Wireless World

August 1971 17½p

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WW—001 FOR FURTHER DETAILS

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7V r.m.s. Sine or Square from 1Hz to 1MHz

FREQUENCY:	1 Hz to 1MHz in 12 ranges. Accuracy ± 2% ± 0·03 Hz.
SINE WAVE OUTPUT:	7Vr.m.s. reducible to < 200μV with R_s = 600Ω at all levels.
DISTORTION:	< 0·1% up to 5V output, < 0·2% at 7V from 10Hz to 100kHz.
AMPLITUDE STABILITY:	< ± 1% variation with frequency up to 300kHz.
SQUARE WAVE OUTPUT:	7V peak reducible to < 200μV. Rise time < 150nS.
SYNC. OUTPUT:	>1V r.m.s. sine wave in phase with the main output.
SYNC. INPUT:	± 1% frequency lock range per volt r.m.s. input.
SIZE & WEIGHT:	7″ high × 10¼″ wide × 5½″ deep. 10 lbs.

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Prices include batteries with 400 hour life. Mains power units are £10 extra.

Types TG200 and TG200M generate only sine waves. Types TG200M and TG200DM have a meter calibrated 0/2V, 0/7V and —14/+6dBm. Types TG200 and TG200D have a calibrated control instead of a meter.

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

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

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

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

CP50 AMPLIFIER. An all silicon transistor 50 watt amplifier for mains and 12 volt battery operation, charging its own battery and automatically going to battery if mains fail. Protected inputs, and overload and short circuit protected outputs for 8 ohms–15 ohms and 100 volt line. Bass and treble controls fitted.
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200 WATT AMPLIFIER. Can deliver its full audio power at any frequency in the range of 30 c/s–20 Kc/s ±1 dB. Less than 0.2% distortion at 1 Kc/s. Can be used to drive mechanical devices for which power is over 120 watt on continuous sine wave. Input 1 mW 600 ohms. Output 100–120 V or 200–240 V. Additional matching transformers for other impedances are available.

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WW—007 FOR FURTHER DETAILS

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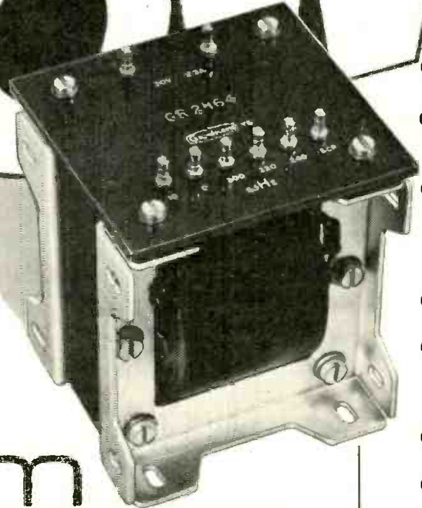

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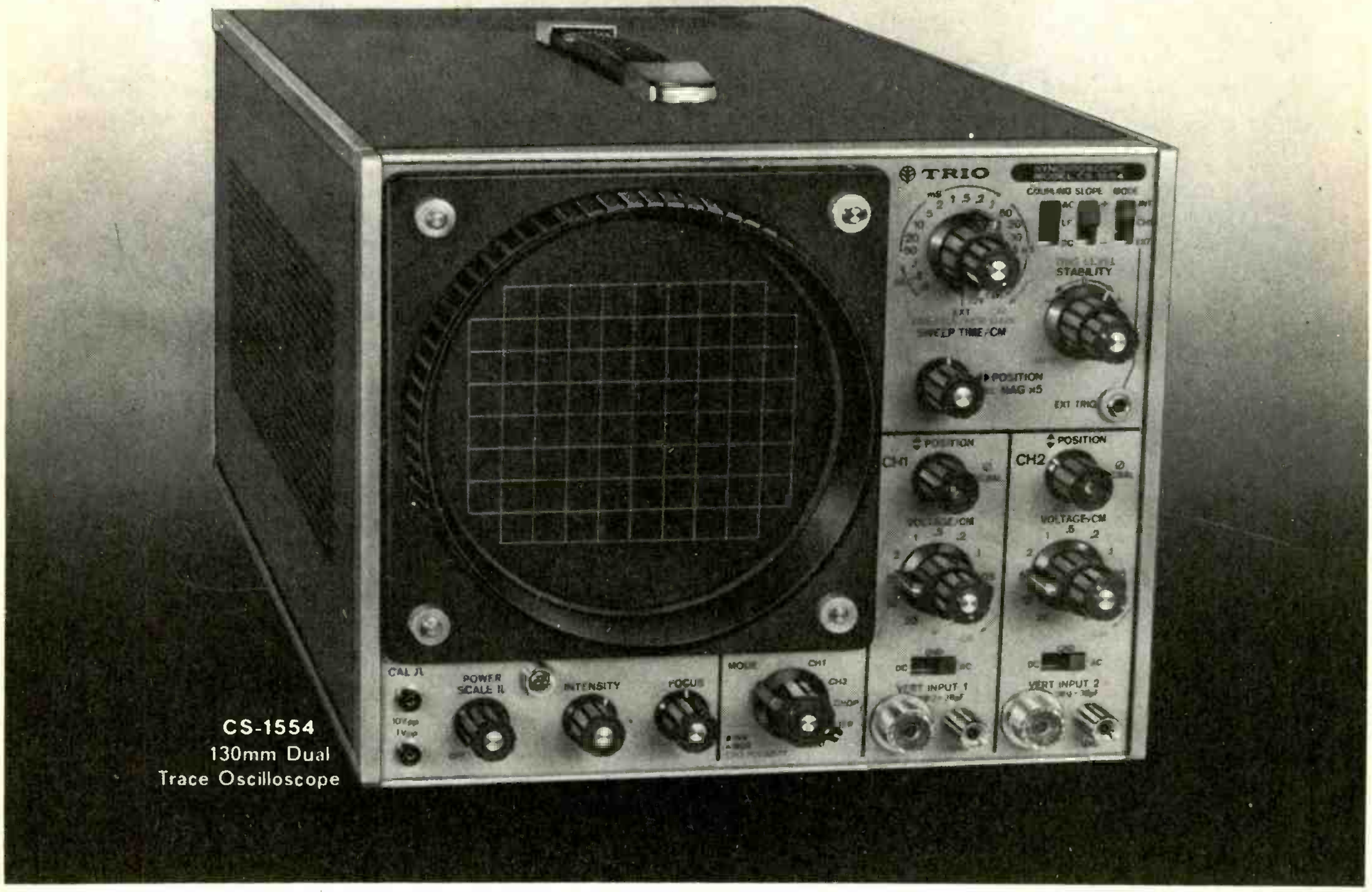

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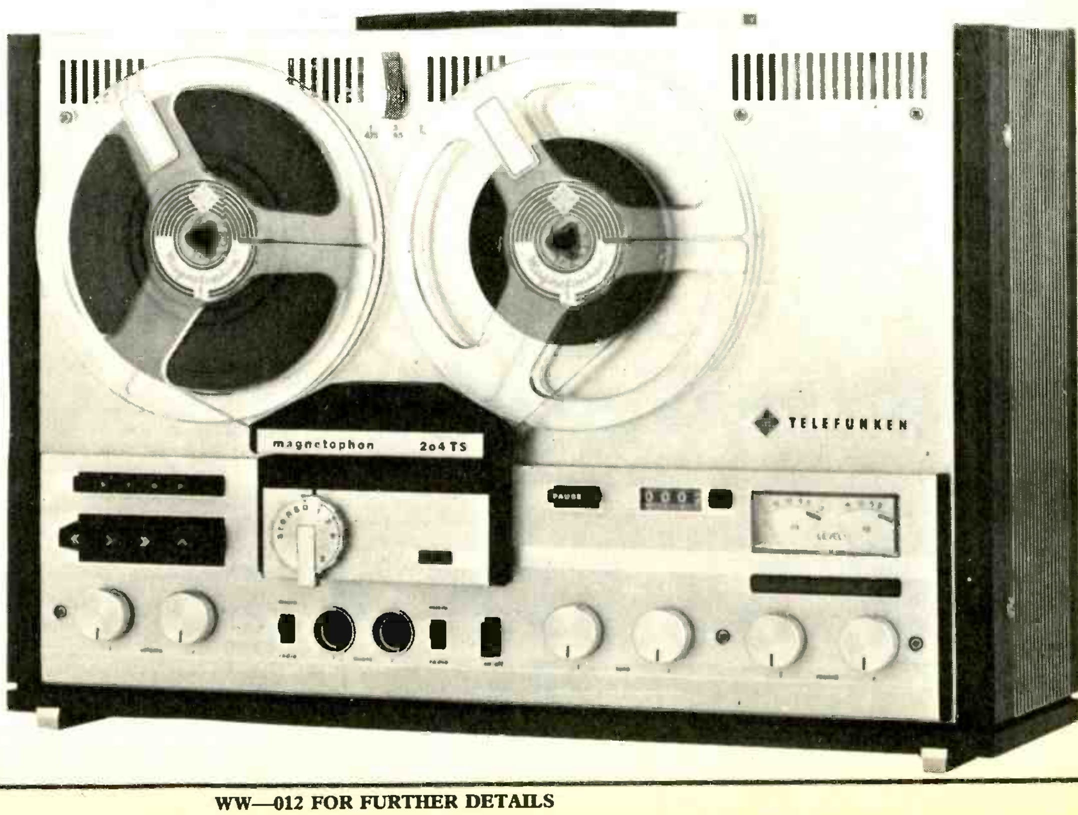

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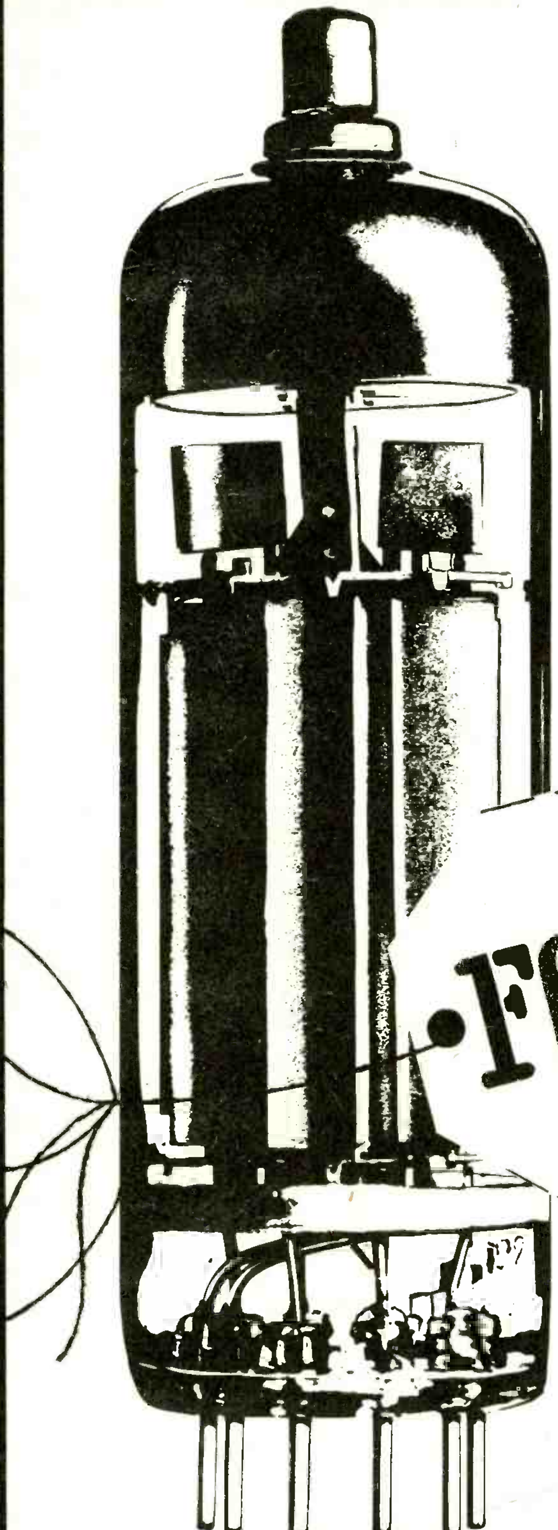

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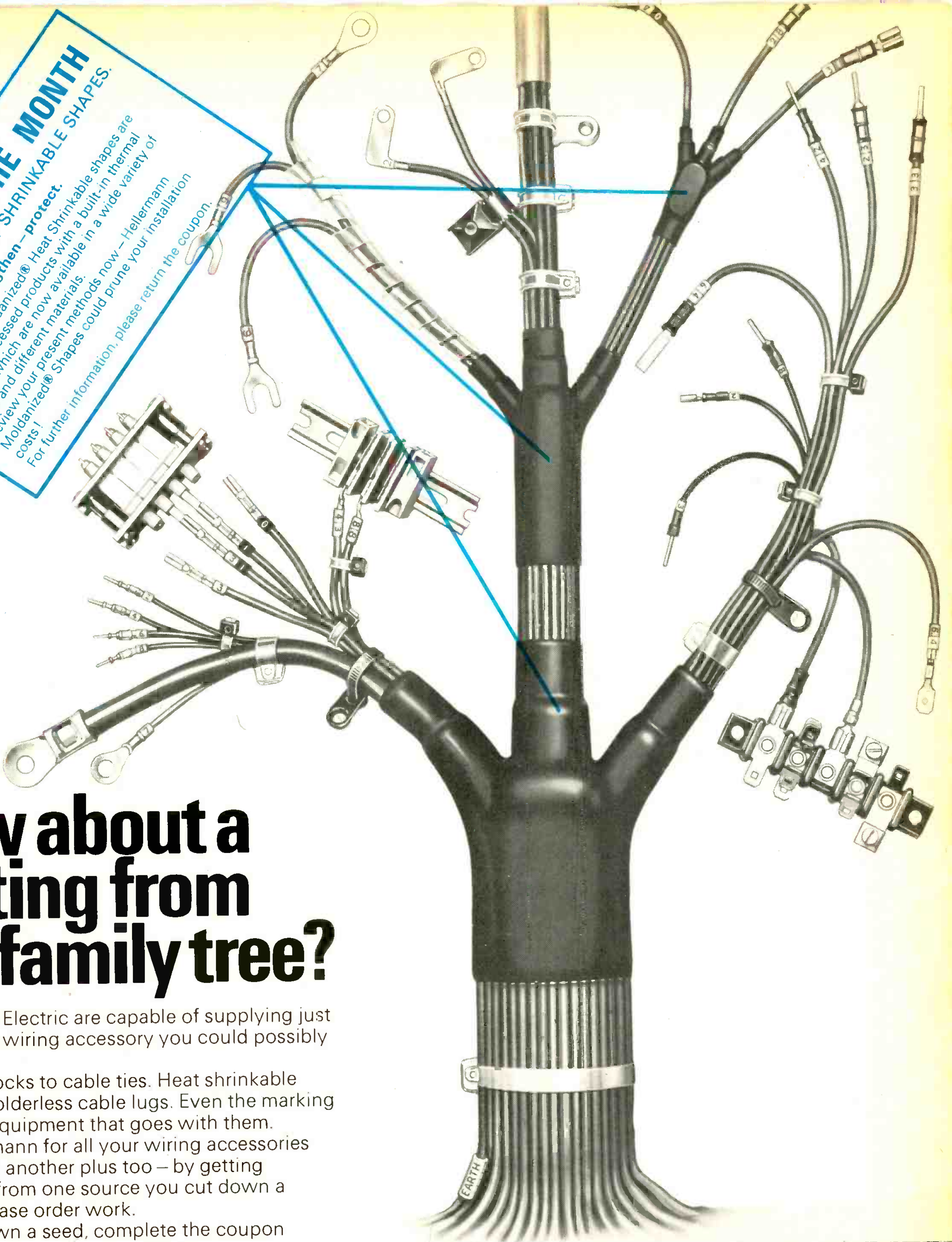

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WW 8/71

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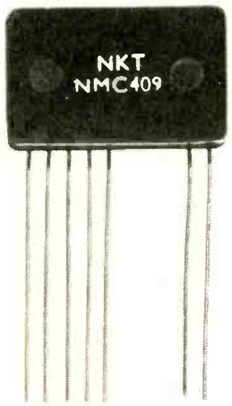


NMC 409

Slow Speed Eccles-Jordan "Divide-by-two"

This RST flip-flop is designed specifically for slow speed switching in industrial controls where standard monolithic TTL/DTL finds it difficult to cope with the large voltage transients arising and where the precise stabilised 5.1Vd.c. supply needed for TTL/DTL is difficult to provide (and costly). The NMC 409 can work on any unregulated supply of 6–24V, and is immune to fast voltage spikes because it is designed **not** to switch faster than 10 kHz.

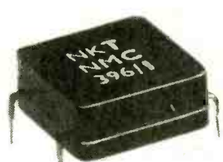
Size: 1.1" x 0.7" x 0.23". One-off price £2.50.

NMC 396

Precision 6V Regulator D.C. Supply

This self-contained d.c. voltage regulator provides a precise 6V, 150mA d.c. output from a 7–15V d.c. input. The hybrid assembly technique allows the output voltage to be set during manufacture typically to within 25mV of 6V (in contrast to the wider absolute tolerances unavoidable in monolithics). The NMC 396 has all the electrical robustness and stability of a discrete-component assembly and incorporates overload protection. Ideal for deriving a precise 6V from a 9 or 12V battery, it can also be fed from a standard d.c. power pack such as the NKT PC 101.

Size: 0.60" x 0.60" x 0.25". One-off price £2.50.

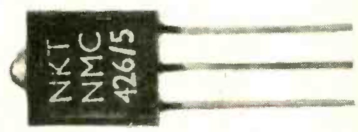


NMC 426

Optoelectronic Solid State Logic Indicator

This microcircuit is designed primarily to indicate visually the state of a binary logic circuit but can be used in any circuit calling for a visual indication of the existence or absence of a d.c. voltage at a test point. Completely self contained it only requires three connections to a nominal 5V d.c. supply, to earth and to the test point. The light display is a gallium arsenide phosphide solid state diode lamp with virtually unlimited life. The NMC 426 incorporates an internal d.c. amplifier enabling the light to switch on with an input drive of only 1μA or 2V, and it takes a current of only a few μA from standard TTL/DTL logic gates.

Size: 0.42" x 0.31" x 0.13". One-off price £2.83.



NMC 809A

Wide Band Amplifier

This wide band amplifier is a self contained d.c. feedback pair (with output buffer stage) with access to the internal feedback loop for response tailoring. The hybrid assembly technique enables the low frequency gain to be set in manufacture to precisely 22dB and gives a narrow gain spread difficult to achieve by monolithic techniques. Usable for bandwidths up to 50MHz, the NMC 809A employs the easily handleable standard dual-in-line package. Its thick film hybrid assembly eliminates the parasitic stray capacitances to earth unavoidable with monolithics and gives it the electrical stability and robustness of discrete component designs.

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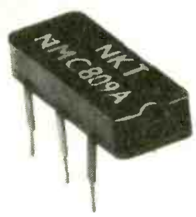

For further details contact one of the distributors listed below. (In the case of large scale requirements you can save time by referring direct to Newmarket.

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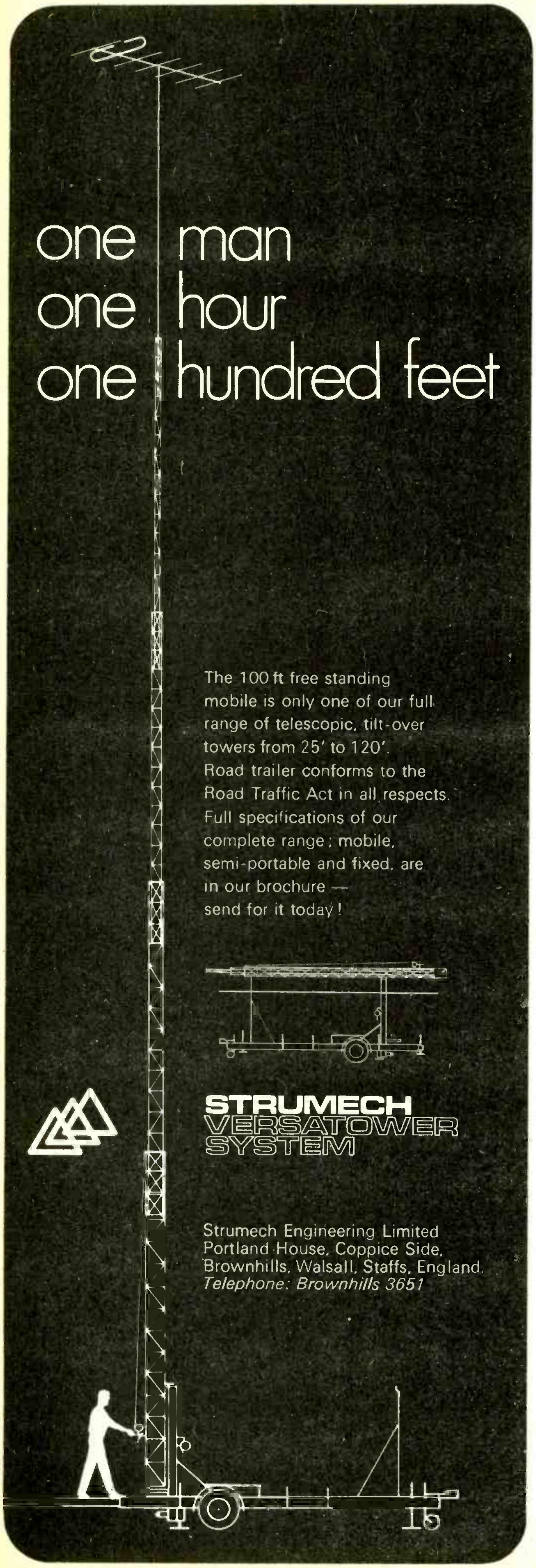

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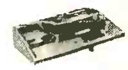

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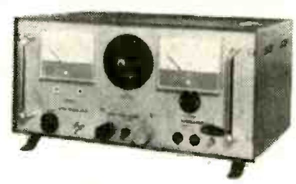

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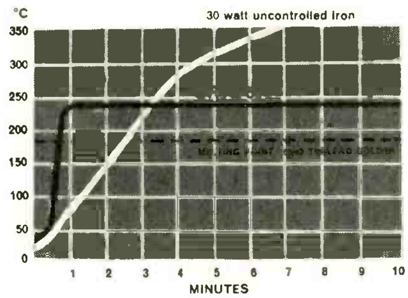

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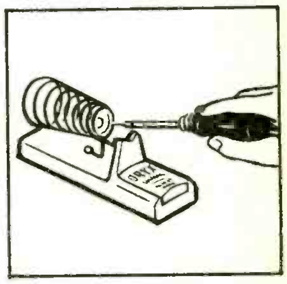

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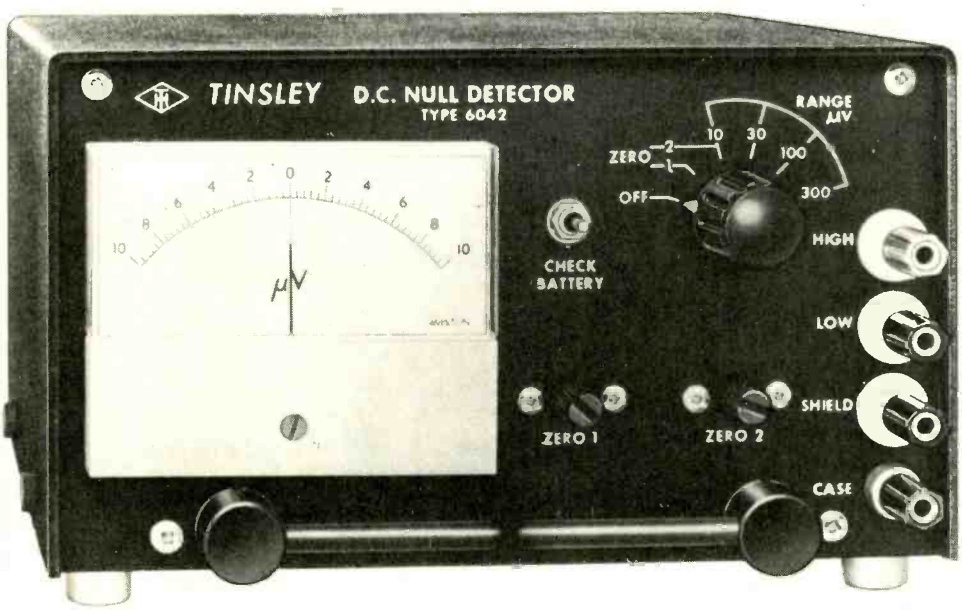

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Resolution 1 µV in 10,000 Ω source resistance. Noise less than 0·15 µV peak to peak.

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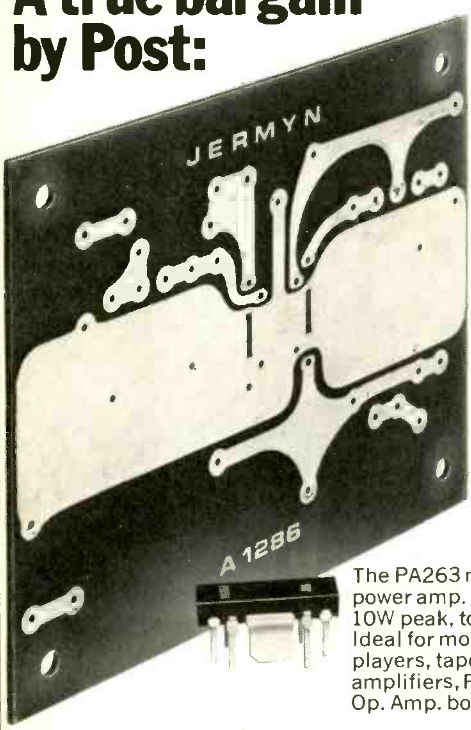

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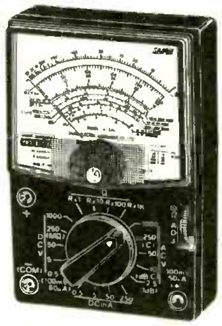

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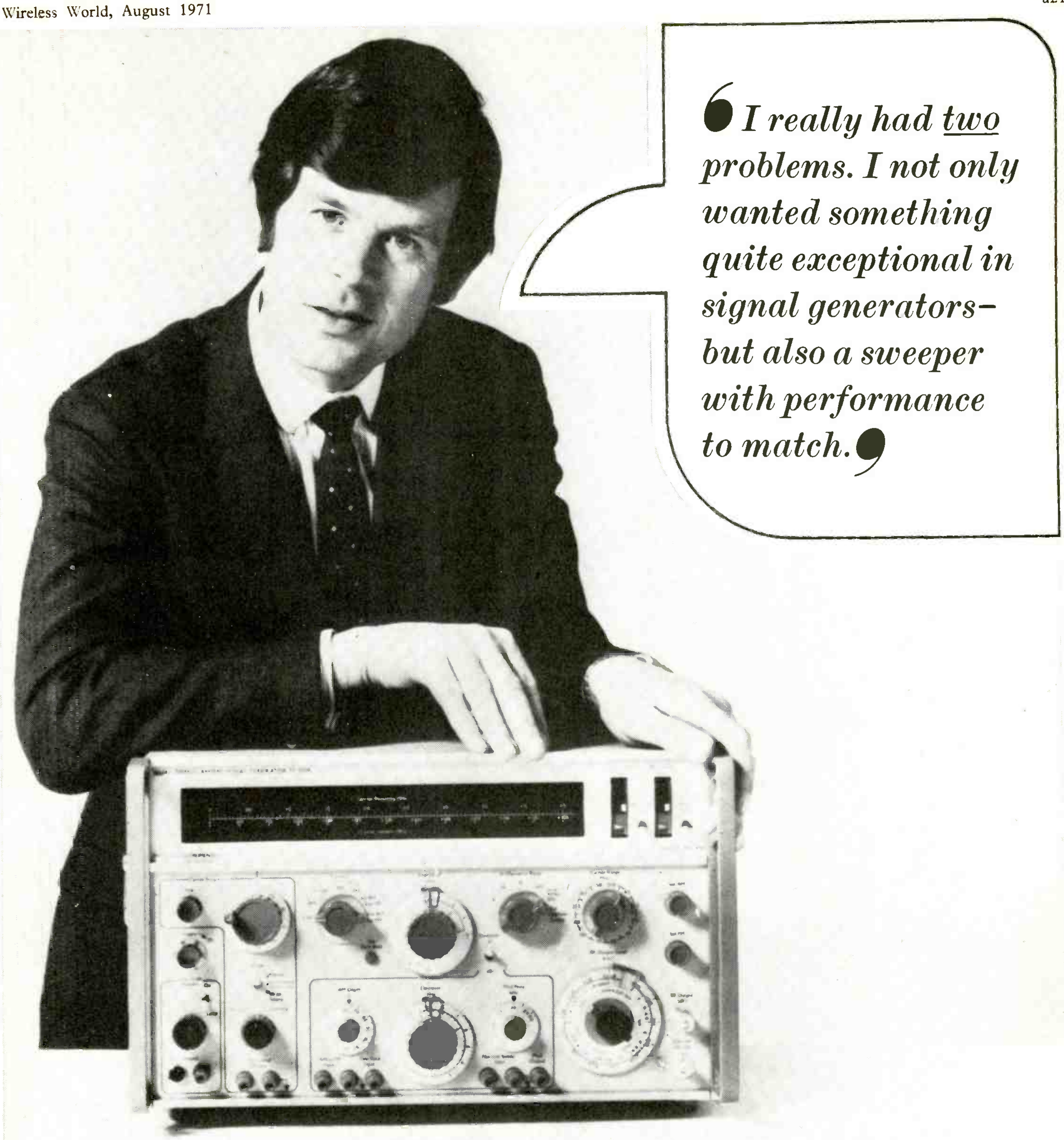

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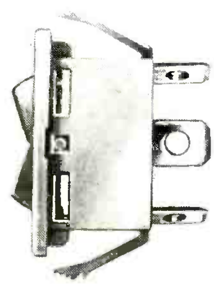
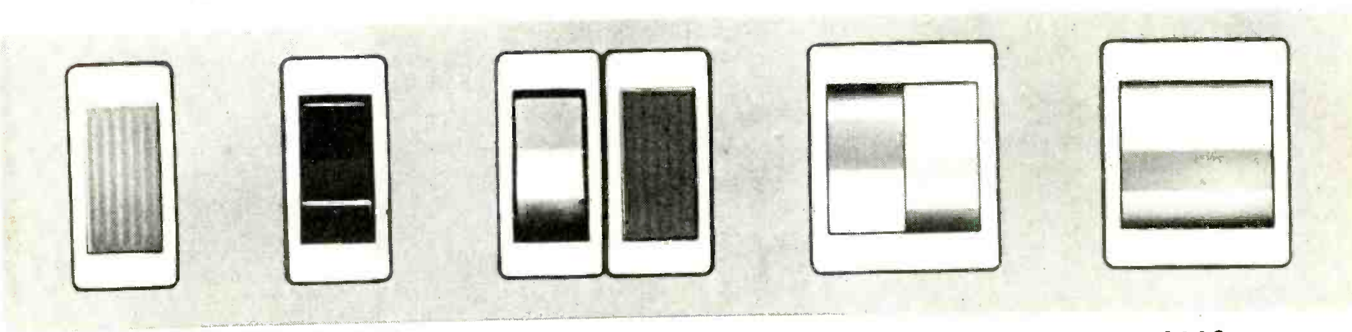


now meet the family



1109 | 1100 | 1100/1109 | 1100 twins | 1110

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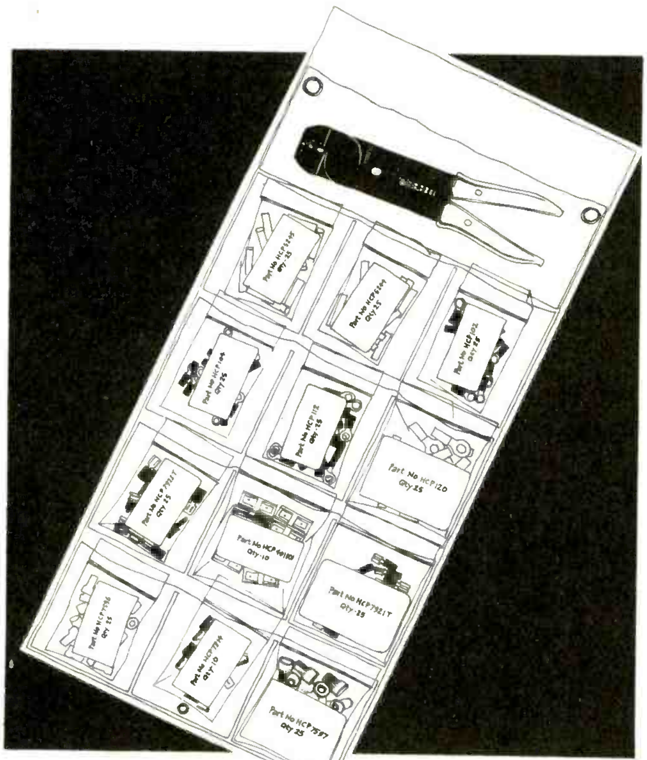

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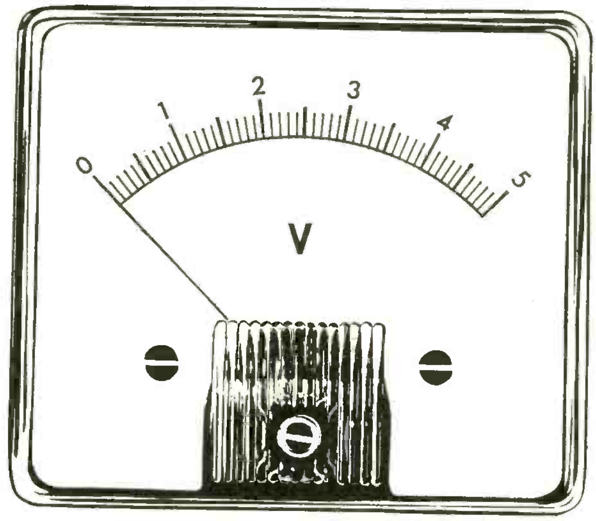

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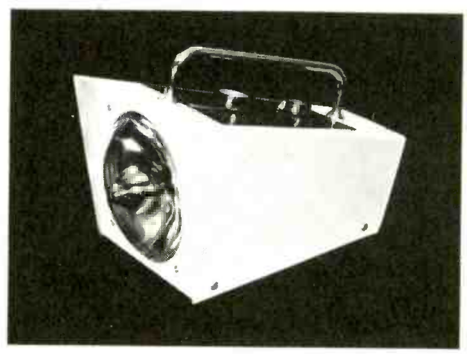

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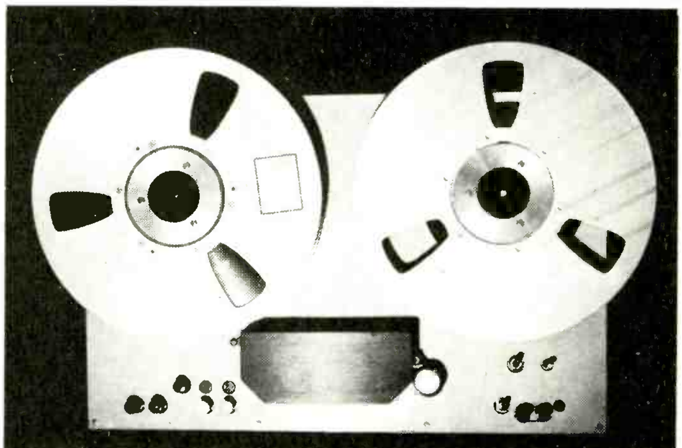

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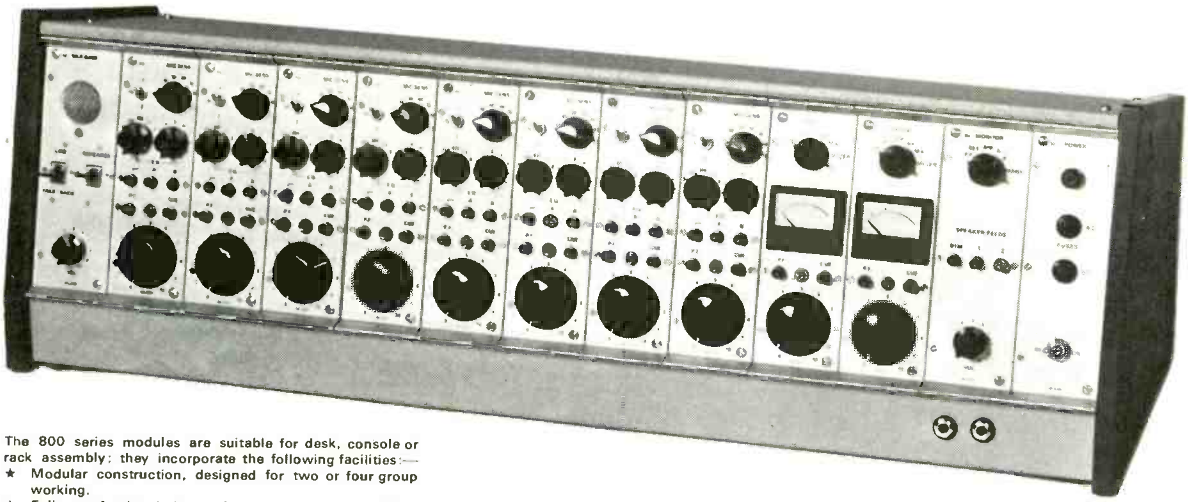

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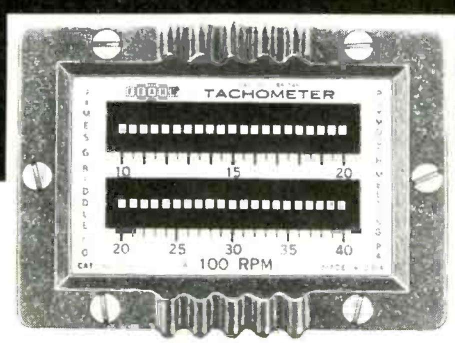

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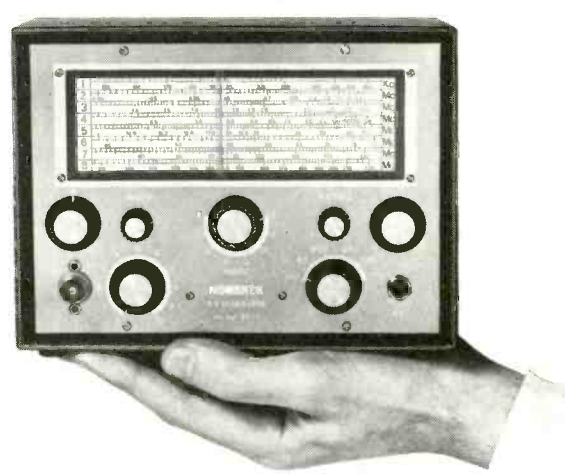

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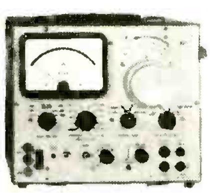

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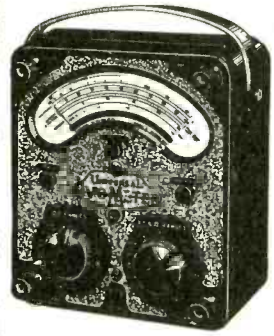

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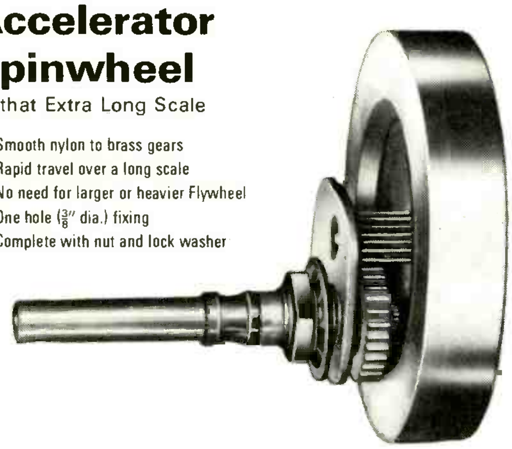

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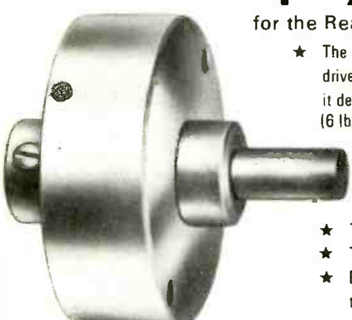

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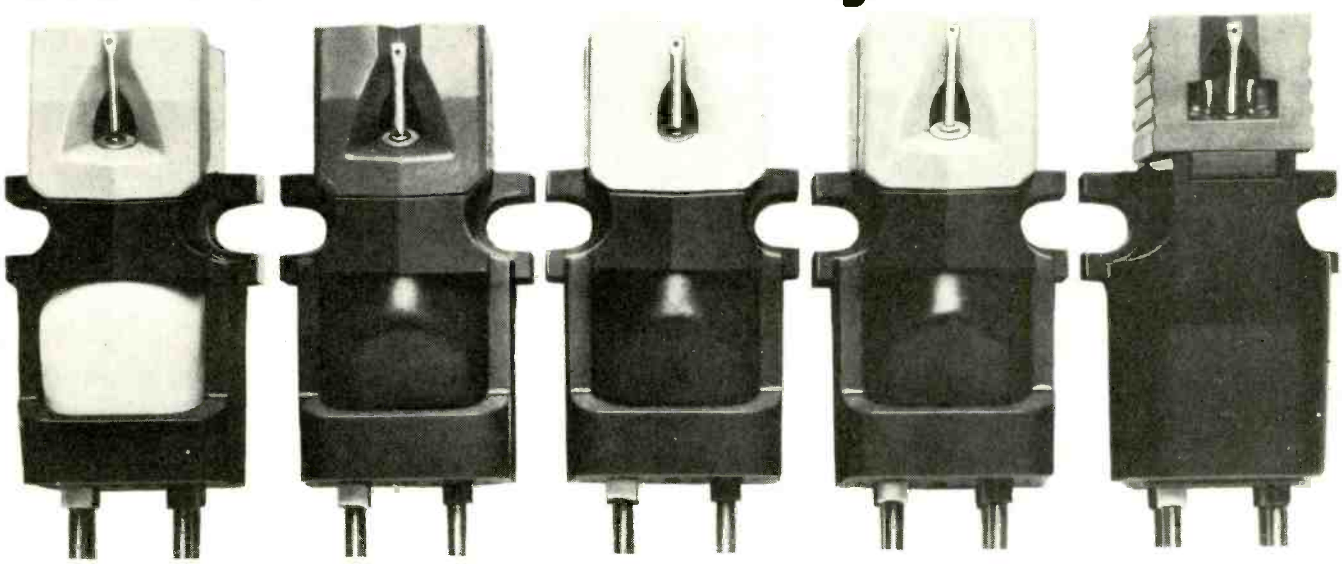

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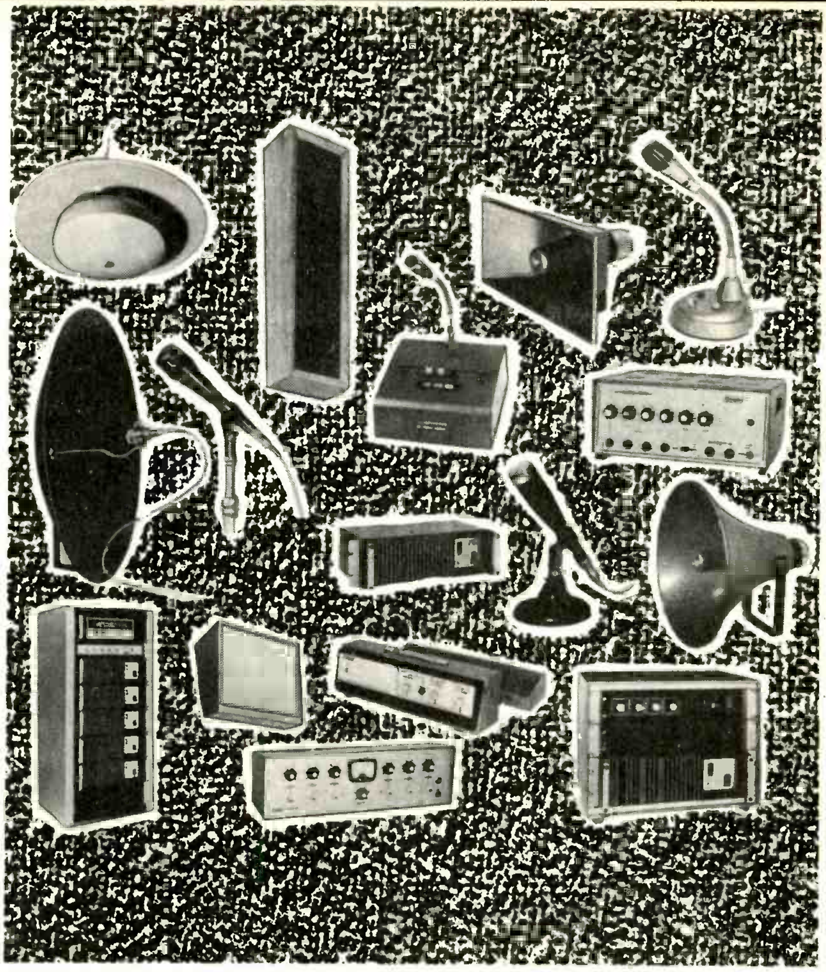

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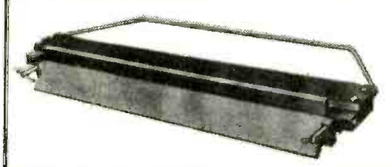

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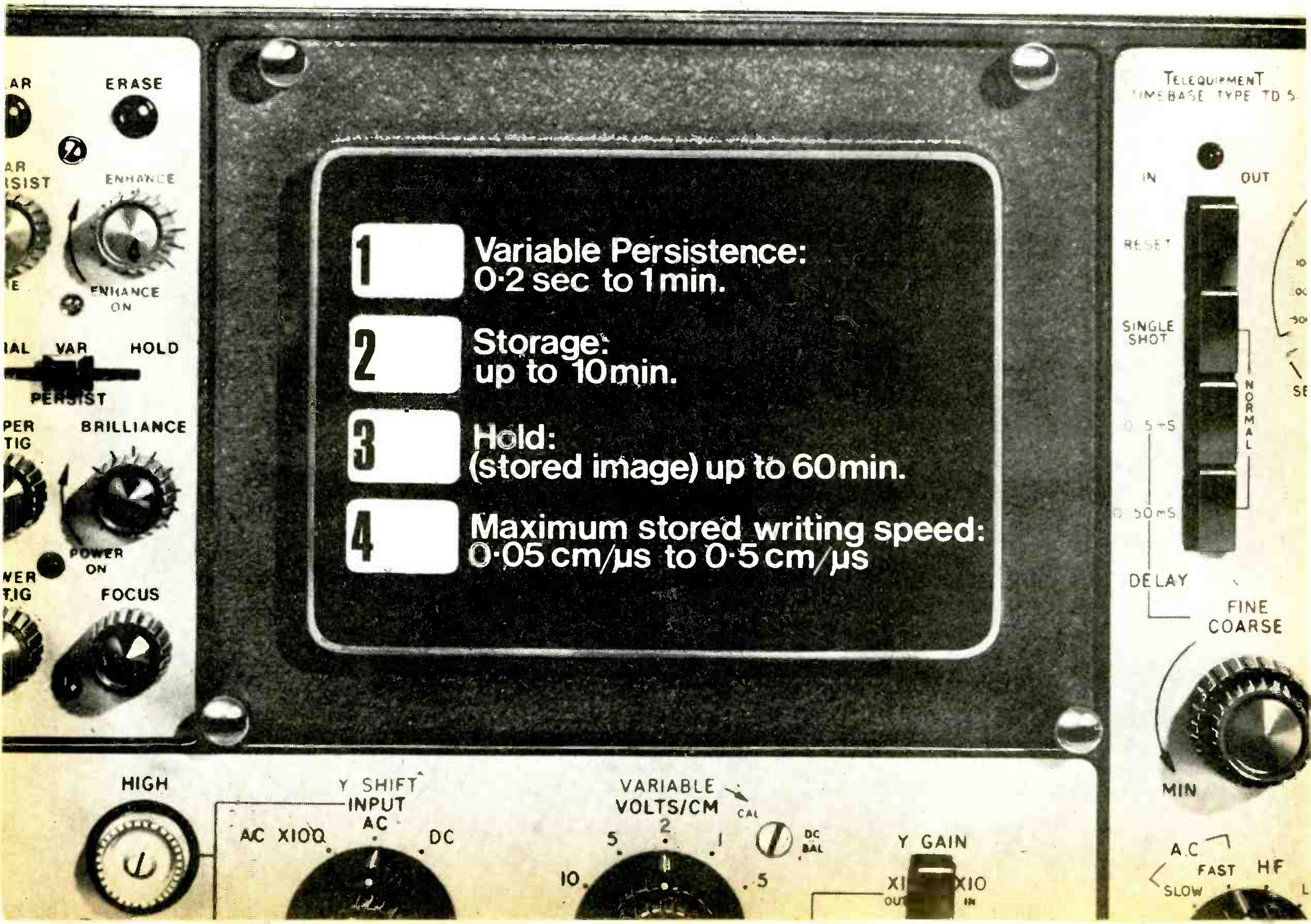

Wireless World

Electronics, Television, Radio, Audio

Sixty-first year of publication **August 1971** **Volume 77 Number 1430**

The rotating 11-dB helical aerial, shown on the **front cover**, forms a major part of receiving equipment for picture transmission from weather satellites. It was designed and manufactured by Rohde & Schwarz, of Munich, whose U.K. agents are Aveley Electric.

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IN OUR NEXT ISSUE

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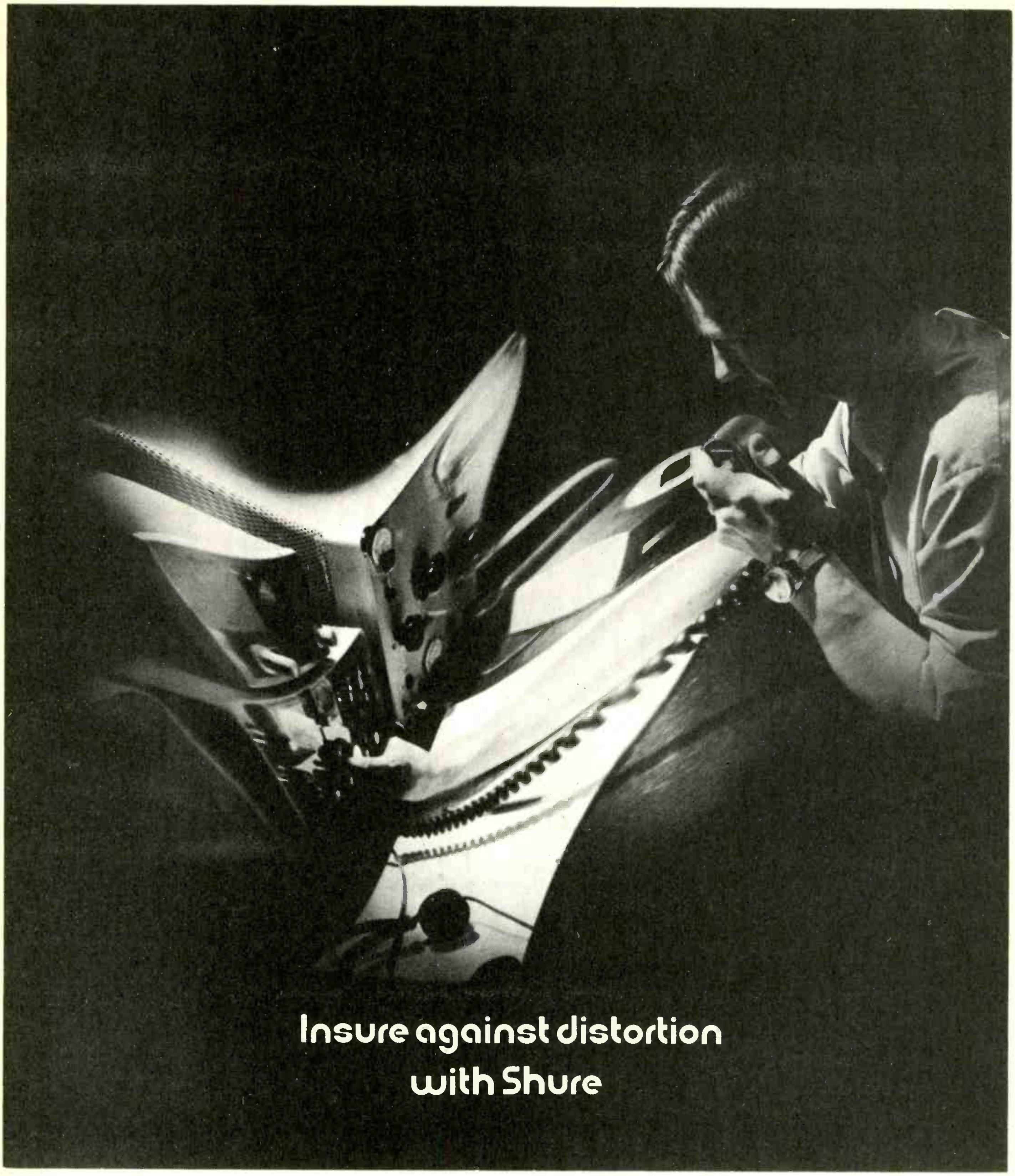

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Wireless World

Wasted R & D

One aspect of research and development costs which we did not consider in our discussion on value for money in R & D in the June issue is highlighted in a report just issued by the Centre for the Study of Industrial Innovation*. It is called 'On the Shelf' and surveys industrial R & D abandoned for non-technical reasons. The main conclusion of the survey, which analyses 53 shelved projects belonging to 20 companies in the UK, is that the failure to make an adequate market assessment before research and development is the most common reason for firms having to abandon technically viable projects. Eight of the companies or divisions (mostly unnamed) are classified as 'electrical and electronics' and, in fact, a third of the 53 abandoned projects were electronic. Incidentally, the nationality of five of the eight companies is given as U.S., one European and two U.K. Together they employ about 1,500 graduate R & D staff and about the same number of technicians and support staff. Details are given of case studies (some under disguised names) and together they raise important questions central to the management of R & D. With hindsight, some projects should never have been started; in others development resources were exhausted beyond the point of economic justification.

There are apparently three main points of project rejection, which can occur for technical or non-technical reasons. Projects can fail first to measure up to initial selection criteria for development expenditure; secondly, to measure up to ciiteria of satisfactory development at a periodic progress review; and thirdly, a fully developed prototype can fail to measure up to the conditions required for marketing. Probably most of the projects described in the report were rightly shelved, although we question the attitude of one research director interviewed who stated that the onus is on the individual at the bench to force his own project through; 'He must know how to sell, what to sell, when to sell and who to sell to'. This attitude which, according to the survey is not untypical of research directors and other senior personnel interviewed, lays a tremendous burden on the initiators of a project and may well inhibit progressive thinking.

One of the aims of the study was to assess what steps firms took after the 'shelving' decision to gain some commercial return from the accummulated, but abandoned, know-how. It is this aspect of shelving which we consider is of paramount importance, for it can turn to good effect what would otherwise be wasted R & D. Of the 53 shelved projects reviewed only six were subsequently economically exploited by three of the 20 companies. Sometimes the resurrection occurred as a result of changed circumstances but only one firm, incidentally Rolls-Royce, had a regular system of project reappraisal. While this aspect of research should not be overlooked by individual companies, it is of paramount importance to organizations undertaking research on behalf of others. In this regard we were particularly interested to learn during a recent visit to the Cranfield Unit for Precision Engineering (see 'Electro-optical Gearbox' in this issue) that written into all its research contracts is a clause permitting the use in any field not competing with the originating company's activities of know-how resulting from research projects.

While it can be said that all R & D efforts contained an element of fruitless endeavour, there must come a point when this proportion is no longer acceptable as inevitable and it is seen that *avoidable* wastage has begun to occur.

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*The Centre for the Study of Industrial Innovation, of 162 Regent St, London W1R 6DD, was set up last year, with industrial backing, to study the economics of innovation and R & D in industry. 'On the Shelf' is its first report.

Dual-trace Oscilloscope Unit—1

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

In this series of articles the development of a unit which enables two signals to be observed simultaneously on almost any cathode-ray oscilloscope will be described and the series will conclude with full details of the final design. In all design work there is compromise and it is necessary to obtain a good balance between conflicting requirements. Sometimes there are several different ways of obtaining a required performance and a designer naturally starts by considering the one which he thinks most likely to be satisfactory. Sometimes, his first choice is a good one; at others, he ends up with something entirely different.

Usually, he says little or nothing about his unsuccessful attempts and only his successful design is presented for all to see. It occurred to the writer that a detailed account of the development, including the unsuccessful arrangements, would be of general interest and might be of some educational value. It is usually true that one learns more from one's mistakes than from one's successes. It might be true that one could learn more from other people's mistakes than from their successes, if one knew about them!

In the course of the development, a great variety of problems was met and some were a little unusual. For example, a continuous control of gain was considered desirable and provided by far the most difficult of all problems. In fact, the final choice of circuit was made almost entirely to suit the requirements of gain control.

Requirements

The first step in design is always to formulate the requirements clearly. The designer does this in the light of his experience of what is practicable. He knows, for instance, that it will probably be difficult to obtain a voltage amplification of 100 times with a bandwidth of 25 MHz from two transistors, He knows, too, that it will probably be easy to obtain a gain of 4 times with a bandwidth of 10 MHz from only one transistor and that it might not be too hard to get a gain of 10 times. The designer has this sort of information available from his past experience but there are always gaps in his knowledge, and then he has to carry out some experiments to see what can be done, or else a theoretical analysis. This usually takes longer, but is generally more valuable.

Coming now to the particular (that is, to the dual-trace unit), the first thing is to decide what it must do. Its purpose is to enable two different signals to be displayed so that they can be viewed simultaneously on the screen of the c.r.o. They cannot, of course, be actually present simultaneously, for the tube has only one electron beam. There must be two separate signal channels and an electronic switch to switch the input of the c.r.o. from one to the other and back again repeatedly at an adequately high speed. Persistence of vision coupled with the persistence of the c.r.t. screen makes the traces appear to be present simultaneously.

Both traces are, of course, displayed by the same horizontal deflection of the beam, and so the two signals must be of the same frequency or harmonically related. Also, if the two traces are separated to appear one above the other, the maximum input to the oscilloscope for each signal can only be one half of the normal. The screen cannot be stretched to accommodate two normal size traces!

Experiment

It is not necessary for the switching frequency to be synchronized to either the signals or to the oscilloscope timebase. Here, for brevity, we are anticipating a little. In reality, at this stage we did not know what would happen, so we rigged up an electronic switch and fed the same sinewave signal to both sides to find out what did happen. This is what we did find. For signals from about 200 Hz to perhaps 1 MHz the best results are obtained and the operation is easiest when the electronic switch is triggered by the oscilloscope timebase. No spurious effects are then observable, the two signals are displayed alternately on successive sweeps and the switching occurs during flyback. It was found, however, that for the display of higher frequencies, the timebase frequency became too high for the electronic switch to operate properly. It was found, too, that at lower frequencies flicker quickly became intolerable. The cure for both is the same, to use an unsynchronized switch. At low frequencies, the switching frequency is made much higher than the signal frequency. Switching occurs 100 times or more during each signal cycle. If, by accident, the frequencies are integrally related, or there is some unintentional synchronizing action by stray coupling, the traces appear dotted. Flicker is not now any worse than in a normal oscilloscope display. At high frequencies, the switching frequency is made much lower than the signal frequency. One signal is then displayed for ten or more sweeps before the other is switched on, but as long as the switching frequency is above a few hundred Hz one does not notice this.

Unsynchronized operation can be used for all signal frequencies, but peculiar effects occur at certain relations between the signal and switching frequencies. They are in the nature of stroboscopic effects and can be most disturbing. To minimize them the ratio of the frequencies must be very large or small and a fine control of switching frequency is necessary.

In the light of these early experiments it was decided that synchronized operation would be used for most signals, but that an alternative pulse generator would be provided for low- and high-frequency signals. It should be noted also that synchronized operation demands that the oscilloscope has a pulse or sawtooth output available from its timebase.

It was noticed, too, in the experiments that it is impossible to use the internal synchronization of the oscilloscope. With unsynchronized operation of the switch, the timebase invariably locks to the switch frequency and not to the signal.

On its most sensitive range the average oscilloscope needs no more than 1 V peak-to-peak of signal for full screen deflection. Many oscilloscopes need less. It was decided that the dual-trace unit should have an overall gain of unity, with a maximum signal output of 1 V. The oscilloscope used in the development was the Marconi Instruments TF 1330. This is now an oldish model but its performance is quite adequate for most general purposes. It has a 3-dB bandwidth up to 15 MHz and an input impedance of 1 MΩ shunted by 30 pF.

When using the dual-trace unit, the input attenuator of the oscilloscope cannot be employed unless the unit is made capable of handling large signal amplitudes. In any case, the two signals to be observed may have very different amplitudes. It follows that each channel must have its own input

*Editor in Chief, *Wireless World*

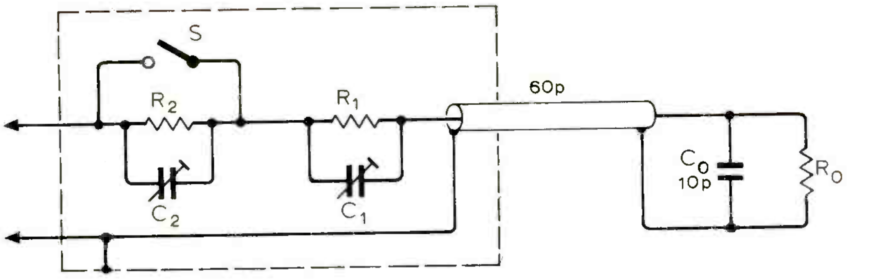

Fig. 1. A passive probe designed to give attenuations of 3·33:1 and 10:1 according to the position of the switch and to reduce the capacitance of the cable and oscilloscope in the same ratios.

attenuator. If it were not for one thing, amplification of the signals would be unnecessary. This thing is cable capacitance. A minimum of 3 ft of coaxial cable is needed for the input. If this is ordinary 75-Ω cable its capacitance will be about 60 pF. Special low-capacitance cable can be used, but is less readily available, and even then its capacitance is unlikely to be under 30 pF. The usual practice is to use a passive probe which attenuates the signal to $\frac{1}{10}$ of the input and at the same time reduces the capacitance by the same amount. This is eminently practical, but necessitates an amplifier with a gain of 10 times to make up for the loss.

At this stage we did not know what gain and bandwidth would be practicable. We felt that the minimum requirement was a 3-dB bandwidth of 5 MHz and that it should be as much greater as proved reasonably practicable. We felt it might be hard to get a gain of 10 times with a bandwidth of more than this, and decided that a compromise was desirable. What we initially decided was this. There would be an input probe with an attenuation of 1/3·33. With a total cable plus unit input capacitance of 70 pF, this would give a probe input capacitance of 70/3·33 = 21 pF about. For the next range, a resistance would be switched in series to give an attenuation of 1/10, making the capacitance 7 pF.

The arrangement is sketched in Fig. 1, where R_0 and C_0 are the input resistance and capacitance of the dual-trace unit. The attenuation is

$$\frac{1}{\alpha} = \frac{R_0}{R_0 + R_1}$$

when the switch is closed and

$$\frac{1}{\alpha} = \frac{R_0}{R_0 + R_1 + R_2}$$

when it is open. If α = 3·33 and R_0 = 100 kΩ, R_1 = 233 kΩ and if α = 10, $R_1 + R_2$ = 900 kΩ, whence R_2 = 667 kΩ. These are non-standard values, but can be obtained from the combination of two or three preferred values. With an amplifier gain of 3·33 times, a 1-V input with S closed will give 1-V output. A 3-V input with the switch open will give (3/10) × 3·33 = 0·99 V = 1 V output.

The combination of this with one 10:1 attenuator in the unit would provide ranges of 1 V, 3 V, 10 V and 30 V, which would suffice for many, if not most requirements. The input resistance would be 333 kΩ on the 1 V and 10 V ranges and 1 MΩ on the 3 V and 30 V ranges.

Frequency compensation of the potential divider requires that all time constants be alike. If the cable capacitance is C_c, this means

$$(C_0 + C_c)R_0 = C_1R_1 = C_2R_2$$

and there must be trimmers C_1 and C_2 in the probe to enable these capacitances to be adjusted precisely. Easy adjustment requires a square-wave signal of suitable repetition frequency. Adjustment is carried out for a square corner to the signal. If C_1 or C_2 in Fig. 1 is too small the square-wave has rounded corners as shown at (a) in Fig. 2, whereas if it is too large there is overshoot as at (c). The correct adjustment gives the square corners (b). If the input signal is a good one, the adjustment is remarkably easy to carry out.

A square-wave generator is not always available, of course, but the switching circuits of the dual-trace unit will, in fact, be operated by a square-wave generator and it was felt that this could be arranged to provide the signal for adjusting the attenuator. At this stage, this was merely noted as a possibility.

At this point it may be advisable to say why 100 kΩ was selected for R_0. It is usual for an oscilloscope to have an input resistance of 1 MΩ. This arose originally because this was about the highest stable value which could readily be provided with valve circuits. It is actually on the low side when the c.r.o. is used to investigate valve circuits, and a 10:1 probe is often used to bring it up to 10 MΩ when the signal is large enough.

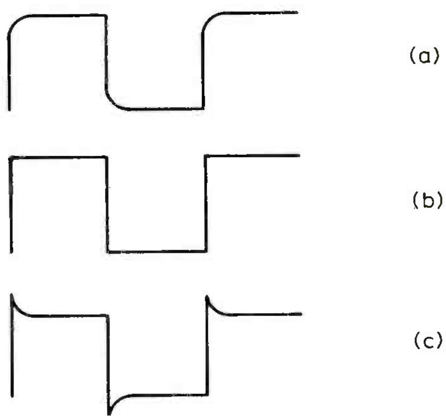

Fig. 2. With the capacitors C_1 and C_2 properly adjusted a square wave is correctly reproduced (b). Too small capacitance gives rounded corners (a) while too much capacitance gives overshoot (c).

Most transistor circuits are of a good deal lower impedance and 1 MΩ is ample for them. It is more important to reduce capacitance than to increase resistance. The use of high value resistors is to be avoided as far as possible because they are more likely to be unstable than lower values and are certainly more affected by surface leakage in damp weather.

It is important that the input resistance R_0 be substantially defined by a resistor and not by a semiconductor. If R_0 is 100 kΩ, this means that the input resistance of the first stage should not be less than 5 MΩ if its effect is to be small. This input resistance is usually highly variable. Of course, if a field-effect transistor is used a much higher input resistance is obtainable, but at this stage we had not decided which would be used and we initially chose values which would suit a bipolar transistor.

Signal Control

It will be noted at this point that we had tentatively decided on an amplifier gain of 3·33 times because we thought that this should be easy to obtain. We note that the scheme worked out has two disadvantages. One is that, as already mentioned, the input impedance varies with the range. The other is the practical difficulty of including a switch, two resistors and two trimmers in a probe head without making it unwieldy. Further, with one range control on the probe and the other in the instrument, one must remember to note the setting of both to determine the actual range employed.

It would clearly be more convenient for the probe to give constant attenuation for then it need contain only one resistor and capacitor and the input impedance would be the same on all ranges viz. 1 MΩ and 7 pF. Two attenuators in the instrument would singly and in combination provide ranges of 1, 3, 10, 30 V; the attenuators having ratios of 3·33:1 and 10:1, under the control of a range switch. The possibility of this depends on being able to obtain a stable gain of 10 times from the amplifier with an adequate bandwidth, and at the start we did not know whether this was reasonably practicable. The gain control range required is, of course, unaltered and remains at about 3·5:1, for it has only to fill in the gaps in the attenuator steps.

Whatever the input stage, protection against overloading is required. Few transistors are rated for more than 6 V reverse base bias and there is always the possibility that the probe will be connected inadvertently to the 240 V supply mains of 340 V peak value or 360 V if 6% high. Protection is obtained by connecting two diodes back to back across R_0, as shown in Fig. 3. On the lowest range R_1 is always in circuit and limits the current to 360/233:1·54 mA. This is the maximum diode current and few diodes will drop more than 1 V at this current.

The signal amplitude is 0·3 V p-p and we hope that, even without bias, silicon diodes will not conduct on it. The circuit

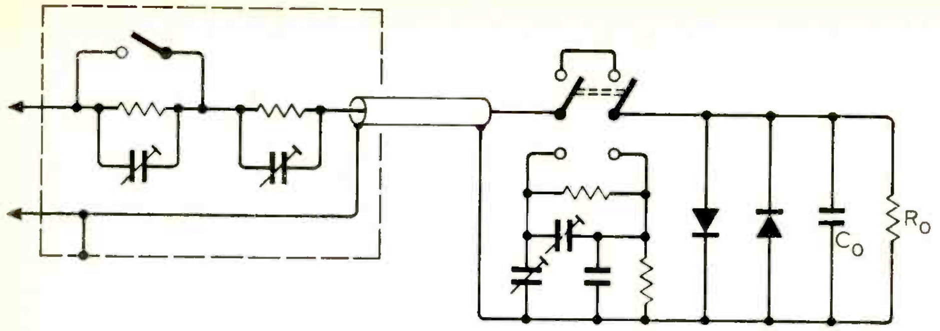

Fig. 3. This diagram shows the probe of Fig. 1 connected via the cable to a further attenuator of 10:1 ratio and diodes arranged to protect the amplifier against overloads.

has now grown to the form of Fig. 3.

One other decision had to be made. This was whether to make provision for a d.c. input. In any case, a series capacitor would be provided for a.c. only. The writer's experience is that a d.c. input is used only rarely and that when it is wanted it often cannot be used, because the same input range cannot be used for d.c. and a.c. together unless the two are comparable in magnitude. The input circuits become complicated if a bipolar transistor is used because of the base supply voltage. It was decided, therefore, to make provision for a.c. inputs only.

The capacitor can be inserted in series with the cable at the output end and the effective resistance is 333 kΩ on the 1 V and 10 V ranges and 1 MΩ on the 3 V and 30 V ranges. The drop in response (i.e., the sag) at a time t after the application of a unit step is simply t/CR. For a 50-Hz square wave, t = 10 msec. If C = 0·5 μF and R = 333 kΩ, the sag is $10^{-2}/(5\times10^{-7}\times3{\cdot}33\times10^5) = 1/16{\cdot}65 = 0{\cdot}06 = 6\%$. This is as much as should be tolerated and 0·5 μF is the minimum capacitance to be used. For a 1 MΩ input resistance, a 0·22 μF capacitor can be used to give a sag of 4.5%.

For the initial experiments we did not build the full arrangement of Fig. 3 but used only the simplified system of Fig. 4. The probe must always be screened, of course, and for bench work it proved essential to screen the capacitor to prevent hum pick-up.

At this stage of the proceedings we had solved in principle the input circuit problems and could define the amplifier requirements more closely, which were:

1. To operate into an output load of 1 MΩ shunted by 55 pF (30 pF oscilloscope input capacitance plus 20 pF for 1 ft cable plus 5 pF strays)
2. To provide an output of at least 1 V p-p
3. To give a voltage amplification of 3·33 times (N.B. It was noted that if it should prove possible to obtain an amplification of 10 times this might be adopted and the attenuator system altered).
4. To have a continuous gain control of at least 3·33:1.
5. To be able to handle an input of up to 1 V p-p (so that full output could be obtained with the gain control at minimum).
6. To include a shift control so that the traces could be moved vertically and independently on the screen. A range of ±0·5 V at the output would be sufficient.
7. The gain and shift controls to have no interaction.
8. The whole amplifier to be stable and easy to set up.

With regard to the last item, it was considered that as this is a piece of test equipment, which will normally be used under laboratory conditions, it would suffice to take the temperature range as ±12·5°C = ±22·5°F about a mean of 65°F. This covers room temperatures of 42·5–87·5°F.

The mean room temperature is thus 18·3°C. The internal case temperature, which is the ambient of the transistors, is higher than this by what is at present a completely unknown amount, but it will vary with the room temperature and by the same amount. Transistor junctions will be higher than the ambient by an amount depending on their dissipation. Most small transistors have a thermal resistance between junction and case of about 0·5°C/mW. Anticipating a little, few, if any, transistors will dissipate more than 20 mW and so their junctions will not be more than 10°C above the ambient. No great attention need thus be paid to temperature.

In what follows, we shall assume at first that all junctions are at 25°C because this is the figure for which transistor characteristics are usually quoted. Corrections can be applied later. Because of the low power needed in this case, no dangerously high dissipation will occur, and the only important thing to watch is that the case is adequately ventilated. Apart from this the only effect of choosing the wrong design temperature is to change slightly the required bias voltages and as they may in any case have to be adjustable to allow for other variations, the result is likely to be trivial.

Before concluding this part, it will be well to say something about the output stage which is controlled by the electronic switch. The arrangement referred to earlier, which was used for some experimental tests, is shown in Fig. 5. The transistors Tr_1 are the output transistors of the two signal channels, and they are switched by Tr_2 which have square waves applied in opposite phase to their bases; when Tr_{2a} conducts Tr_{2b} is cut off and vice versa.

When a Tr_2 is cut off the Tr_1 to which it is connected operates as a normal amplifier with collector load R_c and emitter resistor R_E. When a Tr_2 is conductive it drains sufficient current through R_E to cut off the Tr_1 to which it is connected. Tr_{1a} and Tr_{1b} have a common load resistor R_c and in this way the signals from the two channels are alternatively routed to the oscilloscope.

The oscilloscope input capacitance is about 30 pF and 1 ft of coaxial cable adds 20 pF. With 5 pF for strays, the total capacitance is 55 pF. If R_c is 330 Ω, then at 5 MHz, the response is

$-20 \log [1+\omega^2C^2R^2]$

$$= -10 \log [1+0{\cdot}57^2] = -1{\cdot}22 \text{ dB}.$$

At 10 MHz, it is −3·61 dB. This is very reasonable as a starting point.

If $R_E = R_C$ the gain will be unity, or nearly so.

With a minimum supply of 10·5 V, maximum output demands that V_{CE} be one-half of the supply voltage and so $I_C = 5{\cdot}25/0{\cdot}66 = 7.95$ mA. The emitter is then 2·625 V above earth and the base about 0·65 V higher, or about 3·3 V. The maximum signal output will then approach 5·2 V p-p. The collector dissipation will be 5.25 × 7.95 = 41.8 mW. Each transistor Tr_1 operates for only 50% of the time, however, so each has a mean current of 4 mA and a mean dissipation of 21 mW in round figures.

Experimentally, it was found unnecessary to operate at quite such a high current and the decision was made to set V_B at 2·7 V,

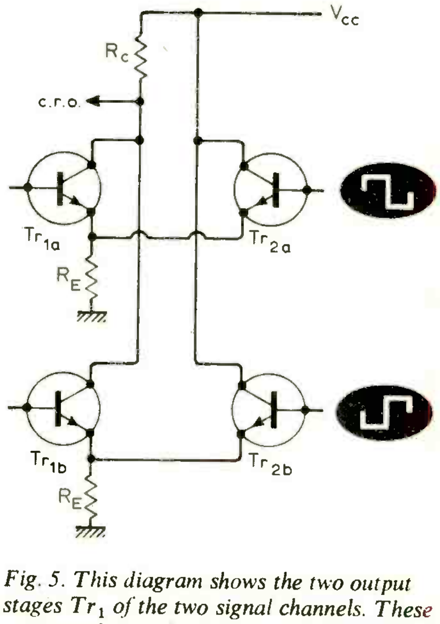

Fig. 5. This diagram shows the two output stages Tr_1 of the two signal channels. These are turned on and off alternately by transistors Tr_2 which are in turn driven on and off by push-pull square waves on their bases.

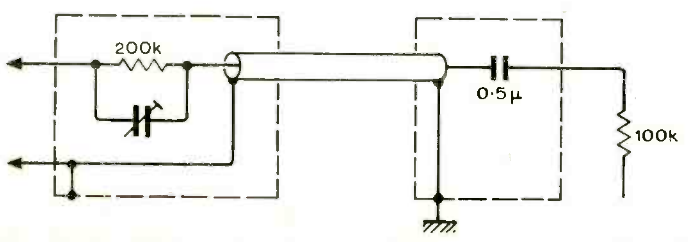

Fig. 4. Simplified probe used in experimental work, and input coupling capacitor to remove d.c.

making V_E = 2·05 V, and I_C = 6·21 mA. Consequently, V_{CE} = 10·5 − 4·1 = 6·4 V and the dissipation is 39·9 mW. With V_{cc} = 13·5 V, if V_B is unaltered the current is unchanged and so V_{CE} rises by 3 V to 9·4 V and the dissipation to 58·4 mW. The maximum mean dissipation is thus 29·2 mW.

Typically, the thermal resistance is 0·5°C/mW, and V_{BE} changes by 2 mV/°C. Thus V_{BE} falls by 1 mV/mW for a constant ambient temperature. The change of mean dissipation with V_{cc} is 29·2 − 21 = 8·2 mW and so V_{BE} decreases by 8.2 mV when V_{cc} is at its maximum, and V_E rises by the same amount and V_{CE} drops by twice this, or 16.4 mV. The current rise is 0.0082/0·33 = 0·0249 mA. At V_{cc} = 13·5 V, therefore, I_C = 6·235 mA and V_{CE} = 9·4 − 0·0164 = 9·384 V, making P_c = 58·5 mW. The change is quite negligible.

The normal output is 1 V p-p maximum. It is desirable to design for twice this to ensure a factor of safety; this is 1 V_p. The base of Tr_1 swings from 1·7 V to 3·7 V with respect to earth, since the bias is set at 2·7 V. To cut-off Tr_1, therefore, Tr_2 must draw sufficient current through R_E to bring the emitter of Tr_1 at least 3·7 V above earth. The current must thus be at least 3·7/0·33 = 11·2 mA. The BC107 transistor has a V_{EB} rating of 6 V maximum. Thus, V_E must not exceed 6 + 1·7 = 7·7 V and so I_{c2} must be under 7·7/0·33 = 23·3 mA.

If Tr_2 is saturated with a high supply voltage (13·5 V), $V_{CE2} \approx$ 0·2 V, and the total resistance must be greater than 13·3/23·3 = 0·57 kΩ. A resistance of more than 570 − 330 = 240 Ω must be included in the collector circuit to limit the current. If the current is to exceed 11.2 mA on low supply voltage (10·5 V), the resistance must not be greater than 10·3/11.2 = 916 Ω, so the collector resistance must be under 916 − 330 = 586 Ω. This assumes that the base current is negligible, which may not be true under saturated conditions. We thus see that the collector resistance of Tr_2 must lie between 240 Ω and 586 Ω, and 470 Ω would seem a suitable choice.

With a conventional bistable driving Tr_2 at its base, the bistable output will vary from about 0·2 V to perhaps 2 V below V_{cc}. It may be less than this, but taking this figure, the maximum will be 11·5 V. The emitter voltage of Tr_2 will be at least 3·7 V, so the effective base-emitter drive will be 11·5 − 3·7 = 4·8 V. If we arbitrarily limit the base current to 0·5 mA, a series resistor of 9.6 kΩ ≈ 10 kΩ must be placed in series with the base of Tr_2. The resistor can, in fact, be a little less than this because the above figure includes the output resistance of the bistable which is likely to be 1·5 − 2·5 kΩ.

The output stages and their switching transistors are shown in Fig. 6 with the above calculated circuit values. A final decision, of course, depends on a trial. We might find, for example, that 10 kΩ base resistors make the switching speed too low and we may have to think again.

So far the supply voltage has been considered but little. It is, however, obvious that with the low signal voltage no high voltage supply is needed. The output stage could, in fact, be designed for a 6-V supply. As will appear later, the amplifier really demands more and the decision was made quite early to adopt a nominal 12 V supply. It was desired to avoid a stabilized supply and so a tolerance of ±1·5 V on the supply was allowed. It was thought that this would be sufficient to cover a ±6% mains voltage and component tolerances.

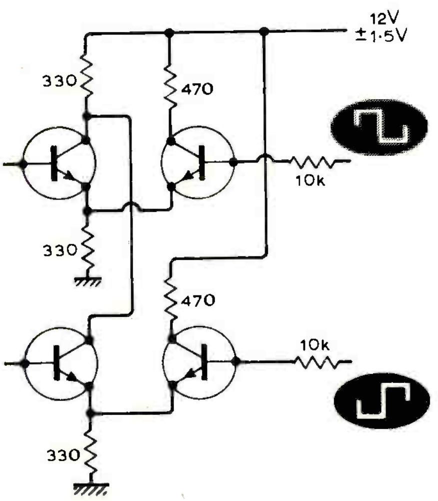

Fig. 6. The circuit of Fig. 5 redrawn with component values and protective resistors in the base and collector circuits of the switching transistors.

High-speed cassette duplicator

A tape speed of 1.9m/s (75 i.p.s.) is used in a new cassette duplicating system, intended for schools, libraries and the like which is being produced by Ampex. The equipment consists of a master unit which plays back the master tape to five slave duplicating units. Each duplicating unit will handle 45, sixty-minute playing time cassettes, in one hour; all tracks are duplicated at the same time. The sequence of events goes something like this: With a cassette in position a slave unit will carry out the recording in 45 seconds; it then takes 17 seconds to rewind the tape which is done at 3.8m/s (150 i.p.s.); finally the cassette is ejected and a new one is automatically loaded, accounting for a further five seconds. The system, which has five slave units, will therefore produce five duplicated cassettes every 67 seconds.

The tape transports employ vacuum servo columns. The tape is pulled out of the cassette into vacuum chambers and against the heads. The result is close tape-to-head contact and precise and gentle tape handling despite the very high tape speed. The bandwidth of the electronics is 320kHz.

Announcements

An S-band **air surveillance radar**, the AR-15, has been introduced by Plessey which replaces the AR-1 introduced in 1965, of which over 100 (valued at approximately £10M) are now in service throughout the world. The AR-15 is available in both static and air transportable versions. It uses fully variable polarization, low noise parametric amplifiers, tunable magnetrons, digital moving target indication, background averaging techniques for clutter suppression, and multi p.r.f. integration for best target response.

Ericsson Marine, the newly formed marine communications department of the Ericsson Group, has set up a **marine training school** for ships' radio officers at the Norway Trade Centre in Pall Mall London. The first three-week course, for Cunard officers, began on 5th July. Initially, courses will be confined to experienced ships' radio officers and electronic technicians to familiarize them with the company's equipment.

A new collective call sign, **GZXV**, has been allocated to Ericsson Marine. It will be principally used to facilitate 'all ships' calls in the operation of the Ericsson Marine service to shipowners.

A course of eight evening lectures on **video recording systems** starts at Norwood Technical College, Knight's Hill, London, SE27. OTX. On 19th October. Fee £2.

The Service Division of Marconi Instruments Ltd has been appointed as an approved **repair and calibration centre** for the Salford Electrical Instruments range of multirange test instruments. Both companies are in the GEC Group.

Eight of Canada's major civil airports are to have Marconi 'bright' **radar displays**, type S3006, incorporated into their air traffic control systems. The value of the order is in excess of £100,000.

The Carrier Corporation, of California, has announced an agreement in principle for the **acquisition of Reliance Controls Ltd**, of Swindon, Wiltshire, formed in the 1930s. Bowmar Instrument Corp., of Fort Wayne, Indiana, at present own 55% of the Reliance share capital and Booker McConnell Ltd of London, 45%. The transaction will involve approximately £0.25M.

Hamlin Electronics Inc., reed switch manufacturers of Wisconsin, U.S.A., have acquired Inter-Market Services Ltd, and re-formed it as **Hamlin Electronics Ltd.** The new company will market the complete range of Hamlin reed switches and power packs in the U.K. and Scandinavia, as did Inter-Market Services.

Servicing of test gear of all types is offered by a new service introduced by S. C. Murison, 9 Leas Road, Warlingham, Surrey CR3 9LN. (Tel.: 01-820 3830.)

Pye Telecommunications Ltd has appointed the Hallicrafters Company, of Illinois, exclusive **U.S.A. distributor** of its land mobile radio equipment.

UK Solenoid Ltd, rotary switch and contractor manufacturers, are moving from Hungerford, Berkshire, to 115 London Road, Newbury, Berkshire. (Tel: Newbury 5991.)

T.E.M. Sales Ltd, of Crawley, Sussex, have been appointed distributors for **R.E.M. Inc.,** of California.

Ten Practical F.E.T. Source-follower Circuits

by J. O. M. Jenkins, M.Sc.*

Virtually every source-follower configuration can be covered from ten basic circuits, and by considering the related parameters a designer can obtain consistent performance despite inherent device variations. It is true to say that insufficient knowledge and a paucity of written matter has rather inhibited the use of f.e.ts in circuit design. This is regrettable, as the high input impedance and low output impedance of the field-effect device suits it to impedance transformations with bipolars.

There are two basic connections for source followers—with gate feedback and without gate feedback, and for simplicity these are taken separately.

Biasing without feedback

1. A self-bias arrangement in which the voltage drop across R_S biases the gate through R_G. Since no gate-to-source voltage (V_{GS}) can be developed when $I_D=0$, the self-bias load line will pass through the origin. Using the 2N4339 as a standard for this and the other configurations, the quiescent drain current lies between 0.25 and 0.55mA when $R_S=1\text{k}\Omega$. Hence the quiescent output voltage lies between 0.25 and 0.55V.

2. A similar arrangement to the above with a negative supply ($-V_{SS}$) added. This provides an advantage over the first arrangement: namely that the signal voltage can now swing negatively to approximately $-V_{SS}$. The two bias lines shown are for $V_{SS}=-15$V and $V_{SS}=-1.6$V. In the first case the quiescent output voltage lies between +0.18 and +0.74V; in the second between +0.3V and +0.82V.

3. Here a current source improves drain-current (I_D) stability, hence the bias load line will be horizontal when I_D= constant current. For I_D = 0.3mA the quiescent output voltage is between +0.15 and 0.7V.

4. This is similar to 3, except that the current source is now f.e.t. A which allows constant current, the value of which corresponds to a $V_{GS}=0$ volts. It will be seen that f.e.t. A loses current linearity as its V_{DS} approaches zero, so that this technique can only be used to bias f.e.ts which have a significantly higher pinch-off voltage than the f.e.t. forming the current source.

5. By using a pair of matched f.e.ts, one as a source follower and the other as a current source, the operating drain current (I_{DQ}) is set by R_{S2}. In this case ($1.5\text{k}\Omega$) the drain current can be in the range 0.2 to 0.42mA (as shown by the intercepts). However, as the f.e.ts are matched $V_{GS1} = V_{GS2}$; and since $I_{D1}=I_{D2}$, by making $R_{S1}=R_{S2}$ the voltage across A-B will equal the voltage across C-D, which in this case is zero. This arrangement exhibits zero or near-zero offset, and if the f.e.ts are temperature matched at the operating I_D, the arrangement will provide zero or near-zero temperature drift.

Biasing with feedback

The following circuits appear in the same sequence as before for comparative purposes. In each case R_G is returned to a point such that almost unity feedback is provided to the lower end of R_G. If the value of R_S is selected so that R_G is returned to zero d.c. volts (except for 6), then the input/output offset is zero. R_1 is usually much larger than R_S.

6. This arrangement is suitable for a.c.-coupled circuits, and with $R_S << R_1$ provides near unity feedback. The bias load line is set by the value of R_S. The output load line, however, is the sum of R_S+R_1. The feedback voltage (V_{FB}) at the junction of R_S/R_1 is determined by the intercept of this $R_S + R_1$ load line with the V_{GS} axis. Quiescent output voltage is $V_{FB} - V_{GS}$.

7. Here R_S can be trimmed to provide zero offset. Reference to the graph shows that R_S will be between 670Ω and $2.5\text{k}\Omega$ (and very much less than R_1). The source load line intercepts the V_{GS} axis at $V_{SS} = -V_{GG} = -15$V. Note that this load line is not perfectly flat; it has a slope of − 1/50k because the current source is not perfect, having a finite impedance however high.

8. Here R_1 is replaced by the ideal current source, and as this has theoretical infinite impedance, the load line is now perfectly flat.

9. By taking the output from the top of R_S, output impedance is reduced, and R_S must be trimmed if the circuit is to operate effectively. The constant-current load line (I_S = 0.3mA) and the effect of a $1\text{k}\Omega$ source resistor is shown to provide an offset voltage between 0.2 and 0.75V. The intercept of the R_S load line and the V_{GS} axis sets the voltage (V_{FB}) at the junction of R_S and the current source. For $R_S = 1\text{k}\Omega$, V_{FB} will lie between −0.1V and −0.45V. Since V_{FB} appears at the gate, it must be zero if the d.c. input impedance of the circuit is to be preserved. This can be done by trimming R_S (dotted line) the biasing, then reverting to that of circuit 8.

10. This is identical to circuit 5 except that feedback is added to raise the input impedance,

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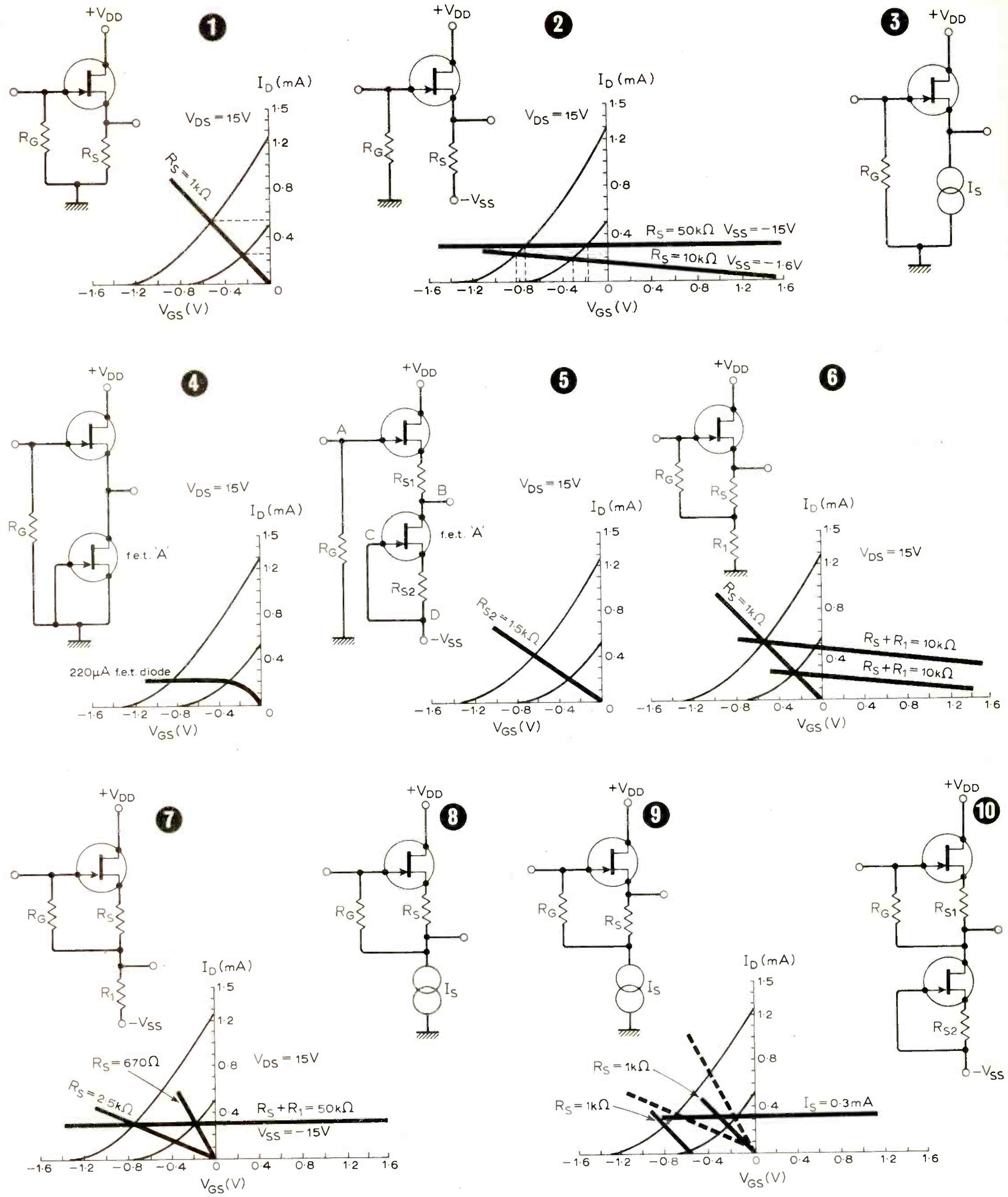
* Siliconix Ltd.



Summary

Circuits 1, 4 and 6 can accept only positive and small negative signals, as the source resistors are to ground. All other circuits can handle large positive and negative signals inhibited only by the available supply voltages and device breakdown voltage. Circuits 3, 4, 5, 8, 9 and 10 employ current sources to improve I_D stability and improve gain. Of these 4, 5 and 10 employ f.e.ts as current sources. Circuits 5, 7 and 10 employ a source resistor, R_S, which may be selected to provide a quiescent output voltage equal to zero. Circuits 5 and 10 use matched f.e.ts. R_S is selected to set I_D near the specified low-drift operating current. The input-output offset voltage is zero.

Simple Crosshatch and Dot Generator

A generator developed from the circuit published in the September 1968 issue which is cheap enough to install permanently in a colour television receiver

*by A. W. Critchley**

The crosshatch pattern of white lines has proved to be the best type of pattern to carry out the convergence adjustments on a television receiver, although white dots are sometimes used. Either pattern is possible with the circuit described by means of a changeover switch or link.

The generator has four disadvantages as can be expected with such a simple device: the receiver has to be synchronized by a transmitted programme; the pattern position on the screen depends on the type of pulses feeding the generator; the pattern can occur during some of the flyback time causing a foldover; and the horizontal lines may not be evenly spaced. The latter three disadvantages are not very serious provided that the pattern is stationary and the lines are fewer in number than the normal crosshatch pattern of some twenty-six in each direction.

*Television Equipment Division of E.M.I. Electronics Ltd.

Waveforms

The waveform required from the generator consists of two independent sets of pulses representing the vertical and horizontal lines of the crosshatch. Vertical lines are some 200ns wide with a repetition every 5μs or so, but occurring only during the active, or scanning, line time, of the picture which is approximately 52μs for 625 line systems). Horizontal line pulses last for one such active line and recur once every thirty-two lines or so, also only during the active line-times of the picture. The repetition rates of these horizontal pattern lines are not important provided that they occur only during the picture time and they are steady. The actual number of crosshatch lines is continuously variable in both directions over a three to one range.

Vertical lines: These are generated by a multivibrator which is permitted to run only during the active lines of the picture

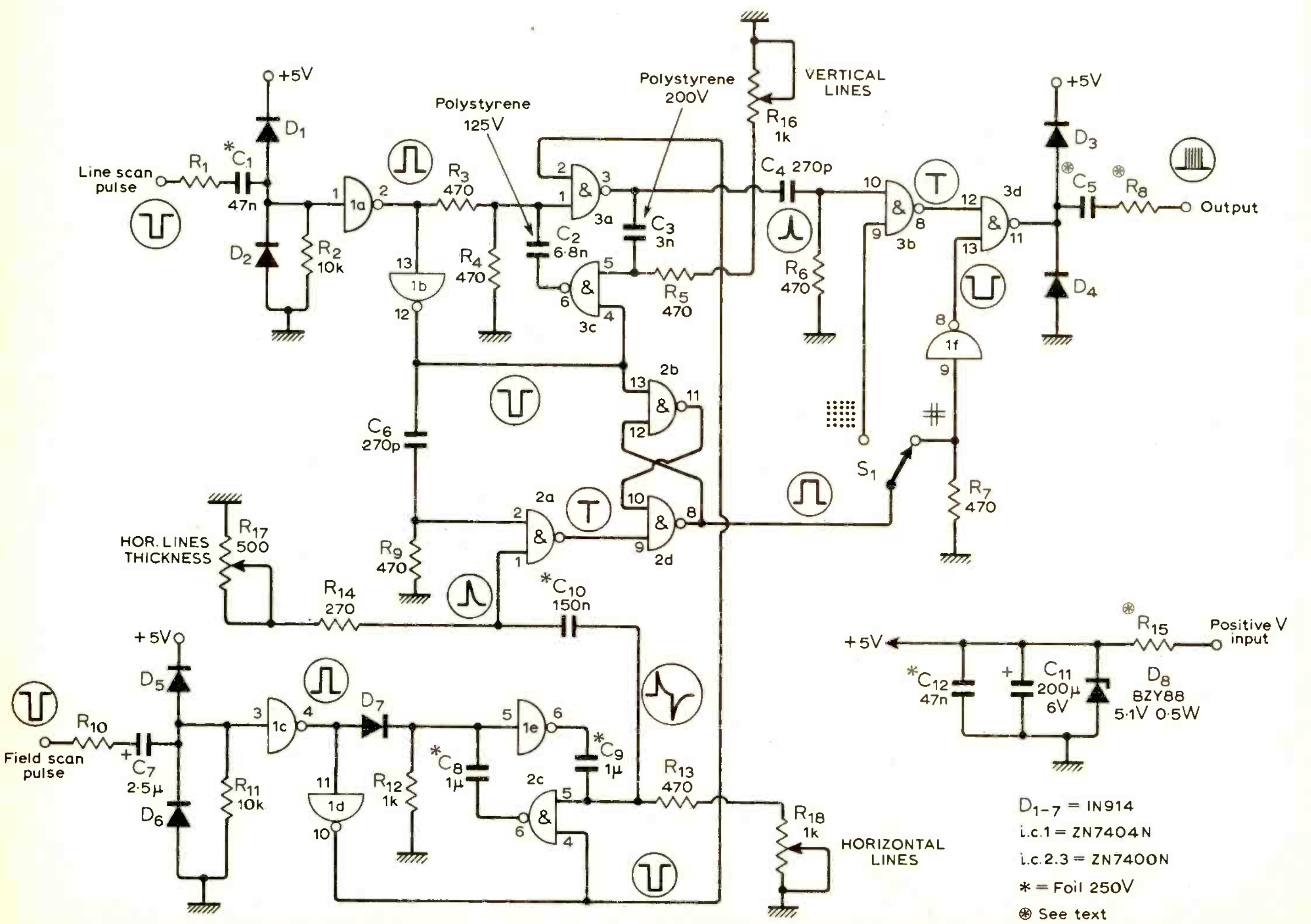


Fig. 1. Block diagram of the crosshatch generator.

as both line and field blanking are applied to prevent any pattern during flyback time. This blanking depends on the widths of the timebase pulses used and varies from receiver to receiver. It is likely that the blanking will not be perfect and some foldover of the pattern is to be expected depending on the receiver.

Horizontal lines: The basic oscillator is a multivibrator which is driven by field flyback pulses. The output square wave is differentiated to form a pulse of about 64μs duration and is used to open a gate which is also fed with narrow line-frequency pulses. The output of this gate will consist of one narrow line pulse for every period of oscillation which is given the timing of the trailing-edge of the line-flyback driving pulse by differentiation before the gate. This timing is also the start of the active-line—as near as can be obtained by simple means. An R-S bistable is triggered by this single pulse and is thereby turned 'on' at the start of the active line. The 'off' input of the bistable is fed with continuous line driving pulses which start at the *end* of the active line and finish *before* the 'on' pulse. The net result is an output from the bistable of one active line once per period of oscillation of the multivibrator.

The effect of varying the oscillator frequency is to cause a 'shuffling' of the horizontal lines as the optimum frequencies are passed through with a relatively smooth variation in the number of horizontal lines obtained. These lines are always of the correct length.

Circuit description (Fig. 1)

C_1, D_1, D_2 and R_1 form an excess-voltage protection circuit for the negative-going line-scan input pulses. Integrated circuit 1a amplifies and clips this signal to give clean rectangular positive-going pulses into i.c. 1b. This pulse is also fed to an attentuating network consisting of R_3 and R_4 which together form one timing resistor for the vertical line multivibrator i.c. 3a and 3c.

R_3 and R_4 are virtually in parallel when the input to the network is low during the picture time and the multivibrator then oscillates normally. When the input from i.c. 1a is high the multivator is prevented from oscillating because the potential at the input of i.c. 3a is such as to turn it off. R_3 is really an isolating resistor to remove the shunting effect of the low-impedance output of i.c. 1a from the timing resistor R_4, but since the parallel combination of R_3 and R_4 is low, then the value of C_2 is correspondingly higher than C_3. By this means the oscillator always has the same conditions at the start of every picture line. C_2 and C_3, with R_5 and R_{16} form the rest of the multivibrator.

The output from i.c. 1b is also used to help to control the starting and stopping of the multivibrator and in fact improves the linearity of the first space in the crosshatch pattern. There is a feed of field scan pulses to i.c. 3a to inhibit the multivibrator during the field flyback time.

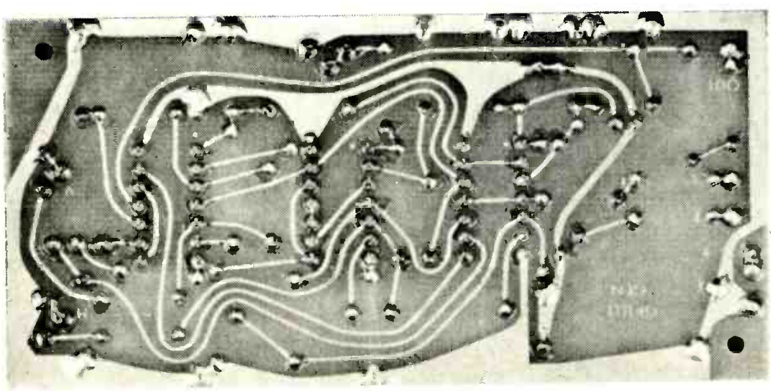
The field-scan negative-going pulse is used to drive the horizontal line multivibrator i.c. 1e and 2c in the same manner as for the vertical oscillator except that the value of C_8 has to be kept low because of its physical size. Therefore the input resistor is replaced by a diode to provide automatic isolation of the timing resistor from the gate output.

Both the multivibrators generate approximately square waves and both of them feed differentiating networks. The vertical line network of C_4 and R_6 provides a positive-going pulse of some 200ns width at the input to i.c. 3b—the negative-going pulses being ignored by this gate because they merely turn the gate 'on' harder than it already is whereas the positive-edges turn it 'off' as required.

A similar network of C_{10} and R_{14} with R_{17} generates the positive-going 64μs pulse at the input to i.c. 2a. The other input to i.c. 2a is the positive-going pulse with the timing of the line-scan drive pulse trailing-edge, which is obtained by yet another differentiating network C_6 and R_9.

The negative-going output of i.c. 2a, which is one narrow line pulse for every cycle of oscillation of the multivibrator, feeds the bistable input of i.c. 2d. The other side of the bistable is fed from i.c. 1b with cleaned-up negative-going line-scan flyback pulses. Integrated circuit 2d provides the output of positive-going single active lines, or horizontal lines of the pattern, and these are combined with the vertical lines in i.c. 3d, via i.c. 1f, to form a crosshatch of 4V peak-to-peak positive-going pulses at i.c. 3d. output. To enable a single-pole switch to be used—or a simple link—for switching to dots—the invertor 1f has to be used in the feed to i.c. 3d and its input has a low value resistor R_7 to earth so that when dots are selected the input of i.c. 1f is virtually earthed and so its output is 'high' and permits i.c. 3d to act as an invertor for the dot signal from i.c. 3b.

The simple multivibrators used in this generator have the very poor stability factor of some 30% change in the period of oscillation per volt of supply.



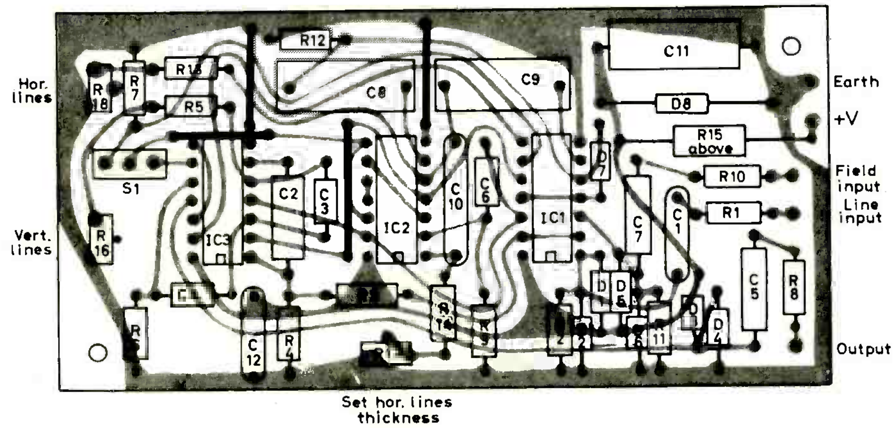


Fig. 2 (Upper) Photograph of the printed circuit board shown actual size (101mm in length). (Below) Drawing of the component side of the board.

Construction and testing

Construction should present little difficulty if the printed circuit board illustrated in Fig. 2, is employed. Normally the amount of testing required for such a unit is very small especially with integrated circuit construction since the unit either works or it doesn't. However in the case of this crosshatch generator the supply arrangement and the various connections need to be optimized.

The value of R_{15}, the zener series resistance should be chosen to allow some 20mA through the zener diode whilst the complete generator takes 40mA making a total of 60mA at 5.1 V.

Next the line pulse resistor R_1 should be chosen to give between 2.5 and 4 V peak-to-peak at C_1. When this is so there should be an output from the generator, with the switch set to crosshatch, which can be fed into the luminance amplifier. R_{16} can then be adjusted to give a suitable number of vertical lines.

For optimum results on the receiver, the colour should be turned off, the brightness increased and the contrast decreased, so that the receiver remains synchronized and the crosshatch appears on top of the picture.

For the best results the output signal should be fed into the luminance amplifier after the detector output amplifier stage, where the video is positive-going for white. R_8 determines the crosshatch amplitude. Feeding into the amplifier before the sync. separator does cause a slight problem with vertical sync. if the horizontal lines occur just before the field sync. pulse. However adjustment of the number of horizontal lines should prevent trouble in which the receiver 'chases its own tail'.

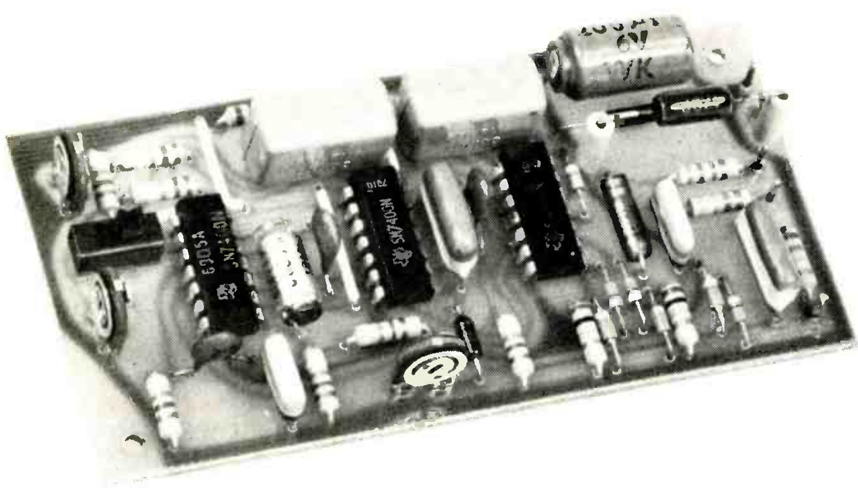
The field input resistor R_{10} is chosen to give a peak-to-peak reading of 2.5 to 4 V at C_7. The polarity of C_7 depends on the input source. If the line & field pulse sources do not exceed the i.c. supply voltages—*at any time*—then the protection diodes are not necessary and should be omitted. This should be observed by means of an oscilloscope.

When the field input pulses are correct the output should contain horizontal lines as well as vertical lines, but they will probably be jittering about and R_{18} should therefore be adjusted. On turning this control clockwise the lines will be observed to get wider apart, and fewer in number, in reasonably smooth steps with certain positions of vertical jitter. It should be a simple matter to find several positions where the pattern is stationary.

R_{17} can now be set so that the horizontal lines are not of double thickness, but at the same time none are omitted. The optimum setting may vary slightly with different settings of R_{18}. The setting of R_{16} may also slightly affect the jitter.

If the generator output resistor R_8 is sufficiently high then the removal of the generator's supply should cause no noticeable effects on the normal picture in which case this is a simple means of switching the crosshatch pattern off. Otherwise the output feed will have to be removed instead of switching off the supply.

The input and output connections may be made with ordinary insulated wire as all feeds are of relatively low impedance, but care should be taken with the run of the output lead due to stray capacitance reducing the amplitude of the vertical lines. If this happens then C^4 should be increased in value slightly.



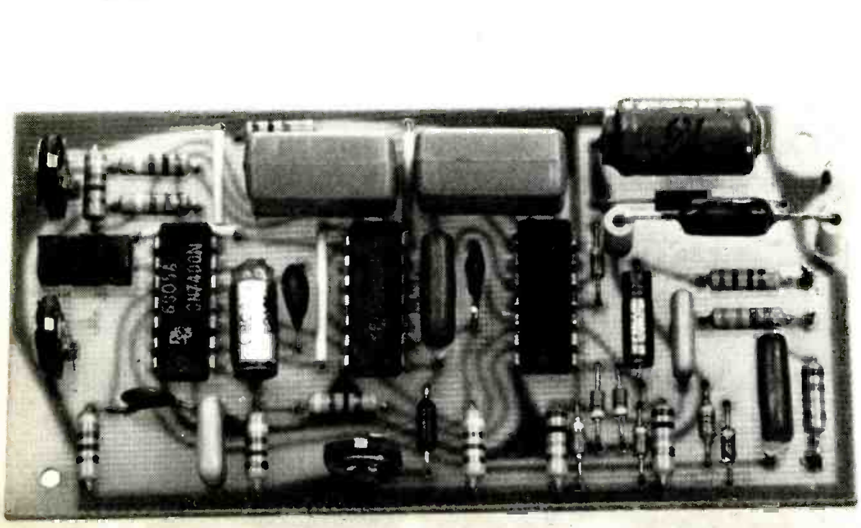


Fig. 3. The prototype.

Appendix

Operation of crosshatch generator with B.R.C. 3000 series colour receivers

R_1 should be 3.3kΩ, R_{10} should be 8.2kΩ, R_8 should be 12kΩ, R_{15} the zener resistor, is 470Ω, 3W—stood away from the board and C_5 should be 150nF.

Line pulse: Chrominance board, Junction of C_{337}, R_{359} and R_{362}. Solder the lead to the end of R_{362} nearest the back of the receiver.

Field pulse: Field Scan board. Solder the wire to the top pin of the R_{427} (field hold potentiometer).

Output: I.F. Board. L_{117}/R_{127}. Solder the wire to the end of this combination nearest to the front of the receiver (above VT_{105})—keep the length fairly short.

Earth: Convenient point on the i.f. board.

+30V. P.U. board. Solder the lead to the 5Ω resistor on the top of the lower board—the end which goes to the positive end, of W_{620}. This lead should be taken via a suitably placed on/off switch to the generator.

Method of operation

Turn off the colour, turn down the contrast, and turn up the brightness a little. The potentiometers should be adjusted for optimum results. Note that the horizontal lines upset the field timebase at certain settings because the crosshatch signal is put into the video chain before the sync. separator and the field timebase tends to chase 'its own tail'.

The Line and Field pulses should be 2.5 to 3.5 V p.p. at the inputs to the i.c's when the generator is switched on and about 2 V when off.

Both these waveforms are fairly wide and thus there is no visible fold-over or flyback.

The pattern is still visible under no-transmission conditions but the video noise masks the crosshatch and renders it unusable.

A worthwhile modification to the receiver would be to replace R_{423} on the field scan board by a 470Ω potentiometer (from earth) with a 1.8kΩ resistor in series. The potentiometer slider is then the field output point. The voltage at this point should be set to be less than 5 V p.p. The input capacitor and diodes on the generator field input can be deleted if this is done. The series resistor should be retained but changed in value to 220Ω or so, to protect the i.c.—otherwise D_5 could be retained instead.

A further improvement would be a series-regulator in the supply to the generator instead of the zener arrangement in order to reduce the supply impedance and thereby eliminate the slight tilting of the vertical lines at the right-hand side of the picture which occurs when the zener supply is used. Each vertical section between horizontal lines is tilted by about a line thickness and whilst the effect does not affect the observation of convergence errors, the pattern does not look good.

Square-root Circuit

Using dual silicon-gate m.o.s.f.e.t. to give 1% accuracy

*B. L. Hart**, *B.Sc., M.I.E.R.E., M.I.E.E.E., and* *A. Cheetham**, *M.Sc., M.I.E.R.E.*

There are various ways of achieving the square-root operation—for instance the biased diode and multiplier techniques.† However, a simple low-cost approach is made possible by the capability to make an f.e.t. with an accurate square-law transfer characteristic, and of making pairs with their electrical parameters almost identical.

Consider the circuit arrangement shown below, in which the direct-coupled differential amplifier has a d.c. and low-frequency small-signal voltage gain A_v, and Tr_1 constitutes two matched p-channel enhancement-mode devices of a dual m.o.s.f.e.t. unit. One of the devices—Tr_{1a}—is in the feedback network of the amplifier and passes the input current I; the other—Tr_{1b}—is connected in series with the output of the amplifier and passes a small constant current derived from the interconnection of the integrated bipolar transistor pair Tr_2. Transistor Tr_{1b} cancels out part of the amplifier output voltage.

As Tr_1 operate with drain-gate straps, each has a voltage-current relationship of the form

$$I_{SD} = \Psi(V_{SG} - V_T)^2$$

where I_{SD} is the source-drain current, V_{SG} is the source-gate voltage, V_T is the threshold voltage, and Ψ is the device constant (a function of material type, doping, geometry). (The order of the subscripts for I, V corresponds to positive values of these quantities for a p-channel enhancement device.).

For simplicity in a first-order approximation assume that Tr_1 have identical V_T's and identical values of Ψ. Assuming $A_v \gg 1$ and ignoring the input current, feedback action ensures that

$$I_{SD1} = I = V_I/R = \Psi(V_{SG1} - V_T)^2 \quad (1)$$

$$\text{If } \sqrt{I_{SD2}/\Psi} \ll V_T \text{ then } V_{SG2} \approx V_T \quad (2)$$

But,

$$V_O = (V_{SG1} - V_{SG2}) \quad (3)$$

Using equations (1) and (2) in (3)

$$V_O = \sqrt{V_I/\Psi R} \quad (4)$$

For the special case $\Psi R = 1$ volt,

$$V_O = \sqrt{V_I}. \quad (5)$$

The successful practical realization of equation (4) depends on the choice of Tr_1.

Now for $V_I \approx 0$, the amplifier output voltage is approximately V_T; thus for maximum range in V_O m.o.s.f.e.ts with a low V_T are required. This suggests the use of devices made by the silicon gate process. Preliminary measurements indicated a $V_T < 1{\cdot}5$ V and a V_T matching of a few millivolts for the two devices of the recent silicon-gate dual m.o.s.f.e.t. type ME1202 (Marconi-Elliott Microelectronics) so this was used. The amplifier can be any good quality operational amplifier: a Burr-Brown type 3057/01 was used. Values for V_{EE} and R_B were chosen so that Tr_2 (SL301-A, Plessey) in the "current mirror" configuration supply a current $I_{SD2} \approx V_E/R_E \approx 5\mu$A.

A convenient way of operating the circuit, and the one used for the tests reported here, is to set V_I at a point V_I^* in the middle of the desired input operating range, then adjust R so that a precision digital voltmeter indicates $V_O = V_O^* = \sqrt{V_I^*}$. This ensures $\Psi R = 1$ in equation (4) and hence the validity of equation (5) at the "set" point

A selection of the results obtained with one of the units is given in the table, in which the fourth column records the error ε calculated from

$$\varepsilon = |(V_O - \sqrt{V_I})/\sqrt{V_I}| \times 100\%.$$

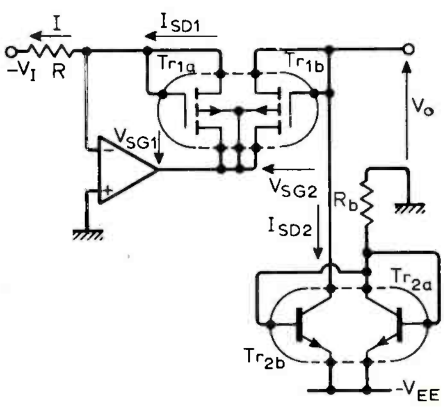
To obtain the readings shown the circuit was set up at $-V_I = -4{\cdot}000$ V. For a 20-V input range the maximum departure from square-root law behaviour is less than 1%. Other readings (not given) show this to be true also when the circuit is set up at $-V_I = -9{\cdot}000$ V.

Test results showing accuracy of square-root circuit

$-V_I$	$\sqrt{V_I}$	V_O	ε
−0·5000	0·7071	0·6960	1·6%
−0·7500	0·8660	0·8692	↑
−1·000	1·000	1·009	
−2·000	1·414	1·424	
* −4·000	2·000	2·000	< 1%
−9·000	3·000	2·998	
−16·00	4·000	4·009	
−20·00	4·472	4·492	↓
−25·00	5·000	5·073	1·4%

* Set-up point

Throughout V_I has been taken as a positive quantity—the circuit extracts the square root of the magnitude of an applied negative signal. To find the root of the magnitude of a positive voltage the circuit must be preceded with a unity-gain inverting amplifier.



Using a m.o.s.f.e.t. with an accurate square-law characteristic in a feedback loop is the basis of this simple square-root circuit.

*North East London Polytechnic

†C. A. A. Wass. "An introduction to electronic analogue computers". Pergamon: 1956

Correction

Audio sweep generator

F. H. Trist has asked us to make some additions to the circuit of his suggested sweep generator (page 337, July issue). In the v.c.o., a 10-kΩ resistor should be connected at the junction of the 10-μF coupling capacitor with the following resistor and to earth. In the output level amplifier, a 470-Ω resistor should be connected between the negative input of the i.c. and earth. The three level-control resistors in the feedback loop should be reduced by three orders of magnitude. In the frequency-to-voltage converter, a 10-kΩ resistor should be connected between the negative input of the second i.c. and earth. In this circuit, we apologise for showing the X-output incorrectly connected. It should be taken from the wiper of switch S_e, and the common connection of the capacitors earthed.

News of the Month

necessary to relay several different types of information between aircraft and ground via satellite and to determine the best way of putting the study into practice.

Aircraft over the North Atlantic are under the control of oceanic air traffic control centres and the present system is under the jurisdiction of several centres including Gander in Newfoundland, Prestwick in Scotland, New York and Santa Maria (Azores). Aircraft report to these stations using normal h.f. radio, to give position information derived from their own on-board navigational instruments.

Improvements to the system are made continuously to cope with the demand of increasing transatlantic air traffic and it is in anticipation of the time when current methods are no longer effective, that consideration of satellite systems is being undertaken on both sides of the Atlantic.

Scientific fellowship for authors

A scientific fellowship, worth over £750, is to be awarded by the Butterworth Group to commemorate 25 years of scientific publishing. The Fellowship, to be presented annually from October, 1972, is designed to allow would-be authors to take time off from their work to write a book. By this means, each year, Butterworths hope to encourage a work on some aspect of a physical or biological science, or its application. Proposals will be judged both on academic merit and relevance to current research.

Candidates should work in a British university or institute or in an industrial laboratory of similar standing. Depending on the amount of work involved, the fellowship will be tenable for a period of three to twelve months, and during this time advances against royalties will be made to cover the loss of normal income. In addition an award of £750 will be made on acceptance of the manuscript.

The fellowship will be awarded by Butterworth's Scientific Advisory Board whose members are: Professor Sir Harold Thompson, C.B.E., F.R.S., (Department of Physical Chemistry, University of Oxford); Professor D. H. R. Barton, F.R.S., (Department of Chemistry, Imperial College, London); J. A. Charles (Department of Physics, University of Bristol) and Professor J. L. Harley, F.R.S., (Department of Forestry Science, University of Oxford).

Applications must be submitted by 1st October, 1971 and must be backed by a head of department. It is expected that the fellow will be selected in the same month. Applicants should write for more information and entry forms to The Scientific Publisher, Butterworth Group, 88 Kingsway, London WC2B 6AB.

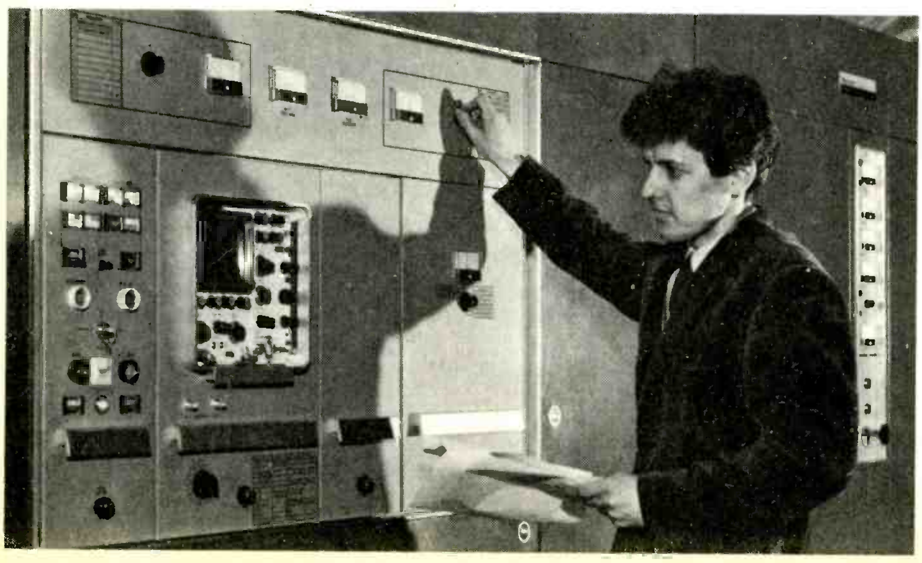
Atlantic air traffic control by satellite

Further steps towards using satellite communication links for air traffic control are being taken with the award of a study contract to the Marconi Company by the Department of Trade and Industry. Under the contract Marconi's Radio and Space Communications Division will prepare a detailed analysis of the ground-based parts of a possible aeronautical satellite system for the North Atlantic. This will entail a detailed study of the ground equipment

Computer telegram system

The Post Office has placed a £3.25M order with Pye/T.M.C. for a computer-controlled telegram routing system which will replace electro-mechanical systems in 1973 at Cardinal House, Farringdon St, London. It will be the largest system of its type in the world and will be controlling the receipt and dispatch of the 21 million international telegrams handled in Britain every year.

Initially the equipment will receive telegrams for transmission abroad from international area offices throughout the country and will perform all the necessary switching and routing automatically. The same process will apply to telegrams received from abroad which will be automatically routed to the appropriate area office. Eventually the system will convert addresses on incoming telegrams to the telex address (if there is one) so that the message can be immediately sent over the telex network.



Radar at Heathrow

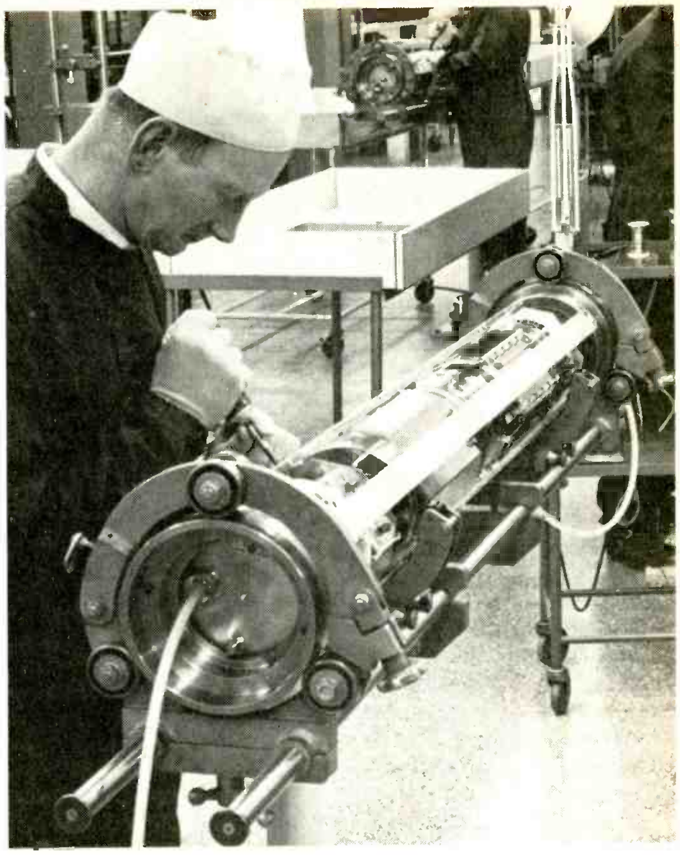
Marconi Radar Systems has received an order from the Ministry of Defence (Aviation Supply), on behalf of the Department of Trade and Industry, to supply a high-power, 50cm transmitter/receiver to replace radar equipment at Heathrow Airport which has been in service for twelve years. The new transmitter/receiver (type S2020) is a self-contained 500kW 50cm equipment designed for use in coherent moving target indication systems and will be installed towards the end of the year. The power amplifier stage is a three-cavity klystron valve, with a typical life of 30,000 hours.

(left) S2020 radar for Heathrow

Surveillance system for Southampton docks

An extensive surveillance system is to be installed to provide increased safety to shipping using the port of Southampton. The scheme is being carried out by the British Transport Docks Board. Decca Radar and Marconi Communications Systems have been awarded contracts totalling over £0.25M.

Decca Radar are to equip two unmanned radar stations, at Hythe and Calshot, from which data will be transmitted by microwave link to six 400mm displays in the operations room at the port communications centre. At Calshot and Hythe the radar stations will consist of 7.6m scanners mounted at a height of 33m. Remote control of both stations will be effected by microwave link to the port communications centre. The six displays to be installed by Decca in the operations room will be able to receive data from either unmanned station (two normally being fed from Hythe and four from Calshot). The Decca computer-assisted measurement system will be provided for all six displays, and a Deccaspot system will be available on all pictures received from Calshot. The former system uses a small Honeywell computer to enable rapid and accurate measurements to be made of any point, such as a ship's position, relative to any other point on the display. Deccaspot, a method employing a series of bright spots on the display to depict with great accuracy any permanent feature required, will be used to delineate the centre of the navigation channel from Southampton Docks.



Submarine cable repeaters being manufactured in an S.T.C. plant under clinical conditions. Repeaters of this sort will be used on a new £22M transatlantic cable (CANTAT-2) which will run from Widemouth Bay in Cornwall to Halifax in Nova Scotia. The 14MHz coaxial cable will carry 1840 simultaneous telephone conversations: Repeaters will be fitted at intervals of about six nautical miles. S.T.C. have been awarded the contract by the Post Office and it is calculated that the cost is about £6 per circuit per mile.

Desk-top optical mark reader

Interscan Data Systems (U.K.) Ltd, normally associated with complex and expensive, optical character recognition machines, have announced a new low-cost relatively simple document reader. The new reader—there are two versions—can be operated by a company for as little as £2,000 per year. Once loaded the reader will continue to operate all day without attention.

The machine, called o.m.r. (optical mark reader) reads characters on special forms and gives an output in computer compatible code. As long as the characters are put in the correct position on the form they can be machine or hand printed.

The reading head, which is made to mechanically scan the rows of characters, consists of two photodiodes which simultaneously read the upper and lower halves of the characters. Only vertical sections of the characters are sensed, horizontal marks being redundant. The reading head also contains two magnetic proximity sensors which provide clock pulses, when a character is under the reading head, from castellations machined into a piece of metal mounted parallel to the moving reading head.

Document size can vary from 50 × 100mm to 216 × 280mm and the reading speed is up to 20 characters per second. The makers say that the equipment costs less than a paper tape station to hire and has ten times the throughput. To another piece of equipment the machines electronically look like a Teletype machine and therefore can be easily interfaced with other data processing equipment or the output can be recorded on a casette tape recorder.

Motorists' laser warning system

Scientifica and Cook Electronics are working hard to find new applications for the laser. Recently they described a system, which could be used on small airfields, employing a laser to provide a visible glide path to assist landing aircraft.

Another idea, and apparently a good one, entailed fitting photocell detectors on the nose of aircraft and connecting them to the aircraft's intercom system. The idea being that the control tower staff could contact an aircraft on the airfield very quickly in an emergency using a modulated laser beam regardless of the channel selected on the aircraft's radio.

An extension of this idea has resulted in photocells being fitted to a motor car, the cells being connected directly to the a.f. stage of the car's radio so that it is possible to transmit warning messages to motorists by using a diffused laser beam directed down the centre of the carriageway. Trials have shown that this idea works well in practice.

One-plus-one equals party line privacy

One-plus-one is the name given to a new piece of equipment which is to be installed on an experimental basis at 10.000 locations up and down the country by the Post Office. It enables two subscribers to share a line to a telephone exchange with complete privacy and if desired both subscribers can use their telephones at the same time.

A filter is fitted at the point where the line from the exchange divides to go to the individual telephones. One of the telephones operates in the normal manner at audio frequencies and does not require any additional equipment. Two carrier frequencies are used for the second telephone, 40kHz for send and 64kHz for receive. Equipment at the exchange and at the subscriber's premises carries out the necessary modulation and demodulation functions. Electronic equipment at the subscriber's end is powered by a small nickel-cadmium battery which is trickle charged over the line from the exchange. The system was designed by G.E.C's Telephone division laboratories at Aycliffe.

Letters to the Editor

The Editor does not necessarily endorse opinions expressed by his correspondents

Ceramic pickup equalization

Without reflecting on other parts of Mr. Burrows' article in the July issue I am appalled at his ability to read out of context.

His quotation from my book 'Pick-ups: Key to Hi-Fi' is given as a *myth* about 'electrical loading affecting the mechanical operation' of a pickup.

But the quotation clearly mentions correction by electrical means (via element *capacity*), of a mechanically accomplished equalization. It has nothing to do with damping mechanical resonances at all. It seems this myth belongs to Mr. Burrows.

JOHN WALTON,
Windsor,
Berks.

I was interested in the excellent article by Mr. Burrows (July issue) basing the mechanical/electro independence of pick-ups on low energy conversion. This is the first time that I have seen this direction of approach.

However, it is only fair to point out that hosts of manufacturers other than Leak imply by instruction booklet or text or input circuit design that an approximation to velocity characteristics is achieved by connecting a piezo pickup across the relatively low value load of an R.I.A.A.-equalized input.

Surely the point of the exercise is that all quality amplifiers are deliberately equipped with R.I.A.A. low-level inputs so that the advantage can be taken of the optimum performance at the present state of the art provided by the magnetic cartridge?

The lack of simple solid-state, high resistance inputs prior to the f.e.t. obviously made it necessary for manufacturers to suggest a simple artifice to accommodate the minority of 'lower-fi' piezo users. Since the f.e.t. has become more commonplace and less costly, manufacturers who consider that the piezo cartridge is being treated unfairly are yielding designs with an f.e.t. input solely for piezo cartridges or in addition to the usual R.I.A.A.-equalized input. The piezo input is typically 2MΩ, and with this kind of cartridge mild bass roll-off is not always amiss.

In my judgment it is debatable whether manufacturers would have very much call for an amplifier with a specifically engineered piezo input possibly requiring adjustment to suit the cartridge used. The hi-fi enthusiast is a magnetic man for various reasons, and now that magnetic species of surprisingly high quality (in terms of the three main parameters of tracking performance, frequency response and crosstalk) are available for a few pounds the man hitherto piezo prone is turning towards electromagnetic energy for this programme source.

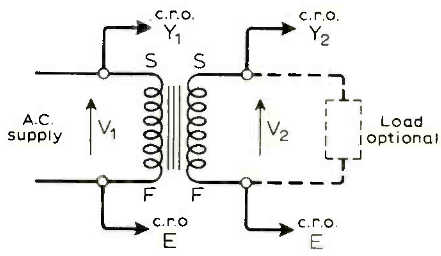
Apart from the obvious lack of true velocity coincidence by running a typical piezo across 47kΩ into an R.I.A.A.-equalized circuit, the major offence is pre-amplifier overload, since this partnership is not uncommonly practised without input attenuation. Bearing in mind the poor overload margin of such pre-amplifiers it is possible that this rates higher in the poor-piezo-quality stakes than lack of absolute equalizing.

GORDON J. KING,
Brixham,
Devon.

Transformer phase reversal

I am most grateful to your eminent contributor 'Cathode Ray' for throwing his very considerable professional weight behind the campaign for the truth about the transformer (June p.285). Although, as he explained, he had to argue the matter on paper without practical demonstration, I take it that your readers can and will check the experimental fact as to the phase relations between terminal voltages and currents in primary and secondary for themselves (see circuit); or perhaps not, since during the past seven years of teaching the experimental fact (preceded by two years of teaching orthodox phase reversal!) I have invariably found that lecturers will argue heatedly for an hour among themselves but when invited to make a five-minute measurement say they haven't got the time.

Electronics is above all (apart from instrument transformers, where only the direction of a wattmeter deflection is at stake) the field where phase cannot be fumbled. A power engineer, paralleling two 10 MVA transformers and assuming a phase reversal in *both*, will come to no harm, being protected no doubt by the same Divinity which looks after children and drunks. But an audio amplifier designer getting his transformer polarities wrong in a feedback amplifier is going to produce fierce oscillations and a damaged loudspeaker. It would be helpful therefore, if manufacturers of interstage transformers who do mark winding starts and finishes,



If the starts and finishes of the windings are not marked they can be quickly established by measuring the inductance of the two windings in series. The connection giving the larger inductance is that in which the finish of one winding is connected to the start of the other winding.

and some others who don't, would tell us what the phase relations in their transformers are, and if manufacturers of feedback amplifiers using interstage transformers and output transformers would say what phase relations they assumed in designing their amplifiers and getting them to work so very satisfactorily.

VICTOR MAYES,
Gloucester Technical College,
Gloucester.

Audio sweep generators

While Mr. F. H. Trist is to be congratulated for answering the long-felt need for an audio sweep generator, we feel that his design (July issue) falls short of engineering requirements on several counts.

1. Sweep frequency range. The 10:1 frequency change satisfies only a small proportion of the possible uses; in fact only those for investigating narrow-band filters. A 1,000:1 change, from 20Hz to 20kHz seems a minimum specification for ampli-

fiers, tone controls and filters, and this sort of range is normally offered by commercial designs.

2. An amplitude accuracy of 1dB is marginally adequate for transducer measurements, and not good enough for amplifier and filter work.

3. A sweep time of four seconds is only suitable for oscilloscopes with c.r.t. phosphors which most users are unlikely to have.

4. Logarithmic scaling of both frequency and amplitude axes in all graphical representation in audio engineering is normal and necessary. To give one example, it is not possible to differentiate between a 26dB and a 40dB notch filter on an oscilloscope, if the system responds linearly to amplitude. (A fast enough sweep time to make the use of a normal oscilloscope possible can be achieved only if the sweep is logarithmic.)

It seems to us that most of the drawbacks in Trist's design result from the wrong choice of oscillator. Any bridge-type oscillator is far too "sensitive" (in the sense that Bode gives the term[1]) to achieve a wide frequency change without unreasonably close matching of components. The design considered demands 5% matching of f.e.t. drain-source resistances for only a 10:1 frequency range, and even then an a.g.c. network is needed to compensate for the varying losses in the bridge. Furthermore this a.g.c. system introduces another time constant into the oscillator, which is too long to allow for amplitude correction during the sweep.

Two alternatives to the bridge oscillator suggest themselves, if only to eliminate component selection and complex setting-up procedures (Trist's calibrator alone contains fifteen pre-sets); these are the non sinusoidal oscillator[2] and the two-integrator loop[3]. A switched Miller integrator, of which Trist's ramp generator is an example, can itself be frequency controlled by another ramp generator, producing a swept triangular wave with its amplitude independent of component matching and fixed only by the reference level of the comparator. Provided this triangular waveform is equilateral, a pure sinusoid can be obtained with a simple function generator. A diode network will produce better than 3% harmonic distortion[2] and other methods easily better this[4]. Alternatively the two-integrator loop generates sine waves with amplitude fixed by a limiter and tracking errors between the two frequency varying elements produce proportionate errors in frequency only, none in amplitude. Frequency ratios of 1,000:1 are easily obtainable, in practice with both the above oscillator types.

We are working on a sweep generator using a two-integrator loop, which we hope to submit for publication shortly. Although our design requires a greater number of i.c. operational amplifiers, it does satisfy requirements 1-4 above namely a 1,000:1 sweep range, good amplitude accuracy, fast sweep rate and logarithmic frequency and amplitude axes. We feel therefore that alternative oscillators to the Wien bridge should be considered by those interested in sweep oscillator design.

A. FALLA, R. S. SNELL,
University of Sussex,
Brighton.

1. H. W. Bode: Network analysis and feedback amplifier design (p52), D. Van Nostrand, N.J. 1945.
2. P. J. Kindlman: 'Sound synthesis: a flexible modular approach with i.cs', *I.E.E.E. Transactions on Audio*, Vol. AU-16 no. 4, Dec. 1968.
3. E. F. Good: 'A two-phase low-frequency oscillator', *Electronic Engineering*, Apr. 19, '57.
4. 'Triangular-to-sine convertor', *Electronics*, Vol. 38, no. 5, p96.

The author replies:
It was with considerable interest that I read Messrs Falla and Snell's comments on my sweep generator. Before answering each point in turn, may I say that all of them occurred to me (unceasingly!) during design stages.

(1). Perhaps I did not state sufficiently clearly that there are four frequency ranges available at the flick of a switch, thus enabling 10-10^5Hz to be covered. This seems to me to be of greater use than squeezing the entire spectrum into some 4 in of c.r.o. display. I do not consider the range quoted by Falla and Snell as adequate; my system allows break points to be studied in detail—you don't gaze at the stars whilst tying your shoelace!

(2). It is doubtful whether a linearity of better than 1dB is necessary in any audio system. In any case, displaying the input to the network under study will reveal where and by how much the amplitude varies during a sweep.

(3). I should point out that:
(a) Only the lowest range is limited to a 4 second sweep.
(b) Ideally, for normal c.r.o. work, a sweep rate in excess of 25/sec. is required, in order to fool the eye. My system would generate garbage at this speed, even if the a.g.c. could respond fast enough, as there is no control over the starting phase of the oscillator. I assume that the two-lag system proposed will control this function, but sweeping at any rate faster than 0.1 of the minimum oscillator frequency will give little indication of response as frequency will change faster than phase.

(4). The prototype contained a logarithmic operator to provide the display timebase; this was of little practical use, due to the non-linearity of the voltage-resistance characteristic of the tuning devices. At the price—£20 including case—I don't apologize. As my unit does not attempt to process the signal from the observed network, how could it possibly be expected to provide a logarithmic amplitude display? Perhaps the writers would have me compress the signal *to* the network!

I do not follow the last sentence of (4). Only an antilogarithmic timebase function could permit faster sweep rates at low frequencies; this would diminish the phase problems detailed above; a logarithmic function must accentuate them.

I do not feel that 5% matching of two devices is too much to ask for. Falla and Snell mentioned diode shaping an equilateral triangular waveform to produce a low—3% is low?—distortion sinusoid. If they were to use the switched Miller integrator proposed, they would require to match a pair of current defining resistors to better than 5%.

It is simply not true that amplitude correction is not applied during a sweep. The sweep frequency is much lower than the minimum oscillator frequency on each range; while the smoothing time-constant all but eliminates ripple from the oscillator, it is small enough to respond to the ramp-generator frequency—the fundamental frequency at which the amplitude attempts to change. I could scarcely claim a maximum deviation of ± 0.5dB unless this were so.

Non-linear shaping of a triangular waveform can, by definition, never achieve the low-distortion of the Wien bridge. My instrument produced less than 1% distortion at 10Hz; on the upper three ranges no reliable reading could be made using a Marconi distortion factor meter.

F. H. TRIST,
Stoke-on-Trent,
Staffs.

Karnaugh map display

Fig. 5 in the article (published in April) showing the 'equivalent' circuit for the ladder network on Fig. 4 demands some clarification. It may have been tempting to suggest that for a 00-input (Fig. 5(a)) the value of the equivalent series resistor does not matter very much (its value is not mentioned) as the operational amplifier, with this network connected to its inverting input and with the non-inverting input at ground, will have an 0V-output whatever the input resistance. However, this resistance together with the feedback resistance determines the amplification of the signal applied to the non-inverting input. The right value is 10/3 kΩ. In the same way Fig. 5(d) for an 11-input is in error: the fact that no current flows through the two paralleled 10kΩ resistors with unloaded ladder doesn't imply that the left hand resistors can be neglected when determining the equivalent circuit; the two remaining 10kΩ resistors would give an equivalent resistance of 5kΩ whereas in reality it should again become 10/3kΩ.

A first inspection of the ladder network shows that if the terminating resistor had not been returned to ground but instead used to feed the operational amplifier, where it sees a virtual earth, then the two voltage sources feeding the ladder would have seen exactly the same load (15kΩ) but this doesn't seem to be a necessary requirement. A second inspection shows

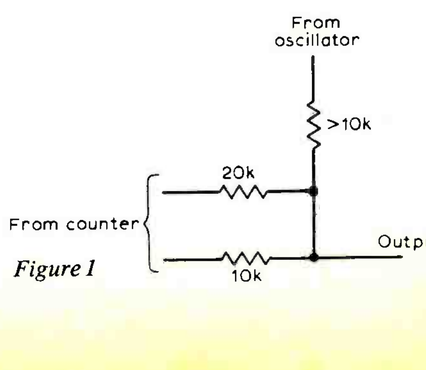


Figure 1

that the terminating resistor could have been dispensed with, even when the ladder output had not been connected to a virtual earth, without upsetting the digital-to-analogue conversion: for an unloaded ladder this would have given a 50% increase in voltage output. The third inspection reveals that two (or three) resistors instead of five (or six) would have done an even better job (Fig.1).

The clamping circuit shown gives considerable voltage loss; if necessary this can be improved upon by replacing the two silicon diodes by one low-voltage zener diode (about 3.3V). With a 4V swing even an oscilloscope having an X-sensitivity as low as 1 cm/volt would still give a readable image. What happens exactly when one doesn't use a clamping network? From Mr. Crank's observations we may infer that only the clock pulse can be responsible for a double image but this is easier to remedy by using an asymmetric clock signal (small ON/OFF ratio); all other waveform distortions of the type shown will cause some of the 16 centre positions of the Karnaugh map to be shifted only slightly from an 'ideal' orthogonal raster in a reproducible way without provoking a double image. As these shifts are very small their effect will hardly be noticeable. A clamping network is therefore unnecessary!

The output swing being much larger now than in the original version the two operational amplifiers are redundant and the output to drive the 'scope can be taken direct from the digital-to-analogue converter. This results in considerable savings as the major part of the power supply can be dispensed with as well.

Having now only 5 or 6V available for driving the phase-shift oscillator, its output amplitude is reduced. The two output resistances may thus have to be reduced as well. The larger resistance is required at the collector output and it is therefore this output upon which the 1/0 switch should act in order to minimize the effect of the switching action upon the X-amplitude. It is also preferable to connect the switching transistor in the "inverted mode" in series with a capacitor.

The total savings are impressive: no operational amplifiers instead of two; one battery supply instead of three; a one-pole switch instead of a three-pole one; one electrolytic instead of three; no need for diode/resistor clamping; two transistors instead of four.

The final conclusion is that, without doing any difficult exercise and while retaining some of Mr. Crank's ideas and statements, his simplified logic display aid could have been further simplified.

G. J. NAAIJER,
Limeil-Brevannes,
France.

The author replies:

Perhaps Mr. Naaijer misunderstood the purpose of my equivalent circuits for the ladder networks. The object was to provide a simple explanation of how the square wave outputs of the counter became a staircase and to have considered the operational amplifier as well would have only confused the issue. If in my quest for simplicity I have offended the purists I apologize. Perhaps if the offending diagram had been labelled 'simplified circuit' instead of equivalent circuit (with all that this implies), the confusion would not have arisen. I would recommend that readers adopt Mr. Naaijer's digital-to-analogue converter circuit because of the component saving it affords.

I can assure Mr. Naaijer that some form of counter output waveform correction is essential to achieve a 'respectable' display. The zener diode idea was considered during the design but rejected on the grounds that two general-purpose silicon diodes can be purchased at a lower cost than one low-voltage zener diode. By far the best solution was that proposed by A. W. Critchley in the May issue (p. 257). He suggested using four 'pull-up' resistors connected to the counter outputs.

The question of dispensing with the two operational amplifiers is debatable and depends on the use to which the unit is to be put. The original intention was that the device should be used in schools, I could not see many private constructors building it. In this application the device would very often be required to operate with long leads to the oscilloscope, or perhaps several oscilloscopes might be used, situated at strategic points around the classroom. In these circumstances the low output impedance afforded by the operational amplifier is essential as the visual effects of hum pick-up are particularly unpleasant with this type of display.

No trouble was experienced in the prototype with the 1/0 switch loading the phase-shift oscillator and I can therefore see no point in altering the 1/0 switch if the rest of the circuit is built as published (with the recommended alterations). If Mr. Naaijer's suggestion is adopted it would probably be necessary to redesign the phase-shift oscillator to run on 6V.

Most of the component savings claimed mean putting up with a high output impedance with the attendant hazard of hum pick-up. Mr. Naaijer's reference to two, instead of four, transistors refers to using the unused exclusive-OR gates as a multivibrator. (This was described in A. W. Critchley's letter already published and, therefore, the print was removed from Mr. Naaijer's letter to avoid duplication.)

BRIAN CRANK

Stereo mixer

For readers who wish to build the designs published in the May and June issues, here are some details of suitable components. Capacitors used in equalization, tone-control and filter networks should be 5% components, polystyrene types for values less than 0.01μF, and polycarbonate (e.g. Siemens B32540) above 0.01μF. The 4.7pF high-frequency compensation capacitors, connected from collector to base of the second transistor in Figs. 3, 8(a) and (b) are not critical and could be increased to 10pF so that polystyrene types can be used. Electrolytic capacitors are from the Mullard C426 and C437 ranges, and non-polarized coupling capacitors are from the Mullard C280 range. Fixed resistors are 5% ¼W carbon film, unless stated otherwise.

The apparently blank statements cocerning residual noise and mixing level made in part 1 (May issue) require explanation as this point was given theoretical treatment in an unpublished part of the manuscript. A noise analysis of the virtual-earth mixer Fig. 10, shows the signal to residual noise to be $v_i/\sqrt{4.k.T.\Delta f.R.n}$ where v_i is the maximum nominal signal at the slider of the channel fader, R is the resistance level of the mixer (i.e. the value of the channel fader or summing resistor) and n is the number of channels. As the maximum output of the pre-mixing circuits is between 8 and 9V r.m.s. an overload margin of 30dB requires v_i to be around 120mV after allowing for a 6dB loss in the channel balance control. If R is 20kΩ and n is 5, then the residual noise level is −84.5dB on a 30kHz noise bandwidth. The expression indicates that the residual noise level deteriorates as the number of channels is increased but is improved by a reduction in the resistance level R, and by an increase in the signal level at mixing. Both the latter effects also reduce the overload margin, so a compromise has to be found. Alternatively the preset sensitivity control can be moved, for example to the feedback loop, though this presents its own problems of stability.

HUGH WALKER,
South Queensferry,
Scotland.

F.M. stereo tuner

I have found that there have been a small number of tuners produced to my design* which have given signs of instability, and I have been able to reproduce this effect in my own tuners. The trouble is not instability in the normal sense, but gives the impression that it is. The trouble is 'squegging' of the local oscillator, and the cure is the standard one—reduce the base time-constant. I have found that the base capacitor, now 47pF, is best reduced to 15 or 22pF, which cures the problem; the only side effect being due to the slight lessening of oscillator amplitude, with a slight reduction in sensitivity. This is of little consequence because of the very high sensitivity and is largely offset by a slight reduction in background noise. After changing the base capacitor to 15pF in two tuners both of which exhibited the apparent instability, there was no trace of any effects nor could they be provoked by any setting of the tuning or trimming controls. In both tuners the background between stations was very quiet despite a sensitivity for 3dB limiting below 1μV.

L. NELSON-JONES,
Bournemouth,
Hants.

**W.W., April & May 1971.*

Phase-locked-loop Stereo Decoder I.C.

Build a high-performance decoder with the minimum number of components

It is possible to make a high-performance phase-locked-loop stereo decoder with just sixteen components and a printed circuit board. Only one coil is required and only one adjustment is necessary. The major component in the decoder is an integrated circuit (CA3090Q), containing 126 transistors, which has just been introduced by R.C.A.

A block diagram of the i.c. is given in Fig. 1. The composite output signal from the discriminator of an f.m. receiver is applied to pin 1 of the i.c. where it is amplified for distribution to other parts of the chip. The phase-locked-loop consists of a voltage controlled oscillator (v.c.o.), two divide-by-two stages and a phase comparator (phase-lock detector). An inductor and a capacitor connected to pins 15 and 16 give the v.c.o. a natural centre frequency of 76kHz. This 76kHz signal is divided by four in two cascaded divide-by-two stages to provide a 19kHz reference for the phase-lock detector. The phase-lock detector compares the locally generated 19kHz signal with the incoming 19kHz pilot tone and provides an output to alter the operating frequency of the v.c.o. if there is any difference. The bandwidth of this loop—which may be likened to a servo system—is determined by an *RC* network connected to pin 14.

The whole purpose of the loop is to regenerate the 38kHz sub-carrier which is suppressed at the transmitter before the signal is transmitted. The 38kHz sub-carrier is necessary to demodulate the composite stereo signal and the action of the loop ensures that the regenerated sub-carrier is very closely related in phase to the transmitted 19kHz pilot tone.

When the v.c.o. is running at exactly the right frequency the output from the phase-lock detector is zero so it is necessary to provide a second detector, to sense the presence of the pilot tone, in order that the chip can distinguish between a stereo and a mono signal—the pilot tone is not present on a mono signal.

This detector is called the pilot presence detector and it is driven by a second divide-by-two stage operating from the chip's 38kHz line. The resulting 19kHz signal is compared with the composite input signal and if a pilot tone is present the pilot presence detector trips a Schmitt trigger. The sensitivity of the pilot presence detector is set by a resistor connected between pins 7 and 8. With the value shown in Fig. 2, a 4mV input signal (pin 1) will be sufficient to operate the Schmitt trigger. If greater sensitivity is required the resistor can be replaced with a 4.7mH coil in series with 15nF capacitor across pins 7 and 8. The Schmitt trigger will then operate at 3.3mV (off at 2mV) and an improved overload characteristic is obtained as a by-product. An *RC* combination connected to pin 6 is a filter for the pilot presence detector.

When the Schmitt trigger operates it lights the stereo indicator lamp via an integral driver amplifier and informs the left/right channel detector that a stereo signal is being received and switches the whole chip to stereo operation.

The left/right channel detector uses the 38kHz sub-carrier (stereo gating signal), generated by the phase-locked-loop, and the composite input signal to produce a stereo difference signal which drives the matrixing circuits. The matrix extracts the left and right channel outputs from the composite input signal in the normal way and after amplification the left and right channel outputs appear at pins 9 and 10.

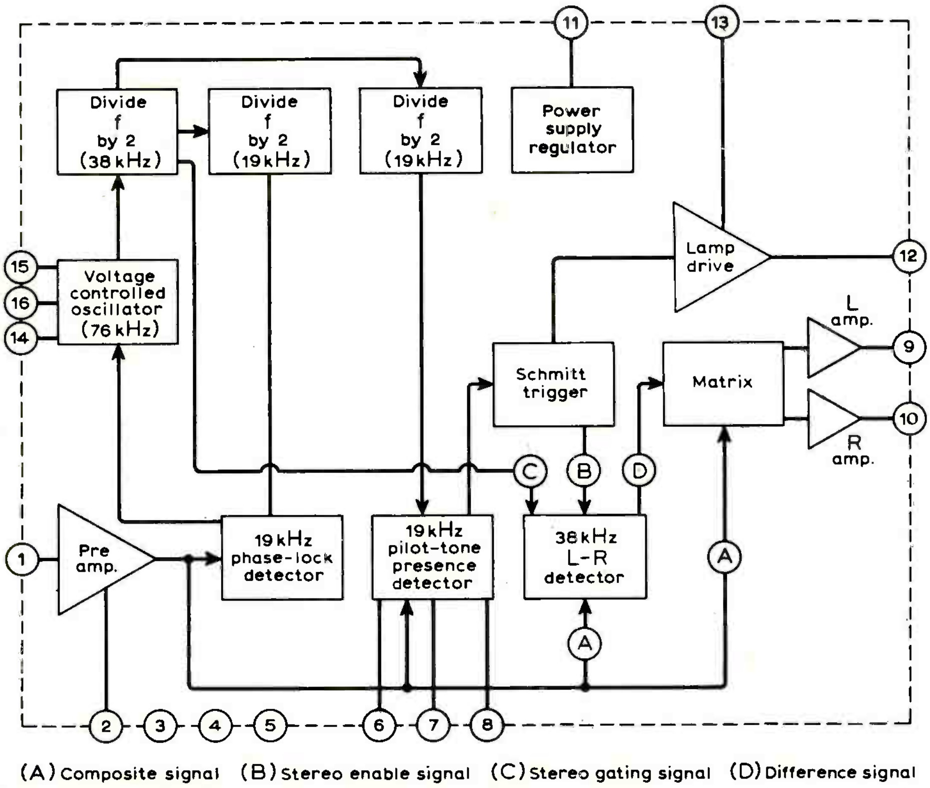


Fig. 1. Block diagram of the CA3090 integrated circuit which forms the major part of a phase-locked-loop stereo decoder.

Practical notes

The complete circuit diagram is given in Fig. 2 and little need be said about it as the purposes of most of the components have already been described. The capacitors C_1 and C_2 provide the necessary de-emphasis and the two 10kΩ resistors are the collector loads of the 'open ended' channel amplifier output transistors.

The stereo indicator lamp can be a light-emitting diode as shown or a normal filament lamp which may be connected in place of the light emitting diode and 680Ω series resistor provided that the lamp does

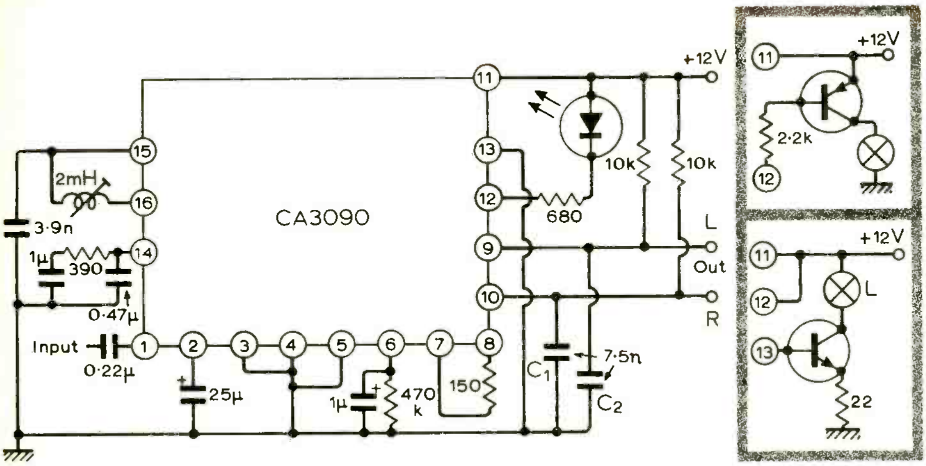


Fig. 2. Additional components required to complete the decoder. For operation in the UK (50µs de-emphasis) change the value of the 7.5nS capacitors to 5nS.

not consume more than 14mA at 12V. If a higher current lamp is used an outboard driver transistor must be added. The inset shows circuits using either a p-n-p or an n-p-n transistor. The transistor type is not critical provided that it can handle the lamp current. For instance, a 40mA, 12V, lamp could be used if it were driven by a BC108 (use the n-p-n circuit in this case). However, the maximum lamp current—whatever the transistor used—should not exceed 100mA because the drive is limited to 14mA. Anyway who wants to use a searchlight to indicate that a stereo signal is being received!

The decoder can be built on the printed circuit board shown in Fig. 3 full size, or 'pin-board' construction can be employed. The 2mH coil can be obtained from Harrogate Radio Ltd., 2/3 Sykes Grove, Harrogate, Yorks., price 15p including postage, etc. Ask for type 87BN135BX2. The prototype used a coil of American origin. The type we have specified in fact contains two coils so for this application use coil pins 3 and 4 only. A slight alteration to the printed circuit board may be necessary. Alternatively use any 2mH coil which allows a ±25% adjustment.

When connecting the decoder to the discriminator output of a receiver care should be taken to ensure that the receiver's de-emphasis network is disconnected. The decoder will accept inputs between 40 and 400mV. If the discriminator of your receiver provides an output higher than this use a potentiometer of about 100k to reduce the signal. Make sure your receiver has enough bandwidth for stereo operation.

Two methods may be employed to set-up the decoder both of which are extremely simple. If you have access to a digital frequency meter connect it to pin 15 of the i.c. and adjust the core of the 2mH coil to give 76kHz. This adjustment is done when there is no input to pin 1.

The second method of adjustment does not require the use of any test equipment. Connect the decoder to a receiver via a 100kΩ potentiometer and tune in a stereo broadcast. Start with the core of the 2mH coil fully out and the potentiometer set to give maximum input to the decoder. Screw in the core of the 2mH coil until the stereo indicator lamp lights; continue turning the core in the same direction, counting the turns, until the stereo indicator lamp goes out. Set the core at a point midway between the points where the lamp came on and went off.

Alter the potentiometer setting so as to reduce the input to the decoder and extinguish the stereo indicator lamp. Rock the core of the 2mH coil about its centre position to see if the indicator lamp lights. If not, slightly increase the potentiometer setting and rock the core again. The correct position for the coil's core is the one that lights the lamp with the minimum input signal.

R.C.A. manufacture two versions of the decoder i.c. One is in a staggered 16-pin dual-in-line package which is used in the illustrated printed circuit board and is called type CA3090Q, the second—type CA3090E— is electrically identical and is housed in a conventional 16-pin dual-in-line package. The i.c. is available from R.C.A. distributors, price £3.46.

Typical Decoder Specification

Input impedance	50kΩ
Channel separation	40dB
Channel balance (mono)	0.3dB
Mono gain	6dB
Stereo/mono gain	0.3dB
Indicator lamp turn-on voltage*	4mV
Capture range (deviation from 76kHz centre frequency)	±10%
Distortion	
2nd harmonic	0.35%
3rd, 4th and 5th harmonic	0.1%
19kHz rejection	35dB
38kHz rejection	25dB
Input voltage range	40 to 400mV
Supply voltage	12V
Supply current (lamp off)	22mA
Operating temperature range	−40 to +85°C

*For improved pilot sensitivity and overload characteristics replace the 150Ω resistor between pins 7 and 8 with a coil of 4.7mH in series with a capacitor of 0.015µF.

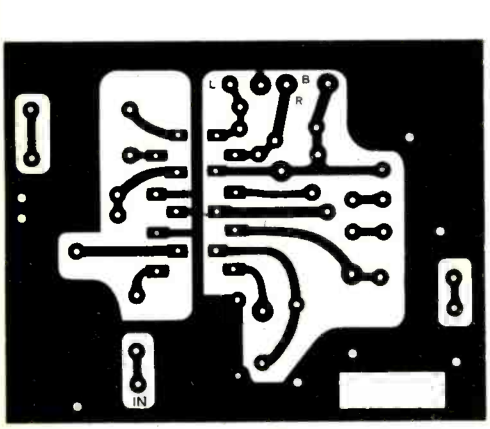


Fig. 3. Prototype printed circuit board layout shown actual size.

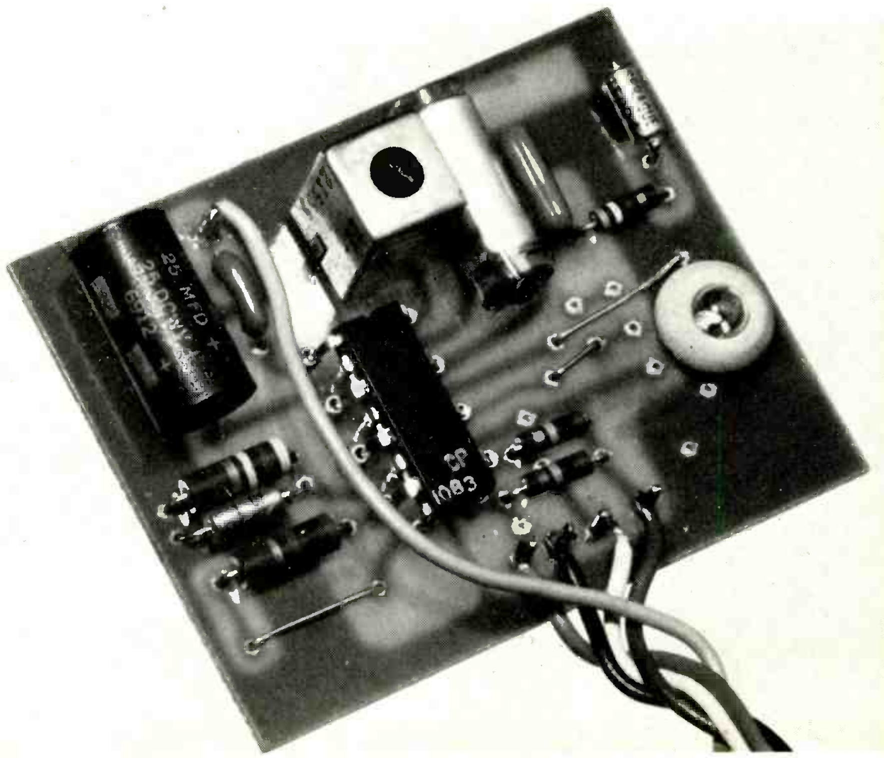


Fig. 4. Photograph of the prototype. Because this is a demonstration model built by R.C.A. some of the components shown in Fig. 2 are not included.

Ceramic Pickup Equalization

2—Practical low-impedance circuits

by B. J. C. Burrows, B.Sc.

This article gives full circuit details of an economy and a high-performance pre-amplifier which use a new design principle to provide optimum performance from stereo and mono ceramic cartridges.

Many ceramic cartridges are capable of a very high standard of performance—but this is seldom realized in practice. This is because conventional pre-amplifiers cannot cope satisfactorily with the wide range of electrical parameters encountered in different makes of ceramic cartridge.

The two factors that cause the problems in pre-amplifiers for piezo-electric cartridges are (i), self capacitance, and (ii), the degree of built-in mechanical equalization. In conventionally designed circuits using high-value load resistances (1 – 2MΩ), the pickup self-capacitance has a profound effect on low-frequency performance and hence on the rumble performance. Fig. 1 shows curves of output voltage against frequency for two well known pickups when operated into a conventional pre-amplifier with 2MΩ input impedance. These show that the overall frequency response is far from flat.

Typical pickups vary in capacitance from 200pF to greater than 1500pF, and with manufacturing tolerances plus the uncertain nature of the lead capacitance an overall variation of 180pF to >2000pF is possible. To obtain good l.f. performance with 180pF needs a loading resistance of 18MΩ (not 1 – MΩ as commonly provided). If 18MΩ were used with a pickup of 2000pF the bass turnover frequency would be 4.5Hz! This of course would result in very objectionable rumble and l.f. arm resonance† problems.

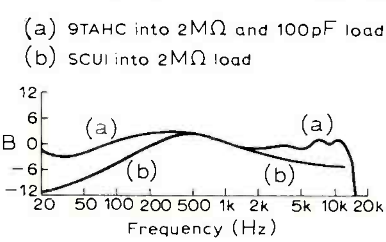


Fig. 1. Voltage/frequency curves of two well-known ceramic cartridges when used with a conventionally-designed pre-amp with R_{in} = 2MΩ, and a flat frequency response.

Conventional pre-amplifier designs do not allow for built-in mechanical equalization which varies from one pickup to another, and unfortunately the usual type of tone controls are not suitable for providing the necessary correction.

We can draw up a list of performance characteristics which an ideal pre-amplifier should possess:

(1) l.f. performance independent of cartridge capacitance;
(2) accurate rumble filtering independent of cartridge capacitance;
(3) means of correcting for variability in mechanical equalization (i.e. some form of 'tone balance' control).
(4) ability to cope with pickups of widely differing output voltages.

To these may be added: low noise, low distortion, good overload capability, built-in tone controls, etc.

Economy pre-amplifier

The complete circuit of the economy design is given in Fig. 2 for a positive h.t.

†See Appendix II.

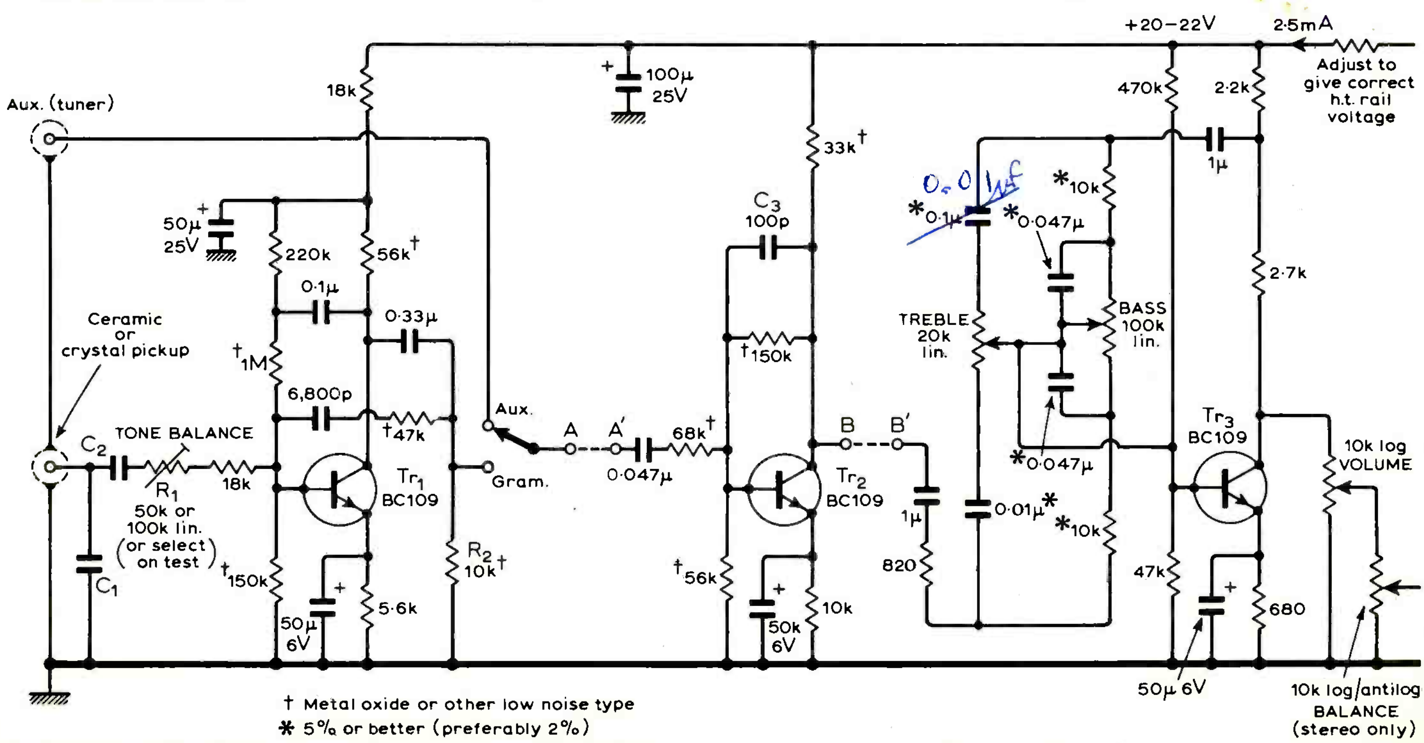


Table of values for C_1, C_2 & R_1 in economy circuit.

Cartridge type	C_1	C_2	R_1 (optimum value)	Comment
Decca Deram, Goldring CS91E	3.3nF	0.1µF	18–27kΩ / 56kΩ	low output
Goldring CS90, Sonotone 9TAHC	3.3nF	0.1µF	56kΩ / 22kΩ	medium output
Connoisseur SCU1	3.3nF	0.1µF	0	medium output
B.S.R. SC5M, Acos GP94/1, Garrard KS40A	10nF	6.8nF	22–56kΩ	high output

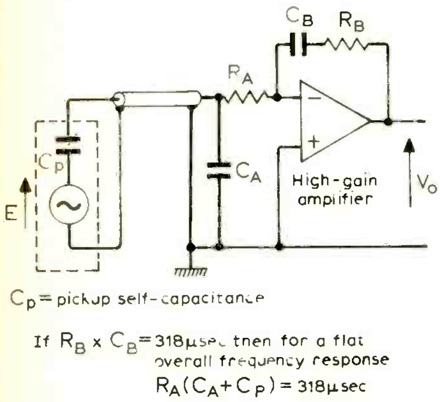


Fig. 3. First-stage design of equalization circuit.

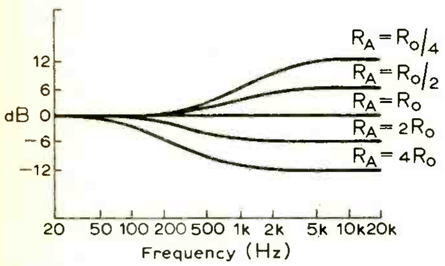
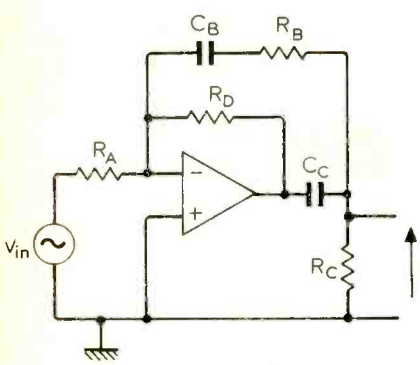


Fig. 4 Operation of tone-balance control, R_A in Fig. 3.



Design formulae for Q = 1

(1) Choose R_C

(2) Make R_B several times R_C

(3) $C_B = \dfrac{1}{2\pi f_1 R_B}$

(4) $C_C = \dfrac{1}{2\pi R_C}\left(\dfrac{1}{f_0} - \dfrac{1}{f_1}\right)$

(5) $R_D = R_B\left(\dfrac{(C_C R_C + C_B R_B)^2}{C_C R_C C_B R_B} - 1\right)$

Fig. 5. Baxandall bass lift-and-cut circuit.

rail system. A negative h.t. rail version is given in Appendix I. For normal use connect A to A' and B to B' and use full circuit. For ultra-economy operation with any of the pickups except the Deram or CS91E, the second stage may be omitted by connecting A direct to B' and omitting the intervening circuitry associated with Tr_2. Thus a very good, yet simple, gramophone amplifier may be built by using only Tr_1 and Tr_3 directly connected into an amplifier with 100mV sensitivity for full output.

Design principles of equalization stage

Last month the merits of the shunt feedback (or virtual earth) amplifier were mentioned as being very suitable for ceramic pickup equalization. Further, it was shown that loading the pickup with a low impedance had no effect on its internal e.m.f. In the present design, then, the effects of the variability in capacitance have been eliminated by swamping the pickup in every case with a shunting capacitor of 3.3nF or more. An input resistor of 75kΩ then gives an input time constant of 318µs (equivalent to 500Hz); to match this, the feedback circuit has a time constant of 318µs also (see Fig. 3); the complete circuit has a *flat* frequency response:

$$\frac{V_O}{E} = \text{constant} = \frac{R_B}{R_A} = \frac{C_P + C_A}{C_B}$$

If any one of the components suffixed A or B is made variable, a 'tone balance' type of control is achieved in a much simpler manner than circuits described previously[1]. R_A is the best one to vary and provides performance variation as in Fig. 4. The value of R_A to give an overall flat frequency response is termed R_0. In practice only values of R_A between R_0 and $R_0/4$ are needed to fully correct all ceramic pickups for their lack of complete mechanical equalization, e.g. the Sonotone 9TAHC pickup needs $R_A = R_0/1.8$ and the Connoisseur SCUI needs $R_A = R_0/4$.

With an infinite gain amplier in Fig. 3, overall gain is flat down to d.c. theoretically. This is no use in audio work because of rumble and the l.f. arm resonance. Some form of rumble filtering is essential and may be built into the equalization stage by using the circuit due to P. J. Baxandall[2]. The essence of this circuit is in Fig. 5, and its performance in Fig. 6.

Economy pre-amplifier specification

rated output	500mV r.m.s.
distortion (1KHz)	0.1% at maximum recorded level
noise	below audibility at normal listening level
hum	depends on layout and h.t. decoupling
overload capacity	>6dB above maximum recorded level
sensitivity	full output for pickup with 50mVcm/sec
sensitivity is reduced by	raising C_1 and lowering C_2 to keep $C_1 C_2/(C_1+C_2) \approx$ 4000pF
input impedance	not applicable (68kΩ for aux input connected as shown)
disc equalization	in conjunction with the better ceramic pickups can be adjusted to flat ±1.5dB 30Hz—10KHz. Low-frequency performance independent of pick-up capacitance.
rumble filter	18dB/oct, f_0 = 50Hz independent of pick-up capacitance
low-pass filter	fixed, C_3 = 100pF gives f_{-3dB} = 12KHz. Scale C_3 up in proportion for low f_{-3dB}
tone controls	h.f. about ±14dB; l.f. about ±14dB
current consumption	≈2.5mA.

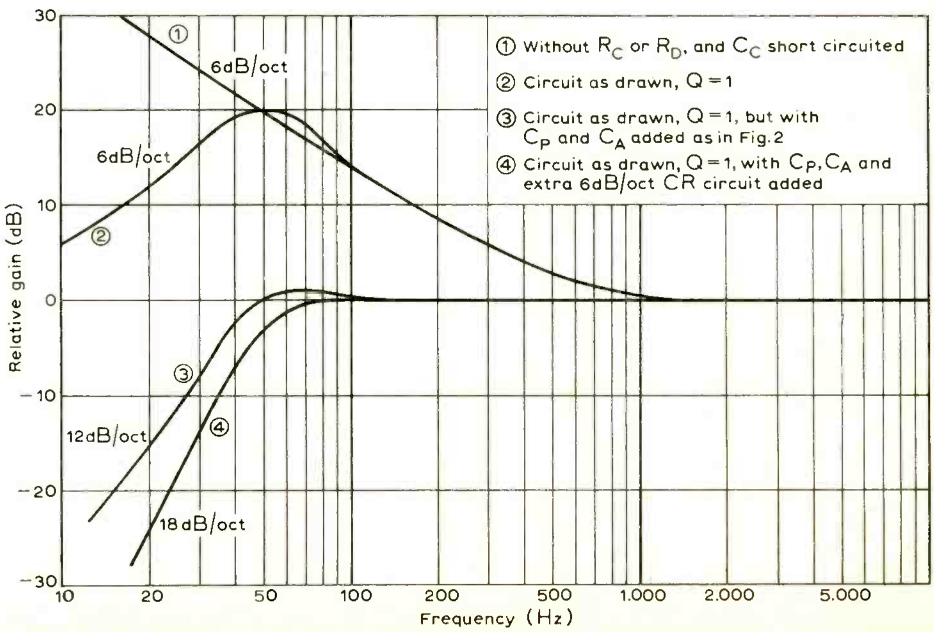


Fig. 6. Performance of circuit of Fig. 5 with f_0=50Hz and f_1=500Hz.

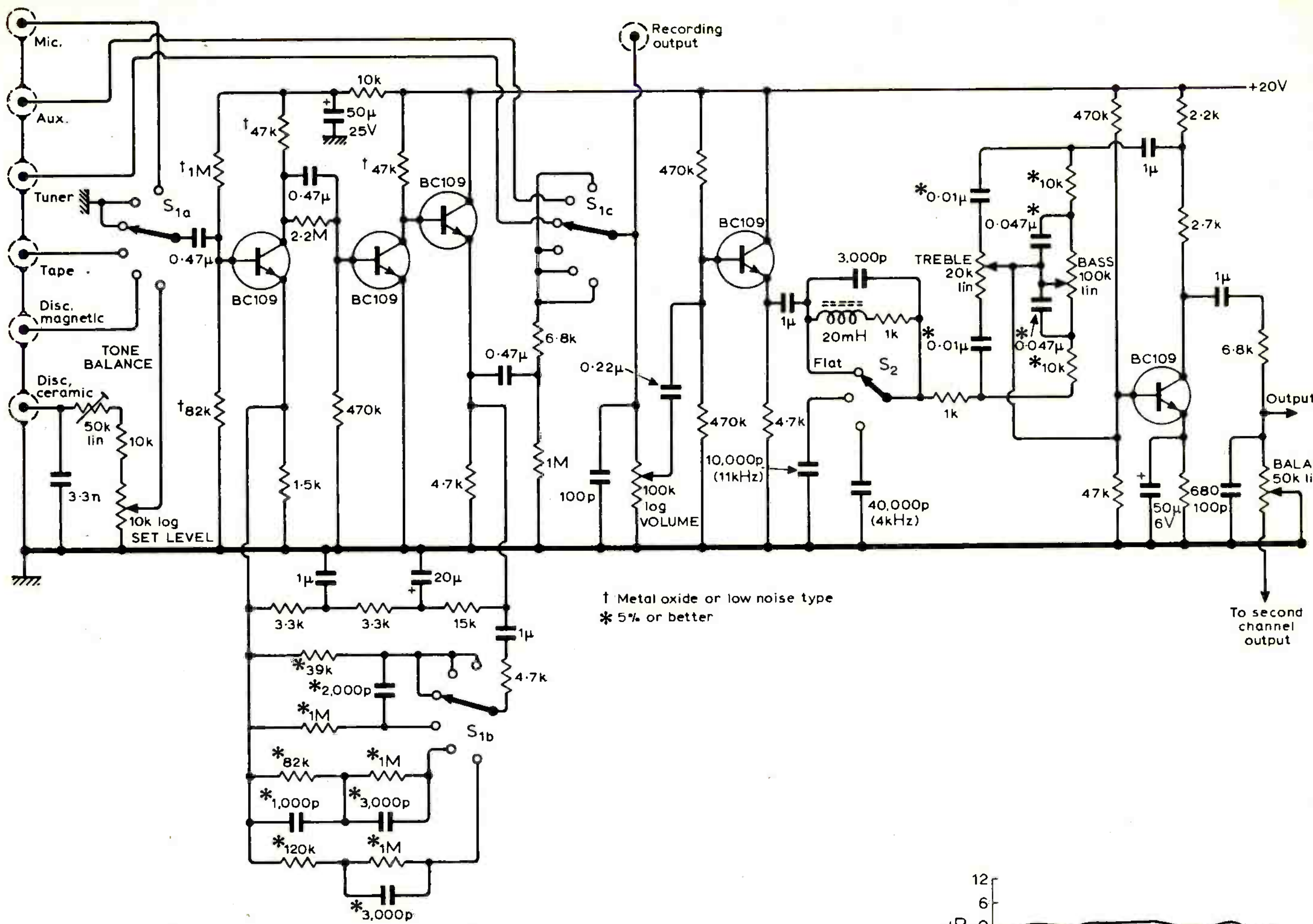


Fig. 7. Complete circuit of one channel of 'Bailey pre-amplifier'. No circuit changes are required for different ceramic pickup cartridges, only adjustment of 'tone balance' and 'set level'.

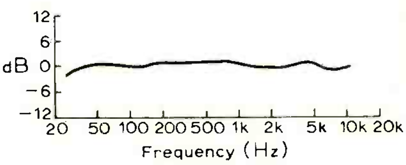


Fig. 8. Measured voltage/frequency curve for a 9TAHC operating into an 'economy design' circuit with $R_A = R_0/1.8$. The curve for the SCU1 would be just as flat, but with $R_4 = R_0/4$.

If a further high-pass *RC* filter is added,

$$f_0 = \frac{1}{2\pi RC}$$

where a flat response to nearly 50 Hz is achieved with a rapid turnover to a slope of 18dB/octave to attenuate rumble. Finally, with R_A adjustable, the tone balance facility is still retained as with the basic circuit of Fig. 3. It is common to design rumble filters with cut-off frequencies much lower than 50Hz; but, to achieve adequate attenuation at 25Hz—a common frequency of the l.f. arm resonance—a high value of f_0 is required. The actual circuit of Fig. 2 achieves −28dB at 15Hz and −15dB at 25Hz. In practice this is very satisfactory.

The economy-design pre-amplifier closely matches the theoretical performance of Figs. 4 and 6 and provides excellent bass, good balance and excellent freedom from rumble. As shown in the table relating to the main circuit, the only circuit changes needed to accommodate different pickups are for curbing those with a very high output voltage with a capacitive divider. In connection with the table of values given for the input capacitors it is very important to stress that the values given must be used as specified and that the manufacturers' recommendations regarding load impedance and equalization must be totally ignored. This circuit has been specifically designed to take care of all the loading, matching and equalization factors and *no further components are needed.*

High-performance pre-amplifier specification

rated output	500mV r.m.s.
harmonic distortion	0.02% at rated output
noise	−60dB all inputs −80dB for tuner and aux inputs
hum	negligible with good layout
overload capacity	23dB over whole audio range, infinite for tuner and aux
sensitivity	tuner 250mV aux 250mV disc magnetic 3mV disc ceramic 20mV tape 4mV mic 10mV
input impedance	tuner, aux 60-100KΩ disc magnetic 47KΩ disc ceramic frequency dependent tape, mic 47KΩ
disc equalization	magnetic—RIAA to within ± 1dB ceramic—can be adjusted to give flat response ± 1½dB l.f. response independent of cartridge capacitance
tape equalization	7½i.p.s. with R_{FB} = 39KΩ 15i.p.s. with R_{FB} = 18KΩ 3¾i.p.s. with R_{FB} = 82KΩ
rumble filter	modified design giving higher cut off frequency; response at 25Hz is −15dB
low-pass filter	switched, flat or cut off at any frequency from 4 to 11KHz (see Ref. 7)
tone controls	Baxandall type treble ±16dB at extreme bass ±20dB at extreme
current consumption	7mA

The economy circuit as described fulfils all the design criteria enumerated earlier except for the slight inconvenience of changing two capacitors if pickups of widely differing output voltages are exchanged. The noise performance is very good with all the cartridges listed apart from two (the CS91E and Deram) with which it is satisfactory for everything but the most exacting requirements.

High performance pre-amplifier

This is based on the Bailey[3] design of 1966 but with all the subsequent modifications to improve the filter[4] and tone control[5] circuits, plus the addition of a complete ceramic-pickup equalizing circuit achieving the same performance with ceramic cartridges as the economy pre-amplifier. The complete circuit is given in Fig. 7, which also incorporates one further modification to raise the cut-off frequency of the rumble filter in accordance with the design philosophy discussed in Appendix II. Equalization for magnetic pickups has been retained and is selected by the input selector switch. The 'set level' control needs a mention. To avoid overloading the input stage, adjust the set level control with any particular

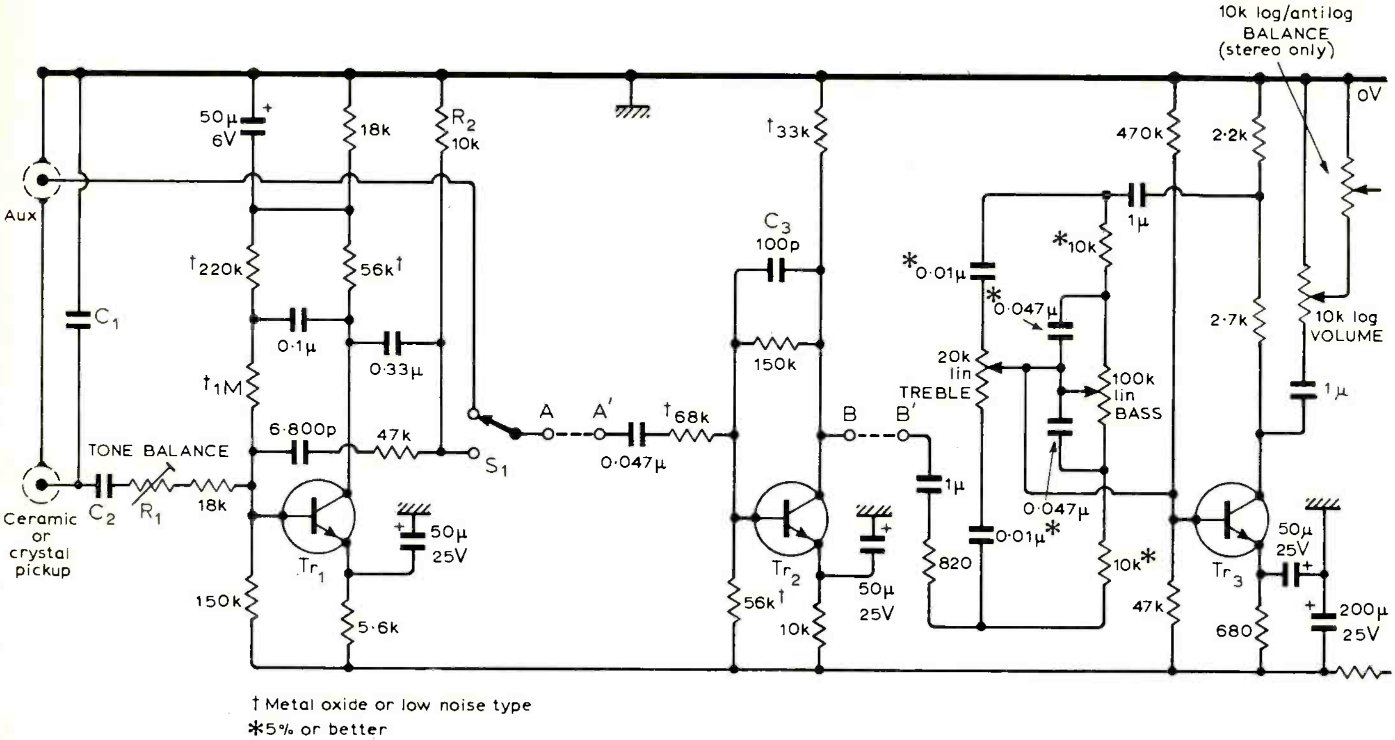


Fig. 9. Economy circuit arranged for negative h.t. rail. For values of C_1, C_2, and R_1, see table earlier.

cartridge to give comfortable listening level with the main volume control at about half of its maximum rotation. This control need be only a preset with screwdriver slot adjustable from the back of the pre-amplifier. The tone balance could be the same, or it could be brought out as a front panel control, or as a skeleton pot mounted internally or even a 'select-on-test' fixed resistor.

On paper, the specification of the high performance pre-amplifier looks most impressive, but subjectively the economy version is very good indeed, and both represent a considerable improvement on conventional designs in that reproducible low-frequency performance, effective rumble filtering independent of pickup capacitance, and a simple means of correcting for partial mechanical equalization have been incorporated. Fig. 8 in conjunction with Fig. 1 gives a comparison of the performance of the Sonotone 9TAHC and Connoisseur SCU1 using conventional loading (2MΩ plus flat amplifier), compared with the measured results on the author's 9TAHC using the economy circuit.

The calculated performance of the Connoisseur SCU1 with $R_A = R_0/4$ is a straight line coincident with the 0dB line on Fig. 8, although in practice there would be a variation of up to ± 1dB about the 0dB line.

Modifications to provide a similar standard of performance with the Dinsdale Mark I and Mark II pre-amplifier circuits were incorporated in a previous article[6].

Appendix I

Alteration of economy circuit for negative h.t. rail operation, e.g. from a germanium-transistor amplifier like the Dinsdale Mark I or II, is basically to return all electrolytic capacitors to the positive potential rail, viz. the earth line (see Fig. 9). There are no modifications to circuit values apart from the voltage rating of the electrolytics.

Appendix II

Arm resonance (l.f.) is the tendency toward damped oscillation at a low frequency and is exhibited by most pickup arms. It has the effect of greatly increasing the cartridge output voltage at or near the resonant frequency. The frequency, f_{lf}, is normally in the range 10-25Hz, so its effect is to greatly increase rumble. The frequency of the oscillation is:

$$f_{lf} = \frac{1}{2\pi\sqrt{MC}} \text{Hz}$$

M is the mass of cartridge plus effective mass of arm measured at cartridge.

C is the compliance of stylus cantilever suspension. With M in grams, C is in cm/dyne.

With modern high compliance cartridges it is desirable to keep M very low—hence lightweight headshells—to make f_{lf} as high as possible. Generally speaking the lower the frequency of resonance the higher the Q, and vice versa. But a higher resonant frequency is more trouble electrically. A low-frequency high-Q resonance causes mechanical difficulties—the pickup tends to leave the record surface when excited. A resonance at 25Hz is acceptable mechanically if the Q is low enough and its electrical effects can be removed with a steep slope filter. Below this resonant frequency the cartridge output voltage falls off very sharply indeed (24dB/octave) thus providing the required severe attenuation of sub-audio frequencies.

With regard to pre-amplifier design, the point to note is that the highest amplitude rumble components will be at, or near, the l.f. arm resonance. A filter in the pre-amplifier should ideally provide 12dB or more of attenuation at 25Hz, yet not interfere with l.f. audio response. A cut off frequency of 50Hz with slope approaching 18dB/octave is a very good compromise since it causes very little error in the R.I.A.A. equalization, yet gives −15dB at 25Hz and −25dB at 15Hz.

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The Diagnosis of Logical Faults

Conclusion

*by R. G. Bennetts**, B.Sc., M.Sc.

One of the problems that the designer and user of logical systems is confronted with is that of testing the logical functioning of the circuits within the system. The procedure is usually split into two main processes—namely a simple go/no go test followed by, in the event of a no go decision, a more thorough analysis to determine the location of the fault. The former is known as fault detection whereas the full detection and location process is termed diagnosis. It is the purpose of this series of two articles to illustrate, through the use of examples, some of the techniques that have been developed to assist in determining the necessary tests and to comment on their advantages and disadvantages. The first part of this article appeared last month and concludes this month with a discussion of Boolean difference and partitioning techniques.

3: Boolean difference

Before describing how the Boolean difference can be used to determine a detection test set, it is instructive to define the term "Boolean difference" and show how it may be derived.

Consider a Boolean function z given by:

$$z = f(x_1 x_2 \ldots x_i \ldots x_n),$$

$$x_1 \rightarrow x_n = \text{primary inputs}$$

If x_i is in error, then a new function z_{x_i} is defined by:

$$z_{x_i} = g(x_1 x_2 \ldots \bar{x}_i \ldots x_n)$$

i.e., z_{x_i} is formed by replacing $x_i(\bar{x}_i)$ in z with $\bar{x}_i(x_i)$. The Boolean difference,

$$\frac{dz}{dx_i}$$

is defined:

$$\frac{dz}{dx_i} = Z \oplus Z_{x_i}$$

$$= h(x_1 x_2 \ldots x_n)$$

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where $\oplus$ denotes the Boolean exclusive-OR operator.

As an example, we will derive the Boolean difference expression for the example circuit with primary input "C_3" as "x_i". (This was given in Fig. 4 last month and is repeated here.)

From Fig. 4,

$$z = \bar{a}\bar{b} + \bar{a}\bar{c} + ab$$

$$= \bar{C}_1\bar{C}_2 + \bar{C}_1\bar{C}_3 + C_1C_2$$

$$Z_{C3} = \bar{C}_1\bar{C}_2 + \bar{C}_1 C_3 + C_1C_2$$

$$\frac{dz}{dC_3} = (\bar{C}_1\bar{C}_2 + \bar{C}_1\bar{C}_3 + C_1C_2) \oplus$$

$$\bar{C}_1\bar{C}_2 + \bar{C}_1 C_3 + C_1C_2)$$

There are mathematical rules for manipulating such expressions but for a small number of input variables, the Karnaugh map (K-map) can be used quite easily and also serves to illustrate very clearly the actual exclusive-OR operation. The procedure is to map Z into one K-map, Z_{C3} into another and by comparing similar locations to derive the mapping of $\frac{dz}{dC_3}$ by inserting a 1 if there is a difference in the values at the two locations, otherwise blank. The method is illustrated in Fig. 8.

Returning to the theory, let us examine the significance of the Boolean difference expression. If there is a fault in the value of x_i, then the function that the faulty network will realize will be that defined by Z_{x_i}. Under these conditions, the faulty output will differ from the true output only for those terms that make $\frac{dz}{dx_i} = 1$, i.e. $\frac{dz}{dx_i}$ defines the full set of inputs (tests) that will cause an incorrect and hence observable output if there is a fault in the logical value of x_i. Note that so far we have not defined whether x_i is s-a-1 or s-a-0—only that it is logically incorrect. It therefore remains to partition the set of tests defined by $\frac{dz}{dx_i}$ into those pertaining to x_i s-a-1 and x_i s-a-0. This is achieved by splitting the list of all tests into those containing x_i and those containing $\bar{x}_i$. The former will demand a 1 on x_i and therefore test for x_i s-a-0 and the latter conversely will test for x_i s-a-1.

Thus, for $\frac{dz}{dC_3}$ in Fig. 8:

$$\frac{dz}{dC_3} = \bar{C}_1 C_2 C_3 + \bar{C}_1 C_2 \bar{C}_3$$

and the $\bar{C}_1C_2C_3$ (t_3) term defines the test for $C_3/0$ (f_5) and $\bar{C}_1C_2\bar{C}_3$ (t_2) defines the test $C_3/1$ (f_6). These can be confirmed from the detection matrix G_D of Fig. 6 (last month). Note that for each fault, there is only one test and hence t_2 and t_3 are both essential.

As another example, we will consider how the Boolean difference can be used to determine the tests for a fault on one of the lines that is not a primary input, C_4 say.

As above, we have:

$$Z = \bar{C}_1\bar{C}_2 + \bar{C}_1\bar{C}_3 + C_1C_2$$

and $C_4 = C_1 + C_2$

$= \overline{\bar{C}_1\,\bar{C}_2}$ (by De Morgan's theorem)

by substitution $Z = \bar{C}_4 + \bar{C}_1\bar{C}_3 + C_1C_2$

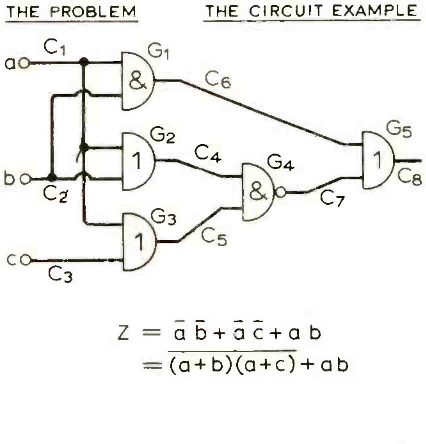

Fig. 4. The circuit example; reproduced from last month's issue.

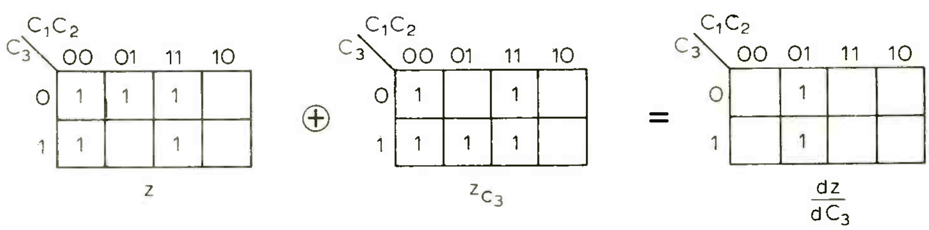

Fig. 8. Karnaugh maps for deriving dz/dC₃.

and $Z_{C4} = C^4 + \overline{C_1}\,\overline{C_3} + C_1 C_2$

By using four variable K-maps, the Boolean difference $\frac{dz}{dC_4}$ is found to be given by:

$$\frac{dz}{dC_4} = C_1\overline{C_2}C_3 + C_1\overline{C_2}\,\overline{C_3} + \overline{C_1}C_2C_3 + \overline{C_1}\,\overline{C_2}C_3$$

Now, since $C_4 = C_1 + C_2$, the only time it will be 0 will be when both C_1 and C_2 are 0. Thus in order to detect for $C_4/1$, the input must contain the terms $\overline{C_1}\,\overline{C_2}$. All other combinations of C_1C_2 will detect $C_4/0$. From this we see that only $\overline{C_1}\,\overline{C_2}C_3$ (t_1) will detect $C_4/1$ whereas $C_1\overline{C_2}C_3$ (t_5), $C_1\overline{C_2}\,\overline{C_3}$ (t_4) or $\overline{C_1}C_2C_3$ (t_3) will serve for $C_4/0$, and again the fault matrix G_D confirms this.

The Boolean difference tends to be limited to circuits having a relatively small number of input variables, but it can be expressed as a fairly rigid algorithm and would seem quite suitable for implementation in a computer program. Its main advantage is in spotting essential tests and once these are known, the path sensitizing procedure (discussed last month) for evaluating all other faults detected by that test can be used. Using these two techniques together can result in an efficient procedure for deriving an optimal test sequence.

At present, the technique is restricted to combinational networks, but successful excursions into the area of sequential networks have been reported though this aspect is still very much in its infancy.

4: Partitioning

As has been indicated previously, the partitioning technique is more applicable to multi-flow testing procedures and this calls for certain criteria to be used. Before considering these criteria in detail, let us consider the basic technique itself.

The circuit under test is usually simulated in order to arrive at the test set for detection and/or location and the simulated model can be converted from its no-fault version f_0 to any of n previously defined faulty versions $f_1 \rightarrow f_n$. (In the case of our example, $f_1 \rightarrow f_{16}$). A test is then applied to all versions of the circuit and this will effect a partition based on the value at the output. The members of each equivalence class, as it is called, indicate that the output is the same and further tests are required to increase the degree of resolution until either f_0 is identified alone (fault detection) or all versions are isolated (fault location).

The value of this procedure lies in its ability to try different tests and ascertain which one is best for the job in hand. This implies the use of criteria and we will consider initially the use of the *checkout criterion* for fault detection only. Again, we will illustrate this through use of the circuit example.

Fault detection using the checkout criterion: The initial equivalence class for the example circuit is $f_0 \rightarrow f_{16}$ inclusive and we require to isolate f_0 as quickly as possible by means of a set of test inputs. This amounts to determining which test separates the largest number of faulty circuits from the good circuit—this being the checkout criterion. If we look at the detection matrix G_D of Fig. 6 (last month) we can list the number of detectable circuits for each test and this is shown in column N_1 of Fig. 9.

Test	No. of faulty circuits detected			
	N_1	N_2	N_3	N_4
t_0	3	2	0	–
t_1	5	(4)	–	–
t_2	4	4	(2)	–
t_3	(8)	–	–	–
t_4	7	2	1	1
t_5	7	2	1	1
t_6	3	2	1	1
t_7	4	3	2	(2)

Fig. 9. Assignment of checkout weighting and selection of best tests.

Obviously, t_3 is first choice and this will create a partition P_1 defined by the two equivalence classes $P_1{}^1$ and $P_1{}^2$ where:

$$P_1{}^1 = \{f_0 f_1 f_4 f_6 f_8 f_{10} f_{11} f_{13} f_{15}\}$$

$$P_1{}^2 = \{f_2 f_3 f_5 f_7 f_9 f_{12} f_{14} f_{16}\}$$

The exercise must now be repeated on the equivalence class containing f_0 and the test weightings are shown in column N_2 of Fig. 9. This can be derived from the detection matrix G_D by removing all those columns in $P_1{}^2$ and then counting the number of detectable faults on the remaining columns. When this is completed, there is a choice between t_1 and t_2 and we shall arbitrarily choose t_1. This creates the partition P_2 given by:

$$P_2{}^1 = \{f_0 f_1 f_6 f_{10} f_{11}\}$$

$$P_2{}^2 = \{f_4 f_8 f_{13} f_{15}\}$$

The procedure is again repeated until eventually at partition P_i (in this case $i = 4$), f_0 is isolated from all other versions and the full detection set can be defined. The remainder of the calculation are shown in columns N_3 and N_4 and the partition sequence is shown pictorially in Fig. 10.

Fault location using the information gain or distinguishability criteria: The prime object for fault location is to continue partitioning of every equivalence class until each version $f_0 \rightarrow f_{16}$ has been completely isolated as far as possible (obviously indistinguishable fault-sets are not subject to any further partitioning). To assist this process, two criteria have been proposed—information gain and distinguishability.

The *information gain criterion* is similar in concept to the entropy function used in information theory. Initially there is uncertainty as to which of the $f_0 \rightarrow f_{16}$ versions of the circuit exists and the application of a particular test will remove some of this uncertainty, i.e. will result in a gain in information. This can be expressed mathematically as a function of the particular test and again a table similar to that of Fig. 9 would be created enabling the correct test selection to be made.

The alternative criterion is the *distinguishability criterion*. This is derived in the following manner: for a particular equivalence class, one wishes to select the test that distinguishes between the greatest number of circuits. This amounts to determining how many pairs of circuits within the same class are distinguishable using test t_i, $0 \leqslant i \leqslant n$ for n tests. This criterion is more applicable to multi-output circuits in which the partitioning is to some other radix rather than two (binary) and it too can be expressed mathematically. Since the example circuit has only one output, the partition is simple binary as shown in Fig. 10.

Both criteria are somewhat complex in their evaluation and the usual process is to derive the full detection partition using the relatively simple checkout criterion; determine the degree of diagnostic resolution that is already available and then use the more complex criteria to increase the resolution to its maximum. If this is applied to the partition of Fig. 10, it is found that only one further test need be specified in order to achieve maximum diagnostic resolution. The full partition is shown in Fig. 11 and the addition of t_4 enables partitioning of $\{f_1, f_{11}\}$, $\{f_4 f_8\}$ and $\{f_5 f_7 f_9 f_{12} f_{14} f_{16}\}$. The remaining classes of $\{f_7 f_9 f_{12} f_{14} f_{16}\}$ and $\{f_6 f_{10}\}$ are indistinguishable fault sets and consequently cannot be further partitioned without the use of extra access such as test points.

The sequence of test dictated by the partition is $t_3 t_1 t_2 t_7 t_4$ and one aspect of this approach is that not only can the fault be located by analysis of the output sequence corresponding to the test set, but that it is now possible to specify a test for a particular fault. This is a common requirement when trouble-shooting new designs.

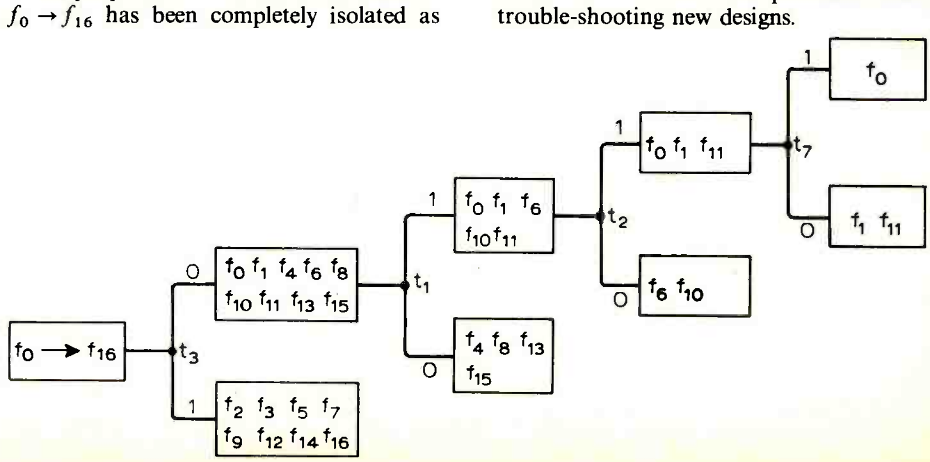

Fig. 10. Partition showing detection test set.

Concluding remarks

I have introduced the general problems associated with the diagnosis of faults in logical systems and described four of the techniques that have been developed to assist in determining a satisfactory diagnostic test sequence. The techniques themselves tend to be restrictive but it has been indicated how they may be combined in an attempt to broaden their overall coverage. The real problem however has been shown to be in diagnosing faults occurring in sequential circuits, and although some of the techniques can be applied, they are not really satisfactory. Other approaches are currently being studied, the most important of which is based on an analysis of the state table for a sequential circuit. (The state table is used to formally describe the behaviour of a sequential circuit—much in the same way as a truth table does for a combinational circuit. Every configuration of the sequential circuit is defined by a *state variable* and there are procedural techniques for deriving the actual circuit, in terms of its connections and gates, from the initial state table description).

One major advantage with state table analysis is that a check can be made on the table at the initial design phase to ascertain the diagnosability of the sequential circuit it describes and if necessary, apply modifications to make it fully diagnosable. This is a departure from previous diagnostic philosophy in that it is now possible to make the diagnosis requirement an initial design restraint and not something that is determined after the circuit has been designed. State table analysis does rely however on being able to formulate the state table for the sequential circuit and in the case of the intuitive design, this represents quite a problem. If however a switching theory approach has been adopted in designing the circuit, then the state table is already known and this in itself is sufficient justification for using switching theory in logical design.

In this paper, we have confined ourselves only to considering faults that can occur in logical circuits. The successful diagnosis of faults at full system level, a digital computer say, is a much greater problem and the "diagnosis is a design restraint" requirement becomes even more important. The current approach is to devise a hierarchical set of tests such that if an overall system fault is detected, a more detailed set of tests can be applied that will theoretically converge onto the fault. This can sometimes be somewhat haphazard and really what is required is a fundamentally new approach to the system design process such that diagnostic capability is a design parameter not only at circuit level, but also at full system level.

One final comment. The advent of m.s.i. and l.s.i. has caused a shift in emphasis in diagnosis requirements in that in general one only requires fault location to the smallest replaceable unit and if this is a full circuit or a sub-system itself, i.e. an l.s.i. chip, this tends to ease the locational extensions of detection techniques, such as the fault matrix, since the faults on the same chip can be grouped together and treated "en bloc". It does however bring us back to the overall system test problems and serves to reinforce the comments about system check-out techniques.

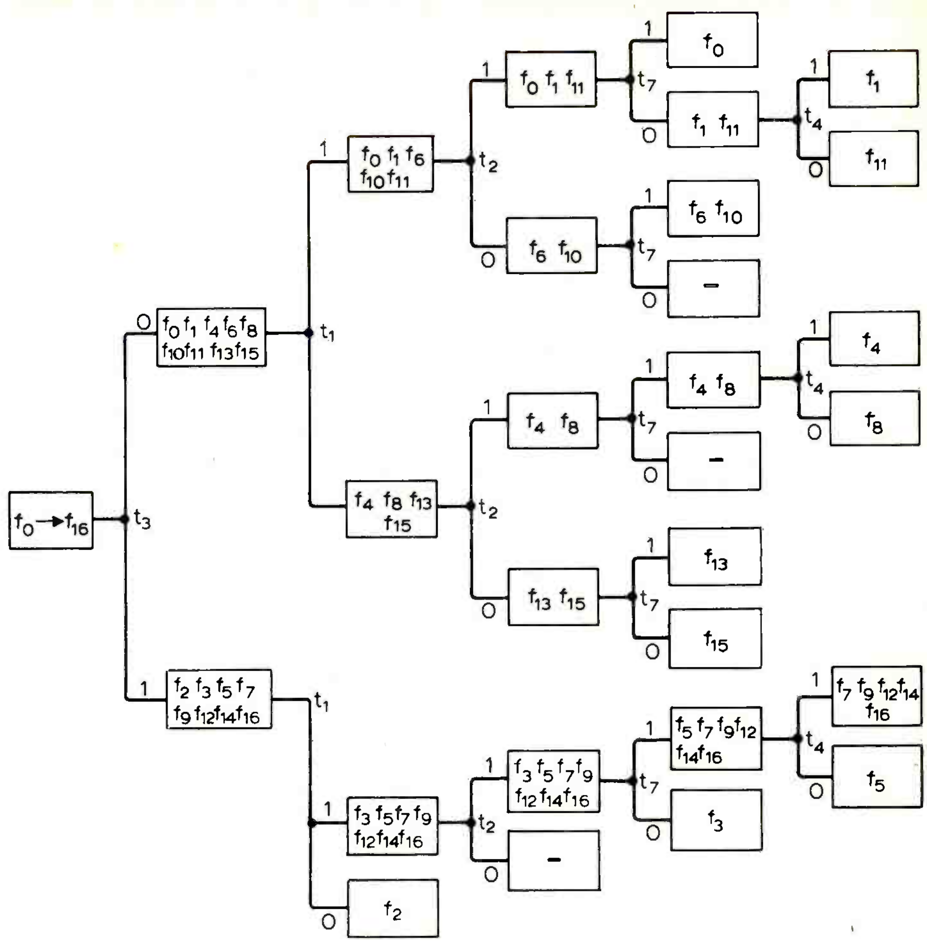

Fig. 11. Partition showing detection and location test set.

References

Since 1960, there has been a profusion of papers dealing with fault detection and location and the most recent bibliography (86 referenced papers) is including in the review[1] written by myself and D. W. Lewin. This paper also summarizes the main techniques and has pertinent comments on the effect of diagnosis requirements on computer system engineering, the requirements of digital systems in terms of diagnosis and functional testing and diagnosis of l.s.i.

We have recently seen the publication of the first book[2] to be entirely devoted to this problem and this in itself is indicative of the importance that is now attached to fault diagnosis.

In terms of the actual techniques, the paper by Kautz[3] is a well written and lucid account of the fault matrix approach and similar comments may be made about the paper by Sellers *et al*[4] dealing with the Boolean difference.

The most famous implementations of path sensitization is the D-algorithm of Roth[5] and its subsequent modification[6]. Both papers are somewhat heavy going due to the "calculus of D-cubes" that he defines and uses to implement the concept and the contents of the first paper is well covered in [2]. The basic D-algorithm and its extensions have been employed by IBM to prepare diagnostic routines for their System/360 range of computers.

The technique of partitioning has been programmed by Seshu[7,8] and the suite of programs, known as the *Sequential Analyser*, has been in use for many years now.

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Circuit Ideas

F.E.T. voltage regulator

The regulator described here provides fairly good performance with a minimum number of components. The basic circuit is shown below (top). Any change in output voltage caused by a change in load resistance alters the gate-source voltage of the f.e.t. via R_1 and R_2. This causes a compensating change in drain current. The stabilization ratio is excellent (≈ 1000) but the output resistance is very high $R_O > 1/Y_{FS} > 500\Omega$) and the output current is low. To overcome these defects, the lower circuit can be used. The output resistance is greatly reduced and the stabilization ratio is still high. The maximum output current is limited by the allowable dissipation in the final transistor. Resistor R_3 is chosen to produce a quiescent current of a few mA in Tr_3. An experimental set-up using the values shown produced a change of less than 0.1V when the load current was altered from 0 to 60mA at 5V output. The effect of temperature on the output voltage has not been investigated but it could probably be minimized by appropriate choice of the drain current of the f.e.t.

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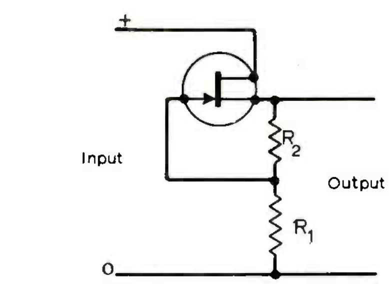
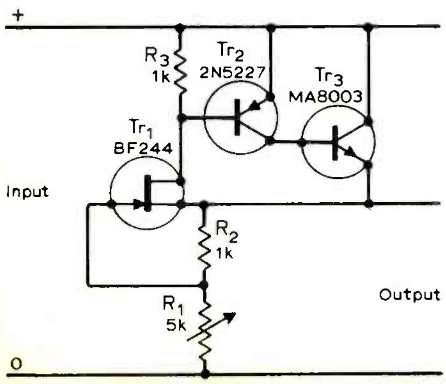
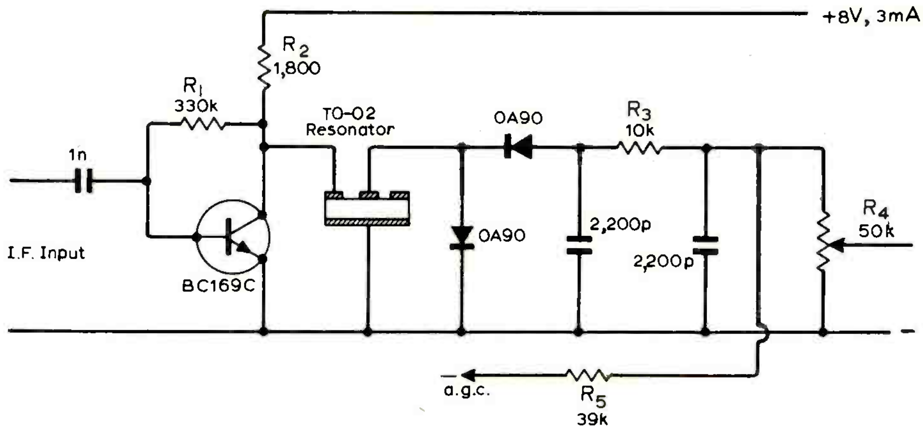




Reversed operation of 'Transfilter'



Piezo-electric overtone resonators (e.g. Brush Clevite "Transfilters") are normally used as interstage couplings in i.f. amplifiers. where the requirement is to match the relatively high output impedance at the collector of one stage to the relatively low base input impedance of the next. This is accomplished by connecting the 'dot' of the resonator to the collector and the 'ring' to the base. In the final i.f. stage shown above the impedances run the other way, and the resonator is used 'backwards' to couple the transistor to a high-impedance detector. This arrangement gives a useful voltage step-up (about 2.5 times) from transistor to detector. The effective loading imposed by the detector on the resonator (which should be six times the impedance at the 'ring') can be taken as one quarter of the net d.c. load resistance.

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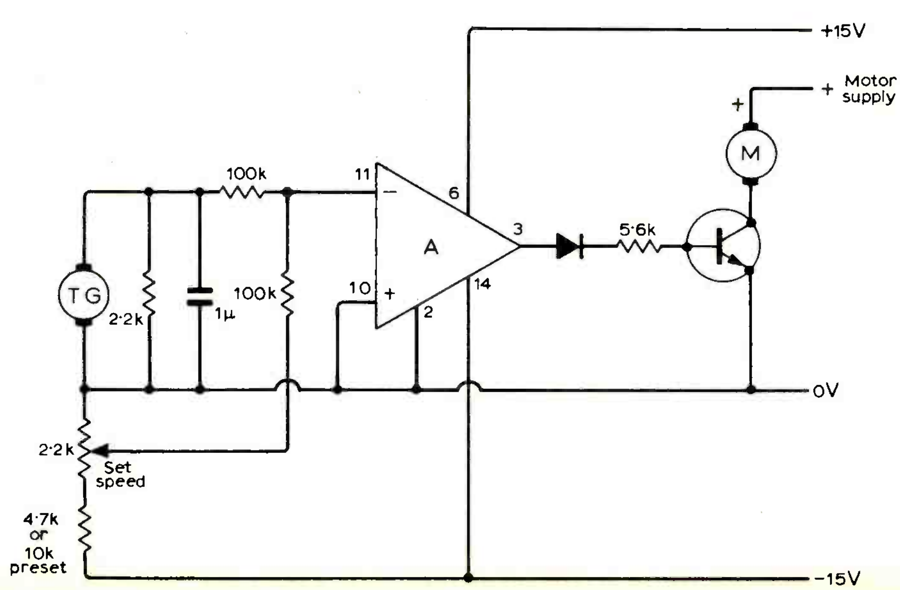
D.C. motor controller

Fine control of a d.c. motor can be obtained using an op-amp and a tachogenerator. The op-amp is used as a voltage sensitive switch. In the circuit shown, when the output of the generator is less than the preset reference voltage the switching transistor will bottom and full power will be delivered to the motor. Switching will take place within one or two millivolts of the reference voltage. A dual power supply is required, but need only be zener stabilized. This system allows for infinitely variable drive without mechanical complication. For a record deck, for example, the speeds can be set by the simple switching of a voltage divider. The op-amp switches to within a volt or two of the supply rails, and by using a double emitter follower large motors can be controlled. The reference voltage may be set by thermistors, light-dependent resistors etc. The experimental arrangement shown used an RCA 3047A op-amp, and a 0.25W 6V motor as generator giving about 4V at 13000 r.p.m.

N. G. A. Boreham,
Newton Abbot, Devon.



Electro-optical Gearbox

using moire fringe technique

by J. Dinsdale, M.A.*

Mechanical gearboxes are generally used either for transmitting rotary power from one shaft to another, where the emphasis is on the torque ratio, or for controlling the angular velocity of one shaft with respect to another, where the emphasis is on the velocity ratio. In both cases the performance of practical gearboxes falls short of the ideal due to variable friction losses, backlash, and non-uniform velocity transmission caused by errors in the form and pitch of individual gears.

Backlash and friction effects are to some extent interdependent; in general, attempts to reduce backlash generally lead to significant increases in friction losses and the degree of backlash may be critically dependent on the working temperature of the gearbox, itself a function of friction losses.

The accuracy with which motion may be transmitted clearly depends on the precision of the form of each tooth of the gears within the gearbox. A continuous linear transmission is desirable first to maintain linearity of motion of the member being controlled by the gearbox, and second, to minimize vibrations which can be set up by a non-linear transmission. The high-frequency vibrations caused by a typical geartrain can lead to rapid deterioration of bearings and, more seriously, to the early onset of fatigue failure. This latter effect is of particular significance in aero engines, and much work has been devoted in recent years to improving the accuracy of gears used in aero engines and machine tools.

In the light of these deficiencies, the design of a "gearless" transmission system for controlling the angular velocity of a shaft with respect to another was investigated, the system to possess the following properties

- variable speed ratio from 1:999 to 999:1, numerator and denominator to be integral
- minimum backlash—less than 20 arc seconds over full working range
- input shaft speed range from zero to 2000 rev/min (nominal)
- output shaft speed range from zero to 200 rev/min (nominal)
- bi-directional motion
- output shaft power to be $\frac{1}{4}$ h.p. (nominal) approx. 200 watts
- transmission errors not to exceed 20 arc seconds at any speed or load up to the specified maxima.

* Principal Research Engineer, Cranfield Unit for Precision Engineering

The system† developed consists essentially of two shafts: an input or driven shaft, and an output or driver shaft on which is mounted an electric motor (Fig. 1). Both of the shafts are fitted with incremental shaft encoders of very high resolution. Each encoder consists of a glass disc on which has been photographed or etched a uniform pattern or grating of alternate opaque and transparent radial lines. It would not be possible to detect individual lines at this spacing by normal electro-optical means, but if such a grating is mounted in close proximity to a further small piece of similar grating (the reference grating) and the pair illuminated by white light, moiré fringes appear as a series of broad light and dark bands normal to the grating lines.

The breadth and pitch of the fringes depend on the angle between the lines on the main grating and the reference. Because each moire fringe is formed over a relatively large area (say one sq. cm) by the integration of a large number of lines on the grating, any small pitch errors or blemishes on the grating tend to average out to give an extremely accurate fringe spacing. In fact, a grating will still give observable fringes even when 95% of its lines have been mutilated or even obliterated.

† Patents applied for

When the main grating is moved with respect to the reference, the fringes move at an equivalent rate; i.e. if the movement of the main grating with respect to the reference is at a rate of 1000 lines per second, then the fringes will move at 1000 fringes per second. The fringes are of such a size that they can easily be detected by a suitable photo-detector arrangement to give a sinusoidal signal whose frequency is proportional to the rate of angular rotation of the grating, and the number of lines on the grating. Typical gratings may have from 10,800 lines to 72,000 lines, giving angular resolutions of 2 arc minutes and 18 arc seconds respectively.

The reading head for moiré fringes normally consists of a number of photo-sensitive devices and a light source

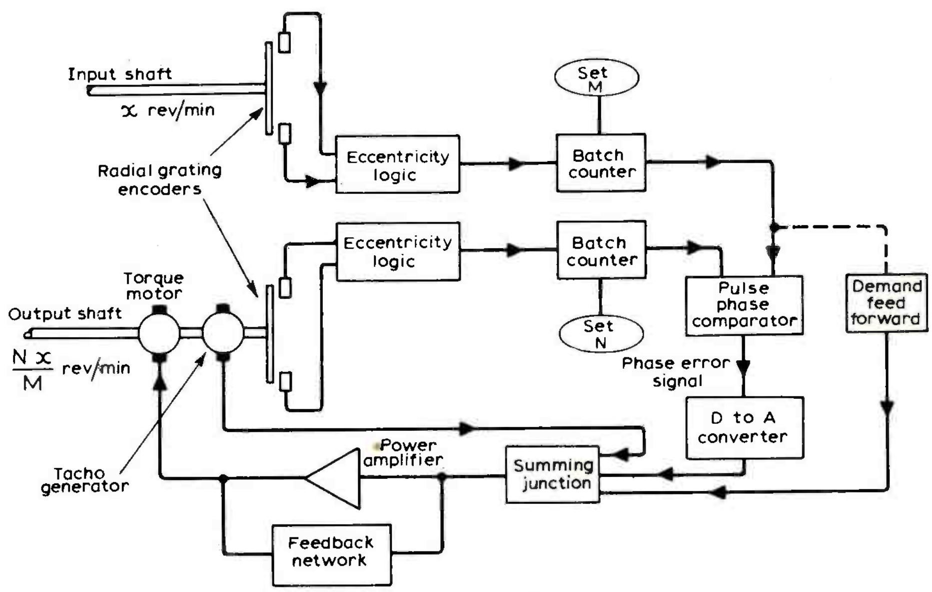


Fig. 1. In the electro-optical gearbox sinusoidal signals whose frequency is proportional to the rate of angular rotation of input and output shafts are fed to separate batch counters to set the gearbox ratio. A phase comparator provides an error signal proportional to their phase difference which controls the torque-motor driving the output shaft.

placed on either side of the small reference grating (Fig. 2). By incorporating multiple photo-sensitive devices, two signals at phase quadrature can be produced, and subsequent circuitry can determine the direction of movement of the grating.

Two diametrically opposed reading heads are normally used at each grating, and the reference and quadrature signals fed to "eccentricity logic" circuits which combine the signals in such a way as to reduce the effects of any eccentricity in mounting of the grating. In addition the signals may be interpolated electronically by a factor of up to 20 times, to increase the resolution of the system. By this means, a 72,000-line grating can give an effective resolution of 0.9 arc second.

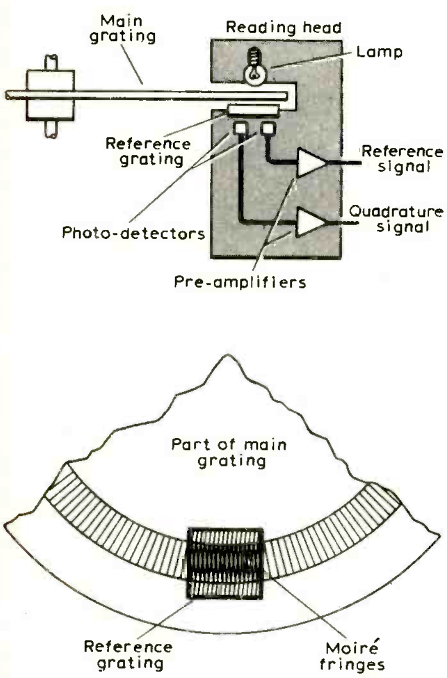


Fig. 2. In practice the encoder gratings are too fine to read directly, and a stationary reference grating is used to produce moiré fringes which move at the same rate as the shaft but are formed over a larger area. In practice two signals—in quadrature—are needed to establish direction of rotation and to reduce the effects of any eccentricity in the mounting.

The signals from each eccentricity logic or pulse multiplier circuit are squared to give a train of pulses whose frequency is exactly proportional to the speed of rotation of the shaft, with every small fluctuation shown immediately as a corresponding variation in pulse frequency.

These pulse trains are now fed to manually set batch counting circuits, which may be arranged to give an integral batch size from 1 to 999 (or higher if need be). It is by means of these batch counters that the gearbox ratio is set, a ratio which may be altered manually at any time, even while the shafts are rotating. The outputs from the batch counters are input to a pulse-phase comparator, which produces an error signal proportional to the instantaneous phase difference between the two pulse trains, and the phase error signal is converted to analogue form, amplified and used to feed the torque-motor driving the output shaft, thus closing the negative feedback loop.

The system is so arranged that the output shaft tries to rotate at a speed which gives pulse trains of equal frequency at the comparator. In this condition the output of the comparator appears as a square wave of unity mark/space ratio, which when integrated gives zero error. Any deviation from the correct shaft speed is detected initially as a small change in the mark/space ratio at the comparator output, *equivalent to a fraction of a fringe spacing.* This means that the maximum error in the transmission can be reduced to a fraction of a fringe over a speed range from zero to several hundred revolutions per minute. It must be emphasized that this is a "phase servo"—not a velocity servo.

In addition to the basic system as described some additional features ensure that the specification is maintained. Local tacho-generator feed-back around the torque motor ensures system stability at very low speeds. "Direction logic" ensures that the direction of rotation of the output shaft is always the same as that of the input shaft. (Of course, a switch can be used to reverse this direction if desired.) A counting system built into the comparator ensures that any gross errors built up during vicious acceleration and deceleration will ultimately be corrected by the system and not lost.

Velocity lag error, an inherent characteristic of position servos, is eliminated. It is explained simply by saying that if the output shaft were running at, say, 100 rev/min and providing, say, 100 watts to an external load, there will be zero signal output from the comparator when the system operates with zero error, zero current either into or out of the power amplifier and hence no power to drive the load. In other words, some inherent error must exist to drive the system. Velocity lag error is reduced by feeding forward part of the demand signal directly to the power amplifier via a frequency-to-voltage conversion circuit.

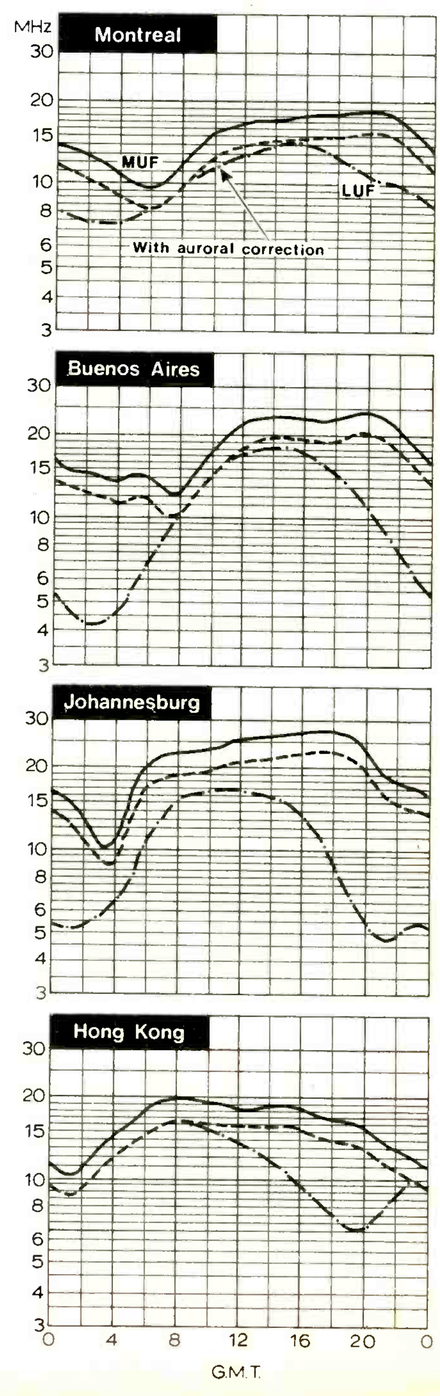
The principal motor-driving signal is always supplied by the input demand, and the error circuit is used solely to correct any deviations from the ideal performance.

The electronic gearbox has many obvious applications, wherever a precise drive between two shafts is required with the absolute minimum of backlash and transmission errors. The technique is already being applied in the machine tool industry, and it is expected that many more situations will arise where the extreme precision and smooth transmission properties of this system, and especially its potentially high reliability and freedom from wear, will make it more attractive than its mechanical counterpart.

H.F. Predictions —August

The charts show median standard MUF, optimum traffic frequency (FOT) and lowest usable frequency for reception in the UK.

LUFs are calculated by Cable and Wireless Ltd. for point-to-point telegraph circuits. Curves for domestic broadcast reception would be almost identical but for the amateur service would be typically 5MHz higher at mid-day. The variable effectiveness of low-power services is caused by day-to-day changes in the ionosphere which are on the increase at this time of the year.



Touch-switch Controller

by R. Kreuzer

This article describes the operation and construction of three units, a touch switch, a variable d.c. memory and a thyristor power control unit. These units can be used separately in other equipment or together as described here for controlling a.c. power. If used as a lamp dimmer the longer one keeps a finger on the touch switch the brighter the lamps will become.

Touch switch

The touch switch is a simple high-gain, high input impedance non-linear amplifier. The f.e.t., Tr_1, provides a high input impedance and some voltage gain. The potentiometer R_2 in the f.e.t's source is the sensitivity control which sets the bias for Tr_2. It should be adjusted so that Tr_2 is just turned on with no input signal to Tr_1. When a finger is placed on the touch plate a minute a.c. voltage appears across R_1 via C_1 because of the capacitive coupling between the mains cable and the operator. This voltage is amplified by Tr_1 and Tr_2 and a 50 Hz square wave appears across R_4.

Memory unit

The square waves across R_4 charge the capacitor C_3 via R_5 and Tr_3 so that Tr_5 (connected as a source follower) provides an output voltage across R_8. A transistor, Tr_3, is used instead of a diode to prevent C_3 discharging because its base-to-collector reverse resistance is much higher than that of an ordinary silicon diode. However, if the 'diode' is too perfect C_3 may charge up slowly due to leakage current from $Tr_{5\&6}$. This is unlikely to occur in practice but if it does a 'less perfect diode' must be used since it is essential that C_3 should be able to discharge *very* slowly. The unijunction transistor Tr_4 discharges C_3 when the voltage across C_3 reaches the emitter trigger voltage of Tr_4; thus enabling the switch to be turned off. The zener diode D_1 is used to bias Tr_5 so that with approximately 0.5V on its gate the voltage across the resistor R_8 is approximately 2V ($R_8 = 2.5\text{k}\Omega$). This voltage can be varied by adjusting R_8. It is essential that when C_3 has been discharged by Tr_4 the voltage across R_8 should not be more than 2V. If this can be achieved only by using very low values of R_8 then a different voltage zener diode should be used.

Thyristor power controller

The voltage across R_8 charges C_4 via R_9. At 10ms intervals C_4 is discharged by Tr_6 because this transistor is operated directly from the rectified mains and, therefore, its emitter junction becomes forward biased when the mains voltage falls to zero. When an input signal is applied the voltage across R_8 increases, C_4 charges to the emitter trigger voltage of Tr_6 and Tr_6 produces an output pulse; the thyristor is triggered on. With a high voltage across R_8, say 4V, the thyristor is triggered on early in the mains cycle and maximum power is supplied to the load.

The power taken by the touch switch and the memory is supplied by R_{12}, D_3 and C_5 running from the rectified mains. The maximum current taken by the two units is 5.5mA at 10V. Diodes D_4 to D_7 ensure that control is provided over both positive and negative half cycles of the mains supply High-frequency noise generated by the thyristor is suppressed by C_6.

Construction

The method of construction used is up to the individual since it is not particularly critical. The prototype switch was assembled on two 50 × 50mm printed circuit boards one being mounted on top of the other behind the faceplate. The touch plate was a piece of copper foil 25 × 12mm glued to the front of the faceplate and covered by a thin sheet of plastic. The following points should be noted:

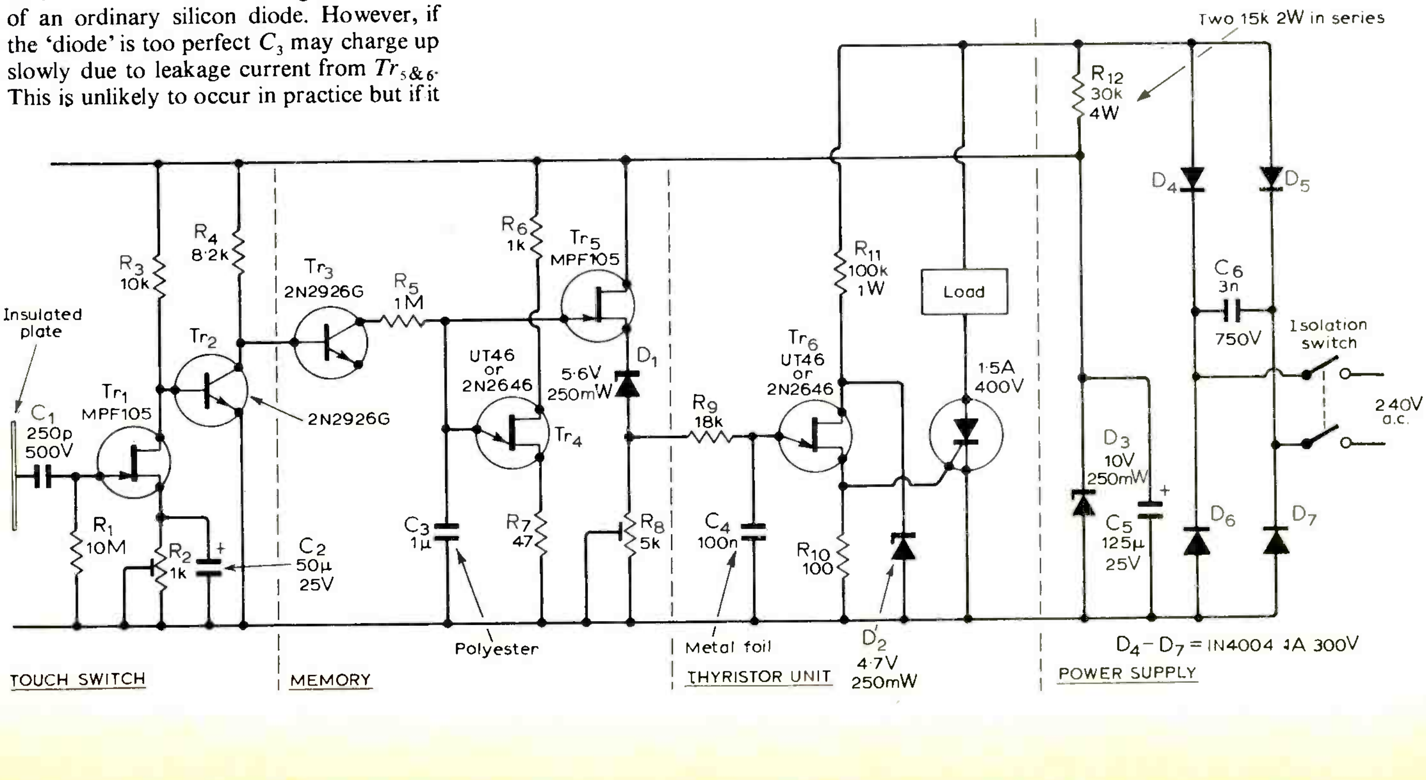
The wiring from the touch plate to the gate of Tr_1 should not be longer than 50mm otherwise feedback from the power supply and cabling to the switch may occur.

All wiring to C_3 and R_5 should be as short as possible and must be self-supporting to minimize leakage current.

Resistor R_{12} should be adequately ventilated as it runs hot.

The mains on/off switch should not be omitted. The circuits can then be isolated from the mains for safety reasons.

To test the unit connect a 200Ω resistor across R_{12}, a 4.7kΩ resistor across R_{11}, connect a 12V a.c. supply to the input of the diode bridge D_4 to D_7 and use a 12V lamp as a load. The unit can then be set up without the danger of getting an electric shock. Remember to remove these additional components before connecting the unit directly to the mains supply. Apart from the diodes D_1 and D_2 and Tr_3 the other component values are not critical. Although the prototype employed a 1.5A thyristor higher current devices may be used. The complete device can be used for dimming lights, controlling heaters or other electrically operated equipment.



Electronic Building Bricks

14. The comparator and subtractor

by James Franklin

In processing information in electronic systems we sometimes wish to compare the value of one electrical quantity with another, decide which is the bigger and which is the smaller, and perhaps measure the difference between the two. This may be needed, for example, in self-adjusting systems—say a power supply stabilizer or an electronic temperature controller—or for the control of switching operations.

Measuring the difference between two quantities is another way of saying subtraction. As such it is an arithmetical process which can be performed electronically by analogue or digital computing methods.

A familiar mechanical analogue of the comparator is the kitchen scales or the laboratory balance. One weight is compared with another and if there is any difference between them the balance arm swings one way or the other (though there is no measurement of the actual difference). The essential principle of the balance, that one weight offsets the effect of the other, can be applied to electrical quantities. We utilize the adding methods shown in Figs 1 and 3 of Part 12*, but reverse one of the e.m.f. or signal sources so that it opposes, instead of assists, the other. This gives the effect of adding a minus quantity—which of course is the same as subtraction.

For example if we use the method of adding voltages by series connection (shown in Part 12 as Fig. 1 (a)), to adapt this for subtraction we reverse the connections of one of the batteries—say the 6-volt one, as at Fig. 1. The 6-volt battery now opposes the effect of the 9-volt battery because, as an e.m.f. source, it is acting to move electrons in the opposite direction to that in which the 9-volt e.m.f. source is moving them. The e.m.f. of the 9-volt battery is offset to the extent of 6 volts and so the net e.m.f. is 3 volts. Thus the subtraction $9-6=3$ has been performed.

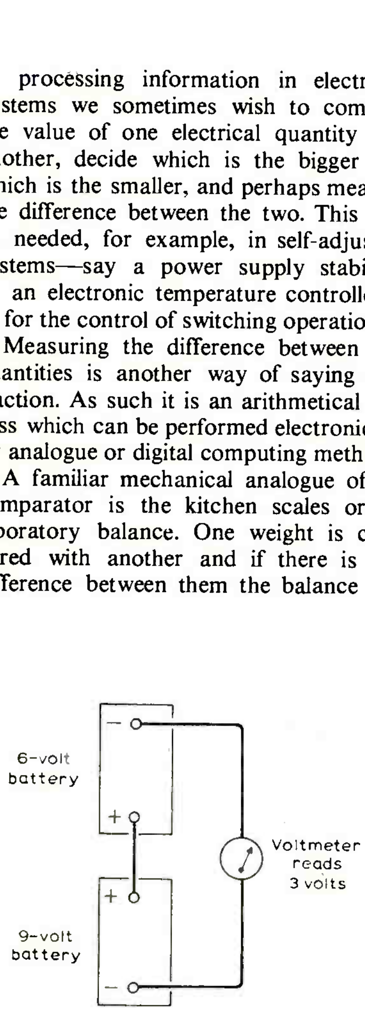


Fig. 1. Two batteries connected in series opposition give an overall voltage that is the difference between the individual battery voltages.

This principle can be applied to the subtraction of one continuously varying e.m.f.—a signal—from another. The connections of one of the signal sources are reversed—shown symbolically in Fig. 2 by "Signal source B" being printed upside-down—and then the varying e.m.f. of source B, instead of assisting that of source A opposes it. At each instant the effect of the e.m.f. of source B on electron movement is subtracted from the effect of the e.m.f. of source A. This is illustrated graphically in Fig. 3, where the voltage scale for v_A is drawn upwards from zero (as in Fig. 2 of Part 12) but the scale for v_B is drawn downwards from zero, by convention, so that graph v_B becomes a "mirror image" of what it was in Part 12. Values of v_B, are subtracted from corresponding values of v_A, giving a set of difference values which are plotted as the graph $v_A - v_B$ So $v_A - v_B$ is the varying voltage, or signal, formed by continuously subtracting v_B from v_A.

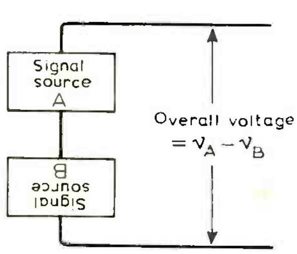


Fig. 2. The subtraction principle of Fig. 1 applied to two voltages which are varying with time.

For subtraction of signals represented by varying currents, again the principle is to use the adding circuit of Part 12 (Fig. 3) but reverse the connections of one of the signal sources so that its e.m.f. acts to move electrons in the opposite direction. Fig. 4 illustrates this for subtracting i_C from i_A and i_B instead of adding it to them. Electron flow in the common path is the result of the combined e.m.fs of the three sources. In this path there is an aggregate movement of free electrons in one direction resulting from sources A and B assisting each other, but also an aggregate free-electron movement in the opposite direction resulting from the oppositely acting source C. Since number of electrons moved in a given time is electron flow rate, which is current, the net current in the common path is i_A plus i_B diminished by i_C or $i_A + i_B - i_C$. Thus the signal i_C is subtracted from the signals i_A and i_B.

Digital subtraction can be performed by for example, a binary computing method or by an incremental system such as a reversible counter. In the last-mentioned, one sequence of events (e.g. electrical pulses) accumulates a total count in the normal way, while another sequence of events causes the counter to work backwards and so diminish (subtract from) this total count.

***Correction.** The Electronic Building Bricks article in the May issue, "Adding quantities and numbers", should have been shown as Part 12.

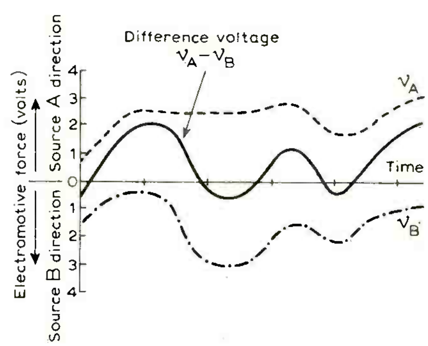


Fig. 3. Graphical illustration of what happens in Fig. 2 over a period of time. At any instant the voltage in the solid-line graph is the result of subtracting v_B from v_A.

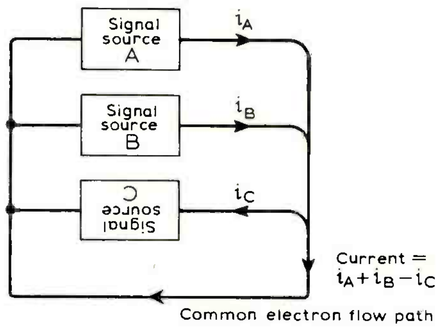


Fig. 4. Principle of subtraction with currents. Current in the common flow path due to source C is flowing in the opposite direction from that due to sources A and B.

Charging

A further look at the CR coupling

by Cathode Ray

In reviewing basic theory since 1911 for the 60th birthday issue of *Wireless World* I mentioned that during the second World War I was shocked to find radar instructors teaching that when (say) a positive-going input signal was applied to a CR coupling the output also went positive *because of the charging of C.* In actual fact (as I went on to say) any charging or discharging of C appears only as *distortion* of the signal at the output. I included also the words 'of course', by way of apology to readers for wasting their time by explaining where the quoted teaching was wrong. Wasn't it too obvious in these enlightened days?

Apparently not, for I soon got a letter to say that it was I, not the instructors, who was wrong. Touched though I was by this loyalty to a fine body of men, I felt that this evidence that my own experience of them was not unique called for some more detailed exposition of the point in question, in case the fallacy lingered on in a bigger way than I had suspected. I admit that some trainees might have misunderstood what their instructors taught about this. I will go farther and declare that many trainees did misunderstand what their instructors taught about this and about many other things. So not all that they taught in 1941 should be judged by what their trainees thought they said. And even if some of them *were* wrong on this point of circuit theory, we won the war so what the hell?

No one is likely to argue that uncertainty on the part of some radar mechs about the precise mode of functioning of inter-stage couplings in pulse amplifiers was responsible for a major loss of effectiveness in Britain's wartime radar defences, but I will and do hold that anybody who wants to be clever with electronic circuits ought not to have a fundamental misconception about how capacitors function in such circuits. So let's make sure.

The vital fact to be remembered is that the potential difference between the plates of a capacitor cannot change instantaneously, but only as a gradual process due to current flowing in or out.

This follows from the basic equation for capacitance, as important for it as 'Ohm's law' for resistance:

$$V = \frac{Q}{C} \qquad (1)$$

in which C is any capacitance (in farads), Q the electric charge stored in it (in coulombs) and V the p.d. between its plates (in volts). We usually think in terms of current (amps) rather than coulombs, so we also have to remember that

$$Q = It \qquad (2)$$

which means that the charge Q in equation (1) is equal to the amount of current I (in amps) that has been flowing into C, and t is the time in seconds during which it has been flowing. (To make things simple we are assuming I is constant.) Putting (1) and (2) together, therefore, we see that the voltage across a capacitor cannot change unless the capacitor receives a proportionate charge, and that takes time. If time were not allowed, t would be zero, so for any charge at all I would have to be infinitely large, which is impossible.

Fig. 1 shows the classic capacitor-charging experiment. Before the switch is closed the capacitor C is uncharged, so in the basic equation (1) $Q=0$, so $V=0$. The moment the switch is closed the voltage E is applied across C and R in series. No time has elapsed since it was closed, so $t=0$, so $Q=0$, so $V=0$ still. So the whole of E appears across R. That means that a current (call it I) is flowing through R, and 'Ohm's law' tells us it is equal to E/R. That same current is flowing into C, charging it. After one second, $t=1$, so equation (2) tells us that $Q=I$. And we already know that $I=E/R$, so $Q=E/R$, so $V=E/CR$. The capacitor voltage is rising at the rate of E/CR volts per second.

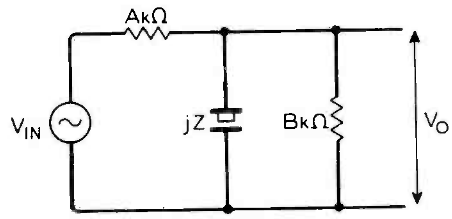


Fig. 1 The familiar circuit used to study the charging of a capacitor.

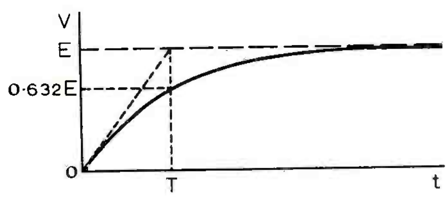


Fig. 2 The familiar (exponential) charging curve; a graph of voltage against time.

But not quite. By the end of the first second the voltage across R is no longer E; it is $E-V$. So the charging current is less than it was, so the rate of charging is less. The nearer the capacitor voltage gets to E, the less voltage is left to drive current through R and the slower the charging continues. This is shown by the familiar rate-of-charging curve, Fig. 2. Theoretically the capacitor never quite gets charged to the full voltage applied, E, but the deficiency soon becomes negligible.

To continue this lesson in elementary theory we draw the dotted line sloping upwards in Fig. 2 to show how the capacitor would charge if the starting rate could somehow be maintained. The instant at which C would be charged to the applied voltage E is indicated by the point at which the sloping line reaches the E level. Dropping a vertical dotted line from there to the time scale shows (or would do if the scale were graduated in seconds) how long this would take. As our scale is not graduated we will call the answer T.

From what we already know we can find a general formula for T. Combining equations (1) and (2) by substituting It for Q in (1) we get

$$V = \frac{It}{C}$$

At the end of our imaginary uniform-rate charge, $V=E$, $t=T$, and $I=E/R$. So

$$E = \frac{ET}{CR}$$

and for that to be true

$$T = CR$$

I'm quite sure that all the radar instructors included this result in their repertoire, whether or not they proved it in the above or any other way. T, the time a capacitance C would take to charge to the applied voltage through a resistance R if the starting rate could be maintained, is called the time constant of the series combination of C and R. If they are in farads and ohms (or more conveniently in microfarads and megohms) T will be in seconds.

Because it refers to a mode of charging that doesn't exist in normal practice you might consider all this a waste of time. But as we noted earlier one cannot say how long a capacitor takes to charge in the real practical Fig. 1 way, because theoretically it always takes an infinitely long time, and that is not a very helpful piece of information. The only thing left, then, is to decide on how charged is 'charged'; 99%, say?

The mere suggestion may bring before you a vision of endless committee meetings all over the world trying to agree on a percentage to use as an international standard. Happily, there is no need for this. It turns out that the actual charging curve in Fig. 2 has a fixed shape, so that the time taken to charge to any given percentage of 'full' is an easily calculated factor of T, which is so simply equal to CR. The simplest possible factor is of course 1, and it happens that CR is the time taken to charge to 63.2% of 'full', as shown in Fig. 2. That looks like rather short measure. 99% requires an odd factor, so I suggest a choice of either $4CR$ (for 98.17%) or $5CR$ (for 99.33%).

The radar instructors probably mentioned the name of the curve of this particular shape (the exponential curve) but they may well have decided it was unnecessary (for the purpose of fitting people to keep radar equipment working) to go into the mathematics of the thing. I too am saying it is unnecessary for our present purpose, and anyone who really wants to know can find it in almost any of the textbooks on electricity (with or without magnetism). The only vital point to carry away just now is that some idea of how long in seconds $C\,\mu F$ takes to charge through R MΩ is given by multiplying C by R, and that charging is practically complete in 4 or 5 times CR.

Now we have got the basic principles straight we can apply them to a circuit of the type which might have given rise to the lecture on CR time constants. It is a circuit in which a square wave developed in the output of one stage has to be passed on to the input of another stage for amplifying, blanking, gating or whatever. Fig. 3(a) shows the relevant part of such a system. Valves are shown, because they were used in wartime radar and because in many cases the input of the second stage had such a high resistance that R was not appreciably shunted by it. Fig. 3(b) is a transistor equivalent for the benefit of those to whom valves are devices that used to be used, too long ago to be worth trying to understand. But an allowance will have to be made for the shunting of R.

The square input waveform is shown in Fig. 3(a), and the object is to reproduce it, with as little distortion as possible, at the input to the next stage—i.e., the junction of C and R. Of course if direct coupling is used C and R are not needed and distortion does not arise, but with valve circuits especially it is usually necessary to maintain a fixed p.d. between the two stages by means of C, to keep the electrode working voltages right. When considering signal voltages this fixed p.d. can be ignored. So in the signal-voltage/time graph (Fig. 4) we can assume both the input voltage (applied across C and R) and the resulting output voltage (across R) start from zero level.

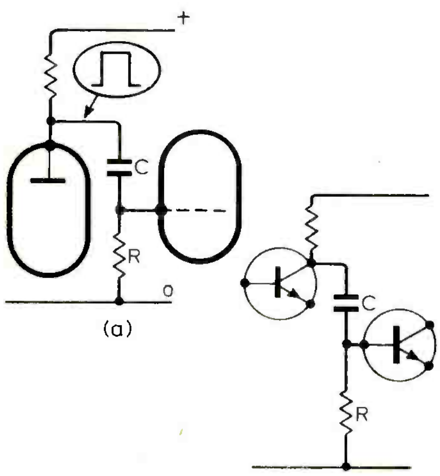


Fig. 3 The part of a circuit in which the theory developed in Figs. 1 and 2 is useful: (a) the valve version considered, and (b) its transistor equivalent.

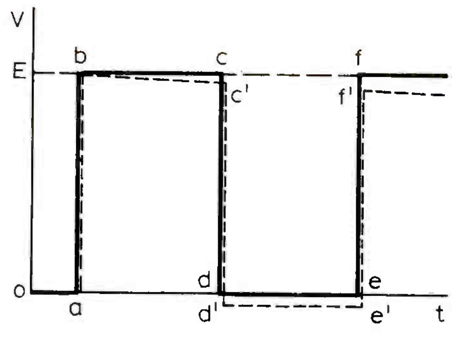


Fig. 4 The solid-line square wave is the input to CR (shown in Fig. 3), less any continuous voltage bias, and the dotted line is the output at the junction of C and R.

Up to the point on the time scale marked a the input signal voltage remains at zero, and so does the output, so there is no voltage across the capacitor, so (as equation (1) tells us) it must be totally uncharged. But at a the input suddenly goes E volts positive. (Of course it can't do this absolutely instantaneously, but let us suppose that compared with the time ad the rise time is negligible.) This is the point at which I have heard instructors go on to say 'so C charges, making the output (which is the input to the next stage) positive'. But I have, I hope, by now convinced even the most instructor-loving reader that it just isn't possible for C to charge appreciably during the rise time, and the fact that the output follows the input and goes positive to the same extent is actually evidence of it. In other words, C does this part of its job by *not* charging. For as long as it stays uncharged, both sides of it are at the same potential and the output is an exact undistorted copy of the input waveform. The ideal, then, is for C never to be charged, at all.

Let us now consider the state of affairs from b to c. Because the input, E volts, is applied across C and R, and the voltage across C alone (at b) is zero, the whole E comes across R, causing a current to flow through it. Assuming (as we did) that the second valve takes no grid current, all the current has to go into C, beginning to charge it at a rate of E/CR volts per second. The voltage now rising across C is no longer available for R as output voltage. So the output voltage falls. How much it falls in the period bc depends on the time constant, CR. If the output is to be undistorted, it mustn't fall at all; which means that CR must be infinite. It can be made very nearly so by removing R altogether, leaving a gap. But then the grid potential would be at the mercy of stray circuit leakages. To ensure that it starts definitely from zero (or any other designed voltage) R must be used, but its resistance should be made not lower that is needed to anchor the grid to zero volts. Provided that C also is made large enough, the drop in output signal voltage, represented in Fig. 4 by cc', can be kept small, as shown. Incidentally, because the voltage across R is nearly constant, the rate of charge is nearly constant and bc' is nearly a straight line.

At c the input returns abruptly to zero volts *(d)*, and as the p.d. across C cannot change so quickly the grid side of C drops by the same voltage *(E)*. As it started from c', less than $+E$ volts, it now goes slightly negative, d'. This negative voltage, dd', to which C became charged during the period bc', is now applied to R, through which the charge leaks away during the period $d'e'$. Because the voltage is so small the rate of discharge is very small and $d'e'$ is practically horizontal. So when the input goes positive again, from e to f, the output at f' is practically the same as at c'. It therefore starts its decline during the next positive half-cycle from a lower voltage than it did in the first.

Effect of d.c. barrier

So long then as the output half-cycles continue to be more positive than negative, the different rates of charge and discharge bring them gradually more nearly equal, as shown by the dotted waveform in Fig. 5. In the end, whatever the input waveform, the output will arrange itself so that the time×voltage area below the line is equal to that above the line. The line, of course, represents the level to which the output is anchored by R; in this case zero volts. This phenomenon, which we have been examining in detail, results inevitably from the fact that a capacitor is a barrier to d.c. So a signal that starts (as in Fig. 4) all above the line, or more one side of the line than the other, inevitably adjusts itself so that this d.c. component disappears and the output is wholly alternating. The less the time constant CR the faster it adjusts—and the more distortion it introduces.

If the signal frequency is very low, so that C has a long time in which to discharge during each half-cycle, a very long time constant is needed to avoid appreciably distorting a square wave. And the system takes a very long time to readjust to a change of input amplitude. This problem arises in oscilloscopes where capacitance couplings are used in the deflection ampli-

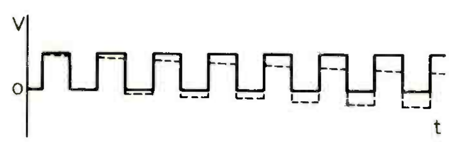


Fig. 5 How the voltage/time graph started in Fig. 4 continues.

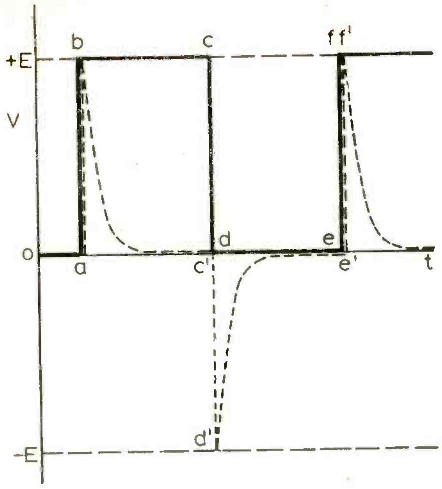


Fig. 6 Here for comparison with Fig. 4 is what happens when the time constant is only a fraction of one half cycle.

fiers. It is so tedious waiting for them to settle down that nowadays designers almost always provide direct-coupled amplifiers.

The d.c.-losing effect can be prevented by suitably connecting a rectifier in the circuit, creating a 'd.c. restorer'—but that is another story.

The only other thing I think I need mention—and it will be familiar to radar trainees past and present—is that a CR coupling is often used not to pass on the original undistorted form but to introduce deliberate distortion. The commonest application is for changing square waves into brief pulses. For this purpose the time constant is made much less, so that instead of a gradual charge such as *bc'* in Fig. 4 the capacitor charges practically completely within the half-cycle, as in Fig. 6. When the end of the square-wave half-cycle comes *(cd)* the output going negativewards by the same amount *(c'd')* yields equal negative and positive half-cycles from the start. The negative ones can then be removed by a rectifier and the positive ones clipped by another, to give a train of pulses.

Note that (whatever the instructor said) C charges from *b* to *c'* and discharges from *d'* to *e'*, in Fig. 4 and in Fig. 6.

I used to find that even fellows who could state Kirchhoff's voltage law quite correctly when asked for it seemed to forget all about it when considering the CR type of circuit. One form of the law says that the sum of the voltages across the components in a series circuit is equal to the voltage applied. Now in Figs. 4 and 6 the voltage applied is represented by the height above zero of the 'input' waveform: alternately *E* and O. The Voltage across R ('output') is represented by the height of the dotted line, so the voltage across C (due to its charge) must, by Kirchhoff's law, be the vertical difference between the two. Looking at the matter this way, one can be in no doubt about when and how much the capacitor is charging and discharging.

The essential thing is to grasp the message of Figs. 1 and 2. Then a correct view of the action of any CR circuit is (to coin a phrase) a piece of cake.

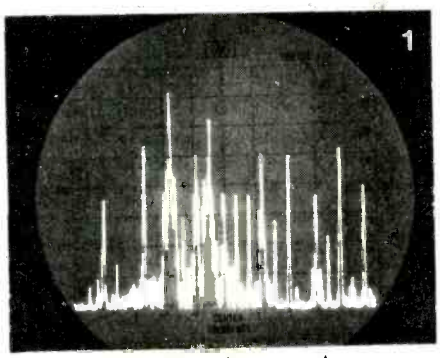
Single-sideband Experimental Broadcasts

For some years there have been discussions on the possibility of utilizing the medium-wave sound broadcasting band more effectively by means of single-sideband transmissions. At first sight it seems attractive in view of the fact that s.s.b. is now so well established in h.f. communications. But there are complications in reception, the main one being that the simple envelope detector found in conventional sound receivers inevitably leads to excessive distortion and must be replaced by a product detector, in which case, for tuning, a local oscillator of high stability, among other things, is required. In Britain the broadcasting authorities don't seem very enthusiastic about s.s.b. but in Germany there is considerable interest—measured by the fact that the Deutschlandfunk broadcasting organization has been putting out experimental s.s.b. transmissions from its station at Mainflingen, near Frankfurt.

The broadcasts took place in the early hours of the morning, after close-down of normal broadcasting, on 1475 kHz. At least one group of British radio research people was willing to stay up in order to study and listen to the transmissions. This was a radio section of the Department of Electrical and Electronic Engineering at University College Swansea, headed by Dr. R. C. V. Macario (author of an article on an s.s.b. receiver module in the July issue). Some results of their monitoring are shown in the accompanying frequency spectra. Fig. 1 is a 200 kHz wide part of the m.f. spectrum showing the s.s.b. transmission at 1475 kHz, in relation to the permanent a.m. transmission from the Mainflingen broadcasting station on 1538 kHz and to Radio Luxembourg on 1439 kHz. More detail can be seen in Fig. 3, which is 50 kHz wide. The upper sideband of the s.s.b. transmission can be seen as an asymmetrical distribution of energy in contrast to the symmetrical distributions, like church spires, of the a.m. stations on each side of it. In Fig. 4 the frequency scale is 20 kHz wide and shows the upper sideband in even greater detail.

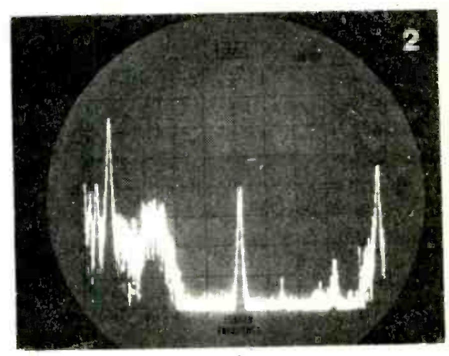
The carrier alone of the s.s.b. transmission was suppressed 20dB below the peak sideband levels, and is shown in Fig. 2, on a frequency scale 20 kHz wide.

The spectra were displayed on a Hewlett-Packard spectrum analyser, model 8552A/8553L, with a stored display. A simple roof wire aerial was used. Recordings of the transmissions were made via various receiving systems, but it is interesting to note that direct conversion was possible since the lower sideband of the transmission was relatively free of interference.



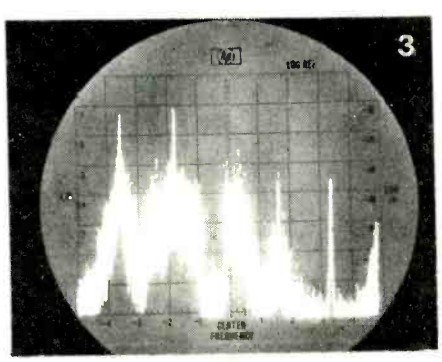
1

Luxembourg s.s.b. Mainflingen



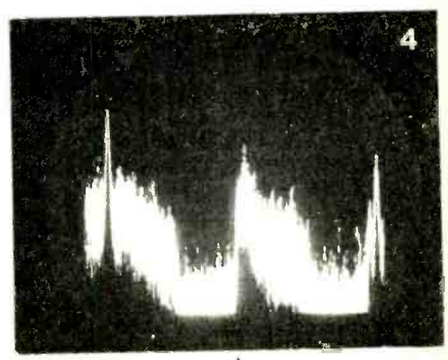
2

s.s.b carrier only



3

u.s.b. 1475 kHz



4

u.s.b. 1475 kHz

Telephone Exchanges of the Future

A new type of telephone exchange is in operation at a GEC-Marconi establishment (at Writtle in Essex) which does not use any electromechanical switches or in fact any moving parts. The system is called Martex and is typical of the sort of exchange which is to be built in the future.

The system is a modular range of equipment which covers all aspects of switching and transmitting telephone traffic, and some types of data communications. The complete system is based on the use of digital switching and computer techniques to switch information in digital form.

Equipment employing pulse code modulation, a particular form of digital speech transmission, is now being used increasingly by the Post Office, to increase the capacity of existing telephone lines. Each telephone channel is converted into a stream of digital pulses which provide a complete representation of the original voice signals. These signals can be reconstituted into normal speech with rather less loss of quality and fidelity than would be experienced by a conventional telephone transmission line.

The great advantage of the digital network of transmission is that the spaces between consecutive pulse groups from a single voice input are arranged to be sufficiently large for a number of other pulse streams, from other telephone circuits, to be fitted into these spaces. If this is done in an ordered fashion, then a number of separate telephone inputs can be fed simultaneously along the same transmission line, and separated at the far end into the original voice signals.

This method of combining channels is known as time division multiplexing, t.d.m. It has the advantage that signals in this form make better use of the digital switching equipment.

At the start of a call, the first event in the complete sequence will be the lifting of the receiver, which will initiate a demand for a signal path into the exchange system. This will be established through a local concentrator system, which will allocate a particular time slot in one of the digital input circuits of the exchange. In the exchange system, a register will be connected to the appropriate line, through the digital switch returning 'dial tone' to the calling subscriber. The subscriber will then dial a code, using either a conventional rotary dial, or push-buttons. When the register has accepted the complete information, the control computer in the exchange will examine the contents of this register. Using information from a magnetic drum store, it will generate control signals to produce the appropriate switching functions in the exchange, together with additional switching instruction codes for onward transmission to a subsequent exchange, depending on the routing of the call. These latter will be assembled in the memory of the 'sender', and transmitted through the system when the switching operation is complete.

On arrival at the exchange, each speech channel will have been converted into digital form by its relevant p.c.m. terminal, allocated on a demand basis in a local exchange system. The digital signals are multiplexed into groups of 30 speech channels to form a single time division multiplex signal. Two additional channels (or time slots) provide control and supervisory information. This format uses a total of 32 time slots in each signal 'frame', with a frame repetition rate of 8kHz. Each slot contains eight digital bits which define the polarity and amplitude of the speech sample being transmitted. Each incoming speech channel is thus sampled at a rate of eight thousand per second. These groups of channels enter the exchange switching system over digital transmission paths linked directly with the digital switch and its associated control system.

Concentrators will be employed which will enable large numbers of subscribers economically to be connected to a central digital exchange. The concentrators will replace small local exchanges, and will normally be connected to the main exchange through three digital links, providing for up to 90 subscribers to be connected simultaneously to the main exchange. With normal circuit usage, this would cater for 1,000 subscribers per concentrator. Twenty five or more concentrators may be connected to the Martex switch to deal with up to 25,000 subscribers.

Each digital input circuit consists of thirty speech channels with an additional two supervisory and control signal circuits. This produces a stream of digital pulses in which every 32nd group of pulses, or time slots, relates to a particular speech channel.

Switching will require connection of input and output circuits in either the same time slot or in a different time slot. In the first case connection is by a relatively simple switching action, but in the second, time delays have to be introduced into both directions of transmission to match up the input and output circuits. This process is in addition to the normal switching process, and is also carried out under the direction of the central computer.

In both cases, any incoming signal, on a given digital input circuit, will need to be connected with another digital output. This part of the switching is carried out by providing physical connections between the appropriate wires on a matrix of crossed wires. The connection is made through solid-state digital switches which are pulsed at the 8kHz repetition frequency of the appropriate pulse group in one of the 32 time slots in each multiplexed input.

However, in general, a second type of switching, incorporating a time delay, will have to be introduced to each switched circuit, in order that it will match up with the appropriate time slot in the output circuit.

If, for example, in order to establish a particular connection, it is necessary to connect the third time slot in one multiplexed input signal to the twelfth time slot of another multiplexed output channel (i.e. nine time slots later), it is necessary to delay the input signals by the equivalent of nine time slots in the forward direction of 35.2μs, and 23 time slots or 89.9μs in the reverse direction. This is achieved by the use of 'junctor' units, which use shift registers, controlled by the central control computer, to provide the appropriate time delay.

The program control unit contains a number of processors in a fully triplicated system. Fixed program, read-only stores, provide the basic programming for the computer control system, while drum stores are used for channel routing instructions and other semi-permanent control data. Magnetic tape units are used to record call charge data and accounting information.

All critical parts of the system are fully triplicated, with a constant comparison of the data passing any point in the system. A majority voting technique is employed to ensure that a fault in one of the three systems will not introduce errors. In the event of two failures at parallel points in the system, the third channel can be switched to provide a continuous service. All three systems work in synchronism under the control of the exchange clock, to ensure that comparable data arrive at the voting point simultaneously.

Elements of Linear Microcircuits

10: Amplitude modulated radio receivers

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

Despite the increasing number of f.m. sets in use, most domestic and car radio receivers are still a.m. only, usually covering the m.w. band, 540 to 1640 kHz, and sometimes also the l.w. band, 155 to 280 kHz. In this article, we will take a look at the application of linear microcircuits in this field.

When off-the-shelf linears first began to come into the hands of set designers in the mid 1960s, they offered a possible alternative to the use of six to ten separate transistors in a conventional superhet circuit, which had by then become almost a way of living. This market presented a tempting large-scale outlet to semiconductor manufacturers, and as a result a lot of effort has gone into trying to develop microcircuits for a.m. receivers.

The ideal microcircuit design for this purpose would be a device with all active and passive circuit components incorporated with the exception of the aerial, tuning control and indicator, volume control, loudspeaker and power supply. This may come some day, but for the present we must be satisfied with microcircuits which do not go as far as this.

Most approaches to the problem started from the conventional superhet circuit arrangement and were aimed at producing monolithic silicon chips containing as many of the transistors, resistors and capacitors of the discrete designs as possible. However, one school of design (using phase-locked-loop techniques to be described later) has abandoned the conventional superhet.

Partitioning superhets

If you cannot reach the ideal solution of the single chip, then you are faced with the problem of how to break the superhet down into sections. Receiver designs using i.cs have followed three main paths:

Discrete approach, in which only the active components are integrated. This fails to make use of the full potential of the monolithic circuit art because separate passive component counts are not reduced.

Functional approach, in which single functions of the receiver are fabricated in separate monolithic circuits and are assembled with additional discrete components to form a complete radio.

System approach, in which multiple receiver functions (e.g. the mixer, oscillator and i.f. amplifier) are fabricated on the monolithic circuit chip.

The discrete approach soon proved to have no advantages over discrete assembly, and is of historical interest only. The functional approach, too, proved uncompetitive with discrete assembly but, although it has now been abandoned, we will take a look at one example of it as a significant step towards current practice.

Single i.f. stage

Fig. 1 (a) shows the internal circuitry of the Motorola MC1550G, a versatile common-emitter, common-base cascode-circuit high-frequency amplifier capable of 30dB gain at 60MHz but which can be used for a 470kHz i.f. amplifier in the circuit of Fig. 1 (b).

It will be seen that all the resistors and

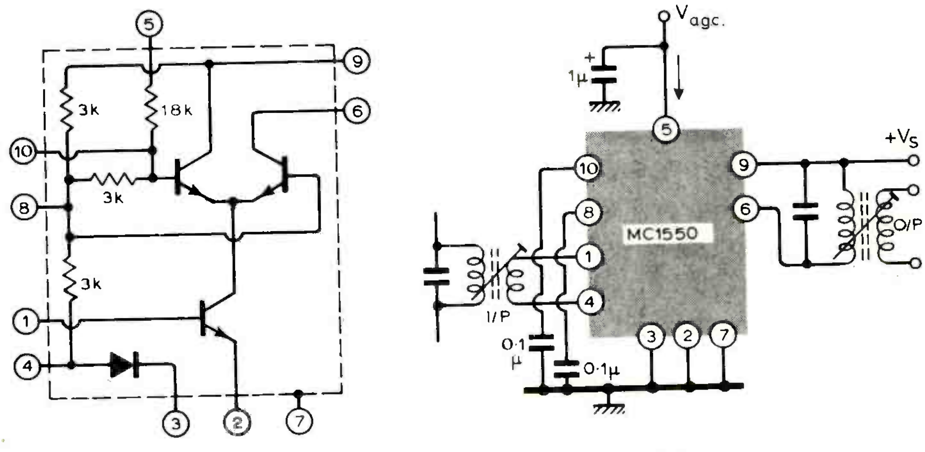


Fig. 1. Example of single-stage integration; (a) internal circuit of Motorola MC1550G r.f./i.f. amplifier; (b) MC1550G in single i.f. stage.

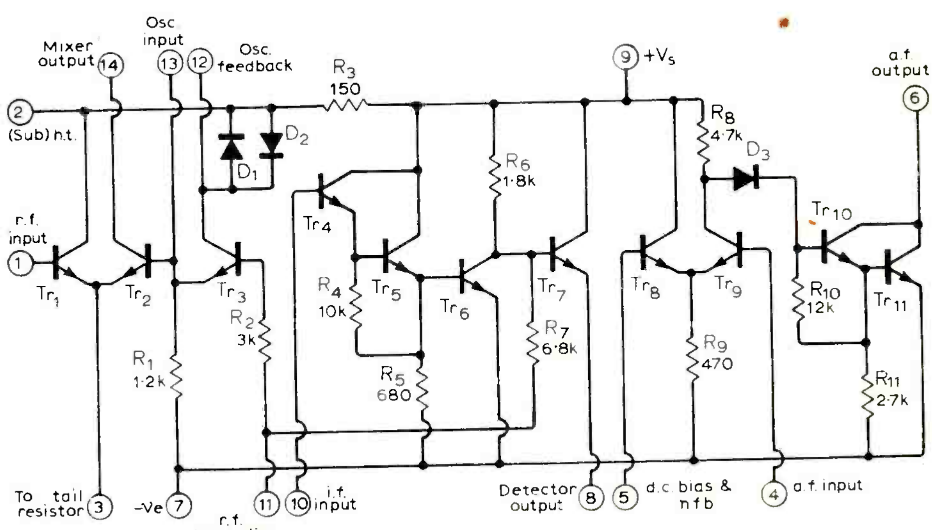


Fig. 2. Internal circuitry of Mullard TAD100 a.m. radio receiver microcircuit handling signal from local oscillator via mixer up to audio driver stage.

*Newmarket Transistors Ltd.

semiconductors for the single stage have been integrated, and apart from the *LC* bandpass circuits, only three external capacitors are required.

One chip, r.f. in to a.f. out

The Mullard TAD100, whose circuit diagram is shown in Fig. 2, was one of the first i.cs designed specifically for a.m. radios. The design aim was a low-cost integrated circuit (not too expensive for economic service replacement), with performance not worse than that of conventional discrete-component receivers, and in standard 14-lead dual-in-line package. It incorporates no fewer than 11 transistors and three diodes, together with many of the passive components from the mixer to the audio pre-amplifier.

Tr_1 and Tr_2 form a long-tail pair mixer stage, and Tr_3 is the local oscillator. Tr_4, $_5$ and Tr_6 comprise a high-gain wideband amplifier for i.f. amplification, and Tr_7 is a transistor detector. Tr_8 and $_9$ are a long-tail pair audio pre-amplifiers and Tr_{10}, Tr_{11} a Darlington common collector audio driver stage. Diodes D_1, D_2 in parallel, back to back, across the oscillator transistor collector coil terminals, serve to stabilize the local oscillator. D_3 is a level shifting d.c. coupling diode to the input of the driver stage.

Typically the TAD100 takes about 20mA quiescent current in a 9V circuit. Its sensitivity for a 26dB signal-to-noise ratio (a standard index) is typically 25 μV at input terminal (1). Its a.g.c. range controlled by feedback from (8) to (1) is typically 62dB change in r.f. input voltage for only 10dB expansion in audio output. For 10mV audio at the detector load, less than 6 μV r.f. input is required at the input.

You can see how the TAD100 is used in practice in the 9V broadcast-band receiver arrangement of Fig. 3. A 180/280pF gang capacitor tunes the rod aerial coil L_1 and the oscillator coil L_3. The r.f. input is connected across (1) and (13), and the local oscillator drive feeds into (13); a.g.c. is fed back from (8) into (1) via a decoupling network and L_2. From (3) a 560 Ω resistor to the negative supply (shunted by a series 56 Ω resistor in series with 0.047 μF) forms the tail of the input long-tail pair. The mixer output from (14) feeds into the input (a) of the 470kHz LP1175 block filter, which is a combination of two tuned *LC* circuits with a ceramic resonator as shown separately inset in Fig. 3. The LP1175 gives the typical normal 6dB bandwidth of 7 to 8kHz and a significant improvement in skirt selectivity over conventional fixed-tuned i.f. transformers.

From the filter output (b), the i.f. signal passes into (10) and is amplified and detected to reappear from (8) to provide the audio drive to the top end of the volume control and the a.g.c. signal to be

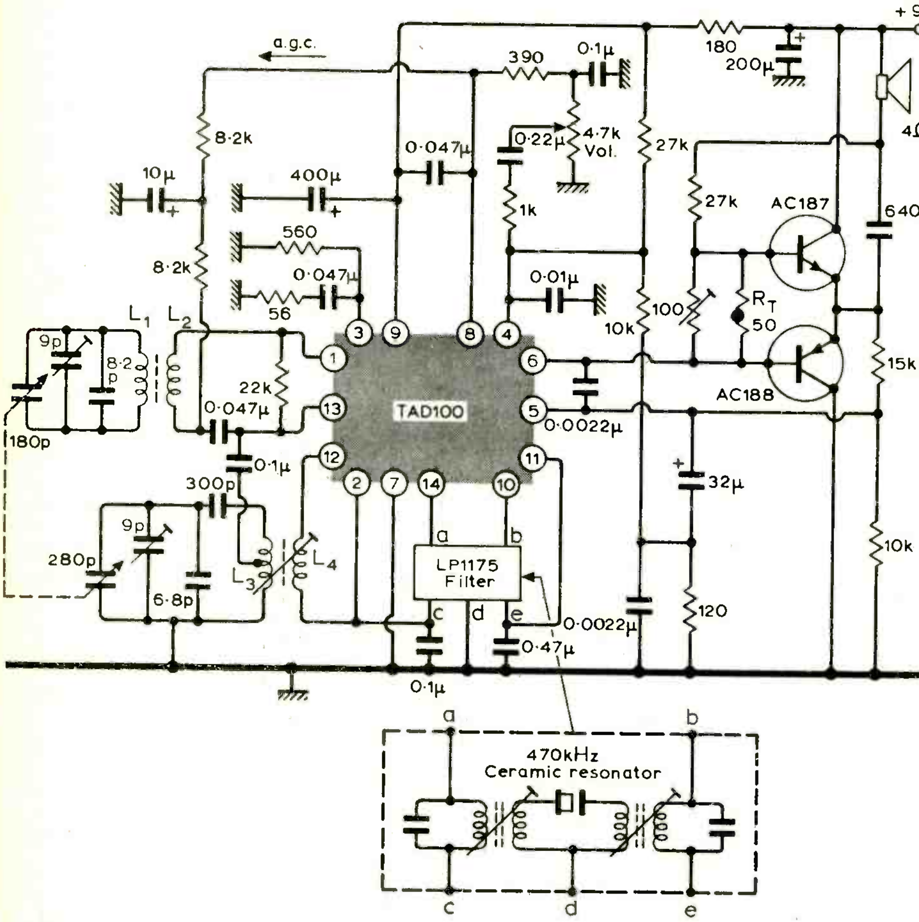


Fig. 3. Broadcast-band a.m. receiver design (9V) utilizing TAD100 microcircuit.

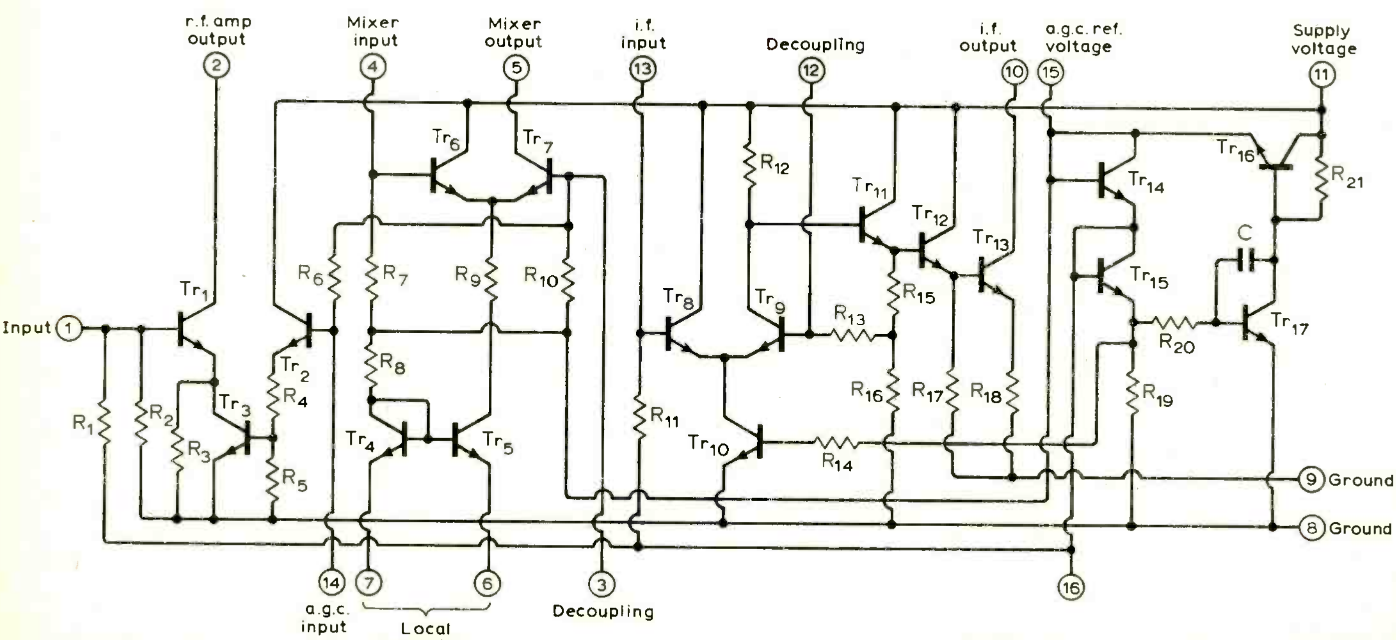


Fig. 4. internal circuitry of S.G.S. TBA651 a.m. radio receiver microcircuit handling signal from r.f. amplifier up to i.f. output.

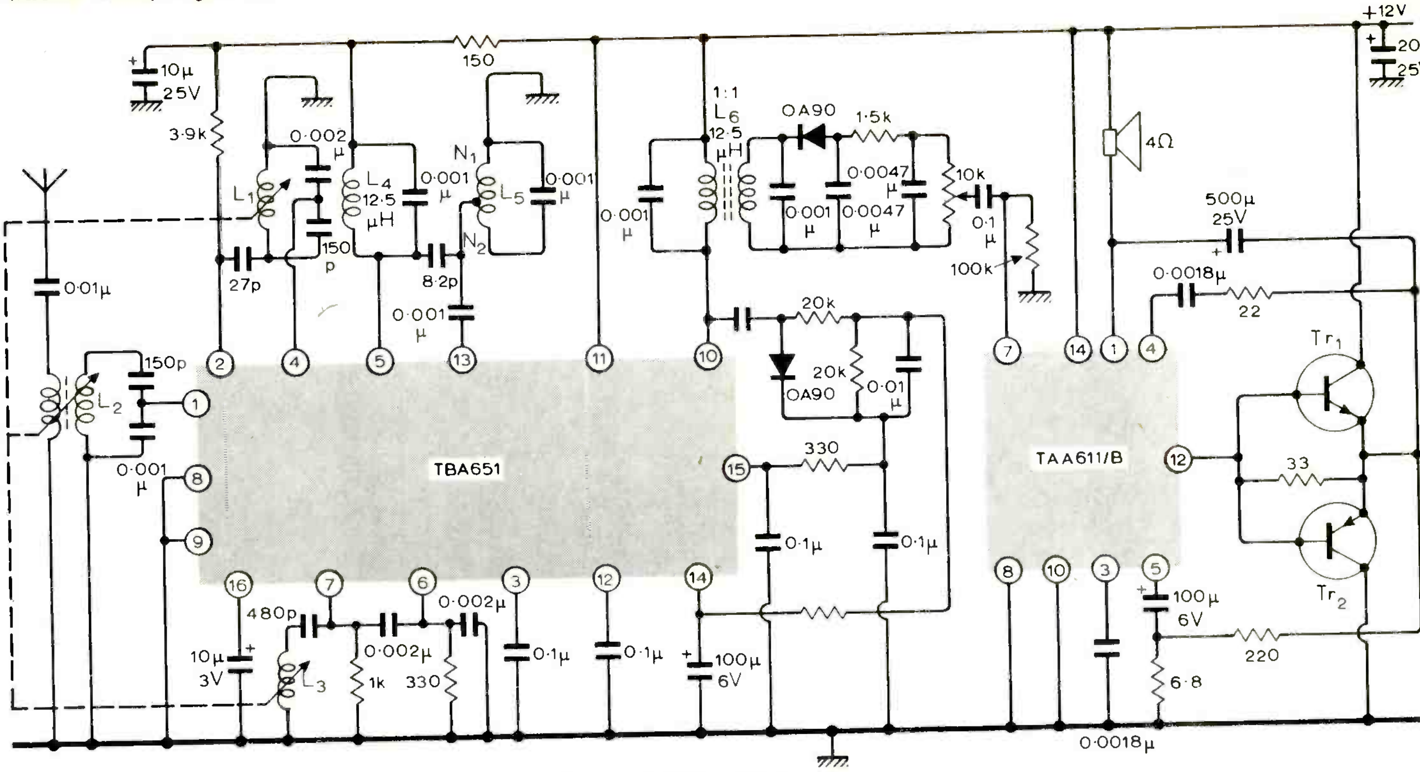


Fig. 5. 12v broadcast-band a.m. car radio receiver utilizing TBA651 microcircuit.

fed back to (1). From the volume control slider the audio is fed into (4) and reappears amplified at (6) to drive the output stage. In this design the output transistors are a discrete n-p-n/p-n-p pair in single-ended push-pull, capacitor-coupled to a 4 Ω loudspeaker to give over 1W output.

At first sight there seems still to be a very large number of components outside the microcircuit, but it should be noted that most of them are passive and of wide tolerance, and unlikely to give trouble in assembly. Also the use of a block i.f. filter requiring no 'adjustment' simplifies set assembly.

One chip, r.f. in to i.f. out

The TAD100 was designed to integrate as much of the a.m. receiver as practicable. The a.f. output stage was left out because of dissipation limitations in the package used. A different partitioning was adopted by S. G. S. in their TBA651 linear integrated circuit that processes the whole high-frequency signal in a.m. receivers. It consists of five stages: r.f. amplifier, mixer, oscillator, i.f. amplifier, and a.g.c. control and voltage regulator and was designed primarily for high quality domestic and car radios. This explains the inclusion of a separate r.f. amplifier stage, and also the ability to work from voltage rails of 4.5 to 18V. The circuit is packaged on a 'split' (staggered pins) 16-lead dual-in-line.

In Fig. 4 you will find details of the internal circuitry of the TBA651. Tr_1 is an r.f. amplifier; Tr_6 and Tr_7 the mixer; Tr_5 (with Tr_4) the local oscillator; Tr_2 and Tr_3 the a.g.c. control on the r.f. amplifier; Tr_8 and Tr_9 (with Tr_{10} tail current source). Tr_{11}, Tr_{12}, Tr_{13} the i.f. amplifier; and Tr_{14}, Tr_{15}, Tr_{16}, Tr_{17} a voltage regulator circuit providing three output voltages to set the d.c. bias conditions of the various transistors.

An a.m. car radio circuit using the TBA651 is given in Fig. 5. A three-ganged permeability unit tunes the aerial input, r.f. amplifier and local oscillator circuits. A double-tuned i.f. bandpass circuit L_4 and L_5 connected between (5) and (13) in series with the input to the i.f. amplifier section provides part of the required i.f. selectivity and the balance is provided by the single-tuned circuit L_6 at the i.f. output (10). The input *LC* filter can be replaced by a ceramic-plus-*LC* filter similar to the LP1175 for greater skirt selectivity.

In Fig. 5 it will be seen that a conventional a.m. diode detector is used externally to the TBA651; unlike the TAD100 where a transistor detector is included in the microcircuit. After the volume control, a number of arrangements are possible. In Fig. 5 the monolithic TAA611/B is used to drive a pair of output transistors (medium power, with a current gain at 3A of greater than 20) to give 5W output. A number of completely integrated 5W, 12V audio amplifiers are coming on the market with sufficient gain to be driven direct from the volume control in applications such as these, and ultimately we should see two-chip complete radio receivers.

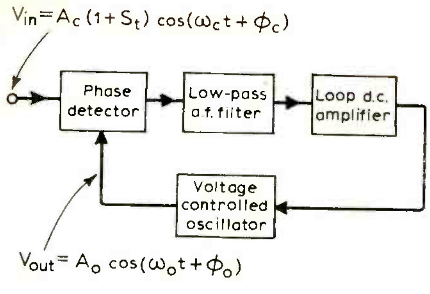
Phase-locked-loop alternative to the superhet

The difficulty of microminiaturizing frequency selective circuits has shown the lack of adaptability of the conventional superheterodyne system to an integrated radio receiver, particularly in the lower frequency bands. Because of this, designers are exploring systems that do not call for such fixed-tuned frequency selective circuits.

One area where there is much activity is the p.l.l. (phase locked loop) receiver. This has been around as an idea since the early 1930s, when H. de Bellescize published an article on 'La Reception Synchrone' in *e'Onde Electrique*, Vol. 11, pp. 230-240, June, 1932. Nothing came of this, but in *Electronic Engineering*, pp. 75-76, March, 1947, D. G. Tucker raised the matter again in 'The Synchrodyne'. The p.l.l. receiver also goes variously under the names of 'Homodyne', 'Synchronous Detector', 'PL' (phase locked) and 'PC' (phase coherent).

Fig. 6 (a) shows the principle of the phase locked loop. A carrier of amplitude A_c frequency f_c, and phase ϕ_c, with modulation S is applied to a phase detector which compares this input with the unmodulated output from a local oscillator of amplitude A_o, frequency f_o, phase ϕ_o. If the local oscillator frequency is adjusted to equal the carrier frequency, the phase detector gives an output proportional to the phase difference $\theta = \phi_c - \phi_o$ between the input and oscillator phases. This output is then passed through a low-pass filter and an amplifier and fed back to vary the control voltage on the local oscillator in such a way as to reduce the phase difference between the two signals. The end result is that the local oscillator phase advances or retards until it is in phase with the carrier phase. The local oscillator need not be tuned exactly to the carrier frequency for the phase locked loop to operate. There is a capture effect, in that the local oscillator need be brought only roughly to the carrier frequency and the system then pulls into frequency and phase synchronism with the carrier.

The most elementary p.l.l. receiver can consist of a voltage-controlled local oscillator, a mixer (phase detector) and an audio amplifier with the audio signal fed back to control the local oscillator. In the mixer the signal carrier is converted to a



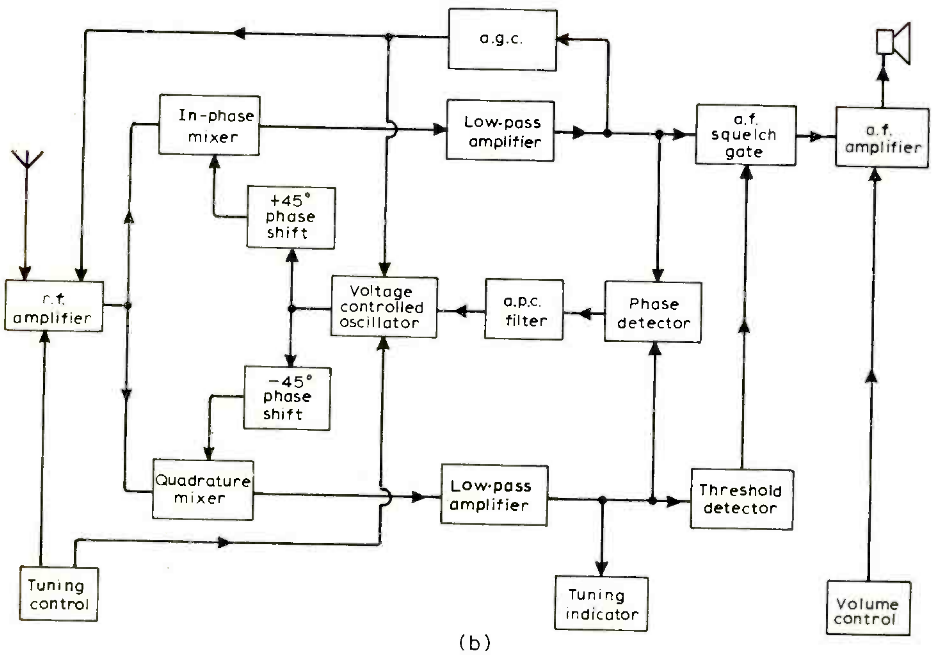


Fig. 6. The phase-locked-loop receiver alternative to the superhet; (a) basic phase-locked-loop; (b) system layout for phase-locked-loop a.m. receiver capable of implementation in microcircuit form.

zero-frequency intermediate frequency, the output from the mixer containing only demodulated information from the sidebands.

There are now indications from theoretical and experimental investigations that p.l.l. receivers are performance and cost-wise competitive with (even perhaps better than) conventional superhets. And the important thing is that the fixed-tuned *LC* bandpass circuits of the superhet are avoided.

The p.l.l. receiver has some distinctive advantages over the superhet, apart from the lack of i.f. coils. Any interference will not be synchronous with the local oscillator, so that the mixer output resulting from an interference signal will be a beat note suppressed by the audio filtering. Also there is no image response in the system because the intermediate frequency is zero. These nearly ideal selectivity characteristics and the lower possible thresholds of reception have led to the wide use of p.l.l. receivers in difficult signal environments such as reception from artificial satellites where low signal level, doppler shift and oscillator drift present problems. In the more mundane field of a.m. receivers, p.l.l. techniques have hitherto been prohibitively expensive, but now monolithics are appearing which would seem to make the p.l.l. domestic receiver a strong contender.

The National Semiconductor LM565 phase-locked-loop (although essentially a high quality professional microcircuit) is indicative of the sort of circuit that will soon become available to set designers. It contains a stable, highly linear voltage controlled oscillator and a double balanced phase detector. The v.c.o. (voltage controlled oscillator) frequency is set with an external resistor and capacitor, and a tuning range of 10:1 can be obtained with the one capacitor.

Fig. 6 (b) shows the outline of an a.m. p.l.l. receiver system that could be put together with currently available monolithic microcircuits. The r.f. input from the aerial is passed through a tunable r.f. amplifier. Unfortunately this still involves some form of inductance. The main purpose of the r.f. amplifier is to reject harmonics of the signal frequency to which the mixer might respond. The bulk of the receiver gain will still be at audio frequencies.

From the r.f. amplifier the input signal passes to the in-phase mixer (which can be a simple diode bridge) where it is mixed with the output from the v.c.o.—not directly but with a +45° phase-shift. The frequency of the v.c.o. will have been adjusted to approximately the right value from the tuning control. The in-phase mixer acts as a phase (and frequency) detector. The output then passes through the low pass amplifier and back via the second phase detector, the a.p.c. (automatic phase control) filter to lock the v.c.o. to the frequency and phase of the r.f. input.

The output from the r.f. amplifier is also fed into the quadrature mixer where it is mixed with a −45° phase shifted output from the v.c.o. Through the second loop amplifier and the path phase detector-a.p.c. filter it also helps to lock the v.c.o. on signal. The quadrature signal channel can be used to drive a visual tuning indicator.

A difficulty with p.l.l. receivers is that an annoying beat note 'heterodyne whistle' is heard as the receiver is tuned between stations. This can be eliminated by a threshold detector and a.f. squelch gate. When the receiver is off-tune, there is a significant output from the quadrature channel which activates the threshold detector and holds the squelch gate closed thus suppressing audio output. On tune, the quadrature channel output falls to virtually zero, the squelch gate is opened and audio output passes to the a.f. amp and the louspeaker.

Finally, an a.g.c. signal is taken from the in-phase channel via the a.g.c. amplifier to control the gain levels of both the r.f. amplifier and the local oscillator.

You can find a fuller discussion of the p.l.l. receiver described above in L.P. Chu 'A phase-locked a.m. radio receiver' in *Trans. I.E.E.E.* Vol. BTR 15, No. 3, pp 300-308, Oct, 1969. For the whole subject of phase-locked-loops an excellent standard reference is 'Phaselock Techniques' by F.M. Gardner, John Wiley and Sons, 1966.

(to be continued)

Conferences and Exhibitions

Further details are obtainable from the addresses in parentheses

OVERSEAS

Aug. 11-13 St. Louis
Automatic Control
(I.E.E.E., 345 E. 47th St., New York, N.Y. 10017)

Aug. 16-20 Jerusalem
Impact of Computers on Developing Nations
(Jerusalem Conf. on Information Technology, 75 Grosvenor St., London W1X 0DT)

Aug. 17-19 Ithaca
H.F. Generation and Amplification
(Prof. L. Eastman, Cornell School of E. Eng., Phillips Hall, Ithaca, N.Y. 14850)

Aug. 18-26 Budapest
Acoustics Congress

Aug. 23-28 Stockholm
Microwave Conference
(Dr. H. Steyskal, Fack 23, 104 50, Stockholm 80)

Aug. 24-27 San Francisco
Western Electronic Show & Convention
(WESCON, 3600 Wilshire Blvd, Los Angeles, Calif. 90005)

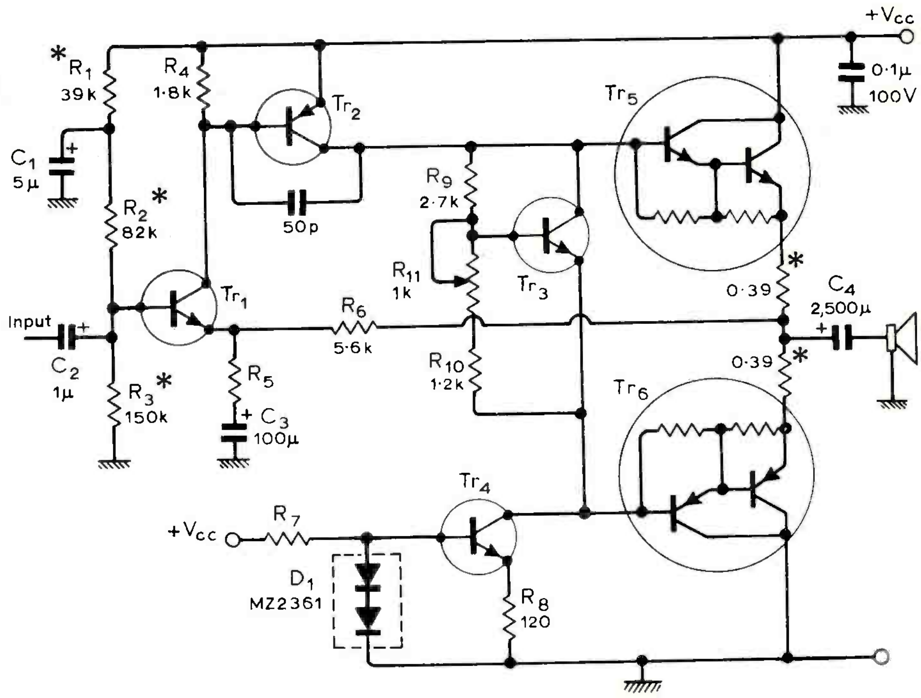
Aug. 25-27 Washington
Geoscience Electronics
(I.E.E.E., 345 E. 47th St., New York, N.Y. 10017)

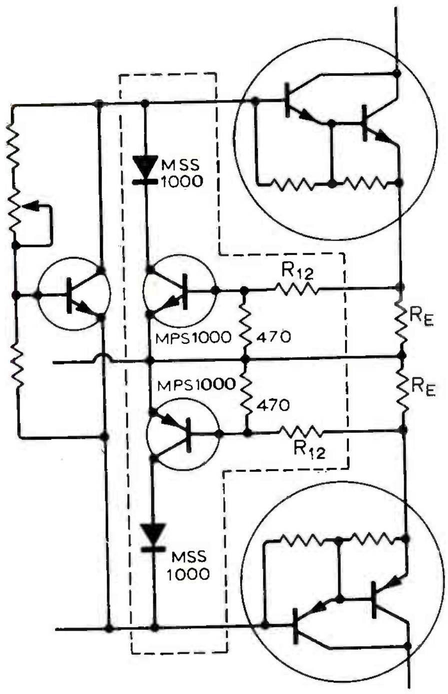
Aug. 27-Sept. 5 Berlin
International Radio & TV Show
(A.M.K., Messedamm 22, 1 Berlin 19)

Complementary Darlington Output Transistors in Audio Amplifiers

Product application note

Circuit shown right is designed around integrated Darlington power transistors, made by Motorola. With these, external bias components are not needed and their high gains limit the gain and power dissipation requirements of driver transistors, thus simplifying amplifier designs. Design is suitable for power outputs from 15 to 60W working into a loudspeaker of 4 or 8Ω—see table. This and a direct-coupled version are contained in Motorola application note AN-483A.





Circuit gives harmonic distortion of less than 0.2% at rated output from 50Hz to 20kHz and 0.1% at 100mW output from 200Hz to 20kHz, rising to 0.25% at 20Hz for both power levels. Intermodulation distortion is 0.2% at half power with 1kHz and 10kHz signals in 4:1 ratio. Resistor R_{11} sets bias current—20mA—to minimize cross-over distortion. As an alternative to bootstrapping, Tr_5 base is connected to a constant-current source—Tr_4 and diodes D_1. (Resistors marked with an asterisk should be 5% tolerance, others 10%.)

Several short-circuit protection techniques can be used. The short-term one shown (left) allows a short-circuit to be driven for a few minutes—average power dissipation increasing by four times—using heat dissipators with thermal resistance specified in the table and at 25° C ambient temperature.

Components for 15 to 60 watt amplifier not specified in circuit

Rated power W	load Z Ω	R_{12} Ω	V_{cc} Ω	R_5 Ω	R_7 kΩ	$Tr_{1,4}$	Tr_2	Tr_3	Tr_5	Tr_6	C_1 rating V	$C_{2,3}$ rating V	C_4 rating V	heat sink†
15	4	330	32	620	33	MPSA05	MPSA55	MPSU01	MJE1100	MJE1090	35	20	40	9.5
	8	150	38	510	39	MPSA05	MPSA55	MPSU01	MJE1100	MJE1090	40	25	45	9.5
20	4	470	36	560	39	MPSA05	MPSA55	MPSU01	MJE1100	MJE1090	40	25	45	7.0
	8	180	46	470	47	MPSA05	MPSA55	MPSU01	MJE1100	MJE1090	50	30	55	7.0
25	4	510	38	560	39	MPSA05	MPSA55	MPSU01	MJE1102	MJE1092	40	25	45	5.0
	8	220	48	390	47	MPSA05	MPSA55	MPSU01	MJE1100	MJE1090	50	30	55	5.0
35	4	750	44	470	47	MPSA05	MPSA55	MJE520	MJ3000	MJ2500	45	25	50	6.0
	8	390	56	330	56	MPSA06	MPSA56	MPSU01	MJ1001	MJ901	60	35	65	5.5
50	4	910	50	390	47	MPSA05	MPSA55	MJE520	MJ3000	MJ2500	50	30	60	4.0
	8	560	65	270	68	MPSA06	MPSA56	MJE520	MJ3001	MJ2501	65	35	75	4.0
60	4	lk	56	330	56	MPSA06	MPSA56	MJE520	MJ3001	MJ2501	60	35	65	3.0
	8	620	72	220	68	MPSA06	MPSA56	MJE520	MJ3001	MJ2501	75	40	80	3.0

†Maximum thermal resistance in deg.C/watt at 55°C ambient temperature and 10%-high supply voltage. Heat sink area can be found from J. Johnstone's nomograph on p.22 of January 1971 issue (instruction 5).

Automatic Titration Potentiometer

by D. R. Bowman, M.I.E.R.E.

The instrument described employs dual-gate m.o.s.f.e.ts and was originally intended to monitor a chemical process known as titration. However the measuring circuit can be used for other applications in which an electrometer is required.

A measuring circuit was required that would link the output of a very high internal impedance probe with an indicating apparatus such as a chart recorder. The probe in question had an internal impedance in the kilo-megohm region and an output of between 100 and 400mV. One of the various thermionic electrometer valves available would have performed well but with the disadvantage of requiring h.t. and l.t. power supplies. Investigation of the various semiconductor amplifying devices available revealed that only the m.o.s.f.e.t. approached the input resistance requirement. Previous experience with these transistors has taught the author to be wary, for although the gate-to-source breakdown rating may be 20 or 30V the high inherent resistance inevitably means that even the smallest charge cannot leak away and is liable to accumulate until the gate insulation is destroyed.

A number of transistor manufacturers being alive to this problem have introduced devices with zener diodes internally connected across the gate electrode. The diodes exhibit a very high shunt resistance until the potential across them exceeds about ±6V. At this potential their resistance drops to a low value and so protects the transistor's gate insulation.

The basic circuit, which is shown in Fig. 1, is a differential amplifier. The d.c. level drift with temperature, an always present problem in electrometer amplifiers, is not so serious here because the drifts in the two transistors are in opposition and therefore tend to cancel each other.

To maintain the maximum input resistance a gate leak resistor has not been included, however, the probe's series resistance provides an earth return for the gate electrode. The first device operates as a source follower, the inherent negative feedback tending to maintain the high input resistance. The second stage is connected as a common gate amplifier. The overall power gain provided by the amplifier is of the order of 70dB.

The second gate electrodes of the cascade devices are connected together and biased to about 0.6 of the drain potential. The two source electrodes are taken via a potentiometer to earth. This couple is adjusted for minimum thermal drift. The output potentiometer alters the gain slightly, but is primarily intended for setting the output to zero when there is no no input signal. The exact amplitude of the output signal is unimportant when the instrument is used in titration so this deficiency has not proved to be a great disadvantage. No attempt has been made to match the m.o.s.ts and yet the temperature stability has proved to be adequate.

Two transistor types are suitable, the 40673 and the 3N187. Of these the 40673 seems to be the best choice; it is identical in performance with the 3N187, but is considerably cheaper.

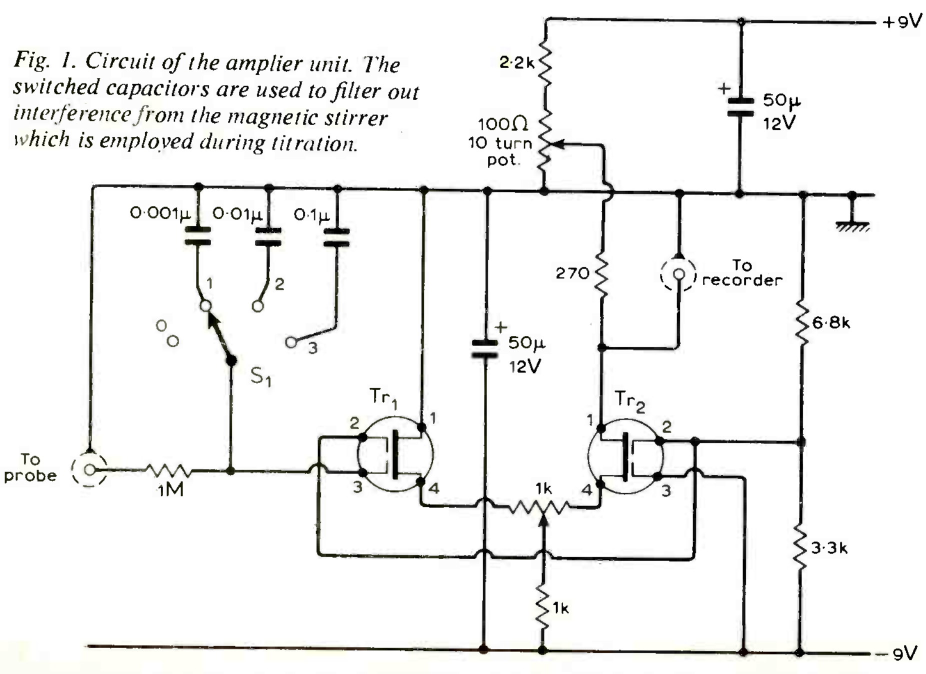


Fig. 1. Circuit of the amplier unit. The switched capacitors are used to filter out interference from the magnetic stirrer which is employed during titration.

Power supply

The circuit shown in Fig. 2 exhibits a very low output ripple together with automatic overload protection. As the series regulating transistor is capable of supplying at least 200mA other auxiliary equipment can be connected to the supply if required. In the diagram an unearthed 9V unit is shown whose polarity can be altered by earthing either the positive lead to produce –9V or the negative lead for +9V. This instrument requires two such supplies, one of each polarity. The mains transformer used is a Radiospares miniature type with two 12V secondaries, but any other transformer with two independent secondaries will do as the current requirement is only 10mA. The two power supply circuits should be adjusted to provide about 9V.

The setting up of the amplifier is extremely simple; the only point needing description being the minimum thermal drift adjustment. The dual gate m.o.s.ts are mounted in an electrically insulated dual heat sink. A hot soldering iron should be brought into thermal contact with this heat sink and the potentiometer adjusted

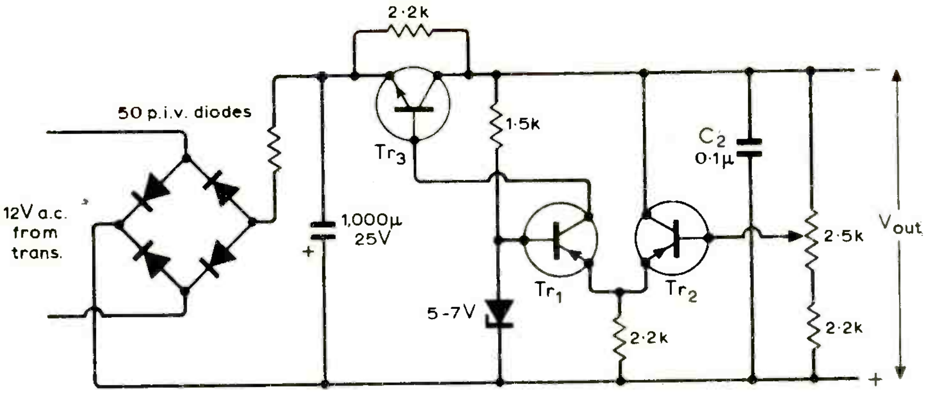


Fig. 2. Power supply circuit. Two of these are required.

for minimum drift as shown by the recorder. The gain potentiometer should be used to set the amplifier for zero signal out with the input short circuited.

Titration

Many quantitative chemical analyses are made by adding measured amounts of acid to the unknown alkali solution until the two cancel one another out to leave a neutral solution. The stage at which balance occurs, the end-point, has to be determined very accurately and is normally done using one of the coloured chemical indicators of which Litmus is an example.

If two electrodes are dipped into the solution during the titration process the voltage across these electrodes will change as the solution goes through the neutral point. It was to detect this change that this instrument was designed.

The probe employed was a 'Silver billet combination electrode' (Cat. No. 39187). During the titration process the mixture was stirred using a magnetic stirrer and a piston burette was used to add one liquid to the other. The piston burette is driven by a motor and adds liquid at an accurately known rate. As this motor is synchronous the chart recorder and the piston burettes will automatically keep in step.

The titration probe and amplifier tend to be sensitive to noise generated by the magnetic stirring system and for this reason a switched filter has been included in the input circuit of the amplifier. This filter should be used with care, only enough smoothing being used to reduce the noise or the response of the whole system may become excessively damped. Fig. 3 shows a basic differentiating circuit which if applied to the output of the amplifier and used in turn to drive the recorder makes the titration end point on the graph more easy to discern. With this simple circuit it will be necessary to increase the sensitivity of the chart recorder.

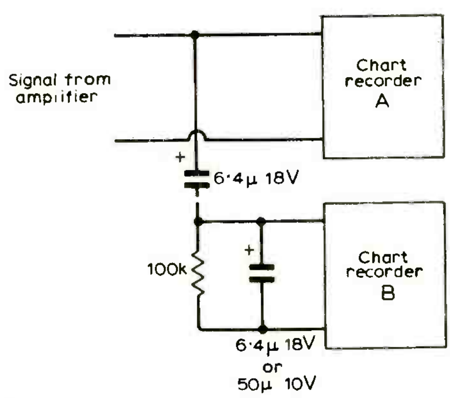


Fig. 3. Chart recorder A is set for 50mV f.s.d. and is the potentiometric titration recorder. Chart recorder B is set for 5mV f.s.d. and is the differential potentiometric titration recorder.

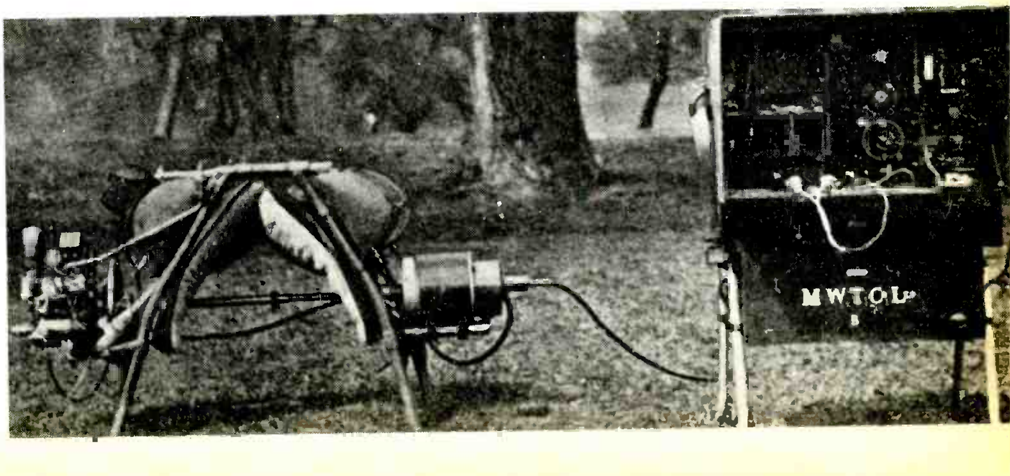
Sixty Years Ago

August 1911. Two reports in this issue were concerned with mobile communications. An article 'Wireless Telegraphy and Aeroplanes' described an experimental installation as follows:

"In a lecture before the Royal Institution, Mr. T. Thorne Baker passed in review some of the work already accomplished in the application of wireless telegraphy to aerial navigation and referred to some satisfactory results obtained by Mr. Farman by using two trailing aerials, each consisting of rather thin wire about one hundred metres in length. Those experiments were carried out some time after Mr. Baker had adapted a similar arrangement to a Bristol biplane in this country. In the latter case no loose wires were used, and thus he had been limited to the amount of aerial that could be attached to the machine itself—about 50 ft. Instead, however, of using balanced aerials, he coupled them to each end of an inductance coil, and increased their effective length to the greatest extent possible without sacrificing efficiency. In the latest form of the apparatus he was using a 6-in. induction coil with a $\frac{5}{8}$-in. spark gap, fixed at a considerable distance from the apparatus, so as to be away from the petrol tank. Two light brass rods extended from the coil well into the space between the two main planes of the machine, and to one side of the tank, and two $\frac{3}{8}$-in. brass rods sliding over these and $\frac{5}{8}$-in. apart formed the spark gap terminals. Shunted across the spark gap was a condenser of the Leyden jar type, and an inductance coil consisting of seven turns of No. 14 copper wire wound on a light ebonite drum. This inductance had sliding contacts so that the number of turns used could be varied in the usual manner, in order to tune the two circuits. The two aerial wires were connected to the two ends of the inductance in use, and the aerial circuit was brought into tune with the shunt circuit. A secondary battery of eight or ten volts supplied the primary energy, about 50 or 60 watts being required.

"Two new arrangements have since been adopted, which should greatly enhance the efficiency of the plant. The chief of these is a long light brass tube attached to, but insulated from, one side of the tail of the aeroplane. This acts as a counter capacity, or 'earth', to a long aerial wire on the other side. This aerial starts from the nose of the machine, is carried thence to the extreme outer edge of the main plane, thence back to the tail, and thence to a loose extension, a length of 60 ft. of copper wire trailing behind."

Coming down to earth, another article, 'At the Royal Investiture', described how two Marconi portable wireless telegraph sets were used at the Investiture at Carnarvon of the Prince of Wales. These particular sets were normally employed by the Cumberland Yeomanry and as can be seen from the photograph, consisted of a motor generator and the wireless set itself. It is pictures like this which emphasize the tremendous advances that have taken place in just sixty years.



World of Amateur Radio

Morse outmoded?

Since the earliest days of amateur radio, the imminent demise of c.w. operation has been regularly forecast—yet dits and dahs still retain the interest of many amateur operators and account for a significant proportion of all activity. But c.w. has its critics. The notes in this column in May on the possible effects of the proposed F.C.C. changes to U.S. phone allocations brought a strongly contrary opinion from Dr John Irwin, (K6SE/5), of Louisiana State University. He feels that my notes showed a "negative attitude" towards "the switch from c.w. to s.s.b." This, he suggests, is happening all over the world and should be encouraged. "Phone is so much more efficient and interesting and satisfying than code that I have not used c.w. at all for the past two years", he writes. In that time he has worked over 900 different Japanese amateurs on s.s.b., many of them using less than 20 watts. "These Japanese are forced to use and speak English and I think this is a great thing for international fellowship and understanding, and they deserve to be commended for overcoming the severe language barrier. I only wish more Russians used s.s.b. . . . It is a complete misconception to believe that non-U.S.A. amateurs cannot work, do not want to work and do not work in the U.S. phone bands. . . . Widening U.S. phone bands will thin out the interference, benefiting all amateurs, the world over. . . . Single-sideband equipment is now so satisfactory, so potent and so cheap that the present trend from code to voice cannot help but continue; and I'm all for it", he stresses.

Those of us who continue to believe there should be a future for c.w. will disagree with several of Dr Irwin's arguments, but must respect his right to express them—the more so since it now seems pretty certain that there *will* be an extension of the U.S. phone allocations. But two amateurs chatting on s.s.b. occupy as much frequency space as perhaps 30 or 40 would need for c.w. Where frequencies are under extreme pressure (e.g. 7 and 14 MHz), surely narrow-band c.w. should be given reasonable priority? On other bands, the decision to opt for c.w. or phone is rightly one for individual amateurs to make.

It is worth noting that c.w. users retain an above average interest in the hobby. A breakdown of 100 British stations worked from G3VA on c.w. (3.5, 7 and 14 MHz) in recent months showed that about 25% had been licensed during the past 5 years; about 13% from 5 to 10 years; 16% from 10 to 20 years; 18% from 20 to 25 years; and 28% over 30 years!

Beyond question s.s.b. is effective—but, because of the peaky nature and wide bandwidth of voice waveforms, c.w. of equivalent power is still a far more effective means of communication, provided that appropriate narrow-band filters are used in the receiver. Essential information can be passed as quickly, and more accurately. So most of us want to see both modes continuing in general use.

Amateur finds radio "bug"

The recent disclosure, as the result of an Old Bailey trial, that W. H. Borland (G3EFS) of Bromley, Kent, had been responsible for first discovering and then tracking down illegal "bugging" equipment installed about half-a-mile from his home, highlights the continued interest in amateur direction-finding. For almost 20 years, each summer, a series of D/F hunts is organized, culminating in the annual R.S.G.B. National Final. The contests usually take the form of hunting down, over distances up to ten miles, in the course of a single afternoon, two concealed 1.8 MHz transmitters.

Space communications and amateurs

Amateurs who have been following the progress of the I.T.U. World Administrative Radio Conference on Space Matters in Geneva are concerned at the long-term implications of the extremely strong pressure for microwave frequencies for all forms of space communications. No longer are there any "unwanted" frequencies in this part of the radio spectrum. Amateurs have been disappointed at the apparent lack of liaison between the national amateur radio societies of a number of European countries and their official delegations, who often appear to be virtually unaware of the amateur service. While it is still expected that some extensions will be granted to amateur space facilities (at present confined to 144 MHz), a number of proposals, supported by the official U.K. delegation, are unlikely to be approved. The position taken up by the delegations from such countries as France, Norway, Sweden and the U.S.S.R. is contrasted with that of the U.K. where Minpostel invited the R.S.G.B. to nominate a member of its Council (Roy Stevens, G2BVN) to attend the meetings as an official adviser to the U.K. delegation.

V.H.F. activities

Several notable tropospheric and sporadic E "openings" were noted during June. TF3VHF, the 70 MHz beacon station in Iceland, was heard in the U.K. on several days. In just over two hours on June 13th, 9H1BL (Malta) worked 13 British stations cross-band 70/28 MHz (70 MHz is not available in Malta). In a long series of observations on the London 70 cm beacon GB3GEC, two Dutch amateurs, PA0VZL and PA0GDV, have been hearing the station consistently, almost regardless of band conditions. A recent 144 MHz portable contest was won by G. W. Tibbetts, GW3NUE/P, who made 331 contacts. Peter Blair, G3LTF, has resumed 1296 MHz "moonbounce" contacts with W2NFA.

In brief

The R.S.G.B. National Mobile Rally is at Woburn Abbey on Sunday, August 8th with talk-in stations GB2VHF, G3VHF and GB3RS on 14, 70 and 144 MHz. Events will include a trade exhibition, demonstrations of amateur TV, bring-and-buy sale, etc. . . . A special station, GB3ESP, will be operated by members of the International League of Esperantist Radio Amateurs during the 56th Universal Esperanto Congress in London from July 31st to August 7th. . . . F.C.C. regional offices in America have been asking a number of "Technician" licensees to submit to re-examination; about half turn in their licences without trying. . . . F.C.C. have issued a Notice of Inquiry seeking to determine what improvement *(including TV receiver design)* could be made to achieve interference-free TV reception; the American Consumers Union intends to report more fully on the susceptibility of TV and hi-fi gear to interference from h.f. transmitters. . . . An American amateur, W0WYX, has his home station located at a height of 11,500 ft on Squaw Mountain, Colorado. . . . Increased subscriptions and the aftermath of the postal strike appear to have hit severely recruitment of new R.S.G.B. members; in the three months March to May only 165 new members were elected compared with 545 in the same period in 1970.

PAT HAWKER, G3VA

Personalities

T. A. Duerden, B.Sc., Ph.D., who joined Plessey as manufacturing facilities planning executive just over a year ago, has been appointed general manager (Pentex). Dr. Duerden, who will be primarily responsible for the Pentex electronic telephone exchange business, will be based at the Group's Beeston, Nottingham, factory. A graduate of Manchester University, where he read physics and later received his doctorate, he was head of management services at the Preston Division of British Aircraft Corporation prior to joining Plessey.

G. C. F. Whitaker, F.I.E.E., F.I.E.R.E., who was for two years on the staff of Yorkshire Television as senior planning engineer followed by a further two years as engineering consultant, has retired. Mr. Whitaker, who is 66, was educated at the Royal Naval Colleges Osborne and Dartmouth. He retired from the Navy in 1928. Re-joining the Navy at the outbreak of war, he was, initially engaged on global, long-range h.f. direction finding, followed by a period in the Radio Physics Laboratory of the University of Sydney, where he studied radio location. At the close of hostilities he was re-instated on the Active List and after appointments in the Department of Naval Ordnance and, on two occasions as deputy superintendent of the Admiralty Signals and Radar Establishment, he was promoted to the rank of Captain. His final Naval appointment was on loan to the Australian Commonwealth Government as director of electrical engineering in the Department of The Navy, Melbourne, Victoria. Retiring in 1959, he was employed by Central Rediffusion Services Ltd, and from 1960 to 1967 was chief engineer of Rediffusion television operating the London weekday contract of the I.T.A.

Derek Stanners is appointed U.K. sales manager of Racal Instruments Ltd, of Windsor. Previously on the board of the B & K Group, with overall marketing control of their instrumentation products company, Mr. Stanners has also worked for the Plessey Group at Northampton. He is an enthusiastic radio amateur. His call sign is G3HEJ.

John R. Brinkley, F.I.E.R.E., A.M.I.E.E., international manager of mobile radio for the I. T. & T. Corporation since 1969, has joined Redifon Ltd as an executive director of the company. The Communications and Marine Division of Redifon is to be formed into a subsidiary company and it is intended that Mr. Brinkley should

John R. Brinkley

be its managing director. Mr. Brinkley received his early training with the Post Office. He transferred to the Home Office Communications Directorate in 1942 and six years later joined Pye. He was managing director of Pye Telecommunications Ltd from 1956 until 1966 when he joined Standard Telephones and Cables where he was executive director until his transfer to I.T.T., the parent company.

Air Chief Marshal Sir Donald Evans, K.B.E., C.B., D.F.C., R.A.F. (Ret'd), has joined Ferranti Ltd in Edinburgh, as a consultant on military aviation matters but will be based at Ferranti's London Office, Millbank Tower, S.W.1. Air Chief Marshal Evans, who is 59, commanded a night fighter trials unit during the war and later the Royal Radar Establishment's Flying Unit. His Air Force service included his appointment as Air Officer Commanding-in-Chief, Technical Training Command (1964-66); as Air Secretary (1966-67); and as Commandant of the Imperial Defence College (1968-69).

C. J. Kent has joined A.P.T. Electronic Industries Ltd, of Byfleet, Surrey, as sales manager. Mr. Kent joins the company from Advance Electronics Ltd where he was employed for four years as senior sales engineer. He served his apprenticeship with A.E.I. at Trafford Park, Manchester.

J. E. Everitt, M.A., M.I.E.E., joins the board of Rank Bush Murphy Ltd in the newly created post of director of overseas operations. Mr. Everitt, who is 35 and took his degree in mechanical sciences at Cambridge, joins Rank Bush Murphy from Ultra Electronic Holdings Ltd, of which he was marketing director.

G. Boris Townsend, B.Sc., Ph.D., F.I.E.E., F.Inst.P., for the past six years head of engineering research at Thames Television, has joined the I.T.A. as deputy head of the Engineering Information Service. Dr. Townsend, a graduate of King's College, London, began his career at the General Electric Company where he worked on the development of colour television receivers. He is co-author with P. S. Carnt of the two volumes on colour television published by Butterworth and received his doctorate from London University for a thesis on colour television. In 1963 he joined Rank Cintel as technical manager of the Professional Television Equipment Division. Dr. Townsend was president of the British Amateur Television Club from 1960 to 1965.

A. R. Wilkinson, M.A., M.I.E.E., has been appointed technical director of Radiatron Ltd and Radiatron Components Ltd, of Twickenham, Middx. He will be chiefly engaged on development work and market research. Mr. Wilkinson was formerly principal test equipment engineer with G.E.C. at Aycliffe, Co. Durham.

Ates Electronics Ltd have announced the appointment of **Howard Prescott,** who will have responsibilities for product marketing and technical liaison on the company's application circuits. Mr. Prescott, started his career with Ultra Electronics Ltd as a student apprentice, and moved to R & D before joining Air-Tech Ltd as projects engineer. Immediately prior to joining Ates, he was applications engineer with S.G.S. Ltd, where he specialized in linear i.cs.

C. Rhodes Oliver, B.Sc., M.I.E.R.E., has joined Semiconductor Production Equipment Co. Ltd, of West Byfleet, Surrey, as technical director. He will be responsible for all technical aspects and development of the Centronic product range which includes diffusion furnaces, laminar flow cabinets, profilers, semiconductor ovens and lighting intensity controllers. After the Second World War, which was spent in the New Zealand Air Force working on radar and navigational aids, Mr. Oliver was with Pye Radio and Newmarket Transistors for several years before joining Standard Telephones & Cables in 1958. This was followed by a period with A.E.I., Brimsdown, as development manager and with R.C.A. at Catania, Sicily.

BIRTHDAY HONOURS

Few men in the world of electronics were included in the Queen's Birthday Honours List. Among those receiving honours are:

Knights Bachelor

John Allen Clark, Companion I.E.E., chairman & chief executive, Plessey.

John Henry Davis, chairman and chief executive, Rank Organisation.

C.B.E.

H. Barker, director, network planning, Post Office Telecommunications.

Rear Admiral B. J. Castles, F.I.E.R.E., R. Australian Navy.

H. W. French, chief inspector, Dept. of Education & Science.

L. S. Yoxall, chairman, Foxboro-Yoxall Co.

O.B.E.

R. E. Burnett, M.A., F.I.E.E., managing director, Marconi Instruments.

R. W. P. Cockburn, controller (admin.) external broadcasting, B.B.C.

W. Nethercot, chairman, Min. Posts & Telecoms advisory technical sub-committee on wireless interference from industrial apparatus.

L. A. Samson, sales & service director, Guided Weapons Div., Brit. Aircrafts Corp.

Wing Commander W. E. Satterthwaite, M.I.E.R.E., R.A.F.

M.B.E.

H. Ledger, senior engineer, Plessey Telecommunications Ltd, Beeston.

M. R. Neville for services to the Electrical & Electronics Industries Benevolent Assoc.

H. J. Plater, asst. manager, studio operations, B.B.C. Television.

OBITUARY

Lord Reith, under whose guidance broadcasting was started in this country in 1922 by the British Broadcasting Company, of which he was general manager, died in Edinburgh on June 16th. He was 81. John Charles Walsham Reith, a mechanical engineer by profession, became the first director-general of the B.B.C. when in 1927 it became a public corporation. Although he resigned from the B.B.C. in 1938 he has left his mark indelibly on British broadcasting.

Literature Received

For further information on any item include the appropriate WW number on the reader reply card

ACTIVE DEVICES

A new c.r.t. brochure has been produced by Brimar, Thorn Radio Valves and Tubes Ltd, 7 Soho Square, London W1V 6DE. Its 34 pages cover all of the Brimar range of 238 types, not counting 'specials'. The sections are printed in English, French, German, Spanish and Italian. As well as details on the various types of phosphors and an equivalents list, a list is given of obsolete tubes, including those not made by Brimar. WW401

A catalogue produced by The National Semiconductor Corp., 2900 Semiconductor Drive, Santa Clara, California 95051, U.S.A., lists, and gives details of, all the low-power transistor-transistor logic, integrated circuits manufactured by the company WW402

Data on germanium and silicon transistors, thyristors, and integrated circuits is given in a new catalogue, which also includes application information, published by Ates Electronics Ltd, Mercury House, Park Royal, London W.5. .... WW403

We have received the following literature from Hewlett Packard Ltd., 224 Bath Rd, Slough SL1 4DS:

'Optoelectronics catalogue'. Gives details of a number of solid-state displays using 5 × 7 dot, and 7-segment formats. The catalogue also includes light-emitting and photo diodes and gives details of a digital panel meter WW404

Separate data sheets give additional information including circuitry:

4 × 7 dot array WW405
7-segment display WW406
A leaflet gives details of a range of hot carrier diodes which may be obtained for £4.65 complete with data WW447
Diode and microwave product catalogue . WW407
Solid-state devices and components price list WW408

'Large scale integration (l.s.i.) products guide,' produced by the Intel Corp., 365 Middlefield Rd, Mountain View, California 94040, U.S.A., lists m.o.s. and bipolar random access memories, read-only memories, shift registers, decoders, drivers, level shifters, gates and latches. One of the read-only memories is a 2,048-bit electrically programmed type WW409

Erie Electronics Ltd, of South Denes, Great Yarmouth, Norfolk, now distribute semiconductor devices manufactured in Japan by Toshiba. Erie have the following literature available:

TH9013P. 20W amplifier hybrid i.c. ... WW410
TA7055P Pre-amplifier i.c. Literature describes the use of this i.c. in several applications and it may be used to drive the 20W power amplifier mentioned above WW411
Toshiba semiconductor catalogue including germanium and silicon transistors and diodes and various other semiconductor devices ... WW448

Transitron Electronics Ltd, Gardner Rd, Maidenhead, Berks, have produced a catalogue called 'Transitron Rangefinder' which is a short-form guide to the semiconductor products manufactured by the company WW412

We have received a 'Medium scale integration (m.s.i.) product guide' from GEC Semiconductors Ltd, Witham, Essex WW413

A 14-page catalogue of silicon rectifiers manufactured by the Semtech Corp., is available from Bourns (Trimpot) Ltd, Hodford House, 17/27 High St, Hounslow, Middx. WW414

Over voltage protection units in hybrid thick-film microcircuit form are the subject of a leaflet available from Coutant Electronics Ltd, 3 Trafford Rd, Reading RG1 8JR WW415

PASSIVE COMPONENTS

East Grinstead Electronic Components Ltd, Imberhorn Industrial Estate, East Grinstead, Sussex, have available a massive catalogue devoted entirely to potentiometers manufactured by Radiohm. Various types are included: presets, slider, wirewound etc. Some have switches WW416

Mecanorma Electronic, a French company, produce a range of printed circuit drafting aids. The range, which is being marketed in this country by the D.T.V. Group Ltd, 126 Hamilton Rd, West Norwood, London S.E.27, is described in a catalogue WW417

The r.f. components division of Sealectro Ltd, Farlington, Portsmouth, Hants., has produced an updated version of the 'Conhex r.f. connector catalogue'. It incorporates a new section covering a series of microminiature connectors called 'Nanohex'. WW418

Playback and record heads manufactured in Germany by Woelke Magnetbandtechnik are described in a catalogue available from Lennard Development Ltd, Lockfield Ave, Brimsdown, Enfield, Middx. . WW419

Banbury Products, 84/85 Bancroft, Hitchin, Herts., have produced a catalogue which lists aluminium, battery clips, boxes, brackets, nuts and screws, cable accessories, clips, and many other items of electronics hardware, including such things as plugs, sockets and knobs WW420

A Japanese company, called Toyo Musen Co. Ltd, manufacture multicolour miniature indicator gas discharge lamps, indicator tubes and a range of small moving-coil meters. Toyo Musen's distributors in this country are Ataka & Co Ltd, Roman House, Wood St, London EC2Y 5BS, who have a catalogue available WW421

A range of hermetically sealed nickel-cadmium accumulators are the subject of a catalogue from Deac (Great Britain) Ltd, Hermitage Street, Crewkerne, Somerset. WW422

Bulletin 111A from Berg Electronic Inc., York Expressway, New Cumberland, Pa. 17070, U.S.A., describes an interconnection system consisting of crimp-to-wire connectors, wire wrapping posts and multiple contact housings for various spacingsWW423

APPLICATION NOTES

Investigation report No L141 produced by the application laboratories of Thorn Radio Valves and Tubes Ltd, Brimsdown, Enfield, Middx, describes an oscilloscope circuit built round the Brimar 100 × 80mm rectangular cathode-ray tube type D14-170GH. All the circuitry and comprehensive component lists are included. Layout information is not given WW424

A company called VG Micromass, Nat Lane, Winsford, Cheshire, have produced a publication, which is known as 01.642, giving a simple explanation of the basis of mass spectrometry WW425

Microsystems International Ltd, 1 Great Cumberland Place, London WIH 7AL, have produced a booklet called 'The operational amplifier as a relaxation oscillator'. WW426

ITT Components Group Europe, Standard Telephone and Cables Ltd, Thermistors Division, Edinburgh Way, Harlow, Essex, have produced the following application notes:

1559A/71. 'Thermistors' by V.H.R. Hole. WW429
1159A/71. 'A 0 to 50°C electronic thermometer'. WW430
1359A/71. 'Projector lamp surge suppression' WW431

EQUIPMENT

We have received the following two wall charts from GDS Sales Ltd, Michaelmas House, Slough, Bucks:

3. 'Plessey Potentiometers' WW427
6. 'I.C. Test Clips', also includes two i.c. breadboards. WW428

The 'Transipack logic trainer' is the subject of a leaflet from Industrial Instrument Ltd, Stanely Rd, Bromley, Kent. WW432

Another logic trainer 'Compukit 2' is the subject of a leaflet from Limrose Electronics, Lymm, Cheshire. WW433

An interesting educational item from Feedback Instrument Ltd, Park Rd, Crowborough, Sussex, is the subject of leaflet No. D327. The equipment is a process control simulator which may be used to simulate a large number of different industrial process control situations. WW434

A wall chart has been produced in English, French and German describing the large number of loudspeakers which are manufactured by Rola Celestion Ltd, Ditton Works, Foxhall Road, Ipswich, Suffolk IP3 8JP. WW436

Digital panel meters manufactured by Daystrom Schlumberger are the subject of a leaflet which may be obtained from Daystrom Industrial Products, Bristol Rd, Glos. G12 1BR. WW437

A leaflet describing a range of modular power units with outputs from 2 × 15V to 5V at currents between 1 and 10A is issued by Fenlow Electronics Ltd, Whittets Eyot, Jessamy Rd, Weybridge, Surrey WW438

P. W. Allen & Co, 253 Liverpool Rd, London N1 1NA, manufacture optical magnifiers, some with illumination, for use in inspecting electronic circuitry. The range is described in a leaflet. WW439

We have received a leaflet which describes a machine for testing bond strength of i.c. leads. Precima Ltd, 7-8 Stepfield, Witham, Essex WW440

Voltmeters, counters, data amplifiers and frequency synthesizers are all described in a new 12-page short-form catalogue which has been produced by Dana Electronics Ltd, Bilton Way, Dallow Road, Luton, Beds. WW441

Various power supplies and voltage reference sources, some of which are encapsulated, encapsualted pulse generators, an oscilloscope, digital voltmeter, phase angle meter, and various other digital meters are featured in a catalogue available from Roband Electronics Ltd, Charlwood Works, Charlwood, Horley, Surrey. WW442

We have received three catalogues from Marconi Communication Systems Ltd, Specialized Components Division, Chelmsford, Essex. These are:

SP219. 'Quartz crystal oscillators, ovens and filters' WW443
SP223. 'Microwave devices' WW444
SP189. 'Quartz crystals' WW445

GENERAL INFORMATION

A leaflet is available from the Mullard Educational Service, Mullard House, Torrington Place, London WC1E 7HD, which lists the publications and films available. WW446

New from Ferrograph

For the maintenance of professional recording equipment.

Now, for the first time, all the major parameters of a magnetic recording system can be measured on a single, inexpensive instrument. The Ferrograph RTS1 Recorder Test Set.

Consisting of 4 basic sections—variable frequency audio generator, millivoltmeter with associated attenuator, peak-to-peak wow and flutter meter, and distortion measuring network—this instrument will measure frequency response, distortion, crosstalk, erasure, input sensitivity, output power and signal/noise ratio.

Completely solid state and lightweight, it may be used in the field as well as the laboratory, operating on voltages of 100-120, 200-250 volts at 50 or 60 hz.

It is developed specially for those people who have to operate, maintain or service all types of tape recorders, sound-on-film equipment and audio apparatus.

The Ferrograph RTS1.
Made to stand the test.
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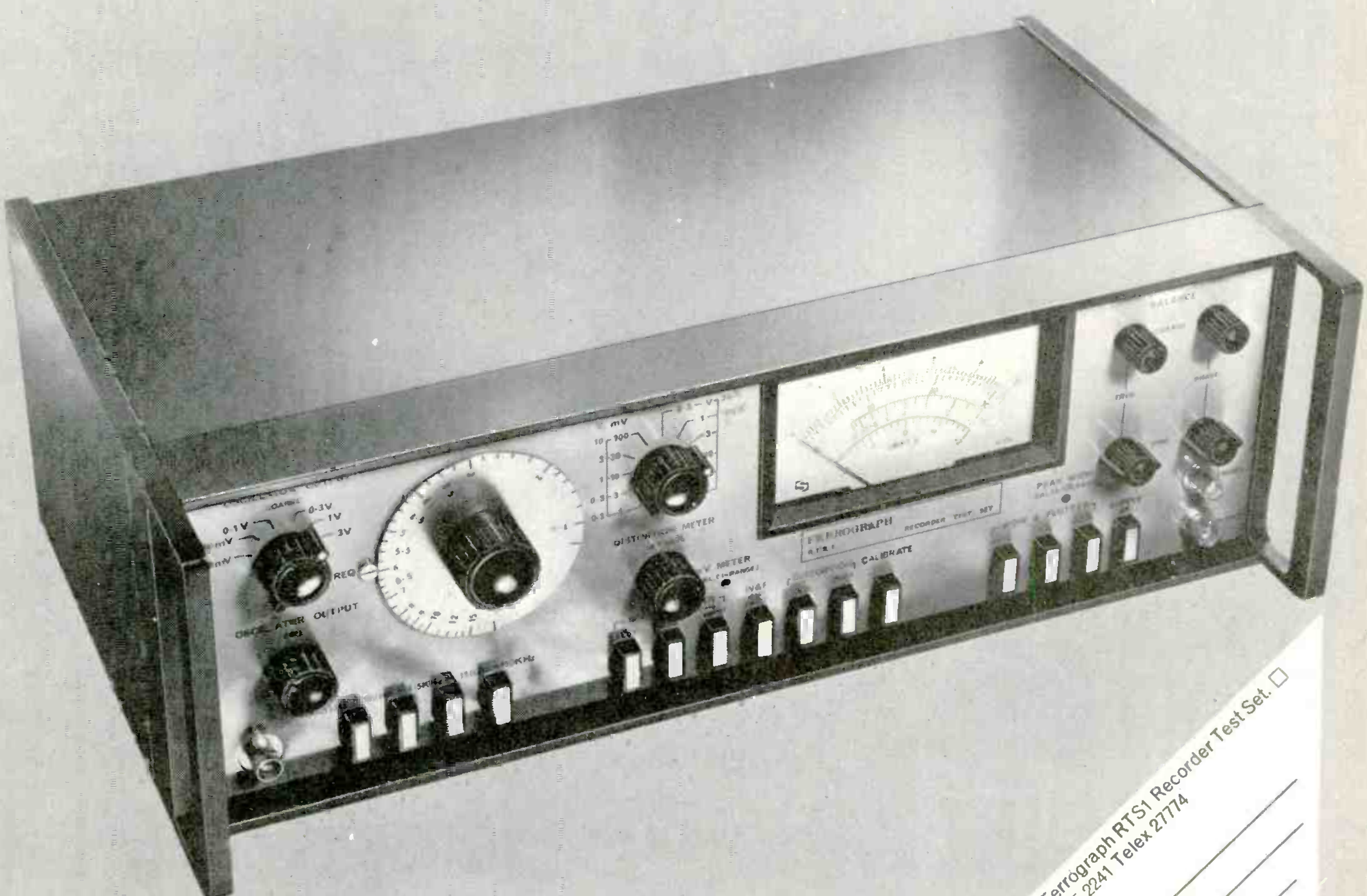


Please send me full details on the Ferrograph RTS1 Recorder Test Set. ☐
or Telephone 01-205 2241 Telex 27774

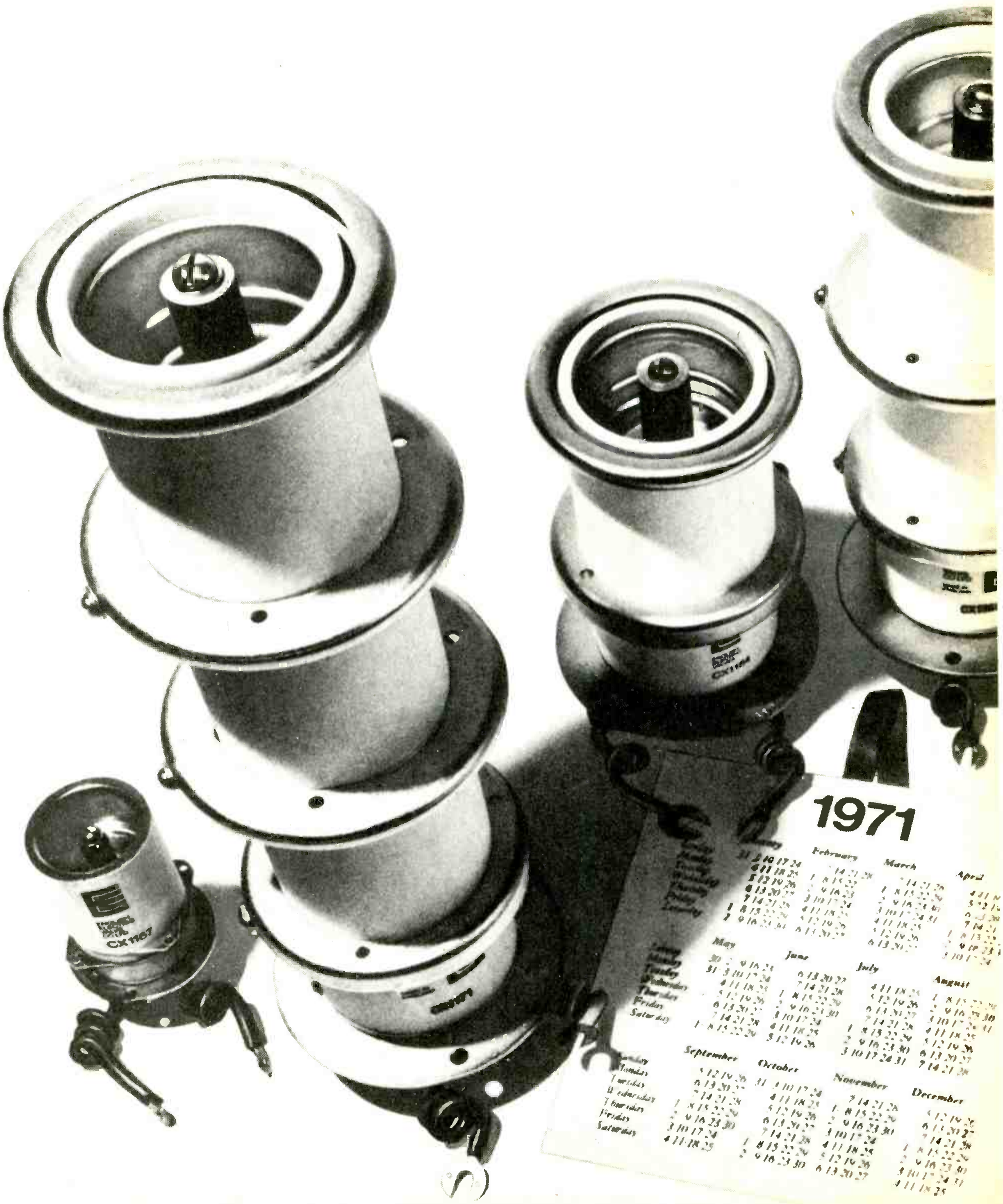
NAME

ADDRESS

WW6

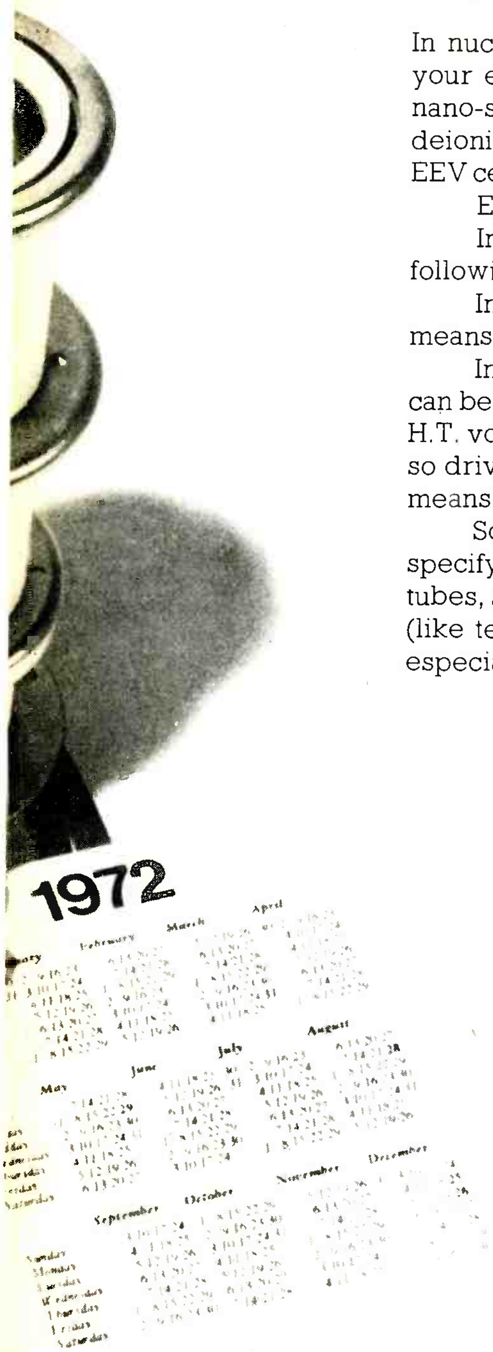
The Ferrograph Company Limited. The Hyde. Edgware Road. Colindale. London NW9.

EEV know how many nano-



CRC 33

seconds make 10,000 hours.



In nuclear physics you need absolute accuracy and long-term reliability from your electronic tubes. Especially thyratrons. EEV thyratrons can be fired with nano-second precision, with repetition rates of up to 50 kHz due to very rapid deionisation characteristics. Long life – 10,000 hours can be achieved – enables EEV ceramic thyratrons to be bolted into the circuit as with passive components.

EEV thyratrons meet the demands of major nuclear physics applications:

In linear accelerators they can withstand peak inverse voltages up to 20 kV following a pulse, and they give trouble-free operation in oil-filled equipment.

In particle accelerator work missed pulses are rare. Annular current-flow means rapid peak-current switching, too, without risk of arc extinction.

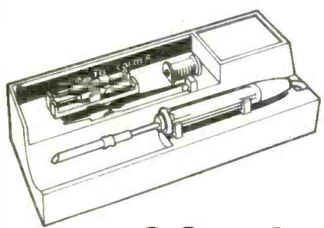
In spark chambers EEV thyratrons will eliminate spurious firing, and jitter can be kept as low as 1 ns. The CX1154 for example operates over a wide range of H.T. voltages at currents up to 10 kA without significant change in characteristics, so drive units can be used with different chambers – and the low trigger voltage means that simple firing circuits are possible.

So, whether you're concerned about nano-seconds or thousands of hours, specify EEV thyratrons. And remember that EEV also make ignitrons, photo tubes, storage tubes, image intensifiers, vacuum capacitors, spark gaps, RF tubes (like tetrodes for driving RF separators) and magnetrons especially for linear accelerators. Send for details.

EEV know how.

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

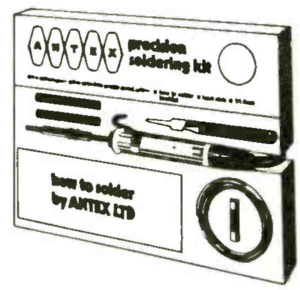
cut out the coupon and answer your soldering problems



SK1 SOLDERING KIT

In rigid plastic "tool box" containing Model CN - 15 watts - 240 volts miniature iron fitted $\frac{3}{16}$" bit. Spare bits $\frac{5}{32}$" and $\frac{3}{32}$". Reel of resin-cored solder, heat sink, cleaning pad, stand and booklet "How to Solder".

£2·75



SK2 Soldering Kit

In polystyrene pack, containing 15 watt miniature soldering iron, 240 volts fitted with $\frac{3}{16}$" bit, 2 spare bits $\frac{5}{32}$" and $\frac{3}{32}$". Coil of resin-cored solder, heat sink, 1A fuse and booklet "How to Solder".

£2·40

Model CN 240/2
15 watts - 240 volts

£1·70

Fitted with nickel plated $\frac{3}{32}$" bit and packed in handy transparent box.

£1·83

ES240 D 25 watt soldering iron

In transparent display pack, fitted with long life iron-coated bit $\frac{1}{8}$" diam.

Interchangeable spare bits $\frac{3}{32}$", $\frac{3}{16}$", $\frac{1}{4}$" (extra) available. Improved design to ensure strong and reliable high speed iron. Heats up in 2 minutes.

GSS Desoldering Tool

Model GSS with $\frac{3}{32}$" tip diameter

£4·67

De-soldering tool working on compressed air for industrial use with an air line or occasional use with foot pump. Efficient, self-cleaning operation on Venturi principle. Split-second action. Press valve control.

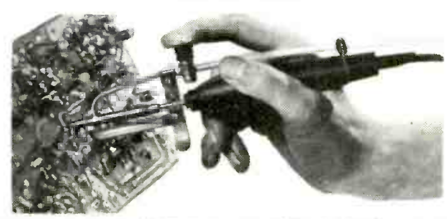
ESS Desoldering Tool

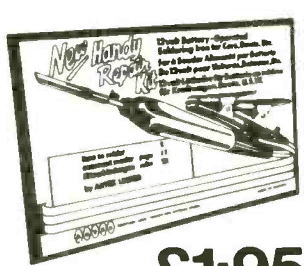
Model ESS with $\frac{5}{32}$" tip diameter

£4·67

Model ESS or GSS complete with foot pump

£5·65





M.E.S. Battery-operated 12 volt soldering iron

Complete with 15 ft (4·50m) lead, 2 heavy gauge clips for instant connection to car battery and a guide 'How to Solder'. Packed in strong plastic wallet.

£1·95

A N T E X

from electrical and radio shops or by Free Post (No stamp required) from **ANTEX Ltd., FREE POST, PLYMOUTH, PL1 1BR.** Tel (0752) 67377/8.

☐ Please send the ANTEX colour catalogue.

☐ Please send the following:

I enclose cheque/P.O./Cash (Giro No. 2581000)

NAME ____________

ADDRESS ____________

WW8

New Products

Rugged disc store

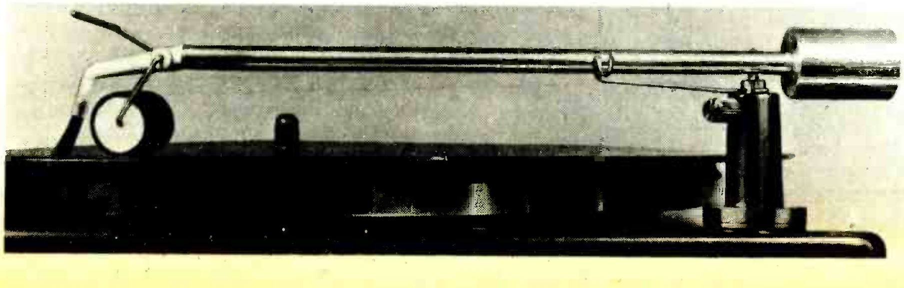
A disc store for computer application which is extremely rugged has been developed by a 16-month old company Process Peripherals Ltd, with N.R.D.C. backing. As the disc rotational speed reaches the crystal-controlled 3000 rev/min, specially profiled heads are lowered very close to the disc. A special head suspension keeps the heads at a constant 'flying' height and attitude even under severe vibration. The ferro-magnetic disc has a capacity of 256,000 words of 16 bits each—4.2M bits—which can be arranged in various ways including four separate stores of 1M bits each. Mean access time is 10ms, which can be halved by simple rearrangement of the heads. An error rate of 1 in 10^{10} has been achieved with this store and operational life is quoted as 100,000h. Process Peripherals Ltd, The Broadway, Thatcham, Berks.

WW 305 for further details

Automatic record cleaner

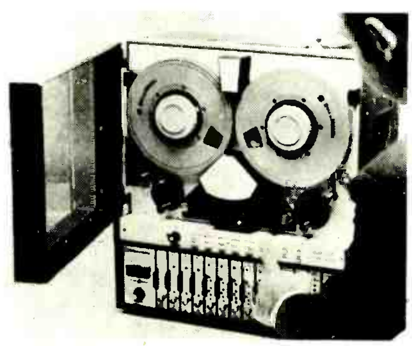
An automatic record cleaner, with the brand name Bib Groov-Kleen model 40, resembles a miniature cartridge arm, being finished mainly in anodized aluminium. The base is supplied with a self-adhesive disc to fix it to the player deck. The base has a chromium-plated pivot pillar which can be raised or lowered so that the arm can be adjusted to be parallel with the turntable. The arm, which is cranked to provide better tracking, has a brush at one end and a counterweight at the other. A small roller mounted behind the brush automatically sets its own level. A swivelling arm-rest is provided to hold the arm when a record is being placed on the turntable. The device has been designed so that it is suitable for mounting on any make of turntable deck, including the Garrard SP.25 Mk.III where very little space is available when the plastic cover is *in situ* on the plinth. When a record is being played, dust which is loosened by the brush is collected on the roller (which does not revolve) and can be removed with a separate brush included in the outfit. From time to time a fresh face of the roller can be presented to the record. A replacement kit of roller and brush is available. Price is £2.59. Bib Division, Multicore Solders Ltd, Hemel Hempstead, Herts.

WW315 for further details



Portable instrumentation recorder

The CPR-4000 portable instrumentation tape recorder from Bell & Howell records up to seven channels on $\frac{1}{2}$in tape, will accept N.A.B. reels up to 230mm in



diameter, and has seven electrically switchable speeds from $\frac{15}{16}$ to 60 i.p.s. Tape speed accuracy when used with the servo loop closed is $\pm 0.05\%$. Frequency range is 300kHz direct at 60 i.p.s. The f.m. system offers both I.R.I.G. wideband group I of 40kHz and an intermediate band of 20kHz at 60 i.p.s. The record and reproduce heads, made of a wear-resistant material, have an edge voice channel for use with the optional voice logging accessory. An optional automatic tape-threading device is also available. Power requirements are 115/230 V a.c. ($\pm$10%), 48 to 420 Hz single phase. Maximum consumption is approximately 200VA. Bell & Howell Ltd, Electronics & Instruments Group, Lennox Road, Basingstoke, Hants.

WW322 for further details

50MHz counter

Model FC50 from Wayne Kerr is a six-digit readout instrument with automatic location of the decimal point. The effective resolution can be increased, in some instances up to eleven digits, by under-ranging. The ranges are 0.1Hz to 50MHz and 1 μs to 10^5 seconds, with a count facility to 999,999. Start and stop can be manual or electrical (or a mixture of the two) and facilities are provided for inhibit, gating, storage and varying the up-dating rate. Clock signals are available for external use and there is an option of

b.c.d. outputs from the six number tubes. The display can be switched to show a 'non-blink' series of completed counts of the run as it proceeds. Acceptable input levels range from 20mV (r.m.s.) to 100V, and provision is made for correctly terminating 50 Ω or 75 lines. The Wayne Kerr Co. Ltd, Roebuck Rd, Chessington, Surrey.

WW328 for further details

Battery-operated soldering iron

The Antex MES 12 soldering iron operates from a 12 volt d.c. supply. Two large crocodile clips on 4.50m of 2-core cable provide connection to the battery terminals. The recommended U.K. price is £1.95. Anglo-Netherlands Technical Exchange Ltd, Mayflower House, Plymouth, Devon.

WW 308 for further details

Gunn oscillator

A Gunn oscillator made by Mullard gives an output of 35mW at 10.525GHz $\pm$20MHz. Type CL8631, it operates at a fixed frequency over the temperature range −20 to +50°C and can be used satisfactorily with any phase or load mismatch up to a v.s.w.r. of 1.3. It requires a power supply of 8V, total consumption being less than 2W. A square flange output mates directly with waveguide size RG-52 (WR90/WG16). The device can replace a klystron oscillator in many applications. Mullard Ltd, Mullard House, Torrington Place, London W.C.1.

WW323 for further details

Shift registers

The MA86S/87S silicon gate 100/128-bit dual independent shift registers, from GEC Semiconductors, operate from a single t.t.l. level clock and the t.t.l. system noise immunity specification is preserved. The registers can be clocked from zero frequency to more than 3MHz. All inputs and outputs (including the clock input) are t.t.l. compatible and the device operates from standard voltage levels. Since the registers are completely independent they may be clocked separately. The device is available in a TO-5 style package. GEC Semiconductors Ltd, Freebourne Rd, Witham, Essex.

WW 304 for further details

Intensifier vidicon

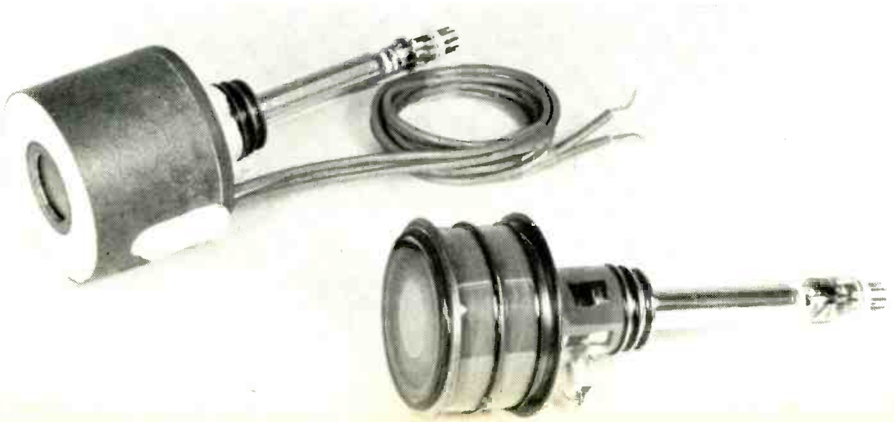
A vidicon camera tube with more than 250 times the sensitivity of a conventional 26 mm vidicon is being produced by the Electron Tube Division of EMI-Electronics. The tube, which employs an intensifier and is designated the Ebitron type 9777 vidicon, is claimed to produce television pictures when illumination is equivalent to half moonlight. The vidicon employs electron-bombardment induced conductivity in the zinc sulphide target with a high sensitivity photocathode. The image section is all electrostatic and the scanning portion similar to a conventional 13mm magnetic vidicon. The Ebitron can replace existing 26mm vidicons in c.c.t.v. cameras, the 9777 tube and its coils being no bigger. The 18.2mm photocathode makes it suitable for use with standard 26mm vidicon lenses. The weight is 230g potted, 100g unpotted.

Typical operating conditions:

image section	
overall e.h.t.	14,000 V
scanning section	
cathode	0 V
g_1 modulator	−30 V
g_2 limiter	300 V
g_3 beam focus	290 to 330 V
g_4 vidicon mesh	500 V
axial magnetic focus field	550 V
output signal	0.15 μA peak white
overall sensitivity	50 mA/1m

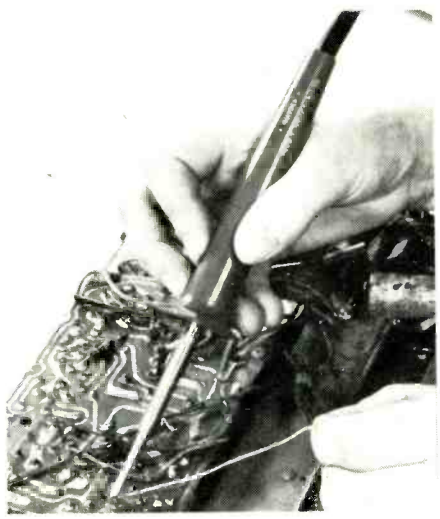
The heater requires 90mA at 6.3V. EMI Electronics Ltd, Hayes, Middlesex.

WW 310 for further details



Thermally controlled soldering iron

A range of lightweight, thermally controlled, soldering instruments has been introduced by Adcola. Known as the Invader, the new models incorporate a proven element combined with a new 'pencil-slim' handle. The rectangular centre heat-shield allows the instruments to be placed on any surface without rolling, and the tool is balanced to keep the working bit clear of the surface. A hanging hook is moulded into the handle. Noryl plastic, used for the handle, does



not readily transmit heat—the company claim the 25W and 27W tools are the slimmest available in these powers. The plug-in element can be replaced in 90 seconds. The collet can also accommodate the complete range of 70 standard and special-purpose bits. Standard Invader models are available for seven voltages—6, 12, 24, 50/55, 110, 220 and 230/250V. Three collet sizes—$\frac{1}{8}$in, $\frac{3}{16}$in and $\frac{1}{4}$in—are available, and the recommended price for the largest tool is £1.95. Elements with bit temperatures between 250 and 410°C can be supplied at no extra charge. The temperature of the standard-bit face is 360°C controlled to ±10°C. Adcola Products Ltd, Adcola House, Gauden Rd, London S.W.4.

WW 307 for further details

Rotary-action switches

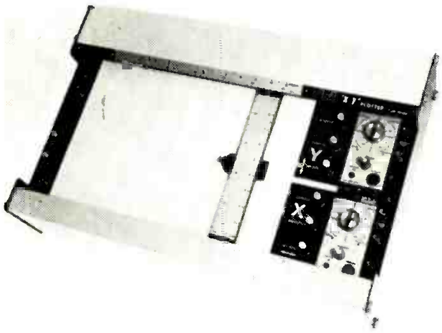
A range of low-torque, rotary-action, miniature switches, with a mechanical life in excess of ten million operations, has been introduced by Honeywell. The 900 Series 'V4' switches can operate in clockwise or anti-clockwise direction with no change in operating characteristics, and alternative shaft positions are possible.

Both s.p.c.o. and s.p.d.t. versions are available with 0.187in quick-connect or solder termination. They are rated at 5A and 125 or 250V a.c. Inrush current values should not exceed 10A. Operating temperature range extends from −40 to +100°C. Honeywell Ltd, Charles Square, Bracknell, Berkshire.

WW327 for further details

Inexpensive *XY* plotter

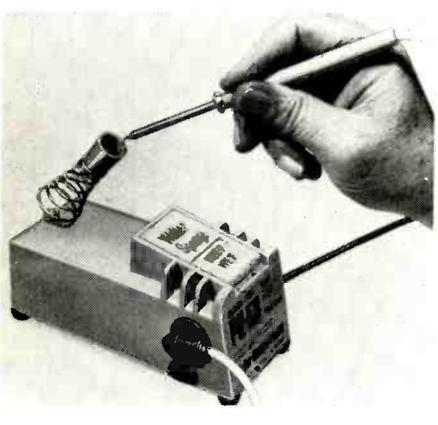
The *XY* plotter type PL100 from J. J. Lloyd Instruments, is suitable for applications where extreme accuracy and high speed are not essential. It is sold as a basic potentiometric assembly with a sensitivity which may be adjusted from 150 to 300mm/V. The response speed is approximately 200 mm/s and adjustable damping is provided for the servos on both *X* and *Y* axes. The amplifiers for both axes are independent, with floating inputs, and a suppressed-zero facility is incorporated which enables the instrument to plot small changes in voltage or current about a given reference level. Calibrated plug-in amplifiers are available to extend the range and enable the instrument to plot either voltage or current. Each amplifier has a calibrated reference, stepped attenuator and vernier sensitivity control, allowing the gain to be adjusted between 0.5mV/cm and 40V/cm or 0.5μ A/cm and 40 mA/cm. The accuracy



and repeatability is $\pm$ 1% $\pm$ 1 mm and the maximum paper size is 254 $\times$ 330mm. Price of plotter only is £124. The plug in amplifier costs £30. J. J. Lloyd Instruments Ltd, Brook Avenue, Warsash, Southampton SO3 6HP.
WW314 for further details

Soldering pencil

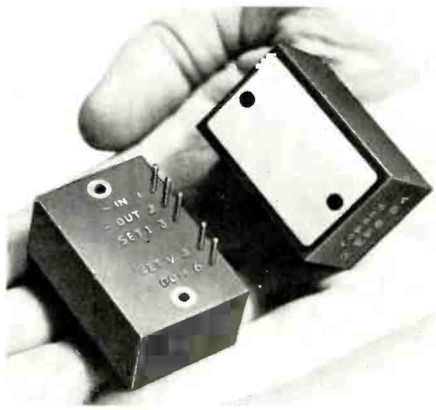
A soldering pencil, the MCP from Weller Electric, can be fitted with any of seven iron-plated tips ranging from 0.01in 'micropoint' to 0.125in double flat. Overall



reach is 2½in. The element operates at 24V supplied from its own power pack operating from the 240V mains. The power unit carries a spring pencil holder, and a cleaning sponge. Price £14.95; tips 45p each. Weller Electric Ltd, Redkiln Way, Horsham, Sussex.
WW326 for further details

Encapsulated regulators

The Roband Limpet range of encapsulated series regulators for stabilized power supply systems achieves high dissipation by providing an isolated metal heat transfer surface in one face of each module. The modules, which operate from a single unstabilized d.c. rail or from a battery, give well stabilized outputs up to 55V or 20A and have full over-current protection. The output voltage and protection levels are each preset externally by a fixed resistor, or they can be remotely programmed. The modules fit a standard heat sink extrusion, but can be mounted on any conventional metal surface. A typical 2A unit which measures 47 $\times$ 30 $\times$ 22mm can give a stabilized rail set anywhere between 6V and 24V with a maximum internal dissipation of 25W. The cost of



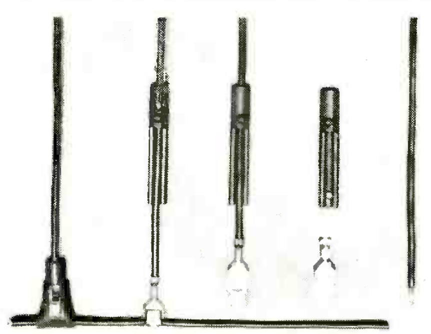
such a unit is £15.50. Roband Electronics Ltd, Charlwood Works, Charlwood, Horley, Surrey.
WW 306 for further details

Coaxial connectors

Sealectro have introduced a new range of r.f. coaxial front panel connectors. The 'Kwick Konnect' range provides locking and exhibits a v.s.w.r. of better than 1.30:1 at frequencies up to 18GHz. Assembly to cables is by crimp or clamp of the outer conductor, and by crimp or solder to the inner conductor. Once mated, it is virtually impossible to break the connection by pulling on the connecting cable. To disconnect a knurled ring is pulled back and the connectors disengage. Sealectro Ltd, Walton Road, Farlington, Portsmouth, Hants.
WW 309 for further details

T line connectors

Pressac have developed a new system of T line connectors. They are designed to allow electrical accessories to be connected into main wiring harnesses without cutting



the conductors. They can be applied directly to insulated wire without stripping. Each connector has an insulating sleeve which is threaded over the accessory lead and a brass contact is crimped to the conductor. The brass connector cuts through the insulation to make an electrical connection. The insulation sleeve is then wrapped around the contact and fixed by an integral latch. The connectors can be supplied either on reels, for machine assembly or loose. Pressac Ltd, Leopold Street, Long Eaton, Nottingham.
WW 311 for further details

Power transistors

A range of hometaxial silicon power transistors from Ates, suitable for high-power amplifier circuits, employs a structure in which the base region exhibits homogeneous resistivity in the axial direction—i.e. emitter-to-collector—eliminating secondary voltage breakdown within the maximum ratings of the device. The 2N3771 of this TO-3 range provides 150W output, with 30A (I_C) at 50V (V_{CBO}). For 100V operation, the 2N3772 gives 20A, and the 2N3773 16A at 160V. Ates Electronics Ltd, Mercury House, Park Royal, London W.5.
WW 303 for further details

Reed switch

Reed switch type DRA-291 from F.R. Electronics is capable of switching up to 5A at 50VA and up to 1A at 100VA. It is

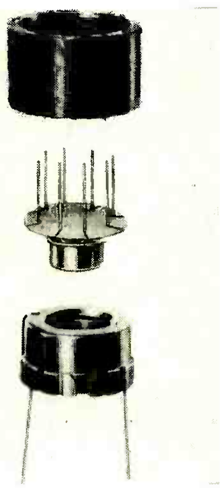
standard size, and has rhodium contacts with low contact resistance. F. R. Electronics Ltd, Wimborne, Dorset, BH21 2BJ.
WW 312 for further details

Logic level pulse generator

From Grange Electronics (Production) we have received details of a wide-range pulse generator which covers repetition frequencies from 1 Hz to 5 MHz in seven overlapping ranges. Delay and output pulse widths are variable between 100ns and 100ms in six overlapping ranges. Additional features include manual and external triggering, a pre-pulse output and simultaneous complementary outputs at t.t.l. levels. The price is £66. Grange Electronics (Production) Ltd, Stone Lane, Wimborne, Dorset, BH21 1HD.
WW318 for further details

Oven for TO-5 devices

Jermyn's 4ST2 self-regulating oven is designed for devices in TO-5 size packages when lead lengths are restricted to 12.5mm. Devices having up to eight leads may be accommodated and can be installed without the use of special tools. Ovens having control temperatures of 65, 80 and 115°C are available and will operate in ambient temperatures from −50 up to 50, 60 and 100°C respectively.



The ovens have no moving parts or electronic circuitry but incorporate a semiconductor heater to provide a self-regulating proportional temperature control. Power requirements are 24V (±4V) a.c./d.c. 0.6W (at 25°C ambient). Maximum warm-up time from −55°C is 3 minutes. Jermyn Industries, Manufacturing Division, Vestry Estate, Sevenoaks, Kent.

WW319 for further details

Transient voltmeter

Model 3206 voltmeter from Sintrom Electronics will measure and hold the peak value of a single pulse which has a 10ms duration or longer. The instrument has a

four-figure digital readout and an accuracy of 1% of full scale. There are four switched ranges with full-scale values ranging from 10mV to 19V. The input impedance is 1 MΩ. The peak value is held in store until reset. Automatic reset for driving a printer or recorder is provided. The input is floating and is double screened to reject radiated transients. Other models in this range include instruments capable of measuring pulses up to 30kV and as short as 50 nanoseconds. Analogue and digital readouts are available. Prices range from £580. Sintrom Electronics Ltd, 2 Castle Hill Terrace, Maidenhead, Berks.

WW 302 for further details

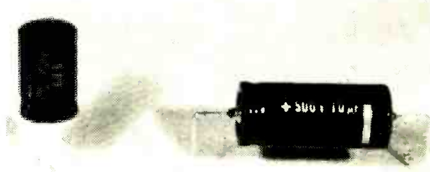
Sub-miniature chokes

Cambion's 550-339 sub-miniature radio frequency choke is available in a wide range of inductance values—0.1 through to 1,000 μ H in 49 steps. Each choke has a small moulded body 6 mm long and 24 mm in diameter. Cambion Electronic Products Ltd, Castleton, near Sheffield, S30 3WR.

WW313 for further details

Axial-lead electrolytic capacitors

A series of axial-lead miniature aluminium electrolytic capacitors, type EN12.12, has been added to the range of ITT single ended miniature capacitors type EN12.35.



The axial-lead versions are available from 1 μ F to 4,700 μ F rated up to 500V (dependent on capacitance value). These capacitors have an operating temperature range of −25 to +70°C. Plastic sleeves are employed for case insulation. ITT Components Group Europe, Standard Telephones and Cables Ltd, Edinburgh Way, Harlow, Essex.

WW316 for further details

High-frequency counters

Series 7900 counters from Dana Electronics are seven-digit units with an optional eighth digit, and all have optional systems interface units. Sensitivity is 1mV up to 500 MHz. Three counters typical of the range are the 7910 (to 150MHz) at £595 (illustrated), the 7920 (to 550 MHz) at £750, and the 7960 (to 3 GHz) at £1395. Dana Electronics Ltd. Bilton Way, Dallow Road, Luton, Beds.

WW324 for further details

Panel drilling bit

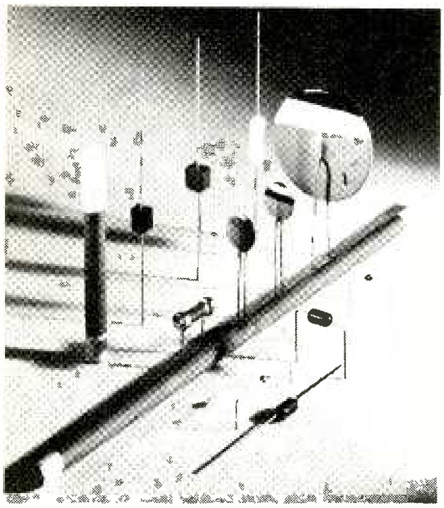
A Bradrad (Type A), from West Hyde Developments, provides panel holes of different sizes, drilling and deburring in a single operation. Two versions are available providing holes of 1½ to 2½ inches in ⅛in steps, or 36mm to 60mm in 3mm steps.

The bit is made of cobalt 'high speed' steel and has a 12.5mm diameter shank. Price £23 plus 35p postage and packing. West Hyde Developments Ltd, Ryefield Crescent, Northwood Hills, Northwood, Mddx.

WW321 for further details

Voltage-dependent resistors

A new range of silicon carbide and diffused junction silicon voltage-dependent resistors (varistors) is available from ITT. Silicon carbide voltage-dependent resistors are available in rod or disc form, and can be supplied with leads for direct wiring into position or without leads for direct mounting. These devices have a wide range of applications for voltage control and component protection. Silicon diffused junction varistors are particularly suitable for a very wide range of currents at low voltage levels. A particular application of this type is for temperature compensation



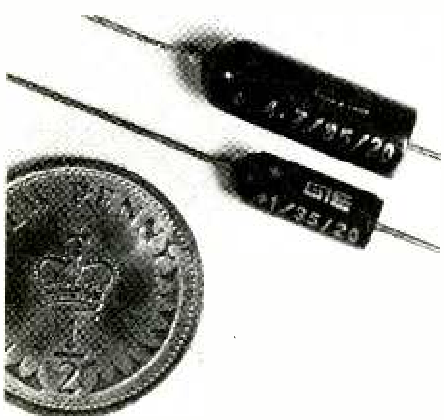
in semiconductor circuits. ITT Components Group Europe, Resistor Products Sales, Edinburgh Way, Harlow, Essex.
WW 301 for further details

Variable transformers

Variable transformers from the Zenith Electric Company, in the Variac-Setavolt range, are fully encapsulated for 200-250 volt operation, covering the current ranges 0.75 to 4A in 5 sizes. The frequency range is 50-400Hz. Motorized two-gang and three-gang units are also available. The Zenith Electric Co. Ltd, Wavendon, Bletchley, Bucks.
WW317 for further details

Tantalum capacitors

The MT series of moulded tantalum capacitors, available from General Instrument (UK) Ltd, are dry sintered anode units, moulded in epoxy resin and not subject to gassing or electrolyte



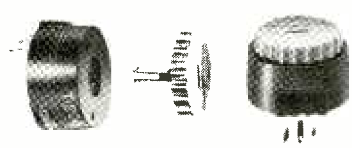
leakage. Capacitance range is from 0.068 to 47μF rated up to 50V. The working temperature can be as high as 85°C. General Instrument Ltd, Stonefield Way, Ruislip, Middx.
WW325 for further details

Improved recording tape

A new family of recording tapes which exhibit increased output and a 4dB improvement in signal-to-noise ratio with no modification to existing equipment has been developed by the 3M Company. Known as High Energy tapes, they are based on a cobalt-modified ferric oxide formulation. Unlike chromium-dioxide tape, which requires separate circuitry to be switched in, High Energy tape can be used on existing cassette machines without any modification to the standard low-noise bias and equalization levels to give greater undistorted output and an increase in dynamic range from 2dB at low frequencies to 6dB at the upper end of the scale. Circuitry designed around the potential performance characteristics of the new tapes could improve reproduction still further. It is expected that the new tapes will be marketed in the U.K. later this year in helical-scan video form, and that broadcast video and audio cassettes will follow. 3M Company, 3M House, Wigmore Street, London W1A 1ET.

Miniature trimmer pot

The T-200-K single-turn wirewound potentiometer in the Contelec range of trimmers has a knurled plastic-moulded knob, with bifurcated



shaft that pushes into the pot and interlocks with the keyway. It can equally easily be turned by a screwdriver. Power rating is 2W at 40°C. Resistance range is 10Ω to 50kΩ. Size is 20 × 10mm. Operating temperature is −25 to 125°C. The T-200 series is available in eight standard versions, in either bush mounting or printed circuit types. Kynmore Engineering Co. Ltd, 19 Buckingham Street, London WC2.
WW 331 for further details

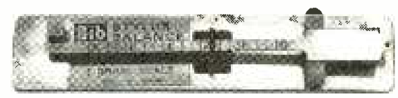
Zero-voltage switch for thyristors

A low-cost version of the RCA zero-voltage switch for thyristor gate triggering is the CA3079. It has the same temperature range as the earlier CA3059 (−40 to 85°C) but the fail-safe, inhibit and over-ride functions are not included. The economy type includes a power supply, allowing operation from an a.c. line of 24 to 277V at 50 to 400Hz, a differential sensing amplifier; a zero-crossing detector and a triac gating circuit. The zero-crossing detector, of course, allows thyristor switching at the voltage zeros of the a.c. line, eliminating r.f. interference when used with resistive loads. The circuit is packaged in a 14-lead dual in-line

plastic case. Price is 79p for 1-24 and 59p for 100 up. RCA Ltd, Solid State Division, Sunbury-on-Thames, Middx.
WW 320 for further details

Stylus balance

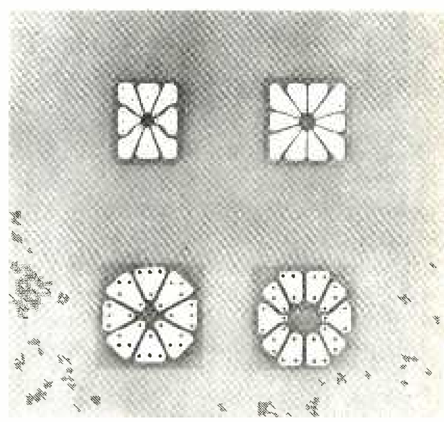
The BIB stylus balance model 32 is produced specifically for determining the 'pressure' of modern cartridges and is calibrated in 0.25g



divisions. It has a non-magnetic base mounted on foam plastic. The cross-bar of the beam has recesses which are mounted on a pair of low-friction pivot points. Price £1.80. BIB Division, Multicore Solders Ltd, Hemel Hempstead, Herts.
WW 330 for further details

Printed circuit elements

Conducting elements for wiring semiconductor devices to printed circuits are made by Circuit-Stik Inc. of California. With an adhesive backing, the 1000 and 2000 series of



elements are designed to suit most types of TO-5 and TO-18 packages. The former are drilled to match a 0.1 in grid and the latter undrilled to save space. Available in the U.K. from Bourns (Trimpot) Ltd, 17 High Street, Hounslow, Middx.
WW 329 for further details

Press-button switches

The Arrow Adapt-a-Switch range of illuminated and non-illuminated press-button switches is based on a small number of components that fit together simply. The actuator can be chosen for momentary or alternate action. Press-in lenses give a range of three shapes—round, square and oblong—in six colours. The standard duty ratings are 5A at 125V a.c., 2A at 250V a.c., and 5A at 28V d.c. Electrical and mechanical life is 100,000 cycles minimum at full rating. Arrow Electric Switches Ltd, Brent Road, Southall, Middlesex.
WW 332 for further details

Real & Imaginary

by "Vector"

On Stopping the Home Fires Burning

I wonder whether you've ever thought of the domestic 'telly' as a lethal instrument? I must confess I hadn't until I read a study of statistics relating to fires in television sets. This paper was written by a member of the Joint Fire Research Organization and the figures quoted give food for thought.

For in 1968 (the last year for which figures were presumably available) 1244 fires occurred in Britain which were directly attributable to the magic box. In 1960, the figure stood at 528 and rose significantly in every subsequent year.

You may well say 'Ah yes, but the number of sets in use increases every year'. True. But other figures given show that the number of fires increased at a considerably higher rate than licences did. In 1965 the incidence of fires to licences was 61.8 per million; three years later it was up to 82.4 per million and after another three years I wouldn't be surprised to find that it had taken another comparable jump. The older the set, the greater the risk, is a logical conclusion and possibly, with the cost of living steadily rising, people are hanging on to their sets longer.

One rather less sombre side is that (taking the 1968 statistics) about 83% of these fires occurred between 3 p.m. and midnight when someone is likely to be able to initiate prompt action. Only 5% of the total—roughly 4.5 per million licences—occurred between 1 and 2 a.m. Compared with the annual incidence of fires from all causes between these hours, which amounted to some 500 per million dwellings, the number of television fires are chickfeed; but they are nonetheless dangerous, since at that time most people are asleep in bed and totally unprepared for disaster. You may remember that recent fire in a hotel, in which eleven people died. That was attributed to a television receiver.

What effect has the advent of colour, with its higher operating voltages, had on the figures? No significant alteration up to 1968, but that doesn't mean much because colour hadn't got going, and even today colour sets are not in wide enough use to make much difference.

How were these fires caused? It was no part of the report's aim to specify and so we don't know. Component breakdown must have played a part but, to be fair on the manufacturers, by no means all TV receiver fires are started in this way. All dealers know the old lady who drapes a blanket over the top of the set to let her cat sleep on, and how, by drooping over the back, this (the blanket I mean, not the cat!) can block all ventilation. Tatty do-it-yourself flex wiring (often using bare staples) with the lead to the set permanently 'live' is another well-known phenomenon. And again, smoke pouring from the cabinet may panic the householder into calling the fire brigade when in fact no fire, as such, exists. The statistics given seem to indicate the presence of this last factor, for of the 1244 fires quoted for 1968, 612 were 'confined to the set' and might therefore have been smoke only—or does a fire brigade have to see flames to record the incident as a fire? As to the remainder, a further 560 were 'confined to the room', while 72 spread to other areas. These 632 were, without doubt, genuine no-nonsense fires, but it would be instructive to know whether outbreaks originating in the mains lead to the set or in its feed wire along the skirting (where this exists) are classified as television fires, or whether the outbreak must originate in the set in order to qualify.

In the U.S.A. the incidence of fires in TV sets is causing considerable concern. In August 1969 the Federal Government's National Commission began to put the whole question under the microscope and in due course came up with the pronouncement that more than 10,000 such fires occurred annually. Predictably, this was hotly denied (no pun intended!) by the Electronic Industries' Association, which put up a rival figure of 2600 over a five-year period. Subsequently, other reports were produced from various sources with figures that fell somewhere between the two extremes.

One such (the 'Jitco') was especially enlightening. This was in essence a tabulation of data supplied by set manufacturers concerning fires reported for each of their models. It did far more than tabulate, however; it also pinpointed the components that were responsible. One startling fact that emerged was that colour sets were *forty times more likely to cause fires than black-and-white models*. Forty times. That's a fantastic jump.

In the list of delinquent components the line output transformer emerges as the worst offender by a considerable margin (29.26% of the total fire/smoke cases, rising to 40% in colour sets). Then come high-voltage components (18.1%), the receiver on-off switch (12.7%), the yoke (7.4%), controls (5.9%) and so on through seven more groupings, ending with fuses at 0.4%. Nothing much to surprise the British service engineer here, I fancy. Understandably, fires occurred in chassis runs—that is, if a given component was fitted which subsequently proved to be unequal to its job, an epidemic of fires would be experienced with the particular model that embodied the component.

Now, to judge from a comprehensive report on the subject in *Electronics*, the United States can scarcely be set up as a pattern upon which to model future British procedure. The bible in the matter of standards seems to be the Underwriters' Laboratories UL492, which runs to 402 paragraphs and which is continuously being updated. But apparently there is no legal obligation to conform to it and it is left to individual cities to decide whether sets used within their boundaries should carry the U.L. stamp. Only three cities insisted on this at the time of the survey (August 1970) and so many manufacturers just don't bother with it. The U.L. standards, it is stated, are not so much those which ensure public safety as ones which the manufacturers can conveniently work to. One example cited is the permissible leakage between case and earth which is 5mA—sufficient to pack a nasty wallop; efforts are now being made to reduce this to 0.5mA. Again, the permitted level of X-ray radiation from TV sets has been set at 0.5 milliröntgen/hour at 5cm, but not because this gives a good margin of safety; it is merely a level that manufacturers can conveniently meet. Recently, however, some improvement has been effected; from January 1st, 1971, all sets have had to conform to this level even if all controls are maladjusted to 'worst case' and component failure increases emission.

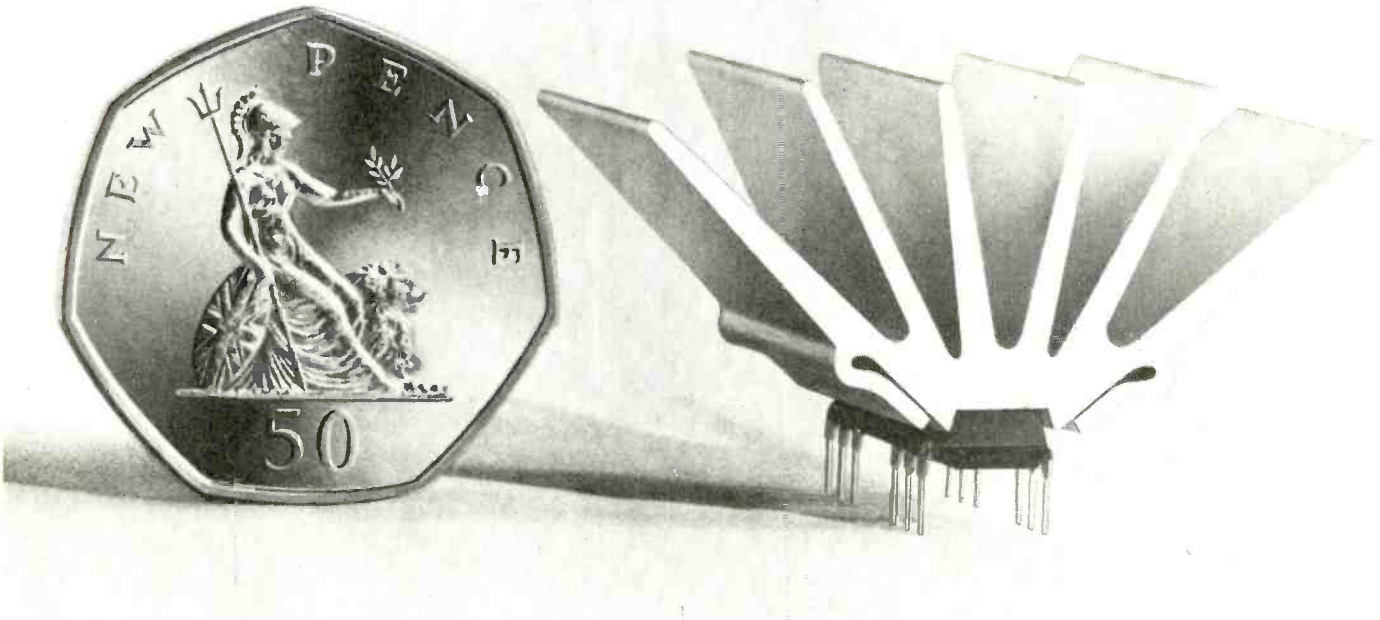
Signs are not wanting, in fact, to indicate that American television manufacturers are at last treating the fire hazard much more seriously than formerly. This may reflect an improved sense of social conscience. On the other hand the more cynical might think that it stems from a test case in the U.S. Courts concerning a man who died in a TV-originating fire. The receiver manufacturers were ordered to pay $212,000 dollars compensation to the man's family. If this establishes a precedent as to where responsibility lies, it could make for an expensive future for television manufacturers.

Returning now to the British scene, one benefit from our delayed entry into colour is that we have a breathing space before colour receivers become the rule rather than the exception. This gives us opportunity to benefit from American mistakes.

For the information contained in the above I am indebted to:- 'Fires in television sets', S. E. Chandler, *Fire*, Sept. 1970. 'Customer hazards: why they happen', and 'Customer hazards: how they can be fixed', *Electronics*, Aug. 3, 1970.

new

Super IC-12



High fidelity Monolithic Integrated Circuit Amplifier

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

1. Higher power.
2. Fewer external components.
3. Lower quiescent consumption.
4. Compatible with Project 60 modules.
5. Specially designed built-in heat sink. No other heat sink needed.
6. Full output into 3, 4, 5 or 8 ohms.
7. Works on any voltage from 6 to 28 volts without adjustment.
8. NEW 22 transistor circuit.

Output power 6 watts RMS continuous (12 watts peak).

Frequency Response 5 Hz to 100KHz ± 1 dB.

Total Harmonic Distortion Less than 1%. (Typical 0.1%) at all output powers and all frequencies in the audio band.

Load Impedance 3 to 15 ohms.

Power Gain 90dB (1,000,000,000 times) after feedback.

Supply Voltage 6 to 28 volts (Sinclair PZ-5 or PZ-6 power supplies ideal).

Size 22 x 45 x 28 mm including pins and heat sink.

Input Impedance 250 Kohms nominal.

Quiescent current 8mA at 28 volts.

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

Price, inc. FREE printed circuit board for mounting.

£2.98 Post free

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

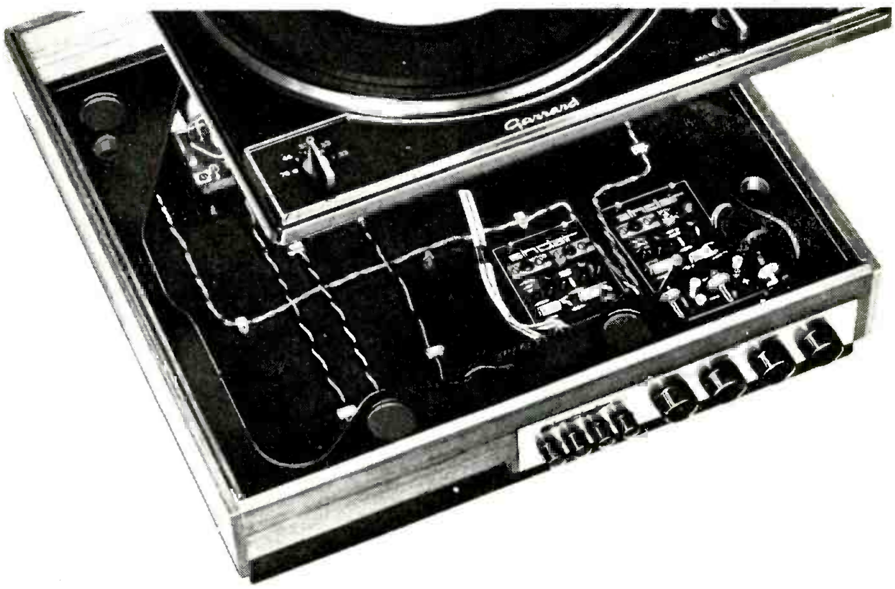
Sinclair Radionics Ltd, London Rd, St. Ives
Huntingdonshire PE17 4HJ
Telephone St Ives (048 06) 4311

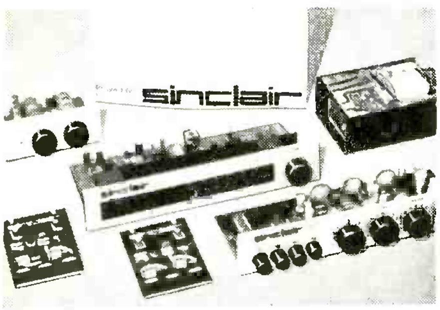
sinclair

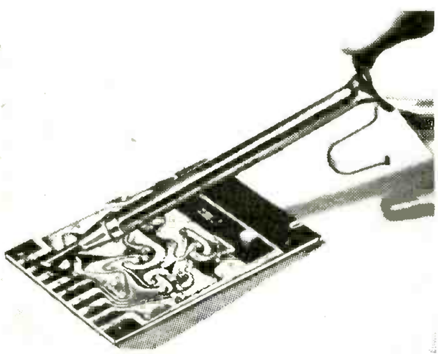
WW—071 FOR FURTHER DETAILS

Sinclair Project 60

The World's leading range of high fidelity modules







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

Typical Project 60 applications

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

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

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

sinclair

from a simple amplifier to a complete stereo tuner amplifier with Project 60 modules

Z.30 & Z.50 power amplifiers

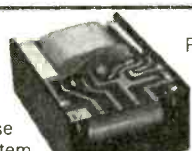
The Z.30 and Z.50 are of advanced design using silicon epitaxial planar transistors to achieve unsurpassed standards of performance. Total harmonic distortion is an incredibly low 0.02% at full output and all lower outputs. Whether you use Z.30 or Z.50 amplifiers in your Project 60 system will depend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

SPECIFICATIONS ***(Z.50 units are interchangeable with Z.30s in all applications).***
Power Outputs
Z.30 15 watts R.M.S. into 8 ohms using 35 volts: 20 watts R.M.S. into 3 ohms using 30 volts.
Z.50 40 watts R.M.S. into 3 ohms using 40 volts: 30 watts R.M.S. into 8 ohms using 50 volts.
Frequency response: 30 to 300,000Hz ±1dB.
Distortion: 0.02% into 8 ohms.
Signal to noise ratio: better than 70dB unweighted.
Input sensitivity: 250mV into 100 Kohms.
For speakers from 3 to 15 ohms impedance.
Size: 14 x 80 x 57 mm.

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

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

Power Supply Units



PZ.5

PZ.8

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

PZ.5 *30 volts unstabilised* **£4.98**
PZ.6 *35 volts stabilised* **£7.98**
PZ.8 *45 volts stabilised (less mains transformer)* **£7.98**
PZ.8 *mains transformer* **£5.98**

The Sinclair Guarantee

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

Project 60 Stereo F.M. Tuner

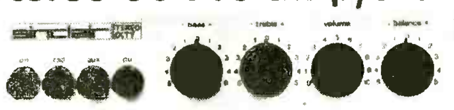
First in the world to use the phase lock loop principle

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

SPECIFICATIONS—Number of transistors: 16 plus 20 in I.C. **Tuning range:** 87.5 to 108 MHz. **Capture ratio:** 1.5dB. **Sensitivity:** 2μV for 30dB quieting: 7μV for full limiting. **Squelch level:** 20μV. **A.F.C. range:** ±200 KHz. **Signal to noise ratio:** > 65dB. **Audio frequency response:** 10 Hz – 15 KHz (±1dB). **Total harmonic distortion:** 0.15% for 30% modulation. **Stereo decoder operating level:** 2μV. **Cross talk:** 40dB. **Output voltage:** 2 x 150mV R.M.S. **Operating voltage:** 25-30 VDC. **Indicators:** Mains on; Stereo on; tuning. **Size:** 93 x 40 x 207 mm.

Built and tested. Post free. **£25**

Stereo 60 Pre-amp/control unit



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

SPECIFICATIONS—Input sensitivities: Radio – up to 3mV. Mag. p.u. 3mV: correct to R.I.A.A curve ±1dB 20 to 25,000 Hz. Ceramic p.u. – up to 3mV: Aux – up to 3mV. **Output:** 250mV. **Signal to noise ratio:** better than 70dB. **Channel matching:** within 1dB. **Tone controls:** TREBLE + 15 to —15dB at 10 KHz: BASS + 15 to —15dB at 100Hz. **Front panel:** brushed aluminium with black knobs and controls. **Size:** 66 x 40 x 207mm.
Built tested and guaranteed. **£9.98**

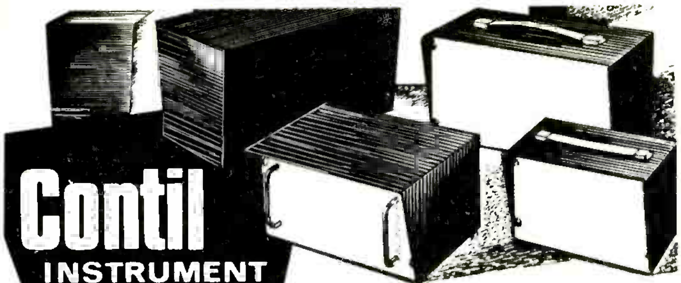
A.F.U. High & Low Pass Filter Unit

For use between Stereo 60 unit and two Z.30s or Z.50s, and is easily mounted. It is unique in that the cut-off frequencies are continuously variable, and as attenuation in the rejected band is rapid (12dB/octave), there is less loss of the wanted signal than has previously been possible. Amplitude and phase distortion are negligible. The A.F.U. is suitable for use with any other amplifier system. Two filter stages – rumble (high pass) and scratch (low pass). Supply voltage – 15 to 35V. Current – 3mA. H.F. cut-off (–3dB) variable from 28KHz to 5KHz. L.F. cut-off (–3dB) variable from 25Hz to 100Hz. Distortion at 1KHz (35V, supply (0.02% at rated output. **Size:** 66 x 40 x 90 mm. *Built tested and guaranteed.* **£5.98**

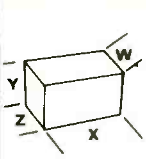
To: SINCLAIR RADIONICS LTD LONDON ROAD ST. IVES HUNTINGDONSHIRE PE17 4HJ

Please send ______	Name ______
______	Address ______
______	______
I enclose cash/cheque/money order.	

WW8



Contil INSTRUMENT CASES



Case No.	W	X	Y	Z
755	5	7	5	4
975	7	9	5	6
867	6	8	7	5
1277	7	12	7	6
16127	12	16	7	11
191010	10½	19¼	10¼	9½
1910100	10½	19¼	10¼	9½

(Panel size—10½ x 19 x 4½ with 6" vertical)

The ideal 'off the shelf' low cost instrument housing. 21-gauge steel. Finished hammer blue, with 18-gauge panel supplied with easy-to-strip protective covering for easy marking out. Individually packed, including feet and screws.

Type	1 off	10 off	100 off	P&P
755	2.75	2.60	2.45	36p
867/975	2.90	2.80	2.30	36p
1277	3.25	3.05	2.85	45p
1277 unpainted	2.65	2.55	2.20	45p
16127	6.10	5.90	5.60	56p
191010	8.30	8.00	7.65	66p
1910100	11.50	11.35	10.90	105p

HANDLES

West Hyde carry stocks of four types of handles. The two Delrin types are 5.5/8" and 8¼" long with prices from 8p to 20p each. The two chrome panel handles are also in two sizes 3" and 5" with prices from 20p to 37p each. Both types of handles are ideal for our cases as the illustration shows.

CHASSIS AND SPARE PANELS

Contil cases are also available with aluminium panels and Contilcote, applied after drilling and cutting. There is also a chassis to fit each size of Contil case. Three smaller sizes in 18 gauge aluminium and three larger sizes in 16 gauge. Prices from 15p to 75p

GROMMETS 100 off	GROMMETS 500 off	PANEL HOLE SIZE INCHES	BLANKING PLUGS 100 off	BLANKING PLUGS 500 off
25p	20p	3/16, ¼, 5/16, 3/8	35p	30p
35p	30p	7/16, ½	35p	30p
		5/8	55p	45p
55p	50p	¾, 1	80p	70p

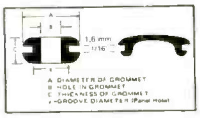
Assorted £1.40 lots (100 3/16", 50 ea. of others) Assorted £1.70 lots (100 off 3/16", 50 ea. of others)

Postage & Packing 15p

FEET

You could tramp the World and not find better feet!

The West Hyde foot is moulded from a resilient, high hysteris material, giving a high friction coefficient. Self-adhesive or screw fixing or both (6BA countersunk). Size 5/8" dia. 3/8" high. Grey. Price from 0.010 to 0.017 each.



WEST HYDE

WEST HYDE DEVELOPMENTS LTD. RYEFIELD CRESCENT, NORTHWOOD HILLS, MIDDX. HA6 1NN
Telephone: Northwood 24941/26732 Telex: 923231 Code: West Hyde Nthwd.

WW—074 FOR FURTHER DETAILS

'Brightlife' NEONS

"Brightlife" neons give greater brightness and 25,000 hours average life. The ½" diameter neons are moulded in polypropylene which diffuses the light and the ⅜" diameter neons are moulded in polycarbonate which gives higher light transmission. Both types give a glow behind the panel to warn maintenance staff. Units are one hole fixing ½" and ⅜" diameter clearance.

The very low cost of these neon/resistor assemblies makes them ideal for safety uses, particularly in transistorised equipment where most voltages are safe to be handled. Usually the mains transformer has the only dangerous terminals and for a few pence these indicators can be soldered on directly as a warning light. Unlike incandescent indicators these can be fitted and forgotten.

	10 off	100 off	1000 off
6" PC, 6" PP, 110PC, 110PP, T, K.	0.15	0.14	0.12
30" PC, 30" PP, R.	0.17	0.16	0.14
PP/G, PP/H, Q, Alpha numeric.	0.20	0.18	0.16
M or M110	0.05	0.04	0.04
N	0.05	0.04	0.03
PP/I, PP/J, L, Spare caps & bodies	0.03	0.02	0.01

Post and Packing—15p any quantity

WEST HYDE

WEST HYDE DEVELOPMENTS LIMITED, RYEFIELD CRESCENT, NORTHWOOD HILLS, NORTHWOOD, MIDDX., HA6 1NN.
Telephone: Northwood 24941/26732 Telex: 923231

WW—075 FOR FURTHER DETAILS

ONTOS UNIVERSAL VICE

For use wherever a third hand is needed. Fully adjustable for any angle in any plane. **£3.60.** *P & P 28p*

Another PAIR of hands. **£5.95.** *P & P 35p*

A unique two-in-one version with 2 sets of jaws, each rotatable through 360° in any plane.

The Ontos is a multi-purpose, multi-position vice, ideal for holding P.C. boards for assembly, soldering or testing. The jaws will hold flat, round, square, or hexagonal parts. It is quickly reset to any new angle, in any plane, making it ideal for building up modules, as a micrometer or gauge stand, as a light general purpose vice, in the laboratory, or whenever you need an extra pair of hands!

CABLE REELS

Always ready for the out of reach socket. Easy-to-carry lightweight reel with neon indicator, moulded in rewind handle and easy wind non-twist cable, 13 amp fused plug and socket. Either 50 ft of 5 amp or 30 ft of 13 amp cable. 30 ft 13 amp or 50 ft 5 amp. 1 at £4.98. P & P 35p.

DISCOUNTS FOR QUANTITY.
POSTAGE & PACKING EXTRA

TEST ADAPTOR

Typically used in quantities by washing machine manufacturers and suitable for lab. use etc. Fitted with non-wire-cutting contacts and fuse. Suitable for up to 13 amps. A neon indicator lights when mains is on the outer sockets. 1 at £1.35. P&P 15p.

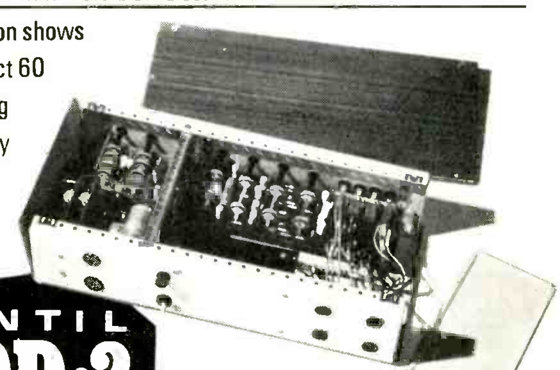
WEST HYDE

SEND FOR FREE LEAFLETS & PRICE LIST

WEST HYDE DEVELOPMENTS LTD., RYEFIELD CRESCENT, NORTHWOOD HILLS, MIDDX., HA6 1NN
Telephone: Northwood 24941/26732. Telex: 923231 WEST HYDE NTHWD

WW—076 FOR FURTHER DETAILS

This illustration shows Sinclair Project 60 made-up using Mod-2 G ready punched case



CONTIL MOD·2

Contil Mod-2 instrument cases are ideal for development and cheaper for production. Made with PVC coated materials there is no paint to scratch, the surface is scuff resistant and easy to clean. Coated aluminium front and back panels gives easy cutting with rigidity and coated steel top, bottom and sides gives strength and ease of assembly. Three heights of cases, four widths and two depths give 48 different cases. Mod-2 means modern design, low cost, off the shelf delivery.

	X	Y	Z	1 off	P & P		X	Y	Z	1 off	P & P
A	4.5	3	6.5	1.90	15p	N	4.5	7	13	3.05	28p
B	4.5	7	6.5	2.20	28p	O	4.5	10	13	4.00	35p
C	4.5	10	6.5	2.75	28p	P	9	3	13	3.05	28p
D	9	3	6.5	2.75	28p	Q	9	7	13	4.00	35p
E	9	7	6.5	3.05	28p	R	9	10	13	4.90	35p
F	9	10	6.5	3.60	28p	S	13	3	13	4.00	35p
G	13	3	6.5	3.05	28p	T	13	7	13	4.90	35p
H	13	7	6.5	3.60	28p	U	13	10	13	6.00	45p
I	13	10	6.5	4.00	35p	V	18	3	13	4.90	35p
J	18	3	6.5	3.60	28p	W	18	7	13	6.00	45p
K	18	7	6.5	4.90	35p	X	18	10	13	7.60	45p
L	18	10	6.5	6.00	45p	G	Woodgrain			4.00	28p
M	4.5	3	13	2.20	28p						

Sizes in inches

Kit of Sinclair hardware inc. capacitors, plugs, sockets, screws, wire heat sink, fuse, fuse holder, etc. £3.40 P & P 22p.
Sinclair punched case and chassis, Mod 2 type G in wood grain, £4.25 P & P 28p.

Type G is now available in simulated teak in wood grain finish and ideally suited for domestic equipment. Also available ready punched for Sinclair Project 60, with or without A.F.U. It is available with a set of fitting plugs, sockets, fuses, etc.

WEST HYDE

WEST HYDE DEVELOPMENTS LIMITED, RYEFIELD CRESCENT, NORTHWOOD HILLS, NORTHWOOD, MIDDX., HA6 1NN. Telephone: Northwood 24941/26732. Telex: 923231

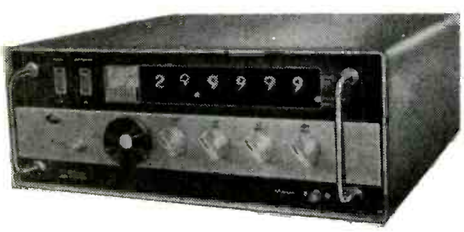
WW—077 FOR FURTHER DETAILS

EXCLUSIVE OFFER of

COMMUNICATION RECEIVERS RC410/R and RC411/R and H.F. SYNTHESIZERS RC460/S

- MANUFACTURED BY WORLD RENOWNED BRITISH COMPANY
- ALL TRANSISTOR/I.C. CIRCUITRY
- COVERAGE RC410/R 2-31MHz in 29 BANDS
  RC411/R 15KHz-31MHz in 31 BANDS
- DIGITAL DISPLAY INDICATING TUNED FREQUENCY GENERATED BY INTEGRAL SYNTHESIZER
- LOCAL OSCILLATOR DRIFT LESS THAN 1 PART IN 10^8 PER DAY
- OVERALL FREQUENCY STABILITY BETTER THAN 5 PARTS IN 10^7

OTHER CHARACTERISTICS INCLUDE:—
Aerial input impedance 50 ohms unbalanced
Maximum Sensitivity:— 0·5μV for 12dB $\frac{(S+N)}{N}$ at standard output (Odbm into 600 ohm balanced load)
Intermediate Frequencies 1·6MHz and 100KHz
I.F. Selectivities:— 3dB Bandwidths of ±3·5KHz, ±1·5KHz, ±0·6KHz, ±0·15KHz.
Notch Filter ±4KHz about a centre frequency of 100KHz.
A.G.C. 3 switched attack/decay times of 10/600, 20/800 and 30/2000 mS.
Audio Output 1 watt into 3 ohms or 10mW into 600 ohms.
Noise Limiter
'S' Meter.
Mains Input 100/125 or 200/250v. 50/60Hz 70W.
Dimensions 9" high, 19·2" wide, 18·75" deep, suitable for 19" rack mounting.



THE SYNTHESIZERS TYPE RC460/S have the following main characteristics:—

- FREQUENCY COVERAGE 1MHz to 29·9999 MHz in 100Hz steps
- FACILITY FOR USING EXTERNAL FREQUENCY STANDARDS OF 5MHz, 1MHz, 200KHz or 100KHz AS WELL AS THE INTERNAL STANDARD of 5MHz
- FREQUENCY STABILITY OF BETTER THAN 1 PART IN 10^6 PER 100 DAYS, 3 PARTS IN 10^8 PER DAY
- OUTPUT 0·3-Iv r.m.s. INTO 50 OHMS (metered)

The Mains supply to the unit is 100/125 or 200/250v. 50/60Hz 60W.
The dimensions 7" high, 19·2" wide, 18" deep, suitable for rack mounting.

PRICES OF THE ABOVE INSTRUMENTS ARE:— **RC410/R £300, RC411/R £350** (List £1,500 approx.)
RC460/S (Bench or Rack Mounting version) **£150**

All instruments supplied complete with handbooks.

Carriage extra at cost but we would recommend customers to arrange to collect from any of the addresses below by appointment at all of which the equipments can be demonstrated. Alternatively, delivery to U.K. Mainland can be arranged by special carrier at a cost of £5 per item (England) or £10 per item (Scotland). (Plus insurance £1.) TERMS: Strictly C.W.O. or supply against official order from approved customers.

THESE RECEIVERS AND SYNTHESIZERS HAVE BECOME AVAILABLE OWING TO RATIONALISATION OF RANGE FOLLOWING AN AMALGAMATION OF COMMERCIAL INTERESTS

DON'T DELAY OUR STOCKS ARE STRICTLY LIMITED!

Demonstration equipments are held at the following points:—
S. and S.W. London: Servo and Electronic Sales Ltd., 67 London Road, Croydon, Surrey. Tel. 01-688-1512. **S.E. London and N.W. Kent:** Servo and Electronic Sales Ltd., 43 High Street, Orpington, Kent. Tel. 31066. **Sussex and Southern England:** G.W.M. Radio Ltd., Portland Road, Worthing, Sussex. Tel. 34897. **E. Kent:** Servo and Electronic Sales Ltd., Mill Road, Lydd (STD 06792), Kent. Tel. Lydd 252. Overseas enquiries and home orders to our Lydd address please.

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AC107	15p	OC170	23p
AC126	13p	OC171	23p
AC127	17p	OC200	25p
AC128	13p	OC201	25p
AC176	25p	2G301	13p
ACY17	15p	2G303	13p
AF239	37p	2N1302-3	40p
AF186	50p	2N1304-5	25p
AF139	37p	2N1306-7	30p
BC154	25p	2N1308-9	35p
BC171=BC107	13p	BC113	10p
BC172=BC108	13p	Power	
BF194	15p	Transistors	
BF274	15p	OC20	50p
BFY50	20p	OC23	30p
BSY25	37p	OC25	25p
BSY26	13p	OC26	25p
BSY27	13p	OC28	30p
BSY28	13p	OC35	25p
BSY29	13p	OC36	37p
BSA95A	13p	AD149	30p
OC41	13p	2N3055	63p
OC44	13p	2SO34	25p
OC45	13p	Diodes	
OC71	13p	AAY42=OA5	10p
OC72	13p	OA91	9p
OC81	13p	OA79	9p
OC81D	13p	OA81	9p
OC139	13p	IN914	7p
OC140	17p		

FREE!

PACKS OF YOUR OWN CHOICE UP TO THE VALUE OF **50p** WITH ORDERS OVER **£4**

CLEARANCE LINES

	1-10	10-50	50+
SL 403D Audio Amp.	2.00	1.95	1.80
IC 709C Linear Opp. Amp.	50p	40p	35p
A.E.I. Fully marked & tested Gates	25p	22p	20p
A.E.I. Fully marked & tested Flipflops	50p	40p	30p
OC71/72. Fully tested, unmarked	5p	5p	4p
Matched Sets, 1-OC44, 2-OC45. Per set	25p	20p	15p
Matched Sets, OC45, 1st & 2nd I.F. Per set	15p	12p	10p
TIC45 Thyristors, 6A, 60V, Texas	15p	15p	12p
OA47 Gold bonded Diodes, marked & tested	3p	3p	2p
1W Zener Diodes: 6.8V, 7.5V, 24V, 27V, 30V & 43V	5p	4p	3p
10W Zener Diodes: 7.5V, 11V, 13V, 20V & 100V	20p	17p	15p
Micro Switches, S/P, C/O. Popular size	25p	20p	15p
1 Amp. Bridge Rectifiers, 25V, RMS	25p	22p	20p

1 Amp Plastic Rectifiers: These are voltage, reverse Polarity and other rejects from the BY127 range. Ideal for low voltage Power Units etc. Price: £1 per 100.

COLOUR T.V. LINE OUTPUT TRANSFORMERS.

Designed to give 25 K.V. when used with PL509 and PY500 valves. As removed from colour receivers at the factory.
ONLY £1 each
post and packing 23p

BUMPER BUNDLES

These parcels contain all types of surplus electronic components, printed panels, switches, potentiometers, transistors and diodes, etc.

2 LBS IN WEIGHT FOR £1
Post and packing 25p

NEW TESTED & GUARANTEED PAKS

B2	4	Photo Cells, Sun Batteries .3 to .5 volt. .5 to 2 ma.	50p
H8	4	BY127 Silicon Recs. 1000 P.I.V. 1 amp. Plastic. Replaces the BY100.	50p
B79	4	1N4007 Sil. Rec. Diodes, 1,000 P.I.V. 1 amp. Plastic.	50p
B81	10	Reed Switches, mixed types, large and small.	50p
B99	200	Mixed Capacitors. Post and packing 13p Approx. Quantity counted by weight.	50p
H4	250	Mixed Resistors. Post and packing 10p. Approx. Quantity counted by weight.	50p
H7	40	Wirewound Resistors. Mixed Values. Postage 7p.	50p
H9	2	OCP71 Light Sensitive Photo Transistors.	50p
H12	20	NKT155/259 Germ diodes, brand new stock clearance.	50p
H18	10	OC71/75 uncoded black glass type PNP Germ.	50p
H19	10	OC81/81D uncoded white glass type PNP Germ.	50p
H28	20	OC200/1/2/3 PNP silicon uncoded To-5 Can	50p
H29	20	OA47 gold bonded diodes coded MCS2.	50p

F.E.T. PRICE BREAKTHROUGH

This field effect transistor is the 2N3823 in a plastic encapsulation; coded 3823E. It is an ideal replacement for the 2N3819. Data Sheet supplied with device.

1—10 = 30p each, 10—50 = 25p each, 50 + 20p each.

OUR VERY POPULAR 3p TRANSISTORS
FULLY TESTED & GUARANTEED

TYPE "A"	TYPE "B"	TYPE "F"	TYPE "E"
PNP Silicon alloy, metal TO-5 can. 2S300 type, direct replacement for the OC200/203 range	**PNP Silicon** PLASTIC ENCAPSULATION, low voltage but good gain, these are of the 2N3702/3 and 2N4059/62 range.	**NPN Silicon** PLASTIC ENCAPSULATION Low Noise Amplifier of the 2N3707/8/9/10/11 Series.	**PNP Germanium** AF OR RF please state on order. Fully marked and tested.

BULK BUYING CORNER

NPN/PNP Silicon Planar Transistors, mixed untested, similar to 2N706/6A/8, BSY26-29, BSY95A, BCY70 etc.
£4.25 per 500. £8.00 per 1,000.

Silicon Planar NPN Plastic Transistors, untested, similar to 2N3707-11 etc.
£4.25 per 500. £8.00 per 1,000.

Silicon Planar Diodes, DO-7 Glass, similar to OA200/202, BAY31-36. £4.50 per 1,000.

NPN/PNP Silicon Planar Transistors, Plastic TO-18, similar to BC113/4, BC153/4, BF153/160 etc.
£4.25 per 500. £8.00 per 1,000.

OC44, OC45 Transistors, fully marked and tested.
500 plus @ 8p each. 1,000 plus @ 6p each.

OC71 Transistors, fully marked and tested.
500 plus @ 6p each. 1,000 plus @ 5p each.

3823E Field effect Transistors. This is the 2N3823 in plastic case.
500 plus @ 13p each. 1,000 plus @ 10p each.

1 Amp Miniature Plastic Diodes:
1N4001. 500 plus @ 3p each. 1,000 plus @ 3p each.
1N4004. 500 plus @ 5p each. 1,000 plus @ 4p each.
1N4006. 500 plus @ 6p each. 1,000 plus @ 5p each.
1N4007. 500 plus @ 8p each. 1,000 plus @ 7p each.

NEW UNMARKED UNTESTED PAKS

B80	8	Dual Trans. Matched O/P pairs NPN. Sil. in TO-5 can	50p
B83	200	Trans. manufacturer's rejects all types NPN, PNP, Sil. and Germ.	50p
B84	100	Silicon Diodes DO-7 glass equiv. to OA200, OA202	50p
B86	50	Sil. Diodes sub. min. IN914 and IN916 types	50p
B88	50	Sil. Trans. NPN, PNP, equiv. to OC200/1, 2N706A, BSY95A, etc.	50p
B60	10	7 watt Xener Diodes Mixed Voltages	50p
H6	40	250mW. Zener Diodes DO-7 Min. Glass Type	50p
H10	25	Mixed volts, 1½ watt Zeners. Top hat type	50p
B66	150	High quality Germ. Diodes. Min. glass type	50p
H15	30	Top Hat Silicon Rectifiers, 750mA. Mixed volts	50p
H16	8	Experimenters' Pak of Integrated Circuits. Data supplied	50p
H20	20	BY126/7 Type Silicon Rectifiers, 1 amp plastic. Mixed volts	50p

Make a Rev. Counter for your Car. The 'TACHO BLOCK'. This encapsulated block will turn any 0-1mA meter into a perfectly linear and accurate rev. counter for any car. **£1 each**

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**ZENER DIODES
TRANSISTORS, RECTIFIERS
FULL PRE-PAK LISTS
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VARIOUS CONTACTS AND COIL RESISTANCES.
NO INDIVIDUAL SELECTION.
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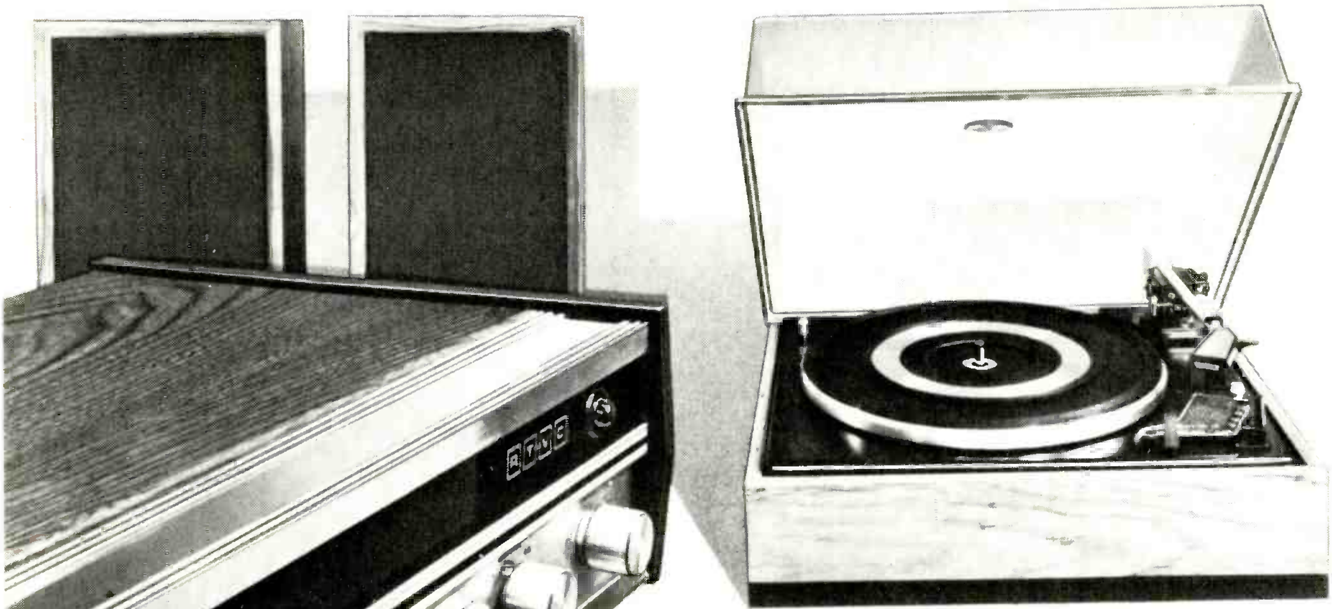
BI-PRE-PAK LTD DEPT. B, 222-224 WEST ROAD, WESTCLIFF-ON-SEA, ESSEX
TELEPHONE: SOUTHEND (0702) 46344

SEE PAGE 93

28watts, r.m.s. 40Hz to 40kHz ± 3dB




Viscount III Audio Suite complete £49

PRICES SYSTEM 1
Viscount III RT101 amplifier £22.00 + 90p p&p
2 x Duo Type II speakers, £14.00 + £2 p&p
Garrard SP25 Mk. III with MAG. cartridge, plinth and cover £23.00 + £1 p&p
Total £59.00
Available complete for only £52.00 + £2.50 p&p.

SPECIFICATION
14 watts per channel into 3 to 4 ohms. Total distortion @ 10W @ 1kHz 0.1%. *P.U.1* 150mV into 3 Meg. *P.U.2* 4mV @ 1kHz into 47K. equalised within ±1dB R.I.A.A. *Radio* 150mV into 220K. (Sensitivities given at full power.) Tape out facilities; headphone socket, power out 250 mW per channel. *Tone controls and filter characteristics.* Bass: + 12 dB to – 17 dB @ 60HZ. Bass filter: 6dB per octave cut. Treble control; treble + 12 dB to – 12 dB @ 15 kHz. Treble filter: 12 dB per octave. *Signal to noise ratio:* (all controls at max) RT101 – P.U.1. & radio – 65dB.P.U.2 – 58 dB. RT100 same as RT101 but P.U.2. 450 mV into 3 Meg. *Cross talk* better than –35dB on all inputs. *Overload charecteristics* 26dB on all inputs.
Size 13¾" x 9" x 3¾".

SYSTEM 2
As System 1, but with 2 x Duo Type III speakers at pair £32.00 + £3 p&p
Available complete for £69 + £4 p&p

SYSTEM 3
Viscount III Amplifier RT100 £17.00 + 90p p&p
2 x Duo Type II speakers, pair £14.00 + £2 p&p
Garrard SP25 Mk. III with CER. diamond cartridge, plinth and cover £21.00 + £1 p&p
Total £52.00
Available complete for only £49.00 + £2.50 p&p

SPEAKERS Duo Type II
Size 17" x 10¾" x 6¾". Drive unit 13" x 8" with parasitic tweeter. Max. power 10 watts. 3 ohms. Teak veneer cabinet. **£14 pair** + £2 p&p.
Duo Type III Size 23½" x 11½" x 9½". Drive unit 13½" x 8½" with H.F. speaker. Max. power 20 watts at 3 ohms. Freq range 20Hz to 20kHz. Teak veneer cabinet. **£32 pair** + £3 p&p.

SOUND 50 — 50 WATT AMPLIFIER & SPEAKER SYSTEM

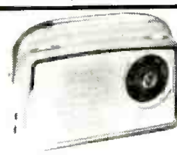
Output Power. 45 watts R.M.S. (Sine wave drive). *Frequency response:* –3 db points 30 Hz at 18 KHz. *Total distortion:* less than 2% at rated output. *Signal to noise ratio:* better than 60 db. *Speaker Impedance:* 3, 8 or 15 ohms. *Bass Control Range:* ±13 db at 60 Hz. *Treble Control Range:* ±12 db at 10 KHz. *Inputs:* 4 inputs at 5 mV into 470 K. Each pair of inputs controlled by separate volume control. 2 inputs at 200 mV into 470K. To protect the output valves, the incorporated fail safe circuit will enable the amplifier to be used at half power. *SPEAKERS:* Size 20" x 20" x 10" incorporating 12" heavy duty 25 watt high flux, quality loudspeaker with cast frame. Cabinets attractively finished in two tone colour scheme—Black and grey.

COMPLETE SYSTEM £50 Plus £4 P. & P.
Sound 50 amp and 2 speakers

or available separately
Amplifier: £28.50 plus £1.50 P. & P.
Speaker: £12.50 each plus £1.75 P. & P.

ELEGANT SEVEN Mk 3
(350mW)

7 transistor fully-tunable M.W.-L.W. superhet portable Set of parts. Complete with all components, including ready etched and drilled printed circuit board—back printed for foolproof construction.
MAINS POWER PACK KIT 75p extra
Price **£5.25** plus 50p P. & P.
Circuit 13p FREE WITH PARTS



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2N697	15p
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2N1132	25p
2N1302	20p
2N1303	20p
2N1304	25p
2N1305	25p
2N1306	25p
2N1307	25p
2N1308	25p
2N1309	25p
2N1613	22p
2N1711	25p
2N2147	75p
2N2160	60p
2N2218	20p
2N2219	20p
2N2222	20p
2N2222A	25p
2N2369	20p
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2N3704	15p
2N3705	15p
2N3707	15p
2N3709	10p
2N3710	10p
2N3819	35p
2N3820	60p
2N4058	15p
2N4061	15p
2N5457	35p
2N5458	37p
2N5459	50p
2S301	50p
2S302	50p
2S303	60p
2S304	75p
40250	50p
40361	50p
40362	55p
AAY30	10p
AAY42	15p
AAZ13	12p
AAZ17	10p
AC107	37p
AC126	25p
AC127	25p
AC128	25p
AC176	25p
AC187	30p
AC188	30p
ACY17	30p
ACY18	25p
ACY19	25p
ACY20	20p
ACY21	20p
ACY22	10p
ACY39	50p
ACY40	15p
AD140	50p
AD149	50p
AD161	37p
AD162	37p
AF114	25p
AF115	25p
AF116	25p
AF117	25p
AF118	62p
AF124	25p
AF125	20p
AF126	17p
AF127	17p
AF139	30p
AF178	47p
AF179	65p
AF180	52p
AF181	42p
AF186	40p
AF239	40p
ASY26	25p
ASY27	32p
ASY28	25p
ASY29	30p
ASY67	47p
ASZ21	42p
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BAX13	6p
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BAY31	7p
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BC108	12p

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BC119	35p
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BC135	20p
BC136	22p
BC137	25p
BC138	25p
BC147	17p
BC148	12p
BC149	20p
BC154	37p
BC157	20p
BC158	17p
BC159	20p
BC169C	15p
BC177	25p
BC178	25p
BC179	27p
BC182L	12p
BC183L	12p
BC184L	15p
BC212	12p
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BCY31	30p
BCY32	50p
BCY33	25p
BCY34	30p
BCY38	40p
BCY39	85p
BCY40	50p
BCY58	25p
BCY59	25p
BCY70	15p
BCY71	20p
BCY72	15p
BCY78	30p
BCY79	30p
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BCZ11	45p
BD112	50p
BD121	65p
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BD131	75p
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BF173	30p
BF177	40p
BF178	25p
BF179	40p
BF180	35p
BF181	35p
BF182	30p
BF184	20p
BF185	20p
BF194	17p
BF195	15p
BF196	15p
BF197	15p
BF200	37p
BF274	37p
BFX13	25p
BFX29	25p
BFX30	25p
BFX37	32p
BFX84	25p
BFX85	35p
BFX86	25p
BFX87	25p
BFX88	20p
BFY18	30p
BFY50	22p
BFY51	20p
BFY52	22p
BFY53	17p
BFY90	65p
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BSX21	20p
BSX76	15p
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MAT101	30p
MAT120	25p
MAT121	30p
MJ2801	£1·37
MJ2901	£2·25
MJE370	97p
MJE520	87p
MJE2955	£1·37
MJE3055	87p
MPF102	42p
MPF103	35p
MPF104	37p
MPF105	40p
NKT217	40p
NKT277	20p
NKT403	75p
NKT404	62p
OA5	20p
OA9	10p
OA10	25p
OA47	10p
OA70	10p
OA73	10p
OA79	10p
OA81	10p
OA85	12p
OA90	10p
OA91	7p
OA95	7p
OA200	7p
OA202	10p
OC16	50p
OC20	97p
OC22	50p
OC23	60p
OC24	60p
OC25	37p
OC26	25p
OC28	60p
OC29	60p
OC35	50p
OC36	60p
OC41	25p
OC42	30p
OC43	40p
OC44	17p
OC45	15p
OC70	12p
OC71	15p
OC72	25p
OC73	30p
OC74	30p
OC75	25p
OC76	25p
OC77	40p
OC81	25p
OC82	25p
OC83	25p
OC84	25p
OC139	25p
OC140	37p
OC141	62p
OC170	25p
OC171	30p
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WE OFFER FROM STOCK AN EXCLUSIVE RANGE OF BRAND NEW CERAMIC FULL SPECIFICATION LOW COST TTL 7400 INTEGRATED CIRCUITS

Part No.	Description	1-24	25-99	100	250+
		Price and Qty. Prices			
7400	Quadruple 2-input Nand Gate	23p	20p	15p	13p
7401	Quadruple 2-input Positive Nand Gate (with open collector output)	23p	20p	15p	13p
7402	Quadruple 2-input Positive Nor Gates	23p	20p	15p	13p
7403	Quadruple 2-input Positive Nand Gates (with open collector output)	23p	20p	15p	13p
7404	Hex Inverters	23p	20p	15p	13p
7405	Hex Inverter with open collector	23p	20p	15p	13p
7410	Triple 3-input Positive Nand Gates	23p	20p	15p	13p
7413	Dual 4-input Schmitt Trigger	35p	32p	29p	25p
7420	Dual 4-input Positive Nand Gates	23p	20p	15p	13p
7430	8-input Positive Nand Gates	23p	20p	15p	13p
7440	Dual 4-input Positive Nand Buffers	23p	20p	15p	13p
7441	BCD to decimal nixie driver	87p	77p	67p	60p
7442	BCD to decimal decoder (4-10 lines, 1 of 10)	87p	77p	67p	60p
7447	BCD-Seven-Segment Decoder/Drivers (15-V outputs)	£1·40	£1·30	£1·20	£1·05
7450	Expandable dual 2-input And-Or-Invert	23p	20p	15p	13p
7451	Dual 2-wide 2-input And-Or-Invert Gates	23p	20p	15p	13p
7453	Quad 2-input Expandable And-Or-Invert	23p	20p	15p	13p
7454	4-wide 2-input And-Or-Invert Gates	23p	20p	15p	13p
7460	Dual 4-input Expander	23p	20p	15p	13p
7470	Single-phase J-K Flip-Flop	35p	32p	29p	25p
7472	Master-slave J-K Flip-Flop	35p	32p	29p	25p
7473	Dual Master-slave J-K Flip-Flop	43p	40p	37p	33p
7474	Dual D type Flip-Flop	43p	40p	37p	33p
7475	Quad latch	47p	45p	43p	40p
7476	Dual J-K with pre-set and clear	47p	45p	43p	40p
7480	Gated Full Adders	87p	77p	67p	60p
7481	16-bit read/write memory	£1·35	£1·25	£1·15	£1·00
7482	2-bit Binary Full Adders	£1·30	£1·20	£1·00	85p
7483	Quad Full Adder	87p	77p	67p	60p
7486	Quad 2-input Exclusive Or Gates	80p	70p	60p	50p
7490	BCD decade counter	87p	77p	67p	60p
7491	8-bit Shift Registers	£1·21	£1·00	87p	75p
7492	Divide-by-Twelve Counters	87p	77p	67p	60p
7493	4-bit Binary Counters	87p	77p	67p	60p
7494	Dual entry 4-bit shift register	87p	77p	67p	60p
7495	4-bit up-down Shift Register	87p	77p	67p	60p
7496	5-bit Parallel in Parallel out Shift Register	87p	77p	67p	60p
74100	8-bit Bistable Latches	£1·75	£1·65	£1·55	£1·35
74118	Hex Set-Reset Latches	£1·30	£1·20	£1·00	85p
74121	Monostable Multivibrators	87p	77p	67p	60p
74141	BCD-to-Decimal Decoder/Driver	87p	77p	67p	60p
74145	BCD-to-Decimal Decoder/Drivers	£1·80	£1·70	£1·60	£1·50
74151	8-bit Data Selectors (with Strobe)	£1·40	£1·30	£1·20	£1·05
74153	Dual 4-Line-to-1-Line Data Selectors/Multiplexers	£1·40	£1·30	£1·20	£1·05
74191	Binary Counter reversible	£3·50	£3·25	£3·00	£2·50

Devices may be mixed to qualify for quantity price.
Data available for above series in booklet form, price 10p. (Ref. No. 30.)
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TRIACS

All stud mounting with accessories. *Larger quantity prices on application. Extn. 4.*

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

SILICON RECTIFIERS

1 AMP MINIATURE WIRE ENDED PLASTIC

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

1·5 AMP MINIATURE WIRE ENDED PLASTIC

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

3 AMP PLASTIC WIRE ENDED RECTIFIERS

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

MINIATURE POTTED BRIDGE RECTIFIERS

(Silicon) Size ¼ in. × ½ in. × ⅜ in.

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

INTEGRATED CIRCUITS

Type	Price	Type	Price
MFC4000P	£1·12	MC1304	£2·75
I.C. 12	£2·75	MC724P	60p
PA246	£2·45	741c (T05)	85p
TAA263	75p	741c (DIL)	85p
TAD100	£1·97	709c (T05)	65p
TAD110	£1·97	709c (DIL)	65p
MC1303	£2·60	Toshiba 20w Amp	£4·47
UL900	40p	Toshiba Pre Amp	£1·50
UL914	40p		
UL923	40p		
LA709C	65p		

Zener Diodes 400 M/W 5% Miniature
BZY 88 Range
All voltages 3·3 Volt-33 Volt.
15p each.
25 + ... 12p
100 + ... 10p
500 + ... 8p
1000 + ... 6p
Any one type.

Zener Diodes 1½ Watt 5% Wire Ends Metal Case
6·8 Volt all voltages to 100 Volts
25p each.
25 + ... 22p
100 + ... 19p
500 + ... 17p
1000 + ... 15p
Any one type.

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

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

POWER RECTIFIERS

Stud Mounting 6 amp Range

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

10 amp Rectifiers

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

SEMI-CONDUCTORS

LOOK AT THESE PRICES FOR QUANTITIES FROM STOCK

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100 + 17p
500 + 15p

AF117 Mullard 25p
25 + 20p
100 + 17p
500 + 15p

2N3055 75p
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25 + 65p
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OC170 Mullard 25p
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25 + 20p
100 + 17p
500 + 5p
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BC107, BC108, BC109 12p each
I.T.T. Planars
25 + 11p
100 + 10p
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1000 + 6p

BY127 Mullard 20p
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100 + 15p
500 + 13p

OCP71 97p
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25 + 85p
100 + 80p
500 + 75p

BC113 15p
SGS
25 + 13p
100 + 11p
500 + 9p
1000 + 8p

OC28 62p
Mullard Power
25 + 55p
100 + 50p
500 + 42p
1000 + 40p

OA202 10p
SILICON Diodes
25 + 8p
100 + 6p
500 + 5p
1000 + 4p

OC71 Mullard 15p
25 + 12p
100 + 10p
500 + 8p
1000 + 7p

OC42 Mullard 30p
25 + 25p
100 + 23p
500 + 21p
1000 + 18p

ORP12 Mullard 50p
25 + 45p
100 + 42p
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OC45 Mullard 15p
25 + 13p
100 + 12p
500 + 10p
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25 + 23p
100 + 20p
500 + 17p
1000 + 15p

OC75 Mullard 25p
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100 + 17p
500 + 15p
1000 + 13p

OC72 Mullard 25p
25 + 20p
100 + 17p
500 + 15p
1000 + 13p

OC20 97p
Mullard 100v
25 + 85p
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OC83 25p
25 + 20p
100 + 17p
500 + 15p
1000 + 13p

OC44 Mullard 17p
25 + 15p
100 + 13p
500 + 11p
1000 + 10p

OC84 25p
25 + 20p
100 + 17p
500 + 15p
1000 + 13p

OC139 Mullard 25p
25 + 20p
100 + 17p
500 + 15p
1000 + 13p

OC81 Mullard 25p
25 20p
100 + 17p
500 + 15p
1000 + 13p

AF239 42p
25 + 35p
100 + 30p
500 + 25p
1000 + 20p

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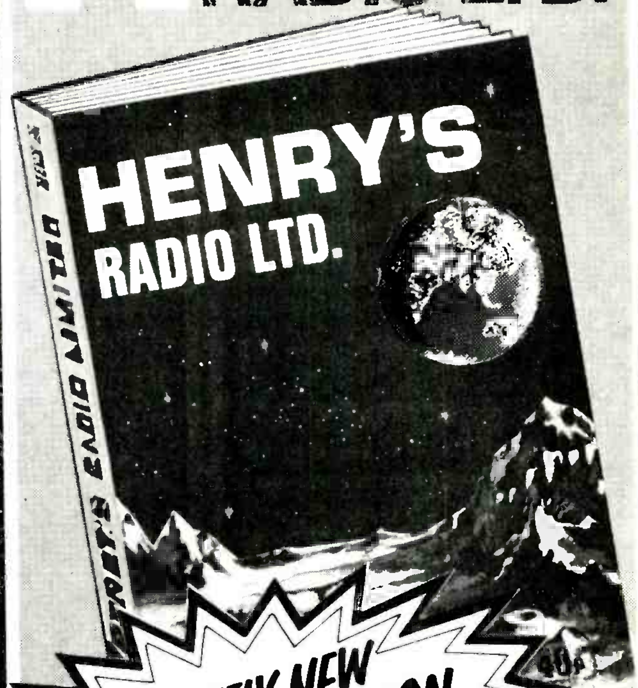

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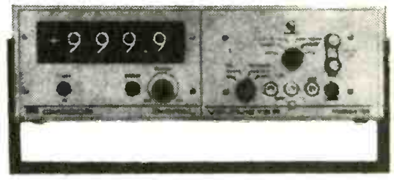

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Scale 9999. D.C. range. 10 micro-volt—1 kV. I/P. Z. greater than 10,000 Mohms. B.C.D. Parallel O/P (isolated). Supplied with D.2 Module. Overhauled Calibration certificate. To maker's specification. New price £765. Our price **£400**. Carriage extra.

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These machines, originally ex-computer, are multi-track recording units, ideal for data storage. Record and Replay heads encased in one common unit. Low resistance heads. Frequency response approximately 0 Kc/s. to 50 Kc/s. Bit density 557 b.p.i. ½ in., 10½ in. spools 230 v. to 380 v. A.C. Capstan Motor speed 1,500 r.p.m. 48 v. D.C. Rewind motors. Finished in brush aluminium and matt-black. Size 27 in. × 26 in. × 8 in. Weight 90 lb. Price **£65**. Carriage extra.

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Ferrite core memory planes with wired Ferrite cores. Used for building your own computer or as an interesting exhibit in the demonstration of a computer. Mounted on plastic material, frame 5×8 in. Consisting of matrices 40×25×4 cores each one individually addressable and divided into 2 halves with independent sense and inhibit wires. **£6·65**. P. & P. inclusive.

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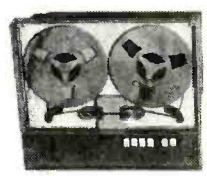
½ in. N.A.B. centres 10½ in. spool only	£1·00

HONEYWELL MODEL 6200 INCREMENTAL DIGITAL RECORDER



Records digital (binary) data on 7 track ½ in. tape in steps of 0·005 in. with a packing density of 200 bits/inch. Almost new and in excellent condition. This recorder offers excellent value for many applications involving date, logging. One only available. Price: **£750**.

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50 MHz. 8 DIGIT FREQUENCY COUNTER SYSTRON-DONNER Model 1037

D.C. I/P 0-50 MHz. A.C. I/P 10-50 MHz. Gate time 1 micro-second—10 seconds in Decade steps. Accuracy ± 1 count ± time base accuracy. Reads in KHz or MHz with positioned decimal point. Sensitivity 100 Mv. r.m.s. B.C.D. O/P. PRINT COMMAND. OVERLOAD PROTECTION. DIMENSIONS: H. 5¼ in., W. 17¼ in., D. 17¾ in. Wt. 42 lbs. Mains I/P. This instrument has been overhauled and calibrated and is offered in excellent condition. **£350**. Carriage extra.

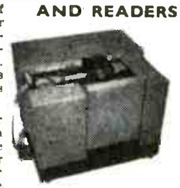
EYELET BONDER PLANER B801

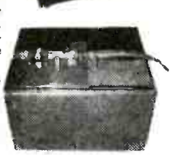
V.G. condition. C/W stand. Overhauled. **£750**.

5 KV IONISATION TESTER AIRMEC 732

Non-destructive insulation testing. Audible indication of ionisation currents. Variable voltage from 250-5 kV. High impedance source. Mains I/P. **£35**.

WELMEC 5-8 CHANNEL TAPE PUNCHES AND READERS





Magnetically driven up to speed of 17 codes/second. Ideally suitable for data logging applications. NO continuously running motor. NO power consumption unless actually punching. Ideal producing tape from keyboards or office machines. Free standing units in attractive cases.

PUNCH contains transport and power solenoids 240V AC (pulsed operation required). Punch magnets, Reverse transport magnet and Tape marker Magnet 110V DC. PARITY unit for checking parity or coincidence. Large chad BOX to prevent jamming. High Chad Bridge to eliminate punch blocking. OUR PRICE **£75** each. Carriage extra.

READER. Transport and Power solenoids 240V DC (pulsed operation). All units completely refurbished and available EX-STOCK. Supplied with circuit diagrams and 3 months warranty. OUR PRICE **£75** each. Carriage extra.

FACSIMILE RECORDERS

D649 K 18 in. Chart Recorder. Helix speed: 60, 90, 120 rev./min. Transmission speed: ½ in.; 15/16 in.; 1⅞ in. per min. Scanning rate 96 lines/in.
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Table size: 11 in. × 17 in. Dimensions: W. 24 in., H. 9 in., D. 16 in. Wt. 55 lbs. Power I/P: 115 v. 1 phase 100 w. Signal I/P: X Axis 0-7½, 15, 75, 150, 750 mV; 0-1½, 7½, 15, 75, 150 v. Y Axis 0-5, 10, 50, 100, 500 mV; 0-1, 5, 10, 50, 100 v. Sensitivity not less than 200 k ohms/V. Accuracy: 0·25% FS on all ranges. Response speeds: 1 sec. for full scale. Supplied complete with copy of handbook. **£310** Carriage extra.

2. HOUSTON INSTRUMENTS MODEL HR 934

Table size: 8½ in. × 10½ in. Dimensions: W. 14 in., H. 8 in., D. 16 in., Wt. 30 lb. Power I/P: 115 v. 1 phase. Signal I/P: "X" and "Y" Axes. 0-7, 7-8, 10, 19, 68 mV and 0-5 v. Switched Attenuators on both Axes. Response speeds: 2 sec. for full scale. **£195**. Carriage extra.

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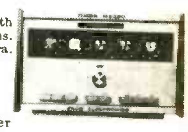

An extremely versatile timer for use with high stability pulse counting systems. Less power supply. **£45**. Carriage extra.

TRANSISTORISED SCALER M5200

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This unit can be used to power the Timer M5220.

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25Hz-500K Hz. Attenuator and O/P meter. Very good condition. **£55** (carriage extra).

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SANDERS MODEL CT 480 (SG 480) and CT 478 (SG 478). Specifications: CT 480 8-11·5 KMHz; CT 478 1·3-4·2 KMHz. O/P of 1mW from 8·0-11·0 KMHz (CT 480) and 1·5-4·0 KMHz (CT 478). These high grade generators comprise a klystron oscillator in a co-axial cavity fed from a stable power source. Provision for application of square wave or pulse modulation internal or external sources. Attenuator calibrated from 0-100 db below 1 mW. I/P 110-250 v. 50-500 Hz. 200 w. Rack mounting. W. 19 in., H. 14 in., D. 15 in. Wt. 74 lb. Supplied complete with copy of handbook. Tested before despatch. **£275**. Carriage extra.

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20-100 MHz. Can be used to 500 MHz. Measurement of deviation up to 400 KHz. Crystal Standard. Used in setting up deviation in VHF Wide Band Multi Channel FM Systems and Radar. I/P 100-150 v. and 200-250 v. 40-100 Hz 120 w. H. 14", W. 20½", D. 17" Wt. 70 lb. **£95·00**. Carriage extra.

NUMICATORS

		Quantity	Price Each (less Base)	Bases
End Reading 0-9 Display (16 mm Fig. Ht.)				
GRIOM/U (Clear)		1– 3	£1·40	
GR1OM (Amber filter)		4– 10	£1·35	20p
		11– 25	£1·30	Each
		26–100	£1·20	

Side Reading (14 m/m Fig. Ht.) 0-9 display

				Less Bases
XN3/FA	38 m/m lead	(Amber filter)		
XN3/F	38 m/m lead	(Red „)	1– 3	£1·15
XN3A/F	6 m/m lead	(Red „)	4– 10	£1·10
XN3A	6 m/m lead	(Clear „)	11– 25	£1·05
XN11/F	38 m/m lead	(Red „)	26–100	£0·95
XN23/FA	38 m/m lead	(Amber „)		

Post Free.

SPECIAL DISPLAYS

XN9	38 m/m leads	(Clear filter)	Displays Fig. "1"
NX10/C	6 m/m leads	(Clear filter)	Displays "+, — and ∞"
NX22	38 m/m leads	(Clear filter)	Displays "Vx, A, Ω Vmv"

RCA U.H.F. SIGNAL GENERATOR Type 710A

Frequency range 370-560 MHz. Modulation facility. I/P 117 v. 50/60 Hz 50w. Overhauled and supplied complete with auto transformer for 230/250 v. I/P. **£85** (carriage extra).

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An exceptionally stable laboratory instrument for the measurement of very small d.c. voltages and currents derived from a high impedance source. The Vibron Electrometer has input ranges of 10 mV, 30 mV, 100 mV, 300 mV and 1 V and the output is 1 mA full scale on all ranges. **£75** (carriage extra).

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To extend the range of the ELECTROMETER to measure very small currents and high insulation resistances. **£15**.

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USED EXTENSIVELY BY INDUSTRY, GOVERNMENT DEPARTMENTS, EDUCATIONAL AUTHORITIES, ETC.

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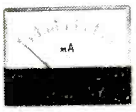


TYPE SW. 100

100 x 80 mm.

50μA	£3·47½	20V. D.C.	£2·97½
50-0-50μA	£3·37½	50V. D.C.	£2·97½
100μA	£3·37½	300V. D.C.	£2·97½
100-0-100μA	£3·25	1 amp. D.C.	£2·97½
500μA	£3·12½	5 amp. D.C.	£2·97½
1mA	£2·97½	300V. A.C.	£2·97½
		VU Meter	£3·75

BAKELITE PANEL METERS

TYPE S-80

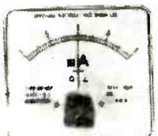
80 mm.

square fronts

50μA	£3·12½	50V. D.C.	£2·47½
50-0-50μA	£2·97½	300V. D.C.	£2·47½
100μA	£2·97½	1 amp. D.C.	£2·47½
100-0-100μA	£2·87½	5 amp. D.C.	£2·47½
500μA	£2·62½	300V. A.C.	£2·62½
1mA	£2·47½	VU Meter	£3·37½
20V. D.C.	£2·47½		

"SEW" CLEAR PLASTIC METERS

Type MR.85P. 4¼in. × 4¼in. fronts.



50μA	£3·60	10mA	£2·60
50-0-50μA	£3·10	50mA	£2·60
100μA	£3·10	100mA	£2·60
100-0-100μA	£3·10	500mA	£2·60
200μA	£2·87½	1 amp.	£2·60
500μA	£2·75	5 amp.	£2·60
500-0-500μA	£2·60	15 amp.	£2·60
1mA	£2·60	30 amp.	£2·60
1-0-1mA	£2·60	20V. D.C.	£2·60
5mA	£2·60	50V. D.C.	£2·60
		150V. D.C.	£2·60
		300V. D.C.	£2·60
		15V. A.C.	£2·60
		300V. A.C.	£2·60
		8 Meter 1mA	£2·87½
		VU Meter	£3·60
		1 amp. A.C.*	£2·60
		5 amp. A.C.*	£2·60
		10 amp. A.C.*	£2·60
		20 amp. A.C.*	£2·60
		30 amp. A.C.*	£2·60

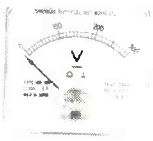
Type MR.52P. 2½in. square fronts.

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

Type MR.65P. 3½in. × 3½in. fronts

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

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



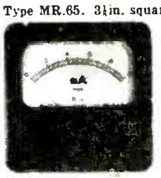
50μA	£2·00	200mA	£1·37½
50-0-50μA	£1·87½	300mA	£1·37½
100μA	£1·87½	500mA	£1·37½
100-0-100μA	£1·75	750mA	£1·37½
200μA	£1·75	1 amp.	£1·37½
500μA	£1·50	2 amp.	£1·37½
500-0-500μA	£1·37½	5 amp.	£1·37½
1mA	£1·37½	10 amp.	£1·37½
1-0-1mA	£1·37½	3V. D.C.	£1·37½
2mA	£1·37½	10V. D.C.	£1·37½
5mA	£1·37½	15V. D.C.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

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

50μA	£2·25	5 amp.	£1·50
50-0-50μA	£2·10	10V. D.C.	£1·50
100μA	£2·10	20V. D.C.	£1·50
100-0-100μA	£1·87½	50V. D.C.	£1·50
200μA	£1·87½	300V. D.C.	£1·50
500μA	£1·60	15V. A.C.	£1·50
500-0-500μA	£1·50	300V. A.C.	£1·50
1mA	£1·50	8 Meter 1mA	£1·87½
5mA	£1·50	VU Meter	£2·25
10mA	£1·50	1 amp. A.C.‡	£1·50
50mA	£1·50	5 amp. A.C.‡	£1·50
100mA	£1·50	10 amp. A.C.‡	£1·50
500mA	£1·50	20 amp. A.C.‡	£1·50
1 amp.	£1·50	30 amp. A.C.‡	£1·50

"SEW" BAKELITE PANEL METERS

Type MR.65. 3¼in. square fronts.



25μA	£3·50	500mA	£1·75
50μA	£2·37½	1 amp.	£1·75
50-0-50μA	£2·25	5 amp.	£1·75
100μA	£2·25	15 amp.	£1·75
100-0-100μA	£2·25	30 amp.	£1·75
500μA	£2·10	50 amp.	£1·75
1mA	£1·75	5V. D.C.	£1·75
1-0-1mA	£1·75	10V. D.C.	£1·75
5mA	£1·75	20V. D.C.	£1·75
10mA	£1·75	50V. D.C.	£1·75
50mA	£1·75	150V. D.C.	£1·75
100mA	£1·75	300V. D.C.	£1·75
		30V. A.C.*	£1·75
		50V. A.C.*	£1·75
		150V. A.C.*	£1·75
		300V A.C.*	£1·75
		500mA A.C.*	£1·75
		1 amp. A.C.*	£1·75
		5 amp. A.C.*	£1·75
		10 amp. A.C.*	£1·75
		20 amp. A.C.*	£1·75
		30 amp. A.C.*	£1·75
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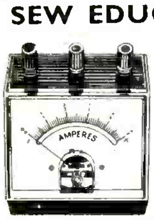

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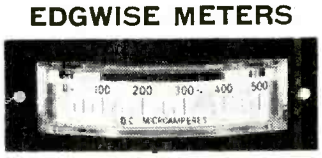

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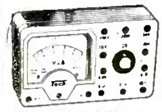

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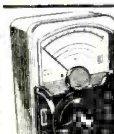

MODEL 500 30,000 O.P.V. with overload protection, mirror scale. 0/.5/2.5/10/25/100/250/500/1,000 v. D.C. 0/2.5/10/25/100/250/500/1,000 v. A.C. 0/50μA/5/50/500 mA. 12 amp. D.C. 0/60/K/6 meg. 60 meg Ω. **£8·87½**. Post paid.

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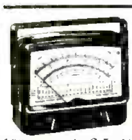

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Number of digits: 3 plus fourth overrange digit.
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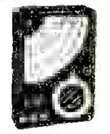

HONOR TE.10A. 20 kΩ/Volt 5/25/50/250/500/2,500 v. D.C. 10/50/100/500/1,000 v. A.C. 0/50μA/2.5 mA/250 mA D.C. 0/6K/6 meg. ohm. −20 to + 22 dB. 10-0, 100 mfd. 0.100-0.1 mfd. **£3·47½**. P. & P. 15p.

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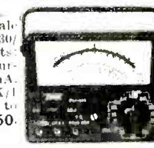

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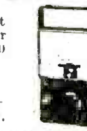

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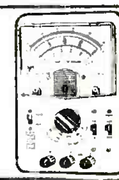

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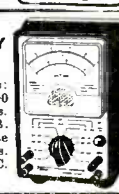

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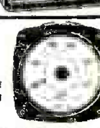

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FJH141	0·87½
FJH161	0·87½
FJH171	0·91
FJH221	0·87½
FJJ101	1·37½
FJJ121	1·87½
FJJ141	3·12½
FJJ191	1·87½
FJJ251	3·12½
FJY101	0·80

MULLARD DTL	£
FCH101	0·87½
FCH121	1·05
FCH161	1·05
FCH201	1·32½
FCH231	1·50
FCJ101	1·62½
FCJ111	1·55
FCJ201	1·80
FCJ211	2·75
FCK101	4·37½
FCY101	1·05

PLESSEY	£
SL403A 3 watt amp.	2·12½
SL701C	1·45

SGS	£
TAA661B	1·92½
TAA621 4 watt amp.	2·15

MULLARD LINEAR	£
TAA241	1·62½
242	4·25
243	1·50
263	0·77½
293	0·97½
300	1·75
310	1·25
320	0·72½
350	1·75
435	1·47½
521	1·32½
522	3·60
530	4·95
570	1·97½
811	4·45
TAB101	0·97½
TAD100	1·97½
TAD110	1·97½

GENERAL ELECTRIC	£
PA222	2·60
PA230	1·40
PA234	0·92
PA237	2·10
PA239	2·10
PA246	1·60
PA264	1·90
PA265	2·00
PA424	2·05
PA436	1·90
PA494	2·05

Data & Application Sheets 5p per type.

TOSHIBA	£
TH9013P 20 watt amp.	4·57
TH9014P Pre-amp	1·65
Data sheets	0·12½

BRIDGE RECTIFIERS

CIR-KIT	AMP.	PIV	£	SILICONE GREASE
1/16" £0·15	1	600	0·40	Redpoint
⅛" £0·15	1·5	100	0·47½	Thermapath
P.C.	2	100	0·60	(approx.
BOARD	4	100	0·70	2 ozs.)
For PA246	4	200	0·75	£0·20
I.C. circuit	6	50	0·62½	
as in Data	6	200	0·80	
Sheet. £0·65	6	400	1·12½	

A. MARSHALL & SON LTD.

See our Ad. on opposite page for Transistors, Diodes, Passive Components and P. & P. charges. Many more types in stock and arriving daily. PLEASE ENQUIRE.

LARGEST STOCK WIDEST SELECTION LOW PRICES AND RETURN OF POST SERVICE

TRANSISTORS Brand new and fully guaranteed. PLEASE NOTE:—Matching charge (Audio Transistors only) 12½p extra per pair. Many more semi-conductors in stock. Please enquire for types not listed.

2G301	0·20
2G302	0·20
2G303	0·20
2G306	0·42½
2G308	0·30
2G309	0·30
2G371	0·15
2G374	0·20
2G381	0·22½
2N388A	0·62½
2N404	0·22½
2N696	0·20
2N697	0·20
2N698	0·25
2N699	0·62½
2N706	0·12½
2N706A	0·12½
2N708	0·15
2N709	0·62½
2N718	0·25
2N718A	0·30
2N726	0·30
2N727	0·30
2N914	0·17½
2N916	0·17½
2N918	0·30
2N929	0·22½
2N930	0·27½
2N987	0·52½
2N1090	0·22½
2N1091	0·22½
2N1131	0·25
2N1132	0·25
2N1302	0·17½
2N1303	0·17½
2N1304	0·22½
2N1305	0·22½
2N1306	0·25
2N1307	0·25
2N1308	0·30
2N1309	0·30
2N1507	0·17½
2N1613	0·25
2N1631	0·35
2N1632	0·30
2N1637	0·30
2N1638	0·27½
2N1639	0·27½
2N1671B	1·00
2N1701	1·62½
2N1711	0·25
2N1889	0·32½
2N1893	0·37½
2N2147	0·82½
2N2148	0·57½
2N2160	0·57½
2N2193	0·40
2N2193A	0·42½
2N2194A	0·30
2N2217	0·27½
2N2218	0·32½
2N2219	0·32½
2N2220	0·25
2N2221	0·25
2N2222	0·30
2N2297	0·30
2N2368	0·17½
2N2369	0·17½
2N2369A	0·17½
2N2410	0·42½
2N2483	0·27½
2N2484	0·32½
2N2539	0·22½
2N2540	0·22½
2N2613	0·35
2N2614	0·30
2N2646	0·52½
2N2696	0·32½
2N2711	0·25
2N2712	0·25
2N2713	0·27½
2N2714	0·30
2N2865	0·62½
2N2904	0·30
2N2904A	0·32½
2N2905	0·37½
2N2905A	0·40
2N2906	0·25
2N2906A	0·27½
2N2907	0·30
2N2923	0·15
2N2924	0·15
2N2925	0·15
2N2926	
Green	0·14
Yellow	0·12½
Orange	0·12½
2N3011	0·30
2N3014	0·32½
2N3053	0·25
2N3054	0·50
2N3055	0·75
2N3133	0·30
2N3134	0·30
2N3135	0·25
2N3136	0·25
2N3340	0·97½
2N3349	1·30
2N3390	0·25
2N3391	0·20
2N3391A	0·30
2N3392	0·17½

2N3393	0·15
2N3394	0·15
2N3402	0·22½
2N3403	0·22½
2N3404	0·32½
2N3405	0·45
2N3414	0·22½
2N3415	0·22½
2N3416	0·37½
2N3417	0·37½
2N3439	1·30
2N3440	0·97½
2N3570	1·25
2N3572	0·97½
2N3605	0·27½
2N3606	0·27½
2N3607	0·22½
2N3702	0·12½
2N3703	0·12½
2N3704	0·17½
2N3705	0·15
2N3706	0·12½
2N3707	0·15
2N3708	0·09
2N3709	0·10
2N3710	0·11
2N3711	0·12
2N3713	1·87½
2N3714	2·00
2N3715	2·22½
2N3716	2·90
2N3773	2·40
2N3791	2·75
2N3819	0·35
2N3823	0·97½
2N3854	0·27½
2N2754A	0·27½
2N3855	0·27½
2N3855A	0·30
2N3856	0·30
2N3856A	0·35
2N3858	0·25
2N3858A	0·30
2N3859	0·27½
2N3859A	0·32½
2N3860	0·30
2N3866	1·50
2N3877	0·40
2N3877A	0·40
2N3900	0·37½
2N3900A	0·40
2N3901	0·97½
2N3903	0·35
2N3904	0·35
2N3905	0·37½
2N3906	0·37½
2N4058	0·17
2N4059	0·10½
2N4060	0·12½
2N4061	0·12½
2N4062	0·12½
2N4244	0·47½
2N4245	0·42½
2N4254	0·42½
2N4255	0·42½
2N4284	0·17½
2N4285	0·17½
2N4286	0·17½
2N4287	0·17½
2N4288	0·17½
2N4289	0·17½
2N4290	0·17½
2N4291	0·17½
2N4292	0·12½
2N4303	0·47½
2N5027	0·52½
2N5028	0·57½
2N5029	0·47½
2N5030	0·42½
2N5172	0·12½
2N5174	0·52½
2N5175	0·52½
2N5176	0·45
2N5232A	0·30
2N5245	0·45
2N5246	0·42½
2N5249	0·67½
2N5265	3·25
2N5266	2·75
2N5267	2·62½
2N5305	0·37½
2N5306	0·40
2N5307	0·37½
2N5308	0·37½
2N5309	0·62½
2N5310	0·42½
2N5354	0·27½
2N5355	0·27½
2N5356	0·32½
2N5365	0·47½
2N5366	0·32½
2N5367	0·57½
2N5457	0·37½
2S005	0·75
2S020	2·00
2S102	0·50
2S103	0·25
2S104	0·25
2S501	0·32½
2S502	0·35
2S503	0·27½
3N83	0·40

3N128	0·70
3N140	0·77½
3N141	0·72½
3N142	0·55
3N143	0·67½
3N152	0·87½
R.C.A.	0·52½
40050	0·55
40250	0·87½
40251	0·87½
40309	0·32½
40310	0·45
40311	0·35
40312	0·47½
40314	0·37½
40315	0·37½
40316	0·47½
40317	0·37½
40319	0·55
40320	0·47½
40323	0·32½
40324	0·47½
40326	0·37½
40329	0·30
40344	0·27½
40347	0·38
40348	0·52½
40360	0·42½
40361	0·47½
40362	0·57½
40370	0·32½
40406	0·57½
40407	0·40
40408	0·52½
40409	0·55
40410	0·62½
40412	0·50
40467A	0·57½
40468A	0·35
40528	0·72½
40600	0·57½
40673	1·25
AC107	0·30
AC126	0·20
AC127	0·25
AC128	0·20
AC154	0·22½
AC176	0·25
AC187	0·62½
AC188	0·37½
ACY17	0·27½
ACY18	0·25
ACY19	0·25
ACY20	0·25
ACY21	0·25
ACY22	0·20
ACY28	0·20
ACY40	0·20
ACY41	0·25
ACY44	0·40
AD140	0·52½
AD149	0·57½
AD150	0·62½
AD161	0·37½
AD162	0·37½
AF106	0·42½
AF114	0·25
AF115	0·25
AF116	0·25
AF117	0·25
AF118	0·62½
AF119	0·20
AF124	0·22½
AF125	0·20
AF126	0·20
AF127	0·17½
AF139	0·37½
AF178	0·42½
AF179	0·72½
AF180	0·52½
AF181	0·42½
AD239	0·42½
AF279	0·47½
AF280	0·62½
AF211	0·32½
ASY26	0·25
ASY27	0·37½
ASY28	0·27½
ASY29	0·27½
ASY26	0·25
ASY50	0·25
ASY51	0·32½
ASY53	0·25
ASY54	0·25
ASY62	0·25
ASY63	0·17½
ASY72	0·25
ASY83	0·25
ASY86	0·32½
ASZ21	0·42½
AU103	1·25
BC107	0·12½
BC108	0·12½
BC109	0·12½
BC113	0·20
BC114	0·25
BC115	0·27½
BC116	0·27½
BC116A	0·27½
BC118	0·32½
BC121	0·20

BC122	0·20
BC125	0·35
BC126	0·35
BC140	0·37½
BC147	0·17½
BC148	0·12½
BC149	0·17½
BC152	0·17½
BC157	0·20
BC158	0·17½
BC159	0·20
BC160	0·62½
BC167	0·15
BC168B	0·14
BC168C	0·15
BC169B	0·14
BC169C	0·15
BC170	0·12½
BC171	0·15
BC172	0·15
BC175	0·22½
BC182	0·12½
BC183	0·12½
BC184	0·15
BC182L	0·10
BC183L	0·10
BC184L	0·15
BC212L	0·12½
BCY10	0·27½
BCY12	0·27½
BCY30	0·27½
BCY31	0·30
BCY32	0·50
BCY33	0·25
BCY34	0·30
BCY38	0·40
BCY39	0·60
BCY40	0·50
BCY42	0·15
BCY43	0·15
BCY54	0·32½
BCY58	0·22½
BCY59	0·22½
BCY60	0·97½
BCY70	0·20
BCY71	0·42½
BCY72	0·17½
BCZ10	0·27½
BCZ11	0·42½
BD116	1·12½
BD121	0·65
BD123	0·82½
BD124	0·82½
BD131	0·75
BD132	0·85
BDY10	1·37½
BDY11	1·62½
BDY17	1·50
BDY18	1·75
BDY19	1·97½
BDY20	1·12½
BDY38	0·97½
BDY60	1·25
BDY61	1·25
BDY62	1·00
BF115	0·25
BF117	0·47½
BF163	0·37½
BF167	0·25
BF173	0·32½
BF177	0·30
BF178	0·62½
BF179	0·30
BF180	0·35
BF181	0·32½
BF184	0·25
BF185	0·42½
BE194	0·17½
BF195	0·20
BF196	0·42½
BF197	0·42½
BF198	0·42½
BF200	0·52½
BF224	0·20
BF225	0·20
BF237	0·22½
BF238	0·22½
BF244	0·32½
BFW61	0·47½
BFX12	0·22½
BFX13	0·22½
BFX29	0·30
BFX30	0·30
BFX43	0·37½
BFX44	0·37½
BFX51	0·20
BFX68	0·67½
BFX84	0·25
BFX85	0·32½
BFX86	0·25
BFX87	0·27½
BFX88	0·25
BFX89	0·62½
BFX93A	0·70
BFY10	0·32½
BFY11	0·42½
BFY17	0·22½
BFY18	0·32½
BFY19	0·32½
BFY20	1·60
BFY21	0·42½
BFY24	0·45

BFY25	0·25
BFY26	0·20
BFY29	0·50
BFY30	0·50
BFY41	0·50
BFY43	0·62½
BFY50	0·22½
BFY51	0·22½
BFY52	0·22½
BFY53	0·17½
BFY56A	0·57½
BFY75	0·30
BFY76	0·42½
BFY77	0·57½
BFY90	0·67½
BFW58	0·27½
BFW59	0·25
BFW60	0·25
BPX25	1·85
BPX29	1·80
BPY10	1·45
BRY29	0·47½
BSX19	0·17½
BSX20	0·17½
BSX21	0·37½
BSX26	0·45½
BSX27	0·47½
BSX28	0·32½
BSX60	0·82½
BSX61	0·62½
BSX76	0·22½
BSX77	0·27½
BSX78	0·27½
BSY10	0·27½
BSY11	0·27½
BSY24	0·15
BSY25	0·15
BSY26	0·17½
BSY27	0·17½
BSY28	0·17½
BSY29	0·17½
BSY32	0·25
BSY36	0·25
BSY37	0·25
BSY38	0·22½
BSY39	0·22½
BSY40	0·32½
BSY51	0·32½
BSY52	0·32½
BSY53	0·37½
BSY54	0·40
BSY56	0·90
BSY78	0·47½
BSY79	0·45
BSY82	0·52½
BSY90	0·57½
BSY95A	0·12½
BSW41	0·42½
BSW70	0·27½
C111	0·75
C424	0·27½
C425	0·55
C426	0·40
C428	0·37½
C744	0·30
ME0402	0·25
ME0411	0·22½
ME0412	0·25
ME0413	0·22½
ME1120	0·25
ME4001	0·15
ME4002	0·15
ME4003	0·20
ME4101	0·15
ME4102	0·17½
ME4103	0·15
ME6101	0·20
MJ400	1·07½
MJ420	1·12½
MJ421	1·12½
MJ430	1·02½
MJ440	0·95
MJ480	0·97½
MJ481	1·25
MJ490	1·00
MJ491	1·37½
MJ802	4·12
MJ4502	4·44
MJ1800	2·17½
MJE340	0·62½
MJE520	0·87½
MJE521	0·87½
MJE2955	1·37½
MJE3055	0·87½
MPF102	0·42½
MPF103	0·37½
MPF104	0·37½
MPF105	0·37½
MPS3638	0·32½
NKT0013	0·47½
NKT124	0·42½
NKT125	0·27½
NKT126	0·27½
NKT128	0·27½
NKT135	0·27½
NKT137	0·32½
NKT210	0·30
NKT211	0·30
NKT212	0·30
NKT213	0·30
NKT214	0·22½

NKT215	0·22½
NKT216	0·37½
NKT217	0·42½
NKT219	0·30
NKT223	0·27½
NKT224	0·25
NKT225	0·22½
NKT229	0·30
NKT237	0·35
NKT238	0·25
NKT240	0·27½
NKT241	0·27½
NKT242	0·20
NKT243	0·62½
NKT244	0·17½
NKT245	0·20
NKT261	0·20
NKT262	0·30
NKT264	0·20
NKT271	0·20
NKT272	0·20
NKT274	0·20
NKT275	0·20
NKT281	0·27½
NKT401	0·87½
NKT402	0·90
NKT403	0·75
NKT404	0·62½
NKT405	0·75
NKT406	0·62½
NKT451	0·62½
NKT452	0·62½
NKT453	0·47½
NKT603F	0·32½
NKT613F	0·32½
NKT674F	0·30
NKT677F	0·30
NKT713	0·25
NKT717	0·42½
NKT734	0·27½
NKT736	0·35
NKT773	0·25
NKT781	0·30
NKT10339	0·32½
NKT10419	0·30
NKT10439	0·37½
NKT10519	0·32½
NKT20329	0·47½
NKT20339	0·37½
NKT80111	0·77½
NKT80112	0·97½
NKT80113	1·12½
NKT80211	0·92½
NKT80212	0·92½
NKT80213	0·92½
NKT80214	0·92½
NKT80215	0·92½
NKT80216	0·92½
OC20	0·75
OC22	0·50
OC23	0·60
OC24	0·60
OC25	0·50
OC26	0·27½
OC28	0·62½
OC29	0·62½
OC35	0·50
OC36	0·62½
OC41	0·22½
OC42	0·25
OC44	0·20
OC45	0·12½
OC46	0·15
OC70	0·15
OC71	0·12½
OC72	0·12½
OC74	0·32½
OC75	0·22½
OC76	0·22½
OC77	0·30
OC81	0·20
OC81D	0·22½
OC83	0·25
OC84	0·25
OC139	0·32½
OC140	0·32½
OC170	0·30
OC171	0·30
OC200	0·40
OC201	0·60
OC202	0·75
OC203	0·42½
OC204	0·42½
OC205	0·90
OC207	0·75
OCP71	0·42½
ORP12	0·62½
ORP61	0·50
P346A	0·22½
TIS34	0·62½
TIS43	0·40
TIS44	0·12½
TIS45	0·12½
TIS46	0·12½
TIS47	0·12½
TIP29A	0·50
TIP30A	0·60
TIP31A	0·62½
TIP32A	0·75
TIP33A	1·02½
TIP34A	2·05

PANEL METERS
38 Series—FACE SIZE 42 × 42 mm. All prices for 1-9 pieces. All meters D.C. £

		£
50	Microamp	2·00
100	,,	1·87½
200	,,	1·75
500	,,	1·50
50-0-50	,,	1·87½
100-0-100	,,	1·75
500-0-500	,,	1·37½
1	Milliamp	1·37½
5	Milliamp	1·37½
10	,,	1·37½
50	,,	1·37½
100	,,	1·37½
500	,,	1·37½
1	Amp	1·37½
5	,,	1·37½
10	Volts	1·37½
20	,,	1·37½
50	,,	1·37½
300	,,	1·37½
500	,,	1·37½

SPEAKERS (3 ohm) £

10" × 6"	2·37½	3"	0·62½
9" × 4"	1·27½	5"	0·72½
8" × 5"	1·27½	8" Ceramic	2·37½
7" × 4"	0·97½	12"	1·97½
5" × 3"	0·75	*Post and packing*	0·15

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

CARBON POTENTIOMETERS £
Log. and Lin. Less switch .. .. 0·16
Log. and Lin. With switch .. .. 0·25
Wire-wound Pots (3 watts) .. .. .. 0·37½
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HEAT SINKS £
4·8" × 4" × 1" Finned for Two TO-3 Trans. .. 0·47½
4·8" × 2" × 1" Finned for One TO-3 Trans. .. 0·32½
For SO-1 0·025 For TO-5 0·05 Finned
For TO-18 0·05 Finned For TO-1 0·05 Finned

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

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

POSTAGE AND PACKING CHARGES
U.K. .. .. 0·12½
EUROPE .. .. 0·25 (minimum)
COMMONWEALTH (AIR) .. .. 0·65 (minimum)

SILICON RECTIFIERS

PIV	50 £	100 £	200 £	400 £	600 £	800 £	1000 £	1200 £	1400 £
1A	0·10	0·12½	0·15	0·16	0·17½	0·19	0·20	—	—
3A	0·15	0·17	0.20	0·22½	—	0·30	—	—	—
6A	—	—	0·25	0·30	0·32½	0·35	0·50	—	—
10A	—	0·52½	0·57½	0·65	0·77½	0·87½	0·97½	1·25	1·60
17A	—	0·57½	0·62½	0·77½	0·90	0·97½	1·20	1·57½	1·87½
35A	—	1·37½	1·60	1·97½	2·37½	2·70	3·10	3·50	4·50

1 amp and 3 amp are plastic encapsulation.

DIODES AND RECTIFIERS

IN914	0·07½	AAZ17	0·12½	BAY31	0·07½	OA10	0·22½
IN916	0·07½	BA100	0·15	BAY38	0·25	OA9	0·10
IN4007	0·22½	BA102	0·22½	BY100	0·17½	OA47	0·07½
IS44	0·10	BA110	0·32½	BY103	0·22½	OA70	0·07½
IS113	0·15	BA115	0·07½	BY124	0·15	OA73	0·10
IS120	0·15	BA141	0·32½	BY126	0·15	OA79	0·09
IS121	0·17½	BA142	0·32½	BY127	0·17½	OA81	0·07½
IS130	0·12½	BA144	0·12½	BY164	0·57½	OA85	0·07½
IS131	0·12½	BA145	0·20	BYX10	0·22½	OA90	0·07½
IS132	0·15	BA154	0·12½	BYZ10	0·35	OA91	0·07½
IS940	0·07½	BA156	0·22½	BYZ11	0·32½	OA95	0·07½
AA119	0·10	BAX13	0·12½	BYZ12	0·30	OA200	0·10
AA129	0·10	BAX16	0·12½	BYZ13	0·25	OA202	0·10
AAZ13	0·10	BAY18	0·17½	OA5	0·17½	TIV307	0·50
AAZ15	0·12½						

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

TRIACS

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

Economy Range Triacs
TC4/10 (Pressfit) 4 amp 100 PIV .. .. 0·65
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1A	0·25	0·27½	0·37½	0·40	0·47½
4A	—	0·47½	0·55	0·57½	0·77½
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3¾" × 5"	0·27½	0·27½
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2·5	16	0·07½	40	16	0·07½	640	16	0·17½
4	10	0·07½	50	12	0·07½	1000	16	0·18
4	40	0·07½	50	25	0·07½	1000	25	0·25
4	350	0·11	50	50	0·10	1000	50	0·37½
5	18	0·07½	64	25	0·07½	2000	25	0·37½
5	50	0·07½	80	16	0·07½	2000	50	0·52½
6·4	6·4	0·07½	80	25	0·07½	2500	25	0·42½
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ACY21	19p	C7V5	15p	OA5	20p	2N698	30p
ACY22	19p	C8V2	15p	OA10	25p	2N706	10p
ACY40	15p	C9V1	15p	OA47	8p	2N706A	12p
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BCY33	25p	NKT229	29p	OC200	37p	2N3704	11p
BCY34	25p	NKT237	31p	OC201	47p	2N3705	10p
BCY38	30p	NKT238	19p	OC202	63p	2N3706	9p
BCY70	19p	NKT239	23p	OC203	37p	2N3707	11p
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2·2	35	22	16
4·7	35	33	10
6·8	25	10	6·3
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IN4006	800	·140	·130	·110
IN4007	1000	·190	·150	·120
	p.i.v.	500+	1000+	
IN4001	50	·045	·040	
IN4002	100	·055	·045	
IN4003	200	·060	·050	
IN4004	400	·070	·060	
IN4005	600	·075	·070	
IN4006	800	·100	·085	
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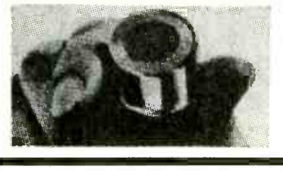

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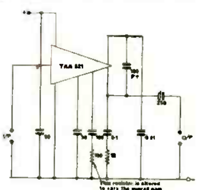

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6AU6	0·21	6L19	1·38	12BH7	0·27	35A3	0·50	CL33	0·91	EC54	0·50	EL37	0·87
6AV6	0·30	6LD20	0·48	12E1	0·85	35A5	0·75	CV6	0·53	EC86	0·63	EL41	0·54
6B8G	0·13	6N7GT	0·40	12J7GT	0·33	35D5	0·70	CV988	0·10	EC88	0·60	EL42	0·53
6BA6	0·21	6P15	0·23	12K5	0·50	35L6GT	·42	CY1C	0·53	EC92	0·35	EL81	0·50
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6BE6	0·22	6Q7G	0·30	12Q7GT	0·28	35Z3	0·50	D63	0·25	ECC33	1·58	EL84	0·23
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EM81	0·40
EM83	0·75
EM84	0·32
EM87	0·36
EY51	0·35
EY81	0·35
EY83	0·55
EY84	0·50
EY86/7	0·31
EY88	0·43
EY91	0·53
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KT8	1·75
KT41	0·98
KT44	1·00
KT63	0·25
KT66	0·82
KT74	0·63
KT76	0·63
KT81	2·00
KT88	1·70
KTW61	·63
KTW62	·63
KTW63	·50
L63	0·19
M8162	0·63
ME1400	·74
MHL4	0·75
MHLD6	·75
MU12/14	0·38
N78	2·05
N108	1·40
N308	0·98
N339	0·45
N709	0·23
P61	0·49
PABC80	·34
PC86	0·49

PC88	0·49
PC95	0·53
PC97	0·38
PC900	0·35
PCC84	0·31
PCC85	0·29
PCC88	0·44
PCC89	0·46
PCC189	0·49
PCF80	0·29
PCF82	0·31
PCF84	0·40
PCF86	0·45
PCF200	0·67
PCF800	0·62
PCF801	0·32
PCF802	0·40
PCF805	0·63
PCF806	0·59
PCF808	0·70
PCH200	·62
PCL82	0·33
PCL83	0·60
PCL84	0·35
PCL86	0·40
PCL88	0·67
PCL801	0·61
PCL805/ PCL85	0·75
PD500	1·44
PEN4DD	1·38
PEN45	0·35
PEN45DD	0·75
PEN46	0·20
PEN453DD	0·98
PENA4	0·98
PENDD /4020	0·88
PFL200	·54
PL33	0·38
PL36	0·47
PL81	0·45
PL81A	0·50
PL82	0·31
PL83	0·33
PL84	0·31
PL302	0·60
PL504/500	0·64
PL505	1·30
PL508	0·90
PL509	1·30
PL801	0·60
PL802	0·75
PM84	0·36
PX4	1·16
PX25	1·16
PY32/3	0·50
PY80	0·33
PY81	0·25
PY82	0·25

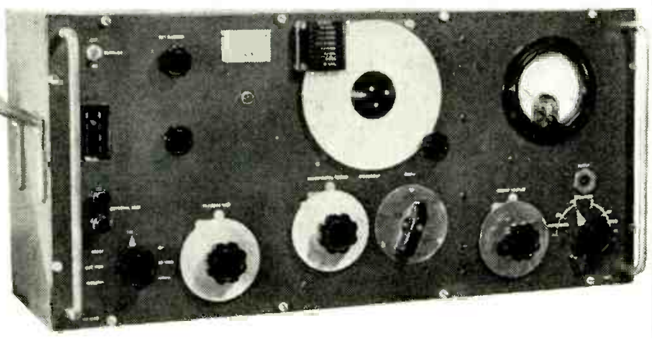
PY83	0·27
PY88	0·33
PY301	0·60
PY500	0·95
PY800	0·35
PY801	0·34
PZ30	0·48
QQV03/10	1·20
QS75/20	0·63
QS95/10	·49
QS150/15	0·63
QV04/7	0·63
R10	0·75
R11	0·98
R16	1·75
R17	0·88
R18	0·50
R19	0·31
R20	0·59
R52	0·35
RG1/240A	1·98
RK34	0·38
SP13C	0·63
SP42	0·75
SP61	0·33
TH4B	0·50
TH233	0·98
TP2620	0·98
UABC80	·30
UAF42	0·50
UBC41	0·45
UBC81	0·40
UBF80	0·29
UBF89	0·31
UBL21	0·55
UC92	0·35
UCC84	0·34
UCC85	0·35
UCF80	0·35
UCH21	0·60
UCH42	0·61
UCH81	0·31
UCL82	0·34
UCL83	0·49
UF41	0·50
UF42	0·60
UF80	0·35
UF85	0·34
UF86	0·63
UF89	0·29
UL41	0·59
UL46	0·88
UL84	0·32
UM80	0·33
UR1C	0·53
UU5	0·38
UU9	0·40
UU12	0·23
UY1N	0·50
UY21	0·55
UY41	0·38

UY85	0·27
U10	0·45
U12/14	0·38
U16	0·75
U17	0·35
U18/20	0·75
U19	1·73
U22	0·39
U25	0·65
U26	0·59
U31	0·30
U33	1·50
U35	0·83
U37	1·75
U45	0·78
U47	0·65
U49	0·59
U50	0·28
U76	0·24
U78	0·22
U107	0·92
U153	0·25
U191	0·60
U192	0·25
U193	0·34
U251	0·70
U281	0·40
U282	0·40
U291	0·50
U301	0·40
U329	0·70
U381	0·27
U403	0·33
U404	0·38
U801	0·95
U4020	0·38
VP2	0·53
VP13C	0·35
VP23	0·40
VP41	0·38
VR75	1·25
VR105	0·33
VT61A	0·35
VT501	0·15
VU111	0·44
VU120A	·60
VU133	0·35
W76	0·34
W81M	0·68
W107	0·50
W729	0·60
XE3	5·00
XFY12	0·48
XH1·5	0·48
X41	0·50
X65	0·50
X101	1·53
Z359	0·70
Z749	0·70
Transistors and Diodes 1N1124A	0·53

1N4952	0·50	AF178	0·68	FSY28A	·23	OC22	0·38
2N404	0·18	AF180	0·48	GD4	0·33	OC23	0·38
2N966	0·53	AF181	0·70	GD5	0·28	OC24	0·38
2N1756	0·50	AF186	0·55	GD6	0·28	OC25	0·38
2N2147	0·85	AF239	0·38	GD8	0·20	OC26	0·24
2N2297	0·23	ASY27	0·43	GD9	0·20	OC28	0·60
2N2369A		ASY28	0·33	GD11	0·20	OC29	0·63
	0·22	ASY29	0·50	GD12	0·20	OC35	0·32
2N2613	0·39	BA102	0·45	GD14	0·50	OC36	0·43
2N3053	0·33	BA115	0·14	GD15	0·40	OC38	0·43
2N3121	2·50	BA116	0·25	GD16	0·20	OC41	0·50
2N3703	0·19	BA129	0·13	GET111	·78	OC42	0·63
2N3709	0·20	BA130	0·10	GET113	·20	OC43	1·18
2N3866	1·00	BA153	0·15	GET116	·40	OC44	0·10
2N3988	0·50	BCY10	0·45	GET118	·20	OC45	0·11
2S323	0·50	BCY12	0·50	GET119	·20	OC46	0·15
AA119	0·15	BCY33	0·20	GET573	·38	OC65	1·13
AA120	0·15	BCY34	0·23	GET587	·43	OC70	0·13
AA129	0·15	BCY38	0·23	GET872	·95	OC71	0·11
AAZ13	0·18	BCY39	0·25	GET873	·15	OC72	0·11
AC107	0·15	BC107	0·13	GET882	·50	OC74	0·23
AC113	0·25	BC108	0·13	GET887	·23	OC75	0·11
AC114	0·40	BC113	0·25	GET889	·23	OC76	0·15
AC127	0·17	BC115	0·15	GET890	·23	OC77	0·27
AC128	0·20	BC116	0·25	GET896	·23	OC78	0·15
AC154	0·25	BC118	0·23	GET897	·23	OC78D	0·15
AC156	0·20	BCZ11	0·38	GET898	·23	OC79	0·40
AC157	0·25	BD119	0·45	GEX13	0·18	OC81	0·11
AC165	0·25	BF154	0·25	GEX35	0·23	OC81D	0·11
AC166	0·25	BF158	0·29	GEX36	0·50	OC82	0·11
AC167	0·60	BF159	0·25	GEX45	0·33	OC82D	0·11
AC168	0·38	BF163	0·20	GEX55	0·75	OC83	0·20
AC169	0·33	BF173	0·38	GT3	0·25	OC84	0·24
AC176	0·55	BF180	0·30	M1	0·15	OC123	0·23
AC177	0·28	BF181	0·40	M3	0·15	OC139	0·23
ACY17	0·25	BF185	0·40	MAT100	·39	OC140	0·95
ACY18	0·20	BF194	0·15	MAT101	·43	OC169	0·23
ACY19	0·19	BFY50	0·23	MAT120	·39	OC172	0·35
ACY20	0·18	BFY51	0·19	MAT121	·43	OC200	0·22
ACY21	0·19	BFY52	0·20	OA5	0·28	OC201	0·38
ACY22	0·15	BTX34/400		OA9	0·13	OC202	0·43
ACY28	0·18		2·00	OA10	0·43	OC203	0·30
AD140	0·36	BY100	0·18	OA47	0·10	OC204	0·30
AD149	0·50	BY101	0·15	OA70	0·15	OC205	0·43
AD161	0·45	BY105	0·18	OA73	0·15	OC206	0·50
AD162	0·45	BY114	0·18	OA79	0·09	OC812	0·40
ADT140	0·63	BY126	0·15	OA81	0·09	OCP71	1·65
AF102	0·90	BY127	0·18	OA85	0·08	ORP12	0·53
AF106	0·50	BYY23	1·00	OA86	0·20	S6M1	0·25
AF114	0·25	BYZ10	0·25	OA90	0·13	SM1036	0·50
AF115	0·15	BYZ11	0·25	OA91	0·09	ST1276	0·50
AF117	0·19	BYZ12	0·25	OA95	0·09	SX/16	0·18
AF119	0·23	BYZ13	0·25	OA200	0·09	U14706	0·25
AF121	0·30	BYZ15	1·75	OA202	0·19	XZ30	0·25
AF124	0·25	CG12E	0·20	OA210	0·48	Y543	0·18
AF126	0·18	CG64H	0·20	OA211	0·68	Y728	0·18
AF139	0·65	FSY11A	·23	OC19	1·25	ZE12V7	·09

MATCHED TRANSISTOR SETS:—
LP15 (AC113, AC154, AC157, AA120). 0·53
1—OC81D and 2—OC81, 0·43
1—OC44 and 2—OC45, 0·43
1—OC82D and 2—OC82, 0·48 Set of 3—OC83 0·65
S.T.C. 1 watt Zener Diodes. 2·4v., 2·7v., 3·0v., 3·6v., 4·3v., 13v., 15v., 16v., 20v., 0·18 each.

All goods are unused and subject to the manufacturers' guarantee. We do not handle manufacturers' seconds nor rejects, which are often described as "new and tested" but have a limited and unreliable life. Business hours Mon.-Fri. 9-5.30 p.m. Sats. 9-1 p.m. Littlehampton closed Sats. Terms of business. Cash or cheque with order. Post/packing 0·03 per item, subject to a minimum of 0·09. Orders over 5·00 sent free. All orders cleared same day by first class mail. Any parcel insured against damage in transit for 0·03 extra. Complete catalogue with conditions of sale 0·07 post paid. No enquiries answered unless S.A.E. is enclosed for reply.



MARCONI SIGNAL GENERATOR TYPE TF-144G: Freq. 85 Kc/s-25Mc/s in 8 ranges. Incremental: ± 1% at 1Mc/s. Output: continuously variable 1 microvolt to 1 volt. Output Impedance: 1 microvolt to 100 millivolts, 10 ohms 100mV - 1 volt - 52.5 ohms. Internal Modulation: 400c/s sinewave 75% depth. External Modulation: Direct or via internal amplifier. A.C. mains 200/250V, 40-100c/s. Consumption approx. 40 watts. Measurements 29 × 12½ × 10 in. New condition. **£45** each, Second hand condition **£27·50** each, Carr. £1·50.

MARCONI SIGNAL GENERATOR TYPE TF-144H/S: Frequency Range 10Kc/s-72Mc/s. RF Output 2µV-2V at 50Ω. Int. Mod. 400 and 1000c/s. Excellent condition with Manuals. **£200·00** each. Carr. £2.

TELEPRINTER CREED TYPE 7B: "as new" condition, in original packing case, **£25·00** each. Second-hand condition (excellent order), no parts broken, **£15·00** each. Carriage both types £2.

FREQUENCY METER BC-221: 125-20,000 Kc/s, complete with original calibration charts. Checked out, working order **£18·50** + £1 carr.; OR BC-221 (as received from Ministry), good condition, less charts, **£8·50** + £1 carr.

FOR EXPORT ONLY

BRITISH & AMERICAN COMMUNICATION EQUIPMENT

VRC.19X Trans-ceiver, 150-170Mc/s, 2 Channel, 20 Watts, Output 12/24V d.c. operation. General Electric Transmitter, 410-419Mc/s, thin line tropo scatter system, with antennae. W.S. Type 88, Crystal controlled, 40-48 Mc/s. W.S. Type HF-156, Mk. II, Crystal controlled, 2.5-7.5 Mc/s. W.S. Type 62, tunable, 1.5-12 Mc/s. C.44, Mk. II, Radio Telephone, Single Channel, 70-85 Mc/s, 50 watts, output, 230V. a.c. input. G.E.C. Progress Line Tx Type DO36, 144-174 Mc/s, 50 watt, narrow band width. A.C. input 115V. BC-640 Tx, 100-156 Mc/s, 50 watt output, 110V or 230V input. STC Tx/Rx Type 9X, TR1985; RT1986; TR1987 and TR1998, 100-156 Mc/s. TRC-1 Tx/Rx, Types T.14 and R.19, FM 60-90 Mc/s. With associated equipment available. Redifon GR410 Tx/Rx, SSB, 1.5-20 Mc/s. Sun-Air Tx/Rx Type T-10-R. Collins Tx/Rx/Type 18S4A. Collins Tx/Rx Type ARC-27, 200-400 Mc/s, 28V d.c. With associated equipment available. ARC-5; ARC-3; and ARC-2 Tx/Rx. BC-375; 433G; 348; 718; 458; 455 Tx/Rx. Directional Finding Equipment CRD.6 and FRD.2 complete Sets available and spares. Complete system with full set of Manuals.

RACK CABINETS: (totally enclosed) for Std. 19 in. Panels. Size 6 ft. high × 21 in. wide × 16 in. deep, with rear door. **£12** each, £2·50 Carr. OR 4 ft. high × 23 in. wide × 19 in. deep, with rear door. **£8·50** each, £2 Carr.

RECEIVER BC-348: Operates from 24V d.c. Freq. Range 200-500 Kc/s, 1·5-18Mc/s. Secondhand **£20** each, £1 Carr.

APR-9 SEARCH RECEIVER: Complete with two Tuning Units TN128, 1000-2600Mc/s, and TN129 2300-4450Mc/s. **£250·00** each.

APR-5 UHF RECEIVER: 1000-6000Mc/s, 115V a.c. Circuit. Oscillator, 6 IF Stages, Detector, Video Amplifier and Audio Amplifier. **£120·00** each, Carr. £2.

RCA COMMUNICATION RECEIVER AR88: A.C. mains input. 110V. or 250V. Freq. in 6 bands, 535 Kc/s-32 Mc/s. Output impedance 2·5-600Ω. Complete with crystal filter, noise limiter, B.F.O., H.F. tone control, R.F. & A.F. variable controls. Good second hand condition (guaranteed working) **£45** to **£65** each. Carr. £2·00.

If wishing to call at Stores, please telephone for appointment.

W. MILLS

3-B TRULOCK ROAD, LONDON, N17 0PG
Phone: 01-808-9213

SOLARTRON PULSE GENERATOR GP1101.2: Period—2 microsecs to 100 msec; Pulse Duration—1 microsec to 100 msec; Delay time—1 microsec to 10 msec. All continuously variable in 5 ranges with fine control. Accuracy ±10%. Pulse Amplitude—0.5V-100V. Accuracy ±10% continuously variable in 4 ranges with fine control. Double Pulses; Pre-Pulse; Triggering; Square Wave O/put; Squaring Amplifier. Input—100-250V, 50-60 c/s. New condition with Manual. Price: **£85** each + £1·25 carr.

USM-24C OSCILLOSCOPE: 3 in. oscilloscope with 2c/s to 10Mc/s vertical response, and 8c/s to 800Kc/s horizontal response. Sensitivity 50 mv. rms/inch. Triggered sweep, built-in trigger pulses and markers. Mains input 115V, 50c/s. Complete with all leads, probes and circuit diagram. **£42·50** each, carr. £2.

OS-46/U OSCILLOSCOPE: A general purpose oscilloscope suitable for measuring signals from 0-1000V d.c. to over 50,000 c.p.s. (Further details on request, S.A.E.) **£35** each, carr. £1·50.

SIGNAL GENERATOR TS-403B/U (or URM-61A): (Hewlett Packard). A portable, self-contained, general-purpose test equipment designed for use with radio and radar receivers and for other applications requiring small amounts of RF power such as measuring standing-wave ratios, antenna and transmission line characteristics, conversion gain, etc. Both the output freq. and power are indicated on direct-reading dials. 115V, AC, 50 c/s. Freq.—1800-4000 Mc/s. CW, FM, Modulated Pulse—40-4000 pulses per sec. Pulse Width—0.5-10 microsecs. Timing—Undelayed or delayed from 3-300 microsecs from external or internal pulse. O/put—1 milliwatt max., 0 to —127 db variable. O/put Impedance—50 Ω. Price: **£120** each + £2 carr.

SIGNAL GENERATOR TYPE 902: (P.R.D.). A portable, general-purpose, broadband, microwave signal generator designed for testing and maintenance of aircraft radio and radar receivers in the SHF band. The RF output level is regulated by a variable attenuator calibrated in dbm. The frequency dial is calibrated in Mc/s. Provision is made for external modulation. Power Supply—115V, ±10% A.C., 50 c/s. Freq.—3650-7300 Mc/s. Internal Transmission—CW, Pulse, FM. External Transmission—Square Wave, Pulse. Power O/put—0.2 milliwatts. O/put Attenuator: —7 to —127 dbm. Load—50 Ω. Price: **£135** each + £2 carr.

TEST SET TS-147C: Combined signal generator, frequency meter and power meter for 8500-9600 Mc/s. CW or FM signals of known freq. and power or measurement of same. *Signal Generator:* O/put —7 to —85 dbm. Transmission—FM, PM, CW. Sweep Rate—0-6 Mc/s per microsec. Deviation—0-40 Mc/s per sec. Phase Range—3-50 microsec. Pulse Repetition Rate—to 4000 pulses per sec. RF Trigger for Sawtooth Sweep—5-500 watts peak. 0.2-6 microsec. duration, 0.5 microsec pulse rise time. Video Trigger for Sawtooth Sweep—Positive polarity, 10-50V peak. 0.5-20 microsec duration at 10% max. amplitude, less than 0.5 microsec rise time between 90% and 10% max. amplitude points. *Frequency Meter:* Freq. 8470-9360 Mc/s. Accuracy—+2.5 Mc/s per sec. absolute, + 1.0 Mc/s per sec. for freq. increments of less than 60 Mc/s relative, ±1.0 Mc/s per sec. at 9310 Mc/s per sec. calibration point. Accuracy measured at 25° C and 60 humidity. *Power Meter:* Input: + 7 to + 30 dbm. Output — 7 to — 85 dbm. Price: **£75** each + £1 carr.

SIGNAL GENERATOR TS-418/URM49: Covers 400-1000 Mc/s range. CW, Pulse or AM emission. Power Range—0-120 dbm. Price: **£105** each + £1·25 carr.

SIGNAL GENERATOR TS-497B/URR: (Boonton). Freq. 2-400 Mc/s in 6 bands. Internal Mod. 400 or 1000 c/s per sec. External Mod. 50 to 10,000 c/s per sec. External PM. Percent Mod. 0-30 for sine wave. Am or Pulse Carrier. O/put Voltage 0.1-100,000 microvolts cont. variable. Impedance 50 Ω. Price: **£85** each + £1·50 carr.

FREQUENCY METER TS-74 (same TS-174): Heterodyne crystal controlled. Freq. 20-280 Mc/s. Accuracy .05%. Sensitivity 20 mV. Internal Mod. at 1000 c/s. Power Supply—batteries 6V and 135V. Complete with calibration book. (Manufactured for M.O.D. by Telemax. "As new" in cartons.) **£75** each. Fully stabilised Power Supply available at extra cost **£7·50** each. Carr £1·50.

CT.54 VALVE VOLTMETER: Portable battery operated. In strong metal case with full operating instructions. 2.4V-480V. A.C. or D.C. in 6 Ranges, 1Ω to 10MegΩ in 5 Ranges. Indicated on 4in. scale meter. Complete with probe, excellent condition. **£12·50**, carr. 75p.

CT.381 FREQUENCY SWEEP SIGNAL GENERATOR: 85Kc/s-30Mc/s and response curve indicator with 6in. CRT tube and separate power supply. Fully stabilised. Price and further details on request.

CANADIAN HEADSET ASSEMBLY: Moving coil headphones 100Ω with chamois leather earmuffs. Small hand microphone complete with switch and moving coil insert. New Condition. **£1·75** each, post 25p.

HEADSET ASSEMBLY TYPE No. 10: Moving coil headphones and microphone. (Similar to above) new cond. **£1·75**, post 25p; or second-hand cond. **£1·25**, post 25p.

HEADSET ASSEMBLY: with lightweight boom microphone. Good second-hand condition. **£2·50**, post 75p.

DLR HEADPHONES: 2 × balanced armature earpieces. Low resistance. **£1·25** a pair, 25p post.

POWER UNITS AVAILABLE FOR FOLLOWING SETS: 52 set—mains input, 150V @ 60mA and 12V @ 3 amps, new cond. **£3·50**. Receiver type 88 (1475)—mains input, 250V @ 80mA and 6·3V @ 4 amps, new cond. **£3·50**. No. 19 set **£2·50**. C12 set **£4·00**. 88 set **£2·50**. Carriage all types £1 extra.

STABILISED BENCH POWER SUPPLY: fully smooth, dual output, positive or negative, 2-6V; 6-9V; 9-12V and 12-16V all at 2 amps d.c. from mains input. **£25** + £2 carr.

DIGITAL VOLTMETER & RATIOMETER Model BIE. 2116, **£65**, carr. £2.

DIGITAL VOLTMETER Model BIE. 2114, **£55**, carr. £2. (Mnftrs. Blackburn Instruments).

MARKA SWEEP GENERATOR MODEL VIDEO (Kay Electric, USA) **£65**, carr. £2.

ROTARY CONVERTERS: Type 8a, 24 v D.C., 115 v A.C. @ 1.8 amps, 400 c/s 3 phase, **£6·50** each, post 50p. 24 v D.C. input, 175 v D.C. @ 40mA. output, **£1·25** each, post 20p.

CONDENSERS: 40 mfd, 440 v A.C. wkg. **£5** each, 50p post. 30 mfd 600 v wkg. d.c., **£3·50** each, post 50p. 15 mfd 330 v a.c., wkg., 75p each, post 25p. 10 mfd 1000 v. 63p each, post 13p. 10 mfd 600 v. 43p each, 25p post. 8 mfd 2500 v. **£5** each, carr. 63p. 8 mfd 600 v. **43p** each, post 15p, 8 mfd. 1% 300 v. D.C. **£1·25**, post 25p, 4 mfd. 3000 v. wkg. **£3** each, post 37p. 4 mfd 2000 v. **£2** each, post 25p. 4 mfd 600 v., 2 for **£1**. 0·25 mfd, 2Kv, **20p** each, post 10p. 0·01 mfd MICA 2·5Kv. **£1** for 5, post 10p. Capacitor 0·125 mfd, 27,000 v. wkg. **£3·75** each, 50p post.

TCS MODULATION TRANSFORMERS, 20 watts, pr. 6,000 C.T., sec. 6,000 ohms. Price **£1·25**, post 25p.

SOLENOID UNIT: 230 v. A.C. input, 2 pole, 15 amp contacts, **£2·50** each. post 30p.

CONTROL PANEL: 230 v. A.C., 24 v. D.C. @ 2 amps, **£2·50** each, carr. 75p.

OHMITE VARIABLE RESISTOR: 5 ohms, 5½ amps; or 40 ohms at 2·6 amps. Price (either type) **£2** each, 25p post each.

TX DRIVER UNIT: Freq. 100-156 Mc/s. Valves 3 × 3C24's; complete with filament transformer 230 v. A.C. Mounted in 19in. panel, **£4·50** each, carr. 75p.

POWER SUPPLY UNIT PN-12A: 230V a.c. input 50-60 c/s. 513V and 1025V @ 420 mA output. With 2 smoothing chokes 9H, 2 Capacitors, 10Mfd 1500V and 10Mfd 600V. Filament Transformer 230V a.c. input. 4 Rectifying Valves type 5Z3. 2 × 5V windings @ 3 Amps each, and 5V @ 6 Amp and 4V @ 0.25 Amp. Mounted on steel base 19"Wx11"Hx14"D. (All connections at the rear.) Excellent condition **£6·50** each, carr. £1.

AUTO TRANSFORMER: 230-115V, 50-60c/s, 1000 watts. mounted in a strong steel case 5" × 6½" × 7". Bitumen impregnated. **£6** each, Carr. 63p. 230-115V, 50-60c/s, 500 watts. 7" × 5" × 5". Mounted in steel ventilated case. **£3·50** each, Carr. 50p.

LT TRANSFORMER: PRI 230V. Output 4 × 6·3 at 3 amps each winding, 3½" × 4" × 5". Fully shrouded **£1·50** post 50p.

MODULATOR UNIT: 50 watt, part of BC-640, complete with 2 × 811 valves, microphone and modulator transformers etc. **£7·50** each, 75p carr.

CATHODE RAY TUBE UNIT: With 3in. tube, Type 3EG1 (CV1526) colour green, medium persistence complete with nu-metal screen, **£3·50** each, post 37p.

APNI ALTIMETER TRANS./REC., suitable for conversion 420 Mc/s., complete with all valves 28 v. D.C. 3 relays, 11 valves, price **£3** each, carr. 50p.

ANTENNA WIRE: 100 ft. long. **75p** + 25p post.

APN-1 INDICATOR METER, 270° Movement. Ideal for making rev. counter. **£1·25**, post 25p.

VARIABLE POWER UNIT: Complete with Zenith variac 0-230V., 9 amps.; 2½ in. scale meter reading 0-250V. Unit is mounted in 19 in. rack. **£15** each, £1·50p carr.

AIRCRAFT SOLENOID UNIT D.P.S.T.: 24V, 200 Amps, **£2** each, 25p post.

RADAR SCANNER ASSEMBLY TYPE 122A: Complete with parabolic reflector (24 in. diameter), motors, suppressors, etc. **£35** each, £2 carr.

DECADE RESISTOR SWITCH: 0.1 ohm per step. 10 positions. 3 Gang, each 0·9 ohms. Tolerance ± 1% **£3** each, 25p post. 90 ohms per step. 10 positions, total value 900 ohms. 3 Gang. Tolerance ± 1% **£3·50** each, post 25p.

MARCONI DEVIATION TEST SET TF-934: 2.5-100Mc/s (can be extended up to 500Mc/s on Harmonics). Dev. Range 0-75Kc/s in modulation range 50c/s-15Kc/s. 100/250V. a.c. **£45** each, £1·50 carr.

CRYSTAL TEST SET TYPE 193: Used for checking crystals in freq. range 3000-10,000Kc/s. Mains 230V, 50c/s. Measures crystal current under oscillatory conditions and the equivalent parallel resistance. Crystal freq. can be tested in conjunction with a freq. meter. **£12·50** each, £1 carr.

LEDEX SWITCHING UNIT: 2 ledex switches, 6 Bank and 3 Bank respectively, 6 Pos.; 1 Manual switch, 16 Bank 2 Pos. **£4** each, 50p post.

GEARED MOTOR: 24c. D.C., current 150mA, output 1 rpm, **£1·50** each, 25p post. **ASSEMBLY UNIT** with Letcherbar Tuning Mechanism and potentiometer, 3 rpm, **£2** each 25p post. **SYNCHROS:** and other special purpose motors available. List 3p.

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FUEL INDICATOR Type 113R: 24V complete with 2 magnetic counters 0-9999, with locking and reset controls mounted in 3in. diameter case. Price **£2** each, 25p post.

COAXIAL TEST EQUIPMENT: COAXWITCH—Mnftrs. Bird Electronic Corp. Model 72RS; two-circuit reversing switch, 75 ohms, type "N" female connectors fitted to receive UG-21/U series plugs. New in ctns., **£6·50** each, post 37p. CO-AXIAL SWITCH—Mnftrs. Transco Products Inc., Type M1460-22, 2 pole, 2 throw. (New) **£6·50** each, post 25p. 1 pole, 4 throw, Type M1460-4. (New) **£6·50** each, post 25p.

PRD Electronic Inc. Equipment: FIXED ATTENUATOR; Type 130c, 2·0-10·0 KMC/SEC. (New) **£5** each, post 25p. FIXED ATTENTUATOR: Type 1157S-1 (New) **£6** each, post 25p.

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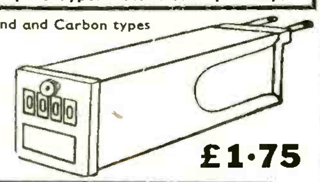

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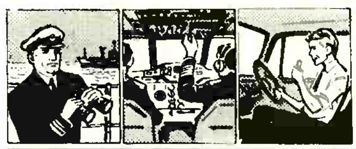

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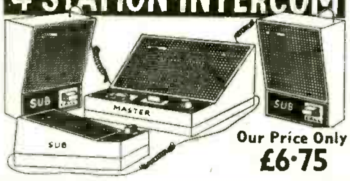

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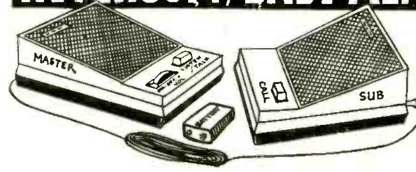

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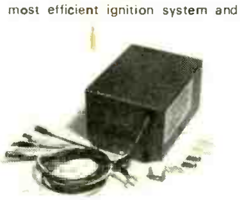

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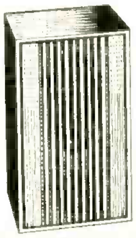
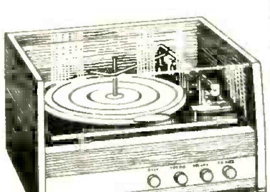
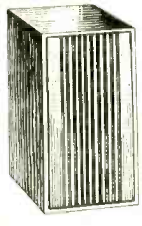
5 + 5 WATT OUTPUT
Garrard 5200 Changer with low mass pick-up arm and Stereo Cartridge.
Controls: TREBLE, BASS, VOLUME, STEREO, BALANCE.
Operation on 200-250 v. A.C. mains. Output rating I.H.F.M.

Luxurious Teak Veneer Finished Cabinets. Transparent plastic (tinted) cover included for main unit. Silver finished facia plate and matching control knobs.

PAIR OF LOUDSPEAKER UNITS
incorporating high flux 8in. × 5in. speaker. Size approx. 13 × 7½ × 8½ ins.

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Terms: Deposit £5.50 and 9 monthly payments £4.50 (Total £46).

A REALLY SURPRISING STANDARD OF QUALITY IS OBTAINED FROM THIS COMPACT LOW PRICED SYSTEM

FANE 807 HIGH FIDELITY LOUDSPEAKER

A full range 8in. 10 watt Unit for excellent sound quality in suitable enclosure. Roll P.V.C. cone surround and long throw voice coil to achieve very low fundamental resonance at 30 c.p.s. Tweeter cone is fitted to extend high note response. Frequency range 25 Hz to 15 KHz. Impedance 3 Ω or 8-15 Ω. Cast Chassis. REMARKABLE VALUE AT ONLY **£3·50**

AUDIOTRINE HIGH FIDELITY LOUDSPEAKERS

Heavy construction. Latest high efficiency ceramic magnets. Treated Cone surround or "L" indicates Roll Rubber surround. "D" indicates Tweeter Cone providing extended frequency range up to 15,000 c.p.s. Exceptional performance at low cost. Impedance 3 or 8-15 ohms.

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HF 801D	8"	8W	£2·71
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HF 120D	12"	15W	£4·75
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FANE ULTRA HIGH POWER LOUDSPEAKERS

All power ratings are R.M.S. continuous.
2 years' guarantee. High flux ceramic magnets. Heavy cast chassis. ALL CARRIAGE FREE.

'POP' 100
18in. 100 watt 14,000 gauss 8/15 ohms
£22·05
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15in. 60 watt 14,000 gauss 8/15 ohms
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FOR BASS GUITAR OR ELECTRONIC ORGAN, ETC.

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12in. 50 watt 13,000 gauss 15 ohms
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PAIR SUITABLE ALL PURPOSES.

AUDIOTRINE HI-FI SPEAKER SYSTEMS

Consisting of matched 12in. 11,000 line 15 watt 15 ohm high quality speaker, cross-over unit and tweeter. Smooth response and extended frequency range ensure surprisingly realistic reproduction. Carr. 30p. **£5·75**
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TA12 MK III 6·5 + 6·5WATT STEREO AMPLIFIER

FULLY TRANSISTORISED, SOLID STATE CONSTRUCTION HIGH FIDELITY OUTPUT OF 6.5 WATTS PER CHANNEL

Designed for optimum performance with any crystal or ceramic Gram P.U. cartridge, Radio tuner, Tape recorder, 'Mike' etc. ★ 3 separate switched input sockets on each channel ★ Separate Bass and Treble controls ★ Slide Switch for mono use ★ Speaker Output 3-15 ohms ★ For 200-250 v. A.C. mains ★ Frequency Response 20-20,000c.p.s. —2dB ★ Harmonic Distortion 0.3% at 1000c.p.s. Hum and noise —70dB ★ Sensitivities (1) 50 mV (2) 400 mV (3) 100 mV ★ Handsome finish Facia Plate and Knobs. Output rating I.H.F.M. Complete kit of parts with full wiring diagrams and instructions. Carr. 40p. **£15·50**
FACTORY BUILT WITH 12 MTH GNTEE. £19·50. Or dep. £3 and 9 mnthly pymts. £2·15 (Total £22·35). Or in Teak veneer housing. £23. Or Dep. £3 and 9 mthly. pymts £2·55 (Total £25·95).

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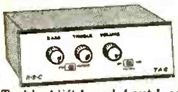
Dual cone 15 Ω (for uses other than Bass Guitar or Electronic Organ. Carr. free.
Or dep.: £1 and 9 monthly payments 75p (Total £7·75).
12in. 25watt **£6·75**

R.S.C. TA6 6 Watt High Fidelity Solid State Amplifier



200-250v. A.C. mains operated Frequency Response 30-20,000 c.p.s. —2dB. Harmonic Distortion 0.3% at 1,000 c.p.s. Separate Bass and Treble 'lift' and 'cut' controls. 3 input sockets for Mike, Gram, Radio or Tape. Input selector switch. Output for 3-15 ohm speakers. Max. sensitivity 5mV. Output rating I.H.F.M. In fully enclosed enamelled case, approx. 9½ × 2¾ × 5½in. Attractive brushed silver finish facia plate 10½ × 3½in. and matching knobs.
Complete kit of parts with full wiring diagrams and instructions. **£7·50** Carr. 40p
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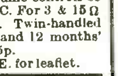

Type BM1. An all-dry battery elliminator. Size 5½ × 4½ × 2in. approx. Completely replaces batteries supplying 1.5 v. and 90 v. where A.C. mains 200/250 v. 50 c/s. is available.
COMPLETE KIT WITH DIAGRAM £3 or READY FOR USE £3·50.

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In teak or afrormosia veneered cabinets.
L13 3 or 15 ohms. 13 × 8in. 8-10 Watt Model Gauss 10,000 lines, Carr. 40p **£5·25**
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Covered in Rexine and Vynair, ideal for vocalists and Public Address. 15 ohm matching.
TYPE C48S, 30 watts. Fitted four 8in. high flux 8w. speakers. Or dep. £3 and 9 mthly pmts £2 (Total £21). Carr. 50p. **£17·75**
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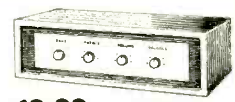
R.S.C. G66 6+6 WATT HIGH QUALITY STEREO AMPLIFIER



Individual Ganged controls: Bass, Treble, Volume and Balance. Printed circuit construction employing 10 Transistors plus Diodes. Output rating I.H.F.M. Suitable for Crystal Pick-ups etc., and for loudspeaker output impedances of 3 to 15 ohms. For standard 200-250 v A.C. mains operation. Attractive silver finished metal facia plate and matching control knobs. Complete KIT of PARTS INCLUDING FULLY WIRED PRINTED CIRCUIT. and comprehensive wiring diagram and instructions. Carr. 40p. **£9·99**
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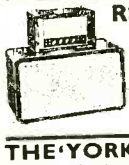
WHARFEDALE FAL PACKAGE OFFER 1 pair of Wharfedale Super Linton Speakers. Rec. Retail £49·90. 1 FAL Phase 32 Hi-Fi 15 + 15 watt stereo Amplifier Rec. Retail £37·80. Total £87·70. Package price £66·50. M.O. only.

R.S.C. A10 30 WATT ULTRA LINEAR HI-FI AMPLIFIER

Highly sensitive. Push-Pull high output, with Pre-amp./Tone Control Stages. Hum level —70dB. Frequency response ±3dB 30-20,000 c/s. All high grade components. Valves EF86, EF86, ECC83, 807 .807, GZ34. Separate Bass and Treble Controls. Sensitivity 36 millivolts. Suitable for High Impedance mic. or pick-ups. Designed for Clubs, Schools, Theatres, Dance Halls or Outdoor Functions, etc. For use with Electronic Organ, Guitar, String Bass, etc. Gram, Radio or Tape. Reserve L.T. and H.T. for Radio Tuner. Two inputs with associated volume controls so that two separate inputs such as Gram and "Mike" can be mixed. 200-250 v., A.C. For 3 & 15 Ω speakers. COMPLETE KIT PARTS, WIRING DIAGRAMS, INSTRUCTIONS. Twin-handled perforated cover £1·75. Or factory built with EL34 output valves and 12 months' guarantee for £19·75. Tech. figs. apply to factory built units. Carr. 65p. **£15·75**
TERMS: Deposit £4 and 9 monthly payments of £2·10 (Total £22·90). Send S.A.E. for leaflet.

RSC BASS-REGENT 50 WATT AMPLIFIER



A powerful high quality, all purpose unit. For lead, rhythm, bass guitar, vocalists, gram., radio, tape. Peak output rating. Employing current valves and reliable components. FOUR JACK INPUTS and TWO VOLUME CONTROLS for simultaneous use of up to 4 pick-ups or 'mikes'. SEPARATE BASS AND TREBLE CONTROLS. OR SUPPLIED COMPLETE with matched twin loudspeaker unit as illustrated for £60. Carr. £1·50. Terms: Dep. £16 and 9 monthly payments £5·75 (Total £67·75). **£30·50** Carr. 90p

THE 'YORK' HIGH FIDELITY 3'SPEAKER SYSTEM

Moderate size (approx. 25 × 14 × 10 in.). Range 30-20,000 c.p.s. KIT COMPLETE Impedance 15 ohms. Performance comparable with units costing considerably more. Consists of (1) 12in. 15 watt Bass unit with cast chassis. Roll rubber cone surround for ultra low resonance, and ceramic magnet. (2) 3-way quarter section series cross-over system. (3) 8 × 5in. high flux middle range speaker. (4) High efficiency tweeter. (5) Appropriate quantity acoustic damping material. (6) Teak veneered cabinet. (7) Circuit and full instructions. **£22** Carr. 63p
REMARKABLE VALUE HEAR IT AT ANY BRANCH

INTEREST CHARGES REFUNDED
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FULLY GUARANTEED. Interleaved and Impregnated. Primaries 200-250v. 50c/s. Screened

MIDGET CLAMPED TYPE 2½ × 2½ × 2in.
250v., 60mA, 6.3v. 2a. 90p
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Official Orders Welcomed, Gov./Educational Depts., Authorities, etc., otherwise Cash with Order

FOR CALLERS. Always a large quantity of components, transformers, chokes, valves, capacitors, odd units, etc., at 'Chiltmead' prices. Callers welcome 9 a.m. to 10 p.m. any day.

CHILTMEAD LTD

7/9 ARTHUR ROAD, READING, BERKS. (rear Tech. College) Tel.: Reading 582605/65916

SERVICE TRADING CO

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VARIABLE VOLTAGE TRANSFORMERS

INPUT 230 v. A.C. 50/60
OUTPUT VARIABLE 0/260 v. A.C.

50 AMP

1 AMP

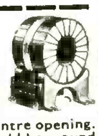
BRAND NEW. Keenest prices in the country. All types (and spares) from ½ to 50 amp. available from stock.

0-260 v. at 1 amp.	£5·50
0-260 v. at 2·5 amps	£6·75
0-260 v. at 5 amps.	£9·75
0-260 v. at 10 amps.	£18·50
0-260 v. at 15 amps.	£25·00
0-260 v. at 20 amps.	£37·00
0-260 v. at 25 amps.	£49·00
0-260 v. at 37·5 amps.	£72·00
0-260 v. at 50 amps.	£92·00

carriage extra.

OPEN TYPE (Panel mounting). ½ amp. £3·93
1 amp £5·50. 2½ amp. £6·63. P. & P. 40p.

RING TRANSFORMERS



Functional Versatile Educational

These multi-purpose Auto Transformers, with large centre aperture, can be used as a Double wound current Transformer, Auto Transformer, H.T. or L.T. Transformer, by simply hand winding the required number of turns through the centre opening. E.g. Using the RT.100 V.A. Model the output could be wound to give 8V @ 12½Amp., 4V. @ 25Amp. or 2V. @ 50Amp., etc.

Price: RT.100VA 3.18 turns per volt, £2·25+28p p. and p.
RT.300VA 2.27 turns per volt, £4·20+38p p. and p.
RT.1KVA 1.82 turns per volt, £6.50+58p p. and p.
RT.2KVA 1.5 turns per volt, £10·50+80p p. and p.
RT.3KVA 1.5 turns per volt, £14·00+80p p. and p.

L.T. TRANSFORMERS

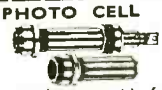
All primaries 220-240 volts.

Type No.	Sec. Taps	Price	Carr.
1	12 v. at 5A	£1·88	28p
2	30, 32, 34, 36 v. at 5 amps.	£4·68	45p
3	30, 40, 50 v. at 5 amps.	£6·88	45p
4	10, 17, 18 v. at 10 amps.	£4·95	45p
5	6, 12 v. at 20 amps.	£6·43	45p
6	17, 18, 20 v. at 20 amps.	£7·28	55p
7	6, 12, 20 v. at 20 amps.	£6·88	55p
8	24 v. at 10 amps.	£5·23	35p
9	4, 6, 24, 32 v. at 12 amps.	£7·15	45p

ALARM BELL

Manufactured by GENTS. 6 inch bell, 3/6 volt D.C. operation. As NEW. Only £1.50 plus 45p P. & P.

LIGHT SOURCE AND PHOTO CELL MOUNTING



Precision engineered light source with adjustable lens assembly and ventilated lamp housing to take MBC bulb. Separate photo cell mounting assembly for ORP.12 or similar cell with optic window. Both units are single hole fixing. Price per pair £2·75 p & p 18p.

LIGHT SENSITIVE SWITCHES

Kit of parts including ORP.12 Cadmium Sulphide Photocell. Relay Transistor and Circuit. Now supplied with new Siemens High Speed Relay for 6 or 12 volt operations. **Price £1·25, plus 12p P. & P. ORP. 12 and Circuit 63p post paid.**

220/240 A.C. MAINS MODEL incorporates mains transformer rectifier and special relay with 1 make, 1 break, H.D. contacts. Price inc. circuit £2·38, plus 20p P. & P.

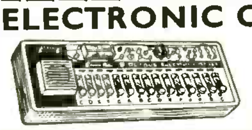
200-250 v. A.C. NEON INDICATOR

Available in RED or AMBER at 20p each, or in GREEN at 32p. Min. order 3 units. P. & P. 5p.

MOTOROLA MAC11/6 PLASTIC TRIAC 400 PIV 8 AMP

Now available **EX STOCK** supplied complete with full data and applications sheet. Price £1·05 plus 7p P. & P. Suitable diac 30p (RCA40583)

ELECTRONIC ORGAN KIT



Easy to build, solid state. Two full octaves (less sharps and flats). Fitted hardwood case, powered by two penlite 1½v. batteries.

Complete set of parts including speaker, etc., together with full instructions and 10 tunes. £3·00. P. & P. 25p.

50 in 1 ELECTRONIC PROJECT KIT

50 easy to build Projects. No soldering, no special tools required. The Kit includes Speaker, meter, Relay, Transformer, plus a host of other components and a 56-page instruction leaflet. Some examples of the 50 possible Projects are: Sound level Meter, 2 Transistor Radio, Amplifier etc., etc. Price £7·75. P. & P. 30p.

CRYSTAL RADIO KIT

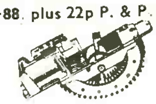
Complete set of parts including: crystal diode, ferrite aerial, drilled chassis and personal ear-piece. No soldering, easy to build, full step-by-step instructions. £1·75 inc. post.

POWER RHEOSTATS

(NEW) Ceramic construction, winding embedded in Vitreous Enamel, heavy duty brush assembly designed for continuous duty. **AVAILABLE FROM STOCK IN THE FOLLOWING 11 VALUES: 100 WATT 1 ohm 10a., 5 ohm 4.7a., 10 ohm 3a., 25 ohm 2a., 50 ohm 1.4a., 100 ohm 1a., 250 ohm ·7a., 500 ohm ·45a., 1k ohm 280mA., 1·5k ohm 230mA., 2·5k ohm ·2a., 5k ohm 140mA.,** Diameter 3½in. Shaft length ⅝in. dia. ¼in., £1·50. P. & P. 15p.
50 WATT 1/2/10/25/50/100/250/500/1K/1·5K/2·5K/5K ohm. All at £1·12, P. & P. 11p.
25 WATT 10/25/50/100/250/500/1K/1·5K/2·5K ohm. All at 78p. P. & P. 5p.
Black Silver Skirted knob calibrated in Nos. 1-9. 1½ in. dia. brass bush. Ideal for above Rheostats, 18p ea.

UNISELECTOR SWITCHES—NEW 4 BANK 25 WAY FULL WIPER

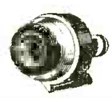
25 ohm coil, 24 v. D.C. operation £5·88. plus 22p P. & P.



6 BANK 25 WAY FULL WIPER
25 ohm coil, 24 v. D.C. operation. £6·50, plus 22p P. & P.

8 BANK 25 WAY FULL WIPER
24 v. D.C. operation. £7·63, plus 22p P. & P.

12-28 VOLT D.C. BLOWER UNIT



Powerful, smooth running, precision made Blower Unit. 5,000 RPM, ·54 amps. Size 3" diameter × 3¾" long over all. Price £2·00 post paid.

VERY SPECIAL OFFER

Cannot be repeated. 500 v. 50 Meg Record insulation testers. Excellent condition, fully tested. Complete with leather carrying case. £12. P. & P. 50p.

STROBE! STROBE! STROBE!

THREE EASY TO BUILD KITS USING XENON WHITE LIGHT FLASH TUBES. SOLID STATE TIMING + TRIGGERING CIRCUITS. PROVISION FOR EXTERNAL TRIGGERING. 230-250v. A.C. OPERATION.

The Strobe is one of the most useful and interesting instruments in the laboratory or workshop. It is invaluable for the study of movement and checking of speeds. Many uses can be found in the psychiatric and photographic fields, also in the entertainment business. It is used a great deal in the motor industry and is a real tool as well as an interesting scientific device.

EXPERIMENTERS "ECONOMY" KIT
Adjustable 1 to 36 Flash per sec. All electronic components including Veroboard S.C.R. Unijunction Xenon Tube + instructions £6·30 plus 25p P. & P.

NEW INDUSTRIAL KIT
Ideally suitable for schools, laboratories etc. Roller tin printed circuit. New trigger coil, plastic thyristor Adjustable 1-80 f.p.s. Price £10·50. 50p P. & P.

HY-LYGHT STROBE
This strobe has been designed for use in large rooms, halls and the photographic field, and utilizes a silica tube for longer life expectancy, printed circuit for easy assembly, also a special trigger coil and output capacitor. Speed adjustable 1-30 f.p.s. Light output approx. 4 joules. Price £12·00. P. & P. 50p.

AND NOW!

THE 'SUPER' HY-LYGHT KIT

Approx. 4 times the light output of our well proven Hy-Lyght strobe.
Incorporating, Heavy duty power supply.
Variable speed from 1-23 flash per sec.
Fantastic Octal based tube with massive electrodes.
Reactor control circuit producing an intense white light.
The brilliant light output of the 'SUPER' HY-LYGHT gives fabulous effects with colour filters.

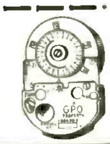
Never before a Strobe Kit with so HIGH an output at so LOW a price. ONLY £20·00 plus 75p P. & P.

7-INCH POLISHED REFLECTOR. Ideally suited for above Strobe Kits. Price 53p and 13p P. & P. or post paid with kits.

RUNNING HOUR METER

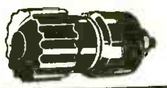
RUNNING HOUR METER. 240 volt, 50 cycle, 2·2 watt. Calibrated in minutes. Six figure. PRICE; £3·00 including Post & Packing.

VENNER ELECTRIC TIME SWITCH



200/250 volt. Ex-GPO. Tested, perfect condition. Two ON, two OFF, every 24 hrs. at any manually pre-set time. Price: 10amp. £2·75. 15amp. £3·25. 20amp. £3·75. P. & P. 20p. Also available with Solar Dial ON at dusk, OFF at dawn. Prices as above.

INSULATED TERMINALS



Available in black, red, white, yellow, blue and green. New 10p each. Post paid.

RELAYS NEW SIEMENS PLESSEY, etc.

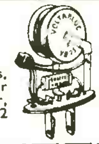
MINITURE RELAYS AT COMPETITIVE PRICES.

1	2	3	4	1	2	3	4
45	6-9	2 HD M	50p	700	12-24	2 c/o	63p*
185	6-12	2 c/o	63p*	700	15-35	2 c/o HD	73p*
185	6-12	4 c/o	73p*	700	16-24	6 M	63p*
230	9-18	2 c/o HD	63p*	1250	24-36	4 c/o	63p*
230	9-12	4 c/o	78p*	2500	36-45	6 M	63p*
280	9-12	2 c/o	73p*	2400	30-48	4 c/o	50p
600	18-32	4 c/o	78p*	5800	40-70	4 c/o	63p*
700	16-24	4 M 2 B	63p*	9000	40-70	2 c/o	50p*
700	16-24	4 c/o	78p*	15k	85-110	6 M	50p*

(1) Coil ohms; (2) Working d.c. volts; (3) Contacts; (4) Price HD = Heavy Duty. All Post Paid. *including Base.

MAINS RELAY
230 v. A.C. coil 3 c/o, 10 amp. A.C. contacts. 50p + 8p p. & p. Similar to above illustration.

RECHARGEABLE NICKEL CAD. BUTTON CELLS.

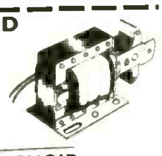


2 × 1.2 v. 250 MA/HR Nickel Cad. Cells, connected to give 2.4 v., at 25 milliamp/10 hour rate, complete with 200/250 v. A.C. charger, unused. Price 48p each plus 8p p. & p. or 2 units for £1·00 post paid.

NICKEL CADMIUM BATTERY

1.2 v. 35 AH. Size 80 high × 3 × 10. £1·50 each, plus 20p P. & P.
Sintered Cadmium Type **1.2 v. 7AH.** Size: height 3½ in., width 2⅜in. × 1¹⁄₁₆in. Weight: approx. 13 ozs. Ex-R.A.F. Tested 63p. P. & P. 15p.

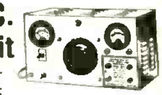
230 VOLT AC SOLENOID



EXTREMELY POWERFUL SOLENOID with approximately 14lb. pull, 1 inch travel. Fitted with mounting feet. Size 4 inches long, 2⅜ inches wide and 3 inches high. Price £2·00 including post & pkg.

230-250 VOLT A.C. SOLENOID
(Similar in appearance to above illustration.) Approx. 1½ lb. pull. Size of feet 1⅛ × 1⅛. Price 85p incl. post. Manufactured by Westool Ltd.

36 volt 30 amp. A.C. or D.C. Variable L.T. Supply Unit



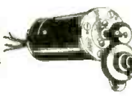
Input 220/240 v. A.C. Output Continuously variable 0-36 v. A.C./D.C. Fully isolated. Fitted in robust metal case with Voltmeter, Ammeter, Panel Indicator and chrome handles. Input and Output fully fused. Ideally suited for Lab. or Industrial use. £58 plus £2 p. & c.

230V/240V COMPACT SYNCHRONOUS GEARED MOTORS

Manufactured by either Sangamo, Haydon or Smith. Built-in gearbox.
1 rev. per hour. Clockwise rotation.
1 rev. per hour. Anti-clockwise rotation.
2 revs. per hour. Clockwise rotation.
3 revs. per hour. Anti-clockwise rotation.
5 revs. per hour. Anti-clockwise rotation.
15 revs. per hour. Anti-clockwise rotation.
60 revs. per hour. Clockwise rotation.

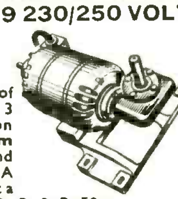
Fraction of makers' price. All at 75p incl. P. & P.

12 VOLT DC MOTOR



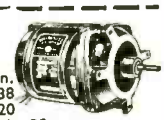
Powerful 12 volt 1 amp REVERSIBLE motor. Speed 3,750 rpm. Complete with external gear train (removable) giving final speed of 125 RPM. Size 4¼in. × 2¼in. dia. Price inc. post 95p.

PARVALUX TYPES D19 230/250 VOLT AC REVERSIBLE GEARED MOTORS



30 r.p.m. 40 lb. ins. Position of drive spindle adjustable to 3 different angles. **Mounted on substantial cast aluminium base.** Ex-equipment. Tested and in first-class running order. A really powerful motor offered at a fraction of maker's price. £6·30, P. & P. 50p.

BODINE TYPE N.C.1 GEARED MOTOR



(Type 1) 71 r.p.m. torque 10 lb. in. **Reversible** 1/70th h.p. 50 cycle .38 amp. **(Type 2) 28 r.p.m. torque 20 lb. in. Reversible** 1/80th h.p. 50 cycle .28 amp.
The above two precision made U.S.A. motors are offered in 'as new' condition. Input voltage of motor 115v A.C. Supplied complete with transformer for **230/240v A.C. input**
Price, either type £3·15 plus 35p P. & P. or less transformer £2·13 plus 27p P. & P.
These motors are ideal for rotating aerials, drawing curtains, display stands, vending machines etc. etc.

ALL MAIL ORDERS, ALSO CALLERS AT:
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SHOWROOMS NOW OPEN
AMPLE PARKING

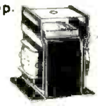
PERSONAL CALLERS ONLY
9 LITTLE NEWPORT STREET,
LONDON, WC2H 7JJ.
Tel.: 01-437 0576

Special offer of AMPEX professional tape heads, mu-metal shrouded. (Designed for model AG20). Full track record, or playback, **£3·00**. Erase head **£2·00**. Set of 3 with mounting bracket and cover **£7·50**. Half track record only, **£3·00** each. Carriage paid.

OXLEY P.T.F.E. BARB TERMINALS. Stand off 11/32" or ½". **£2·75** box of 100.

HARWIN. Tapped (6 Ba) high voltage "stand off" insulators, length ¾", tapped (8 Ba) ⅜" long. **£2·00** per 100. Carriage Paid.

"BENSON BROS." 12v. D.C. HEAVY DUTY SOLENOID. Size: 3" overall × 1¼" × 1". Very powerful. Cont. rated. **£1·00** each. P. & P. 15p.



"DECCO" MAINS SOLENOID.—Compact and very powerful. 16 lb. pull. ⅝" travel which can be increased to 1" by removing captive-end-plate. Overall size 2"×2½"×2¾" high. **£1·50.** P. & P. 25p.

WEBBER MAINS SOLENOID. Robust and strong. On this item the plunger travel is 1⅜". Performance: 6 lb. pull at 1½"; 8 lb. at 1"; 10 lb. at ½". The non-captive plunger has a fixing eye to take up to 3/16" bolt. Size: 2¼" high × 2" × 2". **£1·25** plus 25p P. & P.

SPECIAL OFFER

MAINS SOLENOID BY MAGNETIC DEVICES LTD. A beautifully constructed solenoid at half normal price. A two-sided bracket is incorporated for vertical or horizontal mounting. Size: 2" × 1¼" × 1¼". Pull is approx. 2 lb., plunger travel 1¼". Fixing eye takes up to ⅛" bolt. Plunger non-captive. New in original makers boxes. **75p** each, plus 25p P. & P. Large number available, special price for quantity.

RELAYS

Perspex enclosed, plug in, with base. Size 1¾" × 1½" × ¾"
MQ 308 600 Ω 24v. 4 c/o. **60p** ea., **£5·00** per doz.
MQ 508 10,000 Ω 100v. 4 c/o. **50p** ea., **£4·50** per doz.

S.T.C. Midget Field Relay type 4109EC. 12v. 40 mA 170Ω, single H.D. make. **53p** each.

"B. & R." 3 c/o. 10 amp. contacts (silver) operates on 2 volts D.C. Draws approx. 1 amp. Size: 2" × 1½" × 1¼". **£1·00.**

"OMRON" OCTAL BASE. A.C. mains. 2 × 5 amp. C/O contacts. Perspex enclosed. **88p.**

A.E. Perspex enclosed, plug in, 50 Ω 6v. 2 c/o. **63p** ea. 470 Ω 12v. 4 c/o. **73p** ea. 2,780 Ω 48v. 4 c/o. **73p** ea. 1,260 Ω 48v. 6 c/o. **83p** ea.

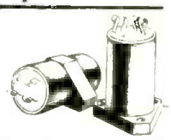
MAGNET DEVICES. 12v. 3×H.D. c/o Contacts size 1¾" × 1" × 1⅞". **63p** each.

E.R.G. 1,000 Ω 6v. DC. 1 make encapsulated reed type. Size: ⅝" × 7/16" × 1⅞". 4 for **£1·00.**

NEW "F.I.R.E." PLUG-IN RELAY.—115v. Coil 50/60 c.p.s. 3 heavy duty silver change-over contacts. Very robust. **63p.**

NEW "ISKRA" 240v. A.C. RELAY.—3 × 6 amp Changeover contacts. **63p.**

SIEMENS HIGH SPEED RELAY, Type 89L. 1,700 Ω + 1,700 Ω coil. New **63p** each.



MINIATURE "LATCH-MASTER" RELAY 6, 12, or 24v. D.C. operation. One make one break, contacts rated 5 amps. at 30v. Once current is applied, relay remains latched until input polarity is reversed. Manufactured for high acceleration requirements by Sperry Gyroscope Co. Size: Length ⅞", dia. 7/16" (including mount). Please state vertical or horizontal mount and voltage. **£1·63** each.

ELECTROLYTIC CAPACITORS MULLARD. 900µF 100v. heavy ripple screw terminals 1 7/16" dia.×3½", **70p** eac., **£6·00** per doz. 1,600µF 64v. 1⅜" dia. × 3" **38p** ea., **£3·50** per doz. 10,000µF 10v. 1⅜" dia. × 3". **38p** ea., **£3·50** per doz. 1,250µF 25v. 1" dia. × 2". **50p** ea., **£4·50** per doz.

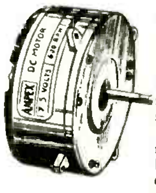
HUNTS 1,000µF 50v. 1⅜" dia. × 2", **25p** ea., 10,000µF 6v. 1⅜" dia. × 2", **30p** ea., **£3·00** per doz. 16µF 350v. 7/16" × 1½" wire ends, **£2·00** per doz. 1,000µF 50v. 1" dia. × 3", **30p** ea., **£3·00** per doz. 32-32µF 275v. 1" dia. × 2", **38p** ea. 100µF 100v. 1" dia. × 2", **25p** ea.

ERIE. Ceramicon capacitor. Type CHV411P. 500 P.F. 30KV Size 1·5" dia. × 1·44" long. **50p** ea. Carriage paid.

HIGH CAPACITY ELECTROLYTICS. Cylinder. type with screw terminals on top. Average size 3" dia. × 4½" high. "Mallory" 20,000µF 30v. D.C. 45v. D.C. surge. "Mallory 25,000µF 25v. D.C., 40v. D.C. surge. Mallory 35,000µF 15v. D.C., 20v. D.C. surge. "Mallory" 40,000µF 10v. D.C., 12v. D.C. surge. "Sprague" 40,000µF 10v. D.C., 12v. D.C. surge. "General Electric" 46,500µF 25v. D.C., 30v. D.C. surge. "General Electric" 55,000µF 15v. D.C., 20v. D.C. surge. **50p** each. Minimum order **£1·00** on these items. P. & P. 10p each.

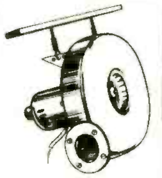
WHERE NO CARRIAGE CHARGE IS INDICATED PRICE IS INCLUSIVE. PERSONAL CALLERS WELCOME.

MOTORS

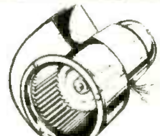


AMPEX 7.5v. D.C. MOTOR. This is an ultra-precision tape motor designed for use in the AMPEX model AG20 portable recorder. Torque 450GM/CM. Stall load at 500ma. Draws 60ma on run. 600 rpm ± 5% speed adjustment, internal AF/RF suppression. ⅛" dia. × 1" spindle, motor 3" dia. × 1⅜". Original cost £16·50. **Our price £4·25.** P. & P. 25p. Large quantity available (special quotations). Mu-metal enclosure available **75p** each.

Brand New "DISCUS" Centrifugal Blower by Watkins & Watson. 240v. 50 Hz. Powered by A.E.I. continuous rating 2850 rpm motor. Cowl diameter 10". Outlet flange 2" I.D. Coupling flange supplied. These superb precision units are ideally suited for **Organ construction.** Offered at approx. half makers price **£12·50.** Carriage £1·50.



POWERFUL DUAL VOLTAGE. 110/240v. 50Hz. Blower by Fanmanco Ltd. A compact powerful unit with 3" dia. × 1¾" wide impeller giving powerful thrust. 2" × 1¾" outlet. Weight 3½lb. These units are unused and offered at only **£3·50.** P.&P. 30p.



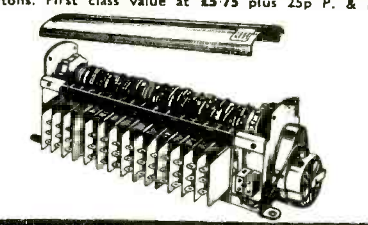
SPECIAL SUMMER OFFER

LIMITED PERIOD ONLY FROM NOW UNTIL 31st AUG. 1971 A DISCOUNT OF 20% WILL BE DEDUCTED ON ALL ORDERS OF £7·50 AND OVER

We welcome orders from established companies, educational depts., etc. (To cover invoicing costs minimum £2·50, please.)

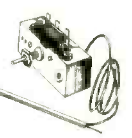
PROGRAMME TIMER BY HONEYWELL

A bank of 15 micro-switches are each independently operated by 15 pairs of cams which in turn are individually adjustable to give switching periods of zero to 12 seconds with infinitely variable combinations. A mains synchronous motor drives the cam shaft at 1 rev. per 12 seconds (5 R.P.M.). Designed originally for vending machines at a cost of **£15·00** plus. Many applications where continuous sequence programmes are required, such as lighting effects etc. New in original makers cartons. First class value at **£5·75** plus 25p P. & P.

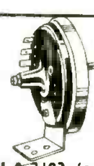


DEAC. RECHARGEABLE PERMA-SEAL Nickel-Cadmium Batteries Type 900D. 1·22v. at 900 mA (10-hr. rate). Size 90 mm. × 13·5 mm. Weight 40 gr. Unused **63p** ea. P. & P. 12p. **Stock now running low.**

"TEDDINGTON" CONTROLS THERMOSTAT.—Adjustable between 75° and 100°C. A further internal adjuster takes the maximum up to 120°C. Circuit cuts in again at 3° below cut-out setting. 42" capillary and sensor probe. The thermostat actuates a 15 amp. 250v. c/o switch. A second single pole on/off switch is incorporated in the adjustment mechanism. **88p.**



"GOYEN" PRESSURE SWITCH.—Incorporating differential adjustment between 2" and 12" water gauge (a max. of approx. ½ p.s.i.). A single pole change-over switch rated 15 amps. 250v. is actuated. Air inlet tube 3/16" dia. Projection 11/16". Overall size: dia. 3½", depth 2" plus 11/16" (air tube). **£1·25.**



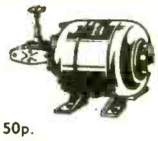
VINKOR POT CORE ASS. TYPE LA2103 (core LA.2100). Normal price £1·48. Our price **75p** each. Special quote for quantity.

UNISELECTORS. 8 Bank 25-way 24v. Double sweep. Brand new in maker's boxes. **£5·25.** P. & P. 25p.

HEAVY DUTY PORTABLE BATTERIES. New ex WD. 12v. 75 AH. Built in stout metal cases with carrying handles and nifam socket outlet. Size 15¼" × 7¼" × 10½" high, weight 73lb. **£8·75.** Carriage £2.

L.T. TRANSFORMER. Prim. 0-110-240v. Sec. 4.5v.-0-4.5v. at 2A. Size 1⅞" × 1¼" × 1 5/16" **60p.** P.&P. 15p.

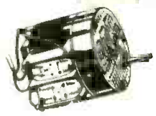
GEARED MOTORS



"Parvalux" Reversible 100 RPM Geared Motor. Type S.D.14, 230/250v. A.C. 22 lb./in. ⅜" spindle. 1st class condition. **£7·50** each. P. & P. 50p. Also limited number only as above. **Brand New. £12·50** each P. & P. 50p.

ELECTRO CONTROL (CHICAGO). Shaded pole 240v. 50 Hz. 200 rpm 10 lb./in. **£2·50.** P. & P. 25p.

MYCALEX. Open frame, shaded pole motors. 240v. 50 Hz, 7 rpm. 28 lb./in. 80 rpm. 12 lb./in. **£2·25** each. P. & P. 25p.



"CROUZET" TYPE 965. 115/240v. 50 Hz. 47/68 watts. 50 rpm. Stoutly constructed. Size: 2 11/16" dia. × 3½" long, plus spindle 1" × ¼" dia. Anti-clock. **£2·75.** P. & P. 25p.

MYCALEX MAINS. Shaded pole, 1425 rpm. 3/16" spindle. 2 for **£1·25.** Carriage Paid.

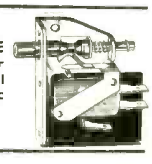
MAINS INDUCTION MOTOR. Open frame, 3/16" spindle, weight ¾ lb. Powerful. **88p** each. P. & P. 12p

E.M.I. PROFESSIONAL TAPE MOTOR. 110/240 v. 50 Hz. 1500 rpm, reversible, silent running. 4½" dia. × 4½" long. Spindle 5/16" × 2". Weight 6 lbs. **£3·50** each or **£6·00** per pair. P. & P. 50p each.

"FIBRE GLASS" COPPER CLAD. Top grade. One size only, 7½" × 4¾" × 1/16". 3 panels **£1·00.** 12 panels **£3·50.** P. & P. 15p.

"SRBP" COPPER CLAD. Sizes: 7¼" × 4 3/16" × 1/16", 16 for **£1·00.** 13 3/16" × 5⅜" × 1/16", 8 for **£1·00.** 14¼" × 5⅛" × 1/16", 8 for **£1·00.** 19⅛" × 7⅞" × 1/16", 4 for **£1·00.**

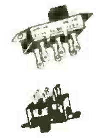
SYLVANIA MAGNETIC SWITCH—a magnetically activated switch operating in a vacuum. Switch speed—4ms. temperature −54 to +200°C. Silver contacts normally closed rated 3 amps. at 120v. 1·5 amp. at 240v. **Price 4 for £1; £2·50** per doz. P. & P. 10p. Special quotations for 100 or over. Reference magnets available **8p** each.



'HONEYWELL' TYPE 23AC-NE.—15 amp. change-over micro switch is fitted on angled metal mount with spring-loaded plastic rod operating cam. **50p** each.

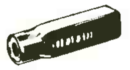
PLUNGER SWITCHES. Spring return. 3 P.D.T. 1 amp. Single action. Size: ⅞" × 7/16" plus plunger. **£1·50** per doz. Carr. Paid.

SLIDER SWITCHES. 3 amp. type D.P.D.T. 1" × 7/16" × ¾" deep. 1 amp. type 3 P.D.T. ⅞" × 7/16" × 7/16" deep. **£1·25** per doz. Either type or mixed as required. Carr. Paid.



"MALLORY" LONG LIFE BATTERIES. Type A. RM12 cell 1·35v. 3,600 ma/H. CAP. 250/300 ma cont. current. Size: 2" × ⅝". 5 for **£1·00** or **£2·00** per doz. Carr. Paid. Type B. Comprises 8 × RM 625 cells. Nom. volts. 1·35 each 10·5v. Overall. 350 ma/H CAP. 20/25 ma cont. current. Size: 2 7/16" × ⅝" × ⅝". 3 for **£1·00** or **£3·00** per doz. Carr. Paid.

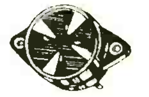
Type A



Type B

A.C./D.C. M/IRON AMMETERS. 0-5 amps or 0-8 amps (suitable battery chargers etc.). Perspex front. Size: 1⅞" × 1⅞". Any 2 for **£1·10.** Carr. Paid.

CURRENT FLOW INDICATOR. Ideal for all types of battery operated equipment (portable machines, tape recorders etc.). Four white segments appear when current flows. Coil is 600Ω 6/12v. Drawing only 8 ma on function. Neat in appearance. Size: dia. 13/16" × 13/16" deep. Fixing centres 1¼". **£1·25** each. Carr. Paid.



BIO-CHEMISTRY AND CHEMISTRY LABORATORIES **PLEASE NOTE** WE HAVE PURCHASED A NUMBER OF THE GRIFFIN AND GEORGE **BIOANALYST CHEMISTRY MODULE** G. & G. CAT. NO. S54-320. COMPLETE AUTOMATED SYSTEM. BRAND NEW IN ORIGINAL MAKER'S PACKING. CURRENTLY LISTED AT £925. WE OFFER THESE AT **£425 NETT.** CARRIAGE EXTRA.

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BUSINESS HOURS: 9.30-6 (1 p.m. Sats.)

264 PENTONVILLE ROAD, LONDON, N.1
(ONE MIN. FROM KINGS X STATION) Tel. 01-837 7401/2

G. F. MILWARD

Mail Orders: DRAYTON BASSETT, TAMWORTH, STAFFS

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Wholesale/Retail: 369 Alum Rock Road, Birmingham B8 3DR. Tel. 021-327 2339

TRANSISTOR EQUIVALENT BOOK. LATEST EDITION	40p
Mikes, Low impedance, dynamic stick type with on/off switch	£1·00
„ Crystal, hand	50p
„ Crystal, Inserts with bracket	20p
Lockable car aerials	£1·25
Dee-Gee 25 watt pencil bit soldering irons	98p
Speakers, 2½in, 8 ohms	50p
Insulating Tape, ½in wide, 10 yard rolls	5p
Miniature Output Transformers	12p
Rotary Switches, 4 pole 3 way or 2 pole 6 way	15p
Switch cleaner, aerosol cans	50p

Transistorised Modules.

BM 1	Phono pre-amp	£1·25
BM 2	Tape pre-amp	£1·25
BM 3	Mike pre-amp	£1·25
BM21	F.M. Transmitter	£1.25
BM22	F.M. Wireless Guitar	£1·25
BM31	Electric Organ	£1·25
BM41	Code Oscillator	£1·25
BM42	Wireless Oscillator	£1·25

Electrolytic Capacitors

2,000 µf 25 volt Rev.	25p
1,000 µf 70 volt	35p
10,000 µf 35 volt	50p
10,000 µf 25 volt	35p
2,000 µf 18 volt	20p
60µf + 200µf 300 volt	30p
400 µf 275 volt	25p
10 µf 6 volt	2p
10 µf 25 volt	4p
16 µf 250 volt	8p
32 µf 275 volt	8p

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ALL RRAND-NEW WITH MANUFACTURERS MARKINGS

ASY22	10p	OC45	10p	2N709	50p	2N3703	13p
ASY29	25p	OC46	15p	2N1302	15p	2N3704	18p
ASZ17 (OC35)	25p	OC141	22p	2N1309	23p	2N3707	15p
BC167	15p	OC139	22p	2N1613	25p	2N3877A	40p
BCY70	18p	OC74	20p	2N1711	25p	7401	40p
BFX12	20p	OC204	25p	2N2646	58p	7410	40p
OC41	20p	2G345	10p	2N2926	15p	7430	40p
OC42	23p	2G371	10p	2N3053	25p	7472	55p
OC43	20p	2G378	10p	2N3055	75p	7473	90p
OC44	15p			2N3702	18p	7475	£1·15

4,000,000 DIODES

SILICON, GERMANIUM OR ZENER (STATE CHOICE)

LOTS OF 100,000—£150
10,000—£20
1,000—£3
500—£2
100—50p

1,000,000 GERMANIUM TRANSISTORS (OC71/OC75)

LOTS OF 100,000—£250
10,000—£30
1,000—£3·50
500—£2
100—50p

VEROBOARD
2½in × 1in × 0·15in **6p**; 3¾in × 2½in × 0·15in **16p**; 3¾in × 3¾in × 0·15in **20p**; 5in × 2½in × 0·15in **20p**; 5in × 3¾in × 0·15in **28p**; 17in × 2½in × 0·15in **55p**; 17in × 3¾in × 0·15in **74p**; 3¾in × 2½in × 0·1in **21p**; 3¾in × 3¾in × 0·1in **24p**; 5in × 2½in × 0·1in **23p**; 5in × 3¾in × 0·1in **28p**
Spot Face Cutter **38p**. Pin Insert Tool **48p**. Terminal Pins (0·1 or 0·15) 36 for **18p**. Special Offer Pack consisting of 5 2½in × 1in boards and a Spot Face Cutter—**50p**.

RECORD PLAYER CARTRIDGES. Well below normal prices! G90 Magnetic Stereo Cartridges, Diamond Needle, 6mV output, **£4**. ACOS GP 67/2 (Mono, Crystal) **75p**. ACOS GP 91/3 (Compatible, Crystal) **£1**. ACOS GP 93/1 (Stereo, Crystal, Sapphire) **£1·25**. ACOS GP 93/1D (Stereo, Crystal, Diamond) **£1·63**. ACOS GP 94/1 (Stereo, Ceramic, Sapphire) **£1·50**. ACOS GP 94/1D (Stereo, Ceramic, Diamond) **£1·88**. ACOS GP 95/1 (Stereo, Crystal with two L.P./Stereo needles) **£1·25**.

TRANSISTORISED FLUORESCENT LIGHTS, 12 volt. All with reverse polarity protection. 8 watt type with reflector, suitable for tents, etc., **£3**. Postage/Packing 25p. 15 watt type, batten fitting for caravans **£4**. Postage/Packing 25p. 13 watt type, batten with switch. 22in × 2in × 1in **£5**. Postage/Packing 25p. THESE CAN BE SENT ON APPROVAL AGAINST FULL PAYMENT.

MULLARD POLYESTER CONDENSERS
1,000pf, 1,200pf, 1,500pf, 1,800pf, 2,200pf, **15p** per dozen (all 400V working). 0·15µf, 0·22µf, 0·27µf, **30p** per dozen (all 160V working). 25% discount for lots of 100 of any one type.

RESISTORS
¼ and ½ watt Most values in stock. **50p** per 100. **10p** per dozen of any one value. WIRE WOUND MAINS DROPPERS. Hundreds of values from 0·7 ohm upwards. 1 watt to 50 watts. A large percentage of these are multi-tapped droppers for radio/television. Owing to the huge variety these can only be offered "assorted" at **50p** per dozen.

SILVER MICA/CERAMIC/POLYSTYRENE CONDENSERS
Large range in stock, 75p per 100 of any one value. 15p per dozen.

RECORDING TAPE BARGAIN! The very best British Made low-noise high-quality Tape! 5in Standard **38p**. Long-play **45p**. 5¾in Standard **45p**. Long-play **60p**. 7in Standard **60p**. Long-play **82p**. We are getting a fantastic number of repeat orders for this tape. Might we suggest that you order now whilst we still have a good stock at these low prices!

STOCKTAKING CLEARANCE! IMPOSSIBLE TO REPEAT!
We have huge numbers of components in quantities too small to advertise individually. In order to "clear the decks" we have made up parcels containing a mixture of carbon and wire-wound resistors, electrolytic and paper condensers, controls, transistors, diodes etc., for a tiny fraction of normal price. It is emphasised that these are mixed parcels only—contents cannot be stipulated! Sold only by weight.

Gross weight 2 lb.	£1 (postage 20p)
Gross weight 5 lb.	£2 (postage 30p)

NEW! NEW! NEW! NEW!
An aerosol spray providing a convenient means of producing any number of copies of a printed circuit both simply and quickly.
Method: Spray copper laminate board with light sensitive spray. Cover with transparent film upon which circuit has been drawn. Expose to light. (No need to use ultra-violet.) Spray with developer, rinse and etch in normal manner.

Light sensitive aerosol spray	£1·00
Developer spray	50p

SPECIAL 50p PACKS. ORDER 10 PACKS AND WE WILL INCLUDE AN EXTRA ONE FREE!!!!

RESISTORS, ¼/½ watt assorted	100	50p
Wire-wound 1 to 3 watt	20	50p
5 to 7 watt	15	50p
10 watts	10	50p
Multi-tapped	12	50p
PAPER CONDENSERS Tv types	50	50p
Miniature	100	50p
ELECTROLYTIC CONDENSERS Suitable for Mains Radio/Tv	10	50p
Transistor types	20	50p
Mixed (both types)	15	50p
POLYSTYRENE CONDENSERS	100	50p
MULLARD POLYESTER COND.	50	50p
SILVER MICA	100	50p
WIRE-WOUND 3-Watt SLIDERS	15	50p
VOLUME CONTROLS Assorted	5	50p
NUTS AND BOLTS. Mixed length/type 8 B.A.	100	50p
6 B.A.	100	50p
4 B.A.	100	50p
2 B.A.	100	50p
METAL SPEAKER GRILLES 7½in. × 3½in.	6	50p
EARPIECES, MAGNETIC No Plug	6	50p
2·5mm Plug	4	50p
3·5mm Plug	4	50p
500 MICRO-AMP LEVEL METERS	1	50p
VEROBOARD. TRIAL PACK 5 BOARDS + CUTTER		50p

TRANSISTORS P.N.P. Untested but mainly O.K.	50	50p
N.P.N. Untested but mainly O.K.	50	50p
OCP.71 equivalent	5	50p
Light-sensitive Diodes (These produce up to 1ma from light)	10	50p
OC44 Mullard 1st grade	4	50p
OC45 Mullard Boxed	5	50p
2G378 Output, Marked	5	50p
2G371 Driver, Marked	5	50p
ASY 22, Marked	5	50p
BY 127 Rectifiers	4	50p
IN4007 Rectifiers (1200V peak)	4	50p
STC 3/4 Rectifiers	6	50p
DIODES (OA 81 & OA 91)	40	50p
WIRE Solid Core. Insulated	100yds.	50p
Stranded ditto	50yds.	50p
SOLAR CELLS Large Selenium	2	50p
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CO-AXIAL CABLE Semi Air-spaced	15yds.	50p
CRYSTAL TAPE RECORDER MIKES	1	50p
CRYSTAL EARPIECES 3·5mm Plug	2	50p
TRANSISTORISED Signal Injector Kit	1	50p
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TRANSISTORISED CAR REV. COUNTER KIT (Needs 1 ma. meter as indicator)	1	50p

G. F. MILWARD, Drayton Bassett, Tamworth, Staffs. Postage (minimum) per order 15p.

OSCILLOSCOPE PROBE TM8119
High impedance 100/1 resistive attenuated probe for accurate display of HF waveforms or short rise time pulse signals, offered brand new with all accessories and instruction manual. List price £17. Our price £7·50 including earth bayonet TM8194. A MARCONI PRODUCT

WAVE ANALYSER MARCONI TF455E 20Hz to 16KHz or modulated RF up to 500MHz.

MARCONI RF WATTMETERS TYPE TF912/A1. Input impedance 50 ohms dual scale 0-5 and 0-25 watts. In good used condition. Price.. .. .. £17·50
Also **MARCONI TF 1020A RF POWER METER.** Range 0-100 watts 75 ohms. £50 P. & P. 75p.

We have in stock wattmeters and RF loads up to 1,000 watts.

BARGAIN OFFER 6V DC TAPE RECORDER MOTORS Type DM148·1. Fully screened * reversible * constant speed * specially designed for Portable Recorders * Price only £1 P.P. 10p

20Kv ELECTROSTATIC VOLTMETER UNIT
5 in. scale Ernest Turner Model 32 contained in polished wood case with HV input sockets. Only £10 Carr. 15p

MARCONI 12 KHz QUARTZ CRYSTAL contained in B7G envelope with flying lead connections. Brand new only 62½p each.

TEKTRONIX TYPE 310. PORTABLE OSCILLOSCOPE. PERFECT CONDITION. PRICE £150.

MARCONI TF930
H.F. field strength measuring equipment. 18-125 mHz. £65.

SPECIAL OFFER
LEVELL TRANSISTOR AC VOLTMETER TYPE TM2A
These small portable instruments measure AC RMS volts from 500V to 100 microvolts. The meter is also scaled in dB. In perfect condition. Price only .. .. .. £18·50

MARCONI DUAL TRACE OSCILLOSCOPE TYPE TF 1331. Offered in little used condition with probe/handbook/guarantee.

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AVO Type 1 with slide rule scale as new £35
Bradley Type 131 LC/R bridge .. £30
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4-INCH G.E.C. DOUBLE GUN
C.R. Tubes Spiral P.D.A. type 1046F. Brand new. Boxed. Price £10·50.

MARCONI TF.1041B ELECTRONIC VOLTMETER. Frequency response 20Hz to 1,500 MHz. AC volts 25Mv to 300 volts; DC volts 10Mv to 1,000 volts. Resistance 0·02 ohm to 500M ohms. Offered in good calibrated condition. Price only £50 P. & P. 50p.

PHILLIPS MODEL GM 6010. DC low level electronic voltmeter measurements from 1mV for full scale deflection to 300vdc in twelve ranges. Indication on 5 inch mirror scale. A first-class instrument at an economical price. Only £40 plus battery. P. & P. 75p.

B. & K. TYPE 2409 ELECTRONIC VOLTMETER. AC measurements can be made at Average, Peak or RMS from 0·01 for FSD to 1,000V frequency response 2Hz to 200KHz in eleven ranges. Mirror scale indication is also scaled in dB from —60 to 40 dB. Function can be either VU damping or slow response. As new condition £75 P. & P. 50p.

ADVANCE TYPE 78A ELECTRONIC VOLTMETER. Range 1mV for FSD to 1,000 volts. RMS frequency response 1Hz to 1MHz. Also scaled in dBm —60 to +50. As new. Price £50
WE HAVE IN STOCK MANY OTHER TYPES, LET US KNOW YOUR REQUIREMENTS

EVERSHED & VIGNOLES CIRCUIT TESTING OHMMETER. Dual scale from 0·1 to 1,000 and 100 to 200K ohms in good serviceable condition .. £3·25 P. & P. 25p

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PYE Electrostatic Voltmeter model 11310 scalamp type Voltage range 18KV mains operated in good used condition .. £22

SPECIAL OFFER

"INSULATION TESTERS" TYPE No. 11 METROHM by famous British manufacturer. All solid state. No handles to crank. Runs off 9 volt transistor battery. Simply press button for function. Range 0·1 to 25M ohms for insulation testing. Also 0·1 to 100 ohms for resistance and continuity checking. Clear, concise scale. Small size modern instrument, complete with carrying strap and protecting cover. Offered in good used condition ready to work. For 250 volt pressure only. List Price £19·50. Our Price £6·00 plus 22½p post/packing.

EVERSHED QUICK RESPONSE RECORDER (DUPLEX) Type QU/CRD 10 with amplifier unit type PA. 10.M/G/2 with cables handbook. In as new condition, these small portable recorders are very popular and are of current manufacture offered at less than half price.

MUIRHEAD PHASE METER Type 729-AM with associated power supply in perfect order £275

CROSSHATCH & DOT GENERATOR OL21 for 625 or 405 lines. Brand new .. .. .. £40 P. & P. 50p

Honeywell Brown Electronic Recorder. Potentiometric type, Sensitivity 0·01 mV & 0·1mV offered as new perfect order £225

Miniature solenoid driven wafer switches, type-Ledex single pole, 7 pos., 3 wafers. Primarily used for channel switching in Radio-Telephones. Wafers may be substituted for any type. Solenoid voltage, 12 or 24V. Brand new. £1·50 each, p.p. 12½p.

AIRMEC PORTABLE RF SIGNAL GENERATOR. AM/FM Type CT212. Specially designed for field use for mains or 12v operation. Frequency range 85kHz to 30MHz. Accurate scale calibration. *Variable output from 1 micro V 100mV 0 to 80db. Offered in excellent condition. Only £45

TEKTRONIX 551 WITH TWO PLUG INS PERFECT CONDITION

MARCONI 801D A.M. SIGNAL GENERATOR 10-470 MHz OUTPUT 0.1 μV to 1V

MARCONI TF867 Standard RF Signal Generator, range 15kHz to 30MHz. Variable output from 4 micro V to 4 Volts. Extremely accurate attenuator, high output stability and discrimination make the generator very suitable for precision measurements on networks and filters. Modulation up to 100% may be applied at 400 or 1000 Hz. Built in crystal calibrator. Offered in first class condition. Price £175.

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Pole		Plug	Socket
2	(Spkr)	12p	10p
3		13p	10p
4		14p	12p
5	180°	15p	12p
5	240°	15p	12p
6		15p	13p

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Even No. SWG only: 2 oz. reels: 16-22 SWG **25p**; 24-30 SWG **30p**; 32, 34 SWG **33p**; 36-40 SWG **35p**. 4 oz. reels: 16-22 SWG only **41p**.

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2N1131	29p	2N3055	60p	AC153K	22p	BC159	12p	C407	17p
2N1132	29p	2N3702	13p	AC176	16p	BC167	11p	MC140	25p
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2N1303	19p	2N3704	13p	ACY22	16p	BC169	11p	MPS6534	30p
2N1304	26p	2N3705	13p	AD140	63p	BC177	14p	NKT211	25p
2N1305	26p	2N3706	13p	AD142	50p	BC178	13p	NKT212	25p
2N1306	33p	2N3707	13p	AD149	58p	BC179	14p	NKT214	23p
2N1307	33p	2N3708	10p	AD161	33p	BC182L	11p	NKT274	18p
2N1308	36p	2N3709	11p	AD162	36p	BC183L	10p	NKT403	65p
2N1309	36p	2N3710	13p	AF114	24p	BC184L	11p	NKT405	79p
2N1613	23p	2N3711	13p	AF115	24p	BC212L	16p	OC71	38p
2N1711	26p	2N3819	23p	AF117	22p	BC213L	16p	OC81	25p
2N1893	54p	2N3904	35p	AF124	33p	BC214L	16p	OC83	20p
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2N2369A	19p	2N4124	18p	BC108	11p	BF194	14p	ZTX501	21p
2N2483	35p	2N4126	27p	BC109	12p	BF195	15p	ZTX502	25p
2N2484	42p	2N4284	15p	BC125	15p	BFX29	31p	ZTX503	22p
2N2646	47p	2N4286	15p	BC126	22p	BFX84	25p	ZTX504	52p
2N2904A	42p	2N4289	15p	BC147	10p	BFX85	34p		

RESISTORS—10%, 5%, 2%

Code	Power	Tolerance	Range	Values available	to 9	10 to 99	100 up
					(see note below).		
C	1/20W	5%	82Ω–220KΩ	E12	9	8	7
C	1/8W	5%	4·7Ω–470KΩ	E24	1	0·8	0·7
C	1/4W	10%	4·7Ω–10MΩ	E12	1	0·8	0·7
C	1/2W	5%	4·7Ω–10MΩ	E24	1·2	1	0·9
C	1W	10%	4·7Ω–10MΩ	E12	2·5	2	1·8
MO	1/2W	2%	10Ω–1MΩ	E24	4	3·5	3
WW	1W	10%±1/20Ω	0·22Ω–3·9Ω	E12	7	7	6
WW	3W	5%	12Ω–10KΩ	E12	7	7	6
WW	7W	5%	12Ω–10KΩ	E12	9	9	8

Codes: C = carbon film, high stability, low noise.
MO = metal oxide, Electrosil TR5, ultra low noise.
WW = wire wound, Plessey.

Prices are in pence each for quantities of the same ohmic value and power rating. NOT mixed values. (Ignore fractions on total value of resistor order.)

Values:
E12 denotes series: 10, 12, 15, 18, 22, 27, 33, 39, 47, 56, 68, 82 and their decades.
E24 denotes series: as E12 plus 11, 13, 16, 20, 24, 30, 36, 43, 51, 62, 75, 91 and their decades.

CARBON TRACK POTENTIOMETERS, long spindles. Double wiper ensures minimum noise level.
Single gang linear 100Ω to 2·2MΩ, **12p**; Single gang log, 4·7KΩ to 2·2MΩ, **12p**; **Dual gang** linear 4·7kΩ to 2·2MΩ, **42p**; Dual gang log, 4·7KΩ to 2·2MΩ, **42p**; Log/antilog, 10K, 47K, 1MΩ only **42p**; Dual antilog, 10K only, **42p**. Any type with ½A D.P. mains switch, **12p** extra.
Only decades of 10, 22 & 47 available in ranges quoted.

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1B	25–33–40–50	10	£7·75	50p
1C	25–33–40–50	6	£6·75	50p
1D	25–33–40–50	3	£4·00	40p
2A	4–16–24–32	12	£7·25	45p
2B	4–16–24–32	8	£5·50	45p
2C	4–16–24–32	4	£3·75	40p
2D	4–16–24–32	2	£2·50	30p
3A*	25–30–35	40	£16·50	75p
3B*	25–30–35	20	£10·25	65p
3C	25–30–35	10	£7·25	60p
3D	25–30–35	5	£4·25	45p
3E	25–30–35	2	£3·25	45p
4A*	12–20–24	30	£13·00	75p
4B	12–20–24	20	£8·25	50p
4C	12–20–24	10	£4·50	50p
4D	12–20–24	5	£3·75	45p
5A	3–12–18	30	£9·75	45p
5B	3–12–18	20	£7·25	50p
5C	3–12–18	10	£4·50	45p
5D	3–12–18	5	£3·00	40p
6A	48–56–60	2	£3·75	40p
6B	48–56–60	1	£2·75	35p
7A*	6–12	50	£10·50	55p
7B	6–12	20	£6·25	45p
7C	6–12	10	£3·75	35p
7D	6–12	5	£2·75	35p
8A	12–24	1	£1·75	35p
9A	17–32	8	£6·25	35p
10A*	9–15	2	£1·50	35p
11A	6·3	15	£2·50	35p
12A	30–25–0–25–30	2	£3·75	35p
13A	36	45	£16·50	75p

Note: By using the intermediate taps many other voltages can be obtained.
Example: No. 1 .. 7–8–10–15–17–25–33–40–50v.
No. 2 .. 4–8–12–16–20–24–32v.
No. 5 .. 3–6–9–12–15–18v.

AUTO TRANSFORMERS
240v.-110v. or 100v. Completely Shrouded fitted with Two-pin American Sockets or terminal blocks. Please state which type required.

Type	Watts	Approx. Weight	Price	Carr.
1	80	2½ lb.	£2·00	30p
2	150	4 lb.	£2·75	35p
3	300	6¼ lb.	£3·75	35p
4	500	8½ lb.	£5·25	45p
5	1000	15 lb.	£7·25	50p
6	1500	25 lb.	£9·75	55p
7*	1750	28 lb.	£14·75	75p
8*	2250	30 lb.	£17·85	75p

* Completely enclosed in beautifully finished metal case fitted with two 2-pin American sockets, neon indicator, on/off switch, and carrying handle.

HIGH CAPACITY ELECTROLYTICS
20,000 mfd. 35v. wkg. 10,000 mfd. 70v. wkg. Size 4½ in. × 2½ in. dia. **74p** each. P.P 10p. 25,000 mfd. 12v. wkg. 16,000 mfd. 25v. wkg. 1,250 mfd., 180v. wkg. **60p.** P.P. 10p. T.C.C. Block type CE40M. 200 mfd. 380v. wkg. Size 9 × 3 × 2 in. **75p.** P.P. 15p. Type CE44H. 250 mfd. 250v. wkg. Size 5 × 4 × 3 in. **50p.** P.P. 15p.

G.P.O. 4-WAY TELEPHONE CORDS
Non kink coil type. Length closed 10 in. Fully expanded, 4 ft. Red only. **40p.** inc. post.

DIAMOND H RELAYS
Type BR 115 BIT-9C 4 CO Contacts, 150 ohms. 26v., 250v. 15a. Enclosed in metal case. Size 1½ × 1 in. dia. **75p** inc. post.

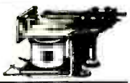
OMRON SUB MINIATURE RELAYS
Type 1051N. 12v. D.C. 1 C.O. 5 amp contact overall. Size 1 × 1 × ⅜ in. New and boxed with mounting screws. **45p.** P.P. 5p.

MAGNETIC DEVICES SEALED RELAYS
5,000Ω, 3 C.O. contacts. Overall size 2 × 2 × 1¼ in. New boxed. **37½p.** P.P. 7½p.

ELECTRO METHODS 2·3v. A.C. CONTACTORS
1 Heavy Duty Change-over Contact. Size 2¾ × 1¾ × 1 in. **50p.** P.P. 10p.

LONDEX PLUG-IN RELAYS
Sealed type. 28v. D.C. Three heavy duty silver contacts. Size 2 × 2 × 1 in. Complete with base. **50p.** P.P. 10p.

MAGNETIC DEVICES 6v. D.C. CONTACTORS
3 Heavy Makes contacts. Size 2 × 1½ × 1 in. **50p.** P.P. 10p.



G.P.O. RELAYS 3000 TYPE
75Ω 3M. 1B. 1 C.O. contacts. **30p.** 200Ω 6M. **35p.** 200Ω 2 heavy duty M. 2M. **35p.** 500Ω 1 C.O. 1M. **30p.** 250Ω 1 heavy make. 3B. 1M. **35p.** P.P. all types 5p.

G.P.O. MAGNETIC COUNTERS
Type 100D. 4 digits. Operating voltage 3-6v. D.C. Size 3¾ × 1 × 1 in. **50p.** P.P. 5p.

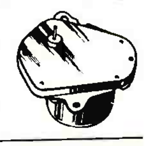
HONEYWELL MICRO SWITCHES
Type YZ RW 84-N88. Lever operated. Make or break (3 tags). Three for **70p** inc. post.

BURGESS MICRO SWITCHES
Type MK 3BR/74. Norm closed or Norm open. ½ in. raised. Press Button, three for **60p.** P.P. 5p.

ADVANCE C/V TRANSFORMERS
Type CV 15/95. Input 95-130v., 190-260v. Output 4v. rms + or —1%. 3 watts. Open frame type. **£1·25.** P.P. 25p.

RANCO REFRIGERATION THERMOSTATS
Type A.10. 100-250v. A.C. ½ h.p. **75p.** P.P. 10p. Teddington type QJ. 100-150v. A.C. ½ h.p. **75p.** P.P. 20p.

NEWMARK SYNCHRONOUS MOTORS
220-240v. 50 cycles, 3 watts 8 r.p.m. Overall size 2 × 2 × 2 in. **50p.** P.P. 10p.



VENNER SYNCHRONOUS BIO-DIRECTIONAL MOTORS
220-240v. 50 cycles 40 r.p.m. automatically reverses wherever spindle stop is placed. Overall size 2½ × 2 × 1 in. Spindle length ½ in. dia. 1/16th. An ideal motor for display, giving a forward and reverse motion. **60p.** P.P. 15p.

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Details of the Show: "Flight" for June 24, 1971, page 942.

Great new OFFER from DIOTRAN

TRANSISTORS

AC 107	15p	AD 149	43p	BC 108	10p	BC 177	17p	BF 119	70p	BFX 84	20p	EC 401	15p	OC 201	27p	2N 524	55p	2N 2194	27p	2N 3403	22p
AC 113	20p	AD 161	35p	BC 109	11p	BC 178	17p	BF 152	35p	BFX 85	27p	EC 403	15p	OC 202	27p	2N 527	60p	2N 2217	20p	2N 3404	32p
AC 115	23p	AD 162	35p	BC 113	25p	BC 179	17p	BF 153	35p	BFX 86	22p	GET 880	27p	OC 203	25p	2N 696	12p	2N 2218	25p	2N 3405	45p
AC 125	17p	AD 161/		BC 114	30p	BC 180	20p	BF 154	35p	BFX 87	25p	MAT 100	15p	OC 204	25p	2N 697	15p	2N 2219	27p	2N 3414	20p
AC 126	17p	162(MP)	63p	BC 115	30p	BC 181	22p	BF 157	45p	BFX 88	22p	MAT 101	17p	OC 205	35p	2N 698	24p	2N 2220	22p	2N 3415	20p
AC 127	17p	ADT 140	50p	BC 116	35p	BC 182	10p	BF 158	25p	BFY 50	20p	MAT 120	15p	OC 309	35p	2N 699	55p	2N 2221	22p	2N 3417	37p
AC 128	17p	ADZ 11	£2.00	BC 117	35p	BC 182L	10p	BF 159	30p	BFY 51	20p	MAT 121	17p	P 346A	17p	2N 706	7p	2N 2222	27p	2N 3525	75p
AC 141K	17p	ADZ 12	£2.10	BC 118	25p	BC 183	10p	BF 160	30p	BFY 52	20p	MPF 102	43p	P 397	45p	2N 706A	8p	2N 2368	17p	2N 3702	12p
AC 142K	17p	AF 114	17p	BC 119	45p	BC 183L	10p	BF 162	30p	BFY 53	17p	MPF 105	43p	OCP 71	43p	2N 708	12p	2N 2369	15p	2N 3703	12p
AC 151	15p	AF 115	17p	BC 125	35p	BC 184	13p	BF 163	35p	BSX 19	15p	OC 19	30p	ORP 12	43p	1N 709	45p	2N 2369A	15p	2N 3704	15p
AC 154	15p	AF 116	17p	BC 126	35p	BC 184L	13p	BF 164	35p	BSX 20	15p	OC 20	50p	ORP 60	40p	2N 711	40p	2N 2411	50p	2N 3705	12p
AC 155	17p	AF 117	17p	BC 132	25p	BC 186	27p	BF 165	35p	BSY 25	15p	OC 22	30p	ORP 61	40p	2N 717	42p	2N 2412	50p	2N 3706	12p
AC 156	17p	AF 118	30p	BC 134	30p	BC 187	27p	BF 167	22p	BSY 26	15p	OC 23	33p	ST 140	12p	2N 718	24p	2N 2646	55p	2N 3707	13p
AC 157	17p	AF 124	21p	BC 135	30p	BC 207	11p	BF 173	22p	BSY 27	15p	OC 24	45p	ST 141	17p	2N 718A	50p	2N 2711	22p	2N 3708	8p
AC 165	17p	AF 125	20p	BC 136	30p	BC 208	11p	BF 176	35p	BSY 28	15p	OC 25	25p	TIS 43	40p	2N 726	27p	2N 2712	22p	2N 3709	8p
AC 166	17p	AF 126	20p	BC 137	35p	BC 209	11p	BF 177	35p	BSY 29	15p	OC 26	25p	UT 46	27p	2N 727	27p	2N 2714	25p	2N 3710	10p
AC 167	20p	AF 127	20p	BC 139	45p	BC 212L	11p	BF 178	45p	BSY 38	15p	OC 28	40p	V 405A	25p	2N 743	17p	2N 2904	25p	2N 3711	10p
AC 168	20p	AF 139	33p	BC 140	35p	BC 213L	11p	BF 179	50p	BSY 39	15p	OC 29	40p	V 410A	45p	2N 744	17p	2N 2904A	30p	2N 3819	40p
AC 169	14p	AF 178	50p	BC 141	35p	BC 214L	12p	BF 180	30p	BSY 40	30p	OC 35	33p	2G 301	19p	2N 914	17p	2N 2905	25p	2N 3820	£1.00
AC 176	23p	AF 179	50p	BC 142	45p	BC 225	25p	BF 181	30p	BSY 41	35p	OC 36	40p	2G 302	19p	2N 918	30p	2N 2905A	30p	2N 3903	25p
AC 177	20p	AF 180	50p	BC 143	40p	BC 226	35p	BF 182	30p	BSY 95	12p	OC 41	20p	2G 303	19p	2N 929	22p	2N 2906	25p	2N 3904	27p
AC 187	30p	AF 181	50p	BC 145	45p	BC 317	12p	BF 183	30p	BSY 95A	12p	OC 42	22p	2G 304	20p	2N 930	25p	2N 2906A	27p	2N 3905	25p
AC 188	30p	AF 186	45p	BC 147	17p	BC 318	12p	BF 184	25p	Bu 105	£3.90	OC 44	15p	2G 306	35p	2N 1131	20p	2N 2907	25p	2N 3906	27p
ACY 17	25p	AF 239	37p	BC 148	12p	BC319	12p	BF 185	30p	C 111E	60p	OC 45	12p	2G 308	35p	2N 1132	22p	2N 2907A	30p	2N 4058	15p
ACY 18	20p	AFZ 11	37p	BC 149	17p	BCY30	20p	BF 188	30p	C 400	30p	OC 70	15p	2G 309	35p	2N 1302	17p	2N 2923	13p	2N 4059	10p
ACY 19	22p	AFZ 12	45p	BC 150	17p	BCY31	22p	BF 194	23p	C 407	25p	OC 71	9p	2G 339	17p	2N 1303	17p	2N 2924	13p	2N 4060	12p
ACY 20	20p	AL 102	85p	BC 151	20p	BCY 32	25p	BF 195	24p	C 424	17p	OC 72	12p	2G 339A	15p	2N 1304	20p	2N 2925	13p	2N 4061	12p
ACY 21	20p	AL 103	85p	BC 152	17p	BCY 33	17p	BF 196	30p	C 425	40p	OC 74	12p	2G 334	15p	2N 1305	20p	2N 2926(G)	12p	2N 4062	12p
ACY 22	19p	ASY 26	25p	BC 153	27p	BCY 34	20p	BF 197	35p	C 426	30p	OC 75	15p	2G 345	15p	2N 1306	22p	2N 2926(Y)	11p	2N 5172	12p
ACY 27	18p	ASY 27	30p	BC 154	30p	BCY 70	17p	BF 200	45p	C 428	20p	OC 76	15p	2G 371	13p	2N 1307	22p	2N 2926(O)	10p	2N 5459	43p
ACY 28	19p	ASY 28	25p	BC 157	20p	BCY 71	30p	BF 222	80p	C 441	27p	OC 77	25p	2G 371B	10p	2N 1308	27p	2N 3010	80p	2S 034	75p
ACY 29	30p	ASY 29	25p	BC 158	17p	BCY 72	15p	BF 257	35p	C 442	35p	OC 81	15p	2G 374	17p	2N 1309	27p	2N 3011	20p	2S 301	50p
ACY 30	25p	ASY 50	25p	BC 159	20p	BCZ 11	20p	BF 270	25p	C 444	37p	OC 81D	15p	2G 377	27p	2N 1613	17p	2N 3053	20p	2S 302A	45p
ACY 31	25p	ASY 51	25p	BC 167	13p	BD 121	85p	BF 271	17p	C 450	17p	OC 82	15p	2G 378	15p	2N 1711	20p	2N 3054	50p	2S 302	45p
ACY 34	18p	ASY 52	25p	BC 168	13p	BD 123	85p	BF 272	80p	C 720	12p	OC 82D	15p	2G 382	15p	2N 1889	35p	2N 3055	63p	2S 303	60p
ACY 35	18p	ASY 54	25p	BC 169	13p	BD 124	75p	BF 273	30p	C 722	25p	OC 83	20p	2G 401	30p	2N 1890	45p	2N 3391	17p	2S 304	£1.10
ACY 36	30p	ASY 55	25p	BC 170	12p	BD 131	80p	BF 274	30p	C 740	25p	OC 84	20p	2G 414	30p	2N 1893	37p	2N 3391A	20p	2S 305	£1.00
ACY 40	15p	ASY 56	25p	BC 171	13p	BD 132	80p	BF 308	35p	C 742	17p	OC 139	15p	2G 417	25p	2N 2160	60p	2N 3392	17p	2S 306	£1.10
ACY 41	18p	ASY 57	25p	BC 172	13p	BDY 20	£1.00	BF 309	37p	C 744	17p	OC 140	17p	2N 388	30p	2N 2147	75p	2N 3393	15p	2S 307	£1.10
ACY 44	35p	ASY 58	25p	BC 173	13p	BF 115	22p	BF 316	75p	C 760	17p	OC 170	15p	2N 388A	50p	2N 2148	60p	2N 3394	15p	2S 321	60p
AD 140	40p	ASZ 21	40p	BC 174	13p	BF 117	45p	BFW 10	55p	C 762	17p	OC 171	15p	2N 404	22p	2N 2192	30p	2N 3395	20p	2S 322	50p
AD 142	40p	BC 107	10p	BC 175	22p	BF 118	60p	BFX 29	27p	C 764		OC 200	25p	2N 404A	30p	2N 2193	30p	2N 3402	22p	2S 322A	45p

2S 323	60p
2S 324	£1.20
2S 325	£1.20
2S 326	£1.20
2S 327	£1.20
DIODES & RECTIFIERS	
AA 119	8p
AA 120	8p
BA 116	22p
BA 126	22p
BY 100	15p
BY 101	12p
BY 105	15p
BY 114	12p
BY 126	15p
BY 127	17p
BY 130	15p
BYZ 10	35p
BYZ 11	32p
BYZ 12	30p
BYZ 13	25p
BYZ 16	35p
BYZ 17	35p
BYZ 18	30p
BYZ 19	25p
OA 5	17p
OA 10	22p
OA 47	7p
OA 70	7p
OA 79	8p
OA 81	7p
OA 85	7p
OA 90	6p
OA 91	7p
OA 95	7p
OA 200	6p
OA 202	7p
SO 10	4p
SO 19	4p
IN 914	6p
IN 916	6p
IN 4148	6p

10 MILLION DIODES
SILICON OR GERMAINIUM
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1000	£2.00	50,000	£30.00
5000	£7.00	100,000	£50.00

2,000,000 SILICON PLANAR TRANSISTORS
TO18 P.N.P. & N.P.N TYPES
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500	£6.00	50,000	£400.00
1,000	£10.00	100,000	£625.00

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709/PC S.G.S.

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

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BRAND NEW UNIJUNCTION TRANSISTORS

BRAND NEW FULLY TESTED EPOXY CASE UNIJUNCTION TRANSISTORS. Type TIS43 and BEN 3000 and replacement for 2N2646. Full data available. LOWEST PRICE AVAILABLE ANYWHERE. 100 off 20p each = £20; 500 off 17½p each = £87.50; 1,000 off 15p each = £150. Sample devices 35p each on request.

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HIGH QUALITY SILICON PLANAR DIODES. SUB-MINIATURE DO-7 Glass Type, suitable replacements for OA200, OA202, BAY38, IS130, IS940. 200,000 to clear at £4 per 1,000 pieces. GUARANTEED 80% GOOD. OA90 GERM. DIODES 30PW 45MA DO-7 GLASS. 30,000 Available New and Coded. Price £3 per 100, £11 per 500, £17 per 1,000 pieces. Once sold cannot be repeated.

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Full money-back guarantee

POSTAGE & PACKING 7p

ELECTRONIC ORGAN DIVIDER BOARDS built to high industrial/computer spec. 5 octave set **£15**. Complete with connection data and oscillator details.

COPPER LAMINATE P.C. BOARD
8½×5½×1/16 in. **12½p** sheet, 5 for **50p**
11×6½×1/16 in. **15p** sheet, 4 for **50p**
11×9×1/16 in. **20p** sheet, 3 for **50p**
Offcut pack (smallest 4×2 in.) **50p** 300 sq. in.
P&P single sheet **4p**. Bargain packs **10p**

SPEAKERS AND CABINETS

E.M.I. 19 × 14 in. 50 watts (14A/600A). Four tweeters mounted across main axis. Separate "X-over" unit balances both bass and h.f. sections. 20Hz to 20,000Hz. Bass unit flux 16,500gss. A truly magnificent system. **£25.** Carr. £1·50.

E.M.I. 13×8 in. (10 watt) with two tweeters and cross-over 3/8/15 ohm models. **£3·75.** P.P. 25p.

E.M.I. 13×8 in. base units (10 watt) 3/8/15 ohm models **£2·25.** P.P. 25p.

E.M.I. 6½ in. rnd. 10 watt Woofers. 8 ohm. 13,000 gss **£2·25.** P.P. 15p.

E.M.I. 20 watt (13×8 in.) with single tweeter and "X-over" 20 Hz to 20,000 Hz. Ceramic magnet 11,000gss. **£8.** P.P. 40p. 20 watt base unit only. **£6.** P.P. 40p.

CABINETS for 13×8 in. Speakers made from ¾ in. teak finish blockboard. 20 watt cabinet (21×15×8½ in.) **£6.** P.P. 50p. 10 watt cabinet (16×11×8 in.) **£4·80.** P.P. 40p.

"AIRMAX" 7½ in. FANS. Aluminium diecast housing (9 in.) 240v. a.c. New. **£5.** P.P. 50p.

"KLAXON" GEARED MOTORS (8 ib-in.) 112 r.p.m. 240v. **£2·25.**

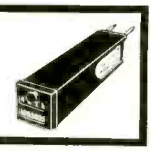
BRIDGE MEGGERS (500v. series 2) **£18** ea. in good working order.

BRIDGE RECTIFIERS (Mullard GEX 54INBIPIF) Output 74volt. at 18 amps. **£2** ea. (brand new).

BULK COMPONENT OFFER. Resistors/Capacitors. All types and values. All new modern components. Over 500 pieces **£2.** (Trial order 100pcs. 50p.) We are confident you will re-order.

BERCO WIRE-WOUND POTS. New individually boxed. 200 ohm 25 watt **50p**; 725 ohm 50 watt **75p**; 300 ohm 100 watt **£1** ea.

HIGH SPEED MAGNETIC COUNTERS (4×1×1 in.) 4 digit. 24/48v. (state which), **32½p** ea. P.P. 5p.
3 Digit (Re-settable) 12v. working **£1·75.**



LEVEL METERS (1½×½ in.) 200 micro amp. Made in Germany **75p** ea. 2×1½ in. (Japan) **£1** ea.

MICROAMMETERS (4 in. sq. Weston) 25-0-25 micro-amps. New/boxed. **£2·25** ea. P.P. 25p.

PRECISION CAPACITANCE JIGS. Beautifully made with Moore & Wright Micrometer Gauge. Type 1. 18.5pf to 1220pf. **£10** ea. Type 2. 9.5pf to 11.5pf. **£6** ea.

POT CORES LA1/LA2/LA3. **50p** ea.

LIGHT DIMMERS (2000 watt) Triac Controlled. 3½×2×1½ in. **£5·75** ea. P.P. 25p.

TRANSFORMERS

L.T. TRANSFORMER. (Shrouded) Prim. 200/250v. Sec. 20/40/60v. 2 amp. **£2** ea. P.P. 40p.

L.T. TRANSFORMER. (Shrouded) Prim. 200/250v. Sec. 20/40v. 1.5 amp. **£1·50** ea. P.P. 30p.

L.T. TRANSFORMER. Prim. 240v. Sec. 8/12/20/25v. 3.5 amp. **£1** ea. P.P. 40p.

L.T. TRANSFORMERS. Prim. 240v. Sec. 14v. 1 amp. **50p**; 10.5v. 1 amp. model **50p.** P.P. either type 15p.

L.T. TRANSFORMER. "ADVANCE VOLTSTAT" Prim. 190-260v. Sec. 6v. r.m.s. 25 watt. **£2** ea. P.P. 30p.

H.T. TRANSFORMERS. Prim. 200/240v. Sec. 300-0-300v. 80 m.a. 6.3v. c.t. 2 amp. **£1·50** P.P. 40p. 350-0-350v. 60 m.a. 6.3v. c.t. 2 amp. **£1.** P.P. 25p.

H.T. TRANSFORMERS (H.D.) Prim. 200/240v. Sec. 550v. 2 amp. **£7·50.** Carr. £1; 440v. 2.8 amp. **£7·50.** Carr. £1. Chokes to match **£4.** Carr. £1.

STEP-DOWN TRANSFORMERS. Prim. 200/240v. Sec. 115v. 120 watt (double wound). **£1·25.** P.P. 25p; 250 watt (D.W.). **£2·25.** P.P. 25p; 500 watt (D.W.). **£5.** P.P. £1; 600 watt (auto). **£4·50.** P.P. 75p; 750 watt (auto). **£5·50.** P.P. £1.

ADVANCE CONSTANT VOLTAGE. Prim. 190/250v. Sec. 115v. 2250 watt. **£15.** Carr. £2·50.

CONSTANT VOLTAGE TRANSFORMER. Prim. 190/260v. Sec. 230v. r.m.s. 150 watt. **£3·25.** Carr. 75p.

120 amp. AUTO TRANSFORMER. 190/270v. 50 c/s. Tapped every 5 volts. **£50** ea. (Carr. by arrangement.)

COMPUTER TAPES. 2400 ft. ¾ in. On N.A.B. Hubs complete with transparent cassette case. **£2** ea. P.P. 50p.

LIQUID LEVEL SWITCH. Detects even mildly conductive liquids i.e. ether etc. N/O-N/C contacts fails to safe. **£10** ea. S.a.e. literature.

"LONG LIFE" ELECTROLYTICS (screw terminal).
25,000 u.f. 40v. (4½×2½ in.) **£1** P.P. 10p.
10,000 u.f. 75v. (4½×2½ in.) **87½p.** P.P. 10p.
7,100 u.f. 40v. (4×2 in.) **75p.** P.P. 10p.
3,150 u.f. 40v. (4×1½ in.) **75p.** P.P. 10p.

TELEPHONE DIALS (New) £1 ea.

RELAYS (G.P.O. '3000'). All types. Brand new from **37½p** ea. 10 up quotations only.
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UNISELECTORS (Brand new) 25-way 75 ohm. 8 bank ½ wipe **£3·25.** 10 bank ½ wipe **£3·75.** Other types from **£2·25.**

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SIEMENS/VARLEY PLUG-IN. Complete with transparent dust covers and bases. 2 pole c/o contacts **35p** ea.; 6 make contacts **40p** ea.; 4 pole c/o contacts **50p** ea. 6-12-24-48v types in stock.

12 VOLT H.D. RELAYS (3×2×1 in.) with 10 amp. silver contacts 2 pole c/o **40p** ea.; 2 pole 3 way **40p.** P.P. 5p.

24 VOLT H.D. RELAYS (2×2×¾ in.) 10 amp. contacts. 4 pole c/o. **40p** ea. P.P. 5p.

240 VOLT A.C. RELAYS (1¾×1¾×1 in.) G.P. contacts 1 make 2 c/o. **60p** ea. P.P. 5p.

REED RELAYS 4 make 9/12v. (1,000 ohm.) **62½p** ea. 2 make **37½p** ea. 1 make **25p** ea. Reed Switches (1¾ in.) **10p** ea. £1 per doz.

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E.H.T. GENERATOR MODULE (Mullard VM1049) input 12 volt, output 1800 volt 1 m.a. **£4** ea. P.P. 25p.

SILICON BRIDGES 100 p.i.v. 1 amp (⅝×⅝×⅜ in.) **45p**; 100 p.i.v. 2 amp (1¼×1¼×½ in.) **75p.**

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ROMFORD 44473 **RM79DD**

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DF96	0·37
DK96	0·41
DL92	0·32
DL94	0·40
DL96	0·41
DM70	0·30
DY86	0·30
DY87	0·32
DY802	0·48
E88CC/01	1·80
E180CC	0·42
E181CC	0·90
E182CC	1·05
EABC80	0·32
EAF42	0·50
EB91	0·15
EBC33	0·50
EBC41	0·52
ECC81	0·30
EBF80	0·42
EBF83	0·42
EBF89	0·30
ECC81	0·30
ECC82	0·28
ECC83	0·30
ECC84	0·30
ECC85	0·40
ECC86	0·50
ECC88	0·37
ECC189	0·52
ECF80	0·35
ECF82	0·35
ECF83	0·75
ECF801	0·62
ECF802	0·62
ECH35	0·60
ECH42	0·65
ECH81	0·28
ECH83	0·42

	£
ECH84	0·45
ECH200	0·62
ECL80	0·45
ECL82	0·32
ECL83	0·65
ECL86	0·42
EF36	0·45
EF37A	0·45
EF39	0·40
EF40	0·50
EF41	0·62
EF80	0·25
EF83	0·55
EF85	0·32
EF86	0·31
EF89	0·26
EF91	0·15
EF92	0·37
EF95	0·30
EF183	0·32
EF184	0·35
EFL200	0·75
EL34	0·52
EL41	0·57
EL42	0·53
EL84	0·23
EL85	0·40
EL86	0·40
EL90	0·35
EL95	0·35
EL500	0·85
EM31	0·25
EM80	0·40
EM84	0·35
EM87	0·55
EY51	0·40
EY86	0·35
EY81	0·35
EY88	0·40
EZ41	0·42
EZ80	0·25
EZ81	0·27
GZ34	0·52
KT66	1·60

	£
KT88	1·15
N78	1·25
OA2	0·35
OB2	0·35
PABC80	0·37
PC97	0·40
PC900	0·47
PCC84	0·37
PCC89	0·45
PCC189	0·55
PCE800	0·75
PCF80	0·30
PCF82	0·33
PCF84	0·46
PCF86	0·57
PCF200	0·77
PCF201	0·77
PCF801	0·48
PCF802	0·48
PCF805	0·72
PCF806	0·65
PCF808	0·72
PCH200	0·70
PCL81	0·47
PCL82	0·37
PCL83	0·65
PCL84	0·42
PCL85	0·42
PCL86	0·42
PFL200	0·57
PL36	0·53
PL81	0·50
PL82	0·40
PL83	0·42
PL84	0·35
PL500	0·73
PL504	0·75
PY33	0·60
PY80	0·35
PY81	0·27
PY82	0·27
PY83	0·35
PY88	0·37
PY800	0·52
PY801	0·52
QQVO 3-10	1·25

	£
QQVO 6-40A	5·25
R17	0·45
R19	0·37
STV 280/40	3·00
STV 280/80	9·00
TT21	2·75
U25	0·75
U26	0·75
U27	0·50
U191	0·70
U801	1·00
UABC80	0·35
UAF42	0·50

	£
UBC41	0·47
UBF80	0·35
UBF89	0·35
UCC85	0·40
UCF80	0·55
UCH42	0·70
UCH81	0·35
UCL82	0·35
UCL83	0·60
UF41	0·50
UF80	0·38
UF89	0·35
UL41	0·60
UL84	0·30
UU5	0·55
UY41	0·45
UY85	0·30
VR105/30	0·35

	£
VR150/30	0·35
Z759	1·65
Z801U	1·50
Z803A	1·25
Z900T	0·75
1L4	0·15
1R5	0·35
1S4	0·25
1S5	0·24
1T4	0·22
1X2A	0·40
1X2B	0·40
3A4	0·30
3D6	0·15
3Q4	0·37
3S4	0·35
3V4	0·45

	£
5B254M	2·20
5B/255M	1·75
5R4GY	0·60
5U4G	0·32
5V4G	0·40
5Y4G	0·40
5Y3GT	0·35
5Z4	0·75
5Z4GT	0·40
6AB7	0·30
6AC7	0·15
6AH6	0·50
6AK5	0·30
6AK8	0·32
6AL5	0·15
6AL5W	0·40
6AM6	0·30
6AN8	0·50

	£
6AQ5	0·35
6AQ5W	0·50
6AS6	0·37
6AS7G	0·80
6AT6	0·30
6AU6	0·25
6AX4GT	0·40
6AX5GT	0·65
6B7	0·40
6BK7	0·40
6BA6	0·25
6BE6	0·30
6BG6G	0·55
6BJ6	0·45
6BQ7A	0·35
6BR7	0·80
6BW6	0·80
6BW7	0·70

	£
6C4	0·30
6C6	0·25
6CH6	0·55
6CL6	0·49
6D6	0·20
6EA8	0·55
6F23	0·75
6F33	1·50
6H6M	0·20
6J4WA	0·75
6J5	0·40
6J5GT	0·25
6J6	0·20
6J7G	0·35
6J7M	0·40
6K6GT	0·56
6K7	0·32

	£
6K7G	0·20
6K8GT	0·45
6K25	0·70
6SA7	0·40
6SA7GT	0·32
6SC7GT	0·25
6SG7	0·35
6SJ7	0·37
6SJ7GT	0·32
6SK7	0·35
6SL7GT	0·32
6SN7GT	0·35
6SQ7	0·39
6SQ7GT	0·35
6V6G	0·17
6V6GT	0·35
6X4	0·27
6X5G	0·25
6X5GT	0·32
6Y6G	0·60
6-30L2	0·70
6Z4	0·32
7B7	0·45
7C5	0·85
7C6	0·40
7-7	0·32
7Y4	0·60
9D6	0·37
11E2	2·50
12AT6	0·30
12AT7	0·30
12AU7	0·29
12AV6	0·30
12AX7	0·30
12BA6	0·35
12BE6	0·35
12BH7	0·27
12C8	0·32
12E1	1·25
12K5	0·55
12K7GT	0·40
12K8GT	0·45
12Q7GT	0·30
12SG7	0·35
14S7	0·75
19AQ5	0·40
19G3	4·25
19G6	1·50
19H4	5·00
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30C17	0·80
30C18	0·75
30F5	0·84
30FL1	0·70
30FL12	0·92
30FL13	0·50
30FL14	0·75
30L15	0·85
30L17	0·80
30P12	0·80
30P19	0·80
30PL1	0·70
30PL13	0·92
30PL14	0·85
35L6GT	0·50
35W4	0·30
35Z4GT	0·45
42	0·45
50C5	0·40
50CD6G	1·60
50EH5	0·60
75	0·40
76	0·40
78	0·40
80	0·45
803	3·25
805	8·00
807	0·50
813	3·75
832A	0·40
866A	0·75
954	0·40
955	0·25
956	0·20
957	0·30
991	0·40
1622	1·00
2051	0·55
5933	1·12

	£
6057	0·50
6060	0·50
6064	0·45
6065	0·65
6080	1·37
6146	1·50
8020	2·25
9001	0·20
9002	0·25
9003	0·50
9004	0·15
9006	0·15

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VCR97	4·50
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VCR517C	7·50
5FP7	1·32
88D	9·00
88J	9·00
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WL417A	1·50
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714AY	4·00
725A	16·00

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OA5	0·20
OA10	0·25
OA70	0·10
OA71	0·10
OA73	0·10
OA74	0·10
OA79 (6D15)	0·10
OA81	0·10
OA91	0·07
OA200	0·07
OA202	0·10
OA210	0·25
OA211	0·37
OAZ200	0·55
OAZ201	0·50
OAZ202 to OAZ206	0·42
OAZ207	0·47
OAZ208 to OAZ213	0·32
OAZ223 to OAZ225	0·50
OC16	0·50
OC22	0·50
OC25	0·37
OC26	0·25
OC28	0·62

	£
OC29	0·62
OC35	0·50
OC38	0·42
OC44	0·17
OC45	0·15
OC70	0·12
OC71	0·15
OC72	0·25
OC73	0·30
OC75	0·25
OC76	0·25
OC81	0·25
OC81D	0·20
OC81DM	0·20
OC82	0·25
OC82DM	0·30
OC83	0·25
OC83B	0·15
OC84	0·25
OC122	0·50
OC139	0·25
OC140	0·37
OC170	0·25
OC171	0·30
OC172	0·37
OC200	0·40
OC201	0·60
OC206	0·90

	£
IN21	0·17
1N21B	0·25
IN25	0·60
1N43	0·10
1N70	0·07
1N702-725	0·36
1N823A	1·30
IN4785	0·50
1ZMT5	0·35
1ZMT10	0·33
1ZT5	0·67
1ZT10	0·63
2G385	0·51
2G403	0·51
2N918	0·37
2N1304	0·25
2N1306	0·25
2N1307	0·25
2N2147	0·75
2N2904A	0·32
2N3053	0·25
2N3054	0·50
2N3055	0·75
2N3730	0·50
2N3731	2·75

	£
2N5109	2·05
40362	0·62
82303	0·50
3F100	0·62
3FR5	0·32
3N128	0·87
3N139	1·75
3N140	0·97
3N154	0·95
3N159	1·45
6FR5	0·45
12FR60	0·73
10D1	0·16
40954	1·37
40595	1·37
40636	1·45
40668	1·35
40669	1·45
AC126	0·25
AC127	0·25
AC128	0·25
AC176	0·25
ACY17	0·30
ACY28	0·17
AD149	0·50
AD161	0·37
AO162	0·37
AF118	0·62

	£
AF127	0·17
AF139	0·30
AF178	0·48
AF186	0·40
AFY19	0·13
ASY26	0·25
ASY28	0·25
ASY67	0·48
BAW19	0·28
BC107	0·12
BC108	0·12
BC113	0·25
BC118	0·38
BCY72	0·15
BF115	0·25
BF173	0·30
BFY51	0·20
BFY52	0·23
BSO5	0·38
BS	0·45
BS2	0·47
BSY29	0·25
BU100	1·80
BYZ13	0·25
BYZ16	0·63
CRS1/10	0·25
CRS1/20	0·38

	£
CRS1/30	0·40
CRS1/35	0·43
CRS1/40	0·48
CRS3/05	0·30
CRS3/20	0·38
CRS3/30	0·43
CRS25/025	0·75
CRS3/40	0·50
GET103	0·23
GET115	0·45
GET116	0·50
GEX66	1·00
NKT222	0·20
NKT304	0·50
SD918	0·26
SD928	0·31
SD938	0·32
SD94	0·21
SD988	0·46
V405A	0·40

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All preferred voltage

¼W	0·17
1W	0·37
1·5W	0·25
7W	0·40

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VALVE VOLTMETER TYPE TF 958 Measures AC 100mV; 20 c/s to 100 mc/s, DC 50mV to 100V, multiplier extends ac range to 1.5kV. Balanced input and centre-zero scale for DC. AC up to 100MHz. **£32·50.**

VIDEO OSCILLATOR TF 885A & 885A I 25Hz to 5MHz and 25Hz-12MHz respectively, fine and square wave output up to 31v. **£55** and **£85** resp. Carriage £1·50.

MARCONI VHF OSCILLATOR TYPE TF 924/I. Complete with power unit Type TM 4230. Frequency range 2,100 MHz to 3,750 MHz, output power 10 to 50mW, Klystron Osc with automatic tracking. Facilities for reflection modulation. **£125.** Carriage £2.

MARCONI VHF ALIGNMENT OSCILLOSCOPE TF 1104. Combined sweep generator and CRO for VHF, IF and VF analysis. RF ranges 41-216kHz. IF range 10-40MHz. VF range 5kHz to 10MHz. Output 10uV to 250MV continuous at 50 ohms. Sweep 500kHz to 10MHz. **£89·50.** Carr. £1.

MARCONI R/C OSCILLATOR TYPE TF 1101. Frequency range 20Hz to 200kHz. Accuracy ± 1%, distortion less than 0·5%. Stabilised Oscillator, no zero setting required. **£72·50.** Carriage £1·50.

HEWLITT PACKARD AUDIO SIGNAL GENERATOR MODEL 206A £89·50. Carriage £1·50. Full specification for S.A.E.

REMSCOPE TYPE 741 STORAGE OSCILLOSCOPE. On trolley, complete with plug-in trace shifter and two plug-in Y amplifiers. Price on application.

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PA 230 **£1·40**; PA 234 **£1**; PA 237 **£2·10**

Mullard
TAA 300 **£1·75**; TAA 320 **£0·73**

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Twinplex combiner type AFS 13 **£65**
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F.S.K. unit type GK185A **£58·50.**

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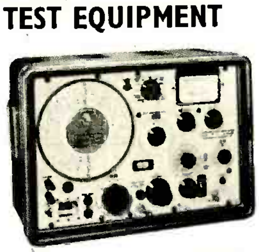
MARCONI TEST EQUIPMENT

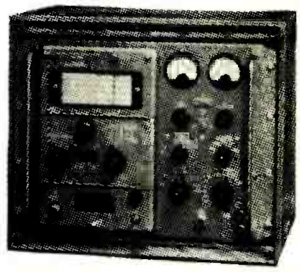
TF 144G SIGNAL GENERATOR. To clear. In very good "as seen" condition. Complete with mains and battery cables, etc. **£15.**

TF1041C VTVM A.C. voltage range 300 MV to 300V in 7 ranges. 20 Hz-1500 MHz. D.C. voltage ranges 300 MV-1000V in 8 ranges. D.C. resistance 50 ohms to 500 Mohms. Price **£62·50.**

TF144H SIGNAL GEN. Freq. range 10 KHz-72 MHz. R.F. output 2uV to 2V at 50 ohms 400 and 1000 Hz internal mod. Limited qty. only available. Full spec and price on request.



SIGNAL GENERATOR TF 801/A. 10-300 Mc/s. in 4 bands. Internal at 400 c/s. 1 kc/s. External 50 c/s to 10 kc/s. Output 0-100 db below 200 mV from 75 ohms source. **£85.** DITTO but **801/A/1** with additional high level output. **£89.** Both P. & P. £1, including necessary connectors, plugs, and instruction manual.



AM/FM SIGNAL GENERATOR TF 937 (CT 218) Frequency range 85kHz-30mHz. 8 bands. Main dial total 56 foot. Built in crystal calibrator 200kHz and 2mHz. RF output ·1μV to ·1V. Four internal mod. freq. FM deviation up to 9kHz. **£115.** Carriage £1/5/0.

F.M. DEVIATION METER TYPE TF934. Frequency range 2.5-100MHz. Can be used up to 500MHz. Deviation range 0-75kHz **£67·50.** Carriage £1·50.

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Regulated and stabilised **P.S.U. SRS 151A,** 20 to 500V positive at 300mA in two ranges. Variable and fixed 170V negative output, **£35.** Carriage £1.
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CD 643.2. Single beam Laboratory Model, DC to 14MHz price upon application.

SIGNAL GENERATOR TYPE CT 480. 7-12kMHz in one range, square and pulse modulation and C.W. **£65.**

SIGNAL GENERATOR TYPE CT 478. As above but 1.3-4.2kMHz in two ranges **£55.**

1½in. DIA. PANEL METERS. 7½-15v —ideal for "Battery Condition" indicators for cars **£0·77.**

BOONTON Q METER TYPE 160A. Freq. range 50kHz to 75MHz, main capacitor 30 to 500pF. Vernier capacitor ± 3pF; q range. 0-250 with 2.5× multiplier. **£85** plus carriage.

VALVE CHARACTERISTIC METER complete with manual **£57·50.** Carriage £1·50.

MULLARD PRECISION VARIABLE CAPACITOR TYPE F.2. 15 pF to 336 pF. Supplied with individual calibration certificate. Brand new in original packing. **£17.** Carriage 75p

SUSPENSION GALVANOMETERS Pye **£25.** P. & P. £0·60. Cambridge instruments **£12.** P. & P. £0·60.

★ **Open 9-12.30, 1.30-5.30 p.m. except Thursday 9-1 p.m.** ★

VACUUM CONDENSERS 12, 50, 55pF each 20,000v 30/-. P. & P. 4/-.

BRADLEY PORTABLE ELECTRONIC MULTIMETER TYPE CT471B. This instrument operates from three 1½V cells, is fully transistorised and measures A.C. and D.C. current, A.C. and D.C. voltage and D.C. resistance. Built-in battery check and calibration check. Full spec. and price on request.
As above but MODEL CT 471A manufactured by AVO. full spec and price on request.

4, 5 and 8 bank 25 way uniselectors, 24V, guaranteed perfect, **£3·75; £4·50; £6·87** respectively.

AR88 SPARES. We hold the largest stock in U.K. Write for list.

AERIAL TUNING UNIT BC 939

Originally made to work with Hallicrafters BC 610E transmitters. 2mc to 18mc, for output up to 450 watts. Brand new **£8·50.** Carriage £1.

PRECISION VHF FREQUENCY METER TYPE 183. 20-300 Mc/s with accuracy 0.03% and 300-1,000 Mc/s with accuracy 0.3%. Additional band on harmonics 5.0-6.25 Mc/s with accuracy + —2×10-4. Incorporating calibrating quartz 100 kc/s + —5× 10-6 120/220 v. A.C. mains. **£85.** Carriage £2.

MUIRHEAD-WIGAN DECADE OSCILLATORS. TYPE 650A 9650B. Frequency range 1 to 111,100 Hz. Accuracy ± 0.2%. Power supply 100-250 v. D.C. £65 and £75 respectively. carr. £1.75.

HARNESS "A" & "B" control units, junction boxes, headphones, microphones, etc.

29/41FT. AERIALS each consisting of ten 3ft., ⅞in. dia. tubular screw-in sections. 11ft. (6-section) whip aerial with adaptor to fit the 7in. rod, insulated base, stay plate and stay assemblies, pegs, reamer, hammer, etc. Absolutely brand new and complete ready to erect, in canvas bag, **£4.** P. & P. £0·50.

FOR EXPORT ONLY
53 TRANSMITTERS. All spares available. COLLINS TCS. Complete installations and spare parts.
COLLINS TYPE 231D 5KW TRANSMITTERS. 10 channel, autotune and manual tuning. Complete with very comprehensive spares. Full specification and price on application. Complete installations and all spares. No. 19 WIRELESS SETS. H.P. SETS and all spares R.210 RECEIVERS with all necessary accessories.
PYE PTC 2002N A.M. Ranger Mobile Radio Telephone, brand new and complete, **£45.**

TELEPHONE ENQUIRIES relating to **TEST EQUIPMENT** should be made to 01-748 8006 Extension 23.
To view **TEST EQUIPMENT** please phone for appointment

COLOMOR (ELECTRONICS LTD.)
170 Goldhawk Rd., London, W.12
Tel. 01-743 0899

APPOINTMENTS VACANT

DISPLAYED SITUATIONS VACANT AND WANTED: £8 per single col. inch.
LINE advertisements (run-on): 45p per line (approx. 7 words), minimum two lines.
Where an advertisement includes a box number (count as 2 words) there is an additional charge of 25p.
SERIES DISCOUNT: 15% is allowed on orders for twelve monthly insertions provided a contract is placed in advance.
BOX NUMBERS: Replies should be addressed to the Box number in the advertisement, c/o Wireless World, Dorset House, Stamford Street, London, S.E.1.
No responsibility accepted for errors.

Advertisements accepted up to THURSDAY, 12 p.m., 5th AUG., for the SEPTEMBER issue, subject to space being available.

Imperial College of Science & Technology

DEPARTMENT OF AERONAUTICS

There is a vacancy in this Department for an

ELECTRONICS TECHNICIAN or SENIOR TECHNICIAN

to work primarily on a general purpose instrumentation project. **Salary ranges are £1,136-£1,535 p.a. and £1,493-£1,832 p.a. respectively.** Superannuation scheme, four weeks holiday and canteen facilities.

Apply in writing giving details of experience and qualifications to the Assistant Director, Department of Aeronautics, Imperial College, Prince Consort Road, London, S.W.7.

1264

UNIVERSITY OF SHEFFIELD

SENIOR TECHNICIAN AND TECHNICIAN

required for University Television Service from September 1971

One post requires appropriate qualifications and experience in field of electronics, particularly T.V.: for the other, training in electrical and/or laboratory techniques. Familiarity with wood and metal work an advantage.

Training given in T.V. operations to enable appointees to become members of a team working on educational T.V. productions.

Applicants for Senior Technician should be at least 25 years old and have C. & G. Final Certificate or equivalent: Technician, minimum age 20, with C. & G. Intermediate Certificate in a suitable subject.

Salary: Senior Technician £1,398-£1,707 p.a. Technician £1,041-£1,410 p.a. each with basic qualification. Supplement for approved higher qualification. Superannuation Scheme.

Write immediately to the Bursar (Ref. B.854), The University, Sheffield S10 2TN.

1265

EXPANDING COMPANY IN SAUDI ARABIA REQUIRES

EXPERIENCED CERTIFICATED ENGINEERS

FOR THE FOLLOWING POSTS

CHIEF ENGINEER

B.Sc. or equivalent with 10 or more years experience in Operation and Maintenance of Transmission and Broadcasting Equipment.

ENGINEERS TECHNICIANS

Experience in Operation and Maintenance of Broadcasting Equipment, Studio Equipment and Teleprinters.

Please submit a complete resume and state availability and salary required. Box WW 1270

Service Technicians

Move to Harlow and enjoy the benefits of a good job with a successful company in the pleasant surroundings of our New Town.

Your job will be to service and repair products from our wide range of Airborne Instruments, Scopes and Test Gear. You will be working in our Harlow base workshop with the opportunity for occasional field trips. We will give you product training but we'll expect a good basic knowledge of Electronics preferably backed up with fault finding experience on transistorised and solid state devices.

Your starting salary would be from £1,310 per annum with excellent opportunities of promotion to Section Leader grades. In many cases we can assist with local New Town housing and help with your removal costs.

If you want to find out how to secure your position then 'phone or write now to:

COSSOR

R. T. Reid,
COSSOR ELECTRONICS LIMITED,
The Pinnacles, Harlow, Essex.
Tel: Harlow 26862

LONDON BOROUGH OF HILLINGDON

EDUCATION DEPARTMENT

Two suitably qualified and experienced technicians are required to undertake the maintenance and repair of visual and aural aids equipment in all parts of the Borough schools and other educational establishments. These are new posts.

POST ONE
£1,605-£1,866 incl. LW. Additional responsibility for planning and operating the maintenance and repair programme.

POST TWO
£1,179-£1,362 incl. LW.
8 cwt. van and tools provided for each post. Work base in Uxbridge. Current clean driving licence essential.

Application form and further particulars from the Establishment Officer, Ref. E/186/30, Manor House, Church Road, Hayes, Mx. Closing date August 2.

1292

Opportunities with Redifon in Radio Communications

Experienced Test Engineers are invited to write to Redifon with regard to vacancies in our Test Department at Wandsworth.

The salary range for these positions is £1,248–£1,749 plus. The Company is engaged in the design and manufacture of a wide range of radio communications and allied equipment from military pack-set to broadcast transmitter, including communications receivers, M.F. beacons, teleprinter terminals, complete radio office installations for the Merchant Marine and mobile H.F. S.S.B. stations. Our Test Engineers have sound technical knowledge coupled with good practical experience in the alignment and test of H.F. and V.H.F. Communications equipment.

The work is varied and interesting and offers excellent opportunity to broaden experience in semiconductors S.S.B. and Frequency Synthesis.

Please write in the first instance to
Norman Manion,
The Recruitment Officer, Redifon Limited
Broomhill Road, Wandsworth, S.W.18

REDIFON
A Member Company of the Rediffusion Organisation
1970

1174

Telecommunications Engineers

required for the installation, maintenance and supervision of modern electronic systems used in our offshore oilfield complex at Das Island in the Arabian Gulf. These are bachelor postings but carry generous home leave and allowances.

Candidates, aged 23 to 40, should possess a minimum of HNC or equivalent, and have several years' practical experience with radio systems ranging from MF to Microwave multi-channel, with a good working knowledge of digital telemetry and automatic telephone systems.

- Please write, quoting reference R.943/ZH and giving relevant information about yourself to: G. I. Andrews, External Recruitment, The British Petroleum Company Limited, Britannic House, Moor Lane, London, EC2Y 9BU, or ring 01-920 6522 for an application form.

POOLE GENERAL HOSPITAL, POOLE, DORSET

Applications are invited from qualified candidates for the following post in the Electronics Department at Poole General Hospital:

ELECTRONICS TECHNICIAN III

Qualifications: ONC, HNC, City & Guilds or equivalent.
Salary: £1,356 × 8 increments to £1,764 p.a.

The Department will be primarily concerned with the installation, testing and maintenance of an extensive range of diagnostic/therapeutic and allied electronic equipment, and ultimately with research and development of bio-medical equipment in consultation with medical staff.

The position offers adequate scope for initiative and career progression, including the possibility of assistance with further training.

Applications, giving full details, including qualifications, experience and the names and addresses of two referees, to the **Hospital Secretary, Poole General Hospital, Poole, Dorset.**

1266

EDINBURGH CITY POLICE
REQUIRE A
WIRELESS TECHNICIAN

for Servicing and Maintenance of fixed and mobile broadcasting receiving system.
Salary scale £1,413 rising by annual increments to £1,611.
Applicants will be required to have a knowledge of UHF and VHF apparatus used on fixed and mobile stations, and be able to diagnose and repair faults.
They would be expected to have attained the City and Guilds Telecommunications Technicians Certificate or an equivalent qualification.
A Current Driving Licence is essential.
Applications to:
EDINBURGH CITY POLICE
RECRUITING DEPARTMENT,
7 CHAMBERS ST., EDINBURGH, EH1 1HR [1269

THE UNIVERSITY OF SUSSEX
ELECTRONICS TECHNICIAN

An interesting post is available in a small growing department for a technician with experience of transistor circuits. Formal qualifications are not essential but applicants should be capable of designing and constructing simple apparatus for a variety of experiments.

Salary scale: (a) £1,011-£1,380 or (b) £1,041-£1,410. Salary scale (a) is applicable to those not holding an approved basic qualification.

Further particulars and forms of application can be obtained from the Secretary (Establishment), Office of Arts and Social Studies, Arts Building, University of Sussex, Falmer, Brighton, BN1 9QN to whom applications should be sent not later than 31st July or by telephoning Mr. Crook, Brighton, 66755, ext. 339.

1276

ST. BARTHOLOMEW'S HOSPITAL LONDON, E.C.1

Applications are invited for two TECHNICIAN posts in the DEPARTMENT OF MEDICAL ELECTRONICS. The work involves routine servicing of electronic apparatus and the construction of new equipment for special purposes.

Applicants must have an O.N.C. or the final City and Guilds certificate, or two 'A' level passes in science subjects and at least four years' relevant technical experience. Experience of hospital work is not essential.

Salary will be on the Technician III and IV scales. £1,446 rising to £1,854 and £1,296 rising to £1,590 respectively. Applications in writing with the names of two referees should be sent to the Clerk to the Governors.

1278

Senior Engineer (Aerials)

£2799-£3258

The INDEPENDENT TELEVISION AUTHORITY is seeking to fill a new post of Aerial Engineer in its Station Operations and Maintenance Department. Although this post will be based in Leeds, the person selected will be required to travel extensively throughout the United Kingdom.

The work will involve the execution and direction of maintenance projects on aerial and combining systems in liaison with the Senior Engineer—Ariel Maintenance. It is essential that applicants have had thorough experience of the techniques used in assessing the performance of aerial and combining systems and they must be prepared to climb and work on tall structures. A recognised qualification at graduate level in the field of R.F. Engineering would be an advantage.

Salary according to qualifications and experience will be in the range quoted above. Those interested should write or telephone for an application form quoting Ref. WW 1685 to:

ITA

The Personnel Officer,
INDEPENDENT TELEVISION AUTHORITY,
70 Brompton Road,
London, S.W.3.
Tel: 01-584 7011 Ext. 482

Completed application forms to be returned by 2nd August 1971.

1303

WESSEX REGIONAL HOSPITAL BOARD and WESSEX HOSPITAL MANAGEMENT COMMITTEES REGIONAL ELECTRONICS SERVICE

Suitably qualified Engineers and Technicians are required for the Board's new Regional Department of Electronics and Bio Medical Engineering and in similar departments in Hospitals located in Hampshire and Dorset.

1. ELECTRONICS ENGINEER

Qualifications: Chartered Member I.E.E., I.E.R.E.

2. ELECTRONICS TECHNICIAN I

Qualifications: H.N.C.—H.N.D. Full Technological Certificate C. & G.

3. ELECTRONICS TECHNICIAN III

Qualifications: O.N.C.—H.N.C.—C. & G.

4. ELECTRONICS TECHNICIANS V

Qualifications: O.N.C. or A.2.

Salary Scales:

1. £2,088, rising by nine annual increments to £2,868 per annum.
2. £1,877 rising by five annual increments to £2,346 per annum.
3. £1,800 rising by eight annual increments to £2,500 per annum.
4. £900, rising by seven annual increments to £1,160 per annum.

Point of entry to the scale dependent on qualifications and/or experience.

Posts (1) and (2) will be based at the Board's Headquarters in Winchester; Posts (3) and (4) in various centres in the Region.

Departments will be concerned with all aspects of design—installation—testing and commissioning of a wide range of diagnostic/therapeutic and allied electronic equipment and data transmission systems.

Research and Development in conjunction with Medical Staff will be undertaken in the short term future.

Application forms available from the Personnel Department, Highcroft, Romsey Road, Winchester, to which they should be returned by 2nd August, 1971.

1291

UNIQUE OPPORTUNITY

Electronic engineer to join the management team of a small but fast expanding company supplying a wide range of advanced projection, sound and lighting control systems.

We want an experienced inventive engineer fully capable of designing and developing, relay and solid state sequence control equipment sound amplifiers, lighting control equipment, etc.

Salary by negotiation.

Apply: Technical Director, Audio Visual Equipment Ltd. 73 Surbiton Road, Kingston, Surrey
01-546-4565

1285

ELECTRONIC ENGINEERS

required

for new Technical Service Centre to be established at Hemel Hempstead by British Manufacturers and Servicing Group of a wide range of Business Equipment Products. Ideally suited for engineers experienced in Radio/T.V. H.M. Forces, Industrial electronics.

Please write to: **Mr. D. D. Davies, Technical Services Manager,**
Control Systems Ltd.,
Technical Services Centre,
1 Frogmore Road, Apsley, Hemel Hempstead, Herts.

1284

TECHNICIAN REQUIRED

September for electronics workshop. Salary according to qualifications,

Senior technician H.N.C. £1,305-£1,712

Technician O.N.C. £902-£1,415

Junior technician 'O' level maths & science £525-£803

Day release possible for technicians and juniors. Written applications stating age, qualifications and experience, and names of two referees to **Administrator, University Laboratory of Physiology, Parks Road, Oxford.**

1271

Closed Circuit Television Engineer

This interesting and responsible position involves all aspects of the installation and service of a wide range of monochrome C.C.T.V. for use with medical X-ray apparatus. The equipment would include vidocon, orthicon, plumbicon and isacon tubes, light intensifying systems and 35 mm. video tape recording apparatus.

The position would ideally suit an engineer experienced in C.C.T.V. systems preferably with ONC/HNC, looking for a responsible position and a secure future in a progressive firm.

A good salary and several fringe benefits including a Company car will be offered to the successful applicant.

Please apply for an application form to:
The Personnel Officer, G.E.C. Medical Equipment Ltd., East Lane, Wembley, Middx. Tel. 904 1288

1277

SITUATIONS VACANT

ARTICLES FOR SALE

17" BBC/ITV TELEVISIONS £5

Working perfectly
PLUS P. & P. £1·00 C.W.O.
SUITABLE FOR ANY AREA

3 Channel 19" D/S TVs. ITV, BBC 1, BBC 2, **£25** inc. carriage. 17" 13 Channel, complete but untested, **£1·50** each, plus £1 P. & P., C.W.O.

SPEAKERS

6" × 4", 7" × 4" 30HM,
20p plus 8p P. & P. each, C.W.O.

REGULAR DELIVERIES THROUGHOUT ENGLAND AND NORTHERN IRELAND

TRADE TV's
407 Thornton Road, Girlington, Bradford 8, Yorks.
77

TV's TV's TV's

SPECIAL OFFER—LIMITED PERIOD ONLY

Thorn 800 Chassis 13 Channel slim TVs. Good working order. Polished cabinets. Only **£9·50** PLUS £1·50 carr.

EX-RENTAL TVs

Complete with 13 channel tuners. Good cabinets. Carriage **£1·50** extra.
17" (Semi-Slim (90° tube) **£2·50**; 17"/21" Slim (110° tube) **£4·50**; 19" Slimline **£6·50**; 23" Slimline **£8·50**; 19" BBC2 Sets **£14·50**.

PERFECT SPEAKERS EX TV

Pm 3 ohm (minimum order two) 5 in. round, 8 in. by 2 in. rectangular, **12½p** each. Add 7½p per speaker p. and p.

VALVES EX EQUIPMENT

EB91	5p	30P4	12½p	PL36	22½p
EBF89	12½p	PC97	17½p	PL81	17½p
ECC82	12½p	PCF86	17½p	PY81	15p
EC180	7½p	PC84	7½p	PY800	15p
EF80	12½p	PCF80	7½p	PY82	7½p
EF85	12½p	PCC89	12½p	PY33	22½p
EF183	12½p	PCL85	22½p	U191	17½p
EF184	12½p	PCL85	17½p	6F23	17½p
EY86	17½p	PCL82	17½p	30PL1	22½p
30PL13	20p	PCL86	17½p	30P12	20p
630LZ	12½p	PCL83	12½p	30F5	10p

Add 2½p per valve p. and p. Orders over £1 p. and p. free

UHF TUNERS

To suit Ferguson 850, 900 chassis **£2·50**. p. & p. 50p.

SLOT METERS—SPECIAL OFFER

Smiths Mk. II 6d. Convertible to 5p (Smiths Kit costs 35p) **£1** each incl. post and packing or 10 for **£5** incl. post and packing.

Please write with SAE for quotations on any spares.

TRADE DISPOSALS (Dept. T.S.), Thornbury Roundabout, Leeds Road, Bradford, Yorks. (Tel. 665670)

NOW UNDER NEW MANAGEMENT

FERRIC CHLORIDE

Anhydrous, Technical Quality

Packed in steel drums containing 100 x 1lb. bags
Guaranteed High Quality—Low Price

S. J. BRANSON
111 Park Road, Peterborough PE1 2TR
1287

Marconi T.F. 144 G. **£10**
Wavemonitor G. 302 **£6**
Signal Injector A/S 85 **£2**
C.T. 54 V.V.M. with P.S.U. **£10**
8 M.F.D., 2,500 volt capacitors **£3**
50 yard Interpolation Oscillator **£3**

GREENWELD ELECTRONICS
24 Goodhart Way, West Wickham, Kent
Phone: 01-777 2001 1288

COMPUTER PERIPHERALS

Closure of computer site makes available the following tape editing equipment:

CREED Model 75 Teleprinter with soundproof cover, desk and auto transmitter, choice of two at £300 each.
CREED Verifyer with Model 92 reader and Model 25 punch at £150.
CREED Teleprinter, type 54 also keyboard perforators (in Ferranti Pegasus Code) at £25.
Teletype punches BRPE 11, 8 hole with soundproof box at £155 also BRPE 1, 5 hole converted to phonic wheel sync, choice of two at £40 each.
ELLIOTT T.2/94. 250 c.p.s. 8 hole Optical Tape readers, choice of four at £150 each.

For further details contact

Business Engineering Services, Gt. Bentley, Colchester, Essex.
Telephone: 0473 (Ipswich)/77197 or 0206 (Gt. Bentley)/25/550.
1293

MARTIN ASSOCIATES

TELEPHONE: ARBORFIELD CROSS 610

Oscilloscope H.P. 175A 0-50MHz c/w 1781B and 1755A Plug-ins	£350
Oscilloscope Tektronix 545A 0-33MHz	£275
Oscilloscope Tektronix Plug-in Type CA	£20
Freq/Timer Counter HP 5233L 0-2MHz 6 digit	£160
Freq/Timer Counter HP 3734A 0-5MHz 5 digit	£210
Freq/Timer Counter Venner TSA 53/HP 0-10KHz 6 digit	£50
PSU Solartron AS 1410 0-30V 1A	£35
PSU Advance PP6 Twin 0-30V 3A	£75
Recorder Record 3" Graphic 0-1mA 1" and 6"/Hr	£42·50
Recorder HP 7035B X-Y Plotter. Almost new	£235
Recorder Cambridge Type L Potentiometric 4 point—100-0+100°C 0-100mV and 0-200mV FSD. Chart width 8". Chart speed 1", 2" and 4"/hr	£95
Wave Analyser Airmec 853 HF Analyser 30 KHz-30MHz	£40
Signal Generator Airmec 210 HF Generator 30KHz-30MHz. Stability ·005%	£75
Signal Generator Marconi TF1446	£10
Millivoltmeter Advance VM 78	£22·50
Digital Voltmeter Dynamco DM 2006	£325
Digital Voltmeter Dynamco DM 2020	£250

1000lb Thrust Vibration Systems Consisting of Shaker and Amplifier. Also available 250lb Thrust. Please ring for fuller details.
We are always in need of Good Test Equipment. Contact us if you are considering disposal.
1306

COLOUR, UHF and TV SERVICE SPARES. SPECIAL OFFER, leading Brit. maker's Colour Monitor Panels designed to BBC standards. Pal filter and delay £6, chrominance £6, luminance £4·50, encoded video input £2·50 P/P 25p (or set of 4 £17·50 P/P 35p). Also quantity Colour TV Camera Panels. Plessey colour scan coils £5·75 P/P 35p, convergence coils £3·80 P/P 25p. Blue lateral £1·25 P/P 10p (or complete set £10 P/P 50p). Latest type colour scan and convergence coils, with electrical control of static convergence £6·25 P/P 35p. Colour LOPT assembly incl. EHT output and focus control £4·50 P/P 35p, luminance/chrominance panel £1 P/P 25p. Integrated transistd. decoder unit incl. circuits £1·25 P/P 10p. SPECIAL OFFER, leading Brit. maker's surplus 625 single standard TV chassis, latest design, almost complete, includes transistd IF stages, frame and line time bases, transformers, etc., incl. circuit, £8·65 P/P 50p. B9D valve bases for colour valves and PL500 series 12½p P/P 5p. UHF tuners transistorised, rotary slow motion drive or push button £5·25 P/P 25p. Integrated UHF/VHF 6 position push button transistorised tuner easily adjusted as 6 position UHF tuner, incl. circuit £4·50 P/P 50p. Transist. UHF/VHF IF panels £4·75 (or salvaged £2·50) P/P 25p. MURPHY 600/700 series complete UHF conversion kits incl. tuner, drive assy., 625 IF amplifier, 7 valves, accessories, housed in special cabinet plinth assembly, £7·50 or less tuner £3 P/P 50p. SOBELL/GEC 405/625 switchable IF amplifier and output chassis, £1·50 P/P 30p. Ultra 625 IF AMP chassis and circuit £1·50 P/P 30p. Philips 625 IF AMP panel and circuit, £1 P/P 30p. SOBELL/GEC 2015 series 405/625 printed circuit IF panel incl. circuit £1·95 P/P 30p. UHF list available on request. VHF tuners AB miniature with UHF injection suitable K.B., Baird, Ferguson 75p P/P 30p, Cyldon C £1 P/P 30p, Pye 13 ch. incremental £1·25 P/P 30p. Ekco, Ferranti, Plessey push button tuner with UHF injection £1·50 P/P 30p. New fireball tuners Ferguson, HMV, Marconi type £1·90 P/P 30p. Philips export continental turret tuners 75p P/P 30p. Many others available. Large selection channel coils, LOPTs, Scan Coils. FOPTs available for most popular makes. Surplus Ultra, Murphy 110° Scan coils 75p P/P 30p. Sobell frame o/p transformers 90p P/P 30p. Transistorised time base panel for Ferguson portable £2·50 P/P 30p. Pye/Labgear transistd. masthead UHF booster £4·25, UHF/VHF/FM set back booster, mains operated £5·90 Wolsey masthead amplifier power unit £2·50 P/P 25p. Surplus BBC2 Belling Lee "Skyline" distribution amplifiers £3 (Callers only).—MANOR SUPPLIES, 172 WEST END LANE, LONDON, N.W.6 (No. 28 Bus or W. Hampstead Tube Station). MAIL ORDER: 64 GOLDERS MANOR DRIVE, LONDON, N.W.11. Tel. 01-794 8751. [60

COLOUR TELEVISION components for the home constructor, all parts listed in new specialist catalogue, including delay lines, scan parts L.O.P.T.'s, Xtals. etc. S.A.E. to Forgestone components. Ketteringham, Wymondham, Norfolk. [1254

FOR sale over 450 Diodes, transistors and thyristors including high power types. All items are new and unused. Write for lists to Box W.W. 1272.

LOWREY Model K Electronic Organ complete working less Keyboards, contains 13 rhythm generator Leslie unit, Power Amplifier, Reverb, 12 note generators 4 dividers on each, etc. £75. Carriage arranged. PB Electronics, 47 Cowleigh Road, Malvern, Worcs. [1302

MINI MAINS Transformer for 9V dc power packs. Robust, yoked, flying leads, 30 × 30 × 37mm, 0-230-250V to 7-0-7V, 120mA. Only £0·70. UK post 5p. Amatronix Ltd., 396 Selsdon Road, S. Croydon, Surrey CR2 0DE. [1161

NEW CATALOGUE No. 18, containing credit vouchers value 50p, now available. Manufacturers' new and surplus electric and mechanical components, price 22½p, post free. Arthur Sallis Radio Control Ltd., 28 Gardner Street, Brighton, Sussex. [94

ONE Slee R.K. Welding Machine complete with Thyratron Synchronous Timer, suitable for welding miniature assemblies, e.g. Radio Valves. Please telephone: The Administrative Officer, Brooke Bond Liebig Research Centre. 073-525 2411 [1295

ONE Collins type 30J Radio Transmitter. Frequencies 40, 20, 10 Metres. Circa 1939. Offers to Yates. Vandervell Products Ltd., Maidenhead, Berks. [1307

SERVICE Sheets (1925-1971) for TV's, Radios, Transistors, Tape Recorders, Record Players, etc.; over 8,000 models available. S.A.E. enquiries. Hamilton Radio, 54 London Road, Bexhill. Tel. Bexhill 7097. [1281

VACUUM pumps, coating plant, pyrometers, recorders spectrophotometers/ovens, etc. Free catalogue. Barrett, 1 Mayo Road, Croydon, CRO 2QP, Surrey. Phone 01-684-9917. 1056

VHF. 80-180 mHZ Receiver, Tuner, Converter Kit, remarkable results from single transistor. £4·13 complete or S.A.E. for free literature. Johnsons (Radio), Worcester WR1 2DT. [WW99

WIRELESS WORLD Jan. 1913-Dec. 1950 (1920-1942 bound). Offers Tel. Huddersfield 52453. [1262

6 MM Tubular Flanged Bulbs, 6V 0·2A, 5p each in lots of 50. Quantity available. Box No. W.W. 1301.

TEST EQUIPMENT — SURPLUS AND SECONDHAND

SIGNAL generators, oscilloscopes, output meters, wave voltmeters, frequency meters, multi-range meters, etc., etc., in stock.—R. T. & I. Electronics, Ltd., Ashville Old Hall, Ashville Rd., London, E.11. Ley. 4986. [64

RECEIVERS AND AMPLIFIERS—SURPLUS AND SECONDHAND

HRO Rx5s, etc., AR88, CR100, BRT400, G209, S640, etc., etc., in stock.—R. T. & I. Electronics, Ltd., Ashville Old Hall, Ashville Rd., London, E.11. Ley. 4986. [65

NEW GRAM AND SOUND EQUIPMENT

GLASGOW.—Recorders bought, sold, exchanged; cameras, etc., exchanged for recorders or vice-versa.—Victor Morris, 343 Argyle St., Glasgow, C.2. [11

TAPE RECORDING ETC.

YOUR TAPES TO DISC.—£6,000 Lathe. From £1·50. Studio/Location Unit. S.A.E. Leaflet. Deroy Studios, High Bank, Hawk St., Carnforth, Lancs. [70

FOR HIRE

FOR HIRE CCTV equipment, including cameras, monitors, video tape recorders and tape—any period. —Details from Zoom Television, Chesham 6777 [75

ARTICLES WANTED

HIGHEST CASH PRICES for Revox, Ferrograph, Brenell, Vortexion, Tandberg. 9.30-5.00. 01-837 8200. [102

SPEAKERSET STENTORIAN WHITELEY HF1012, T816, CX1500. Box No. W.W. 1268

SERVICEABLE CRT for Tektronix 555 double beam oscilloscope also plug-in amplifier units working or not and circuit manual. Ring Oxshott (Surrey) 3311. [1310

WANTED, all types of communications receivers and test equipment.—Details to R. T. & I. Electronics, Ltd. Ashville Old Hall, Ashville Rd., London, E.11. Ley. 4986. [63

WANTED, televisions, tape recorders, radiograms, new valves, transistors, etc.—Stan Willetts, 37 High St., West Bromwich, Staffs. Tel. Wes. 0186. [72

VALVES WANTED

WE buy new valves, transistors and clean new components, large or small quantities, all details, quotation by return.—Walton's Wireless Stores, 55 Worcester St., Wolverhampton. [62

CAPACITY AVAILABLE

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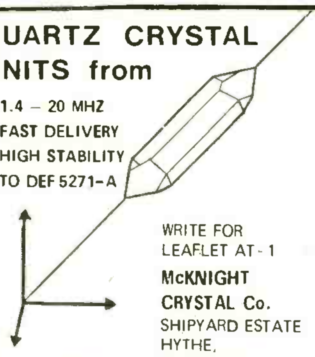

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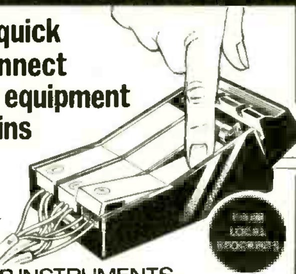

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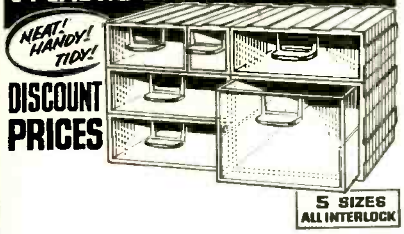

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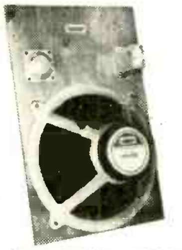

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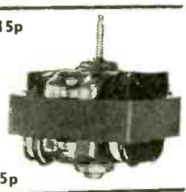

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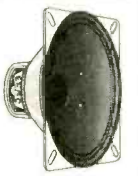

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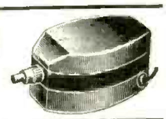

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When soldering fine copper wire, ordinary tin/lead solder alloys will absorb some of the copper, so that the diameter of the wire will be reduced.
Ersin Multicore Savbit Type 1 solder contains a small percentage of copper so that the solder is already 'saturated' with copper and will not absorb it from copper wire or copper laminate.
Savbit will also prolong the life of copper soldering iron bits by 10 times, thus eliminating the need for frequent resurfacing of copper bits and by keeping the copper bits in good condition, the soldering speed and efficiency are increased.
Savbit Type 1 alloy contains 5 cores of non-corrosive extra fast rosin based Ersin Flux. Melting point is 215°C. Recommended bit temperature is 275°C.
Savbit Type 1 alloy with Type 362 Ersin Flux has received Ministry approval under number DTD.900/4535. It may be used for soldering processes on equipment for Services use in lieu of solder to BS.219.

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7 lb. REELS
Available in standard wire gauges from 10–22 swg., on strong plastic reels.

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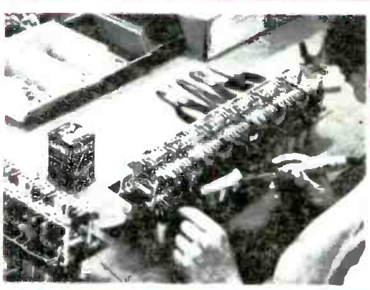

HOLLAND
Ersin Multicore Savbit Alloy is used by Bull Nederland of Amsterdam, Holland for the assembly of administration and statistics machines.

NEW ZEALAND
Ersin Multicore Savbit Alloy is seen being used at the factory of Bell Radio Television Corpn. Ltd., Auckland, New Zealand.

For further details, please apply on your Company's notepaper to:
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