180	40p	BF178	32p	OC70	12p	2N3710	11p
AC131	12p	AF181	40p	BF179	32p	OC71	12p	2N3711	11p
AC132	12p	BC107	12p	BF180	32p	OC72	12p	2N3819	32p
AC176	15p	BC108	12p	BF181	32p	OC81	12p	2N4062	12p
AC187	22p	BC109	12p	BF194	14p	OC82D	12p	2N4286	20p
AC188	22p	BC147	12p	BF195	14p	2N2646	60p	2N4289	20p
AD140	50p	BC148	12p	BF197	15p	2N2904	20p	40360	35p
AD149	45p	BC149	12p	BF200	32p	2N2926	10p	40361	35p
AD161	33p	BC157	14p	BF750	20p	2N3054	58p	40362	40p
AD162	36p	BC158	14p	BF751	20p	2N3055	60p	40408	40p
AF114	20p	BC159	14p	BF752	20p	2N3702	13p	ZTX108	15p
AF115	20p	BC187	22p	BU105	225p	2N3703	12p	ZTX300	15p
AF116	20p	BD131	75p	OC26	45p	2N3704	13p	ZTX302	20p
AF117	20p	BD132	75p	OC28	50p	2N3705	12p	ZTX500	15p
AF118	38p	BD133	75p	OC35	50p	2N3706	11p	ZTX503	20p

ZENER DIODES

400mW 5% 3·3V to 30V, 12p.

WIRE WOUND POTS

3W, 10, 25, 50Ω and decades to 100kΩ, 35p.

DIODES

RECTIFIER

BY127	1250V	1A	12p
1N4001	50V	1A	7p
1N4002	100V	1A	8p
1N4004	400V	1A	8p
1N4006	800V	1A	10p
1N4007	1000V	1A	12p

SIGNAL

OA85	7p
OA90	5p
OA91	5p
OA202	7p
1N4148	5p
BA114	8p

BRUSHED ALUMINIUM PANELS

12in x 6in, 25p; 12in x 2½in, 10p; 9in x 2in, 7p

SLIDER POTENTIOMETERS

86mm x 9mm x 16mm, length of track 59mm.
SINGLE 10K, 25K, 100K log. or lin, 40p.
DUAL GANG, 10K + 10K etc. log. or lin. 60p.
KNOB FOR ABOVE, 12p.
FRONT PANEL, 65p.
18 Gauge panel 12in x 4in with slots cut for use with slider pots. Grey or matt black finish complete with fixings for 4 pots.

THYRISTORS

2N5060	50V	0·8A	30p
2N5064	200V	0·8A	47p
106F	50V	4A	40p
106D	400V	4A	65p

MULLARD POLYESTER CAPACITORS C296 SERIES

400V: 0·001μF, 0·0015μF, 0·0022μF, 0·0033μF, 0·0047μF, 2½p. 0·0068μF, 0·01μF, 0·015μF, 0·022μF, 0·033μF, 3p. 0·047μF, 0·068μF, 0·1μF, 4p. 0·15μF, 6p. 0·22μF, 7½p. 0·33μF, 11p. 0·47μF, 13p.
160V: 0·01μF, 0·015μF, 0·022μF, 0·033μF, 0·047μF, 0·068μF, 3p. 0·1μF, 3½p. 0·15μF, 4½p. 0·22μF, 5p. 0·33μF, 6p. 0·47μF, 7½p. 0·68μF, 11p. 1·0μF, 13p.

MULLARD POLYESTER CAPACITORS C280 SERIES

250V P.C. mounting: 0·01μF, 0·015μF, 0·022μF, 3p. 0·033μF, 0·047μF, 0·068μF, 3½p. 0·1μF, 4p. 0·15μF, 0·22μF, 5p. 0·33μF, 6½p. 0·47μF, 8½p. 0·68μF, 11p. 1·0μF, 13p. 1·5μF, 20p. 2·2μF, 24p.

MYLAR FILM CAPACITORS 100V

0·001μF, 0·002μF, 0·005μF, 0·01μF, 0·02μF, 2½p. 0·04μF, 0·05μF, 0·068μF, 0·1μF, 3½p.

CERAMIC DISC CAPACITORS

100pF to 10,000pF, 2p each.

ELECTROLYTIC CAPACITORS—MULLARD 015/6/7

(μF/v) 1/63, 1·5/63, 2·2/63, 3·3/63, 4·7/63, 6·8/40, 6·8/63, 10/25, 10/63, 15/16, 15/40, 15/63, 22/10, 22/25, 22/63, 33/6·3, 33/16, 33/40, 47/4, 47/10, 47/25, 47/40, 68/6·3, 68/16, 100/4, 100/10, 100/25, 150/6·3, 150/16, 220/4, 220/6·3, 220/16, 330/4, 6p. 47/63, 100/40, 150/25, 220/25, 330/10, 470/6·3, 7p. 68/63, 150/40, 220/40, 330/16, 1000/4, 10p. 470/10, 680/6·3, 11p. 100/63, 150/63, 220/63, 1000/10, 12p. 470/25, 680/16, 1500/6·3, 13p. 470/40, 680/25, 1000/16, 1500/10, 2200/6·3, 18p. 330/63, 680/40, 1000/25, 1500/16, 2200/10, 3300/6·3, 4700/4, 21p.

SOLID TANTALUM BEAD CAPACITORS 12p

0·1μF	35V	2·2μF	35V	22μF	16V
0·22μF	35V	4·7μF	35V	33μF	10V
0·47μF	35V	6·8μF	25V	47μF	6·3V
1·0μF	35V	10μF	25V	100μF	3V

VEROBOARD

	0·1	0·15
2½ x 3¾	22p	16p
2½ x 5	24p	24p
3¾ x 3¾	24p	24p
3¾ x 5	27p	27p
17 x 2½	75p	57½p
17 x 3¾	100p	78p
17 x 5 (plain)	—	82p
17 x 3¾ (plain)	—	60p
17 x 2½ (plain)	—	42p
2½ x 5 (plain)	—	12p
2½ x 3¾ (plain)	—	11p
Pin insertion tool	52p	52p
Spot face cutter	42p	42p
Pkt. 50 pins	20p	20p

JACK PLUGS AND SOCKETS

Standard screened	18p	2·5mm insulated	8p
Standard insulated	12p	3·5mm insulated	8p
Stereo screened	35p	3·5mm screened	13p
Standard socket	15p	2·5mm socket	8p
Stereo socket	18p	3·5mm socket	8p

D.I.N. PLUGS AND SOCKETS

2 pin, 3 pin, 5 pin 180°, 5 pin 240°, 6 pin
Plug 12p. Socket 8p.
4 way screened cable, 15p/metre.
6 way screened cable, 22p/metre.

BATTERY ELIMINATOR £1·50

9V mains power supply. Same size as PP9 battery.

LARGE (CAN) ELECTROLYTICS

1600μF	64V	74p	2500μF	64V	80p	4500μF	16V	50p
2500μF	40V	74p	2800μF	100V	£2·60	4500μF	25V	£1·68
2500μF	50V	58p	3200μF	16V	50p	5000μF	50V	£1·10

HIGH VOLTAGE TUBULAR CAPACITORS—1,000 VOLT

0·01μF	10p	0·047μF	13p	0·22μF	20p
0·022μF	12p	0·1μF	13p	0·47μF	22p

POLYSTYRENE CAPACITORS 160V 2½%

10pF to 1,000pF E12 Series Values, 4p each.

SMOKE AND COMBUSTIBLE GAS DETECTOR—GDI

The GDI is the world's first semiconductor that can convert a concentration of gas or smoke into an electrical signal. The sensor decreases its electrical resistance when it absorbs deoxidizing or combustible gases such as hydrogen, carbon monoxide, methane, propane, alcohol, North Sea gas, as well as carbon-dust containing air or smoke. This decrease is usually large enough to be utilized without amplification. Full details and circuits are supplied with each detector.
Detector GDI, £2. Kit of parts for detectors including GDI and P.C. board but excluding case. Mains operated detector £5·20. 12 or 24V battery operated audible alarm £7·30. As above for PP9 battery, £6·40.

PRINTED BOARD MARKER 97p

Draw the planned circuit on to a copper laminate board with the P.C. Pen, allow to dry, and immerse the board in the etchant. On removal the circuit remains in high relief.

TRANSFORMERS

All have 240V Primary

MT 30/2	0—12—15—20—24—30V	2A	£2·85
MT 50/½	0—19—25—33—40—50V	½A	£1·90
MT 50/1	0—19—25—33—40—50V	1A	£2·55
MT 50/2	0—19—25—33—40—50V	2A	£3·50
MT 60/½	0—24—30—40—48—60V	½A	£2·10
MT 60/1	0—24—30—40—48—60V	1A	£2·80
MT 60/2	0—24—30—40—48—60V	2A	£3·80

HEAT SINKS—REDPOINT

2W 24p 4W 45p TO5 Clip 5p TO1 Single 5p
3W 36p 6W 60p TO18 Clip 5p TO1 Double 8p

METERS £1·90

1½" Scale 500uA. 1mA. 10mA. 100mA.

WAVECHANGE SWITCH 23p

1p—12W, 3p—4W, 2p—6W, 4p—3W.

ROTARY MAINS SWITCH 32p

DP. 2A.

THERMISTORS

VA 1005	15p
VA 1026	15p
VA 1033	15p
VA 1055S	15p
VA 1066S	15p
VA 1077	15p
R 53	£1·35

LINEAR IC's

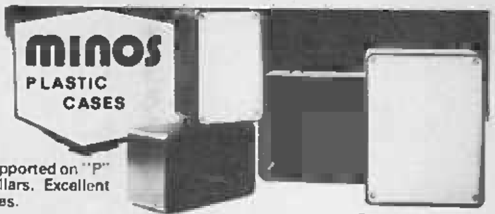
709 14 pin DIL	40p
741 8 pin DIL	40p
741 14 pin DIL	38p
723 14 pin DIL	95p
747 14 pin DIL	85p
748 8 pin DIL	45p
DIL Sockets 14 pin and 16 pin	16p

ALUMINIUM BOXES

AB7	2¾"×5¼"×1½"	50p	AB14	7"×5"×2½"	84p
AB8	4"×4"×1½"	50p	AB15	8"×6"×3"	108p
AB9	4"×2¾"×1½"	50p	AB16	10"×7"×3"	122p
AB10	4"×5¼"×1½"	50p	AB17	10"×4½"×3"	108p
AB11	4"×2½"×2"	60p	AB18	12"×5"×3"	120p
AB12	3"×2"×1"	44p	AB19	12"×8"×3"	160p

BULGIN MAINS CONNECTORS

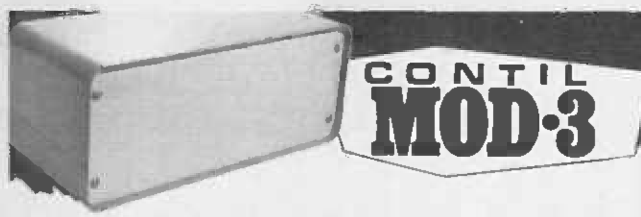
3 PIN 1½A	CHASSIS PLUG	10p
	LINE SOCKET	13p
3 PIN 3A	CHASSIS PLUG	10p
	LINE SOCKET	14p
3 PIN 5A	CHASSIS PLUG	16p
	LINE SOCKET	18p
3 PIN 1½A	CHASSIS SOCKET	18p
	LINE PLUG	13p
3 PIN 3A	CHASSIS SOCKET	21p
	LINE PLUG	23p
2 PIN 5A	LINE PLUG	20p



A smart miniature case in tough, rigid, high-gloss black ABS. Front panels in either aluminium or white PVC/Steel. Built-in slots for PC cards, dividers, or screens. Chassis or PC boards can be supported on "P" clips for internal pillars. Excellent as encapsulation boxes.

		One off	10 off
M2	65mm × 100mm × 50mm 2½" × 3⅞" × 2"	47p	40p
M3	100mm × 130mm × 50mm 3⅞" × 5" × 2"	63p	55p

Prices include P. & P. and VAT.
Also available less panel and screws.
Less for quantities. Min. order £1.



Contil Mod-3 cases are in six sizes and offer the manufacturer of small instruments an attractive low cost case available ex-stock. Made in blue PVC-coated steel and complete with front and rear panels and chassis, they are light, strong and rigid. PCB and PSU mounting systems available.

		width	height	depth
Mod 301	£3·54	7"	3"	5¼"
Mod 302	£3·71	7"	4½"	5¼"
Mod 303	£4·20	7"	6"	5¼"
Mod 304	£4·20	11"	3"	5¼"
Mod 305	£5·21	11"	4½"	5¼"
Mod 306	£5·77	11"	6"	5¼"

Less for quantities *Prices correct to April 30*

The West Hyde prestige case
The smartest of the West Hyde cases, all anodised aluminium, with top and bottom panels only; in black PVC-covered steel (plain or louvered). Free standing or 19" rack mounting with aluminium brackets. Supplied ex-stock, fully assembled, with SS Pozidrive screws.

	1 off	Pr. brackets	Extra for louvres
BC21 (3½" whole rack)	£13·46	88p	81p
BC22 (3½" half rack)	£10·90	88p	81p
BC31 (5¼" whole rack)	£15·53	£1·24	81p
BC32 (5¼" half rack)	£12·79	£1·24	81p

Prices include panels, feet, P. & P. and VAT. State whether ¼, ½ or full panels required.

BRADRAD DRILLING & DEBURRING TOOL equals eleven drills. One cut drills and deburrs the normal run of steels, aluminium, brass, copper and all types of plastics, perspex, fibreglass, etc., and hardboard should the need arise it is designed to overcome all the problems associated with drilling thin materials—it drills interlocking holes for instance.

⅛"–2½" in ⅛" steps or 6–36mm in 3mm steps. Both with ½" shanks £10·75
Also 1½"–2½" and 36–60mm £27·88

Prices correct to April 30.

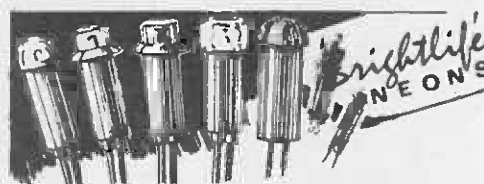
Q.MAX PUNCHES
⅜" £1·18
½" or ⅝" £1·38
¾" or ⅞" £1·47
1", 1⅛", 1¼" £1·88
1½" £2·20

ADEL
The Adel cuts holes of virtually any shape and size starting from a 7/16" hole, cutting cleanly like a punch and die. Ideal for notching clearances on flanges of cabinets or chassis £6·76.
All prices include P. & P. and VAT.

AMTRON METAL CABINETS GIVE EXTRA VENTILATION
Ideal for Stabilised Power Supply Units. A lightweight case with perforated sides and top. The front panel is of heavy-gauge anodised ali. The top, bottom, sides and back interlock, secured by four screws. The front frame is a clever moulding holding the panels, allowing for four hidden fixings for a chassis if required (not supplied). Integrally moulded front feet also form the mounting for the tilt support which is standard with this matt blue painted case.

Height	Length	Depth	Code	1 off, incl. feet tilt, VAT and P. & P.
120mm	284mm	138mm	00/3009-00	£6·40
120mm	224mm	138mm	00/3009-10	£5·61
120mm	284mm	188m	00/3009-20	£7·07

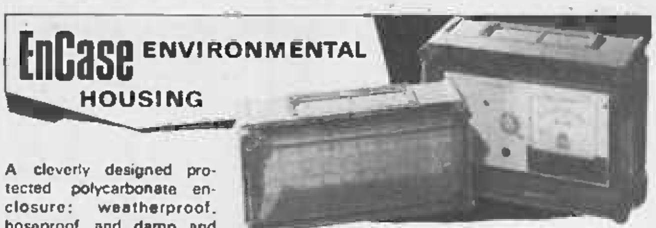
Less for quantity.



Brightlife neons, illustrated are PC/A or C, PC/F, PC/G or I, PP/A or B, Q & S, are brighter and give an average of 25,000 hrs life. The 0·5" dia. are red or white, the 0·375" are red, amber or white: these have three cap shapes, and all may be supplied for 115, 240V or the PP neons in 110, 240 and 440V, with 6" or 30" leads.

dia.	leads	volts	10 off	100 off incl. P. & P.
⅜" PC/A to I	6"	110 or 160–260	17½p	16½p
⅜" PC/A to I	30"	110 or 160–260	19½p	18½p
½" PP/A	6"	110 or 160–260	17½p	16½p
½" PP/A	30"	110 or 160–260	19½p	18½p
Q type	none	110 or 160–260	29p	27p
S type	none	—	23p	21p

Add 10% VAT. Min. quantity each type ten off.
Send for details in new catalogue.

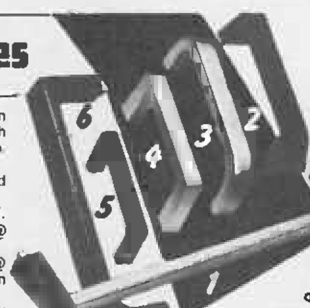


A cleverly designed protected polycarbonate enclosure: weatherproof, hoseproof and damp and dust protecting. Its high impact strength will withstand rough handling. The seven sizes can interconnect and any case will extend vertically or horizontally or both, while maintaining full protection. Send for new catalogue.

Encase includes chassis, retaining screws, cover, gasket and cover-retaining screws: also includes P. & P. and VAT. Many extras available, incl. hinges, etc.

ENA	7½" × 7½" × 5"	£4·15
ENB	11" × 7½" × 5"	£5·32
ENC	15" × 7½" × 5"	£7·07
END	11" × 11" × 5"	£7·22
ENE	15" × 11" × 5"	£9·24
ENF	22" × 11" × 5"	£12·77
ENG	22" × 15" × 7"	£17·66

CONTIL handles



(1) No. 265. Anodised aluminium centre bar. Black plastic brackets with moulded-in core. 75mm @ 97p. Five more sizes up to 154mm.
(2) No. 281.1. Nylon 112mm. Load 50Kg @ 45p.
(3) No. 277. Ali., ground, polished, anodised. 88m @ 94p. 120mm @ £1·06.
(4) No. 268. Satin ali. 57·5mm @ 94p. 102mm @ £1·01. 145·5mm @ £1·17.
(5/6) No. 250. Black nylon, very comfortable. 75mm @ 29p. 110mm @ 41p. 155mm @ 67p.

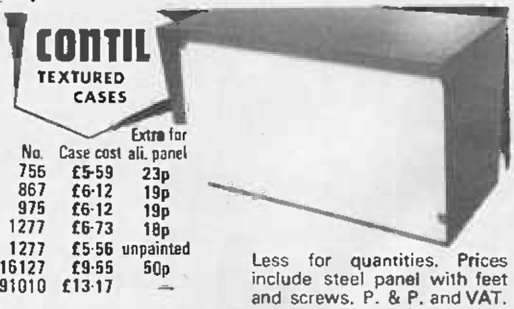
Prices include VAT. Less for quantity.

P. & P. 22p any quantity.
Write or phone for new catalogue.

The design of these cases permits the instrument to be built or serviced within their external panels. 48 shapes. Low cost. Blue PVC/steel with white PVC-coated aluminium panels.

Width		Height	Depth	1 off	Width		Height	Depth	1 off
A	4·5"	3"	6·5"	£3·17	M	4·5"	3"	13"	£3·91
B	4·5"	7"	6·5"	£3·91	N	4·5"	7"	13"	£4·79
C	4·5"	10"	6·5"	£4·32	O	4·5"	10"	13"	£6·07
D	9"	3"	6·5"	£4·32	P	9"	3"	13"	£4·79
E	9"	7"	6·5"	£4·79	Q	9"	7"	13"	£6·07
F	9"	10"	6·5"	£5·52	R	9"	10"	13"	£7·39
G	13"	3"	6·5"	£4·79	S	13"	3"	13"	£6·07
H	13"	7"	6·5"	£5·52	T	13"	7"	13"	£7·39
I	13"	10"	6·5"	£6·07	U	13"	10"	13"	£8·95
J	18"	3"	6·5"	£5·52	V	18"	3"	13"	£7·39
K	18"	7"	6·5"	£7·39	W	18"	7"	13"	£8·95
L	18"	10"	6·5"	£8·95	X	18"	10"	13"	£10·70

Woodgrain: D @ £4·79, E & G @ £5·52, H @ £6·07.
Prices include screws, rubber feet, one or two chassis according to size, and P. & P. and VAT



Available in a range of six sizes in 21-gauge Zintec with blue Acrylic texture. Front panels white Zintec steel or PVC/Aluminium.

Width	Depth	Height	No.	Case cost	Extra for ali. panel
7"	5"	5"	755	£5·59	23p
8	6	7	867	£6·12	19p
9	7	5	975	£6·12	19p
12	7	7	1277	£6·73	18p
12	7	7	1277	£5·56	unpainted
16	12	7	16127	£9·55	50p
19	10	10	191010	£13·17	—

Less for quantities. Prices include steel panel with feet and screws, P. & P. and VAT.

WEST HYDE

WEST HYDE DEVELOPMENTS LTD., Ryefield Cres., Northwood Hills, Northwood, Middx. HA6 1NN
Tel. Northwood 24941 or 26732 Telex: 923231
Prices correct April 30th, 1974

BENTLEY ACOUSTIC CORPORATION LTD.

7A GLOUCESTER ROAD, LITTLEHAMPTON, SUSSEX. Tel. 6743
ALL PRICES SHOWN INCLUDE V.A.T.

Type	Price
0A2	0·40
0B2	0·40
0Z4	0·47
1A3	0·52
1A5GT	0·50
1A7GT	0·65
1B3GT	0·62
1C2	0·70
1G6	1·00
1H5GT	0·65
1L4	0·20
1LD5	1·00
1LN5	1·00
1N5GT	0·65
1R5	0·45
1S4	0·33
1S5	0·30
1U4	0·65
1U5	0·90
2D21	0·49
2GK5	0·65
3A4	0·50
3B7	1·00
3D6	0·40
3Q4	0·60
3Q5GT	0·55
3S4	0·35
4CB6	0·55
5CG8	0·55
5R4GY	0·75
5T4	0·35
5U4G	0·35
5V4G	0·54
5Y3GT	0·45
5Z3	0·70
5Z4G	0·35
5Z4GT	0·45
6/30L2	0·80
6A8G	1·25
6AC7	0·49
6AG5	0·27
6AH6	0·60
6AJ5	0·75
6AJ8	0·30
6AK5	0·34
6AK6	0·60
6AK8	0·38
6AL5	0·15
6AM8A	0·65
6AN8	0·60
6AQ5	0·42
6AQ8	0·34
6AS5	0·65
6AR6	1·00
6AS7	1·00
6AT6	0·38
6AU6	0·30
6AV6	0·33
6AW8A	0·65
6AX4	0·75
6B8G	0·30
6BA6	0·28
6BC8	0·60
6BE6	0·32
6BQ6G	1·05
6BH6	0·70
6BJ6	0·55
6BK7A	0·60
6BQ5	0·23
6BQ7A	0·55
6BR7	1·00
6BR8	0·65
6BS7	1·40
6BW6	0·90
6BW7	0·68
6BX6	0·25
6BY7	0·34
6BZ6	0·49
6C4	0·30
6C6	0·40
6C9	1·25
6CB6A	0·40
6C12	0·30
6C17	1·00
6CD6G	1·00
6CG8A	0·75
6CH6	0·60
6CL6	0·55
6CL8A	0·80
6CM7	0·75
6CU5	0·75
6CW4	1·00
6D3	0·60
6DE7	0·75
6DT6	0·75
6EW6	0·75
6E5	1·00
6F1	0·70
6F6G	0·50
6F12	0·37
6F13	0·55
6F14	0·75
6F15	0·65
6F18	0·55
6F23	0·80
6F24	0·85
6F25	1·00
6F26	0·34
6F28	0·60
6F32	0·65
6G6G	0·75
6GH8A	0·75
6GK5	0·65
6GU7	0·75
6H6GT	0·25
6J5GT	0·40
6J6	0·25
6J7G	0·30
6J7(M)	0·45
6JU8A	0·75
6L1	2·00
6L6GT	0·58
6K7G	0·25
6K8G	0·45
6L7(M)	0·50
6L12	0·36
6L18	0·49
6L19	2·00
6LD12	0·38
6LD20	0·65
6N7GT	0·60
6P15	0·23
6PL12	0·34
6Q7G	0·50
6Q7GT	0·50
6Q7(M)	0·55
6R7G	0·60
6R7(M)	0·75
6SA7M	0·44
6SC7GT	·33
6SG7M	0·44
6SH7	0·44
6SK7GT	·44
6SQ7GT	·45
6U4GT	0·70
6U7G	0·75
6V4	0·28
6V6G	0·17
6V6GT	0·45
6X4	0·40
6X5GT	0·40
6Y6G	0·75
6Y7G	1·00
7A7	1·00
7B6	0·75
7B7	0·70
7F8	1·00
7H7	0·75
7R7	0·80
7V7	1·00
7Y4	0·65
7Z4	0·80
9BW6	0·65
9D7	0·65
10C2	0·65
10C14	0·38
10D1	0·70
10DE7	0·55
10F1	0·50
10F9	0·65
10F18	0·55
10L14	0·45
10LD11	0·70
10LD12	0·40
10PL12	0·38
10P13	0·70
10P14	2·00
10P18	0·42
12A6	1·00
12AC6	0·65
12AD6	0·65
12AE6	0·65
12AT6	0·38
12AT7	0·34
12AU6	0·45
12AU7	0·28
12AV6	0·50
12AX7	0·28
12AY7	0·80
12BA6	0·40
12BE6	0·60
12BH7	0·50
12E1	3·00
12J5GT	0·33
12J7GT	0·55
12K5	1·00
12K7GT	·45
12Q7GT	0·45
12SA7GT	·55
12SC7	0·50
12SG7	0·40
12SH7	0·35
12SJ7	0·44
12SQ7GT	0·65
14H7	0·55
14S7	1·00
15	1·00
19AQ5	0·50
19BG6G	0·55
19G6	1·40
19H1	2·00
20D1	0·55
20D4	2·00
20F2	0·75
20L1	0·88
20P1	0·35
20P3	0·80
20P4	1·00
20P5	1·30
25A6G	0·38
25L6G	0·60
25Y5	0·80
25Y5G	0·70
25Z4G	0·33
25Z5	0·80
25Z6G	0·70
28D7	1·00
30A5	0·65
30C1	0·28
30C15	0·75
30C17	0·90
30C18	0·75
30F5	0·80
30FL1	0·75
30FL2	0·75
30FL12	1·00
30FL13	0·55
30FL14	0·70
30L1	0·40
30L15	0·75
30L17	0·70
30P4MR	1·00
30P12	0·80
30P16	0·40
30P19/30P4	0·75
30PL1	0·66
30PL12	0·35
30PL13	0·75
30PL14	0·80
30PL15	0·90
35A3	0·65
35A5	0·80
35D5	0·75
35L6GT	·55
35W4	0·40
35Z3	0·75
35Z4GT	0·55
35Z5GT	1·00
50B5	0·65
50C5	0·45
50CD6G	1·25
50EH5	0·55
50L6GT	·65
72	0·33
77	0·53
85A2	0·60
85A3	1·00
90AG	3·38
90CG	2·40
90CV	1·68
90C1	0·75
150B2	0·75
150C2	0·40
215SG	0·50
301	1·00
302	0·83
303	0·76
305	0·63
807	0·59
956	0·30
1821	1·00
5702	0·80
5763	2·00
6060	1·00
7193	0·53
7475	1·00
A1834	1·00
A2134	0·98
A3042	0·75
AC2PEN	0·98
AC2PENDD	0·98
AC6/PEN	0·38
AC/PEN(7)	0·98
AC/TH1	1·00
AC/TP	0·98
AL60	1·00
ARP3	0·35
ATP4	0·40
AZ1	0·60
AZ31	0·60
AZ41	0·65
B319	0·40
BL63	2·00
CL33	1·50
CV6	0·33
CV63	0·53
CV988	0·25
CY1C	1·00
CY31	0·45
D63	0·25
DAC32	0·65
DAF96	0·44
DC90	0·60
DD4	1·00
DF91	0·30
DF96	0·44
DH63	0·50
DH76	0·45
DH77	0·38
DH81	0·75
DK32	0·65
DK40	0·70
DK92	0·70
DK96	0·60
DL92	0·35
DL96	0·55
DM70	0·44
DM71	2·00
DW4/350	1·00
DY87/6	0·30
DY802	0·33
E80CC	1·65
E80F	1·20
E83F	1·20
E88CC	1·00
E92CC	1·00
E180CC	0·95
E180F	1·00
E182CC	1·00
E1148	0·53
EA50	0·27
EA76	1·00
EABC80	0·38
EAC91	0·75
EAF42	0·60
EAF801	·75
EB34	0·25
EB91	0·15
EBC41	0·65
EBC81	0·35
EBC90	0·38
EBC91	0·33
EBF80	0·39
EBF83	0·43
EBF89	0·30
EBL21	2·00
EC53	1·00
EC54	1·00
EC86	0·70
EC88	0·70
EC92	0·45
ECC32	1·50
ECC33	1·60
ECC35	0·95
ECC40	1·00
ECC81	0·34
ECC82	0·28
ECC83	0·28
ECC84	0·30
ECC85	0·36
ECC86	0·85
ECC88	0·44
ECC189	0·85
ECC804	0·80
ECC807	1·00
ECF80	0·34
ECF82	0·38
ECF86	0·75
ECF804	2·10
ECH21	2·00
ECH35	1·25
ECH42	0·70
ECH81	0·30
ECH83	0·44
ECH84	0·44
ECL80	0·40
ECL82	0·34
ECL83	0·57
ECL84	0·60
ECL85	0·60
ECL86	0·40
EF22	1·50
EF40	0·75
EF41	0·70
EF42	0·55
EF73	1·50
EF80	0·26
EF83	0·95
EF85	0·34
EF86	0·30
EF89	0·27
EF91	0·37
EF92	0·40
EF94	0·30
EF97	0·60
EF98	0·80
EF183	0·29
EF184	0·32
EF804	1·20
EFP60	2·00
EH90	0·45
EK90	0·32
EL32	0·60
EL33	2·00
EL34	0·64
EL35	2·50
EL37	2·50
EL41	0·60
EL81	0·60
EL83	0·55
EL84	0·23
EL85	0·44
EL86	0·38
EL91	0·40
EL360	1·20
ELL80	1·00
EM80	0·45
EM81	0·65
EM83	0·55
EM84	0·40
EM85	1·00
EM87	0·70
EMM803	2·00
EY51	0·40
EY81	0·40
EY83	0·54
EY84	0·70
EY87/6	0·33
EY88	0·40
EY91	0·58
EZ35	0·40
EZ40	0·55
EZ41	0·75
EZ80	0·28
EZ81	0·27
EZ90	0·40
FW4/500	1·00
FW4/800	1·00
GY501	0·75
GZ30	0·35
GZ32	0·54
GZ33	1·00
GZ34	0·65
GZ37	0·67
HABC80	0·50
HL13C	0·50
HL23DD	0·75
HL41DD	2·00
HL42DD	0·70
HN309	1·50
HVR2	1·00
HVR2A	1·00
IW3	1·00
KT2	0·50
KT8	2·00
KT41	0·98
KT44	1·00
KT63	0·50
KT66	2·40
KT71	1·00
KT76	1·00
KT81	2·00
KTW61	1·00
KTW62	1·00
KTW63	1·00
M8162	1·00
MHL4	0·75
MHLD6	1·00
MKT4	0·98
MU12/14	1·00
N308	1·00
N339	2·00
P61	1·00
PABC80	0·38
PC86	0·60
PC88	0·60
PC95	0·75
PC97	0·38
PC900	0·45
PCC84	0·40
PCC85	0·44
PCC88	0·60
PCC89	0·50
PCC189	0·53
PCF80	0·28
PCF82	0·35
PCF84	0·59
PCF86	0·55
PCF87	0·90
PCF200	0·67
PCF800	0·75
PCF801	0·48
PCF802	0·50
PCF805	0·73
PCF806	0·55
PCF808	0·70
PCH200	0·70
PCL82	0·35
PCL83	0·54
PCL84	0·38
PCL86	0·47
PCL88	0·80
PCL800	·75
PCL801	0·66
PCL805/PCL85	0·55
PD500	1·44
PEN4DD	2·00
PEN45	·80
PEN45DD	0·50
PEN46	0·50
PEN453DD	2·00
PENA4	0·98
PENDD/4020	2·00
PL33	0·50
PL36	0·55
PL81	0·44
PL81A	0·55
PL82	0·40
PL83	0·45
PL84	0·33
PL302	0·75
PL504/500	0·67
PL508	0·90
PL509	1·15
PL801	0·80
PL802	0·95
PM84	0·60
PY33/2	·50
PY80	0·38
PY81	0·31
PY82	0·30
PY83	0·35
PY88	0·38
PY301	0·70
PY500	0·85
PY500A	·85
PY800	0·35
PY801	0·35
PZ30	0·48
QP21	0·60
QQV03/10	1·75
QS75/20	1·00
QS95/10	1·00
QS150/15	1·00
QV04/7	1·00
R11	0·98
R16	1·75
R17	0·88
R18	0·70
R19	0·38
R20	0·60
R52	0·35
RK34	1·00
SP13C	0·63
SP61	0·75
TH4B	1·00
TH233	0·98
TP2620	·98
UABC80	·40
UAF42	0·60
UBC41	0·53
UBC81	0·45
UBF80	0·38
UBF89	0·40
UBL21	0·77
UC92	0·45
UCC84	0·75
UCC85	0·45
UCF80	0·65
UCH21	2·00
UCH42	0·70
UCH81	0·38
UCL82	0·38
UCL83	0·55
UF41	0·70
UF42	0·70
UF80	0·35
UF85	0·44
UF86	1·00
UF89	0·38
UL41	0·65
UL84	0·42
UM80	0·44
UR1C	1·00
UU5	1·00
UU9	0·55
UU12	0·27
UY41	0·49
UY85	0·38
U10	1·00
U12/14	1·00
U16	1·00
U17	0·35
U18/20	1·00
U19	1·73
U22	0·50
U25	0·80
U26	0·60
U31	0·33
U33	1·60
U35	1·50
U37	1·75
U45	0·78
U47	0·80
U49	0·60
U50	0·45
U76	0·55
U78	0·40
U153	0·31
U191	0·70
U192	0·30
U193	0·35
U251	0·80
U281	0·55
U282	0·65
U291	0·60
U301	0·58
U329	0·80
U381	0·38
U403	0·78
U404	0·49
U801	0·85
U4020	0·55
VP2	0·53
VP13C	0·35
VP23	0·78
VP41	0·75
VT61A	0·35
VU111	0·44
VU120	0·60
VU120A	·60
VU133	0·35
W76	0·45
W81M	1·00
W107	1·00
W729	1·00
XE3	5·00
XFY12	0·48
XH1-5	0·48
X41	1·00
X61	1·25
X65	1·25
X66	1·25
Z329	0·80
Z729	0·30
Z749	0·80

Transistors and Diodes

Type	Price
1N1134A	·58
1N4952	0·55
2N404	0·20
2N968	0·58
2N1756	0·65
2N2147	0·94
2N2297	0·25
2N2369A	·24
2N2613	0·43
2N3053	0·36
2N3121	2·75
2N3703	0·21
2N3709	0·22
2N3866	1·10
2N3988	0·55
2S323	0·55
AA119	0·17
AA120	0·17
AA129	0·17
AAZ13	0·20
AC107	0·17
AC113	0·28
AC114	0·44
AC126	0·14
AC127	0·19
AC128	0·22
AC132	0·22
AC154	0·28
AC156	0·22
AC157	0·28
AC165	0·28
AC166	0·28
AC167	0·66
AC168	0·42
AC169	0·36
AC176	0·61
AC177	0·31
ACY17	0·28
ACY18	0·22
ACY19	0·21
ACY20	0·20
ACY21	0·21
ACY22	0·17
ACY28	0·20
AD140	0·40
AD149	0·55
AD161	0·50
AD162	0·50
ADT140	·69
AF102	0·99
AF106	0·55
AF114	0·28
AF115	0·17
AF117	0·21
AF121	0·33
AF124	0·28
AF125	0·19
AF126	0·20
AF139	0·72
AF178	0·75
AF180	0·53
AF186	0·61
AF239	0·42
ASY27	0·47
ASY28	0·36
ASY29	0·55
BA102	0·60
BA115	0·15
BA116	0·28
BA129	0·14
BA130	0·11
BA153	0·17
BCY10	0·50
BCY12	0·55
BCY33	0·22
BCY34	0·25
BCY38	0·25
BCY39	0·28
BC107	0·14
BC108	0·14
BC109	0·11
BC113	0·28
BC115	0·17
BC116	0·28
BC118	0·25
BCZ11	0·42
BF164	0·26
BF158	0·32
BF159	0·28
BF163	0·22
BF173	0·42
BF180	0·33
BF181	0·44
BF185	0·44
BF194	0·17
BFY50	0·25
BFY51	0·21
BFY52	0·22
BTX34/400	2·20
BY100	0·20
BY101	0·17
BY105	0·20
BY114	0·20
BY126	0·17
BY127	0·20
BYY23	1·10
BYZ10	0·28
BYZ11	0·28
BYZ12	0·28
BYZ13	0·28
BYZ15	1·93
CG12E	0·22
CG64H	0·22
FSY11A	·25
FSY41A	·36
GD4	0·26
GD5	0·31
GD6	0·31
GD8	0·21
GD9	0·22
GD11	0·22
GD12	0·22
GD14	0·56
GD15	0·44
GD16	0·22
GET113	·22
GET116	·44
GET118	·22
GET119	·27
GET573	·42
GET587	·47
GET8721	·06
GET873	·17
GET882	·55
GET887	·25
GET889	·25
GET890	·25
GET896	·25
GET897	·25
GET898	·25
GEX13	0·20
GEX35	0·25
GEX36	0·55
GEX45	0·36
GEX65	0·53
GT3	0·28
M1	0·17
MAT100	·42
MAT101	·47
MAT120	·42
OA5	0·31
OA9	0·14
OA10	0·47
OA47	0·11
OA70	0·17
OA73	0·17
OA79	0·10
OA81	0·10
OA85	0·09
OA86	0·22
OA90	0·14
OA91	0·10
OA95	0·10
OA200	0·10
OA202	0·11
OA210	0·63
OA211	0·75
OC19	1·38
OC22	0·48
OC23	0·42
OC24	0·48
OC25	0·42
OC28	0·66
OC29	0·60
OC35	0·47
OC36	0·47
OC41	0·55
OC42	0·60
OC43	1·38
OC44	0·11
OC45	0·12
OC46	0·17
OC65	1·24
OC70	0·14
OC71	0·12
OC72	0·13
OC74	0·25
OC75	0·13
OC76	0·17
OC77	0·30
OC78	0·17
OC78D	0·17
OC79	0·44
OC81	0·12
OC81D	0·12
OC82	0·13
OC82D	0·13
OC83	0·22
OC84	0·26
OC123	0·25
OC139	0·25
OC140	1·05
OC169	0·25
OC172	0·39
OC200	0·24
OC201	0·42
OC202	0·47
OC203	0·55
OC204	0·55
OC205	0·47
OC206	0·55
OC812	0·44
ORP12	0·55
S6M1	0·25
SM1036	0·55
ST1276	0·55
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U14706	0·25
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2N456	0·75
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2N457A	0·80
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2N696	0.15
2N697	0·15
2N698	0·25
2N699	0·29
2N706	0·10
2N706A	0·12
2N708	0·13
2N709	0·40
2N711	0·30
2N718	0·21
2N718A	0·30
2N720	0·50
2N721	0·55
2N914	0·15
2N916	0·17
2N918	0·30
2N929	0·14
2N930	0·14
2N1090	0·23
2N1091	0·24
2N1131	0·20
2N1132	0·20
2N1302	0·16
2N1303	0·16
2N1304	0·20
2N1305	0·20
2N1306	0·22
2N1307	0·22
2N1308	0·25
2N1309	0·37
2N1483	0·90
2N1507	0·24
2N1613	0·20
2N1631	0·35
2N1637	0·36
2N1638	0·32
2N1701	1·10
2N1702	2·15
2N1711	0·22
2N1893	0·34
2N2102	0·30
2N2147	0·70
2N2148	0·94
2N2192	0·40
2N2192A	0·40
2N2193	0·40
2N2193A	0·81
2N2194	0·27
2N2194A	0·30
2N2195	0·37
2N2195A	0·16
2N2218A	0·30
2N2219	0·37
2N2219A	0·51
2N2220	0·20
2N2221	0·20
2N2221A	0·33
2N2222	0·31
2N2222A	0·41
2N2368	0·11
2N2369	0·15
2N2369A	0·17
2N2646	0·70
2N2647	1·20
2N2711	0·12
2N2712	0·12
2N2713	0·17
2N2714	0·17
2N2904	0·28
2N2904A	0·25
2N2905	0·71
2N2905A	0·88
2N2906	0·24
2N2906A	0·30
2N2907	0·32
2N2907A	0·33
2N2923	0·12
2N2924	0·12
2N2925	0·15
2N2926	
Green	0·12
Yellow	0·10
Orange	0·10
2N3053	0·31
2N3054	0·60
2N3055	0·75
2N3390	0·20
2N3391	0·20
2N3391A	0·22
2N3392	0·13
2N3393	0·12
2N3394	0·17
2N3402	0·12
2N3403	0·18
2N3404	0·24
2N3405	0·27
2N3414	0·10
2N3415	4·10
2N3416	0·15
2N3417	0·21
2N3570	1·25
2N3571	1·12
2N3572	0·97
2N3702	0·11
2N3703	0·10
2N3704	0·14
2N3705	0·10
2N3706	0·09
2N3707	0·10
2N3708	0·70

2N3709	0·09
2N3710	0·12
2N3711	0·09
2N3712	0·05
2N3713	1·95
2N3714	2·28
2N3715	2·16
2N3716	3·00
2N3773	3·96
2N3779	3·15
2N3790	4·21
2N3791	4·20
2N3792	5·04
2N3794	0·10
2N3819	0·32
2N3820	0·47
2N3823	1·42
2N3824	1·33
2N3826	0·23
2N3854	0·16
2N3854A	0·16
2N3855	0·16
2N3855A	0·16
2N3856	0·16
2N3856A	0·16
2N3858	0·16
2N3858A	0·16
2N3859	0·16
2N3859A	0·16
2N3860	0·16
2N3866	1·09
2N3877	0·25
2N3877A	0·26
2N3900	0·20
2N3900A	0·21
2N3901	0·82
2N3903	0·24
2N3904	0·27
2N3905	0·24
2N3906	0·27
2N4036	0·46
2N4037	0·40
2N4058	0·16
2N4059	0·09
2N4060	0·11
2N4061	0·11
2N4062	0·11
2N4302	0·25
2N4303	0·47
2N4916	0·20
2N4917	0·17
2N4918	0·50
2N4919	0·63
2N4920	0·71
2N4921	0·50
2N4922	0·55
2N4923	0·60
2N5172	0·12
2N5174	0·22
2N5175	0·26
2N5176	0·32
2N5190	0·92
2N5191	0·96
2N5192	1·24
2N5193	1·01
2N5194	1·10
2N5195	1·48
2N5245	0·35
2N5457	0·35
2N5458	0·33
2N5459	0·33
3N128	0·73
3N138	1·05
3N139	1·42
3N140	0·92
3N141	0·81
3N142	0·58
3N143	0·75
3N152	0·92
3N153	0·81
3N154	0·84
3N159	1·17
3N187	1·55
3N200	2·49
3N201	1·05
40050	0·78
40251	0·81
40309	0·30
40310	0·50
40313	0·92
40316	0·50
40318	0·92
40360	0·46
40361	0·43
40362	0·45
40363	0·88
40389	0·46
40394	0·56
40395	0·65
40406	0·44
40407	0·33
40408	0·50
40409	0·52
40410	0·53
40411	2·00
40414	3·55
40467	0·69
40468A	0·44
40600	0·69
40601	0·67
40602	0·46
40603	0·58
40604	0·56
40636	1·10
40673	0·70
AC107	0·35
AC113	0·16
AC115	0·16
AC117	0·20
AC121	0·13
AC126	0·25
AC127	0·20
AC128	0·20
AC141K	0·30

AC142K	0·25
AC151V	0·14
AC152V	0·17
AC153	0·22
AC153K	0·23
AC154	0·20
AC176	0·18
AC176K	0·20
AC187K	0·20
AC188K	0·26
ACY17	0·23
ACY18	0·24
ACY19	0·27
ACY20	0·22
ACY21	0·26
ACY22	0·16
ACY28	0·20
ACY30	0·42
ACY39	0·65
ACY40	0·17
ACY41	0·17
ACY44	0·31
AD136V	0·96
AD142	0·54
AD143	0·45
AD149V	0·66
AD150	0·63
AD161	0·45
AD162	0·45
AD161 }	Pr.
AD162	1·05
AF109R	0·40
AF114	0·25
AF115	0·24
AF116	0·25
AF117	0·20
AF118	0·50
AF121	0·22
AF124	0·24
AF125	0·20
AF126	0·18
AF127	0·20
AF139	0·38
AF170	0·25
AF172	0·25
AF178	0·55
AF179	0·65
AF180	0·50
AF186	0·40
AF200	0·35
AF211	0·55
AF239	0·41
AF240	0·72
AF279	0·54
AF280	0·54
AFY42	0·54
AL102	0·75
AL103	0·70
ASY26	0·30
ASY27	0·35
ASY28	0·28
ASY29	0·36
ASY50	0·20
ASY55	0·35
BC107	0·15
BC108	0·15
BC109	0·19
BC113	0·13
BC114	0·12
BC115	0·15
BC118	0·15
BC116A	0·18
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BC118	0·11
BC119	0·27
BC121	0·23
BC125	0·15
BC126	0·20
BC132	0·50
BC134	0·11
BC135	0·11
BC136	0·15
BC137	0·15
BC138	0·24
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BC212K	0·11
BC212L	0·18
BC214L	0·21
BC237	0·09
BC238	0·09
BC239	0·09
BC251	0·20
BC252	0·18
BC253	0·23
BC257	0·09
BC258	0·09

BC259	0·13
BC261	0·20
BC262	0·18
BC263	0·23
BC300	0·42
BC301	0·34
BC302	0·27
BC303	0·54
BC307	0·10
BC307A	0·10
BC308	0·09
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BC308B	0·09
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BC309A	0·10
BC309B	0·10
BC327	0·24
BC328	0·22
BC337	0·19
BC338	0·19
BCY30	0·43
BCY31	0·40
BCY32	1·15
BCY33	0·34
BCY34	0·35
BCY38	0·53
BCY39	1·05
BCY40	0·50
BCY42	0·15
BCY43	0·15
BCY58	0·21
BCY59	0·22
BCY70	0·17
BCY71	0·22
BCY72	0·13
BCY87	3·47
BCY88	2·40
BCY89	0·97
BCZ10	0·35
BCZ11	0·50
BD115	0·75
BD116	0·50
BD121	0·75
BD123	0·82
BD124	0·67
BD130	0·57
BD131	0·40
BD132	0·50
BD135	0·43
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BD139	0·71
BD140	0·83
BDY10	1·25
BDY11	1·50
BDY17	1·50
BDY18	1·75
BDY19	1·97
BDY20	0·05
BDY38	1·65
BDY60	0·90
BDY61	1·25
BDY62	1·00
BF115	0·23
BF115	0·23
BF117	0·43
BF119	0·58
BF121	0·25
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BF152	0·20
BF153	0·28
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BF166	0·35
BF167	0·21
BF173	0·24
BF177	0·29
BF178	0·35
BF179	0·43
BF180	0·35
BF181	0·32
BF182	0·40
BF183	0·40
BF184	0·17
BR185	0·17
BF194	0·14
BF195	0·17
BF196	0·15
BF197	0·15
BF198	0·15
BF199	0·18
BF200	0·40
BF224J	0·14
BF225J	0·19
BF237	0·22
BF238	0·22
BF244	0·16
BF245	0·33
BF246	0·43
BF247	0·49
BF254	0·16
BF255	0·17
BF257	0·41
BF258	0·46
BF259	0·45
BF270	0·25
BF272	0·53
BF273	0·25
BF274	0·26
BF457	0·53
BF458	0·65
BFS21A	2·30
BFS28	0·82
BFS61	0·27
BFS98	0·28
BFW11	0·61
BFW15	0·35
BFX13	0·23
BFX29	0·30
BFX30	0·25
BFX37	0·30
BFX44	0·33

BFX63	2·48
BFX68	0·68
BFX84	0·24
BFX85	0·29
BFX86	0·24
BFX87	0·28
BFX88	0·25
BFX89	0·45
BFY10	0·35
BFY11	0·45
BFY17	0·90
BFY18	0·35
BFY19	0·35
BFY20	0·50
BFY29	0·40
BFY37	0·20
BFY41	0·43
BFY43	0·65
BFY50	0·22
BFY51	0·15
BFY52	0·20
BFY53	0·15
BFY56	0·34
BFY64	0·41
BFY75	0·40
BFY76	0·22
BFY77	0·24
BFY78	0·36
BFY90	0·60
BRY39	0·30
BSX19	0·13
BSX20	0·14
BSX21	0·20
BSX26	0·40
BSX27	0·34
BSX28	0·25
BSX29	0·47
BSX30	0·68
BSX59	0·78
BSX60	0·54
BSX61	0·42
BSX76	0·15
BSX77	0·20
BSX78	0·25
BSW70	0·28
BSY24	0·20
BSY25	0·15
BSY26	0·20
BSY27	0·15
BSY28	0·15
BSY38	0·20
BSY39	0·20
BSY51	0·25
BSY52	0·25
BSY53	0·25
BSY54	0·30
BSY56	0·70
BSY65	0·15
BSY78	0·40
BSY79	0·40
BSY790	0·45
BSY95A	0·09
BU104	1·42
BU105	2·25
C111	0·53
D40N3	0·55
GET1[illegible]	0·45
GET113	0·20
GET114	0·20
GET115	0·50
GET119	0·35
GET120	0·25
GET535	0·20
GET536	0·20
GET538	0·20
GET873	0·12
GET873	0·12
GET880	0·30
GET883	0·20
GET887	0·20
GET890	0·22
GET895	0·23
TIP29A	0·49
TIP30A	0·58
TIP31A	0·62
TIP32A	0·74
TIP33A	1·01
TIP34A	1·51
TIP35A	2·90
TIP36A	3·70
TIP41A	0·79
TIP42A	0·90
TIP2955	0·98
TIP3055	0·60
ME0401	0·18
ME0402	0·20
ME0404	0·13
ME0411	0·17
ME0412	0·18
ME0413	0·14
ME1120	0·25
ME4001	0·09
ME4002	0·11
ME4003	0·14
ME4101	0·10
ME4102	0·11
ME4103	0·10
ME4104	0·11
ME6101	0·14
ME6102	0·16
ME8002	0·17
ME8003	0·18
MJ400	0·78
MJ420	0·86
MJ421	0·80
MJ430	0·75
MJ440	0·71
MJ480	0·75
MJ481	0·85
MJ490	0·84
MJ491	1·10
MJ802	14·2
MJ901	2·65
MJ1001	2·34
MJ1800	1·88
MJ2500	2·92
MJ2501	3·25
MJ2955	1·00

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RL4850	31p
DL707 (Alphanumeric)	2 35

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All devices are brand-new & guaranteed

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400mw.	11p
1w	17p
1 w	25p
10w	40p
20w	52p

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Prices exclusive of VAT

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MJE370	0·73
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MJE521	0·73
MJE1092	1·03
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Each month we will show a different range of i.c.'s which are kept in stock.

TTL (SN 7400 Series)

Type	Price £	Type	Price £	Type	Price £	Type	Price £
SN7400	20p	SN7437	35p	SN7483	£1·20	SN74154	£1·66
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SN7401AN	38p	SN7440	20p	SN7485	£1·58	SN74157	£1·09
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SN7404	24p	SN7445	£1·50	SN7491	£1·10	SN74162	£1·58
SN7405	24p	SN7446	£2	SN9792	75p	SN74164	£2·01
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Diodes & Rectifiers

PIV	50	100	200	400	600	800	1000
1·5	0·08	0·09	0·10	0·11	0·12	0·15	0·20
3	0·15	0·17	0·20	0·22	0·25	0·27	0·20
10	—	0·35	0·40	0·47	0·56	—	—
35	0·84	0·92	1·16	2·15	2·52	3·65	4·20

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IN3766 (35 amp 800 pv) £3·65 IN3768 (35 amp 1000 pv) £4·20

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IN916	0·07	BA144	0·12	BYZ11	0·32	DA85	0·10
AA119	0·07	BA145	0·17	BYZ12	0·30	OA90	0·07
AA129	0·15	BA154	0·12	OA9	0·10	OA91	0·07
BA100	0·15	BY100	0·15	OA10	0·23	OA95	0·07
BA102	0·25	BY126	0·15	OA47	0·07½	OA200	0·07
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	Plastic 1A	2A	4A	6A	Metal—Professional quality 5	15	25	50A
50	0·24	0·32	0·60	0·62	2·22	2·64	3·36	12·30
100	0·36	0·37	0·70	0·75	2·24	3·00	3·60	12·36
200	0·30	0·41	0·75	0·80	2·82	3·78	4·32	14·40
400	0·36	0·45	0·85	1·18	3·72	4·20	5·40	16·38
600	0·40	0·52	0·95	1·25				

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Singles (Log and linear) 15 pence
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0·1 watt 6 pence
0·2 watt 6 pence
0·3 watt 7½ pence

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We are the sole distributors in U.K.

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I.C.s

Here too a wide range of TTL types are shown, together with linear and special purpose types. Over 80 circuit and connection diagrams as well as much other useful information is included.

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3015F Seven segment filament, compatible with standard logic modules. **0–9 and decimal point; 9mm characters** in 16 lead DIL. **£1·20**
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3015G showing + or – & 1 & dec. pt. **£1·20**

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POLYESTER C.280

Radial leads for P.C.B. mounting. Working voltage 250V d.c.
0·01, 0·015, 0·022, 0·033, 0·047 ea. **3p**
0·068, 0·1, 0·15 ea. **4p**
0·22, **5p**; 0·33, **7p**; 0·47, **8p**; 0·68, **11p**; 1·0, **14p**; 1·5, **21p**; 2·2, **24p**

TANTALUM BEAD
0·1, 0·22, 0·47, 1·0 mF/35V ea. **13p**
2·2/16V, 2·2/35V, 4·7/16V, 10/6·3V ea. **13p**
4·7/35V, 10/16V, 22/6·3V ea. **16p**
10/25V, 22/16V, 47/6·3V, 100/3V ea. **18p**

POLYCARBONATE
Type B42540 Working Voltage—250V
Values in mF: 0·0047; 0·0068; 0·0082; 0·1; 0·012; 0·015 ea. **3p**
0·018; 0·022; 0·027; 0·033; 0·039; 0·047; 0·056; 0·068; 0·082; 0·1 ea. **4p**

SILVERED MICA
Working voltage 500V d.c.
Values in pFs—2·2 to 820 in 32 stages ea. **6p**
1000, 1500 **7p**; 1800 **8p**; 2200 **10p**; 2700, 3600 **12p**; 4700, 5000 **15p**; 6800 **20p**; 8200, 10,000 **25p**

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1000pF/500, 2000/500, 5000/500, 0·01mF/50, 0·02mF/50, 0·1mF/3—each **2p**; 0·05mF/50V—**3p**

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In a range of 26 values from 22 to 6800pF/50V d.c., each **2p**

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P.20 SINGLE log. 4·7Kohms to 2·2megohms ea. **14p**
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JP.20 DUAL GANG log. 4·7Kohms to 2·2megohms ea. **48p**
JP.20 DUAL GANG Log/antilog 10K, 22K, 47K, 1 megohm only ea. **48p**
JP.20 DUAL GANG antilog 10K only **48p**
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Decades of 10, 22 and 47 only available in ranges above.
Skeleton Carbon Presets Type PR, horizontal or vertical **6p** each.

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Linear or log. 10K to 1 meg in all popular values ea. **30p**
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2 circuit unswitched S1/SS **12p**
2 circuit 2 break contacts S1/BB **15p**
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3 circuit with 3 break contacts S3/BBB **20p**
2 circuit with chrome nut and black/white/red/green or grey unswitched S5/SS **16p**
with 2 break contacts S6/BB **20p**
Miniature 3.5mm 2 circuit, (black) 2 br. cont S6/BB **9p**

PLUGS
2 circuit screened top entry P4 **24p**
side entry SEP1 **36p**
Line socket mono 231 **40p**
Line socket stereo 244 **45p**
3 circuit unscreened, black/grey/white P4 **46p**
2 circuit, unscreened, black/white/red/black/green/grey P2 **18p**
3 circuit screen top entry P3 **53p**
side entry SEP3 **55p**
Miniature 3·5mm 2 circuit screened P5 **13p**
Miniature 3·5mm 2 circuit unscreened various colours P6 **10p**

INSULATED SCREW TERMINALS

In moulded polypropylene, with nickel plate on brass. With insulating set, washers, tag and nuts. 15A/250V in black/brown/red/yellow/green/blue/grey/white. Type TP.1 ea. **14p**

DIN CONNECTORS

2 way loudspeaker	Socket 10p	Plug 12p
3 way audio	Socket 10p	Plug 12p
5 way audio 180°	Socket 12p	Plug 15p
5 way audio 240°	Socket 12p	Plug 15p
6 way audio	Socket 13p	Plug 15p

RESISTORS

Code	Watts	Ohms	1 to 9	10 to 99	100 up (see note below)
C	1/20	82–220K	9	8	7·5
C	1/3	4·7–470K	1·3	1·1	0·9 nett
C	1/2	4·7–10M	1·3	1·1	0·9 nett
C	3/4	4·7–10M	1·5	1·2	0·9 nett
C	1	4·7–10M	3·2	2·5	1·9 nett
MO	1/2	10–1M	4	3·3	2·3 nett
WW	1	0·22–3·9	9	9	8
WW	3	1–10K	7	7	6
WW	7	1–10K	9	9	8 nett

Codes:
C = carbon film, high stability, low noise.
MO = metal oxide, Electrosil TR6, ultra low noise.
WW = wire wound, Plessey.
Values: All E12 except C 1/20W, C 1/3W, and MO 1/2W.
E12: 10, 12, 15, 18, 22, 27, 33, 39, 47, 56, 68, 82 and their decades.
E24: as E12 plus 11, 13, 16, 20, 24, 30, 36, 43, 51, 62, 75, 91 and their decades.
Tolerances:
5% except WW 10% ±0·05Ω and MO 1/2W 2%.
Prices are in pence each for quantities of the same ohmic value and power rating. NOT mixed values. (Ignore fractions of one penny on total value of resistor order.) Prices for 100 up in units of 100 only.

ZENER DIODES

Full range E24 values: 400mW: 2·7V to 36V, **14p** each; 1W: 6·8V to 82V, **21p** each; 1·5W: 4·7V to 75V, **48p** each. Clip to increase 1·5W rating to 3 watts (type 266F), **5p.**

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Copper clad 0·1 matrix—2·5 x 3·75 ins. **24p**; 3·75 x 3·75 ins.—**27p**; 2·5 x 5 ins.—**27p**; 3·75 x 5 ins.—**30p.**
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Axial Lead

µF	3V	6·3V	10V	16V	25V	40V	63V	100V
0·47	—	—	—	—	—	—	11p	8p
1·0	—	—	—	—	—	11p	—	8p
2·2	—	—	—	—	11p	—	8p	9p
4·7	—	—	—	11p	—	8p	9p	8p
10	—	—	—	—	8p	9p	8p	8p
22	—	—	8p	—	9p	8p	8p	10p
47	8p	—	9p	8p	9p	8p	10p	13p
100	9p	8p	8p	8p	9p	10p	12p	19p
220	8p	8p	9p	10p	10p	11p	17p	28p
470	9p	10p	10p	11p	13p	17p	24p	45p
1,000	11p	13p	13p	17p	20p	28p	41p	—
2,200	18p	18p	23p	26p	37p	41p	—	—
4,700	26p	30p	39p	44p	58p	—	—	—
10,000	42p	46p	—	—	—	—	—	—

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AMERICAN SWEEP GENERATOR type 452. Covers from 5 to 100 MHZ. Has built in display and 101 DB Push Button RF Attenuator in one DB steps, plus Calibrated Marker Generator covering 5 to 100 MHZ continuous. American Government Contract, so quality is high. Supplied for 240V 50 HZ operation with plugs and leads. Size 13½ × 9½ × 19in. Price £70 each. Carriage £1·50.

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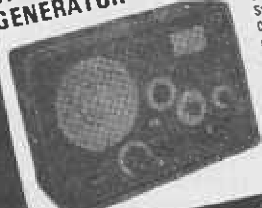

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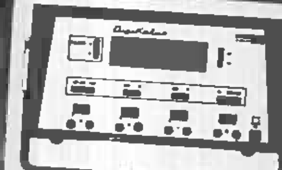

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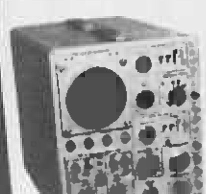

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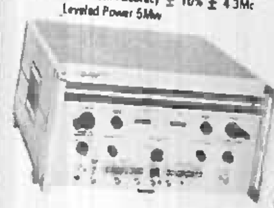

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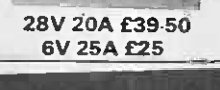

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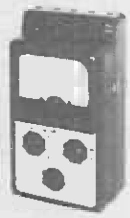

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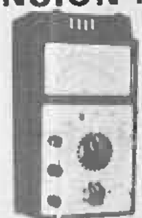

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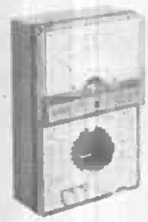

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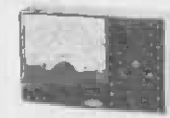

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Systems Laboratory Engineers

to carry out commissioning and proving tests of laboratory models and the first exchanges; to evaluate design and then to propose and demonstrate improvements. This work will sometimes require travel to the various locations and applicants should be prepared to take on early responsibility.

Circuit Design Engineers

to analyse and design a wide range of digital circuits using discrete components. The work will involve in-depth analysis, to worst-case limits, of a variety of circuits including the effect on performance of temperature and voltage fluctuation and ageing of components.

Customer Application Engineers

to analyse customers' specifications, identify manufacturing requirements, overcome any interfacing problems with other existing types of equipment and produce detailed installation plans. Application Engineers must ensure that all aspects are properly scheduled so that new exchanges can be handed over to the customer in full working order and on time.

Test Engineers—Hardware

to join teams working on the Automated Test Equipment of the future. The job involves the design and development, up to laboratory model stage, of specialized digital test equipment. Initially a major task will be the development of equipment due to be on field-trial in Europe in the near future and the subsequent development of test equipment for use in various aspects of the manufacture, commissioning and maintenance of electronic switching systems.

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Pye Telecommunications is the world's largest exporter of radio-telephone equipment and is engaged in a major expansion programme designed to double present turnover during the next five years. There are, therefore, excellent opportunities for promotion within the company. Pye also encourages its staff to take higher technical and professional qualifications.

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If you are interested in a challenging and rewarding career with an expanding company, please airmail a resume of your educational and technical background, work experience, and personal history to William L. Rorden, Chief Engineer, The Grass Valley Group, Inc., P.O. Box 1114, Grass Valley, California 95945, USA. Resumes need not be formal; however, we are interested in learning as much about you and your experience as possible. Immediate consideration will be given and response made to suitable applicants, with a view toward arranging personal interviews in London in early 1974. All resumes will be treated in confidence. References will be required at or prior to the time of interview.

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Applicants should not be more than 27 years of age and should have one of the following qualifications:

(a) A degree in a scientific or engineering subject;
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(c) A Higher National Certificate or Higher National Diploma in a scientific or engineering subject;
(d) A qualification equivalent to (c) above.

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(a) Applicants with 1st or 2nd class honours degree—at least 2 years post-graduate experience;
(b) Applicants with other qualifications—at least 5 years post-qualification experience.

Salary Scale: £2,221–£2,854 (subject to review) with entry point dependent upon experience beyond the minimum required.

SENIOR SCIENTIFIC OFFICER

Applicants should be at least 25 and under 32 years of age, although the upper age limit may be waived if experience of special value can be offered.

Applicants should have obtained a 1st or 2nd class honours degree and have had a minimum of four years appropriate post-graduate experience.

Salary Scale: £2,798–£3,895 (subject to review). Entry will normally be at the minimum of the scale but applicants with experience of special value may be entered above the minimum.

Applications stating the field of work and grade required should be made to:

Administration Officer
HM Government Communications Centre
Hanslope Park
Hanslope
MILTON KEYNES MK19 7BH

3660

ELECTRONIC EVALUATION ENGINEER

We are manufacturers of the specialist range of Leak and Wharfedale Hi-Fi products and the demand for our quality products, which are designed, developed and manufactured to precise published specifications, is continually increasing. The company's policies, therefore, include controlled expansion, continuous improvement to current products and the extension of our product range.

A vacancy is available in the Engineering Function for an Electronic Evaluation Engineer to provide a technical support service on product evaluation and the supply of factored products. This will involve him in the assessment of performance, construction, safety and suitability of factored products and others and the preparation of written reports. This position will also demand close liaison with suppliers, quality control departments and product planning for the preparation and assistance with the technical specifications required.

Applicants should be educated to HNC or degree level and have had a minimum period of four years project or product experience in Hi-Fi Electronics or a closely related field.

The company's premises are located at Idle, Bradford, convenient for travelling from both Bradford and Leeds and near to the pleasant rural surroundings of the Aire Valley.

The company can offer competitive employment conditions including free life assurance and contributory pension scheme.

Salary: £2,200–£2,700

Application forms may be obtained from:

J. R. Murgatroyd,
Personnel Officer,
Rank Radio International,
Bradford Road, Idle,
Bradford BD10 8SF.
Tel: 612552

RANK RADIO INTERNATIONAL

3633

COME DOWN UNDER

Here's a once in a lifetime opportunity to work for Australia's leading electronics company specialising in the supply of components to hobbyists and industry. The Dick Smith Electronics Centre, situated in Sydney, is expanding its activities very rapidly and we desperately need staff, both for counter sales and mail orders. Interested?

We want people with experience in this field who will come out for at least two years. In return we will guarantee your return flight (but we know with all the opportunities out here you will never go back).

Pay naturally depends on experience but would be in the vicinity of £3,000 P.A. for counter and mail order staff rising to £5,000, for those with management experience.

The weather is great, our winter is like your summer. The beaches fabulous. The future unlimited. So please write to Dick himself (airmail of course) giving a brief life story and enclosing a photo if possible. All replies will be treated in strict confidence.

Write now to Dick Smith, Managing Director, Dick Smith Electronics Centre, 162 Pacific Highway, Gore Hill, N.S.W. 2065, Australia.

P.S. This advertisement was written by someone who grabbed a similar opportunity three years ago and hasn't looked back since!

3639

Trials and Commissioning Engineers

EMI

The international music, electronics and leisure Group.

The Systems and Weapons Division of EMI Electronics Ltd. at Feltham is expanding its Trials and Commissioning Staff in order to fulfill major new commitments in the Aero-space field. Therefore the following vacancies have arisen.

Trials Engineers

Senior Trials Engineers are required with specialist experience in some of the following technical areas or other related fields. 'L', 'C', and 'S' band transmitting and receiving equipment.

Minicomputers and digital data handling systems
Analogue data communication
Specialised peripheral test equipment

Following a period of training and familiarisation, the appointments involve overseas travel for short periods while some positions will involve overseas residence.

Commissioning Engineers

These positions, although based at Feltham, offer the opportunity of spending varying periods of time testing and commissioning a complex radar type equipment at service establishments. The work involves the investigation of defects and repair of faults found during installation. Familiarity with modern test equipment is essential and applicants should be qualified to at least ONC level.

If any of the above positions appeal to you please contact: J. Morrison, Personnel Officer, EMI Electronics Ltd., Victoria Road, Feltham, Middlesex. Tel: 01-890 3600 Ext. 44 or 117 or outside normal hours 01-890 3921.

3662

ELECTRONIC TECHNICIANS

WALSGRAVE HOSPITAL

Two Electronic Technicians are required for the Electronics Department dealing with the maintenance of a wide variety of electronic and electro-medical apparatus.

Applicants must possess H.N.C., H.N.D., or O.N.C. in electronics or equivalent City and Guilds Certificate.

General diagnostic maintenance experience in the electronic field is necessary. Training in maintenance of specialised hospital equipment will be given.

Salary scale from £1,773 to £2,211 p.a. Additional payments are made if overtime is required.

Applications stating age, qualifications and experience, together with two referees, should be sent to the Group Engineer, Coventry Hospital Management Committee, P.O. Box 92, The Birches, Tamworth Road, Keresley End, Coventry.

Coventry Hospital Management Committee

3601

UNIVERSITY COLLEGE OF NORTH WALES, BANGOR

School of Electronic Engineering Science

Industrial Development Unit

Electronic Design Engineer

required to join a small team engaged in the design and development of radio navigation tracking systems.

QUALIFICATIONS: Degree or equivalent plus relevant experience in radio system engineering.

SALARY: Within range £2,000 to £2,500 per annum.

The successful candidate will be required to take design responsibility in the areas of R.F. signal processing circuits, and telemetry interface systems. A knowledge of digital integrated circuit techniques would be useful.

Applications (two copies), giving details of age, education and experience, together with the names and addresses of two referees, should be submitted to the Secretary and Registrar, University College of North Wales, Bangor, by not later than 31st May, 1974.

3665

Microwave Engineer

EEV needs another top-flight man or woman, for R & D work on duplexing devices

At the English Electric Valve Co., Lincoln, we have some of the best facilities in the United Kingdom for microwave research and development work. Right now, we need a man, or woman, who can use these facilities to the full, and contribute original thinking to the next generation of duplexing devices. He, or she, will also work on new and improved allied low-power microwave components such as TR tubes, solid state limiters, filters, noise generators, mixers, etc.

Age is less important than experience in microwave work—that's why we are operating within an age range of 25 to 50 for this important post. We would prefer to take on a Chartered Engineer, but those with lesser qualifications who feel they have a vital contribution to make, will be very seriously considered. Salary will be based on previous experience.

Please contact Mr. J. L. Scott, giving details of your career to date, and tell him how you think you could contribute to the future development of duplex devices. English Electric Valve Co. Ltd., Waterhouse Lane, Chelmsford, Essex.
Telephone: Chelmsford (0245) 61777.

English Electric Valve Co. Ltd.

3647

COLLINS

COMMUNICATION SYSTEMS ENGINEERS

Qualified Engineers are required as Senior members of a team engaged in evaluation, design and installation of communications systems which cover the use of HF/SSB, VHF, UHF, BROADCAST, MICROWAVE, TROPOSCATTER and DATA TRANSMISSION techniques.

Recent contract awards have necessitated an expansion of the Systems Engineering Group, primarily in the HF/SSB and UHF communication fields. Participation will include negotiations at a senior level with military and commercial organisations, and will involve some overseas travel.

Successful applicants must have a broad theoretical and practical background in communication methods, principally HF/SSB and UHF, and be able to undertake projects from inception to final system implementation.

Remuneration and conditions are in line with the importance of these positions and include free life insurance and non-contributory pension scheme.

Further information regarding these positions can be obtained by telephoning 01-759 9911, ext. 55.

Written applications quoting ref: WW/CSE to The Personnel Manager,

COLLINS RADIO COMPANY OF ENGLAND LTD,
Heathrow House, Bath Road, Hounslow TW5 9QW

3619

ELECTRONIC VACANCIES

Engineers

Draughtsmen ● Designers

Service and Test Engineers

Technicians ● Technical Authors

Sales Engineers

£1,600-£5,000 pa

Permanent or Contract

Phone MICHAEL NORTH
01-388 0918
MALLA TECHNICAL STAFF LIMITED
334 Euston Rd., London NW1 3BG

3635

Electronic Equipment Mechanics

required for

Assembly and Servicing of high power level photographic flash equipment.
Good prospects for enthusiastic types.

£35 to £40 p.w.

Telephone 01-253 0791. [3609

WANTED

Leading importer of Russian radio and photographic equipment requires

EXPERIENCED TROUBLE SHOOTERS/ FAULT FINDERS AND REPAIRERS

Top salary paid to the right men. Generous staff purchase scheme and annual bonus.

PLEASE CONTACT:

J. K. DEVLIN on 01-263 0951
Technical and Optical Equipment London Ltd.,
Zenith House, Thane Villas,
London, N7 7PD [3652

IMPERIAL COLLEGE

TECHNICIAN

GRADE 5

required to assist in the maintenance of the S.R.C. sponsored AE1 EM7 1MEV high voltage electron microscope. The successful candidate will work under the guidance of a Grade 7 Technician to maintain and improve a wide range of electro-mechanical, electronic and vacuum systems. Applicants must have a good knowledge of electronics and will be expected to provide technical guidance with respect to the design of transistor circuitry. Salary range £2,182-£2,557, including London weighting.

Applications giving details of qualifications and experience together with the names of two referees should be sent to Mr. G. J. Green, Department of Metallurgy and Materials Science, Imperial College, London, SW7 2BP, before 17 May 1974. [3643

Are your ears big enough–

to pick up the sound of £2,500 per year?

We are looking for young people with finely tuned ears to the technical world of audio and hi-fi who know what is going on in the marketing fields as well. This ability, coupled with experience of technical writing or publications work, could secure them a post with our group of leading hi-fi publications.

**Write to the Group Editor,
Clement Brown,
Haymarket Publications,
Gillow House, 5 Winsley Street,
London W1A 2HG.**

3624

Telecommunications

South West England

Applications are invited from recently qualified technicians to train for appointments in telecommunications within the South Western Region of the Central Electricity Generating Board.

The successful applicants will initially be based at Durley Park, Keynsham, near Bristol, where training will be given on the Generating Board's telecommunications equipment. After training staff may be asked to move to any of the Region's locations for which relocation expenses will be paid.

Applicants should have a telecommunications or light current background and have academic qualifications leading to H.N.C. or full C. & G. Technological Certificate.

Salary within a range £1,836–£2,535; the starting point will depend upon qualifications and relevant experience.

Application forms may be obtained from Bristol 32251, extension 33 or 3, or by writing to the Personnel Manager; please quote Vacancy No. 142/74.

3607

**Central Electricity Generating Board
South Western Region**
Oakfield Grove, Clifton,
Bristol BS8 2AS

Service Engineer

for Audio/Hi-Fi Department.

Good practical knowledge of leading makes. Attractive employment terms.

Write or telephone for appointment to:

JOHN KING (FILMS),
71 East Street, Brighton
Tel: 25918/27674

3654

**ULSTER:
THE NEW UNIVERSITY**

C.C.T.V. TECHNICIAN

Applications are invited for the above post (Technician: Grade 5) from persons with at least seven years relevant experience including work in the field of CCTV.

Qualifications: H.N.C. or equivalent. Salary scale: £2,007–£2,382 per annum.

Application forms and further particulars should be obtained from The Registrar, The New University of Ulster, Coleraine, Northern Ireland (quoting Ref: 74/36) to whom completed applications, including the names and addresses of three referees, should be returned not later than 31st July, 1974.

3659

TRANSISTOR APPLICATIONS ENGINEER

FERRANTI have a vacancy in the Applications Laboratory of their Electronic Components Division at Chadderton, Lancs., for an Engineer to work on the application of R.F. Power Transistors at VHF and UHF frequencies. The work involves the design of appropriate circuits, customer liaison and general technical back-up to the marketing and device development engineers.

Candidates should possess a degree or H.N.C., have previous experience in this field, and be able to work with the minimum of supervision.

Application forms may be obtained from T. J. Lunt, Staff Manager, Ferranti Limited, Hollinwood, Lancs. Please quote reference GH.

FERRANTI

3596

A COMPUTER ENGINEER

is required by the Express & Star Newspaper to maintain Real Time Digital equipment PDP-11 Computer system with a variety of peripheral equipment.

We are the fourth largest provincial evening newspaper in the country and are the only one, possibly in Europe, to have this type of computer system. It is an integral part of our daily production/publishing systems. Because of this it is vital that the equipment is available at all times and maintenance and servicing are of the utmost importance.

The person appointed will probably have some two years experience in mainframe and peripheral equipment and be educated to at least H.N.C. standard. He must be able to work without direct supervision, work the hours that are necessary to complete the task and fit into a young team. He should also be able to maintain an adequate spares level.

Anyone interested should write to:—

Group Personnel & Staff Welfare Manager,
EXPRESS AND STAR,
Queen Street,
Wolverhampton WV1 3BU.

[3622

ELECTRONIC ENGINEERS

In 1961 we introduced the world's first electronic desk-top calculators, with the trade name of ANITA. There have been many changes in technology since then, but we have remained leaders in the field and our calculators have been sold in many countries around the world including the U.S.A. and Japan. Due to further expansion of our activities with calculators and more complex systems we have vacancies for service engineers at our National Service Centre at Hemel Hempstead. Our range of electronic business equipment is wide and our engineering requirements are correspondingly varied. We are now seeking additional staff ranging from junior technicians (with day release, where appropriate) to qualified, experienced engineers. The positions are permanent and we offer first class conditions of employment. Please write or telephone for an application form from D. D. Davies, SUMLOCK COMPTOMETER LTD., 1, FROGMORE ROAD, HEMEL HEMPSTEAD, HP3 9RJ, HERTS. TEL: 0442 — 61771

Rockwell International

3427

PAPUA, NEW GUINEA
DEPARTMENT OF POSTS AND TELEGRAPHS

The Department of Posts and Telegraphs, Papua, New Guinea, invites applications for appointments in the following categories of the telecommunications service:

1. Assistant Director (Level 1)
   A$ 17.300
2. Engineer (Class 5)
   A$ 14.882-15.845
3. Engineer (Class 4)
   A$ 13.332-14.208
4. Engineer (Class 3)
   A$ 11.348-12.664
5. Engineer (Class 2)
   A$ 9.581-10.702
6. Senior Technical Officer (Grade 3)
   A$ 10.227-10.522
7. Senior Technical Officer (Grade 2)
   A$ 9.379-9.932
8. Senior Technical Officer (Grade 1)
   A$ 8.599-9.103
9. Technical Officer (Grade 2)
   A$ 7.843-8.347
10. Technical Officer (Grade 1)
    A$ 6.003-7.613
11. Clerk (Class 9)
    A$ 12.019-12.510
12. Clerk (Class 8)
    A$ 11.032-11.525
13. Clerk (Class 7)
    A$ 9.876-10.538
14. Clerk (Class 6)
    A$ 8.886-9.548

QUALIFICATIONS
Assistant Director and Engineers to be graduates and/or Chartered Engineers with previous relevant experience in a telecommunications administration or industry.

Senior Technical Officers and Technical Officers to be holders of approved Diploma or Certificate from a recognised institution.

Clerk (Class 9) to be a graduate in Economics or similar discipline, other Clerks will fill positions as Traffic Officers, marketing and tariff managers, accounting, licensing and similar positions.

DUTIES
A wide variety of appointments are available and more detailed descriptions are obtainable (see below).

CONDITIONS
Contracts will be for four years. Fares to Papua, New Guinea and to the U.K. on completion of duty.

Three months leave after 21 months service with leave fares paid to Sydney.

Government accommodation with heavy furnishings available at reasonable rental.

Apply in first instance for Application Form. Information on service conditions and available vacancies to the Personnel Manager, Preece, Cardew and Rider, Paston House, 165-167 Preston Road, Brighton, BN1 6AF, Sussex.

[3664

FOR RECRUITMENT ADVERTISING

RING ALLAN PETTERS

01-261 8508
01-928 4597

Visual and Aural Aids
Technician

Education Department

Fully qualified and experienced person required to assist in the installation, repair and maintenance of Radios, Tape Recorders, Projectors, Televisions, etc., in schools and other educational establishments. Five day, 40 hour week.

Wages £33.30 per week, plus bonus.

CROYDON

Applications with details of relevant experience to: The Stores Assistant, Education Service Centre, Princess Road, Croydon CR0 2QZ (telephone: 01-684 9393.

[3640

Electronics Engineers up to £5000

Many jobs which would suit you down to the ground – either in the U.K. or overseas – are never advertised. Yet it will cost you nothing whatever to give yourself the opportunity to be considered for them.

Join the Lansdowne Appointments Register – used by hundreds of employers to select electronics engineers. You have nothing to lose, everything to gain – and it's all conducted in strict confidence. So post the coupon – find out exactly how you can make use of a service which is all the more valuable for being free!

To: Stuart Tait, Lansdowne Appointments Register, Design House, The Mall, London W5 5LS. Tel: 01-579 6585 (anytime – 24 hour answering service).

Please send me further details.

Name..

Age (20-45 only) ....

Address.......................................

....

.... WW 29/4

lansdowne Appointments Register

97

TECHNICIANS AND ENGINEERS FOR ST. ALBANS AND LUTON

QUALIFIED OR NOT!

OPPORTUNITIES for challenging work on testing and calibrating valve and solid-state electronic measuring equipments embracing all frequencies up to u.h.f. in Production, Service and Calibration departments.

APPLICATIONS are invited from people of all ages with experience or formal training in electronics and from Ex-Services technicians.

HIGHLY COMPETITIVE SALARIES, negotiable and backed by valuable fringe benefits. Overtime normally available.

GENEROUS RE-LOCATION EXPENSES available in most instances.

CONDITIONS excellent; free life assurance, pension schemes, canteen, social club.
$37\frac{1}{2}$ hour, 5-day, working week.

WRITE or phone for application forms quoting reference WW

MARCONI INSTRUMENTS LTD,
Longacres, St. Albans, Herts
Tel: St. Albans 59292
Luton Airport, Luton, Beds
Tel: Luton 33866

A GEC-Marconi Electronics Company

94

WORK IN CENTRAL AMERICA

Radio Technician
needed for Guatemala.
Radio Engineer
needed for Honduras.
Work with the British Volunteer Programme.
Information: Fran Chadwick, Overseas Volunteers, 41 Holland Park, London, W.11.

13346

INSTITUTE OF PSYCHIATRY

TECHNICIAN

The Department of Psychology require a Technician for the Departmental Workshop.

Duties will include construction and maintenance of Electronic apparatus for use in the research carried out in the department. Applicants should possess ONC or C & G Final Certificate or equivalent.

Salary:— Technician on a scale £1,440-£2,292 plus London Weighting (£126).

Starting point dependent on Age, qualification and experience.

Application forms and details can be obtained from The Secretary, Institute of Psychiatry, De Crespigny Park, Denmark Hill, London SE5 8AF quoting ref. IM/WW.

13642

Sales Engineer

Power Grid Tubes

A Sales Engineer is needed by the English Electric Valve Company Limited to sell its expanding range of power grid tubes. He will visit customers in the U.K. and overseas and be responsible for ensuring the satisfactory conclusion of negotiations with customers at both the technical and commercial levels.

His brief will also include the preparation and implementation of medium and long term marketing plans to further the already considerable success of this major European Company in this field.

The successful candidate will possibly have a recognised professional qualification in engineering and preferably experience in the power tube field, although these are not essentials, as comprehensive product training can be given.

An excellent salary and other benefits consistent with a major Company will be offered.

Write or telephone J. L. Scott,
English Electric Valve Company Limited,
Waterhouse Lane, Chelmsford, Essex.
Tel: Chelmsford (0245) 61777.

English Electric Valve Co. Ltd.

3648

ELECTRONIC ENGINEERS AND TECHNICIANS

Ferranti Limited in Edinburgh have a variety of vacancies for Electronic Engineers and Technicians involving work on avionics systems. This includes test equipment design and maintenance, quality and test engineering, reliability engineering and environmental testing.

A background of experience and knowledge in some of the following areas of technology would be particularly relevant:

Digital and analogue techniques
Microwave Engineering
Servo Techniques
Lasers and Optics
Electronic Displays

We are particularly interested in applications from ex-Services personnel who have relevant experience of 2nd- and 3rd-line maintenance and fault diagnosis. We offer a variety of interesting work in fault finding and acceptance testing of electronic systems.

Qualifications ranging from degree level to Ordinary National Certificate or their Services equivalent will be acceptable.

Those recently qualified with a degree or H.N.D. (Mechanical or Electrical) but who lack the above experience, should also apply.

These posts are based in Edinburgh which offers an attractive living environment with many recreational activities within easy reach.

The Company operates a contributory pension and life-assurance scheme and will assist with relocation expenses where necessary.

Apply in writing with particulars of qualifications and experience to the:

FERRANTI

Staff Appointments Officer,
Ferranti Limited,
Ferry Road,
Edinburgh EH3 2RS.

3655

JUNIOR TECHNICAL ASSISTANT + SCHOOL LEAVER

We are a busy major international advertising agency working on household name clients. To assist in the operation and maintenance of audio visual equipment we now require a further two assistants.

One should preferably have had experience in using this type of equipment, although full training will be given. Salary is negotiable, four weeks holiday, B.U.P.A. and excellent working conditions.

Ring Colin Forster 01-836 2424 at Leo Burnett Ltd.
48 St. Martin's Lane, London WC2.

3634

SENIOR PROJECT ENGINEER—ELECTRONICS

An exciting and challenging position exists for an experienced Electronics Engineer. He would be required to take charge of the design and manufacture on fixed price contracts, and also to allocate part of his time to in-house product development.

The company, situated in Hadleigh, enjoys an International reputation and manufactures a range of function generators, phasemeters, r.m.s. voltmeters, stepping motor control systems, and air velocity meters.

Please send complete resume before telephoning for an interview. Salary in range £2,750 to £4,000 per annum. Profit sharing scheme.

ELECTRONIC ENGINEERS

This position is open to qualified electronics engineers with H.N.C. or equivalent who have at least two years practical industrial experience in the electronics manufacturing industry. The position entails working under a project leader and will cover the whole gamut of electronic circuit and manufacturing design.

Good basic salary on the scale £1,800 to £2,600 per annum. Profit sharing scheme.

Applications, to include a resume, to:

J. N. Prosser,
PROSSER SCIENTIFIC INSTRUMENTS LTD.,
Lady Lane Industrial Estate,
Hadleigh, Ipswich, IPT 6OQ.
Telephone: Hadleigh (047 338) 3005.

3605

ELECTRONICS MARKET RESEARCH

£2,000 + Bonuses

Man with HNC/HND in Electronics, clean driving licence, required by market research agency to maintain, transport and operate tachistoscopic reaction timer, and photographic equipment in varying locations in Great Britain (and Europe if linguist).

Please contact Managing Director specifying qualifications and career to date.

PACKAGING and PERCEPTUAL RESEARCH LTD.,
18-20 Dryden Chambers,
119 Oxford Street,
London, W1R 1PA.
Telephone: 01-734 0528/9

3627

ELECTRONICS ENGINEER

Qualified Engineer required for interesting work on a wide range of devices and systems used by and for blind people.

A sound basic knowledge of analogue and digital techniques, together with several years experience in a field of design, development and maintenance is necessary. Some experience of light electro-mechanical devices would be an advantage. Applications in writing, giving full details of education, qualifications and experience, including present post and salary, to Personnel Officer, Royal National Institute for the Blind, 224 Gt. Portland Street, London W1N 6AA.

3636

ELECTRONIC SERVICE

Office Machine Company has the following vacancy:

SENIOR SERVICE ENGINEER
to assist Workshop Manager, must have experience of repairing digital printed circuit boards, preferably electronic calculators, good electronic knowledge and experience in a Service Department. Salary £2,700.

ELECTRONIC WORKSHOP SERVICE ENGINEER
to repair calculator printed circuit boards. Good basic electronic knowledge required and experience in a Service Department. Salary up to £2,200.

Apply to:

Mr. V. Knight,
Automatic Business Machines Ltd.,
104, New Kings Rd, Fulham, S.W.6.
01-736 5196

3621

WALTHAM FOREST COLLEGE

FOREST ROAD, LONDON, E17 4JB

offers the following academic posts because of continuing expansion.

DEPARTMENT OF TECHNOLOGY

LECTURER II: RADIO, TELEVISION AND ELECTRONICS

Applicants must have good practical experience of the Industry and possess INC or the appropriate City and Guilds qualifications, or equivalent. Knowledge and experience of CCTV an advantage.

LECTURER I: RADIO, TELEVISION AND ELECTRONICS

Applicants must have good practical experience and should possess City and Guilds 172 (old No. 48), City and Guilds 272, or equivalent qualifications.

Most posts are tenable from 1st September, 1974, but some appointments may be made earlier unless specifically stated. College of Education students may be appointed from the end of their course.

SALARIES—Burnham F.E. Scale:

Lecturer I—£1,660-£2,847 plus London Allowance £118;

Lecturer II—£2,515-£3,243 plus London Allowance £118;

Senior Lecturer—£3,291-£3,655 plus London Allowance £118;

Head of Dept. Grade IV—£3,968-£4,396 plus London Allowance £118.

Application forms and further particulars may be obtained from the Principal (Staffing), Waltham Forest College, Forest Road, Walthamstow, London, E17 4JB. Tel. 01-527 2268. Ansafone Service 17.00-09.00 hours.

Closing date 2 weeks from the appearance of this advertisement.

[3631

CHELSEA COLLEGE

University of London

Electronics Technician

(GRADE 3)

required for interesting work in Applied Acoustics research group. Salary Scale £1,825 to £2,095 per annum including £175 London Allowance.

Further details and application forms from the Departmental Superintendent (3AA), Departments of Physics and Electronics, Pulton Place, London, SW6 5PR.

[3628

AUDIO TESTERS

EXPERIENCED

FOR LEADING ELECTRO-MUSICAL COMPANY

INTERESTING WORK WITH MIXERS, ECHO UNITS, AMPLIFIERS (VALVE AND TRANSISTOR) ETC.

HIGH RATES FOR RIGHT MAN

wem 66 OFFLEY ROAD, LONDON SW9. Tel. 735 6568

93

Sales Engineer

Microwave Tubes

The English Electric Valve Company need a Sales Engineer to join a team marketing advanced microwave tubes and devices. Based in Chelmsford, his key objectives will be to develop and exploit new markets for a rapidly expanding product range. He will visit and negotiate with customers in the U.K. and overseas and will be personally involved in all aspects of the microwave product marketing plans.

The successful candidate will possibly have a recognised professional qualification in engineering and preferably experience in the power tube field, although these are not essentials, as comprehensive product training can be given.

The Company is the most important professional electronic tube company in Europe and is recognised throughout the world as a major force in the industry. An excellent salary and other benefits consistent with joining this major company will be offered.

Write or telephone J. L. Scott,
English Electric Valve Company Limited,
Waterhouse Lane, Chelmsford, Essex.
Tel: Chelmsford (0245) 61777.

English Electric Valve Co. Ltd.

3649

telesonic marine ltd.

MARINE ELECTRONICS ENGINEER

Are you experienced in installing and servicing marine electronic equipment such as Radar, Navigation Equipment, and radio telephones? We require such a man for a fascinating job travelling to luxury yachts, etc., all round the country. If you live near London and are able to drive, a good salary awaits you working in idyllic friendly atmosphere.

Apply **Telesonic Marine Ltd.** Tel: 01-387 7467

3608

PHILIPS MEDICAL SYSTEMS LTD.

require a

SERVICE ENGINEER

IN NORTH LONDON

Suitable applicants should have experience in electro-medical and closed circuit TV equipment. Applicants with minimum ONC or equivalent qualifications and relevant experience should apply in writing to:—

The Personnel Manager,
PHILIPS MEDICAL SYSTEMS LTD.,
45 Nightingale Lane,
London,
S.W.12.

[3598

FIJI
RADIO ENGINEER

required by the Posts and Telecommunications Department to lead a small team engaged in the installation and commissioning of VHF, UHF and SHF radio links, both single channel and multi-channel and all associated equipment. May also be required to assist with detailed planning of systems and installations.

Candidates must hold a Final City and Guilds Certificate in Telecommunications (including Radio C) or equivalent plus five years supervisory experience on maintenance or installation of VHF, UHF or SHF radio systems.

SALARY in the range £2,280 to £3,340 p.a. which includes an allowance, normally tax free, of £700 to £1,000 p.a. Terminal gratuity 20% on basic salary, 25% on allowance. For a married man with two children paying tax at the standard rate the total emoluments described above, including gratuity, approximate to a gross (i.e. before tax) UK return of £3,500 to £4,750 and for a single man about £3,300 to £4,800 p.a.

Other benefits include: low local income tax, generous paid leave, subsidised accommodation; free family passages, children's education allowances and holiday visit passages; (tour 2½-3 years), appointment or disturbance grant up to £200, car loan up to £600.

The post described is partly financed by Britain's programme of aid to the developing countries administered by the Overseas Development Administration of the Foreign and Commonwealth Office.

For further particulars you should apply, giving brief details of experience to

crown agents

M Division, 4 Millbank, London SW1P 3JD, quoting reference number M2K/740307/WF

3599

TECHNICIANS

We are engaged in the manufacture and servicing of sophisticated audio electronic equipment for the music industry. Due to expansion there are now vacancies for Technicians experienced in this field and top salaries plus fringe benefits are being offered.

For further details please phone or write, giving qualifications and experience to:

MAVIS LTD.,
11a Sharpleshall Street,
London N.W.1.
Tel. 722 7161.

3327

Recording Studio Maintenance Engineer

This is an important position in an international company involving interesting work with a small team concerned with the maintenance of all sound equipment in the studio.

Previous experience is necessary and it will be rewarded by an attractive salary and fringe benefits.

CBS

Ring the Studio Manager on 01-636 3434
—or, if you prefer, write to him at
CBS Records,
31–37 Whitfield Street, London W1.

3618

HI-FI ENGINEERS

This could be the opportunity you've been looking for. Due to continued expansion we are looking for experienced engineers to join our teams in Liverpool, Manchester and Preston.

You will be fully experienced in servicing a wide range of audio equipment and will be capable of supervising a modern, busy workshop.

Salary negotiable around £1,750.

Assistance with re-location expenses will be given by the company.

HARDMAN RADIO

Applications in writing to
The Managing Director
Hardman Radio
33 Dale Street
Liverpool L2 2HF

3551

RADIO OPERATORS

Leaving the Service in the next 18 months? If your trade involves radio operating, you qualify to be considered for a Radio Officer post with the composite signals organisation.

On satisfactory completion of a 7 months specialist training course, successful applicants are paid on a scale rising to £2,893 p.a.; commencing salary according to age—25 years and over £2,126 p.a.

During training salary also by age, 25 and over, £1,607 p.a. with free accommodation. The future holds good opportunities for established status, service overseas, and promotion.

Training courses commence at intervals throughout the year. Earliest possible application advised.

Applications only from British born U.K. residents up to 35 years of age (40 years if exceptionally well qualified) will be considered.

Full details from :

Recruitment Officer,
Room A/1105,
Government Communications Headquarters,
Priors Road, Oakley, Cheltenham,
Glos., GL52 5AJ.
Telephone Cheltenham 21491 Ext. 2270.

92

WORK IN CENTRAL AMERICA

RADIO ENGINEERS AND TECHNICIANS NEEDED IN HONDURAS AND GUATEMALA

The local Radio Stations in Guatemala and Honduras transmit classes in agriculture, adult literacy, and simple health topics, to the people in the rural areas—approximately 90% of the population.

The training of local people to maintain the transmitters and to deal with the technical production of the programmes is being carried out by four British volunteers. We need people to replace them for a further two-year period.

Information: Frances Chadwick, Overseas Volunteers/CIIR, 41 Holland Park, London, W.11. Tel: 01-727 3195. Visitors welcome.

3630

LEEDS POLYTECHNIC
EDUCATIONAL TECHNOLOGY UNIT

(Re-advertisement)

Recording Services Technicians T4

(£1,644 - £1,926)

(according to qualifications and experience)

Ref. 13/17

To operate and maintain the off-air recording service and maintain the television equipment used in the distribution system for all video recording. Must be able to maintain hetical scan VTRs.

Application forms (quoting ref. no.) together with further details may be obtained from the Administration Officer, Leeds Polytechnic, Calverley Street, Leeds LS1 3HE, and should be returned as soon as possible.

3608

BOTSWANA
BROADCASTING ENGINEER

With either a Final City and Guilds Certificate in Telecommunications, HNC, Engineering Diploma, or equivalent, and five years experience of installation and maintenance of studio equipment is required for operational, maintenace and training duties. He must be conversant with all studio equipment and be capable of diagnosing faults and carrying out repairs. He is required to negotiate with Posts and Telecommunications engineers for Outside Broadcast circuits and to establish technical facilities at OB locations. The duties also include drawing up training schemes for local Technical Assistants, normal instruction and 'on the job' training.

SALARY in the range £2,470 to £3,740 p.a. which includes an allowance, normally tax free, of £640 to £1,340 p.a. Terminal gratuity 25% on basic salary. For a married man with two children paying tax at the standard rate the total emoluments described above, including gratuity, approximate to a gross (i.e. before tax) UK return of £4,100 to £5,500 and for a single man about £3,700 to £4,900 p.a.

Other benefits include: Low local income tax, generous paid leave, subsidised accommodation, free family passages, children's education allowances and holiday visit passages, tour 2-3 years, appointment grant up to £200 and car loan up to £600 normally payable.

The post described is partly financed by Britain's programme of aid to the developing countries administered by the Overseas Development Administration of the Foreign and Commonwealth Office.

For further particulars you should apply, giving brief details of experience to

crown agents

M Division, 4 Millbank, London SW1P 3JD, quoting reference number M2K/740234/WF

3600

Electro-Medical Service
Department requires

ENGINEERS

for testing and servicing electronic apparatus. Applicants should be aged 20-30, and should be of O.N.C. standard.

Apply in first instance in writing to:

SIEREX LIMITED
Electro-Medical Department,
Heron House, Wembley Hill Road,
Wembley, Middlesex, HA9 8BZ

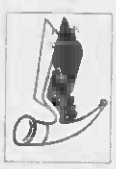
3244

Avionics Inspector

Due to continued growth and expansion in our Avionics Service Centre, an interesting opportunity exists for an experienced electronic test engineer to join our Quality Control team as Avionics Inspector.

Have You?:

ONC or equivalent.
Practical electronic equipment experience including calibration.
Working knowledge of Ministry and C.A.A. procedures.



If so, you could be the engineer we are seeking.

Attractive salary negotiable from £2,200.
3 weeks' paid annual leave, excellent sickness benefits and contributory pension scheme.

Please apply immediately for interview:
Mr. M. J. Hinge, FieldTech Limited, Heathrow Airport (London), Hounslow, TW6 3AF. Tel: 01-759 2811, ext 28.

3548

TECHNICIAN
CARDIFF
£1,416-£1,644 (Tech 3)

required to work in the Llandaff College of Technology in the Marine Electronics Section of the Maritime Studies Department. Experience required in the installation, maintenance and repair of the electronic equipment as installed on ships of the Mercantile Marine. An M.R.G.C. or P.M.G. certificate preferred, but other electronic qualifications would be considered.

Application forms are available from the Personnel Officer, County of South Glamorgan, City Hall, Cardiff, CF1 3ND (Telephone Cardiff 31033, ext. 454) and must be returned within 10 days of the appearance of this advertisement.

COUNTY OF SOUTH GLAMORGAN

3668

SCOTTISH HOME AND HEALTH DEPARTMENT

WIRELESS TECHNICIAN

Applications are invited from men, aged 17 or over, for four posts of Wireless Technician in the Scottish Home and Health Department. The location of the posts are—1 in Edinburgh, 1 in Inverness, and 2 in East Kilbride.

QUALIFICATIONS: Sound theoretical and practical knowledge of Wireless Engineering, including HF, VHF and UHF and Communications equipment generally. Possession of an HN or C & G Certificate an advantage but provision may be made for those who wish to continue their studies for one of these qualifications. The work involves installation and maintenance of equipment located a considerable distance from headquarters. Candidates must be able to drive private and commercial vehicles and have a clean driving licence.

SALARY: £1,253 (age 17) to £1,836 (age 25 or over); scale maximum £2,158. These are unestablished appointments with prospects of establishment after one year's continuous satisfactory service.

Application forms and further information may be obtained by writing to the Scottish Office Personnel Division, Room 220, 22/25 Queen Street, Edinburgh EH2 1LY quoting reference PM4/4/74. Closing date for receipt of completed application forms is 16 May 1974.

3626

Electronics Engineers

Audio

Engineer required for design and development of high quality audio equipment for home and professional use.

Laboratory Instruments

Engineer required for design and development of laboratory measuring instruments and power supplies.

TECHNICIAN

A technician or junior engineer is required for general duties in drawing office and factory liaison in the manufacture of audio equipment, laboratory instruments and power supplies.

Based at factory in Bristol.

Write in first instance giving qualifications and experience:

RADFORD ELECTRONICS, LTD.,
Bristol, BS3 2HZ

[3658

Electronics Appointments Register

Why are you looking for a job, when we've got a job looking for you?

Even if you scour the Sits Vac columns you won't find all the good jobs to fit your qualifications. Because the best jobs aren't always advertised.

More and more companies are using the Electronic Appointments Register to find qualified men and women.

Join one of our Registers and soon you could be on a short list for a better job. Our confidential service costs you nothing.

Send in the coupon—we'll mail you by return.

GAR Graduate Appointments Register

Please send me details of how to enrol on one of your Appointment Registers:

Name

Address

Age limits 20-45. WW7

Post to G.A.R. 76 Dean Street London W.1. 01-734 6536

3468

Senior Estimator

Telecommunications

is required to work in our Technical Services Dept. He will be responsible for cost estimating of installation and maintenance work for both audio and telephone equipment.

Practical experience in a similar activity is essential and an O.N.C. or City & Guilds in telecommunications is desirable.

The successful applicant will be based at our new offices in Cambridge, but must be willing to travel. A company car, plus attractive salary will be provided.

Please telephone or write to:
John Bell, Personnel Manager,

Pye Business Communications Ltd
Cromwell Road, Cambridge CB1 3HE. Tel: Cambridge (0223) 45191

3655

Run your own hi-fi store

A unique opportunity to become the outright owner of a franchise that's the first of its kind in Britain.

Tandy Corporation (Branch UK) is completely new to Britain. A division of the Tandy Corporation of America, where its 'Radio Shack' operation has now grown to approaching some 2,000 outlets.

Nowhere else will you find a similar operation, because a Tandy franchise is your very own business.

You'll be selling exclusive Tandy brands of radio, audio and communications equipment, plus parts and kits. All of the highest possible quality, yet so competitively priced that you can be assured of high volume and substantial profits within a surprisingly short time.

Previous radio trade experience is not essential. You get the full benefit of Tandy's 50 years' experience—covering everything from your grand opening to everyday routines—plus regular newspaper advertising and full merchandising and promotional support.

A minimum of £14,000 initial investment is required.

Company-owned and managed shops are now actively trading and are available for franchise in Birmingham, Coventry, the Potteries, West Midlands and Manchester areas. Additional shops will also shortly be available for franchise in Bristol, Cheltenham, Doncaster, Gloucester, Liverpool, Nottingham and Worcester.

If you would like more information, please write in confidence to the Senior Vice-President, Mr. Richard O'Brien.

TANDY

TANDY Corporation (Branch UK), Briston Rd. Wednesbury, WS10 7JN, Staffs

3566

Hayes Middlesex

A major programme of expansion has created a number of new opportunities for engineers to join our development teams.

The EMI-SCANNER computerised X-ray system, introduced by EMI LIMITED in 1972 and since acclaimed by leading neurological hospitals in Europe and the United States as a major breakthrough in diagnostic radiology, has now surpassed the £8 million mark in export orders.

EMI

The international music, electronics and leisure Group.

Engineers for X-ray Systems

Project Leaders

Experienced team leaders with proven managerial ability are required to plan and control the progress of development teams building advanced prototype equipment. The work will require the use of modern management techniques.

Candidates, qualified to degree/HNC level should have a good background in digital and analogue development work but some experience in minicomputers andmechanics would be an advantage.

An appreciation of the problems and requirements of putting electronic equipment into production is most essential.

Project Development Engineers

Engineers are required to join project development teams engaged in putting advanced prototype equipment into production. The work involves development and production engineering during the pre-production run of equipment containing analogue, digital and mechanical hardware.

Candidates, qualified to degree/HNC level should have a good background in the development and production of electronic capital goods. Some experience in minicomputers would be an advantage.

Senior Development Engineer

We require a senior man qualified to degree/HNC level to take part in and control the progress of hardware and software developments requiring the use of modern management techniques.

He will have several years experience in analogue and digital circuit design and should be familiar with use of minicomputers. Some experience in mechanical design would be an advantage. The man appointed must be acquainted with the processes and the problems of putting electronic capital goods into production.

Development Engineers

Engineers are required for hardware developments. This will principally include analogue and digital circuit design but some mechanical work will be involved. Some programming experience with minicomputers would be an advantage.

Candidates, should be qualified to degree/HNC level with at least three years experience in a similar field.

American I.R. 100 Award 1973

Attractive salaries appropriate to experience and qualifications will be offered. These could be up to £4,000 for exceptional candidates. There are good fringe benefits including a contributory Pension Scheme and assistance with removal expenses where appropriate. Please write giving brief details of career to: **Mr. K. E. Goodman, Personnel Department, EMI LIMITED, 135, Blyth Road, Hayes, Middx.**

3669

UNIVERSITY OF DURHAM

Department of Applied Physics and Electronics

Applications are invited for the post of

SENIOR DEMONSTRATOR

to supervise the Electronics Laboratory and demonstrate in it. The post is tenable from 1 October 1974 for two years in the first instance renewable for a third and final year.

Salary on the scale £1,719-£2,613 plus F.S.S.U. benefits.

Applications (3 copies), naming three referees should be sent by 3 May 1974 to the Registrar and Secretary, Science Laboratories, South Road, Durham, from whom further particulars may be obtained. 3673

Technical Publications Assistant

We require a Data Sheet Writer/Editor to compile information and write product data sheets, write and produce leaflets, operating manuals and similar technical publications. Applicants should be qualified to ONC/HNC level in Electrical or Electronic Engineering. A knowledge of electronic tubes would be an advantage.

Applications in writing to:
Mr. R. E. Hinsley,
Personnel Officer,
English Electric Valve Co. Ltd., Chelmsford, Essex.

3650

English Electric Valve Co. Ltd.

British Solomon Islands
RADIO TECHNICIAN

Required by the Posts and Telecommunications Department to be responsible to the Senior Technician for workshop construction, manufacture, modification, installation and maintenance of electronic equipment such as transmitters, receivers, radar, distance measuring equipment, aerials and auxiliary apparatus.

Candidates must have passed a five year trade course or have equivalent services qualifications and three years field or factory experience. Knowledge of air navigation aids and raido teletype an advantage.

SALARY in the range £2,460 to £3,350 p.a. which includes an allowance, normally tax free, of £1,310 to £1,550 p.a. Terminal gratuity 25%. For a married man with two children paying tax at the standard rate the total emoluments described above, including (gratuity, approximate to a gross (i.e. before tax) UK return of £3,800 to £5,250 and for a single man about £3,000 to £5,400 p.a.

Other benefits include—low local income tax, generous paid leave, subsidised accommodation, free family passages, childrens education allowances and holiday visit passages, tour 2 years, appointment grant up to £200, car loan £600 and outfit allowance up to £80 normally payable.

The post described is partly financed by Britain's programme of aid to the developing countries administered by the Overseas Development Administration of the Foreign and Commonwealth Office.

For further particulars you should apply, giving brief details of experience to

crown agents

M Division, 4 Millbank, London SW1P 3JD, quoting reference number M2K/740259/WF

[3613

EAST SUSSEX COUNTY COUNCIL
BRIGHTON TECHNICAL COLLEGE
FACULTY OF ENGINEERING
ELECTRICAL ENGINEERING DEPARTMENT

SENIOR TECHNICIAN

Required as soon as possible for work in the Radio and Television Laboratories. Applicants must possess a City & Guilds Final Certificate in radio and television servicing and have had relevant practical experience. Salary within the T4 Scale (£1,644-£1,926), according to age, experience and qualifications. An additional allowance is payable for approved qualifications.

Application form and details available from Chief Administrative Officer, Brighton Technical College, Pelham Street, Brighton, BN1 4FA. Tel: Brighton 685971.

Applications to be returned within ten days of advertisement.

[3667

FOREIGN AND COMMONWEALTH OFFICE
COMMUNICATIONS OFFICERS

APPLICATIONS ARE INVITED TO FILL VACANCIES IN THE TELECOMMUNICATIONS BRANCH OF HM DIPLOMATIC SERVICE.

Member of the telecommunications branch serve in more than 60 diplomatic missions overseas and also in the UK.

Applicants should be skilled in the operation of HF radio communication equipment and be competent at sending and receiving the Morse code. They should produce evidence of a sound knowledge of radio and electronic theory, e.g. MPT/PMG grade I or equivalent City & Guilds certificates. Successful candidates will receive training on specialised equipment before taking up overseas appointments.

Futher particulars may be obtained from:

Communications Administration Department,
Foreign and Commonwealth Office,
Hanslope Park, HANSLOPE,
Milton Keynes MK19 7BH.

[3604

SITUATIONS VACANT

CAN YOU WRITE CLEAR, concise technical handbooks? If you think you could, and have a thorough understanding in electronics, why not join us as a technical author. Obviously, previous experience would be an advantage but is not necessary as full training would be given. We have vacancies in many parts of the country. Starting salaries are high with excellent prospects for advancement. Box No. WW 3414.

ELECTRONICS MAINTENANCE ENGINEER required for major London studios. Must be willing to travel at moment's notice. Ring 229 2345. [3612

HI-FI AUDIO ENGINEERS. We require experienced Junior and Seniors and will pay top rates to get them. Tell us about your abilities. 01-437 4607. [19

PIANO P.C.B.'s for W.W. Electronic pianos. Enquiries to Baldock Electronics, 23 Turpins Way, Baldock, Herts. Tel: Baldock 2559. [3670

YOUNG ELECTRONICS TECHNICIAN required for the construction, testing and servicing of electronic equipment at our works in N.W.1. Very varied work. Qualifications: ONC or C&G or ex-apprentice or similar desirable. Excellent opportunity for right person with a small expanding company. Please write for an application form to: Young Electronics Ltd., 54 Lawford Road., London. NW5 2LN. [3641

SITUATIONS WANTED

EXPERIENCED Radio, TV and CTV, hifistereo Service Engineer—Dutch Nationality—seeks per 1st August 1974 a suitable position in Holland or abroad after his return from West Africa. He is 28, married with one child. Is in possession of Certificate N.E.R.G. (British Equivalent for Communication Technician) and studying for M.T.S. (Technical Schooling) application). Used to be responsible for a Service Department. Please send reactions with salary statement to Box WW 3638 of this magazine.

ANNOUNCEMENT

REWARD for information leading to the recovery of the following stolen instruments. Cossor 'scope CDU110 serial No. 1213. Solartron DVM A223 serial No. 401238. avo meter MK8 serial No. 34813. Telephone 01-352 5623. [3617

ARTICLES FOR SALE

AARVAK ELECTRONICS. 3-channel sound-light converters, from £18. Strobes, £25. Rainbow Strobes, £132.—12A Bruce Grove, N17 6RA. 01-808 9096. [23

BACK numbers of Wireless World, 1950 to 1973 inclusive, with odd issues missing. Offers invited, buyer collects. Craigmore, East End, Witney, Oxfordshire. Tel. Freeland 882135. [3614

BUILD IT in a DEWBOX quality plastic cabinet 2 in. x 2½ in. x any length. D.E.W. Ltd. (W.), Ringwood Rd., Fernwood, Dorset. S.A.E. for leaflet. Write now—Right now. [76

CONSTRUCTION AIDS—Screws, nuts, spacers etc., in small quantities. Aluminium panels punched to spec. or plain sheet supplied. Fascia panels etched aluminium to individual requirements. Printed circuit boards—masters, negatives and board, one-off or small numbers. Send 6p for list. Ramar Constructor Services, 29 Shelbourne Road, Stratford on Avon, Warwks. [28

HEWLETT PACKARD 565A digital recorder, £60; Solartron LM1426 digital voltmeter, £75; Marconi wobbulator TF 1104/1, £40; I.C.L. 80 column punch, £30; I.B.M. 80 column card reader, £120; creed 7B teleprinters, £12; Record pen chart recorder, £15. Denby, 104 Rooley Lane, Bradford, Yorks. [3672

HIGH voltage equipment for sale. Oil filled capacitors, 0.25mfd., 32.5KV DC working, price £10 each. Ribbed porcelain standoff insulators, 60p each. Carriage extra. Box: WW 3645.

LADDERS 8ft 10in closed—21ft extended, £23.54, delivered. Home Sales Ladder Centre (WW2), Haldane (North) Halesfield (1) Telford, Shropshire. Tel: 0952-586644. [23

NORDMENDE Globetraveller II. 11 shortwave bands V.H.F., M.F., L.F. superb world wide reception, nearly new, £50 or offer. Harpenden 64463. [3623

PRINTED Circuit Board in 6 widths: 2 in., 2½ in., 3 in., 3½ in., 4 in. and 5 in. x any length; 1/16 in. single-sided fibreglass, 2p per 3 sq. in. Double-sided 1p per sq. in. P & P 5p per order. SAE quotations for other sizes and quantity discounts.—J. Knopp, 11 Connaught Gardens, Braintree, Essex, CM7 6LY. Tel. Braintree 25254. [15

SUPERB Instrument Cases by Bazelli, manufactured from heavy duty PVC faced steel, choice of 30 types, send for free list. Bazelli Instrument Cases, Dept. 22, St. Wilfrids, Foundry Lane, Halton, LA2 6LT, near Lancaster. [3646

Classifieds continued on page 111

ARTICLES FOR SALE

For ££'s more profit just look at these prices!

Big Savings on TOSHIBA Valves

Type	Goods Price
DY 87	27p
DY 802	27p
EB 91	10p
ECC 82	27p
EF 80	28p
EF 183	32.5p
EF 184	32.5p
EH 90	29.5p
PCC 89	38p
PCC 189	39p
PCF 80	30p
PCF 86	37p
PCF 801	40p
PCF 802	38p
PCL 82	37p
PCL 84	31p
PCL 85	37.5p
PCL 86	38.5p
PFL 200	48.5p
PL 36	53p
PL 84	24p
PL 504	56p
PL 508	57p
PY 88	34p
PY 800	27p
PC 900	23.5p

Valves packed individually

Semi-Conductors

Type	Goods Price
AC 127	17p
AC 128	15p
AC 141K	30p
AC 142K	30p
AC 151	20p
AC 154	18p
AC 155	18p
AC 156	20p
AC 176	22p
AC 187	19p
AC 187K	30p
AC 188K	30p
AD 142	45p
AD 149	40p
AD 161	38p
AD 162	38p
AF 114	24p
AF 115	23p
AF 116	23p
AF 117	23p
AF 118	50p
AF 139	42p
AF 178	45p
AF 180	45p
AF 181	45p

Type	Goods Price
AF 239	45p
BA 145	14p
BC 107	11p
BC 108	11p
BC 109	12p
BC 113	25p
BC 116	25p
BC 117	20p
BC 125	25p
BC 132	25p
BC 135	20p
BC 137	25p
BC 138	40p
BC 142	26p
BC 143	30p
BC 147A	08p
BC 148	08p
BC 149	12p
BC 153	20p
BC 154	22p
BC 157	12p
BC 158	10p
BC 159	14p
BC 173	18p
BC 178B	20p
BC 182L	12p
BC 183L	12p
BC 187	28p

Type	Goods Price
BC 214L	15p
BD 124	70p
BD 131	45p
BD 132	45p
BF 115	20p
BF 160	20p
BF 167	20p
BF 173	25p
BF 178	35p
BF 179	40p
BF 180	35p
BF 181	35p
BF 184	21p
BF 185	21p
BF 194	15p
BF 195	15p
BF 196	20p
BF 197	17p
BF 200	25p
BF 218	30p
BF 224	35p
BF 258	40p
BF 337	35p
BFY 50	22p
BFY 52	20p
BSY 52	35p
BY 126	11p
BY127	12p

Type	Goods Price
E. 1222	30p
IN 60	05p
OA 202	7·5p
OC 71	15p
OC 72	15p

Type	Goods Price
BU 105/02	£2.40
2SC1172B	£2.40
R2008B	£2.00
R2010B	£2.00

EHT RECTIFIER TRAY ASSEMBLIES

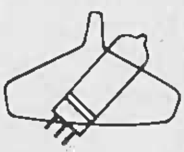
Type	Goods Price
1TH Decca Col.	£4.50
ITN GEC/Sobell	£4.50
2TQ 1400 - 950 Mk II	£1.85
2TAK 1500 5 Stick	£2.00
2DAF 1500 3 Stick	£1.85
2HD 950 3 Stick	£1.70
11 TAM Philips G8	£4.50
TCQ Pye/Ekco	£3.50
11 TAQ ITT/KB	£4.50
3 TCU BRC 3000	£5.00
11 TAZ GEC 2010	£5.35

12 MONTHS GUARANTEE

COLOUR TUBES

Type	Goods Price
19" A49/191X C.C.R.T.	£38.70
20" 510DJB22 C.C.R.T.	£39.80
22" A56/120X C.C.R.T.	£44.30

FULLY GUARANTEED



cpc

All goods subject to settlement discount of 5% 7 days and 2% monthly.

New Price List from 1st December 1973

Combined Precision Components (Preston) Ltd.
194-200 North Road, Preston PR1 1YP
Telephone 55034 Telex No. 67129

PRICES SUBJECT TO 10% VAT 83

PRECISION POLYCARBONATE CAPACITORS

Close tolerance. High stability. Extremely low leakage. All 63V D.C. Plus or minus 1% tolerance: 0.47µF-56p; 1·0µF-66p; 2.2µF-80p; 4·7µF-£1·30; 6.8µF-£1·64; 10.0µF-£2.00; 15µF-£2.75. Also available ±2% and ±5%, ex. Stock.

TANTALUM BEAD CAPACITORS: Values available: 0.1, 0.22, 0.47, 1.0, 2.2, 4.7, 6.8µF at 15v/25v or 35v. 10.0µ at 16/20v or 25v; 22.0 µF at 6/10v or 16v; 33·0 µF at 6v or 10v; 47·0µF at 3v or 6v; 100µF at 3v.
All at 10p each; 10 for 95p; 50 for £4.00.

TRANSISTORS: BC107, BC108, BC109; all at 9p each; 6 for 51p; 12 for 96p. May be mixed for quantity price. BC182 and BC212 at 10p each; AF178 at 30p each. All brand new and marked. Full spec. devices.

POPULAR DIODES IN914—6p each; 8 for 45p; 18 for 90p. IN916—6p each; 6 for 45p; 14 for 90p. IS44—5p each; 11 for 50p; 24 for £1. All brand new and marked.

NEW LOW PRICE—400 mW Zeners. Values available 4·7, 5.6, 6.8, 7.5, 8.2, 9·1, 10, 11, 12, 13.5, 15V. Tol. ± 5% at 5 mA. All new and marked. Price 7p each; 6 for 39p; 14 for 84p. Special offer 6 of each voltage (66 zeners) £3.65.

RESISTORS. Carbon film 5%. ½ W at 40°C, 1/3W at 70°C. Range from 2.2Ω to 2.2MΩ in E12 series, i.e. 10, 12, 15, 18, 22, 27, 33, 39, 47, 56, 68, 82 and their decades. High stability, low noise. All at 1p each; 8p for 10 of any one value; 70p for 100 of any one value. Special pack—10 of each value 2·2Ω to 2·2MΩ (730 resistors) £5.

440V A.C. CAPACITORS. 0.1µF, size 1¼in × ⅝in. 43p; 0.25µF, size 1½in × ⅝in. 55p; 0.47 and 0.5µF, size 1½in × ¾in. 66p; 1.0µF, size 2in × 1in. 83p; 2·0µF, size 2in × 1in. £1.15p each.

SILICON PLASTIC RECTIFIERS 1·5 Amp. Brand new wire-ended DO27. 100PIV at 7p each or 4 for 26p; 400PIV at 8p each or 4 for 30p; 800PIV at 11p each or 4 for 42p.

7p post and packing on all orders below £5.00

Export Orders—please add cost of air/sea mail

PLEASE ADD 10% V.A.T. TO ALL ORDERS

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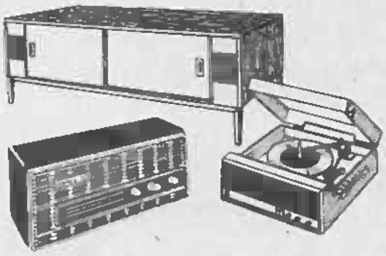
Articles For Sale—Continued

Classifieds continued on page 115

The items below are from the March Supplement to our 1974 Catalogue. You can receive this catalogue and the next 12 supplements by sending 66p.



STEREO RADIOGRAM CABINET
Long, Low and Modern. Teak veneered with sliding front and tapered legs. Speaker spaces each end. Size approx. 4' 2" X 18" X 15". Probably cost over £20 to make. Our Price **£8·10** each. We can arrange delivery within 200 miles if you can order 10 or more.

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Bush Ref. No. SRP 64. Separate bass and treble controls help give this unusually good sound quality. A suitable amplifier speaker unit converts this to full stereo. Cabinet size 7½" X 18½" X 18" deep. Finished in charcoal grey leather cloth. Fully transistorised with 8" X 5" speaker. Controls bass, on/off, treble and volume. Socket stereo. Makers recommended price £27·72. Our Price **£17·72.** A saving of over £10. Post and insurance £2.

ERRES TABLE RADIO
Dutch made. Three wavebands (L. M. & S.). Nice size (16½" X 8½" X 5") wooden cabinet with high gloss finish. 6" X 4" speaker gives better than average tone—these radios are very well made from good quality components and should not be confused with Hong Kong makes. They recently retailed at £18 each and were well worth it. The ones we have are brand new and working but have failed inspection because either they will work only on mains or only on batteries. It is unlikely that the fault is very much however and we are arranging for a circuit diagram. Price **£8·64** plus £1 post and insurance.

ELECTRIC WELDER
Big transformer in metal case with carrying handle and control switch, output through very heavy duty terminals. Output volts 1·9–4·25 volts max. 117 amps.—normal mains input socket for optional foot switch. **£19·80** plus £2 carriage up to 200 miles. A further £1 for each 100 miles extra.

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Upright mounting with fixing clamps, standard primary 240/200/195/160—**£2·80** plus 30p post and service.

MAINS TRANSFORMER
(6·5v–0–6·5v at 500 mA and 1v at 1 amp.) Normal tapped primary. Upright mounting with fixing lugs. **£1·00.**

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(18v–37v–39v–41v at 2 amp or this would function at 18v–0–18v.) Primary tapped 110, 115, 127, 200, 220 and 240v selected by labelled plug. Primary screen and multi-tapped. Upright mounting with fixing lugs **£2·08.**

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PHOTO RESISTOR
Mullard type. This drops its resistance from approx. 250K ohms in dark to only approx. 200 ohms in bright light but it is only quite small. In fact less than ⅛" square with leads coming out of corners on one side. Price **22p.**

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I.F. TRANSFORMERS
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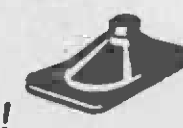

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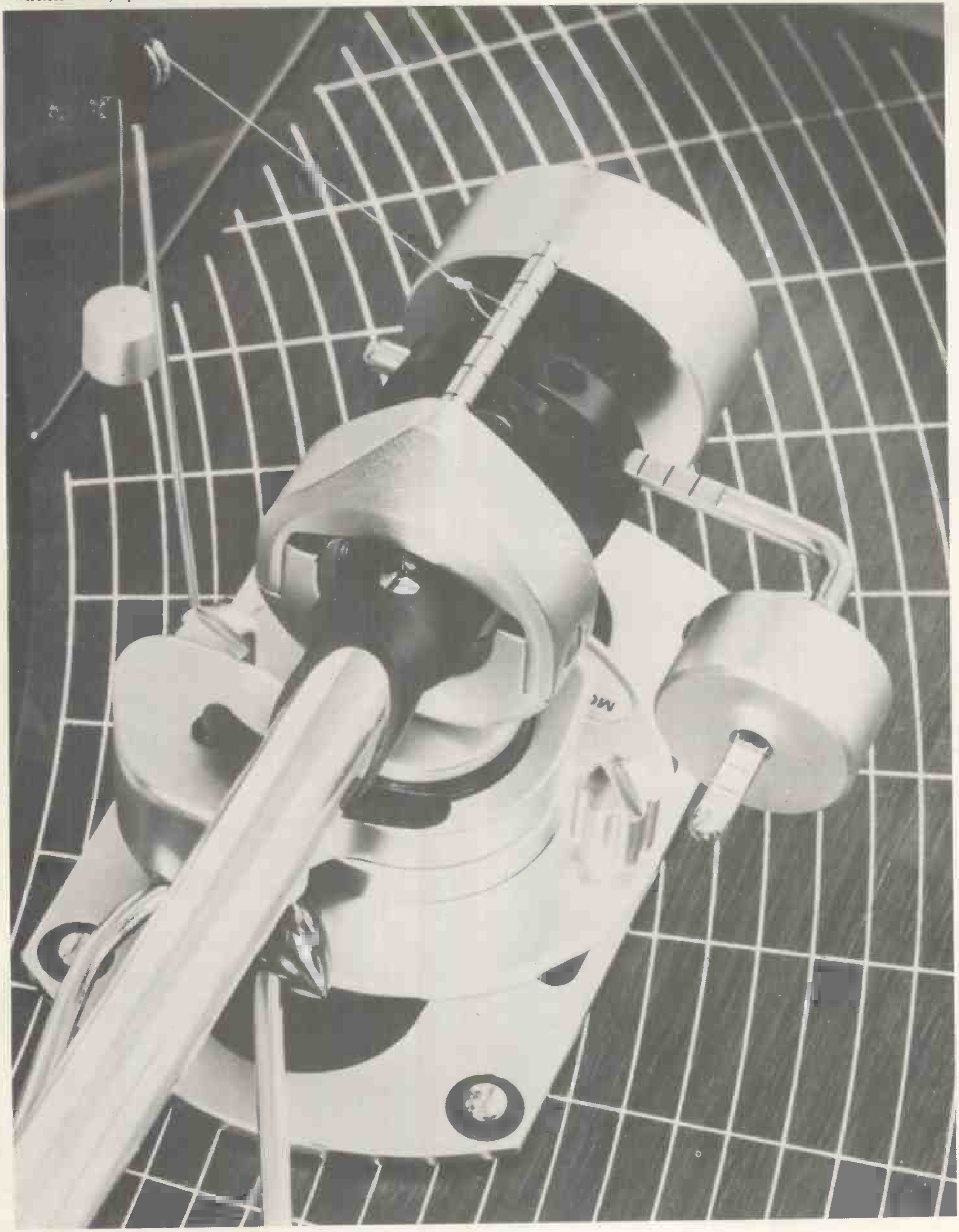

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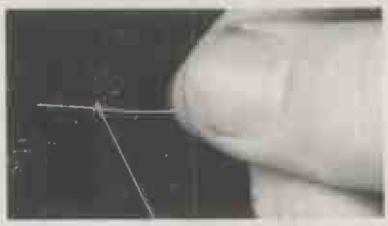

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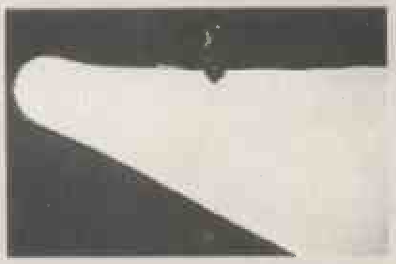

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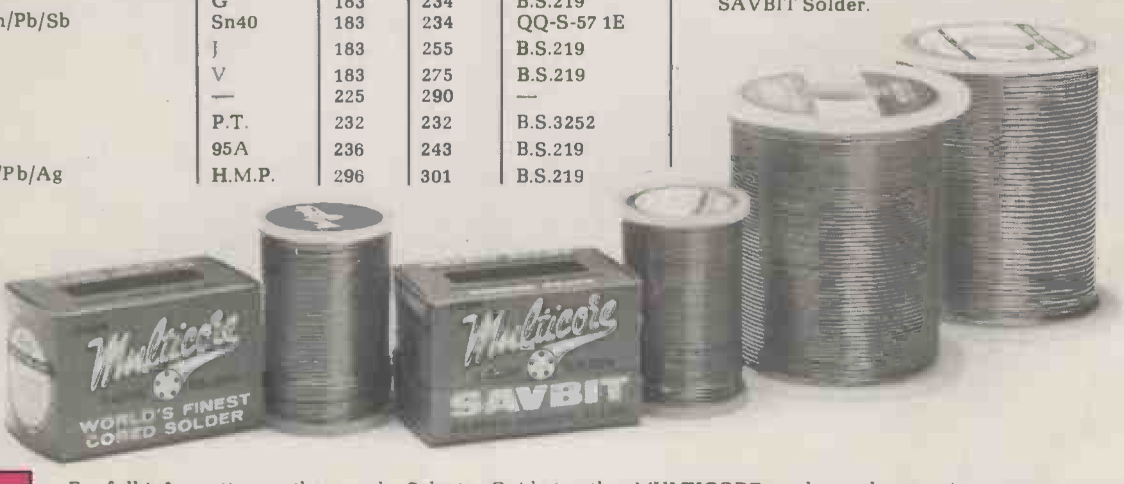
62/36/2 Sn/Pb/Ag	LMP	179	179	DIN 1707
62/35.7/2/0.3 Sn/Pb/Ag/Sb	Sn62	179	179	QQ-S-57 1E
63/36.7/0.3 Sn/Pb/Sb	Sn63	183	183	QQ-S-57 1E
60/40 Sn/Pb	K	183	188	B.S. 219
60/39.7/0.3 Sn/Pb/Sb	Sn60	183	188	QQ-S-57 1E
50/50 Sn/Pb	F	183	212	B.S.219
50/49.7/0.3 Sn/Pb/Sb	Sn50	183	212	QQ-S-57 1E
50/48.5/1.5 Sn/Pb/Cu	Savbit 1	183	215	DTD 900/4535 DIN 1707
45/55 Sn/Pb	R	183	224	B.S.219
40/60 Sn/Pb	G	183	234	B.S.219
40/59.7/0.3 Sn/Pb/Sb	Sn40	183	234	QQ-S-57 1E
30/70 Sn/Pb	J	183	255	B.S.219
20/80 Sn/Pb	V	183	275	B.S.219
15/85 Sn/Pb	—	225	290	—
Pure Tin	P.T.	232	232	B.S.3252
95/5 Sn/Sb	95A	236	243	B.S.219
5/93.5/1.5 Sn/Pb/Ag	H.M.P.	296	301	B.S.219



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