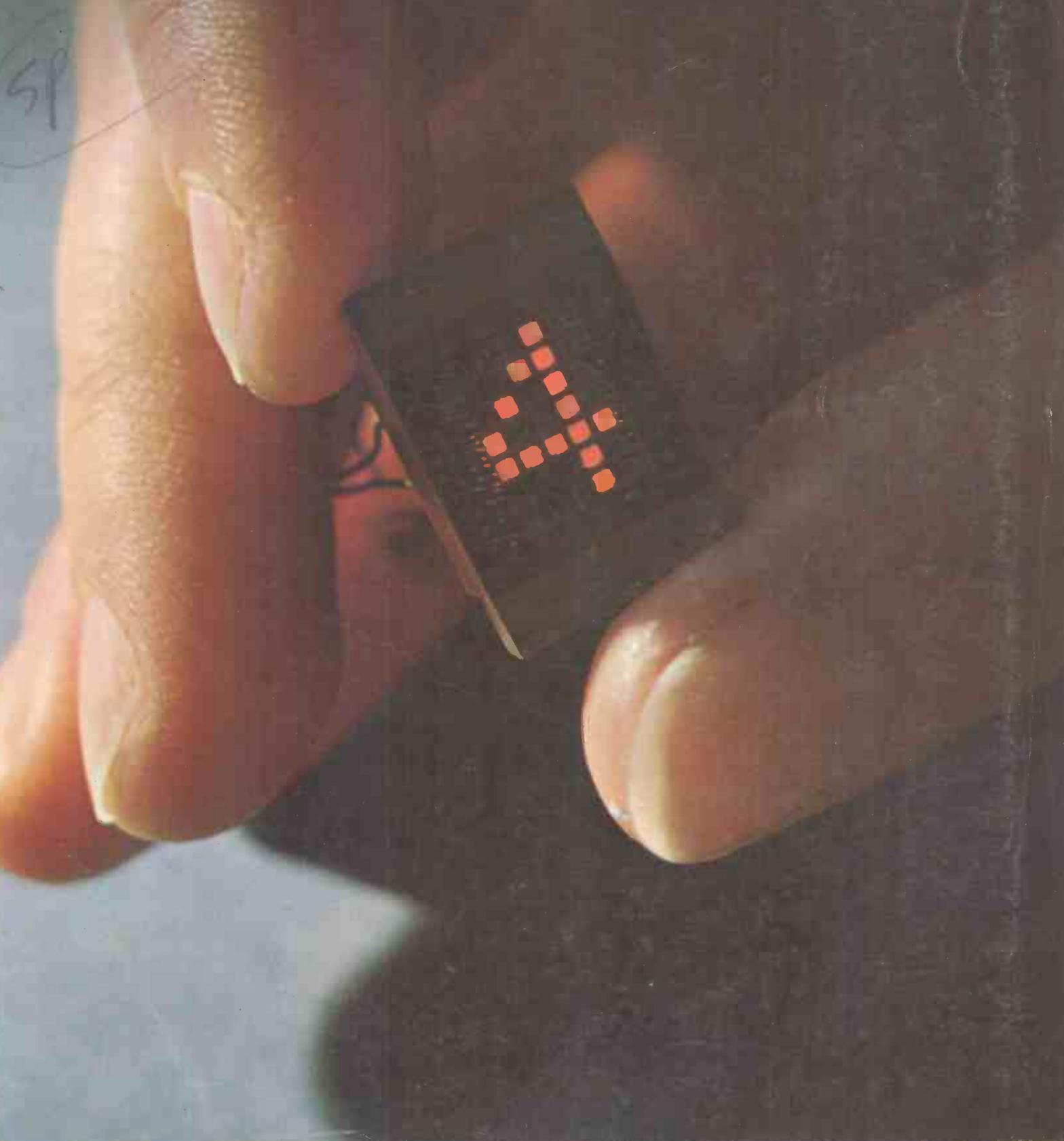


# Wireless World

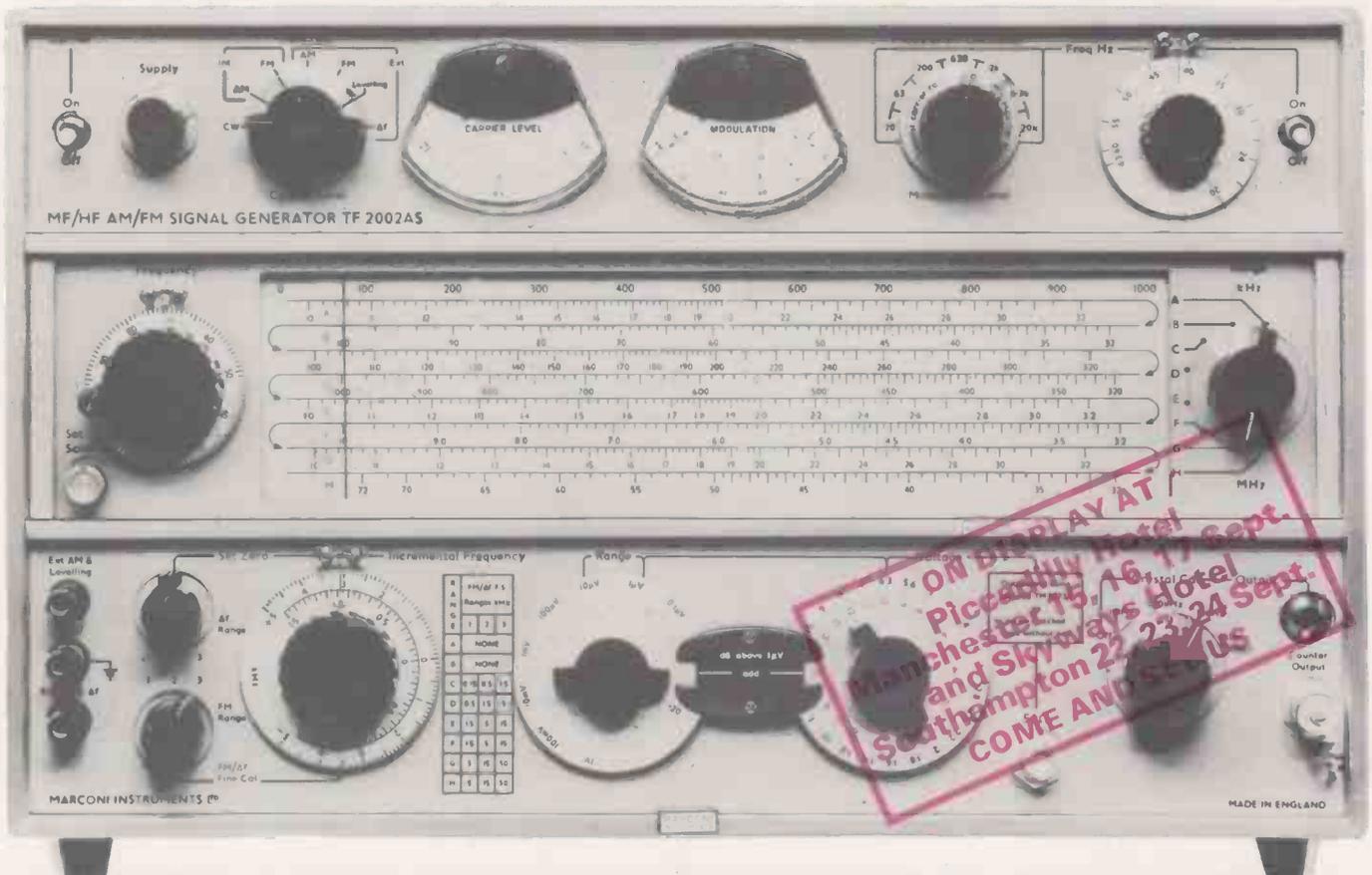
September 1970 3s 6d

Stereo decoder without coils

Television wobulator design



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# Wireless World

Electronics, Television, Radio, Audio

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Our cover picture this month, which might be called "two kinds of digits", shows a five-by-seven array of light-emitting diodes made by Standard Telecommunications Laboratories. Display devices are discussed on page 444.

### IN OUR NEXT ISSUE

The first of a series of articles on the elements of linear i.c.s

Constructional details of a 100-watt quality amplifier

Review of some of the latest techniques in domestic sound and television receivers



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# Wireless World

## The I.C. Industry—who will pick up the bits?

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When Dr. F. E. Jones, managing director of Mullard Ltd, Britain's largest manufacturer of integrated circuits, admits that his company is losing £1M per year on i.c. production and says that he "cannot see his way through the dense undergrowth of the i.c. world" it is time for us all to sit up and take notice. In particular the Government should heed his words for if it does not Britain's integrated circuit industry will be doomed.

The problem is simply one of price. Take for example one of the simple integrated circuits, the t.t.l., quad, two-input gate. This device requires 28 separate manufacturing processes and consists of a chip of silicon about 1.5mm square containing 24 components, four of which are transistors. At the beginning of 1969 the selling price of this device was 15s 6d, by the end of the year it had fallen to 5s 6d but, at the present time, it must be marketed at between 1s 2d and 1s 8d—which is well below manufacturing costs—in order to compete with American concerns.

How can the Americans sell at this price in the U.K. when Dr. Jones has said that he cannot see any way to produce the circuit for this sort of money now, or in one year's time or even five years' time no matter what production methods are used?

The Americans, of course, have a huge home market, most of which is a closed shop to outsiders because of the "Buy American Act". During 1969 this market absorbed 413.4M integrated circuits, of which about 342M were digital. In the same period the U.K. produced only 12M integrated circuits. Also the Americans have a huge investment in the Far East where they employ 20,000 to 30,000 workers. It would appear that the silicon chips are made in America and sent by air to the Far East where they are assembled into packages by workers paid about 8d per hour.

If the finished products are taken back to the U.S. for distribution, tax is paid only on the added value. But what is the difference in value between a processed silicon chip and the same chip in a package? Because of the difficulty in assessing this added value the amount paid in tax could be negligible. When asked if the U.K. could not mount such an "offshore" operation to their advantage Dr. Jones said that the cost savings produced in this way would be nullified by our own import duty which is based on the *selling price* and not the added value. Even taking into account the obvious advantages the Americans have Dr. Jones said that he still could not see how they achieved such a low price.

It is obvious that either the Americans are selling off their surplus production in this country or they are making a deliberate attempt to undermine our own integrated circuit industry. The thought is frightening when one considers all the industries which employ integrated circuits and would therefore have to rely entirely on American sources of supply.

Before the Americans can be accused of dumping it has to be proved that they are selling components at a price which is lower than in the country of origin. But what *is* the country of origin when the various processes are carried out in different parts of the world?

If British-component manufacturers wish to export to America they have to prove to the American excise authority, before the goods are shipped, that the price takes into account shipping costs and is not less than the price in this country. British manufacturers have no such protection where American goods are concerned. They cannot go on sustaining such huge losses and prompt action is needed from the Government in the form of import controls if the integrated circuit industry is to survive.

In view of the gravity of this threat to the U.K. semiconductor industry, and indeed the whole of the electronics industry, it is surprising that no reference is made to the prevailing situation in the latest "statistical survey" of the industry issued by the Electronics "Little Neddy" on the day Dr. Jones made his announcement.

# Phase-locked Stereo Decoder

## Improved channel separation and low distortion obtained using an inductorless circuit

by R. T. Portus\*, A.M.I.E.E. and A. J. Haywood\*, A.M.I.E.E.

During a stereo broadcast the f.m. carrier transmitted by the B.B.C. is composed of three parts, as shown in Fig. 1. The components are:

1. Left plus right (L + R) forming the compatible mono signal containing frequencies up to 15 kHz.
2. Left minus right (L - R) which amplitude modulates a 38 kHz carrier. (The carrier is suppressed to better than 1% in order to make full use of the maximum deviation available at the transmitter.)
3. A low level "pilot tone" at half the carrier frequency, i.e. at 19 kHz, whose zero crossing points are coincident with those of alternate cycles of the 38 kHz suppressed subcarrier. This tone is used as a reference to regenerate the suppressed subcarrier at the receiver.

### Stereo decoders

There are many forms of decoders,<sup>1</sup> the most popular being the switching type where the 19 kHz pilot tone is filtered by a tuned circuit, frequency doubled (to 38 kHz) and used to switch the complex signal—as shown in Fig. 2. Appendix III explains why complete channel separation is not achieved by such simple switching.

### Limitations of tuned-circuit decoders

Poor separation results if the derived 38 kHz switching signal is modulated by any extraneous signal. This means that all the stereo information has to be removed by the tuned circuit. Also, if the output from the 19 kHz tuned amplifier contains any frequencies which pass through subharmonics of 38 kHz, the frequency multiplication stage will produce a modulation of the recovered 38 kHz. This in turn will produce sum and difference frequencies ("birdies") when switching the incoming

\* Rolls-Royce Ltd.

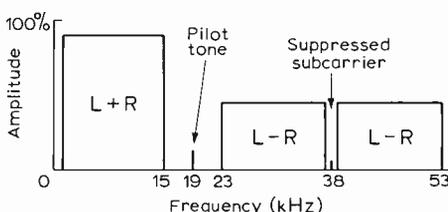


Fig. 1. Frequency spectrum of a stereo multiplex signal.

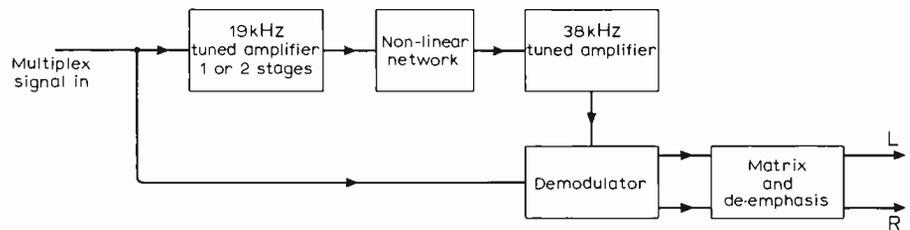


Fig. 2. Block diagram of switching stereo decoder.

complex signal. From the above considerations it may be seen that a high- $Q$  tuned circuit is required. On the other hand, if the  $Q$  is made very large the phase of the recovered subcarrier becomes extremely drift sensitive. Any change in phase will reduce the separation. The effect of uncompensated phase error on separation is as follows.

Phase error at 19 kHz (deg.)	Separation (dB)
1	82.5
2½	54.5
5	42
10	30
15	23

Fig. 3 shows the change for small changes in tuned circuit  $L$  or  $C$  with various values of  $Q$ .

### Phase-locked decoder

Because of the shortcomings of tuned decoders the authors decided to use a phase locked loop to regenerate the 38 kHz suppressed subcarrier. A phase-locked loop is used to lock a locally generated signal in phase with an input signal whose frequency is liable to vary. Such a system may be given a very narrow bandwidth so that noise components of the input signal will not affect the loop operation.

If a locally generated 38 kHz signal is binary divided the remaining 19 kHz may be phase locked to the "pilot tone". This means that alternate zero crossings of the 38 kHz signal are coincident with those of the 19 kHz pilot tone. The locally generated 38 kHz signal is therefore in phase with the suppressed subcarrier.

The performance of such a system may be made superior to that of decoders using tuned circuits for the following reasons:

1. A phase-locked oscillator is a closed-loop

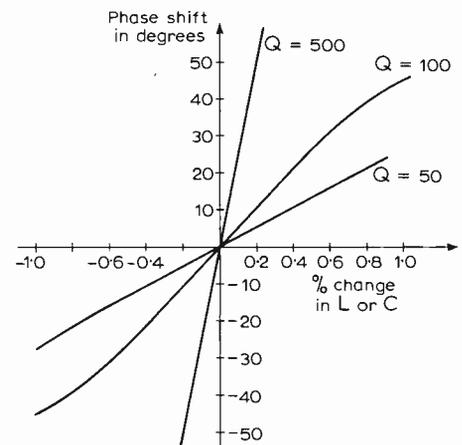


Fig. 3. Phase changes due to variation of  $L$  or  $C$  in a parallel tuned circuit.

system and so changes in component values, due to ageing, temperature etc., are corrected. Other systems have no comparison between input and output, and so errors may only be reduced by careful matching, the use of high quality components and accurate setting up.

2. The generation of "birdies" is very much reduced because the loop is given a low bandwidth, ensuring that phase modulation of the 38 kHz switching signal can only occur at low frequencies.

3. The setting up of a phase-locked loop is a simple matter, a d.c. voltmeter being the only instrument used. For other decoders an oscilloscope is usually required.

### Performance of phase-locked decoder

The decoder (British patent application No. 35600/69) was tested using a Radiometer stereo signal generator, and the following specification obtained.

Frequency	Separation
80 Hz	28 dB
1 kHz	45 dB
10 kHz	40 dB

In a decoder fitted with a variable matrix the separation was 56 dB at 1 kHz.

Distortion at 1 kHz and with full modulation is 0.3% (predominantly 2nd harmonic), and the distortion introduced by crosstalk at 1 kHz is 67 dB down at full modulation. The mono and stereo gains are within 1 dB of each other. Cancellation is 45 dB. The input voltage range is 130 mV r.m.s. to 1.3 V r.m.s., and the output voltage 250 mV r.m.s.

The separation at 80 Hz could be improved by using matched components in the p.s.d. stage, but directional information is negligible at this frequency so that component matching is hardly worthwhile.

### Operation of a phase-locked loop

The phase-locked loop (Fig. 4) can be looked upon as a servo-amplifier in which the 19 kHz pilot tone is used as an input reference phase, and the servo loop used to control a local oscillator in a fixed phase relationship. If there is a fixed phase between two signals then they must be at the same frequency. A phase-locked sub-carrier may be regenerated by deriving the 19 kHz from 38 kHz by use of a binary divider. Alternate zero crossings of the 38 kHz signal are therefore held locked to the incoming 19 kHz.

The operation of the loop is as follows. The balanced phase sensitive detector (p.s.d.) produces a d.c. output proportional to the difference in phase between the input frequency ( $f_{in}$ ) and a locally derived frequency ( $f_o$ ), plus higher frequency components produced by the chopping of the input signal. For a balanced p.s.d. the lowest frequency present is that produced by the highest audio frequency (15 kHz) beating with the 19 kHz chopping signal. The difference signal is 4 kHz (19 kHz - 15 kHz). This error signal is then amplified and low pass filtered by the error amplifier. The filtering removes the high frequency signals produced by the balanced modulator. The error amplifier output is used to control a voltage controlled oscillator (v.c.o.).

If the p.s.d. is not perfectly balanced small low-frequency audio signals will be present at the p.s.d. output. If the frequency of these signals approaches the loop bandwidth they will not be completely filtered out by the error amplifier. The resulting "ripple" on the error amplifier output will cause "jitter" on the v.c.o. output (i.e. phase modulation).

Loop operation is such that a change in phase between ( $f_{in}$  and  $f_o$ ) (e.g. due to drift)

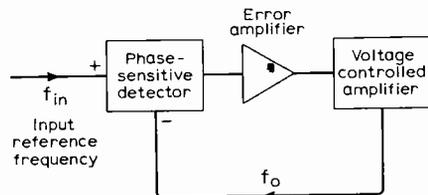


Fig. 4. Block diagram of phase-locked loop.

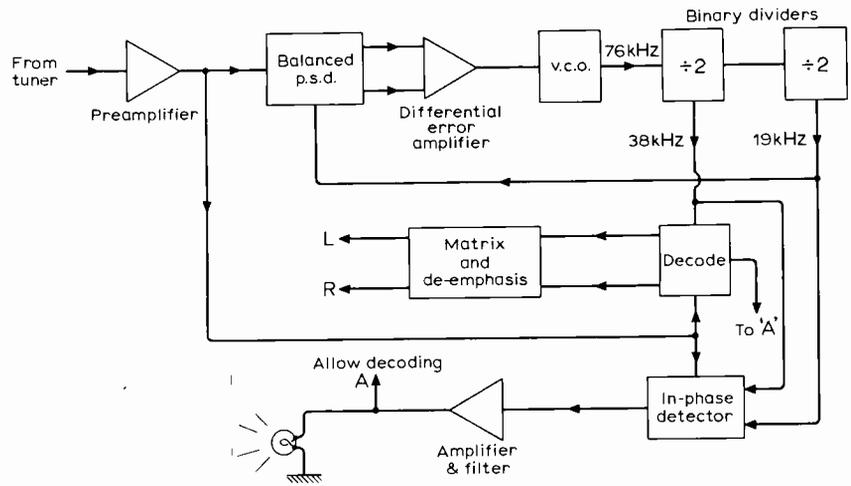


Fig. 5. Complete stereo decoder system built round the phase-locked loop.

causes the output of the p.s.d. to drive the v.c.o. in such a direction as to hold the phase of  $f_{in}$  locked to that of  $f_o$ .

The system behaves as a servo-loop with a bandwidth determined by the time constant of the filter in the error amplifier.

When deciding on loop bandwidth two points have to be considered. These are "jitter" on the v.c.o. and the time required to pull into lock. The first point is important because phase jitter will reduce channel separation. Jitter is minimized by having a low loop bandwidth.

On the other hand if loop bandwidth is made too small the loop will take a long time to pull into lock.

A compromise must therefore be made and a bandwidth of 25 Hz was found to be adequate.

Theory and design equations for the loop are given in appendices I and II.

### Practical decoder system

In Fig. 5 the pre-amplifier acts as a buffer on the tuner output. Its gain is made variable so that a fixed level of pilot tone is presented to the loop independent of the tuner output level.

The phase detector is balanced, and the error amplifier is made differential in order to maintain balance. The output from the error amplifier constitutes the control voltage of the voltage controlled oscillator (v.c.o.) which is free running at approximately 76 kHz.

By the use of binary dividers square-wave outputs are obtained at 38 kHz and 19 kHz. The former output drives the decoding transistors and the latter the loop p.s.d. transistors. The decoder outputs are matrixed and de-emphasized to provide the left and right channel outputs.

On acquiring lock an output is obtained from the in-phase detector. This output is amplified and filtered, and used to allow decoding to begin, and to drive a stereo indicator lamp, if required.

### Circuit description

The complete decoder circuitry is shown in Fig. 6.  $Tr_1$  and  $Tr_2$  comprise a pre-amplifier whose output level is adjusted by  $RV_1$  to set the p.s.d. gain constant. The p.s.d. consists

of  $R_5$ ,  $R_7$ ,  $Tr_3$  and  $Tr_4$ , and these transistors are used in the inverted mode to minimize offset voltage. Since the bases of  $Tr_3$  and  $Tr_4$  are driven alternately at 19 kHz the p.s.d. and differential error amplifier  $IC_1$  form a double-sideband suppressed-carrier modulator, the output of which is modified by the error amplifier response.

Audio signals close to the loop bandwidth are attenuated by  $C_3$ . The phase shift due to  $C_3$  ( $10\frac{1}{2}^\circ$ ) is corrected for in the matrix which is fully described in a later section.

The error amplifier  $IC_1$ , type U6E7709393 or similar, is a low cost differential integrated operational amplifier. This is chosen for its high gain and low input offset voltage. At  $\pm 6$  V supply the typical open loop gain is 72 dB.

$C_4$  and  $C_6$  provide an additional h.f. roll-off beyond the loop unity gain frequency so that loop stability is not affected.

The amplifier response is tailored to give an overall loop bandwidth of 25 Hz with an error response damping factor of 0.707. The d.c. gain is chosen from a consideration of the static error due to v.c.o. drift. The error is  $< 1^\circ$  at 19 kHz.

$RV_2$  provides an adjustment for input offset voltage, which would otherwise appear as a phase error. The low input offset voltage temperature drift of  $IC_1$  ensures good phase stability.

The v.c.o. ( $Tr_6$  and  $Tr_7$ ) is a conventional astable multivibrator with the timing voltage of the bases controlled by  $IC_1$ . It is arranged to free run at approximately 76 kHz.  $RV_4$  provides a fine frequency control by adjustment of the mark/space ratio.

$R_{25}$  and  $D_1$  ensure that the v.c.o. will not operate above 80 kHz, by clamping the error amplifier input to approximately +0.6 V.

The 76 kHz signal is then applied to  $IC_2$  which is a dual D-type SN7474 or similar binary divider.  $IC_2$  will then provide a 38 kHz and a 19 kHz switching signal with a 1:1 mark/space ratio. The 19 kHz signal is applied to the loop p.s.d. transistors  $Tr_3$  and  $Tr_4$ , thus closing the loop. The 38 kHz signal is applied to the decoding transistors  $Tr_{11}$  and  $Tr_{12}$ .

The bases of all the switching transistors are pulled negative to remove stored charge and to hold the transistors off in the presence of audio signals.

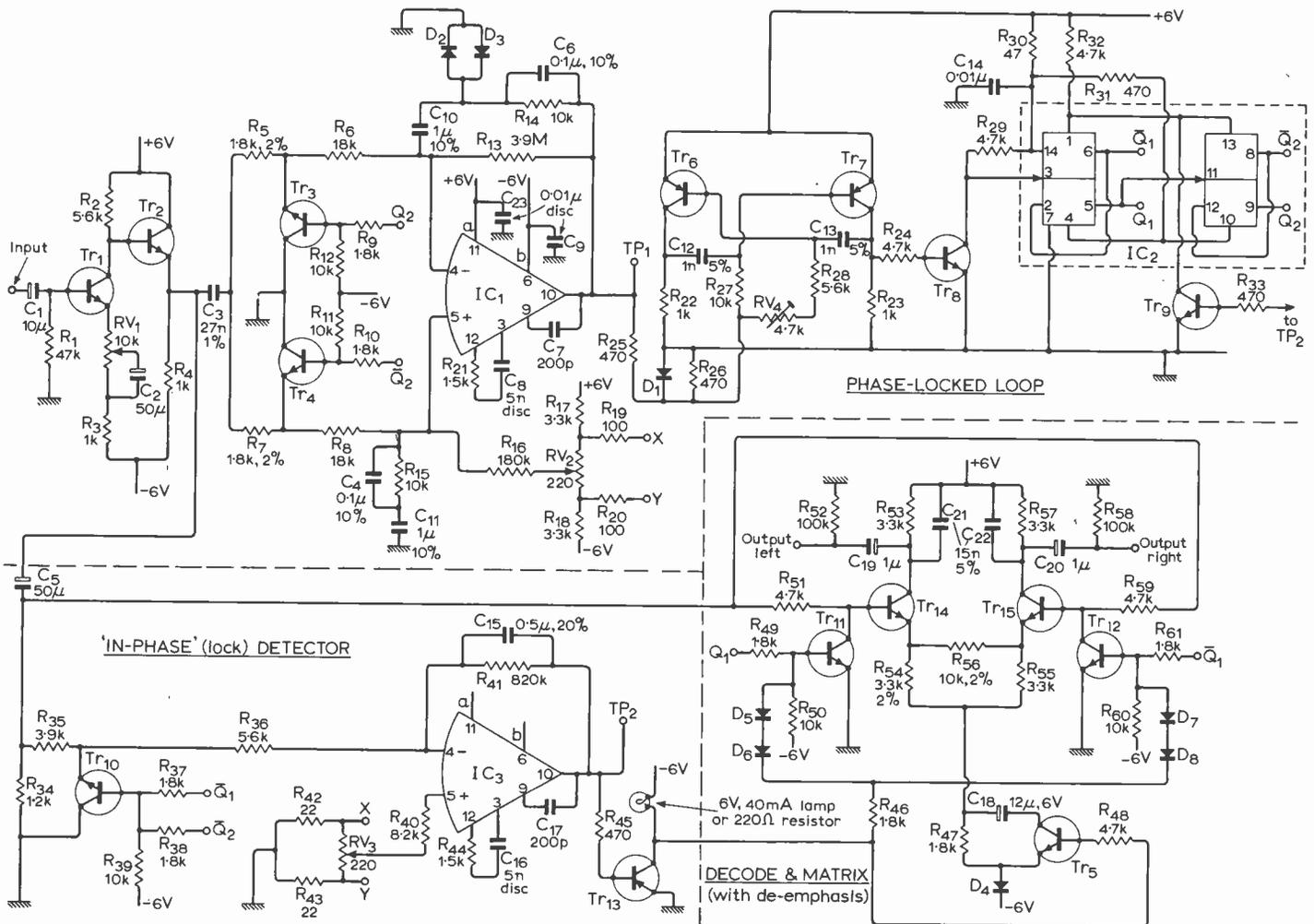


Fig. 6. Circuit diagram of decoder. Integrated circuits IC<sub>1</sub> and IC<sub>3</sub> are type U6E770 9393 or equivalent, and IC<sub>2</sub> type SN7474N or equivalent. Transistors can be BC108 or equivalent for n-p-n types, and ZTX500 or equivalent for p-n-p. Diodes are 1S44 or equivalent. Resistors can be 1/4W 5% tolerance unless specified otherwise.

The action of D<sub>2</sub>, D<sub>3</sub> is to speed up lock-in at switch-on for outputs greater than ±0.6 V. The diodes shunt current away from C<sub>10</sub> and effectively increase loop bandwidth. Between ±0.6 V the diodes have no effect.

**In-phase detector.** Transistor Tr<sub>10</sub> is driven by both binary dividers so that it is off for 1/4 cycle only of the 19 kHz. Thus a pulsed d.c. component is produced when the loop is locked. This signal is filtered and amplified by IC<sub>3</sub> and used for the following purposes:
 

1. To turn on a stereo indicator lamp, if required.
2. To allow decoding to begin in Tr<sub>11</sub> and Tr<sub>12</sub>. If the decoder is allowed to switch during mono transmission, supersonic noise around 38 kHz will be heterodyned into the audio bandwidth causing a deterioration in s/n ratio. Also from some transmitters a 23 kHz low-level tone is present during mono transmission. This tone would produce a "beat" at 15 kHz in a free running decoder. For this reason the v.c.o. is not

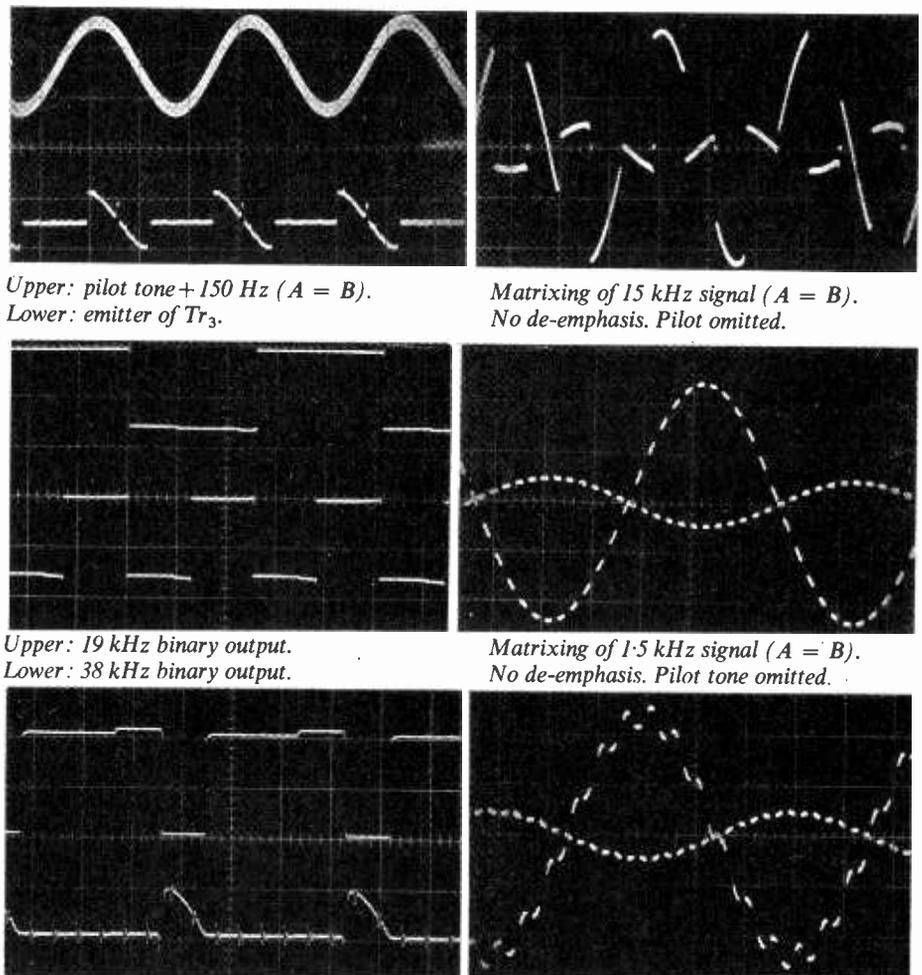


Fig. 7. Oscillograms of typical waveforms generated by the locked-loop.

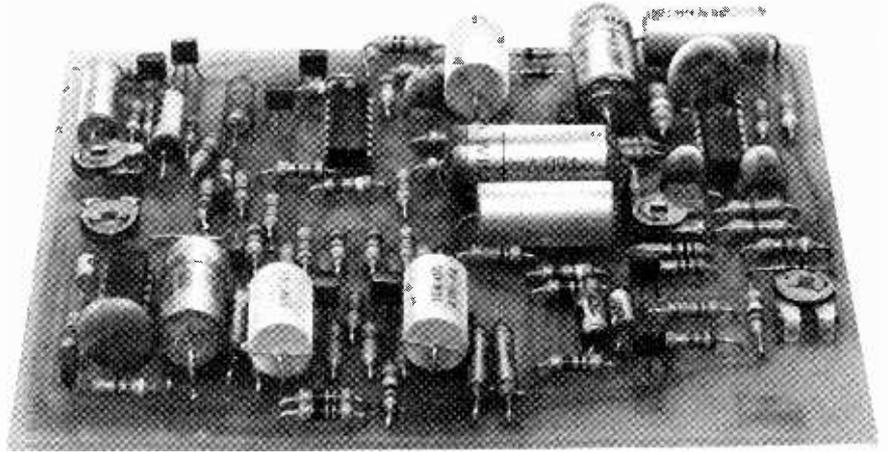
Upper: Tr<sub>10</sub> base drive. Lower: Tr<sub>10</sub> emitter.

As above with 19 kHz pilot tone included.

allowed to operate above 80 kHz, i.e. the binary output cannot exceed 20 kHz.

3. To ensure that the l.h. and r.h. channels do not reverse in the presence of noise etc. If the loop initially locks in the wrong direction i.e. l.h. and r.h. channels are reversed, a positive output will be produced by the in-phase detector,  $Tr_9$ , will be turned on thus clearing the binaries, and reversing l.h. and r.h. This will also be the case if a line transient flips one binary only. In the writers' experience the loop has never locked in the wrong direction. Typical waveforms of the loop in operation are given in Fig. 7.

4. To keep the mono and stereo gains approximately constant via  $Tr_5$ .



Decoder components mounted on a printed circuit board approximately 100 mm x 125 mm.

**Matrix.** Once the signal has been decoded by  $Tr_{11}$  and  $Tr_{12}$  it is matrixed and deemphasized via  $Tr_{14}$  and  $Tr_{15}$ . Matrixing is necessary in any switching decoder as may be seen from the theory given in appendix III.

**Power supply.** The circuit of Fig. 6 is shown for a supply of  $\pm 6$  V. Fig. 8(a) shows a suitable low cost regulator using a miniature mains transformer.

Single supply operation is accomplished from an unregulated (15 V minimum) supply by altering the "earth" rail from the 0 V to the -6 V line as shown in Fig. 8(b).

In this case there are two minor circuit alterations: capacitor  $C_1$  is reversed; and resistors  $R_{52}$  and  $R_{58}$  are returned to the former -6 V rail i.e. instead of the former 0 V rail. The signal "earth" line becomes, of course, the former -6 V line.

**Setting up procedure**

The decoder is set up using a d.c. voltmeter. The stages are as follows:

1. With no input signal adjust  $RV_2$  and  $RV_3$  for 0 V at test points  $TP_1$  and  $TP_2$  respectively.
2. Apply a stereo signal and adjust  $RV_1$  until a negative voltage 1.5 V appear at  $TP_2$  (Adjust  $RV_4$  if necessary).
3. Adjust  $RV_4$  to bring  $TP_1$  back to zero.
4. Adjust  $RV_1$  to bring  $TP_2$  to -1.5 V.

**Operation**

Several decoders have been built and tested by the authors, using both single and dual supply operation.

Over the last year they have proved to be

reliable and have required no adjustment beyond the initial setting up procedure.

The high inherent separation, in particular at high frequencies, produces a marked improvement in performance over that obtained with more conventional decoders.

**Notes**

This decoder design arose from work done on a phase-locked loop frequency multiplier made to improve the resolution of an engine tachometer.

The authors are grateful to J. W. Hill and D. L. Lynas for the use of equipment and for helpful criticism, and thank Rolls-Royce Ltd for permission to publish.

A kit of parts including a printed circuit board is available, mail order only from Integrex Ltd, P.O. Box 45, Derby, DE1 1TW. The price is £8 19s 6d plus 2s 6d for carriage and packing. This printed circuit board is adapted to single or dual supply options. The size of the board is 100 mm x 125 mm (approx.) and it may be seen from the photograph that a high packing density has been achieved. To simplify assembly, component positions have been marked and the track is roller tinned. A power supply kit is also available.

**REFERENCE**

1. "Receiving Stereo Broadcasts", *Wireless World*, September 1966.

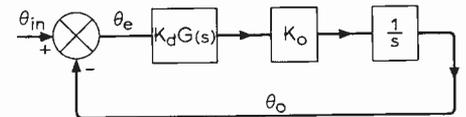
**Appendix I**

**Loop Theory**

The constants used are defined as follows:

- $K_d$  = phase detector gain constant in volts/radian.
- $K_o$  = v.c.o. gain constant in radians/s/V ( $= 2 \times \text{Hz/V}$ ).
- $G(s)$  = error amplifier transfer function
- $\theta_{in}$  = input reference phase angle.
- $\theta_o$  = locally generated phase angle
- $\theta_e$  = phase angle error ( $= \theta_{in} - \theta_o$ ).

The loop block diagram is redrawn below.



The integration term (1/s) is introduced by the conversion of the frequency of the v.c.o. to its phase.

By inspection of the diagram

$$\frac{\theta_o}{\theta_{in}} = \frac{K_o K_d G(s) 1/s}{1 + K_o K_d G(s) 1/s} = \frac{K_o K_d G(s)}{s + K_o K_d G(s)} \quad (1)$$

The error amplifier has a response that can be shown to be

$$G(s) = \frac{A(1 + sT_2)}{1 + s(T_1 + T_2)} \quad (2)$$

where

$$A = \frac{R_1}{R_3}; \quad T_1 = CR_1; \quad T_2 = CR_2$$

Substituting (2) in (1) we get

$$\frac{\theta_o}{\theta_{in}} = \frac{[K_o K_d A / (T_1 + T_2)] (1 + sT_2)}{s^2 + \frac{s K_o K_d A T_2}{T_1 + T_2} + \frac{K_o K_d A}{T_1 + T_2}} \quad (3)$$

Where it is assumed  $K_o K_d A T_2 \gg 1$ . This is of the form

$$\frac{\theta_o}{\theta_{in}} = \frac{2\eta\omega_n s + \omega_n^2}{s^2 + 2\eta\omega_n s + \omega_n^2}$$

where using servo terminology  $\omega_n$  = natural (undamped) frequency of the loop and  $\eta$  = loop damping factor.

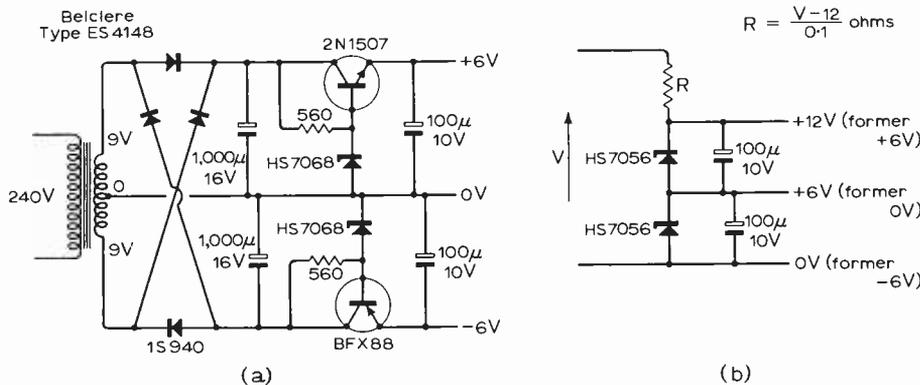


Fig. 8. Decoder power supply arrangements. (a) Stabilized supply for  $\pm 6$  V. (b) Supply obtained from an unregulated 15 V (or greater) d.c. source.

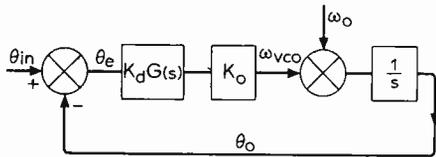
$$\text{Thus } \omega_n = \left( \frac{K_o K_d A}{T_1 + T_2} \right)^{\frac{1}{2}} \quad (4)$$

$$\eta = \frac{T_2}{2} \left( \frac{K_o K_d A}{T_1 + T_2} \right)^{\frac{1}{2}} = \frac{T_2}{2} \omega_n \quad (5)$$

**Static phase errors**

Since the phase loop contains an integrator term then the steady state phase error will be reduced to zero if the v.c.o. free-running frequency is the same as that of the input frequency.

The response of the loop to a disturbance causing drift in the v.c.o. free running frequency can be obtained from the figure below.



where

$\omega_{v.c.o.}$  = free running v.c.o. frequency

$\omega_o$  = disturbance (or drift) frequency.

It can be seen that

$$\frac{\omega_{v.c.o.}}{\omega_o} = \frac{1/s \cdot K_o K_d G(s)}{1 + 1/s \cdot K_o K_d G(s)} \quad (6)$$

By referring  $\omega_{v.c.o.}$  back to an equivalent  $\theta_e$  we get

$$\frac{\theta_e}{\omega_o} = \frac{1/s}{1 + 1/s K_o K_d G(s)} = \frac{1}{s + K_o K_d G(s)} \quad (7)$$

For a step input of  $\omega_o = \Delta\omega_o$  then

$$\theta_e \cdot s = \frac{\Delta\omega_o}{s} \cdot \frac{1}{s + K_o K_d G(s)} \quad (8)$$

Applying the final value theorem we get

$$\text{steady state phase error} = \frac{\Delta\omega_o}{K_o K_d A} \quad (\text{since } G(0) = A) \quad (9)$$

This phase error is required in order to pull the v.c.o. away from its free-running frequency. By making  $K_o K_d A$  sufficiently large the phase error can be made as small as required.

For those who wish to pursue phase-locked loop theory a very good account is given in "Phase-lock Technique" by Floyd M. Gardner, published by John Wiley and Sons Inc.

**Appendix II**

**Loop equation constants**

**P.S.D. gain constant.** For a phase error  $\gamma$ , when the loop is locked the mean output voltage from the phase detector,  $V_o$ , is given by:

$$V_o = \frac{V_{in}}{\pi} \int_{\frac{\pi}{2} + \gamma}^{\frac{3\pi}{2} + \gamma} \sin \theta \, d\theta$$

where  $V_{in} \sin \theta$  is the input signal.

Thus  $|V_o| \approx \frac{2}{\pi} \times V_{in} \times \gamma$  where  $\gamma$  is small.

Thus, if we choose an input signal of 200 mV

peak to peak amplitude:

$$K_d = 63.7 \text{ mV/radian}$$

$$\text{or } \frac{K_d}{K_o} = 63.7 \times 10^{-3} \text{ V/radian}$$

**Steady state error.** From equation (9) it may be seen that the steady state error is given by:

$$\text{Error} = \frac{\Delta\omega_o}{K_o K_d A}$$

where  $\Delta\omega_o$  is the frequency difference of the free running v.c.o. and the pilot signal,  $K_d$  is the phase detector gain constant and  $K_o$  is the v.c.o. gain constant.

Now

$$K_d = 63.7 \times 10^{-3} \text{ V/rad and}$$

$$K_o = 1.2 \times 10^3 \times 2\pi \text{ rad/s/V (measured)}$$

For the v.c.o., the frequency drift is approx. 0.075 %/°C. It follows that for a steady state error of 1° over 20°C temperature change.

$$A = 214$$

From equation (4)

$$\omega_n = \frac{K_o K_d A}{T_1 + T_2} \quad T_1 + T_2 = 4.16 \text{ s}$$

From equation (5)

$$\eta = \frac{T_2 \omega_n}{2} \therefore T_2 = 9 \text{ ms}$$

**Appendix III**

**Matrixing in switching decoders**

In an f.m. stereo broadcast the instantaneous deviation of the transmitter is given as:

$$f = 0.9 \left[ \frac{1}{2}(A+B) + \frac{1}{2}(A-B) \sin \omega_s t + 0.1 \sin \frac{\omega_s t}{2} \right]$$

where  $\frac{\omega_s}{2\pi} = 38 \text{ kHz}$

The pilot tone is  $0.1 \sin \frac{\omega_s t}{2}$ .

In a switching decoder the input signal is treated as if it were time division multiplexed. The signal is multiplied by a square wave:

$$= \left( \frac{1}{2} + \frac{2}{\pi} \sin \omega_s t + \frac{2}{3\pi} \sin 3\omega_s t + \dots \right)$$

Suppose there is phase error  $\phi$  existing between the 38 kHz carrier used for modulation and the local 38 kHz decoding signal.

The output signal will be proportional to  $V_1$  where:

$$V_1 = [(A+B) + (A-B) \sin \omega_s t]$$

$$\left[ \frac{1}{2} + \frac{2}{\pi} \sin(\omega_s t + \phi) + \frac{2}{3\pi} \sin(3\omega_s t + \phi) + \dots \right]$$

(neglecting  $\sin \frac{\omega_s t}{2}$ )

$$= \left( \frac{1}{2} + \frac{1}{\pi} \cos \phi \right) A + \left( \frac{1}{2} - \frac{1}{\pi} \cos \phi \right) B$$

plus modulation

around  $\omega_s, 3\omega_s$ , etc, which is of the form:

$$V_1 \propto (A + \Delta B)$$

where  $\Delta$  is dependent on the phase shift  $\phi$ .

If the decoding signal is shifted by 180°, the output signal may be shown to be proportional to  $V_2$  where:  $V_2 \propto (B + \Delta A)$ .

The purpose of matrixing is to subtract  $\Delta V_2$  from  $V_1$  and vice-versa.

$$\text{i.e. } V_1 - \Delta V_2 \propto A + \Delta B - \Delta B - \Delta \Delta A$$

$$\propto A - \Delta \Delta A$$

It may be seen that signals from channel A only are present in one output and from channel B in the other.

Thus, if the phase shift  $\phi$  is known, and hence  $\Delta$ , complete separation of an ideal broadcast is achieved.

**Announcements**

A lecture on the **British Trans-Arctic Expedition 1968/69** will be given by Sq. Ldr. F. W. Church, D. J. Collins and R. G. Shears at a meeting of the R.S.G.B. at 18.30 on 28th September at the I.E.E., Savoy Place, London W.C.2.

A post-graduate evening course of sixteen meetings entitled "**Integrated Circuit Electronics**" will be held at North East London Polytechnic, Romford Road, London E.15, beginning 22nd October. Fee £4.

"**Single Standard Colour Television Receivers**" is the title of a 6-week course of evening lectures to be held at Norwood Technical College, Knight's Hill, London S.E.27, commencing 20th October. Fee £1.

**Basic Electronics** is the subject of two ten-evening courses comprising lectures and practical work to be held at Twickenham College of Technology, commencing 15th October and 21st January. Further details from The Principal, Twickenham College of Technology, Egerton Road, Twickenham, Middx. Fee 5gn per course.

A course in **Modern Sound Studio Techniques** is to be held through the winter at the Northern Polytechnic, Holloway Road, London N.7. Sessions will be on Thursday evenings beginning 29th October. The fee for the fifteen sessions is 6gn.

The scope of the **annual Manchester exhibition** of measuring equipment is to be extended next year to include professional-grade products in three main groups: electronic equipment, electronic components and apparatus for industrial measurement and control. The show will be held at the City Hall, Deansgate, from 5th to 8th October, 1971. Organizers: Industrial Exhibitions Ltd, 9 Argyll Street, London W1V 2HA.

Following the acquisition of **Painton & Co.**, of Northampton, by the Plessey Co., the Resistor and Connector Divisions of Plessey have combined with Painton in whose name the business will in future be conducted with R. W. Addie continuing as managing director. Painton now have four operating divisions, three commercial—connectors, resistors and exports—and one production.

# Television Wobbulator

## 2. Circuit Details

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

In last month's article the general principles of a wobbulator specially designed for the alignment of television i.f. amplifiers were discussed. The complete circuit diagram of the instrument is shown in Figs. 1 and 2. The heart of it is the section labelled "Wobbly Oscillator" with the transistor  $Tr_2$ . This is an h.f. type operating as a Colpitt's oscillator.

The inductor is  $L_1$  connected between the collector and the earth line, which is the positive of the 17-V power supply. The base is earthed for r.f. through the 1-nF capacitor  $C_5$  and the capacitors  $C_7$  and  $C_6$ , of 6.8pF and 82pF respectively, are between collector and base with the emitter joined to their

junction. These two form the split capacitance of a Colpitt's oscillator. The tuning capacitance proper comprises  $D_2$  in series with  $C_8$ ,  $D_2$  being the varactor diode the capacitance of which is varied by a 50-Hz voltage applied through  $R_9$ . The purpose of  $C_8$  is merely to prevent  $L_1$  from shorting  $D_2$  at 50Hz.

The emitter resistor  $R_8$  completes the d.c. path of  $Tr_2$  but allows the emitter to be free at radio frequency. It is effectively in shunt with the base-emitter path of the transistor. The other resistor  $R_7$  and the zener diode  $Z_1$  give a stabilized supply of some 12V for the oscillator.

Wound in bifilar fashion with  $L_1$  is  $L_2$

which feeds the diode  $D_1$  with load  $R_3$  returned to a potential divider  $R_1, R_2$  across the 17-V supply. The diode load capacitance is  $C_2$  with a filter  $R_4, C_3$ . The rectified output of the diode is positive-going and is applied in series with the small voltage from the potential divider to the base of  $Tr_1$  which acts as a d.c. amplifier with emitter resistance  $R_6$ . Its collector is joined to the base of  $Tr_2$  and fed through  $R_5$ . In Fig. 1, this stage is labelled a.c. for automatic amplitude control, and it forms a kind of a.g.c. system, whose purpose is to minimize variations of the amplitude of oscillation of  $Tr_2$  as its frequency is varied.

If, for any reason, the amplitude increases

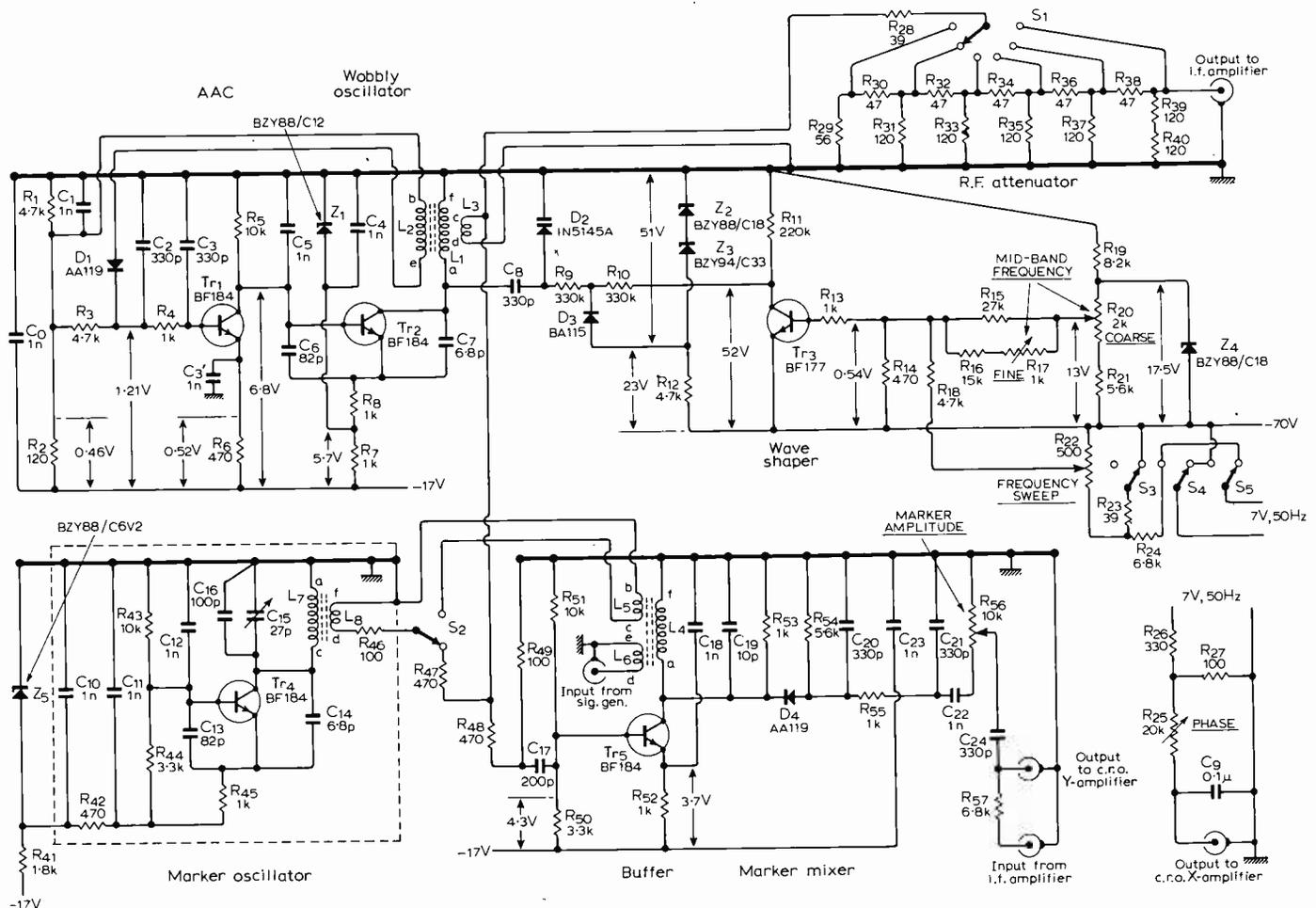


Fig. 1. Complete circuit diagram of the wobbulator, apart from the power supply.  $Tr_2$  generates a signal varying in frequency between 30.5MHz and 42.5MHz which is fed to the amplifier under test through the attenuator controlled by  $S_1$ .  $Tr_3$  is the wave shaper which enables a linear relation between frequency and displacement on the c.r.o. to be obtained.

the rectified output of  $D_1$  increases and  $Tr_1$  passes more current. Consequently the voltage drop across  $R_5$  increases and the base-emitter voltage of  $Tr_1$  is reduced and this reduces the amplitude of oscillation. The net result is to reduce the magnitude of any changes in the amplitude of oscillation.

The output of the oscillator is taken from the single-turn coil  $L_3$  coupled to  $L_1$  and connected to the r.f. attenuator. This comprises a ladder network of resistors with a single-pole 6-way switch  $S_1$ . When terminated at the output socket by  $75\Omega$  this network has a constant impedance of  $37.5\Omega$  at the switch arm for any position of the switch and, because of  $R_{28}$ , a constant impedance of  $75\Omega$  is presented to the coupling coil  $L_3$ . The actual impedance is slightly different because  $R_{28}$  actually has the standard value of  $39\Omega$ . Further, resistor tolerances in the network affect the impedance relations slightly.

Viewed from the output socket the impedance varies with the switch position, but the variation is appreciable only between the full output and the next-to-full output positions. This is inevitable with a simple ladder attenuator. The attenuator is intended merely to adjust the output to the required level in steps of about 5dB. It is not intended to provide precisely equal and known steps; that would entail a more elaborate construction and the use of precision resistors.

The total attenuation available is not more than some 30dB. More may be needed with some i.f. amplifiers and it is recommended

that any such extra attenuation be provided externally. For this purpose, the Belling-Lee coaxial attenuators type L729 are particularly convenient and two 6-dB types (L729/6) and one 12-dB (L729/12) in conjunction with the internal attenuator should be sufficient for almost any amplifier.

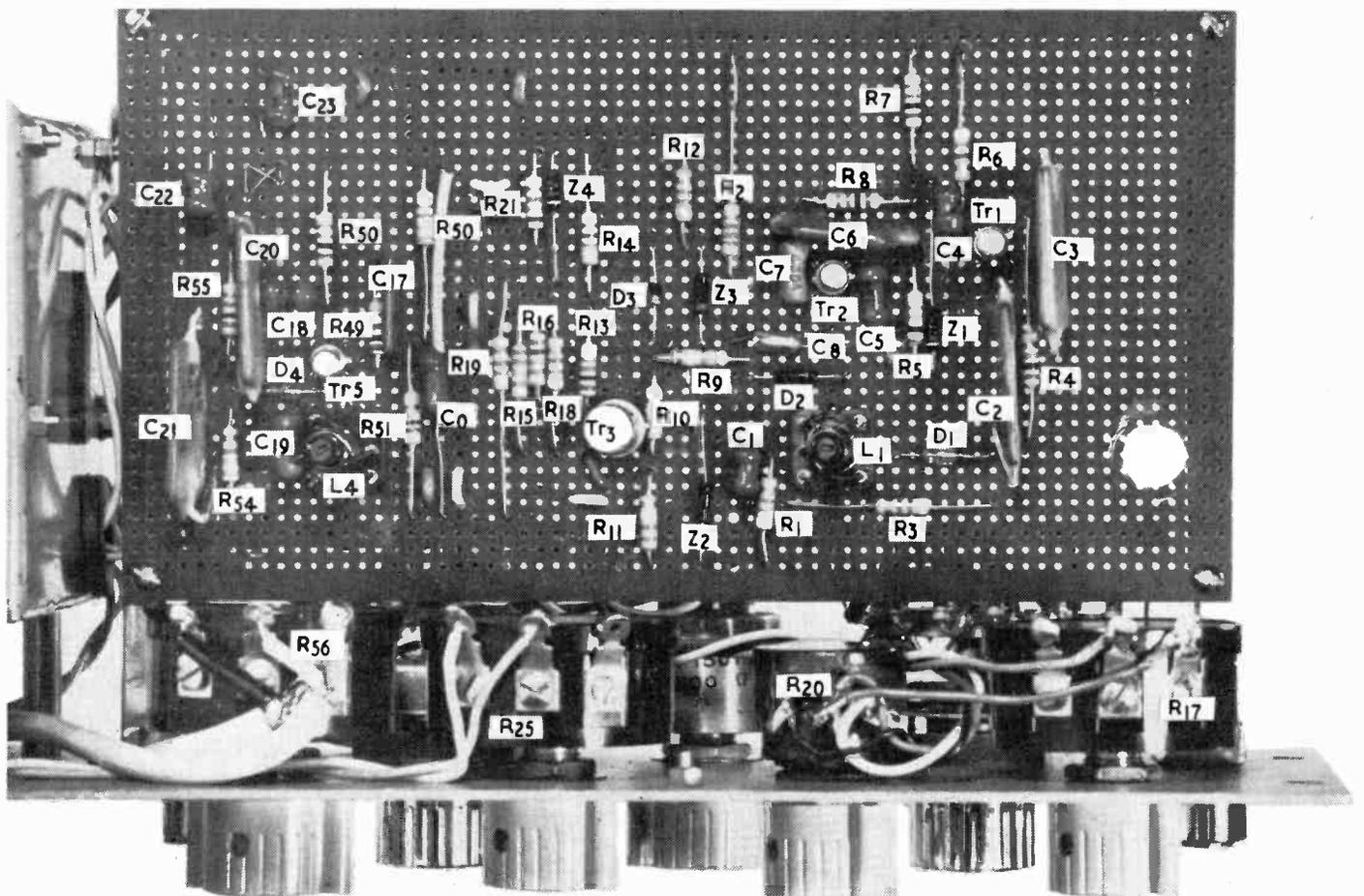
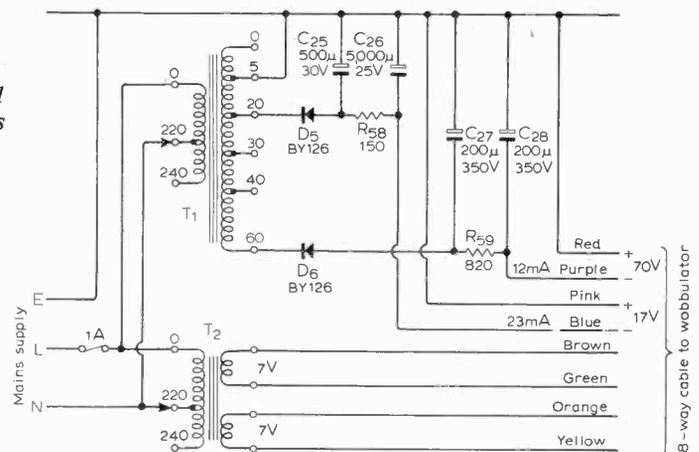
We now come to the wave shaper,  $Tr_3$ . It was explained in Part 1 that the relation between the frequency generated by the oscillator and the voltage applied to the varactor diode  $D_2$  is logarithmic and that to obtain a linear relation between frequency and the X-deflection voltage of the oscilloscope it is necessary for the voltage applied to  $D_2$  to have an exponential relation to the deflecting voltage. This exponential relation

is provided by  $Tr_3$ .

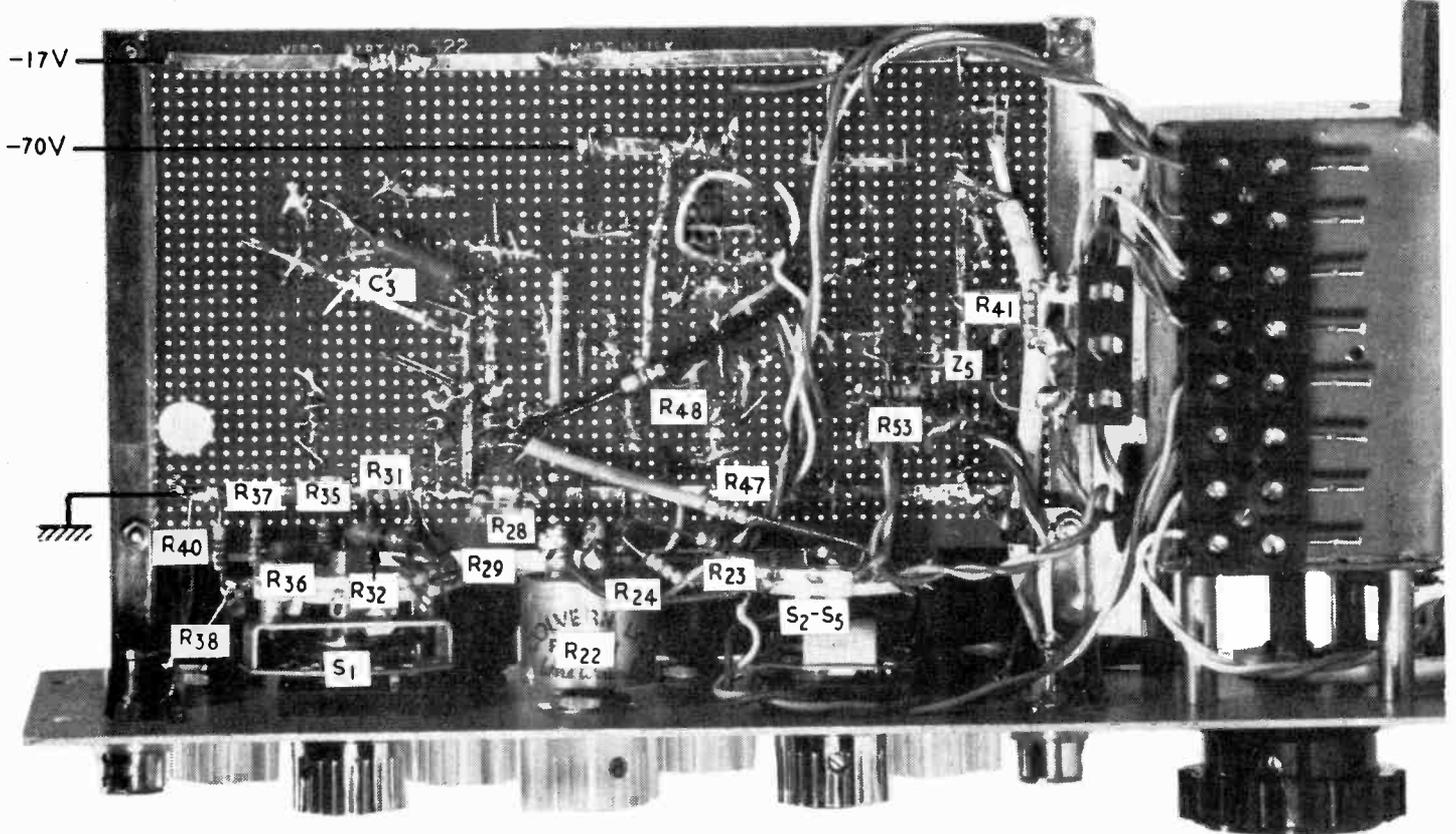
A BF177 transistor is used. This is primarily intended for use as a video output stage and is rated for operation at 100V. It is used here on a 70-V supply, its collector being taken to earth (positive) through  $R_{11}$  of  $220k\Omega$  and its collector voltage being fed to  $D_2$  through  $R_9$  and  $R_{10}$  of  $330k\Omega$  each. The emitter is returned to the negative of the 70-V supply. The collector potential with respect to earth can thus vary from zero (collector current cut-off) to almost  $-70V$  (bottoming).

The varactor diode  $D_2$  is rated for a maximum of 60V. The application to it of a higher voltage is thus dangerous to its life and as it is an expensive component it is

Fig. 2. Circuit diagram of the power supply. Two transformers are used since the requirements are then met by stock-item components.



Top of the circuit board showing the placement of components.



Underview of the circuit board.

important to protect it from the accidental application of anything more than 60V. The protective device comprises the diode  $D_3$  with  $R_{12}$  and the two zener diodes  $Z_2$  and  $Z_3$ . The zener diodes keep the anode of  $D_3$  at 51V ( $\pm 5\%$ ) negative to the earth line irrespective of variations of the supply voltage or the tolerance of  $R_{12}$ .

As long as the junction of  $R_9$  and  $R_{10}$  is less negative to earth than this  $D_2$  is non-conductive and has no effect. When the junction becomes slightly more negative than the zener voltage  $D_2$  conducts and clamps the junction of  $R_9$  and  $R_{10}$  at about 0.7V more than the voltage across  $Z_2$  and  $Z_3$ . Even if  $Tr_3$  is bottomed, therefore, the voltage applied to  $D_2$  is limited to 54.35V, allowing for 0.8V drop across  $D_3$  and for 5% high tolerance on the zener diodes. Two zener diodes in series are used instead of a single one to reduce the dissipation per diode. It is thought that this should reduce the risk of a diode going open-circuit, for that would put the protective circuit out of action.

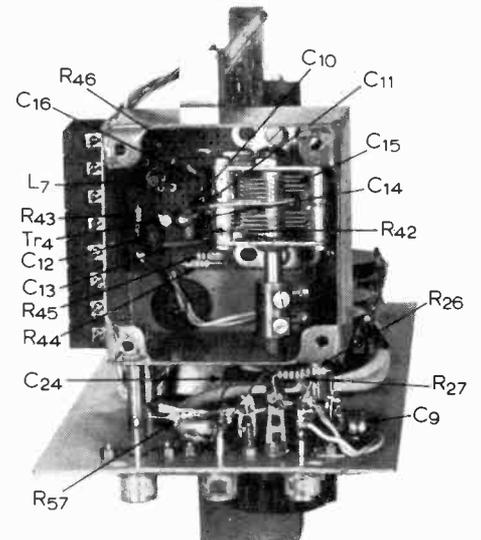
The d.c. bias for  $Tr_3$  comes from the 70-V supply. A stabilized supply of 18V is first derived from  $R_{19}$  and  $Z_4$ . A variable voltage of 13.3V to 18V is available from the slider of the "Coarse mid-band frequency control"  $R_{20}$ . Roughly 1/20 of this voltage is applied to the base of  $Tr_3$  by a potential divider comprising  $R_{14}$  and the network  $R_{15}$ ,  $R_{16}$  and  $R_{17}$ , the last of which is variable to form a "Fine mid-band frequency control". This is essential when the equipment is used to provide a narrow-band sweep for sound-channel alignment. It is not essential with the wide-band sweep for vision channel use, but even then it is convenient.

A 7-V, 50-Hz, supply from a mains

transformer is applied through a phase-reversing switch  $S_4$ ,  $S_5$  to a potential divider  $R_{22}$ ,  $R_{24}$ . The maximum voltage available from  $R_{22}$  is 0.48V r.m.s. and roughly 1/10 of this is applied to the base of  $Tr_3$  through the potential divider  $R_{14}$ ,  $R_{18}$ . The voltage actually applied to the transistor is thus variable from zero to a maximum of about 130mV peak-to-peak. For the narrow sweep for the sound channel  $S_3$  connects 39 $\Omega$  in shunt with  $R_{22}$ , and this reduces all voltages to about 1/12.

Another 7-V, 50-Hz, supply provides the X-deflection voltage for the oscilloscope. It is reduced to about 1.63V r.m.s. by  $R_{26}$ ,  $R_{27}$ ; this is about 4.7V peak-to-peak. It is sufficient with the oscilloscope used to give an X-trace of about two-thirds of the screen width and the X-expansion control on the oscilloscope permits the length of trace to be increased beyond this as desired. If the oscilloscope used does not have such a control, then  $R_{26}$ ,  $R_{27}$  should be replaced by a variable potentiometer. Of course, if the oscilloscope used needs more than some 20V p-p for full X-deflection, a higher supply than 7V r.m.s. must be provided.

The voltage across  $R_{27}$  is applied through a simple variable integrator  $R_{25}$  and  $C_9$  to provide an X-deflection voltage which is lagging in phase on the input, the phase being adjustable by  $R_{25}$ . This is necessary to correct for phase shift in the Y-deflection circuits. This occurs mainly in the wave shaper and is caused principally by  $C_8$  with  $R_9$  and  $R_{10}$ . Some also may occur in the receiver under test, especially if the output from it is taken from a video stage. The capacitance of  $D_3$  also has an effect and, indeed, the addition of only 10pF across  $D_3$  produces a noticeable phase shift. This may seem surprising in view of the frequency of 50Hz, for few realize how sensitive circuits



Interior of the marker oscillator.

are to phase shift.

It is important to keep stray capacitance low in the collector circuit of  $Tr_3$ , for the waveform is not sinusoidal and so a phase shift introduced here cannot be completely corrected. It is found in practice that the residual error can be no more than the thickness of the trace on the c.r.t., which is quite adequate for all normal requirements.

This is the basic wobulator. On one half-cycle of the sine-wave deflection the oscillator frequency varies from 30.5MHz to 42.5MHz, or such smaller range as may be set. On the next half-cycle it varies from 42.5MHz to 30.5MHz and, of course, the X-deflection varies in the opposite direction.

The traces for increasing frequency and for decreasing superpose to give a single visible trace only if the X and Y channels have the same phase shift and only if the

i.f. amplifier gives the same response to increasing and decreasing frequencies. The latter does not necessarily occur, and it will not if the sweep repetition rate is too great in relation to the bandwidth of the amplifier. With wideband amplifiers, such as television amplifiers, the effect is unlikely to be observed with a 50-Hz sweep except, possibly, at the troughs introduced outside the passband by high- $Q$  trap circuits. Even there, however, they have not so far been observed.

It is essential to have at least one marker on the oscilloscope trace to indicate frequency and it is a convenience to have two markers. An internal marker oscillator is provided and is  $Tr_4$ . Its circuit is substantially the same as that of the wobbly oscillator, but it is tuned by an ordinary variable capacitor  $C_{15}$  of 27pF. It operates at 6.2V from a supply stabilized by  $Z_5$ . It is built into a screening box, the zener diode and  $R_{41}$  being outside it to reduce the total dissipation within the box and so the temperature rise within it. The output is taken from a 2-turn coil  $L_8$  through a 100- $\Omega$  resistor  $R_{46}$  and thence by a twisted pair of wires to  $S_2$  and to  $L_5$  or  $R_{47}$ . The earthy lead from  $L_8$  is earthed at one point only, close to where it emerges from the screening box of the marker oscillator. This is important.

A socket for an input from a signal generator is provided on the front panel and is connected by a pair of twisted wires to  $L_6$ . The only earth point is that of the coaxial socket on the front panel. Again, this is important.

With the marker system used here it is desirable that r.f. from the signal generator

or from the internal marker oscillator should not reach the input of the i.f. amplifier. Unless each coupling circuit is earthed at one point only, it has been found impossible to prevent greatly excessive leakage. Even with the single-point earthing, there is still some leakage and with the marker amplitude control turned right down traces of the markers are visible on the screen. They are not at all troublesome in normal usage, however.

The internal marker oscillator has a second use. When  $S_2$  connects  $R_{46}$  to  $R_{47}$  the output is connected to  $L_3$  and so to the input of the attenuator. It is thus mixed directly with the output of the wobbly oscillator. The switches  $S_2$  to  $S_5$  are ganged together; they are actually a rotary switch wafer having 4-poles, each 2-way. When  $S_2$  connects the marker output to the attenuator it also brings  $R_{23}$  into circuit to reduce the sweep and by  $S_4$  and  $S_5$  it reverses the phase of the 50-Hz voltage applied to  $Tr_3$ .

This is the condition for aligning an inter-carrier sound channel. The marker oscillator is set at 39.5MHz to simulate the vision carrier, and the wobbly oscillator is set by the mid-band frequency controls to sweep about a centre frequency of 33.5MHz. The 6-MHz beat between the two is developed in the receiver under test just as it is when a television signal is being received.

Reversal of the phase of the 50-Hz drive to  $Tr_3$  is by no means essential, but is desirable in order that the frequency sweep shall be in the same direction for both channels. It is desirable to have frequency increasing to the right on the display and the connections are made to provide this

for the vision channel. Because the sound-channel signal is generated as a difference frequency with the fixed frequency higher than the variable, the same connections would give a sound-channel display with frequency increasing to the left. This is remedied by reversing the phase of one 50-Hz channel.

We now come to the buffer and marker mixer, which is operative only for vision-channel alignment.  $L_3$  is connected through a potential divider  $R_{48}$ ,  $R_{49}$  to the input of  $Tr_5$ . This is a normal r.f. amplifier stage with a tuned collector circuit comprising  $L_4$ ,  $C_{19}$  damped by  $R_{53}$ . It is tuned to mid-band and has a 3dB bandwidth of 12MHz. Marker inputs from the internal marker oscillator and from a signal generator are coupled into  $L_4$  and there mixed with the signal from the wobbly oscillator. The whole is applied to the diode detector  $D_4$  and the beats between the signals are produced at its output. The marker amplitude control  $R_{56}$  is fed through quite a small capacitor  $C_{22}$ . This has been found desirable to remove some residual hum which otherwise produced a slight unwanted vertical deflection on the c.r.t. The output from  $R_{56}$  is mixed with the output of the receiver under test, which necessitates bringing this into the wobulator instead of taking it directly to the c.r.o.

This output is brought in at the socket "Input from i.f. amp" and is taken through  $R_{57}$  of 6.8k $\Omega$  to the socket marked "Output to c.r.o. Y-amp" and the marker signal is also fed to this through  $C_{24}$ .

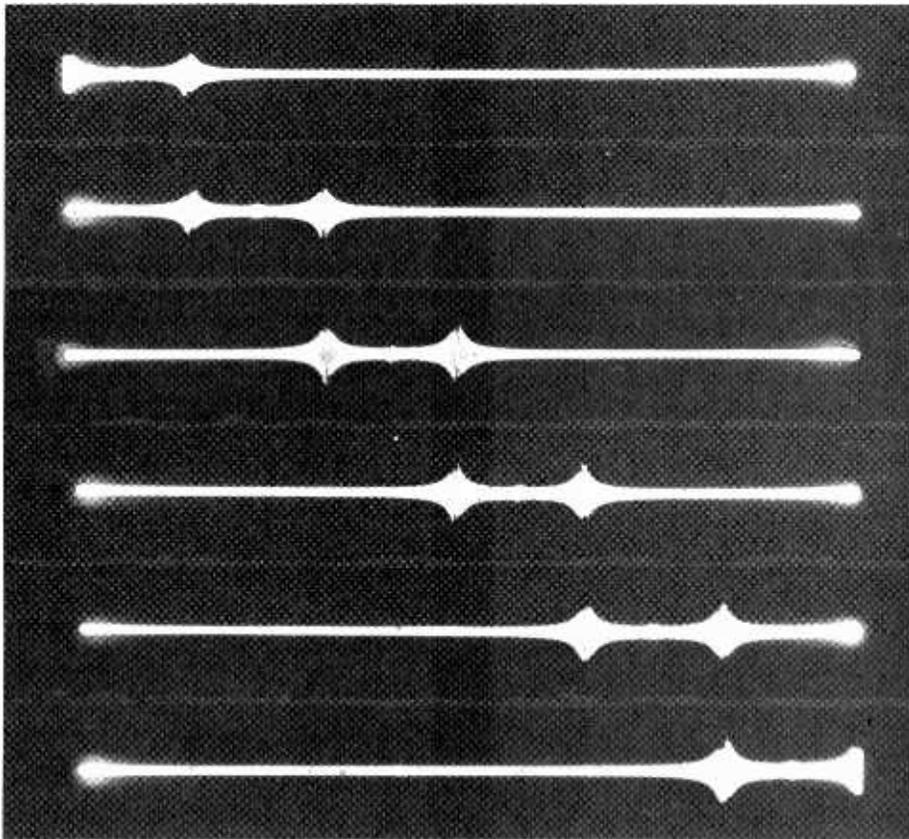
The maximum amplitude of the marker signals is fixed by the design and can only be reduced by  $R_{56}$ . The amplitude required depends on the peak-to-peak amplitude of the output of the i.f. amplifier. The maximum marker amplitude has been made about right for an i.f. output of about 2V p-p, and it is usable, although a little small, for outputs up to some 4V. Naturally, for small outputs of under 1V it is too great, and that is why the amplitude control is provided.

The newcomer to a wobulator will undoubtedly think the amplitude available is too small, but he will soon find that it is adequate. It is essential that the marker amplitude should not be too great, since if it is it can greatly distort the trace.

The wobulator is designed for use with an oscilloscope which has provision for an external X-deflection voltage and has some kind of amplitude adjustment for it. It must also have a Y-amplifier which is capable of giving undistorted reproduction of pulses of some 5ms duration which are repetitive at 100Hz, for that is what the output signal from the amplifier under test approximates to. An amplifier with a 3dB response at 50-Hz would be useless. The gain should be such that an input of 1V p-p will give full Y-deflection, and there must be adequate gain control.

The power supply is shown in Fig. 2 and is self-explanatory. The two 7-V windings of  $T_2$  could quite well be on the core of  $T_1$ , but this would have necessitated a specially-wound transformer. By using separate transformers two standard components could be employed.

Half-wave rectification is used for both supplies with the diodes  $D_5$  and  $D_6$ .



Sequences of traces with the markers moved by 2MHz in each photo. The slight variation of trace length is caused by mains voltage fluctuation.

# News of the Month

## Television camera design for constructors

The latest and most ambitious design to be issued by the Mullard Educational Service is for a closed-circuit television camera using a 1-inch vidicon pick-up tube. According to the designers it can be built for about £45, which is less than half the price of the cheapest professional camera. A model we saw made up and working produced pictures which, although not of professional c.c.t.v. quality, were certainly good and would be acceptable to most schools, technical colleges and individual constructors.

Cost is saved by using a sub-specification vidicon of one of the simpler types (e.g. Mullard XQ1030, Philips 55850), by winding your own deflection and focus coils, by circuitry designed for cheap and readily available transistors (e.g. BCY70), by the use of a photographic camera lens rather than a television camera lens, and by an elementary type of housing (e.g. a piece of plastic drain pipe and a tobacco tin lid). In addition the camera circuitry is simplified by the adoption of sequential (non-interlaced) scanning; the model we saw demonstrated was working on  $312\frac{1}{2}$  lines per field, 50 fields per second.

The electronic circuits in the camera

are: a video amplifier with a bandwidth of 4.5MHz and an output signal of 1V p-p into  $75\Omega$ ; horizontal and vertical timebase generators; a synchronization mixer (feeding sync signals into the video amplifier); a blanking mixer (providing blanking pulses at the vidicon cathode); and a power unit (-15V for the transistor circuitry and -120V and +330V for the vidicon). The circuitry uses 23 transistors of six well-known types and 10 diodes of five types. Several monitors can be operated from the one camera.

To build the camera for £45 the designers admit that the constructor will have to "shop around" to some extent, but for those who are willing to pay for more to save this trouble, a complete kit of parts is available from Linstead Electronics, Roslyn Works, Roslyn Road, London N.15, at £70 (or £45 without the tube and lens). This company will also supply individual parts from the kit, and are offering a ready built camera with a professional looking chassis and case for £99 17s 6d. The Mullard Educational Service (Mullard House, Torrington Place, London W.C.1), of course, only supplies the design information. Their literature is not yet ready but will be available later.

The camera in use with its picture displayed on a monitor.



## R.S.G.B. Exhibition

The Radio Society of Great Britain's International Radio, Engineering and Communications Exhibition will be held at the Royal Horticultural New Hall, Westminster, London S.W.1. from the 19th to 22nd of August. The exhibition will be open during this period from 10.00 to 21.00 and the admission charge is 4s.

At 14.30 on the second and third days there will be lectures on mobile equipment and s.s.b. receivers.

*Wireless World* will have a stand at the exhibition (No. 11) and we plan to demonstrate the phase-locked loop stereo decoder and the television wobulator described in this issue. We also hope to demonstrate the surface temperature thermometer described in April 1969, the logic display aid described in the May to December 1969 issues and the electronic dice which was described in the April 1970 issue. Also on the stand we shall be selling a selection of books and reprints of some of the articles which have appeared in *Wireless World*.

Other exhibitors include: Adcola, Amateur Radio Shop, Angus McKenzie Hi-fi, Baginton Electronics, British Amateur Radio Teleprinter Group, British Amateur Television Club, City and Guilds of London Institute, E.M.S.A.C., J. Michael Gale, Garex Electronics, J. Beam Engineering Ltd, K. W. Electronics Ltd, Lowe Electronics, Microwave Modules Ltd, Ministry of Posts & Telecommunications, Nombrex (1969) Ltd, *Practical Wireless*, Professional & Academic Book Exhibition, Radio Amateur Invalid and Bedfast Club, Radio Shack Ltd, Radio and Space Research, R.A.F., Royal Navy A.R.S., Royal Signals A.R.S., Telecomms, Weller Electric Ltd, Western Electronics, World Association of Methodist Radio Amateurs and Clubs.

## CAT-70

The British Amateur Television Club celebrated its 21st anniversary during the weekend 25th-26th July with a Conference on Amateur Television ("CAT-70") held at Churchill College, Cambridge.

Over 100 people registered, including delegates from Belgium, France, Germany, Switzerland and the U.S.A.

The major event of the weekend took place on the Saturday afternoon. Signals from several amateur television stations were received and displayed on monitors in the Wolfson Hall, from 14.30 until 16.00. Stations contributing included G6ADM/T from Haddenham, Cambs. (11 miles); G6NOX/T from Duddenhoe End, Essex (14 miles); G6REH/T from the top of his 110ft tower at Sutton St. James, Lincs. (36 miles); G6AEV/T/A from a caravan in Cambridge (2 miles); and G6WJ/T in Great Canfield, Essex, relayed via

G6NOX/T giving a total path length of 27 miles. A wide range of equipment was shown by amateurs, ranging from vidicon cameras to integrated circuit colour pattern generators.

The main social event was the Convention Dinner, attended by over 80 people on the Saturday evening.

On the Sunday morning, lectures were presented by C. Grant Dixon on "Slow Scan Television", by Arthur Critchley on "Integrated Circuits for the Amateur", and by M. P. Davies, of the Ministry of Posts & Telecommunications, on "The Amateur Licence".

## Starting your own business

A conference to be held at Fulmer Grange, near Stoke Poges, from the 27th to 29th of November will appeal to all those with ideas and a hankering to start their own business. For this type of person, with the determination to make a go of it, the conference should be a weekend well spent.

Ten successful entrepreneurs will talk about their experiences, the difficulties they faced and how they overcame them. Other speakers will explain how to raise the necessary finance and how to assess the market. For a period the conference will break up into discussion groups and each one will deal with a particular new business. Finally the type of person most likely to succeed will be discussed.

The fee for the conference is £6 for a single man but the organizers realize that once the plunge is taken your wife is going to have to share your affections with the business and they feel that she should be in at the start. So for an extra £2 you can take her along as well! Application forms are available from The Meetings Officer, The Institute of Physics and the Physical Society, 47 Belgrave Square, London S.W.1.

## Hong Kong radio sales halved in Britain

In contrast to the trend in the rest of the world sales of radio receivers manufactured in Hong Kong have fallen in this country from 34 to 17% of the total market. This means that Hong Kong has slipped to second position behind Japan as far as total U.K. sales is concerned. Hong Kong attributes this decline to their concentration on the six-transistor single waveband receiver for the American market which is not popular here.

These figures are taken from a survey conducted by the Hong Kong Development Council which says that the concentration on the American market results from the heavy U.S. investment in the industry. Eight American firms employ more than a third of Hong Kong's radio

industry's 18,000 work force. Britain's only representative in the industry is Pye who has a 51% interest in Coronet Industries Ltd, a firm in Kowloon which employs about 600 workers.

## Venus-Mercury spacecraft

The National Aeronautics and Space Administration have selected seven scientific investigations for the Mariner-Venus-Mercury 1973 (MVM-73) spacecraft to photograph the two planets, measure the particles and fields surrounding them and study their atmospheres and ionospheres. The 900-pound spacecraft is planned to be launched in the autumn of 1973 and should pass within 3,300 miles of Venus in February 1974 and 625 miles of Mercury in March 1974.

Teams of scientists have been formed to conduct the seven investigations listed below.

**Imaging science:** Weighing 61 pounds the experiment will employ two television cameras fitted with 1,500-mm Cassegrain telescopes. These will produce pictures of Mercury with a resolution similar to that of pictures of the Moon taken through Earth-based telescopes.

Because three 210-foot diameter aerials will be in operation in 1974 (two are now under construction at Tidbinbilla, Australia, and near Madrid, Spain), many of the pictures will be transmitted directly to Earth instead of being recorded for later transmission. Some 5,700 frames of Venus and about 2,740 frames of Mercury will be taken.

**Radio science:** Using radio signals from MVM-73's two transmitters (20-W S-band and 200-mV X-band) the spacecraft's trajectory will provide dual occultation of the radio signals at Mercury and a single occultation of the radio signals at Mercury and a single occultation at Venus. This will provide the investigators with information on the interplanetary phenomena during flight and, at planetary encounters, information on the atmospheres, ionospheres, mass, radius and surface characteristics of both planets.

**Plasma science:** Will use an instrument called a scanning electronic analyser which is a set of hemispherical analyser plates and an electron multiplier mounted on a scan platform. It will measure ions from 80 to 8,000 eV and electrons from 40 to 400 eV. During the flight, the instrument will study the structure of the solar wind between the orbits of Earth and Mercury while the Pioneer-F and -G spacecraft, to be in flight during the same period, will be measuring the solar wind between the orbits of Earth and Jupiter. This will make possible a unique comparison of measurements at wide distances across the solar systems for the first time.

**Magnetometer:** An experiment to measure the magnetic field, it weighs 11 pounds and uses two triaxial, fluxgate

magnetometers mounted at different distances from the spacecraft on one boom. The magnetometer team will use measurements near Venus and Mercury to make the first experimental study of the solar wind interaction with Mercury and to determine whether or not a magnetic field exists at the planet.

**Ultraviolet spectrometer:** Consisting of two ultraviolet grating spectrometers, direct studies of airglow and occultation techniques will be used to gather data. The spectrometer team will use the data obtained by solar occultation to search for the presence of an atmosphere on Mercury and to determine its structure and composition. Additional information on the character of the atmosphere of Venus will also be obtained.

**Infrared radiometer:** Consists of two one-inch-diameter telescopes each calibrated for a broad spectral band to measure temperature emissions from the two planets.

**Charged particles:** A six-pound instrument will measure electrons above 2keV and protons above 6keV.

## 3D colour TV

An experimental broadcast is to be made in Holland on November 9th using a principal which was applied long before the war in cinemas. The viewers will wear spectacles with one red and one green eyepiece so that they will see the programme in three dimensions and in colour.

## Professional engineers, the choice

Members of the fourteen institutions which constitute the Council of Engineering Institutions can opt to join two other organizations which will handle such matters as welfare, pay, conditions and the like. An institution, being a learned society with the object of furthering science, cannot concern itself with the affairs of private individuals.

The engineer who wishes to have the full backing of a trade union, with all that this implies, can join the United Kingdom Association of Professional Engineers (UKAPE). This organization is intent on building a reputation for ethical and responsible conduct but it will also use its powers to protect the individual from exploitation. It aims to improve his conditions of employment and to regulate the relations between employer and employee.

Some engineers may not wish to join a trade union, maybe because they are employers themselves or for some other reason, but they would still like to belong to an organization with their welfare at

heart. Such an organization is the newly formed Professional Engineers Association Ltd (PEAL). Members of the institutions within C.E.I. are being invited to join this organization and providing 15,000 do so PEAL say that they will be able to provide an efficient service. If PEAL is successfully launched the assets of the Engineers Guild, which was formed in 1938, will be made available to PEAL.

### Tubes of Babel

If the current demand continues the number of public telephone circuits on Britain's trunk system will double in the next four years. In order to cope with this increase the Post Office have developed a 60-MHz cable which will provide 97,200 circuits. The first example of this cable will be laid in 1973 between London and Birmingham and will be followed shortly after by a similar cable in the reverse direction.

The cable will consist of nine coaxial pairs, or tubes, operating from 4 to 60MHz. Each pair will carry twelve 900-circuit broadbands using a frequency division multiplex system. Repeaters, energized over the cable from power feeding stations, will be placed every 1,500 metres to compensate for the high attenuation in the cable at 60MHz. The cable will be laid in a specially constructed concrete duct deeper than is normal for telephone cables and access will be through manholes.

### C.E.I. changes its exam

Part 1 Of the Council of Engineering Institutions' examination—describable as "what every engineer should know"—has not so far been very successful in the radio-electronics sphere in the sense that few aspiring engineers have chosen to take it and even fewer have passed. To make it more attractive the C.E.I. has made some changes, both in subject matter and standard, which will come into force in 1972.

Originally Part 1 consisted of six compulsory subjects, of which only one, applied electricity, had to do with electro-technology, and the standard was equivalent to about half way through a three-year degree course. At present the electronics man can, if he wishes, replace three of the six (properties of materials, applied thermodynamics, fluid mechanics) with three subjects more closely related to electronics. The changes for 1972 will be the introduction of certain optional subjects and a reduction of the standard to a point about 12 months through a three-year degree course. Passes will be required in four compulsory subjects, mathematics, mechanics, properties of materials, and presentation of engineering information, and in two of the following

optional subjects: electrotechnics, electronics, chemistry, thermodynamics.

Details of the changes, syllabuses and specimen papers are given in C.E.I. Statement No. 8 which may be obtained from the C.E.I. (2 Little Smith Street, London S.W.1) or any of its constituent institutions, price 4s 0d post free. Also under review is Part 2 of the exam, but any changes which may result will not come into effect until 1974 at the earliest.

### Colour receiver sales

During June 38,000 colour television receivers were delivered to the trade. This is 2,000 more than in May and brings the total number of deliveries since the inauguration of the colour service in 1967 to half a million. The upward trend is illustrated by the fact that half of this total (0.25M receivers) have been delivered during the last nine months. The increasing sales of colour receivers is reflected in a slight slackening in sales of monochrome sets [1970 (1969), May 133,000 (149,000), June 124,000 (135,000)]. Single standard monochrome receivers accounted for 40% of the June total.

### Experimental communications link

A 30km experimental communications link which uses a 50mm circular waveguide to transmit up to 300,000 simultaneous two-way telephone conversations or 200 colour television channels is to be installed by the Post Office between the research station at Martlesham Heath and Mendlesham in Suffolk. The Marconi Company Research Division is to develop and supply the prototype terminal and repeater equipment under a Post Office contract worth £180,000.

For the experimental link the frequency range will be divided into two main bands, 32 to 50GHz and 50 to 90GHz, although ultimately, this will be extended to 100GHz.

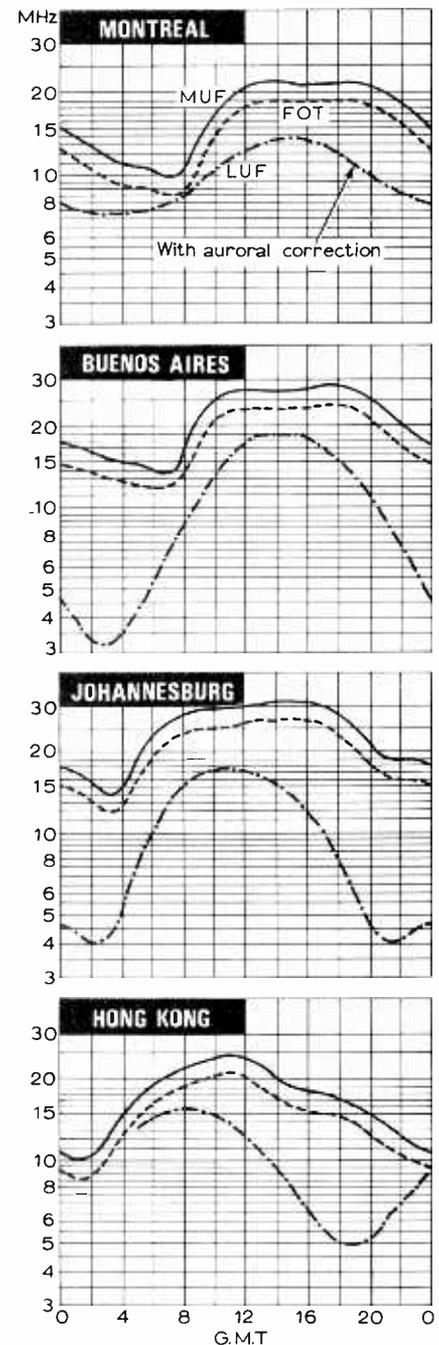
### Correction

Please make the following amendments to Fig. 9 of the article "Electronic Morse Keyer" by C. I. B. Trusson and M. R. Gleason published last month. On the upper view of the circuit board the lead from the tune/operate switch should be connected to pin 3 of the MP104 (not pin 2) and the pin numbering of the MP102 should be altered to read 5 to 9 from top to bottom on the left-hand side and 4, 3, 2, 1, 1G on the right-hand side. On the underside view of the board the pin numbering of the MP102 should be amended as described and the position of the conductor breaks at the following points should be lowered by one position: 29/22, 29/28, 25/22, 26/33, 28/37, 27/37. Finally the break at 11/41 should be moved one place to the right.

## H.F. Predictions—September

Seasonal change is evident as a slight increase in peak median standard usable frequencies (MUFs). This is sustained during daylight on all routes illustrated except Hong Kong which, due to the large time difference between control points, develops a continuously varying MUF.

MUFs shown are predicted medians of day-to-day values for the month. Distribution of daily values about the median varies with geographic location, season and time of day. Long-term observations have shown that the optimum traffic frequency (FOT)—i.e. MUF exceeded on 90% of days—is between 72% and 90% of MUF. A constant 85% is used for these charts, prepared by Cable & Wireless.



# PUT

## The programmable unijunction

by O. Greiter

The unijunction transistor and some of its applications have been described in articles in *Wireless World*, last month and the month before. To remind readers who have never met the unijunction we may note that it consists essentially of a silicon bar with an ohmic, non-rectifying, contact at each end and a tapping point near the middle. It is a resistor with a tap, except that the tap is a rectifying junction: one junction, hence the name. With a voltage applied to the bar it behaves just as a fixed-tap potentiometer with a diode in series with the tap. Unless the bias on the diode exceeds the sum of the diode starting voltage and the voltage at the tap, the diode is cut off. The tap is about two-thirds of the way along the bar, and this fraction is called the stand-off ratio. Problem: how accurately can you attach a tap to a sliver of silicon? The geometry actually used makes the problem even more difficult, so that the production line stand-off ratio has a wide tolerance and it costs extra money to get even a moderate tolerance.

When the diode is brought into conduction carriers are injected into the silicon bar, and as they are swept into the bottom part of the potentiometer they alter its resistance, drop the tap ratio, let more carriers in through the diode and so on. Rather like a one-man band, each part of the unijunction plays many parts.

The disadvantage of this device is that the tolerances must be dealt with in the external circuit. Oscillators and timers need to have a wide range of adjustment to take up the tolerance in the stand-off ratio, and this is particularly objectionable if it is required to choose components with the right temperature coefficients to compensate for the temperature changes in the unijunction itself.

### The PUT

The programmable unijunction, so-called because the parameters are fixed by external elements and because it has three junctions, not one, gets rid of many of the disadvantages of the standard unijunction, even though it is just about the same price. It is officially described as a complementary thyristor, although by thyristor standards it is a very low level device indeed. We shall see that it is related to another, older, device.

where  $\eta = R_1/(R_1 + R_2)$ . This is just what we have in the unijunction, except that now  $R_1$  and  $R_2$  are ordinary resistors, which we can choose of any value, and any tolerance, we like. We can fix the stand-off ratio with as much precision as our money will buy, and certainly 1% will not cost very much.

So far we have added two resistors, and the cost of connecting them. However, in an ordinary unijunction circuit we put a resistor in the B2 lead, both to limit the current and, by choosing the right value for a particular specimen, to get the right temperature coefficient. We also need, in many circuits, a resistor in the B1 lead so that the current through the untriggered B2-B1 path will not flow through the thyristor gate, or transistor base, which is to be pulsed. In the quiescent state there is no current out at the cathode of the PUT and unless a resistor is needed for other reasons, to help with the voltage rating of the load device, for example, we need not use one. Thyristor trigger circuits thus come out, as we see in Fig. 3, with exactly the same number of components.

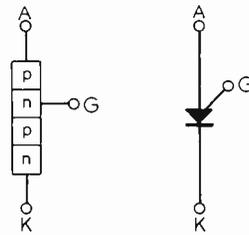


Fig. 1. The structure and symbol for a programmable unijunction transistor, showing anode, gate (anode gate) and cathode connections.

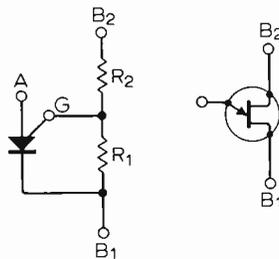


Fig. 2. Adding resistors  $R_1$  and  $R_2$  to the PUT gives the equivalent of the ordinary unijunction.

The basic structure of the PUT and the symbol used are shown in Fig. 1. In normal use the basic connection, the starting point, is to set up the simple circuit of Fig. 2. The gate is connected to the junction of  $R_1$  and  $R_2$ , so that the upper junction is held at  $\eta V_s$ .

### Performance analysis

The standard description of the behaviour of thyristors is based on the operation of cutting the device diagonally. This (shown in Fig. 4) allows the three junction device to be split into two transistors, forming an interconnected p-n-p, n-p-n, pair. The equations are

$$I_{c1} = h_{fe1}(I_{c2}) + (h_{fe1} + 1)I_{co1}$$

$$I_{c2} = h_{fe2}I_{c1} + (h_{fe2} + 1)I_{co2}$$

The input current at the anode is

$$I_A = I_{c1} + I_{c2}$$

Solving these equations gives

$$I_A = \frac{(1 + h_{fe1})(1 + h_{fe2})(I_{co1} + I_{co2})}{(1 - h_{fe1} \cdot h_{fe2})}$$

At very low currents,  $h_{fe1}$  and  $h_{fe2}$  are very small and  $I_A \approx I_{co1} + I_{co2}$ . Thus if the currents are small, the gain is low and thus the currents are small. As soon as we apply forward bias to either base we raise the value of  $h_{fe}$  for that transistor and in consequence let more current flow into the other; raising its  $h_{fe}$ , thus, and so on. When the

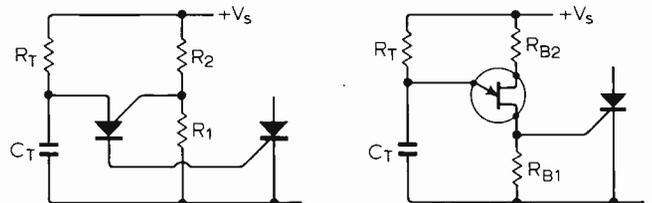


Fig. 3. In a practical scheme the number of components is the same with unijunction and PUT.

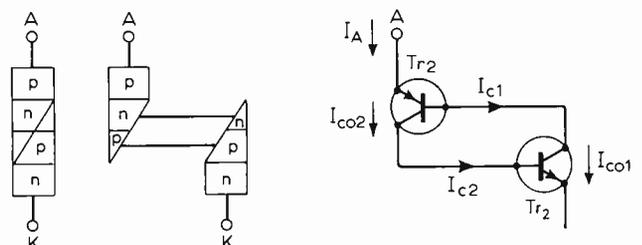


Fig. 4. The classic thyristor analysis.

product  $h_{fe1} \cdot h_{fe2}$  reaches unity,  $I_A \approx \infty$ .

A more elegant analysis can be carried out using the circuit of Fig. 5. If we use the current gain, emitter to collector, notation,

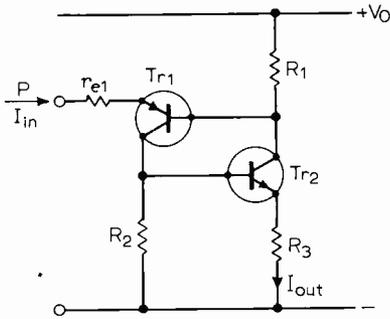


Fig. 5. Resistors added for more detailed analysis.

the overall current gain,  $I_{out}/I_{in} = \alpha$ , is given approximately by

$$\alpha = \frac{\alpha_1 R_2}{(1 - \alpha_2) R_2 + R_3}$$

and the input impedance at P is

$$R_{in} = \kappa - R_1 [\alpha \alpha_2 - (1 - \alpha_1)].$$

Here  $\kappa$  is a positive term which contains device impedances. Very simply this boils down to a condition that the input resistance is negative if  $R_1 [\alpha \alpha_2 + \alpha_1 - 1] > r_{e1}$ , the base-emitter input resistance of the p-n-p device.

The addition of these resistance elements, and the inclusion in a full analysis of the device resistances, leads to a situation in which the negative region of  $R_{in}$  has a reasonably constant value. The infinities do not appear. The overall characteristic becomes something like the one shown in

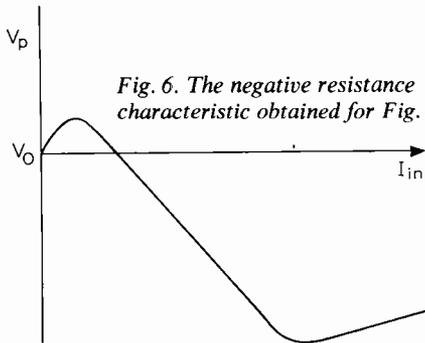


Fig. 6. The negative resistance characteristic obtained for Fig. 4.

Fig. 6. This, with its peak point and valley point, where both transistors are bot tomed, is just the shape we have already seen for the unijunction. Some of us, indeed, have already seen this a good many years ago. Fig. 7 shows a common base amplifier, without the supply connections. The input impedance at the emitter is

$$R_{in} = r_e + (1 - \alpha) R_B.$$

A negative resistance will be obtained if

$$(\alpha - 1) R_B > r_e$$

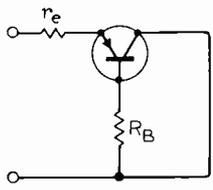


Fig. 7. In this circuit  $R_B$  includes the internal  $r_b$ .

or  $\alpha > (r_e + R_B)/R_B$

**The PUT as a point-contact transistor**

Those readers who cut their teeth on junction transistors will regard this as a rather pointless exercise. Those who spent confused years with point-contact transistors will know that  $\alpha$  can be greater than unity, and will remember that a stable amplifier needed a low impedance in the base line. The point contact transistor was, in general, a p-n-p-n device, but this was not an essential piece of knowledge. The essential detail was that you could measure  $\alpha$  and it was greater than unity.

By accepting the fact that, current ratings apart, the PUT can be considered as a point contact transistor, we are free to look at various pulse circuits which we used twenty years ago. We can also get rather more "feel" to the conventional use of the PUT. The circuits of Fig. 2 can be rearranged in

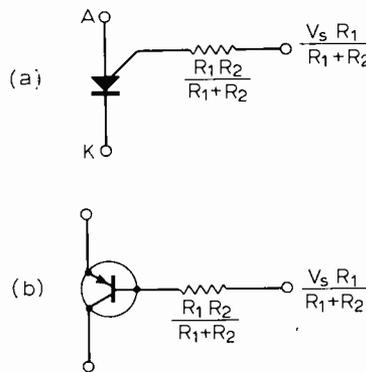


Fig. 8. The basic gate supply circuit, for PUT, and base bias for point-contact transistor.

the form of Fig. 8. We see that  $R_B$  is, in fact, the parallel combination,  $R_1 R_2 / (R_1 + R_2)$ . The peak point, at which  $R_{in} = 0$ , will be when

$$\alpha - 1 = \frac{r_e}{R_B}$$

Memory, always a bad guide, suggests that  $\alpha$  was not very dependent on current at low levels. The current dependent term is  $r_e$ . This would give us a peak point which was dependent in just the same way on  $R_B$  and we would expect to be able to choose the peak point current by choice of  $R_B$ . It turns out that this is indeed so, and the curves for a cheap and a more expensive

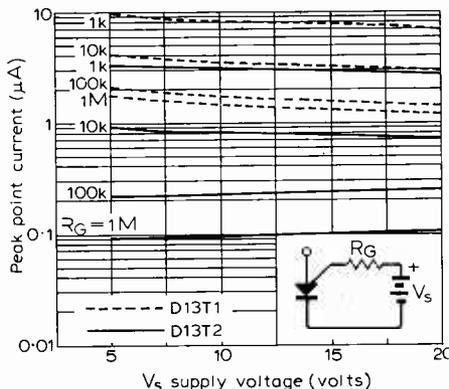


Fig. 9. From G.E. data.  $I_p - V_s, R_G$  parameter.

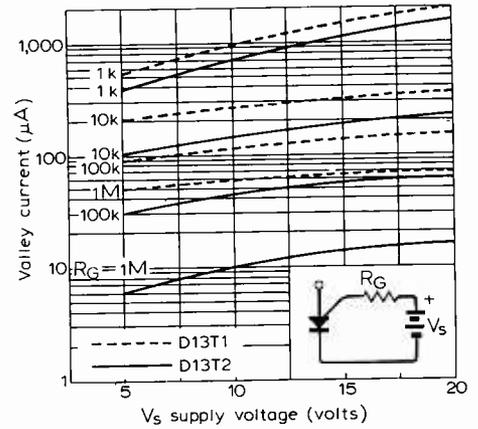


Fig. 10. From G.E. data.  $I_v - V_s, R_G$  parameter.

type of PUT shown in Fig. 9 shows this quite clearly. For high values of  $R_B = R_B$ , the peak point current is very small.

It is not surprising that the valley point current is also very dependent on the gate supply impedance. The characteristics are shown in Fig. 10. Very roughly we see that  $I_v = 100 I_p$ . It is a feature of the PUT, however, that these characteristics are determined by an external element. An approximate expression for the impedance looking

$$\text{in at the base is } Z_B = r_b + \left( \frac{1}{1 - \alpha} \right) R_E.$$

Forgetting the internal  $r_b$ , and looking for the turning point at which  $R_B + Z_B = 0$

$$(\alpha - 1) R_B = R_E.$$

We can get results rather nicely if  $R_B$  is very large indeed, and since the peak point current is small the base current will be small. A non-linear resistance element will give just the right effect of high resistance round the peak point but, when the current increases, a low resistance to allow a high valley current to be set up. Two ways of

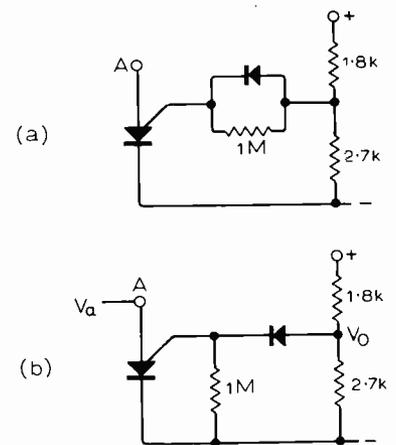


Fig. 11. Two ways of getting a low value of  $I_p$  combined with high  $I_v$ .

connecting this are shown in Fig. 11. The off-state gate current is very small, less than  $0.1 \mu A$ , so that it is desirable to stabilize the peak point working condition by means of a  $1 M\Omega$  resistance. This is the form shown in Fig. 11(a). In Fig. 11(b) the gate supply impedance is not so high, as the arrangement leads to a small drain current down

through the diode and 1 MΩ. The equivalent gate supply impedance is then between five hundred thousand and seven hundred thousand ohms. However, if the diode is reasonably similar to the upper p-n junction of the PUT and is operated at a current equal to the peak points current—say 1.5 A for the D13T1—the two temperature coefficients will stay in balance and the device will always trigger at  $V_A = V_o$ .

Both these circuits give a ratio  $I_v/I_p$  of above 500, compared with the ratio of about 100 if the diode is not used. It is probably desirable to look at the detail of this diode temperature compensation in terms of the point contact transistor. In Fig. 12 the transistor is shown with a leakage resistance  $R_t$  from base to collector. This represents the current path at the peak point. The circuit reduces then to the bridge form on the right, in which the "detector zero" is

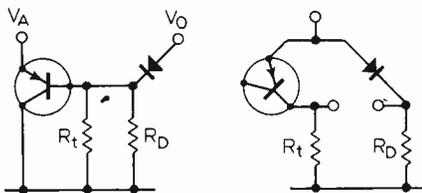


Fig. 12. Temperature compensation in terms of the point-contact transistor, and the bridge equivalent.

obviously maintained so long as the two diodes stay in step. One might expect that without going to an individually matched solution the improvement would be a factor of about 10. Just what the original temperature dependence would be is a matter of the form of the circuit. The data sheets give temperature curves, but they do not line up with the other characteristics. Nor do the characteristics shown in Figs. 9 and 10 line up with the tables. The data sheet information is added as an appendix.

**Operational limits**

Once we know what a device will do, in the sense of knowing that *nature* of its performance, we need to know the *quantity* of its performance, and the sort of circuit in which that performance can be exploited. The PUT is limited to 40 V working and to a steady state current of 150 mA—say 100 mA for a reasonable temperature range. It is imprudent to ask for pulses of more than 0.5 A. The maximum discharge, in an RC oscillator, with no extra resistance to limit the current, is 250 μJ. This means that if the circuit uses a 4 μF capacitor you should see that it triggers at below 10 V, so that  $(\frac{1}{2})CV^2 = (\frac{1}{2}) \cdot 4 \cdot 10^{-6} \cdot 10^2 = 200 \mu J$ . In such a circuit, the supply resistance will probably need to be more than 50 kΩ and less than 10 MΩ with the cheap device. The time range thus extends up to about half a minute.

**Relaxation oscillator**

The most common circuit application is in the simple relaxation oscillator shown triggering a thyristor in Fig. 3. The capaci-

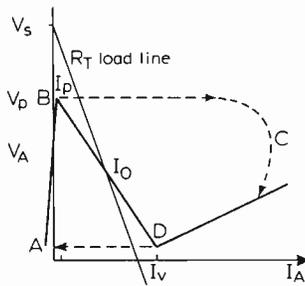


Fig. 13. Relaxation oscillator behaviour.

tance  $C_T$  is charged through  $R_T$  until the peak point is reached. The PUT is triggered, to discharge  $C_T$  into the cathode load. As this is much the same as the unijunction we can use Fig. 13 to remind us that the anode voltage moves up on the first stroke from zero towards B, along the path AB. At B the voltage can no longer be sustained across the PUT, and since the voltage across the capacitor will not change instantaneously the system switches to the only stable point, out beyond C. During the flight, current is flowing, and the voltage drops to give an intersection in the region C. The only current which can be supplied through  $R_T$  is much less than this, and the capacitor discharges, carrying the working point down to D. For the working point to approach  $I_o$  it would be necessary to follow the path  $DI_o$ .  $C_T$  is not capable of changing its voltage quickly upwards, because it can only charge through  $R_T$ . The working point jumps from D to A. There are some much more elegant ways of treating this circuit. We could use the negative resistance concept and look for the way the root dodges about between the left-hand side of the plane and the right-hand side. No doubt some of the brighter contributors to *Wireless World* will explain all this to us one day. The simple approach tells us how it behaves, if it works: the theory tells us if it works.

Notice that the  $R_T$  load line must cut the device characteristic once only, in the negative impedance region. This means, very roughly

$$\frac{\eta V_s}{I_p} > R_T > \frac{V_s}{I_v}$$

To get a particular frequency we choose  $R_T$  within this range, and then put

$$C_T = \frac{1}{f R_T \log\left(\frac{1}{1-\eta}\right)} = \frac{1}{f R_T \log(1 + R_1/R_2)}$$

If we make  $R_1/R_2 = 1.7$  this reduces, since  $\log e^{\eta} = 1$ , to a simple equation:  $f C_T R_T = 1$ .

A disadvantage of the PUT is that in general the value of  $R_T$  needed for operation is a good deal higher than the value used in the corresponding unijunction circuit. Fortunately the fact that it is operating by transistor action rather than by resistance modulation means that it comes on quick and it comes on hard. The saturation voltage at 50 mA is 1.5 V, giving a saturation resistance of 30 Ω maximum, and they say

that this drops to 3 Ω at higher currents. The switching time is fast, 60–80 ns. A quick calculation shows that if we take 100 mA from a 1000 pF capacitor it will discharge at the rate of 7 V in 70 ns. Thus we shall not swing down to an unreasonable trajectory until we go below the 0.001 μF value of  $C_T$ . Rather roughly, we lose half our pulse. With the ordinary unijunction the limit is in the region of three times this value.

**Other PUT applications**

There is a useful G.E. application report (90:70:11/67). Some of the following circuits are taken from this report, which also contains some thyristor trigger circuits. The first is a particular relaxation oscillator, which operates at only 3 V. The circuit is shown in Fig. 14. In this low voltage circuit

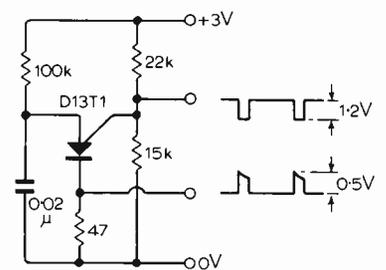


Fig. 14. 1 kHz oscillator for 2 V working.

there is the problem that the voltage needed to get the first junction into conduction, the emitter-base voltage of the equivalent point contact transistor, is an important fraction of 3 V. The anode gate is held at about 1.2 V, so that the anode must be brought up to about 1.7–2.0 V for triggering. If the more conventional stand off ratio of around  $\frac{2}{3}$  had been used, the capacitance would have had to charge to above 2.5 V on its exponential run up to 3 V. This would mean a very flat approach to triggering and a great deal of uncertainty about the frequency, stroke by stroke. This circuit also gives very low drain on the battery. The total current is less than 100 μA. A conventional low voltage unijunction would demand about 1 mA.

Circuit action in which advantage is taken of the low operating current levels is exemplified by the circuit of Fig. 15. The

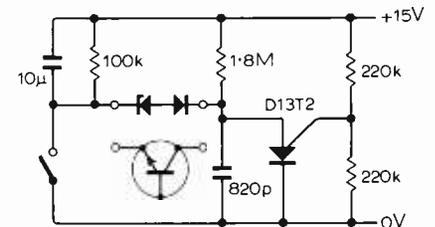


Fig. 15. Tone-pulse oscillator.

zener diode—diode circuit can be replaced by the emitter-collector path of a small transistor. As it stands, the 100 μA available at the anode through the 100 kΩ resistance will hold the PUT, a low-current type, beyond the valley point. If the switch is

closed for a short time the 10  $\mu$ F capacitor is charged, biasing the diode off and leaving only the 1.8 M $\Omega$  resistor to supply the anode. This is an oscillatory situation, and the circuit runs at about 1000 Hz until the capacitor has discharged through the 100 k $\Omega$  to the point where the zener diode will conduct. With the values shown the tone should be on for about 1 second.

**Timers.** These are basically oscillators of which the frequency is so low that all the attention is concentrated on a single cycle. The important advantage of the PUT is that because the stand-off ratio is determined by two external resistances almost all the parameters of the timer can be selected in advance. The circuit shown in Fig. 16 uses

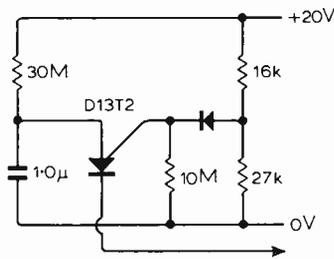


Fig. 16. 30-second timer using expensive PUT.

1% tolerance components. The stand-off ratio is 0.61, or  $R_1/R_2 = 1.69$ , which agrees with our earlier finding that this is the value to make  $fC_T R_T = 1$ , or

$$\tau = C_T R_T$$

The effective value of  $R_G$  is not too certain, but the circuit does not make sense if it is above 1 M $\Omega$ : it is the resistance of the diode when passing about 1.5  $\mu$ A. The peak-point current will be in the region of 0.1  $\mu$ A. This can be supplied by the 30 M $\Omega$  resistor. It would appear that trouble might occur at very low temperatures. At -25°C the peak point current is 1  $\mu$ A, and there is only 0.3  $\mu$ A available. The circuit could stick just below peak point.

To operate a circuit of this kind at low temperatures, or to use the cheaper PUT, the technique is to pulse the anode gate. This technique was described in connection with the conventional unijunction. The

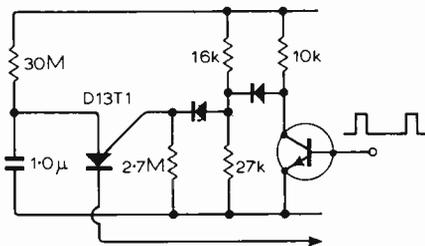


Fig. 17. Modified circuit of 30-sec timer to use cheaper PUT.

modified circuit is shown as Fig. 17. The application report quotes a 10  $\mu$ s pulse at 1000 Hz, but as the circuit is a 30-second timer in the 1% class it would be reasonable to settle for a much slower sampling rate.

Time or frequency trimming is claimed to be much simpler with the PUT. The comparison made is with trimming provided

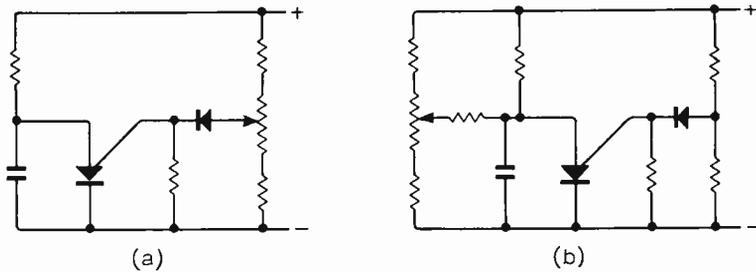


Fig. 18. Two alternative ways of frequency trimming.

by means of a variable resistance in  $R_T$  itself. It is, however, possible to trim the frequency of the unijunction and PUT circuits in the timing path in a way which still leaves a lot of flexibility in the choice of values. The two alternative ways of adjusting the frequency over a small range are shown in Fig. 18.

A number of other applications are to be found in the GE application report, which is essentially thyristor-minded in the view of this writer. The circuits for ring counters and thyristor triggering are interesting and useful, but there are some speculations to which the remaining space in this article may well be devoted.

We have seen that the PUT is very much like a point contact transistor. One difference, of course, is that it is a silicon device, whereas all, or at any rate almost all, the point contact transistors were germanium devices. The other feature is that junction technology has given us very low saturation resistance, thus widening the available working band inside the supply voltage. For the D13T1 we find that at 10 V  $V_s$  we have a valley current of 1 mA with an  $R_G = 1$  k $\Omega$ . This valley current gives an average value of

$$R_{in} = 10 \text{ k}\Omega$$

so that, roughly

$$(1 - \alpha) = R_{in}/R_B = R_{in}/R_G = 10$$

$$\text{Thus } \alpha = 11$$

$$\text{At } R_G = R_B = 10 \text{ k}\Omega$$

$$R_{in,e} = -10/0.25 = -40,000$$

$$\text{Thus } \alpha = 5.$$

It is apparent that the equivalent point contact transistor is a rather non-linear device of rather uncertain characteristics. Even so, there is no reason why we should not attempt to use the PUT in some of the circuits which were evolved in the days of the point contact transistor. Fig. 19 shows a greatly simplified equivalent common-base amplifier. The input impedance of this arrangement has already been given, on the assumption that  $R_c$  is small. The input impedance of the common emitter circuit

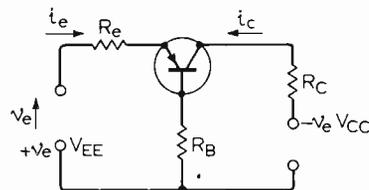


Fig. 19. Common-base point-contact circuit.

is, in simplified form

$$R_{in,b} = R_B + \left( \frac{1}{1 - \alpha} \right) R_c.$$

This gives a negative resistance for the same condition as for the common base circuit. The difference is that with the common base circuit the impedance at the emitter line input is open-circuit stable, while with the common emitter circuit the impedance at the base input is short-circuit stable. We have already seen how, by putting a device which is a short-circuit at very high frequencies across the emitter input we achieve instability which drives the system from one limit condition to the other. This is the capacitance or controlled relaxation oscillator. The same effect can be produced by the use of inductance in the base circuit. A relaxation oscillator can be constructed using the arrangement of Fig. 20. The setting-up condition is, as in the

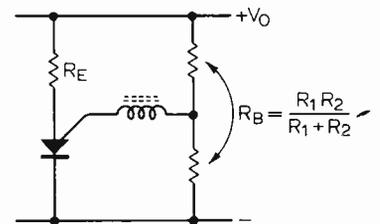


Fig. 20. Inductance controlled relaxation oscillator.

RC circuit, the choice of  $R_E$  to give a static current which is between the peak point and the valley point. If the effective value of  $R_B$  is 10 k $\Omega$  and, to make life simple we take  $R_1 = R_2 = 20$  k $\Omega$ , and  $V_o = 20$  V, the valley current will be rather over 200  $\mu$ A. A good mid-point will be at  $I_o = 100$   $\mu$ A, giving  $R_E = 100$  k $\Omega$ . At very high frequencies the inductance will hold the base current constant, and if instantaneously this base current is insufficient to allow 100  $\mu$ A to flow the circuit will progressively cut itself off. Base current will disappear, because of the movement of the emitter. There is a voltage spike at the base, just as in the RC circuit there is a current spike when the circuit triggers. The whole action can be described on a negative resistance S-curve. It is not profitable to go into detail, because the actual device has been designed to handle high peak currents, but not to handle high peak voltages.

More interesting, from a practical point of view, are the circuits shown in Fig. 21. These two circuits provide the required high or low impedance required for oscillation at a single finite frequency. These oscillators

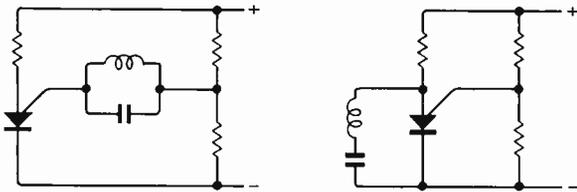


Fig. 21. Negative resistance LC oscillators.

are simple but are not likely to be very high class circuits, relying as they must on a very non-linear negative resistance to maintain oscillation, and a sharp limiting action to determine the amplitude. If we continue on the lines suggested by point contact transistor experience we arrive at a circuit of the type shown in Fig. 22, in which a low

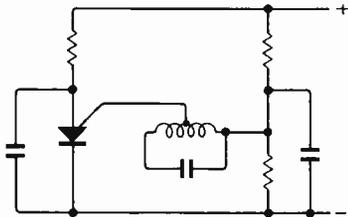


Fig. 22. High stability should be obtained by decoupling and a tapped tank circuit.

inductance, high-Q, circuit is used together with a good deal of decoupling. It would seem to be reasonable to add a thermistor in parallel with the LC circuit to set the amplitude of oscillation so that it remains inside the cut-off and saturation regions of the transistor.

One area in which the point contact transistor is missed is in the design of simple pulse regenerators. It is thus interesting to compare two circuits, one for a point contact device and one for a PUT (Fig. 23). The PUT circuit produces the output pulse when the transistor is switched off. If we consider the essential circuit as a monostable we see that the only real difference is in the choice of trigger points.

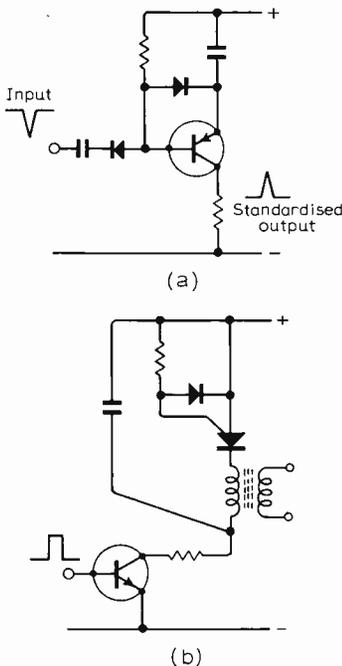


Fig. 23. Two ways of producing standard sharp pulses.

The purpose of this article, and of the two of the conventional unijunction which preceded it, has been to draw the attention of readers who have not met these devices to the wide range of circuits in which they can be applied. The PUT, in particular, would seem to be of much wider application as a transistor than is implicit in its official designation of a general purpose low power thyristor. There is enough circuit information on point contact circuits which may be applicable to keep a lot of people happy for a long time.

# Conferences and Exhibitions

Further details are obtainable from the addresses in parentheses

- LONDON**  
Sept. 7-9 Imperial College  
**Computational Physics**  
(I.P.P.S., 47 Belgrave Square, London S.W.1)
- Sept. 7-11 Grosvenor House  
**International Broadcasting Convention**  
(I.B.C., c/o I.E.E., Savoy Place, London WC2R OBL)
- Sept. 15-18 Savoy Place  
**Gas Discharges**  
(I.E.E., Savoy Place, London WC2R OBL)
- Sept. 15-18 Olympia  
**Bio-medical Engineering Exhibition**  
(U.T.P. Exhibitions Ltd, 36-37 Furnival Street, London E.C.4)
- Sept. 22 William Beveridge Hall, University of London  
**Computer Output on Microfilm**  
(Microfilm Association of Great Britain, 109 Kingsway, London WC2B 6PU)
- Sept. 28-Oct. 1 Savoy Place  
**Centralised Control Systems**  
(I.E.E., Savoy Place, London WC2R OBL)
- BIRMINGHAM**  
Sept. 18-20 The University  
**The Nuffield Advanced Physics Course**  
(I.P.P.S., 47 Belgrave Square, London S.W.1)

- BRIGHTON**  
Sept. 15-17 Hotel Metropole  
**Power Sources Symposium**  
(International Power Sources Symposium Committee, P.O. Box 136, 26 Wellesley Road, Croydon, CR9 2EG, Surrey)
- DURHAM**  
Sept. 2-9  
**British Association Meeting**  
(British Association for the Advancement of Science, 3 Sanctuary Bldgs, 20 Gt. Smith Street, London S.W.1)
- EXETER**  
Sept. 15-18 The University  
**Solid State Devices**  
(I.P.P.S., 47 Belgrave Square, London S.W.1)
- HARROGATE**  
Sept. 18-20 Cairn Hall  
**Audio 70**  
(Exhibition & Conference Services Ltd, Victoria House, Claremont Avenue, Harrogate)
- MANCHESTER**  
Sept. 8-11 Hotel Piccadilly  
**Electronic Instruments Exhibition**  
(Industrial Exhibitions, 9 Argyll Street, London W1V 2HA)
- OXFORD**  
Sept. 14-16 The University  
**Photo-electron Spectroscopy**  
(I.P.P.S., 47 Belgrave Square, London S.W.1)
- Sept. 28-Oct. 1 New College  
**Quality Assurance in Action**  
(Inst. of Engineering Inspection, 616 Grand Bldgs, Trafalgar Square, London W.C.2)
- READING**  
Sept. 7-9 The University  
**Ion Implantation**  
(I.P.P.S., 47 Belgrave Square, London S.W.1)
- SHEFFIELD**  
Sept. 22-24 The University  
**Microwave and Laser Instrumentation**  
(R. A. Ganderton, Design Electronics, Dorset House, Stamford St., London S.E.1)
- SOUTHAMPTON**  
Sept. 7-10 The University  
**Measurement Conference**  
(British Society for Strain Measurement, 281 Heaton Road, Newcastle upon Tyne NE6 5QB)
- Sept. 22-24 Skyway Hotel  
**Electronic Instruments Exhibition**  
(Industrial Exhibitions, 9 Argyll Street, London W1V 2HA)
- SWANSEA**  
Sept. 21-24 University College  
**Electronic Engineering in Ocean Technology**  
(I.E.R.E., 8-9 Bedford Square, London W.C.1)
- TEDDINGTON**  
Sept. 2-4 National Physical Laboratory  
**Man-Computer Interaction Conference**  
(I.E.E. Savoy Place, London WC2R OBL)
- WARWICK**  
Sept. 21-23 The University  
**Temperature Measurement**  
(I.P.P.S., 47 Belgrave Square, London S.W.1)
- OVERSEAS**  
Aug. 31-Sept. 4 Munich  
**Hybrid Computation**  
(Prof. Dr. J. Heinhold, Kongressburo AICA-IFIP 1970, Institut für Angewandte Mathematik, Arcisstr. 21, D-8 München 2)
- Sept. 8-12 Budapest  
**Magnetic Recording Conference**  
(Hungarian Optical, Acoustical and Film-technical Society, Keszűt: 200-pld-ban 70/2808-MTESX HNY.Bp.)
- Sept. 18-27 Berlin  
**German Industries Exhibition**  
(Berliner Ausstellungen, 1 Berlin 19, Charlottenburg, Messedamm 22)
- Sept. 21-24 Panama City  
**Engineering in the Ocean Environment**  
(I.E.E.E., 345 East 47th Street, New York, N.Y. 10017)
- Sept. 23 & 24 New York  
**Electron Device Techniques**  
(I.E.E.E., 345 East 47th Street, New York, N.Y. 10017)

# Vehicle Location Systems

## Electronic techniques to improve road traffic control

by R. A. Tyler\*, M.I.E.R.E.

It has been standard practice in the past to apply static means of control to traffic movements, i.e. road signs, markings in the road, fixed 'one-way' systems, etc, but as traffic flow is a dynamic function, adequate control has demanded dynamic methods, such as traffic lights and policemen on point duty. By applying more modern control techniques we should be able to progress a particular vehicle through a traffic system from starting point to destination in the most economical way. Although cost effectiveness at present precludes the use of such techniques for the benefit of the ordinary motorist, the advantages afforded a vehicle fleet operator in being able to control the dispositions of his vehicles in a given area make such a system attractive.

A promising scheme is to provide a supervisory control facility which, by continuous situation reporting, enables route plans to be revised and corrective measures to be reported to the vehicles involved (Fig. 1). Radio links which have voice, data, or voice and data channels can carry the necessary information between vehicle and base, and control room devices exist for displaying this information. However, in order to provide an overall control system there remains the need for a method of determining the position of the vehicle to a sufficiently high degree of accuracy within the traffic system.

The ease with which a vehicle position may be determined depends largely on the vehicle operating mode and the degree of co-operation which may be expected from it. Land transportation vehicles may operate in any of the following three modes:

- (a) Free range—where vehicles are allowed to move about without restriction over a specified two-dimensional space, as when operating in a desert environment.
- (b) Road restricted—in which vehicles, usually wheeled, are free to move anywhere within the confines of a predetermined road network. This category includes private cars, police and emergency vehicles, etc.
- (c) Route plying—vehicles restricted to particular routes within a specified road or rail network. All rail vehicles are included in this group. Although fundamentally of

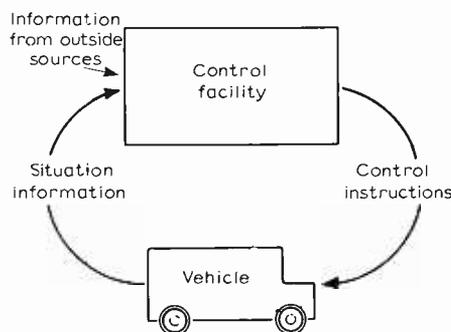


Fig. 1. Vehicle control loop.

type (b) buses may be considered as a sub-group in that they are usually constrained to the route-plying mode.

Clearly, the greater the number of constraints on a vehicle the easier it is to track. A mode (c) vehicle may be quite satisfactorily tracked along the route simply by a knowledge of start time and distance travelled.

Taking full advantage of up-to-date technology it is possible to rule out the use of radio telephone links, which demand a high degree of crew participation, and confine discussion to consideration of location systems which can automatically provide a fixed base station with regularly updated vehicle position information.

Location methods fall into two main categories. The first requires means of discovering the whereabouts of the vehicles directly from the base station. The second needs each vehicle to be provided with equipment to determine its own position and for passing this information to the base station. By using radio, both methods become practicable.

### Location methods, category 1

Radio location systems falling into this category include those employing direction finding, navigation and radar. Direction finding does not easily lend itself to automatic detection of large-vehicle fleets, and ground clutter problems present considerable difficulties when using conventional radar systems.

The most promising approach would appear to come from the use of navigational aid methods which apply triangulation techniques to a signal

radiated from the vehicle. Location accuracies of better than half-a-mile within an area of open terrain of 20-30 miles radius have been achieved using phase comparison, and there is no reason to suppose that this represents the limits of either range or accuracy. A major difficulty encountered with all methods where location information is to be extracted by reference to the physical nature of the radiated signal is one of multi-path reflection.

Although this difficulty is considerably reduced over areas of open countryside, it remains perhaps the most serious problem in urban environments. Early expectations of using first returned pulse (FRP) delay measurements have been shown experimentally to be disappointing. In this method the vehicle carries a pulsed transmitter which is triggered from the master base station. The difference in delay of the reply pulse from the vehicle arriving at two separated slave receiving stations is related to the receiving station base line, and the vehicle position may then be fixed using standard hyperbolic navigation techniques.

When multi-path propagation conditions exist the vehicle reply appears as a string of pulses at the receiving stations and it is difficult to determine the vehicle position (Fig. 2). In FRP systems, delay comparison is made only on the first pulse to return in each case as this must have arrived over the direct path and later pulses are neglected. Provided that the first pulse to return can be positively identified, this somewhat complex method can be used quite effectively. But in heavily built-up areas the welter of closely spaced reflected signals makes definition of the first returned pulse difficult and the accuracy of such a system thereby suffers. Also the FRP system is in considerable difficulty where more than one vehicle is involved unless selective calling is used. However, this principle may be applied to vehicles operating in any of the three modes referred to previously.

Operation in urban environments, where road junctions frequently occur at less than one hundred-yard intervals, imposes stringent accuracy requirements on any method of vehicle location. Accuracies of one hundred feet or less are simply not feasible in such an environment

\* The Marconi Company Ltd.

when using any of the methods in this category. Thus, we have to look elsewhere for a workable solution to the location problem, and from what follows it will be seen that methods falling into the second category show more promise.

**Location methods, category 2**

This method is basically the same as the simple one referred to in Category 1, but the vehicle is expected to know where it is at all times. It is, in effect, questioned on its position whenever the base station requires to update its record of vehicle dispositions.

The problem therefore may be split into two requirements, (a) some form of location equipment within the vehicle which allows it to determine its own position, and (b) a means of transferring this positional information back to base on demand.

There are a number of ways of achieving the requirement outlined in (a), two of which will be dealt with in greater detail later. But in order to use this method requirement (b) demands some form of communication channel between vehicle and base and some important experiments in the development of one such link will now be described.

**Data link 1**

In the planning stage a number of constraints were placed on the information channel such that the following initial specification was considered desirable.

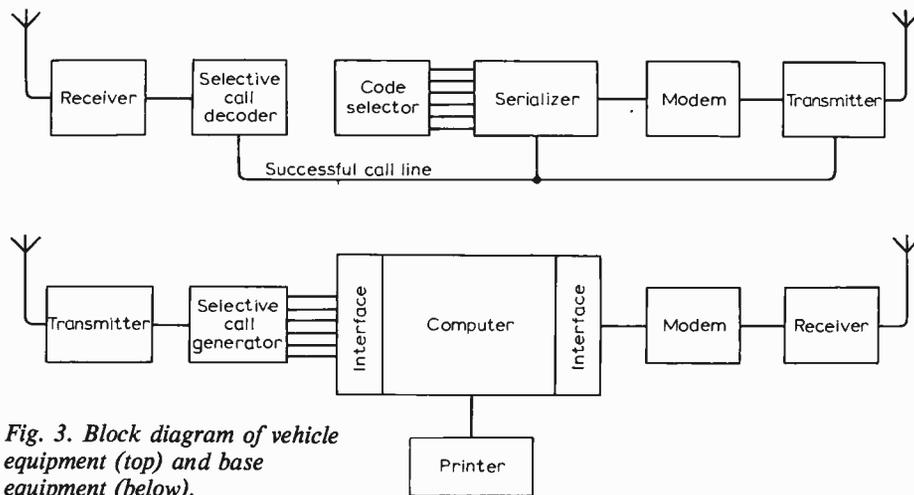


Fig. 3. Block diagram of vehicle equipment (top) and base equipment (below).

- (1) The radio part of the link should consist of commercially available two-way v.h.f. equipment, so the information must be fitted into a baseband a few kHz wide.
- (2) Selective calling of vehicles was essential for the interrogation methods used. As the overall system was to be automatic, a digital computer would be used to provide correctly timed interrogation signals and to interpret returned information.
- (3) As returning information was to be fed into the on-line computer, it was desirable to make the return path a digital link.

It was discovered in the early stages that very little was known about the behaviour of v.h.f. data links applied to vehicles moving in and around an urban environment. Therefore it became imperative to obtain statistical results using practical equipment, and a series of experiments were set up using the computer to gather and sort the necessary data.

Early experiments were conducted using audio-tone selective calling on the base-to-vehicle link. When a particular address was recognized the vehicle would reply to base with a 40-baud message. Upon reception at the base station, this message would be de-serialized in the computer and the contents compared with a replica of the original message. If incorrect, details of this comparison would then be printed out and at the end of each run statistical data would be computed and printed (Fig. 3).

The experiments were organized in the following manner. Two complete sets of vehicle equipment were made available, each set comprising a two-way selective call f.m. radio and a specially developed digital generator which provided, on command, a pre-set message 16 bits in length. Each vehicle had a particular call sequence allocated to it, which the computer could select on a rotational basis, together with four sequences representing imaginary vehicles.

In the event of receiving no reply from a call to a genuine vehicle, the computer would break the rotational calling routine and recall the offending vehicle. If again no reply was received, a third call would

be made. If still no reply was forthcoming the legend NO REPLY would be printed out and the routine calling sequence resumed. Further, if after an interval of five minutes no reply at all had been received from a particular vehicle, it was assumed that a major failure had taken place and a visual indication would be given at base (Fig. 4).

After a great number of runs had been made with the vehicles operating over diverse routes covering both urban areas and open countryside, the considerable amount of data acquired was analysed and compared with similar results obtained using the radio equipment in voice communication surveys over the same routes.

The field pattern associated with v.h.f. radio installed in a vehicle operating within an urban environment is extremely complex and difficult to analyse. It can be

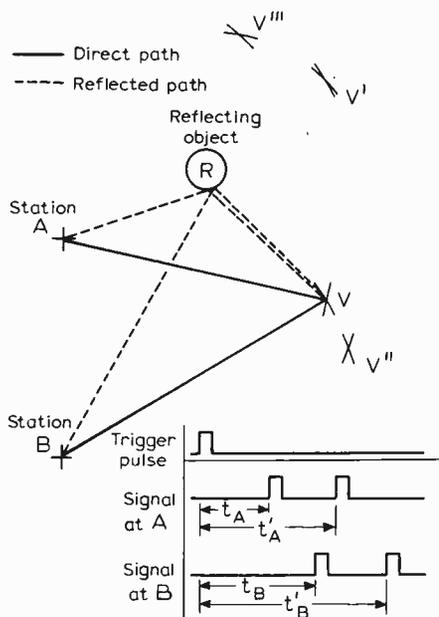


Fig. 2. Anomalies which can occur in a pulsed system.

$t_A$  represents path A-V taken with  $t_B$  giving vehicle position V  
 $t'_A$  represents path A-R-V taken with  $t'_B$  giving vehicle position  $V^I$   
 $t_B$  represents path B-V taken with  $t'_A$  giving vehicle position  $V^{II}$   
 $t'_B$  represents path B-R-V taken with  $t_A$  giving vehicle position  $V^{III}$   
 By using the first returned pulse method only delays  $t_A$  and  $t_B$  would be used to fix the position of the vehicle at V.

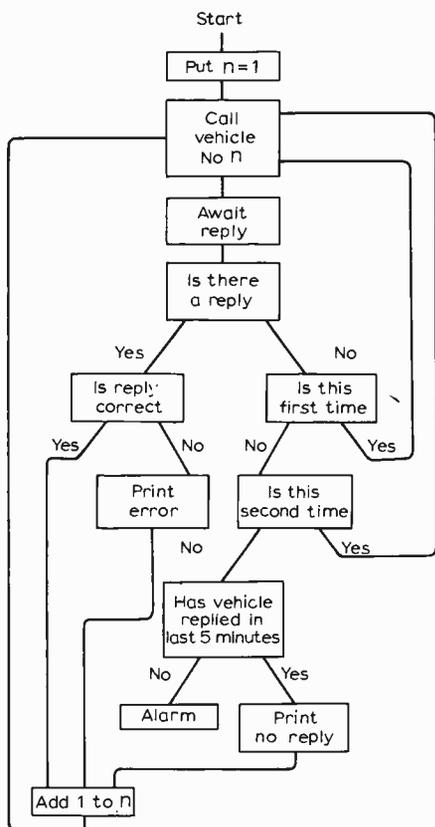


Fig. 4. Flow diagram for data link experiment.

visualized as a fixed pattern due to multiple reflections from stationary objects, buildings, street furniture, other vehicles, etc. On this is superimposed a continuously varying micro-structure due to traffic moving in the vicinity of the vehicle aerial. The situation is further complicated by the fact that the aerial is being caused to move in a somewhat erratic manner, due to traffic conditions, through this complex and changing pattern. The net result is that between vehicle and base there is an indeterminate transmission path, the characteristics of which change drastically from moment to moment. It has been shown that the field strength at the base receiver can vary as much as 20-30dB at a rate dependent upon the speed of the vehicle and further modified by the relative presence and speed of surrounding traffic.

The transmission of voice over such a path generally causes little concern as the intelligibility of speech is not greatly affected by such rapid fading. But the very nature of digital data usually demands a near perfect transmission path. Additionally, the signal may fade during the 0.4s time slot used for transmitting the 16-bit message, with consequent corruption of data. However, in spite of this gloomy picture, the experiments showed that over a known good speech path in an urban area, data error rates of only a few per cent were likely. But even with error rates of this magnitude, data, to be usable, must be subjected to some form of error detection and subsequent correction.

**Obtaining navigational information**

Having established provisional parameters of a mobile data link (b) the question remained, how could the necessary information be obtained and passed successfully over the link.

To solve the problem the vehicle requires some means which will enable it to determine its own position as outlined in (a). This is similar to the conditions imposed in conventional navigation and it would not be unreasonable to expect a solution to be obtained using the same approach. Indeed this approach is possible within the restraints of road traffic movements.

The classical method of navigation between two places requires several points, or 'fixes', to be taken along the route, where an accurate knowledge of actual position may be obtained. The number of fixes required depends on the accuracies of the results, distance between start point and destination, etc. Location between one fix and the next is determined by a

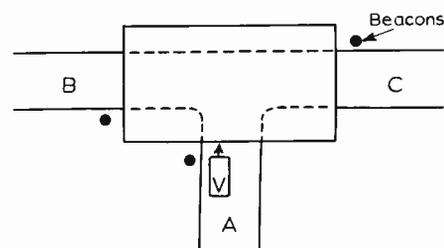


Fig. 5. T-junction as a three-port system.

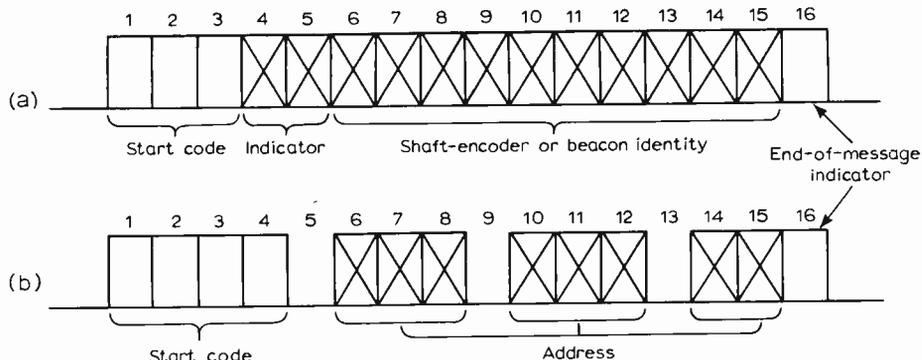


Fig. 6. (a) Vehicle to base—location message, (b) base to vehicle—vehicle address message.

procedure known as 'dead reckoning', which is based on a knowledge of the direction and distance travelled from the last fix; consequently provision must be made for measuring this direction and the distance travelled.

It is of course possible to navigate entirely by dead reckoning. To be able to do so over large distances requires extremely accurate vector measurements with such expensive items as inertial platforms and on-board computers. However, the land vehicle operating in modes (b) or (c) is confined to a specific network of routes over which it is constrained to travel, and location systems can make use of these restraints.

By way of illustrating how such restrictions may be used, consider a T road junction as a three port sub-system (Fig. 5). A vehicle V entering at port A must emerge at Port B or C, or reverse out of port A, otherwise it must have stopped within the confines of the junction. In this example three detectors would be needed to cover the conditions of vehicle movement in areas between junctions.

Returning to the conventional method of dead reckoning with fixes, it is easily seen that such an approach can be made in a simpler manner in the road transport situation. All that is required to provide a system of vehicle location (i) to arrange within the vehicle a means of measuring distance travelled, (ii) to establish along each route a number of fixed points which, as each one is passed, may be identified by apparatus installed in the vehicle, and (iii) to determine whether or not the v.h.f. data link is adequate to pass this information to the central base station. It is, of course, assumed that the base station has data handling equipment available. This should be able to extract the necessary information from the link and display it in a form suitable for human operators to comprehend, thereby enabling control strategies to be applied.

**Wheel revolution counting**

In a wheeled land vehicle a simple, if somewhat crude, method of measuring distance travelled is to count the number of revolutions made by the wheels while traversing a given route. Because this can be easily arranged in a modern motor car, experiments were planned in order to gain experience of this

form of measurement and to determine just how seriously data link 1 could be used in a practical system. To this end a suitably geared mechanical pick-off, operating a 10-bit digital shaft-encoder, was fitted into the speedometer drive cable of one of the vehicles used in the previous experiments.

The equipment was so arranged that a call from the base station would initiate a reply from the vehicle containing an up-to-date indication of shaft-encoder position. Tone selective calling was used to address the vehicle but in this case each of the 16 bits of the reply message was given a different significance. The first three became a fixed start code, the next two were used as an indicator, followed by 10 bits of Gray code from the shaft-encoder, and the final bit was used as an end of message indicator (Fig. 6a).

Two routes were selected, both of which started and ended at the base station site. Route A was about 3¼ miles long mostly through lightly built-up areas. The longer route B, about 8½ miles, included a 4-mile figure-of-eight loop in a heavily built-up town centre, situated about 3 miles from the base transmitter. A number of marker points, spaced one quarter to half a mile apart were chosen on each route and the vehicle crew was asked to throw a switch when passing each marker. The operation of the switch caused the two indicator bits in the message to change, signifying to the computer that such a point had been reached.

Several calibration runs were made and the information was stored in the computer. Operational runs were then performed, the results of which were printed out in the following form. A first column identified the marker points on the route. The second and third columns showed the times at which the vehicle reached the positions indicated in the first column. These were determined both by comparing the shaft-encoder information with that obtained during the calibration run, and by a change in indicator bit condition. The fourth column indicated distance error and a fifth column provided some indication of average vehicle speed between markers. Statistical data on radio-link conditions during the run were collated at the end of each print-out.

Results showed that under good radio conditions adequate accuracies could be

achieved even with a simple set-up, position indications within 50ft being frequently obtained, to some extent vindicating the wheel count method. Tracking became difficult, if not impossible, with the simple system under bad radio conditions, i.e., heavy interference, shadowing, etc., indicating that, as had been expected, some form of error detection would be essential under such conditions.

As the system contained a computer it seemed natural to attempt a software solution to this problem. A vehicle tracking programme was written which enabled a number of credibility checks on the incoming data to be made and only those able to pass this screen were considered reliable. Tests with this programme gave very good tracking, even under quite heavy interference conditions, and it was felt that the feasibility of such a system for tracking route-plying vehicles had been demonstrated.

The next major step in this particular line of development was to improve the method of presenting results to a controller. It was therefore arranged to present the vehicle situation as a visual picture using a graphical display unit. It was logical to make use of this approach, as a computer was included in the system and flexibility of display afforded by this means made the case overwhelming. The opportunity to be able to switch from a map of the area showing the immediate disposition of all his vehicles (Fig. 7) to another presentation showing the up-to-the-minute operational situation on any particular route of his choosing gives the vehicle fleet operator a unique degree of operational control at the press of a button.

Clearly, the information that might flow over a vehicle-to-base digital link need not be restricted to positional data only. In fact it was arranged on certain occasions to make a change in message indicator bits to represent a 'driver alarm' signal. By this means the vehicle driver could alert a controller simply by throwing a switch in the vehicle, which caused a flashing alarm indication to appear on the controller's display screen. In a practical system a great variety of data could be sent back to base over the link. For instance, bus operation controllers might wish to know the passenger loading at certain times, and passengers could be counted automatically when boarding or alighting at bus stages, the information being relayed back to base.

### Data link II

The work so far had been done with only one, or sometimes two, vehicles. Because of the capital outlay required for such a system, it would only become really economic when applied to fleets containing probably a few hundred vehicles. This being so, some attempt had to be made to speed-up the calling rate of data link I which had been held to about one per second, for three reasons. These were, first, the use of tone-selective calling required 500ms to achieve a successful

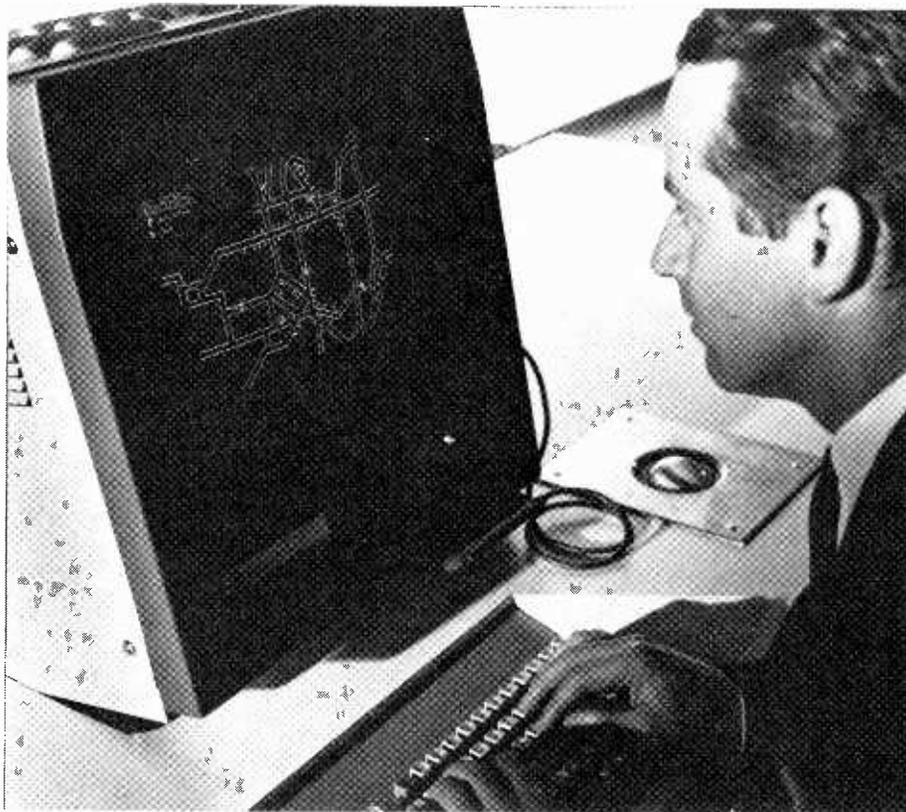


Fig. 7. Map display of the area showing the position of all vehicles.

interrogation, second, upon being called some time was needed for the vehicle transmitter to reach full power, and third, even a 16-bit message took 400ms to send at the 40-baud rate. So a faster link—data link II—was considered.

The philosophy behind any system which might be produced was that of providing add-on digital equipment to any good commercially available mobile v.h.f. radio. In consequence it was felt that only the first or third items above could be tackled at this point in time. Indeed, by increasing the signalling rate to 1,000 bauds and providing a similar outgoing digital link for pulse code addressing, the interrogation and reply time would be substantially reduced. The next step therefore was to determine the feasibility of signalling over the link at this higher rate.

It was felt that the emphasis on the two main types of error would change when using 1,000-baud rate, as opposed to 40-baud signalling, due to the nature of the radio signal. The time required to transmit a complete message at the faster rate was less than that for just one bit at the slower, and this would manifest itself in a greater number of 'no replies' than 'corrupt messages'. Experiment largely confirmed this expectation, although there was a marginal increase in overall errors. However, it was established that there was no great penalty to be paid for using the increased data rate and work could now go ahead on providing a similar digital link from base to vehicle.

This entailed major changes in the hardware used so far at both ends of the link. For instance, the serializer in the vehicle had to be modified in order to

de-serialize the incoming message, and similar arrangements were required at the base end. Further, results had shown the need for some form of error detection for the outgoing link and this would now need to be accomplished by hardware methods in the vehicle. Some form of protection could be achieved by building a fair degree of redundancy into the interrogation message sent to the vehicle. For convenience, a 16-bit message was used but only 8 bits were made available for address purposes. A start code of four 'ONES' followed by a 'ZERO' preceded each address, which in turn was split into two blocks of 3 bits followed by a block of 2 bits, each block being punctuated by a 'ZERO' bit. A final 'ONE' acted as an end of message indicator as before (Fig. 6b).

A check was applied to incoming data at the vehicle end of the link to ensure that each message fitted into this format; if it did not the message was disregarded. A vehicle recognizing an address as its own would formulate a reply from the data contained at that moment in its data register and then transmit this back to base. Thus, as before, all that is required to complete a location system is to set suitably coded up-to-date vehicle position information in this register.

### Further navigational methods

Having already established that a simple wheel revolution counting system could be adequate for vehicles operating in mode (c), and that using a faster data link large fleets could be controlled, attention was turned to the more difficult problem of vehicles of the mode (b) type.

A clue to the solution to this problem might be found by returning to the subject of conventional navigation. So far we have explored the dead-reckoning approach and have found comfort in this for vehicles which are restricted to given routes. A little thought will show that this, combined with fixes arranged at strategic points within a given urban network, could provide a suitable location system.

Consider a vehicle which is operating in mode (b) travelling along a straight road in an ordinary town. Before very long it is likely to reach a crossroads and is presented with an element of choice. It may continue on past the junction or it may turn left or right; somehow the location system must determine which of these possibilities has been chosen. The system previously described, within limits, measures distance travelled, and it can be assumed that the base station has good knowledge of the town geography. Such a system can determine when a vehicle arrives at a particular junction but is unable to decide by which port it leaves. Some means must therefore be provided to overcome this dilemma.

As a first approach, a measurement of the degree of turn could be considered and, given sufficient accuracy, this method has a lot to recommend it. However, most practical methods of achieving this to the required degree of accuracy entail somewhat complex modifications to the mechanical parts of the vehicle. It is interesting to note that the principle of the ancient Chinese "southpointing chariot", which was chronicled some 5,000 years ago, provides one form of solution to this problem<sup>1,2</sup>. Further methods rely upon magnetic compass indication, but the presence of a large and variable number of oddly assorted metallic vehicles in the immediate vicinity rather precludes such an approach in this type of environment.

### Location systems using beacons

Another way of achieving the desired result is to provide a beacon at the side of each road leading away from the junction. If each beacon is uniquely coded and can be interrogated from the vehicle then, knowing the sites of each beacon, the base station is able to follow the progress of the vehicle. Again, if enough beacons are erected, one on each lamp-post perhaps, quite a good degree of positional accuracy may be obtained; sufficient for most practical purposes without the use of other methods such as wheel-revolution counting. This type of system bears a strong resemblance to railway 'block signalling', the position of each vehicle being determined by which block it is in at any time. The blocks in this case need be only a few tens of feet long.

Until recently the use of beacons was not considered to be particularly viable for vehicle location, the economics of such a system being most unfavourable. Some advantage had been gained elsewhere by using beacons in conjunction with wheel revolution counting for largely route-plying purposes. But the sheer number of

beacons required for mode (b) vehicles (several at each junction), even when combined with wheel revolution counting, demands a beacon which is cheap to produce, install, maintain and run. Although in the practical case a high initial cost may be defrayed to a considerable extent by a leasing agreement with other operators. For example, once installed, beacons could be used by police, bus and tram operators, taxis, delivery van fleets, etc. As such a system can easily be made mutually exclusive, the interference problem need not arise.

Beacons, and the way they are interrogated, may take various forms. The requirement is basically one of short-range communication and any of the standard methods from optics to ultrasonics can be used. The beacons themselves may be either active or passive. Active beacons are those which continuously emit pre-coded information and the marine lighthouse is a common example of an active beacon. Passive beacons transmit their address signal only when triggered by some external source and may be further classified into two sub-groups, passive-active and passive-passive, depending upon the method by which they are powered.

Passive-active types need some form of power to drive them even in the quiescent state. A radio beacon is usually of this form in that the receiver must remain on at all times, other than when the transmitter operates, in order to amplify and detect the triggering signal. For this purpose a source of external power is required. The wartime I.F.F. transponder is a practical example of this type of beacon.

Passive-passive beacons are completely inert, requiring no external power at all while waiting to be triggered. They derive the power which enables them to reply, solely from the external energy required to trigger them. For example, the rear reflector on a motor car needs no external power supply but emits a red-coded 'address' when triggered from a white-light source. Clearly, the advantages gained from using passive-passive beacons in a vehicle location system are considerable. No batteries or mains supply are needed so that installation and maintenance effort required are minimal and they cost nothing to run. At the present time the use of optics allows the most practical method of applying a passive-passive beacon solution to the vehicle location problem.

In one such system beacons consisting of horizontal reflective strips are illuminated by a vertical scanning beam emanating from the vehicle. The reflected reply is de-scanned, detected by a photo-cell, and after amplification provides an electrical analogue of the beacon code. This information is stored in a register until a demand is received over the v.h.f. data link, whereupon the beacon address is transmitted back to base. Knowing that the code is that of a particular beacon, and the beacon is situated in a certain place, the base station now has the exact position of the vehicle and can display this to the operator in some pre-arranged form.

Using optical passive-passive methods the beacons become purely reflective, and a first requirement is to devise some way of coding each beacon in order to give a unique reply. In the present system this is achieved by using strips of retro-reflective material. Retro-reflection is the property of a material to reflect a beam of light back along the axis of the incident beam. A ray of light incident on a plane reflecting surface is reflected at the same angle as that made by the incident beam to the normal, but on the opposite side of the normal. A plane surface is only retro-reflective to light reaching it along the normal.

Beacons could be coded digitally by using the presence of a strip to represent 'ONE' and no strip to represent 'ZERO', but this simple method is unsatisfactory for the following reasons. In practice a vehicle may pass a beacon at any distance across the carriageway, it may be travelling in the inside lane when interrogating one beacon but in the outside lane when passing the next. Therefore the beacon reading equipment must be able to read and store the beacon information at distances ranging from a few feet to a few tens of feet. This means that the frequency and pulse width of a reply can vary considerably in the practical case, because the angle subtended by the beacon alters with distance from the reading head.

Further difficulties occur due to a difference in the installed heights of various reading heads. Clearly, for a system to be practicable it must accommodate reading equipment which can be fitted on the roof of a Mini or on top of a double-deck bus. In this respect too it is most desirable to allow a wide tolerance on the installation height of the beacons themselves. For these reasons the beacons must be capable of being read at a variety of vertical angles and the reading equipment must be able to extract the beacon code under these conditions. This possibility of a slant presentation results in a further change in pulse width and frequency during a single scan, but both these difficulties can be overcome by devising a method of extracting both timing and code information from the reply signal.

Modulation of the light beam by frequency shift (two colour), polarization, or pulse-width techniques afford ways of deriving the required information, and both methods have been used in the system under consideration. But before discussing these methods in greater depth some thought must be given to how the beacon is to be read.

As previously mentioned, the beacon is scanned vertically. The light source needs to supply an extremely well collimated beam, one which can project a spot of less than about  $\frac{1}{4}$ -in diameter at a distance of about 40 feet. This is a very exacting requirement but one which can be readily met by using a low-power laser. The monochromatic property of the laser, used together with suitable filtering, also provides a considerable signal-to-noise advantage. The beam is deflected on to an eight-sided mirror-drum which rotates at

about 2,500 r.p.m., thereby scanning any beacon in its path. The need for retro-reflection now becomes clear, the return signal so formed is de-scanned by the mirror-drum and deflected on to the sensitive area of a photo-diode (Fig. 8). This is all the optics required for the pulse-width coded beacon as the necessary information can be extracted from the photo-diode output electronically, and we are now able to consider the operation of this system in greater detail.

Width-coded beacons (Fig. 9a) are divided into  $1\frac{1}{2}$ -in horizontal zones, the first inch of a 'ONE' zone and the first half-inch of a 'ZERO' zone consist of reflective material (Fig. 10a). The signal received from such a beacon is of the form shown in Fig. 10b, and this is used to gate an up-and-down counter which normally counts a faster-running pulse signal. A positive-going edge causes the counter to count up until a negative-going edge reverses the count. The state of the counter is read out at each positive edge and if it contains a positive number the appropriate register position is written to 'ONE' if negative a 'ZERO' is written. Immediately after reading the counter the counter is reset ready for the next signal bit. This process is shown diagrammatically in Fig. 10c.

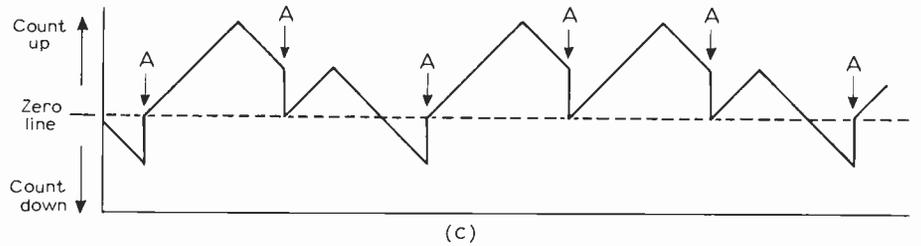
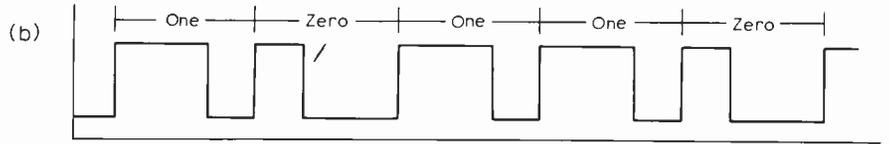
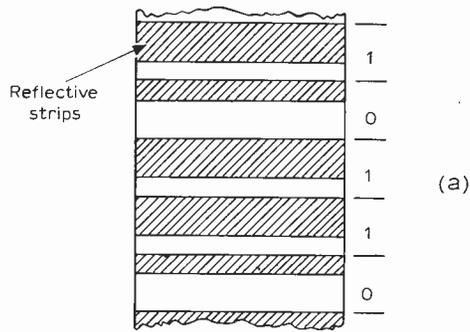


Fig. 10. (a) Width-coded beacon, (b) width-coded beacon waveform, and (c) the counting operation of up/down counter. The counter is read and then reset at points marked A.

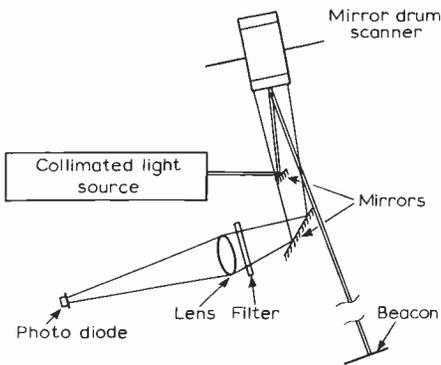


Fig. 8. Basic optical system.

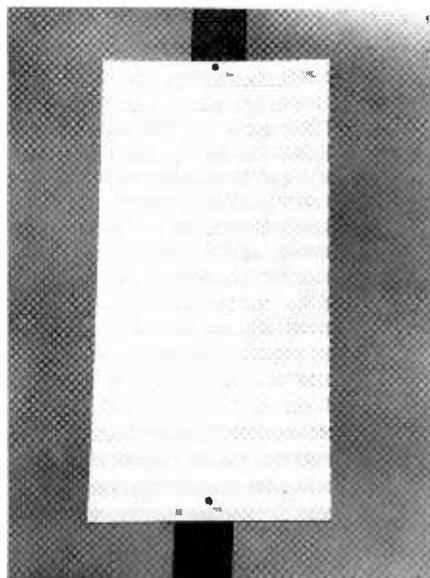


Fig. 9. (a) Width-coded beacon and (b) beacon for polarized light method.

Beacons for the polarized light method consist of alternate equal width strips of reflective and non-reflective material (Fig. 9b). Coding is achieved by covering certain reflective strips with polarizing material and the whole beacon is scanned by a beam of polarized light. This causes a rotation of direction of polarization to occur on light returning from the covered strips while no change occurs on the uncovered ones. By splitting the returned beam after de-scanning, and passing each split beam through suitably arranged polarizing filters, the output of one of the two photo-cells detecting these signals will

contain information from each strip, and the other only that from the polarized strips. The signal from the second cell may therefore be clocked into the register using the output from the first cell as a strobing signal.

All estimates existing today predict a continued rise in the number of road vehicles over the next 50 years. In Britain alone this number is expected to top 35 millions. With this order of density it becomes transparently clear that the present "Brownian motion" of traffic can no longer be tolerated and orderly control will have to be applied to a greater extent.

Over the past year several small location systems have been demonstrated. Wheel revolution counting, polarized and width-coded beacon methods have been shown in an attempt to illustrate that solutions do exist to the somewhat difficult problem of vehicle location. The first faltering steps have been taken into the realms of practicability, and it is not unreasonable to suppose that great strides will now be made in this particular subject.

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- 1 "Differential Gears" by Ernest F. Carter, *Design and Components in Engineering*, 9th February 1967.
- 2 "The History of Marine Navigation", by Per Collinder (translated by Maurice Michael), Batsford 1954.

# Letters to the Editor

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

## Electronics in medicine

In expressing my support for the editorial "Electronics in Medicine—the Future" in the June issue, I should like to draw attention to an underlying handicap retarding the development of biomedical engineering technology in the United Kingdom.

Medical electronics is a branch of biomedical engineering, a multi-disciplinary scientific activity. In 1958, following the initiative of Dr. Zworykin, the first of the International Conferences on Medical Electronics was held in which many kinds of specialists from the life and basic sciences have contributed. In hospitals of the National Health Service and Medical Faculties of the Universities, where direct collaboration between medical and engineering personnel is possible and desirable, there is still no recruiting, training or career structure for chartered engineers. Is it merely a rhetorical question to ask how the engineering side of biomedical engineering can be carried out without the participation of professional engineers?

Some hospital physicists, aware of the need for engineering in the medical environment, have retrained themselves as engineers. The situation in the universities is even less satisfactory, for the normal staffing structure in an electronics laboratory is the "one- (or two-) man-band", each one organized independently, one or more to a department according to the demand. There is no need to emphasize the consequent duplication of capital outlay and failure to utilize available skill.

It appears to the writer that the engineer is not yet accepted in biomedical engineering, and that non-engineers do not understand either the need for engineers, or the work they do. The remedy, of necessity, must originate from within the engineering profession. The initiative must be both practical and independent of external support or patronage. Only when engineers, as a profession, are making an indispensable contribution to the inter-disciplinary cause, also providing training and research facilities, will the engineer be welcomed by non-engineers. Five years ago, Dr. Zworykin proposed the setting-up of an Institute of Biomedical

Engineering. May I as an engineer, propose that the Council of Engineering Institutions give consideration and support for the creation of such an institute?

R. E. GEORGE,  
Physics Dept.,  
Medical School,  
Guy's Hospital, London S.E.1.

Your editorial in the June issue rightly draws attention to the difficulties faced by companies manufacturing medical electronic equipment, especially for the U.K. market. In it you suggest that equipment produced for the general user has potential applications in medicine, but the converse is just as often true.

The evolution of electronics from radio began before the incentive of war-time radar, helped greatly by physiologists and associates who asked for the impossible, and then provided it themselves. For example, between the wars, Matthews, Offner, Tonnie, Schmitt and others transformed the crude audio amplifier by adding differential inputs, increasing gain and stability, and extending the frequency response towards zero. Since the war, medical workers have been constantly breathing down the necks of solid-state designers, demanding higher input impedances, less noise and many other characteristics that have proved invaluable elsewhere.

It is not only in the fields of circuit techniques and components that biomedical engineering (as it is now known) has influenced electronics in general. Many items of hardware developed specifically for medicine have found other applications, perhaps after minor modifications.

This company manufactures a patient monitoring system that has evolved from initial work in a medical research establishment, but the specially developed indicators and chart printers are now proving to be of a great interest to instrumentation and control engineers in many industries. By exploiting this greatly extended market, it is possible to provide the hospitals with what they want at a price the nation can afford.

ANTHONY S. VELATE,  
T.E.M. Engineering Ltd,  
Crawley, Sussex.

## Rationalizing trade associations

I was most interested in the editorial in your issue for July because a rationalization of the many trade associations in the electronics field is long overdue.

In 1956 I was appointed secretary of R.C.E.E.A.—now E.E.A.—and a year later I put up a scheme (which would probably have led to my immediate retirement) for the administration of all these associations within the general confines of the British Electrical and Allied Manufacturers' Association. I learnt very quickly that this was a non-starter at that time, although the economic factors and almost entirely common membership of E.E.A. with B.E.A.M.A. made it a logical development.

There were two reasons why it was not acceptable then. One you have high-lighted. That is the reluctance of some associations (or their council members) to surrender their autonomy. The second was never publicly recorded, but was the intense jealousy between member companies, which led them to believe that their own interests were more important than those of the industry, or indeed of the nation. I am convinced that the latter has been the real reason why no rationalization of the electronics industry representation has so far taken place.

However, the last few years have seen a major re-grouping of the companies in this field, and there are consequently fewer heads of businesses to be convinced of the obvious economies to be achieved by ending the proliferation. One would therefore hope that the rationalization of the trade associations, which the E.E.A. is apparently trying to achieve, will go forward. The resulting benefits to the nation should in the long term benefit the member companies also.

The top men who would comprise the "voice that could speak to governments, other associations and foreign organizations" are unlikely to have the time to do it in B.E.A.M.A. and E.E.A. etc. Perhaps after thirteen years the jealousies are becoming less pronounced, and the powerful voice may yet emerge.

H. E. F. TAYLOR,  
Torquay,  
Devon.

## Mobile radio and amateur bands

In your issue of July 1970 you quote from the recently published Annual Report (1969) of the Electronic Engineering Association: "The lack of spectrum space continues to be seen as the most likely factor which could seriously limit the expansion of mobile radio communications. Negotiations have therefore now begun with the Ministry of Posts and Telecommunications to secure the use of the 68 to 71.5 MHz and 420 to 450 MHz bands."

The reason why our Association has suggested to the Ministry of Posts and

Telecommunications that 68 to 71.5 MHz should be made available to mobile radio communications arose from the recent announcement that the GEE navigational chain which operated in that band had closed down. In making the recommendation I do not think that any of our members were aware that this part of the frequency spectrum was used by amateurs. Indeed, it seems that the allocation was made without the usual formality, and only upon a non-interference basis.

In regard to the 420-450 MHz band, I feel sure that the amateurs will understand our concern as an industry that substantial frequency space, without which mobile radio cannot expand, is being made available above 470 MHz in the United States and below 450 MHz on the Continent. Mobile radio activity and the size of the industry it can support, and the amount of research and development that the industry can support, are in the last analysis dependent upon the adequate availability of frequencies. If the problem of expansion in the all important u.h.f. sector is not solved then leadership in product development and export will undoubtedly pass from Britain to those industrial countries who are now receiving generous new allocations. It is against this background that our members question whether the country can afford, even on a non-interference basis, the allocation of 22 MHz to amateur television.

Our members have the highest regard for amateur activities including their brilliant pioneer work above 1.5 MHz nearly fifty years ago, and would not wish to see them deprived of all facilities in the u.h.f. bands. We should welcome discussion on the subject with representatives of amateur associations.

R. A. VILLIERS,  
The Electronic Engineering Assoc.,  
London, W.1.

## Class AB—some questions

Following the two articles on a class AB amplifier design by Mr. Linsley Hood and also the correspondence in the August issue, we would like to raise several points concerning the specification.

Total harmonic distortion is specified as less than 0.02% at all power levels below maximum output, but this is presumably (see Figs. 6 and 7) only at 1kHz though not specified as such. What are the distortion levels at 100Hz and 10kHz at full output, for example?

When quoting a noise level for the amplifier, the noise bandwidth of the measurement was unspecified thus rendering the result as meaningless as quoting a frequency response without limits (e.g.  $\pm 3$ dB).

A value for "square-wave transfer distortion" is given as 0.2% at 10kHz but the power level is not specified. As "square-wave transfer distortion" is a non-standard quantitative measurement, for the result to be meaningful, an explanation is required as pointed out by Mr. Gibbs in his letter in the August issue.

Also results for other amplifiers, for example a good class B amplifier, would be useful for comparison.

MARTIN SMITH and  
H. P. WALKER,  
Southampton, Hants.

Notwithstanding the perfection of Mr. Linsley Hood's latest amplifier in practice, I would differ with him over some of the points he raises in the July issue.

A Darlington pair has a lower mutual conductance than the output transistor on its own. The converse can only be true of the complementary pair configuration. His first paragraph attributes a higher value to both pairs.

The overall linearity of the output stage of his Fig. 2, when driven from a genuinely low source impedance, does depend on the quiescent current contrary to his expectations. A high drive impedance is the answer, with a low inter-base impedance. This does not impair the cut-off performance as the conducting transistor presents a low base-emitter impedance to the one being cut off.

The output stage of Fig. 3 operates between the common emitter and the common collector modes. The true emitter follower of Fig. 2 has an inherent distortion of about 100 times less than Fig. 3, provided that the source impedance is low enough and the quiescent current is appropriate. Infinite values of bootstrap capacitance are necessary to secure pure common emitter operation; this circuit is predominantly common emitter above 30 Hz. His calculation of class A output power assumes that the output transistors have a constant mutual conductance. Due to the bend in this characteristic at low collector currents they do not cut off as soon as expected. The class A output of either version is nearly 2 amps pk-pk. Using a standing current of 100 mA and no emitter resistors, a class A output of over 5 amps pk-pk is available. (The traditional definition of class A does not preclude current ratios between the two halves of  $10^8$ .)

A high class A power is not, *ipso facto*, a particular virtue. The correct quiescent current is related to the linearity of the output stage under dynamic conditions, and this ought to be significantly lower than that required by full class A operation, in a good class AB design.

The mutual conductance of MJ 481/491 with 0.82-ohm emitter resistors is 1 mho at high currents; this falls to 0.5 mho at a collector current of around 20 mA. If  $Tr_{3,4,5}$  have high current gains, so that the drive impedance really is low, this is the optimum quiescent current with a bandwidth of a few kHz. Higher quiescent currents worsen the performance. A current of 200 mA is undoubtedly right for bandwidths greater than this, but no compromise would be necessary if the drive impedance was high enough for all combinations of transistors.

Poor matching of the output transistors is extremely unlikely to cause any noticeable deterioration of the performance, except to a distortion meter; low

gains may even be advantageous in certain cases. Full class A operation is unnecessary in both these circumstances.

My final point concerns the avoidance of temperature-compensation in the biasing of the output stage. The penalty for this is very poor thermal stability in the 8-ohm version.

D. L. D. MITCHELL,  
University of Bradford.

## I.C.s in stereo pre-amplifiers

We were very interested in the article in July 1970, by L. Nelson-Jones, describing an application of the RCA CA3048 as a stereo pre-amplifier.

The original RCA stereo pre-amplifier circuit was intended for use in low-cost applications and had a few shortcomings as observed by Mr. Nelson-Jones. A later RCA report published in June 1969 (A Monolithic Integrated Circuit for Stereo Pre-amplifiers, by L. Kaplan) describes several circuits which produce comparable performance to the circuit described by Mr. Nelson-Jones but use passive tone controls. The problem of signal-to-noise ratio was overcome by increasing the loop gain of the first pre-amplifier whilst still maintaining adequate overload capability.

The CA3052 is capable of producing a similar noise performance to the CA3048 when used as a stereo pre-amplifier provided amplifiers A2 and A3 are used for the magnetic inputs. These amplifiers are tested in production for equivalent input noise with full R.I.A.A. compensation, and amplifiers A1 and A4 are checked with a simple 'C' filter connected at the output. We should be happy to provide any further applications information to interested readers.

L. R. AVERY,  
RCA Ltd,  
Sunbury-on-Thames,  
Middx.

## Jupiter probe

In the feature "News of the Month" in your August issue under the heading "Space Probe to Jupiter" you state that "This planet is believed to be the only one in our solar system which radiates more energy than it absorbs from the sun, current measurements indicating about twice as much." This is not true as all planets containing any radioactive material must radiate more energy than they absorb from the sun. No other planet, however, radiates as large an excess as Jupiter.

A planet must radiate enough energy to maintain its thermal equilibrium, and it is reasonable to assume that any planet will contain some radioactive core material, the decay of which will produce heat energy. It is evident, therefore, that to maintain thermal equilibrium a planet must radiate as much more energy than it absorbs from the sun as it generates itself in internal radioactive decay.

JAMES M. BRYANT,  
Cheltenham, Glos.

# Transistor Breakdown-voltage Meter

Constructional details of a useful instrument which provides direct reading of junction breakdown voltage at fixed reverse currents

by Jens Langvad\*, M.Sc. (Danish)

Designers of power amplifiers, power supplies or any equipment using transistors working at high supply voltages often require to know the actual breakdown voltage of the transistors. The instrument described here was designed to replace the conventional method of just increasing the voltage slowly to see what happens.

The maximum collector-to-emitter or collector-to-base voltage specified by the transistor manufacturer is often grossly understated. This leads the circuit designer into buying expensive high-voltage transistors in cases where a standard type may do the same job just as well. The cheap BC107, for instance, usually exhibits a collector-to-base breakdown voltage [ $V_{(BR)CBO}$ ] in excess of 80V, although the stated maximum operating voltage is only 45V.

The reason for this is that in the planar manufacturing process it is not easy to keep the  $V_{(BR)}$  within narrow limits. By stating a  $V_{(BR)}$  well below the production average, but still above the need of most customers, allowance is made for a greater number of freaks and a lower rejection factor.

## Breakdown characteristics

For an ordinary silicon planar junction transistor three breakdown characteristics are of interest. These are: (1) the  $V_{(BR)EBO}$ , (2) the  $V_{(BR)CBO}$  and (3) the  $V_{(BR)CEO}$  voltage-current curves. (In accordance with accepted terminology the "O" stands for open and refers to the third terminal.) The first is quickly dealt with; the EB junction breaks down like an avalanche zener diode with a knee voltage of 6-12V, according to type (most BC 107s lie quite accurately at 8V).

The CB diode breaks down in a similar manner, but the knee voltage is much higher. The  $V_{(BR)CBO}$  is the most important of the three, as it determines the maximum peak-to-peak collector voltage swing one can expect from the transistor.

The CEO characteristic is shown in Fig. 1 together with the CBO. (There is no scale factor, as this depends entirely on the type of transistor investigated.) At very low currents the two curves are seen to coincide, but after reaching the knee the  $V_{(BR)CEO}$  drops with increasing current, thus exhibit-

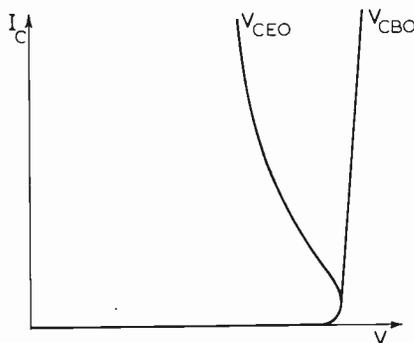


Fig.1. Typical breakdown characteristics.

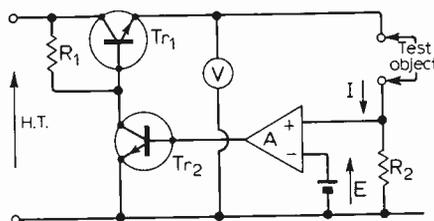


Fig.2. Principle of breakdown-voltage meter.

ing a negative resistance characteristic. If, however, an external resistance is present between the base and the emitter the CE curve approaches that of the CB. If, for a low-level transistor,  $R_{BE}$  is less than 100k $\Omega$  (and this will be the case in most amplifier applications) the two curves may be considered as coinciding.

## Breakdown-voltage meter

The breakdown-voltage meter itself comprises a simple d.c. supply giving the unusually high output voltage of 200V, in connection with a current limiter covering the equally unusual range of 0.1 $\mu$ A—1mA in decade steps. In Fig. 2,  $Tr_1$  and  $Tr_2$  are high-voltage type transistors.  $A$  is a differential input amplifier working as a voltage comparator and  $E$  is a reference voltage. When no current flows in the test object the output of  $A$  is zero, so that  $Tr_2$  is cut off and the series transistor  $Tr_1$  saturated through  $R_1$ . When the test object is connected, the current flowing through it will produce a voltage drop across  $R_2$ . This

voltage cannot exceed  $E$ , because if it did, the voltage comparator would turn over, saturate  $Tr_2$  and thus drive the supply voltage towards zero.

Provided that the input impedance of  $A$  is much greater than  $R_2$ , the current in the test object is seen to be limited to  $I = E/R_2$ . Thus  $I = 1\mu$ A and  $E = 0.5$ V require  $R_2 = 0.5$ M $\Omega$ . The voltmeter  $V$  indicates the voltage required to drive  $I$  through the test object, plus the reference voltage  $E$ . But the latter is small enough to be neglected.

## Practical circuit

The complete circuit diagram is shown in Fig. 3. Any transformer giving 200-250V and 6.3V may be used. The zener-stabilized low voltage supplies the voltage comparator and also works as a reference for the voltage limiter. (This is of the usual kind and serves only to limit the maximum voltage to full scale deflection on the meter.) There are two voltage ranges: 0-100 and 0-200V, and the voltage divider for the limiter and the pad for the meter are switched simultaneously by  $S_1$ . Transistors  $Tr_1$ ,  $Tr_2$  and  $Tr_3$  are high-voltage devices, RCA type 2N440, but any type with a  $V_{(BR)CBO}$  of 300V or more would do.

Transistors  $Tr_4$ ,  $Tr_5$  and  $Tr_6$  constitute the voltage comparator. The f.e.t. input transistor provides the amplifier with an input impedance approaching infinity. The diode-resistor network in the input protects the f.e.t. against voltage surges.  $S_2$  selects the current ranges 0.1 $\mu$ A—1mA. The selected value of current obviously depends on the type of transistor under test, but usually the  $V_{(BR)CBO}$  is remarkably independent of the current at which it is measured. Generally speaking, one should use the low-current ranges for low-level planar transistors, and the two highest ranges for germanium or power devices. When measuring  $V_{(BR)CEO}$  one can get a fair impression of the shape of the breakdown characteristic just by rotating  $S_2$ .

$S_3$  switches between positive and negative supply for n-p-n and p-n-p transistors respectively, and  $S_4$  connects the transistor either CBO or CEO. In the mid-position the transistor is disconnected and the supply voltage turned down. This is achieved by  $S_{4C}$  shorting the base of  $Tr_1$  to ground.  $S_4$  could be a keyswitch biased in both directions, so as to ensure that the

\* Philips Records Ltd.

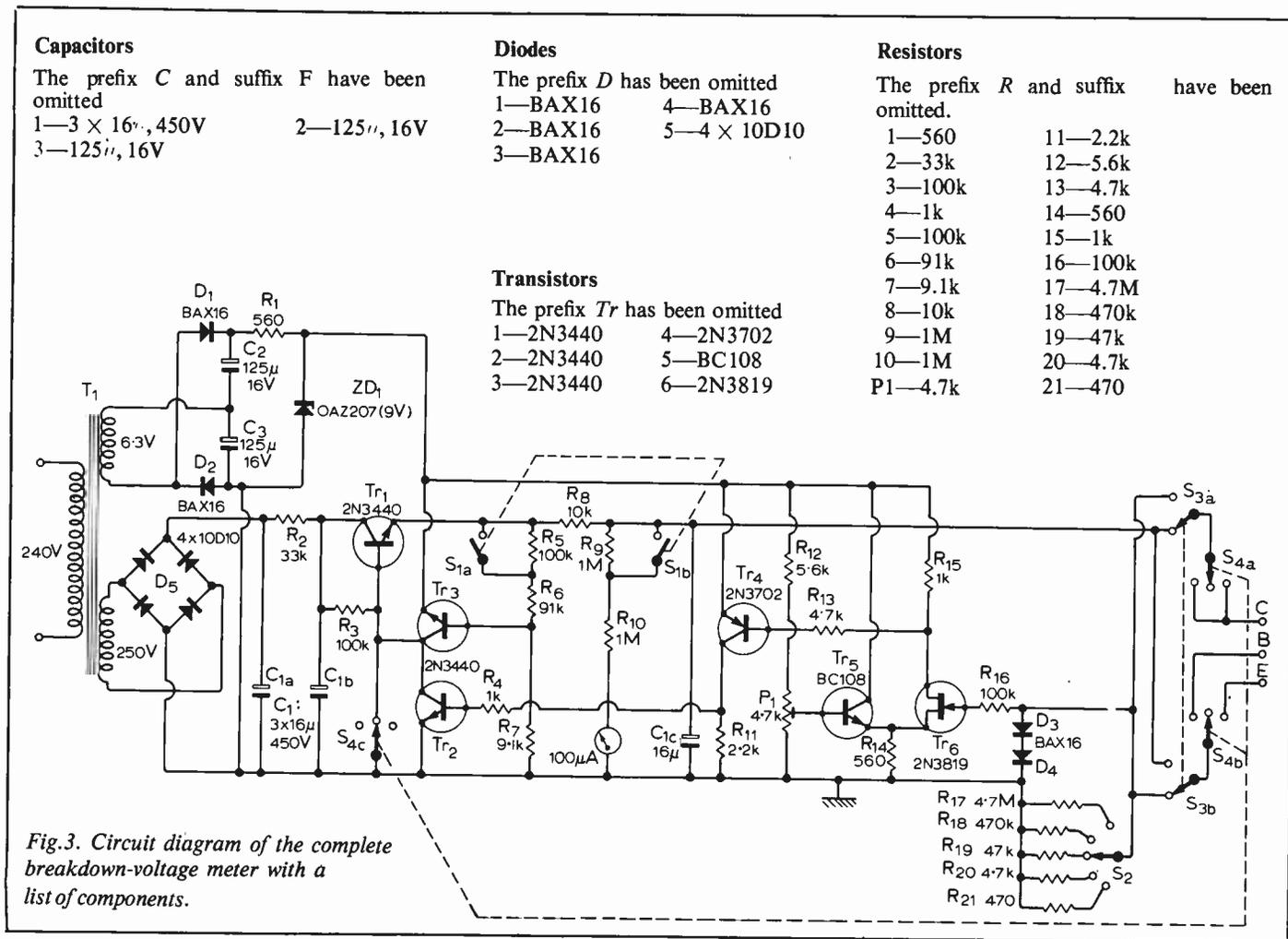


Fig.3. Circuit diagram of the complete breakdown-voltage meter with a list of components.

switch is always in the neutral position when the transistor is inserted. When  $S_4$  is operated, the voltage does not jump but rises fairly slowly owing to the  $10k\Omega/16\mu F$  RC network. This is necessary in order to avoid dangerous current surges in the test object.

The test current may be adjusted by altering the base voltage of  $Tr_5$ . It is easily set to the correct value by means of a known resistor. With  $470k\Omega$  connected between C and B terminals,  $S_4$  in position CB and  $S_2$  in position  $100\mu A$ ,  $P_1$  should be adjusted until the meter reads 47V. ( $100\mu A \times 470k\Omega = 47V$ ). In this context it can be mentioned that the instrument is ideal as a megohmmeter, having a linear scale and covering a range of 0.1 to 2000M  $\Omega$  f.s.d.

Mounting of the components is far from critical; yet it is recommended to put the whole in a closed metal box and connect this to circuit earth so as to avoid the disturbing influence of hum voltages on the high impedance input. However, insulate the box externally (a coat of paint may suffice), or be very careful with external test-leads, as a short from either of the connecting terminals to the case will prove fatal for at least half of the transistors.

If the components are mounted on a printed circuit board, trouble might be experienced with the low current ranges owing to stray currents on the board. This can be countered by keeping the gate of the f.e.t. and associated leads and components on a "stand-off", away from the etched side of the board.

## A Quick Look at Display Devices

Information present inside a piece of equipment—be it a computer, a measuring instrument or what have you—is of no use unless it can be made to do something or it can be presented to the outside world in a way that can be understood by human beings.

Ordinary incandescent lamps can be used individually to show simple on-off or yes-no information or they can be used to illuminate a more complex legend, "No. 3 alternator failure", for instance. Early counter-timers used such lamps to illuminate the digits 0 to 9 either by edge-lighting perspex sheets or by illuminating an engraved or printed window. However the flexibility is limited and the current consumption is high, and most of the power consumed is wasted as heat.

Some of the above remarks apply to simple neon indicators, but here, low brightness and high-voltage replace the high-current and heat disadvantages.

Gas-filled indicators, such as the Nixie, have long reigned supreme in the instrumentation field where a numeric only readout is required but they are of no use when letters and words have to be displayed.

The cathode-ray tube is now much used to display alphanumeric information and the methods of doing so are as varied as they are numerous. Character generators for c.r.t.s can now be purchased in integrated circuit form which use the seven-segment method of presentation. Seven lines are generated which can be used to assemble all the numbers from 0 to 9 plus a few letters. More complex electronics can be employed to produce on a

c.r.t. upper and lower case alphabets, all the numerals and a varied assortment of symbols. Although expensive with complex scanning, blanking, decoding, addressing and storage circuitry this type of display is much used, often in association with computers.

The single incandescent lamps and the neon lamps can be grouped together in a  $5 \times 7$  matrix to provide a display capable of showing a full range of alphanumeric characters and symbols. The array of lamps in this case is driven by a logic network which receives coded input information and determines which lamps have to be lit to display a given character. The same  $5 \times 7$  matrix approach can be, and is, used with c.r.t.s, here the matrix is formed by dots on the tube face.

The latest contender in the field of displays is the light emitting diode and our front cover this month shows an integrated array produced by Standard Telecommunication Laboratories Ltd which, as can be seen, is based on a  $5 \times 7$  matrix. These lamps are forward biased diodes which emit a narrow band of light by the recombination of injected holes and electrons across the energy band gap of a single crystal material. The diodes are manufactured from a mixture of gallium phosphide and gallium arsenide. They have the advantage of requiring voltages and currents that are compatible with those normally found in transistor and integrated circuitry.

Another display medium which we will be hearing a lot about in the future is liquid crystal; a substance which can be held in a layer between two transparent surfaces and turns opaque when an electric field is applied.

# Active Filters

## 13. Applications of the active-ladder synthesis

by F. E. J. Girling\* and E. F. Good\*

The application of the active-ladder synthesis to low-pass and high-pass filters with and without zeros in the stop band, and to simple band-pass filters is discussed.

### Butterworth ladder filters

Because only moderate  $Q$  factors are needed, Butterworth responses are in general suitable for realisation by factors. Nevertheless, by misalignment of the factors

on the frequency axis or by errors in  $Q$  factor, an appreciable slope can be introduced into the pass-band response by component errors which would cause very little change in pass-band response in an equally terminated filter (much as in the example shown in Fig. 3 of Part 12).

Now although Butterworth responses have relatively rounded corners, over much of the pass band they show a high degree of flatness, e.g. 5th-order response is 1% down from the zero-frequency level at about 0.85 of  $\omega_c$ . If this degree of flatness is to be achieved in practice, therefore, without calling for a tight tolerance on the values of the reactances (or their equivalents in an active filter, the values of the  $T$ s— or  $CR$  products), an equally terminated ladder filter is the preferable choice. Diagrams for orders 2 to 7 are shown in Fig. 1 (although the filters of orders 2 and 3 do not really come within the scope of the present argument) and it is interesting to notice that the normalised reactance values coincide with the reciprocals of the  $Q$  factors (Part 9, table 6).

The theoretical structure for a 5th-order active ladder has already been given (Fig. 13(d) of Part 12) and may be turned into practical form as in Fig. 2 herewith. In this diagram the inverting stages have been moved to new positions to reduce the number of resistors connected to the second and fourth integrators.

If the frequency response is compared with that of the 5th-order constant- $k$  filter, Fig. 6, it is seen that the shapes are little different, except that the constant- $k$  filter gives a more rapid fall into the cut-off region. When normalised for -3dB at 1 radian/second the element values of the constant- $k$  filter are as given in Fig. 3, and

comparison with those of the Butterworth filter give an indication of the tolerances allowable without losing flatness in the pass band or attenuation in the stop band.

In a filter such as that shown in Fig. 2, if  $R_{in} = R_5$  the voltage gain is the same as that of the passive model,  $\frac{1}{2} = -6dB$ . There is no necessity to stick to this figure, however. First  $R_{in}$  may be varied over a considerable range. Secondly the gain of any stage in the forward path may be changed provided the gain of the surrounding backward path or paths is/are changed in inverse ratio. Thus the signal level at the output may be raised without altering the shape of the response curve by reducing  $R_1$  and increasing the lowest-positioned of the three resistors  $R'$  by the same ratio; by reducing  $R_2$  and increasing the already mentioned resistor marked  $R'$  and the lower of the two resistors marked  $R_3$ ; etcetera. Such changes assume, of course, that each affected amplifier has sufficiently high internal gain to behave still sensibly ideally.

As the first and last integrators have a feedback resistor connected across the capacitor, they provide in effect a simple lag and an unwanted sign change. More economical ends may be used, therefore, as shown in

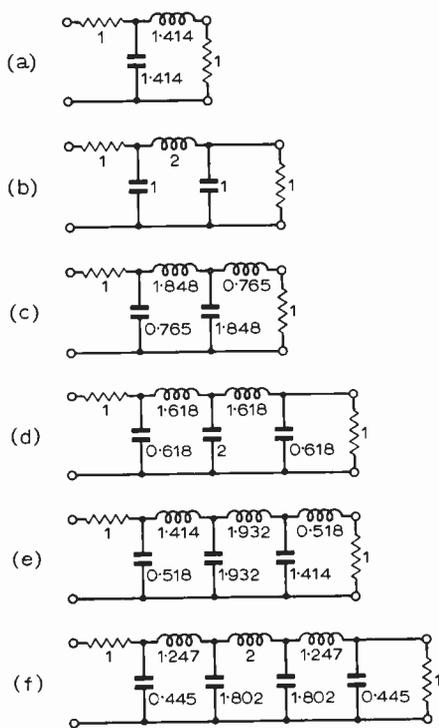


Fig. 1. Butterworth ladder filters normalised for  $\omega_c = 1$  rad/s.

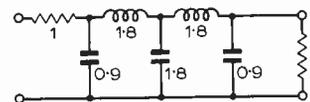


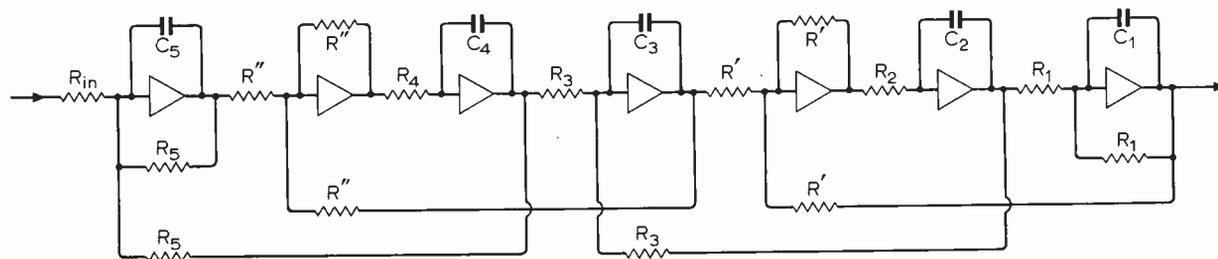
Fig. 3. Constant- $k$  filter normalised for -3dB relative to zero-frequency level at 1 rad/s.

Fig. 4. These are lag and integrator circuits (Part 5) and they replace the end two integrator loops of the basic active ladder. The input resistor is now part of a time constant and so cannot be varied independently. Other means of varying the overall gain remain, however.

For a sharper corner and increased attenuation in the stop band Chebyshev filters may be used, and element values may be taken from reference works (e.g. Ref. 1). There is also something to be said for taking as a model a "classical" constant- $k$  filter.

### Constant- $k$ filters

Constant- $k$  or  $A$ -type filters (Ref. 2) have attractive regularity, Fig. 5, which allows all the integrators of the active ladder to have the same  $T$  (except the end ones, which are of half value). When the central elements



for  $\omega_c = 1$  rad/s

$T_1 = C_1 R_1 = 0.618; T_2 = 1.618; T_3 = 2; T_4 = 1.618; T_5 = 0.618; R', R'',$  and  $R_{in}$  arbitrary

Fig. 2. Active 5th order Butterworth filter modelled on Fig. 1(d).

\*Royal Radar Establishment

of the passive models are designated  $2L$  and  $2C$ , as shown, the nominal cutoff frequency is given by

$$\omega_n = 1/\sqrt{LC} = 1/T \text{ (say)}. \quad (1)$$

Hence, since  $R = \sqrt{L/C}$ ,  $L/R = CR = T$ . In the basic active ladder, therefore, all the integrators have  $CR$  products equal to  $2T$ , except the end ones which have value  $T$ .

From the responses shown in Fig. 6 it can be seen that these filters are not of equal-ripple type. They are not, therefore, optimum designs: a Chebyshev filter of equal order and with the same maximum depth of ripple in the pass band gives a steeper initial fall into the cutoff region, though the ultimate rate of fall is necessarily the same; or alternatively for the same steepness of initial fall the Chebyshev filter gives a smaller maximum depth of ripple.

The 3rd-order filter is identical with a Butterworth filter; the high-frequency and low-frequency asymptotes intersect at the nominal cutoff frequency, and  $\omega_n = \omega_c$  (the

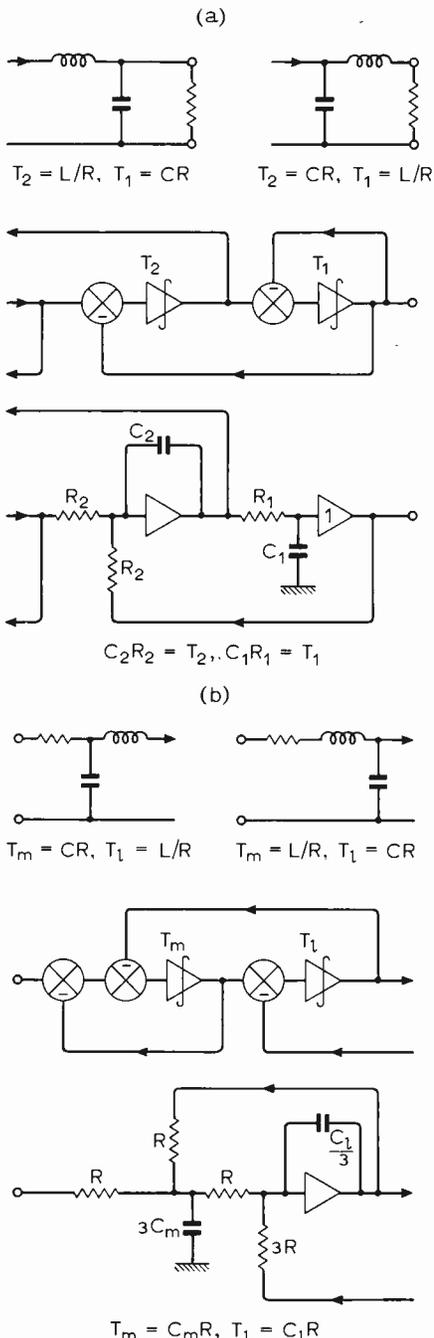


Fig. 4. Methods of making economical ends.

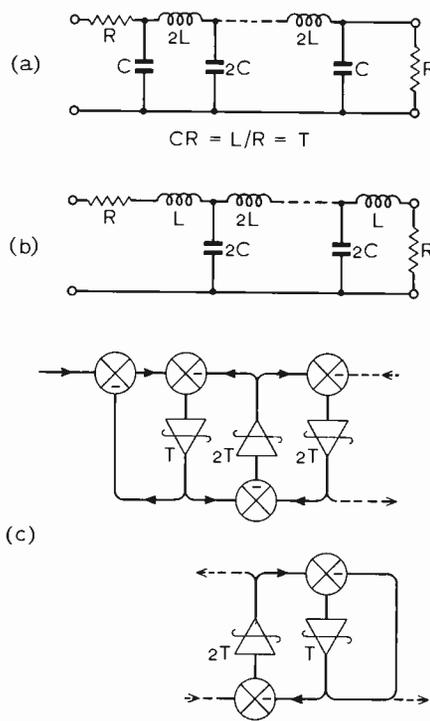


Fig. 5. Constant-k low-pass ladders.

–3dB frequency). As the order increases, an increasing proportion of the reactances (or integrators) have the value 2, and the high-frequency asymptote moves down the frequency scale. This causes the initial fall into the cutoff region to be steeper than the asymptote: for the 5th-order about 35 dB/octave, compared with 30 dB/octave; for the 7th-order about 60 dB/octave, compared with 42; for the 9th-order about 90 dB/octave, compared with 54. By the 9th-order a pronounced and unpleasant ripple has appeared towards the end of the pass band; but up to the 7th-order the amplitude response is quite good enough for many purposes, and the fact that the integrators can be made up using a number of resistors all of one value, and a number of capacitors also all of one value, can make these filters a convenient choice in experimental work.

Also shown in Fig. 6 are curves for the voltage at the output of the centre integrator, which is the replica of the voltage across the centre capacitor (if there is one) of the passive model, or of the current through the centre inductor. These show an increasingly large resonant peak as the order increases. This means that the centre integrator could overload before full output is reached at the final integrator. This possibility can be avoided, however, by increasing the forward gain of one or more of the loops at the output end of the filter and reducing the gain of the feedback parts of the loops as already described.

Some peaking occurs at the centre of Butterworth filters, but to a less degree as they are less resonant. This can be seen by comparing the  $Q$  factors of a Butterworth filter (Part 9, Table 6) with those of a resistance-terminated constant- $k$  filter given here-with (Table 1). The high  $Q$  factors are, of course, the price paid for the steeper initial cutoff, and if the integrators do not have high zero-frequency gain this will show as

an imperfection in the realised response more than with a Butterworth filter.

**Effect of finite gain**

In a realisation by factors it is easy to estimate the effect of finite gain and make correction by adjusting element values (provided more than the minimum necessary

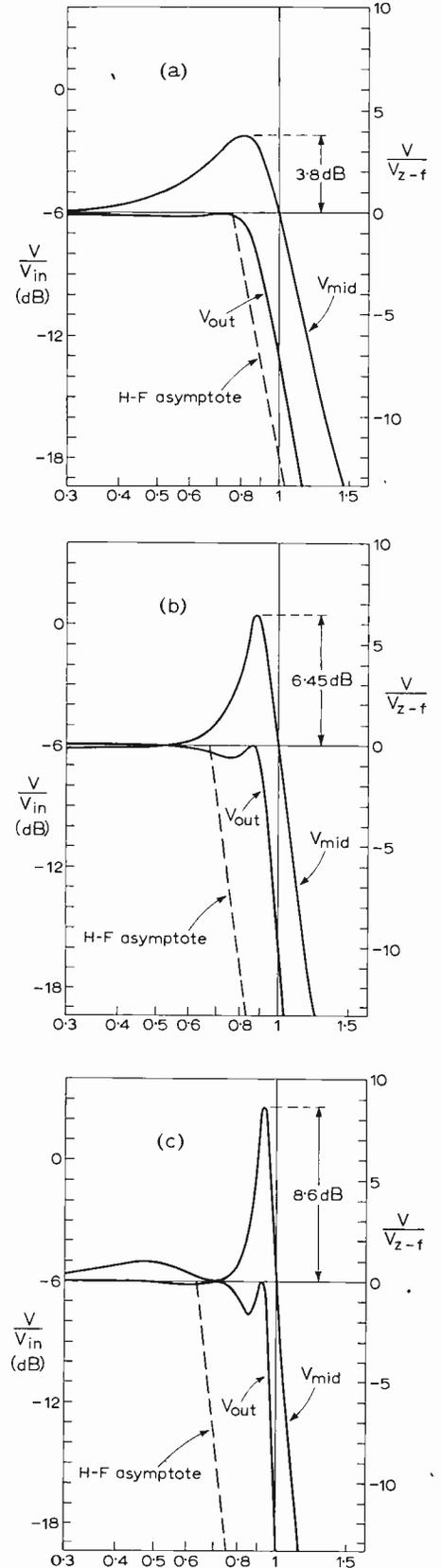


Fig. 6. Constant-k filters: output voltage and voltage at centre. (a) 5th order; (b) 7th order; (c) 9th order.

gain is available)—see Part 9. In a ladder it is a straightforward matter to calculate the effect of finite gain in an integrator, which as shown in Part 7 is equivalent to finite  $Q$  in the corresponding reactance. But when the model is an equally terminated filter, and all but the reactances should be of infinite  $Q$ , no adjustment of element values can compensate for finite  $Q$  in these reactances or finite gain in the corresponding integrators. In the active ladder, the loss may be compensated by raising the effective amplifier gain to infinity by positive feedback. This may be applied through a sign inverting amplifier, as shown in Fig. 7; or

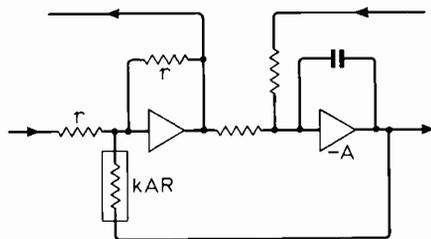


Fig. 7. A method of applying positive feedback to compensate for finite gain in an integrator.

if a differential input terminal can be found (e.g. the emitter of the input transistor) the positive feedback may be applied directly over the integrating amplifier. What is aimed at is that each of the inner resonant loops when freed of loading from the rest of the filter should have infinite  $Q$ , and in practice it is sufficient to apply positive-feedback correction of approximately double magnitude to only one integrator of each loop. It need hardly be said, however, that nowadays the best course of action, at any rate for a low-frequency filter, is to use an operational amplifier of ample intrinsic gain so that no compensation is needed. It should, of course, not be forgotten that capacitors do not have zero loss. But the availability of polystyrene capacitors showing  $Q$  factors from 2000 to 5000 makes it unlikely that much difficulty will be experi-

enced on this score; and polycarbonate capacitors showing  $Q$  factors of about 500, and having the advantage of much greater compactness in capacitances of 0.1  $\mu$ F and over, are usually quite satisfactory.

The effect of finite amplifier gain in distorting the pass-band response is shown by some experimental results obtained by the present authors many years ago. At that time transistors were in a very primitive state, and the only sensible choice of amplifier seemed to be a single pentode valve, Fig. 8. With the loss in the coupling and mixing networks it is probable that the effective amplifier gain was 50 to 100, and the measured response is shown in Fig. 9, curve (b). To increase the effect the valves were connected as triodes, giving an effective gain of probably 10 to 20, and the result is shown in curve (c). The curves have been adjusted vertically for easy comparison, i.e. the extra zero-frequency loss is not shown, and it is clear the main effect is felt near the "pole" frequency of the highest- $Q$  factor and indicates a damping down of the  $Q$  of that factor.

**Adding zeros in the stop band**

The performance of a filter is often improved at small expense by adding zeros in the stop band, as mentioned in earlier parts; and in a passive low-pass ladder filter a zero is obtained if either (1) a series arm inductance is tuned with a parallel capacitance (so that, ideally, the impedance of the arm becomes infinite at the required frequency) or (2) a shunt arm capacitance is tuned by a series inductance (so that the impedance of the arm tends to zero at the required frequency). Strict correspondence between the internal working of the passive filter and an active counterpart would require an extra integrator for every added reactance. However, the present writers' colleague, Dr R. L. Ford, has shown that satisfactory results can be obtained by making some additional interconnections to the simple (all-pole) structure, in much the same manner as

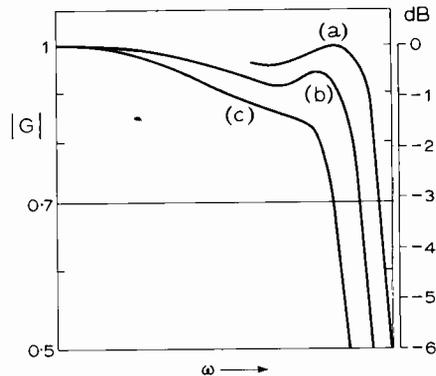


Fig. 9. Responses of 7th-order low-pass active ladder filter: (a) theoretical, (b) measured using pentodes, (c) measured using triodes.

notch response can be obtained from a two-integrator loop (Part 7).

The basic idea is that in Fig 10, for example, the current in  $C_2'$  is proportional to  $(pV_3 - pV_1)$  and therefore to  $(I_3 - I_1)$ , the difference of two quantities which, at least potentially, are already available in counterpart in the active system. Hence the counterpart of the required difference  $(I_3 - I_1)$  can be formed and added with a suitable scaling factor to the counterpart of  $I_2$  to represent the addition of  $I_2'$  to  $I_2$  without the use of any additional integrators (or differentiators). This is shown in Fig. 10(b). The additional links are  $r_1$  and  $r_3$ , and their correct values relative to  $r_2$  can be found by the following analysis.

In the passive network

$$I_2'/pC_2' = V_2 = V_3 - V_1 \quad (2)$$

so for the counterpart quantities in the active system we should have

$$I_2'R = (V_3 - V_1)pT_2' \quad (3)$$

where  $T_2' = C_2'R$ ,  $R$  being the scaling factor chosen for converting the currents of the passive network into voltages in the active system.

The voltages shown as available in Fig. 10(b) are

$$I_3R = V_3pT_3 \text{ and } I_1R = V_1pT_1.$$

$I_2'R$  may therefore be obtained by implementing the equation

$$I_2'R = V_3pT_3 \left( \frac{T_2'}{T_3} \right) - V_1pT_1 \left( \frac{T_2'}{T_1} \right). \quad (4)$$

Table 1. Factors of constant-k filters with resistance terminations for nominal cutoff frequency of 1 rad/s.

$n$	$T_0$	$T_1$	$q_1$	$T_2$	$q_2$	$T_3$	$q_3$	$T_4$	$q_4$
5	1.54	1.14	2.47	1.414	0.707				
7	2	1.10	6.47	1.414	1.414	1.82	0.642		
9	2.41	1.063	13.3	1.29	3	1.709	1.13	2.19	0.613

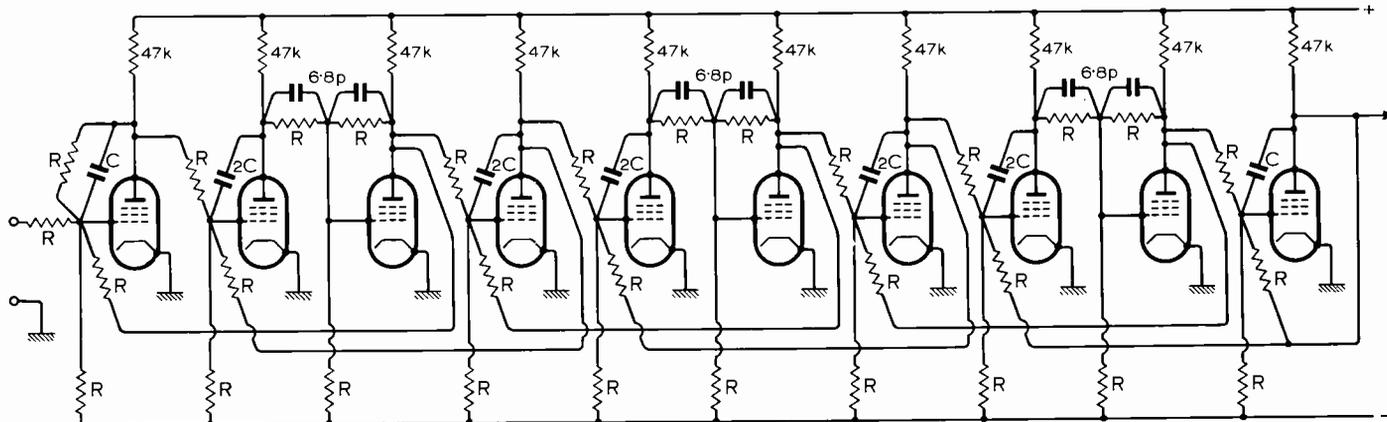
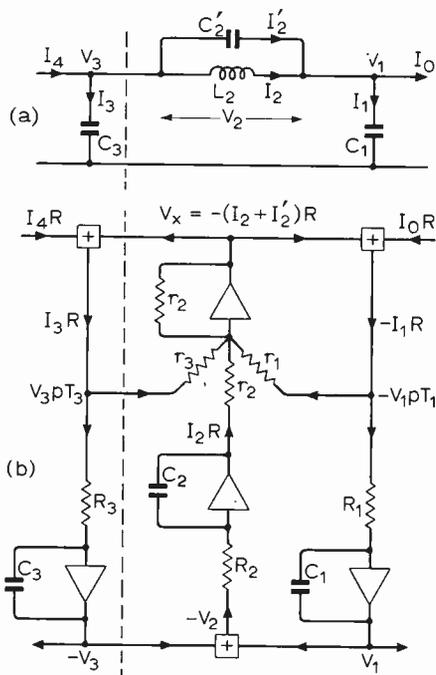


Fig. 8. Very early version of 7th-order low-pass active ladder filter.  $R = 390k\Omega$ ,  $C = 1000pF$ ,  $2C = 2,000pF$ ,  $V_1 - V_{10} = CV138$ .

Now for the system as shown in Fig. 10(b)

$$V_x = I_2R\left(\frac{r_2}{r_2}\right) + V_3pT_3\left(\frac{r_2}{r_3}\right) - V_1pT_1\left(\frac{r_2}{r_1}\right) \quad (5)$$



	Passive	Active	
$T_1$	$C_1R$	$C_1R_1$	$\frac{r_3}{r_2} = \frac{T_3}{T_2}$
$T_2$	$L_2/R$	$C_2R_2$	
$T'_2$	$C'_2R$		$\frac{r_1}{r_2} = \frac{T_1}{T'_2}$
$T_3$	$C_3R$	$C_3R_3$	

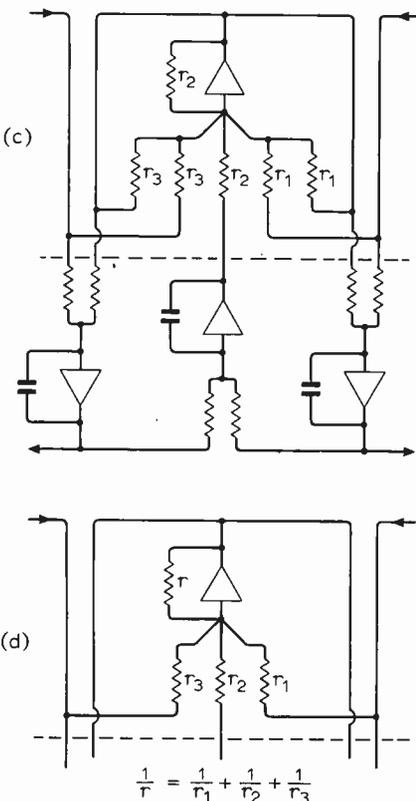


Fig. 10. A method of introducing a zero of transmission by adding only resistors.

So  $V_x = I_2R + I'_2R$  as required if

$$\frac{r_3}{r_2} = \frac{T_3}{T'_2} \text{ and } \frac{r_1}{r_2} = \frac{T_1}{T'_2} \quad (6), (7)$$

In practice the synthesis must be modified somewhat, since  $I_3R$ , the quantity representing  $I_4 + (-I_2)$  (we suppose for a moment that  $C'_2$  is not present) does not appear as a single voltage, the summation being done by giving the  $T_3$  integrator two input resistors. This situation is met by providing two input resistors  $r_3$  for the inverting amplifier, as shown in Fig. 10(c), and the same is done for  $-I_1R$  as shown on the right-hand side of the diagram. The result at this stage is rather cumbersome. But two of the added resistors are in parallel with the feedback resistor  $r_2$ , so the system may be simplified as shown in Fig. 10(d), the resistor  $r$  being made equal to the parallel combination of  $r_1, r_2$  and  $r_3$ .

Fig. 11 illustrates how the method can be applied to reproduce a 5th-order filter with two added stop-band zeros. The parameters have been chosen to realise a Darlington characteristic of the same shape as that shown in Fig. 1 of Part 1, and used as an example in Part 9, but scaled to a lower frequency to set the first zero at 50 Hz. The required time constants, in milliseconds, are given in the table.

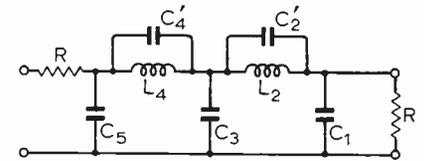
**Variable tuning**

The filter shown in Fig. 11 also serves to illustrate how variable tuning may be applied. The requirement is to vary the  $T_s$  of all five integrators in unison. ( $T'_2$  and  $T'_4$  follow automatically.) Methods for tuning an integrator were described in Part 8 (Figs 10 and 11). In particular, it was shown (Fig. 10(d) of Part 8) that by "plotting down" the input to an integrator by a factor  $k$  ( $< 1$ ) the  $T$  of the integrator is increased to  $T/k$ . When several inputs are summed at the virtual earth of an integrator amplifier it is obviously necessary to vary all these inputs. However, if thought is given to the placing of the potentiometers, each one may generally control an input to two integrators. This is achieved in Fig. 11 by breaking the circuit at the places marked X and feeding the potentiometers from the outputs of the adjacent amplifiers, the onward signal lines being reconnected to the sliders. It will be noticed that there also has to be a potentiometer in the input line; but the total number has been reduced to six, against the total of eleven separate inputs to the integrators.

The problem of providing a multi-gang potentiometer can be avoided by using the electronic switching method shown in Fig. 11 of Part 8. Using this method filters have been built covering a tuning range of 10 to 1; but because the action of "potting down" reduces the zero-frequency loop gain of the two-integrator loops (and hence their quality—see also Parts 5 and 7), some droop towards the corner of the pass-band response may be expected as the cut-off frequency is reduced, unless an adequate surplus of zero-frequency gain is provided.

**High-pass**

In Part 7 it was shown how a two-integrator loop can be used to produce the basic 2nd-



Parameters for first zero at 50Hz

$T_1$	4.77	$T'_2$	0.8215	$T'_4$	2.447
$T_2$	5.62	$\frac{T_1}{T_2}$	5.808	$\frac{T_3}{T_4}$	3.058
$T_3$	7.50	$\frac{T_3}{T_2}$	9.118	$\frac{T_5}{T_4}$	1.484
$T_4$	4.14				
$T_5$	3.63				

( $T_1 = C_1R, T'_2 = C'_2R$ , etc in milliseconds)

$\omega_p = 33.9\text{Hz}$

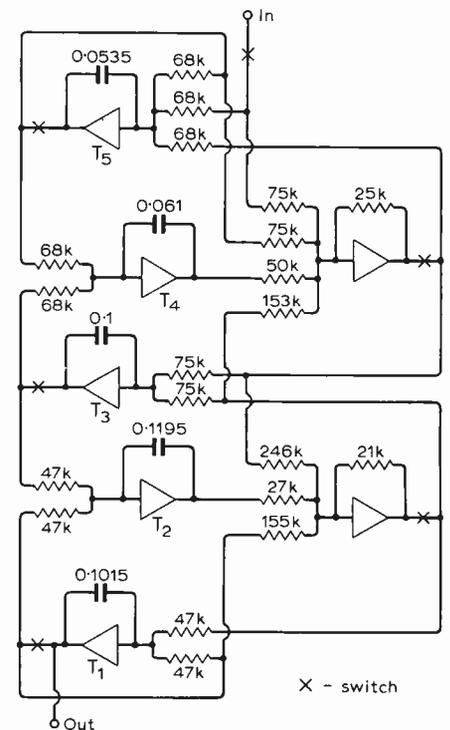


Fig. 11. Realisation of a 5th-order Darlington low-pass response.

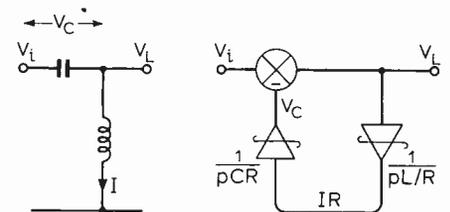


Fig. 12. High-pass sections.

order high-pass response. As a reminder of this, Fig. 12 shows an undamped high-pass section and the corresponding functional diagram. The essential feature is that the output,  $V_x$ , is obtained by subtracting the voltage across  $C$  from the input  $V_i$ . This puts both integrators in the feedback path.

If the same principle is to be followed when a system of integrators is used to copy the working of a high-pass ladder structure, for example that shown in Fig. 13, it follows that the functional diagram must be arranged so that  $V_o$  is derived from  $V_{in}$  by successively subtracting voltages,  $V_6, V_4$

and  $V_2$ , corresponding to those across the series-arm impedances of the passive circuit. As usual, it is convenient to work backwards from the output end, and so, assuming  $V_3$  given, it is required to form the relationship

$$V_0 = V_1 = V_3 - V_2. \quad (8)$$

To do this,  $V_2$  must be obtained by copying the working as follows:

$$I_1 p L_1 = V_2 \quad (9)$$

and hence

$$I_1 R = V_1 / p T_1 \text{ (where } T_1 = L_1 / R). \quad (10)$$

$$I_2 R = I_1 R + I_0 R \text{ (where } I_0 R = V_1), \quad (11)$$

$$V_2 = \frac{I_2}{p C_2} = \frac{I_2 R}{p T_2} \text{ (where } T_2 = C_2 R). \quad (12)$$

Similarly  $V_3$  is obtained, assuming  $V_5$  is given,

$$V_3 = V_5 - V_4, \quad (13)$$

and so on.

The resulting functional diagram is deceptively simple. Turning it into a practical circuit using Blumlein feedback integrators and sign inverting stages leads to a formidable number of interconnections. At the output end, however, these may be reduced to more manageable proportions by using a modified integrator as shown in Fig. 14 which gives the voltage transfer ratio

$$1 + 1/p T_1.$$

In this way both  $-V_0$  and  $-V_0/p T_1$  are fed back together on a single wire (c.f. Fig. 7, Part 7).

It is also possible without much extra complexity to make additional connections to produce stop-band zeros, and quite high-performance filters have been built by this method. All things considered, however, other methods of building an active high-pass filter, which will be described in a later article, are generally to be preferred.

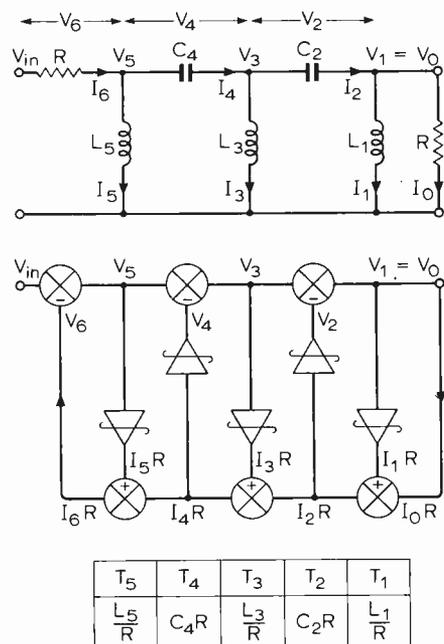


Fig. 13. High-pass ladders.

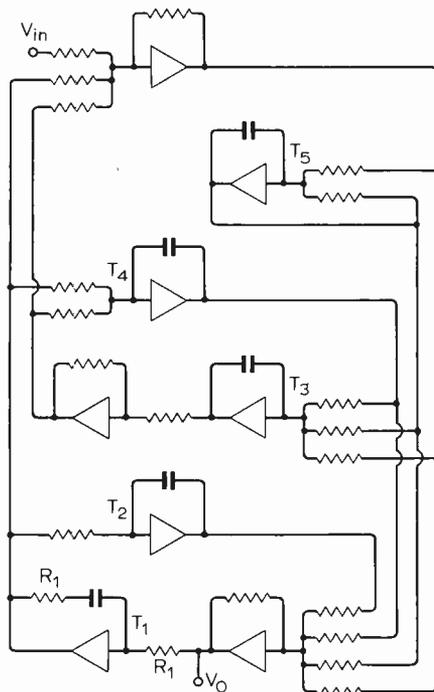


Fig. 14. Electrical version of 5th-order h-p active ladder filter.

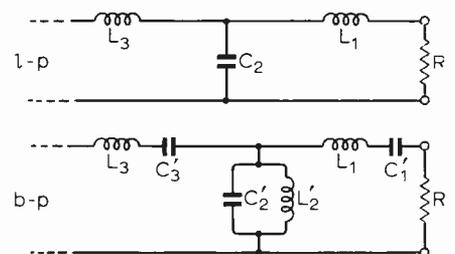
### Band-pass

The transformation of a low-pass ladder to band-pass was described in Part 2. Briefly, each reactance in the low-pass ladder is formed into a tuned branch by the addition, either in series for a series arm, or in parallel for a shunt arm, of a reactance of the opposite sort. Each of the tuned branches so formed is tuned to the same frequency, the geometric centre frequency of the required band-pass characteristic. Thus the shape and bandwidth of the band-pass characteristic are determined by the original low-pass filter, and the added reactances simply transfer the characteristic to the required position on the frequency scale. This process is illustrated in Fig. 15, where the output ends of passive ladders of alternative types, T and  $\Pi$ , are shown. The table shows the  $T$ s which must be equal if the filters are to have the same bandwidth and (for the band-pass filters) centre frequency.

The working of these band-pass filters could be copied step by step, each reactance being considered individually; but the result can be reached more quickly by first noticing two related correspondences. The first, Fig. 16(a), is the familiar one (see Part 7, for example) between a two integrator loop and a series tuned circuit. When the parameters are appropriately matched, the active system in response to an input voltage  $V$  produces an output voltage  $IR$ , which is proportional to the current  $I$  which the same voltage produces in the passive circuit. The second, Fig. 16(b), is the correspondence between a two-integrator loop and a parallel tuned circuit. Here, when the parameters are appropriately matched, the active system produces an output voltage  $V$  in response to an input voltage  $IR$  which is proportional to the current  $I$  which produces the same voltage  $V$  across the passive parallel tuned circuit. In both cases  $R$  may, in principle, have any arbitrary value.

Thus it is seen that an integrator representing an inductance is transformed to represent a series tuned circuit by connecting across it in a feedback link a second integrator, and that an integrator representing a capacitance is transformed to represent a parallel tuned circuit by the same addition. In each case the two-integrator loops so formed are tuned to the same frequency as the passive tuned circuit

It follows that the equivalent of the passive transformations shown in Fig. 17 is to connect a second integrator across each integrator of the active low-pass ladder to form a two-integrator loop. Each of these loops is tuned to the required centre frequency, and ideally gives infinite gain at this frequency just as the single integrators in a low-pass ladder ideally give infinite gain at zero frequency.



	$T_3'$	$T_3$	$T_2'$	$T_2$	$T_1'$	$T_1$
l-p		$\frac{L_3}{R}$		$C_2 R$		$\frac{L_1}{R}$
b-p	$C_3' R$	"	$\frac{L_2'}{R}$	"	$C_1' R$	"
l-p		$C_3 R$		$\frac{L_2}{R}$		$C_1 R$
b-p	$\frac{L_3'}{R}$	"	$C_2' R$	"	$\frac{L_1'}{R}$	"

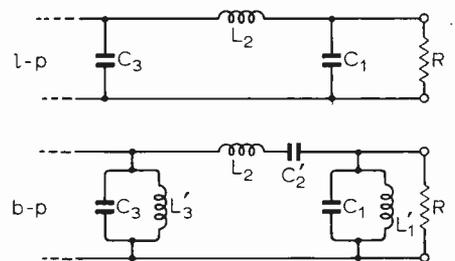


Fig. 15. Derivation of band-pass structures from low-pass.

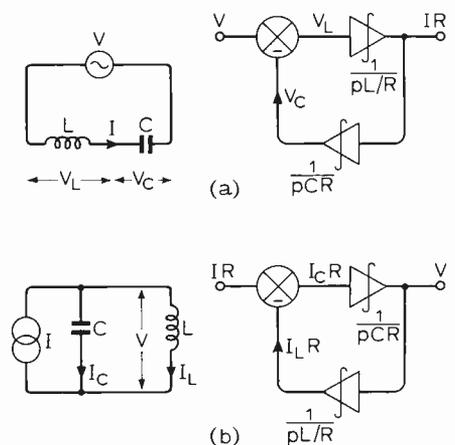


Fig. 16. Active equivalents of the two types of tuned branch.

An example is shown in Fig. 17(b), where for convenience the arbitrary scaling resistance is taken as equal to the terminating resistance of the passive model, Fig. 17(a). The two-integrator loops representing the series-tuned branches develop  $I_1 R$  from  $V_1$ ,  $I_3 R$  from  $V_3$ , etc.; and those representing the parallel-tuned branches develop  $V_2$  from  $I_2 R$  etc. The interconnections via the several difference elements provide that (1) each two-integrator loop which represents a series-tuned branch is fed with the voltage across that branch, i.e.  $V_1 = V_2 - V_0$ ,  $V_3 = V_4 - V_2$ , etc.; and that (2) each two-integrator loop which represents a parallel-tuned branch is fed with a voltage proportional to the current through that branch,  $I_2 R = I_3 R - I_1 R$ , etc.

For the sake of completeness Figs 17(c) and (d) illustrate the derivation of an active ladder from the alternative form of passive model; but since, for the same response,  $T_1 (= L_1/R)$  in the one form must equal  $T_1 (= C_1 R)$  in the other, Figs 17(a) and (d), and so on for all the  $T$ s, the resulting active system, Fig. 17(d), is identical to that of Fig. 17(b).

The functional scheme derived above can be realised by a variety of means. If attention is confined to conventional feedback arrangements of the virtual-earth sort, it is necessary to take account of the sign reversal that accompanies each operation, and also to order the circuits so that subtractions are replaced by summations. A rule that must be followed is that all loops must

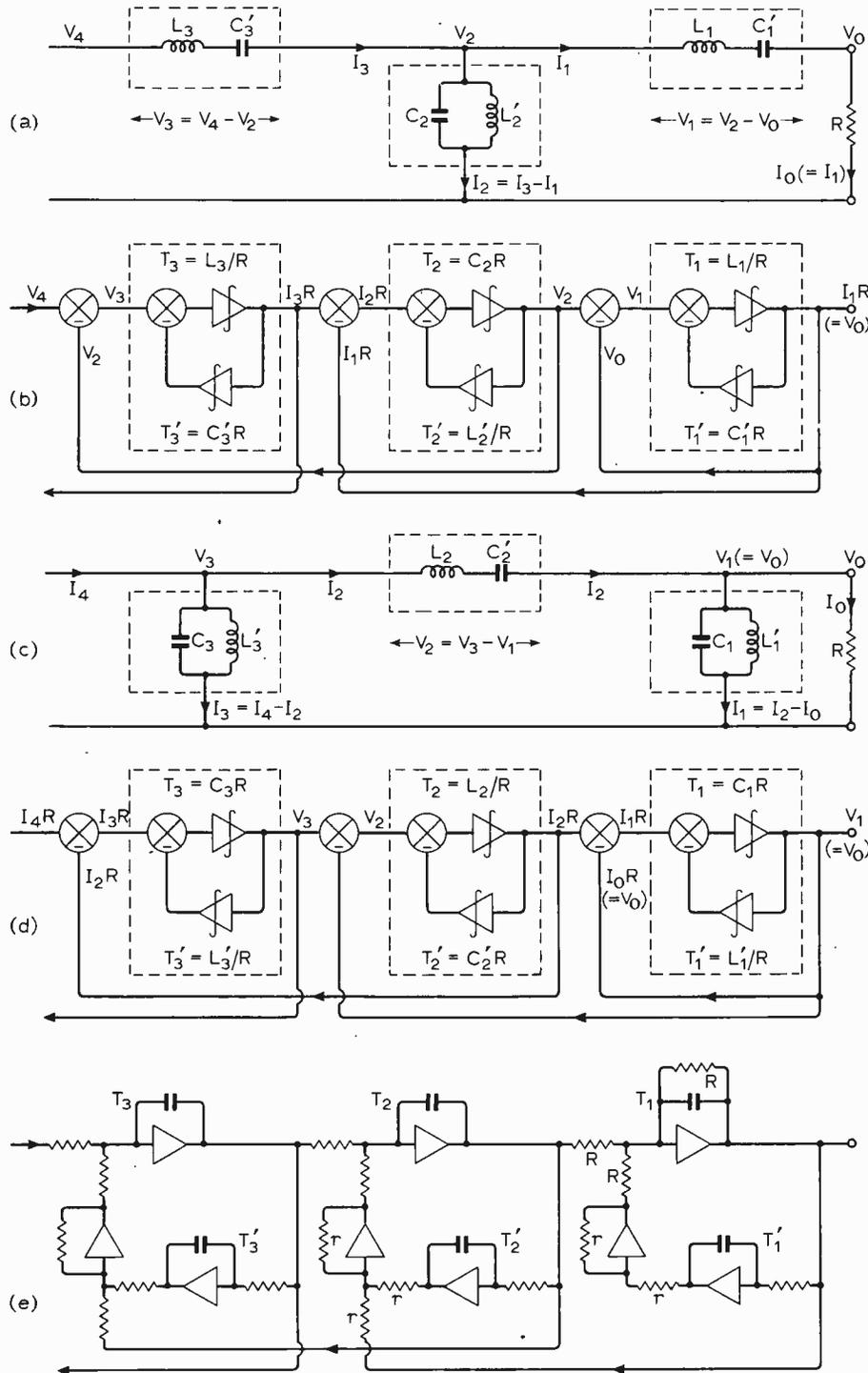
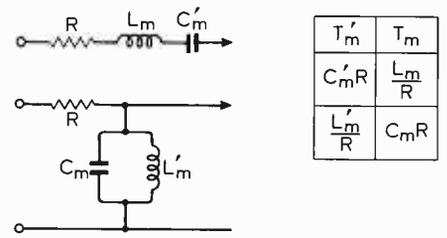


Fig. 17. Derivation of active band-pass ladder.

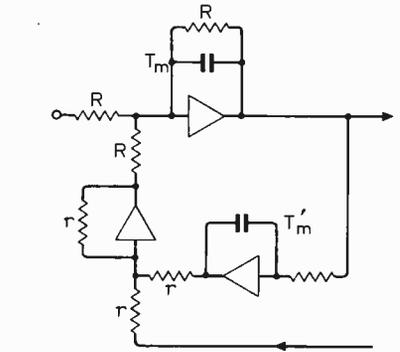


Fig. 18. Modelling the input end of a band-pass ladder filter.

contain an odd number of amplifiers, one or three. Each two-integrator loop must include a third amplifier for sign inversion, and a straightforward application of these rules gives Fig. 17(e). Clearly a large number of possible variations exist, though normally the circuits will be drawn to give a similar high degree of regularity. At the input end the action of the terminating resistance is easily reproduced as in Fig. 18, and again results in a resistor placed across the capacitor of an integrator.

When the filter modelled is of relatively narrow bandwidth the  $T$ s of the integrators representing the reactances of the original low-pass filter,  $T_1, T_2, T_3$  etc., are much larger than the  $T$ s of the integrators representing the reactances added in the band-pass transformation,  $T'_1, T'_2, T'_3$  etc. (because the low-pass corner frequency, which is also the band-pass width, is much smaller than the band-pass centre frequency). This, as we know from analysis of a single two-integrator loop, does not make good use of the integrator amplifiers. The flexibility of the active system is such, however, that a much larger resistance than  $R$  may be chosen to give the two integrators in each loop approximately equal  $T$ s. This increases relatively the voltages at the outputs of the top row of integrators, and the resistances in all the remaining links connected to these points must be increased to compensate, if the bandwidth of the filter is to be unaltered.

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1. "Simplified Modern Filter Design" (book) by P. R. Geffe. Iliffe, London, and Rider, New York, 1963.
2. "Tchebyshev Filters and Amplifier Networks", by V. Belevitch. *Wireless Engineer*, April 1952, Vol. 29, No. 343, pp. 106-110.

# Improving the 13A Oscilloscope

## A few extra parts increase the bandwidth of this popular 'scope to 5MHz

by N. W. Vale

The needs of scientific research and colour TV construction, both carried out on a limited budget, led the author to develop a modification which considerably improves the bandwidth of the Hartley 13A double-beam oscilloscope currently available at low cost on the surplus market. The instrument typically has a 3-dB bandwidth of 10 Hz to 3.5 MHz, although it will display a 4.5-MHz signal of 3V peak-to-peak.

The modified oscilloscope retains a maximum sensitivity of 300mV peak-to-peak, and it has a virtually flat response from 20 Hz to 4.5 MHz. The 3-dB points are at 10 Hz and 5 MHz.

Experiments with *Wireless World* colour TV circuits show that the modified oscilloscope will successfully display and lock video signals at the detector stage, giving a clear indication of the colour burst. It was found that all the important waveforms in the colour decoder could be readily displayed. In other tests the instrument was found to give a useful display at frequencies up to 10 MHz.

All extra components for the modification are easily fitted inside the oscilloscope case and the external appearance and control functions remain unaltered.

### General description

The bandwidth of the original instrument can be improved by reducing the value of the feedback resistor ( $R_{46}$  in the circuit diagram normally fixed inside the lid of each instrument) in the h.f. deflection amplifier.

Naturally, such a modification gives an appropriate loss of amplification. The deflection amplifier gain may be restored by adding a simple compensated wideband amplifier. A transistor design was originally considered for this application but was rejected for the wider dynamic range and better compatibility of a valve amplifier.

The compensated amplifier finally used is of conventional design and relies on the high slope of a frame grid r.f. pentode to obtain a good sensitivity while a low value of anode load is used to obtain the required bandwidth. Fig. 1 gives the circuit of this amplifier.

The 6AK5 is a triode-connected

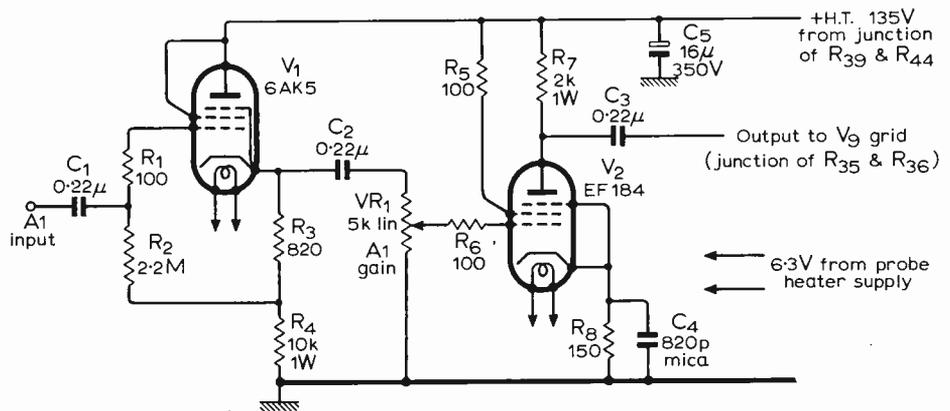


Fig. 1. The circuit of the new wideband amplifier.

cathode-follower input stage, to obtain smooth gain control at high frequencies and maintain a high input impedance.

To provide compensation at high frequencies, the cathode resistor of  $V_2$  is bypassed by  $C_4$  the value of which has been selected to give compensation for the h.f. losses which occur in the oscilloscope and its active probe input circuits.

It is suggested that the modified oscilloscope be used with its cathode follower probe plugged in at all times. This is to avoid changes in the h.t. supply voltage to the new amplifier. In any case, it is advisable to use the probe for all work requiring the full frequency response of the modified instrument.

### Practical details

Remove the negative feedback resistor  $R_{46}$  from the instrument and replace it with a 1.8 kΩ non-inductive carbon resistor rated at 0.5W ( $R_9$ ).

Interconnect contacts 1 and 2 of the probe switch  $S_4 A$  in the oscilloscope. This keeps the h.t. supply connected to the probe valve in all switch positions. The object of this is to prevent cathode poisoning of the probe valve, which might occur if the valve was allowed to run with heater only supplies for any length of time, and to keep the h.t. requirements for the input section as steady as possible.

Remove and discard  $C_{35}$  (a large paper dielectric type). Fit two suitable valve holders in the region previously occupied by  $C_{35}$  and build in the new amplifier. The

aluminium chassis bracket which passes the site of the new valves may have an appropriate piece cut out of it to allow easier access.

Remove the existing A1 gain control ( $R_{38}$ ) and connect the wire which originally fed this control from  $R_{37}$  to the chassis. Fit  $VR_1$ , the new A1 gain control, using the same panel hole.

Wire a 20-kΩ 10-W resistor ( $R_{10}$ ) in parallel with resistors  $R_{39}$  and  $R_{40}$  of the oscilloscope. This compensates for the increased h.t. load due to the added valves.

Remove and discard  $C_{34}$ , the original input coupling capacitor to  $V_9$ , and connect new amplifier output to  $V_9$ .

Connect the input of the new amplifier to contact 6 on  $S_4 B$  (i.e. to A1 input) and check that the other connections to the new amplifier are as shown in Fig. 1.

### Shopping list

$R_1$ 100Ω	$R_7$ 2kΩ*	$C_3$ 0.22μF
$R_2$ 2.2MΩ	$R_8$ 150Ω	$C_4$ 820pF#
$R_3$ 820Ω	$R_9$ 1.8kΩ†	$C_5$ 16μF <sup>b</sup>
$R_4$ 10kΩ*	$R_{10}$ 20kΩ§	$VR_1$ 5kΩ lin.
$R_5$ 100Ω	$C_1$ 0.22μF	$V_1$ 6AK5
$R_6$ 100Ω	$C_2$ 0.22μF	$V_2$ EF184

\*1W rating. †0.5W rating. §10W rating.

All other resistors rated at 0.25W.

#mica. <sup>b</sup>350V working.

All capacitors 250V working polyester unless otherwise specified.

# Electronic Building Bricks

## 4. Transducers—analogue and digital

by James Franklin

In Part 2 we saw how information could be represented by electrical variables, both in static and dynamic form. A "travelling representation" is called a signal. Two examples given were pulses of electrical energy representing number of objects travelling on a conveyer, and a continuous variation of electrical energy representing sound-wave energy. To obtain these electrical signals a converting device was needed in each case—a photo-electric cell to convert the light energy and a microphone to convert the sound energy. There are in fact a great many converting devices in use, particularly in industrial control equipment. A familiar one at home is the gramophone pickup. Some convert the mechanical or other energy directly into electrical energy, as shown in Fig.1(a), while others—for example, the oven thermostat—use it to control electrical energy coming from a separate source, as shown at (b).

In Part 3 we saw that electrical energy is constituted by electrons, and that a general movement of many electrons is an electric current, measurable as a flow rate in coulombs per second (amperes). Current is an electrical variable, and as

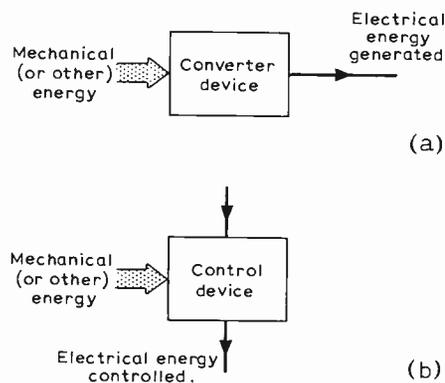


Fig.1. Obtaining information in electrical form from information represented by some other type of energy: (a) direct energy conversion; (b) control of electrical energy.

such can be controlled. Thus in Fig.1(b) we could replace the words "electrical energy" by "electric current" or indeed by words denoting any other electrical variable. Also in (b) we could replace the words "mechanical (or other) energy" by

words describing a particular physical variable, such as force or temperature.

We can, in fact, develop from Fig.1 a much more general concept—a device that receives some physical variable representing information and transforms this into an electrical variable representing the same information. The variables change but the essential information does not. Any actual device which does this is called a *transducer*\*. This is our first "building brick", and we are showing it, according to plan, just as a functional block—Fig.2.

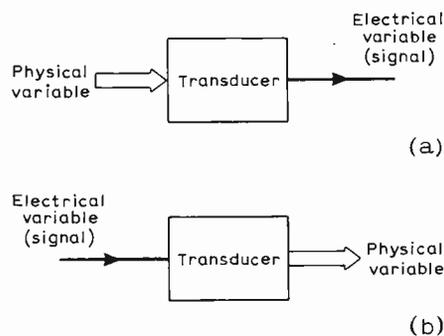
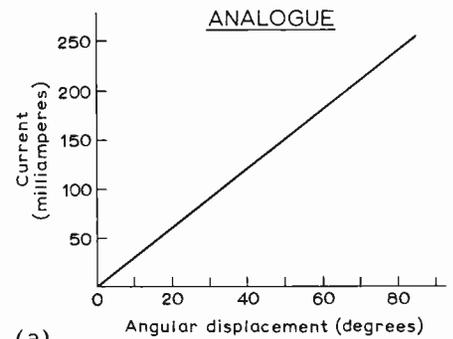


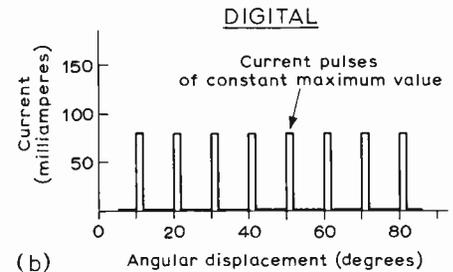
Fig.2. Electronic building brick No.1—the transducer; (a) an input transducer; (b) an output transducer.

It must be quickly added that "transducer" can also mean a device that works in the reverse direction, converting an electrical variable into a physical variable, as shown at (b) in Fig.2. This may be thought confusing, but in practice the transducer's direction of operation in an electronic system becomes obvious from the position the device occupies in a block diagram, say at the input as against the output. Domestic examples of the Fig.1(b) type of transducer are the loudspeaker and the television picture tube, though these are not often described as transducers. But the term is used frequently in industrial electronics (Fig. 2 (a) could be a "pressure transducer") and sometimes in sound reproduction.

From Part 2 we saw that information may be represented in a signal in two ways. In the electronic counting system the number of objects was represented by that *number* of pulses of electrical energy. In fact the exact form of the energy-time



(a)



(b)

Fig.3. Graphs illustrating the action of (a) an analogue transducer and (b) a digital transducer, both responding to angular displacement of a shaft.

graph did not matter very much: the pulses could equally well be triangular or some other shape provided their number was correct. This type of representation, in which the number of electrical events gives the essential information, is called a *digital*<sup>†</sup> signal.

With the other type of representation, the continuously varying electrical energy obtained from a microphone responding to a violin note, the successive values of electrical energy were proportional to the successive values of sound energy—they had to be, otherwise distortion of the information would occur. In other words the electrical energy time-graph was similar in form to the variation with time of the sound energy (supposing this were plotted as a graph). As such the electrical variable was a sort of model, or analogue, of the sound variable. Such a representation is called an *analogue*<sup>‡</sup> signal.

Some transducers are designed to work with analogue signals, others with digital signals—it depends on what is needed for a particular electronic system. For example, for a system in which a digital computer is the main element, digital transducers might well be the more convenient. To illustrate the difference between the modes of operation, Fig.3 shows the relationships in two transducers, both representing a given physical variable, rotation of a shaft: (a) an analogue transducer giving a proportional electric current (3 milliamperes per degree of rotation), and (b) a digital transducer giving a related number of pulses of current (one pulse per 10 degrees). Both transducers use current as the electrical variable, the analogue type directly, the digital type merely as a medium for denoting number.

<sup>†</sup> From Latin *digitus* (finger). The link with counting is obvious.

<sup>‡</sup> From Greek *ana* (up to), *logos* (proportion).

\* From Latin *trans* (across), *ducere* (to draw).

# Circuit Ideas

## Hybrid push-pull deflection amplifier

A requirement arose for a push-pull deflection amplifier for an electrostatic cathode ray tube system where it was not practicable to provide the additional negative h.t. and heater supplies which would be required by the usual constant-current pentode coupling circuit. To satisfy the requirement a hybrid circuit was devised which uses a double triode valve in a standard long tailed pair configuration and a two terminal constant current circuit using transistors<sup>1,2</sup> in the common cathode lead. Assignment of component values is very simple. First anode resistors and anode currents are chosen to meet the output requirements and this fixes the standing grid-to-cathode bias and the necessary input voltage swing. It is then possible to determine the offset voltage for the grids relative to ground from the inequality:  $-V_{gg} + V_{gk (min)} \geq V_{cc (min)}$  where  $V_{gg}$  is the required offset voltage,  $V_{gk}$  is the grid-to-cathode voltage,  $V_{cc (min)}$  is the minimum voltage which can appear across the constant current circuit for correct operation

provided that a value for  $V_{cc (min)}$  is fixed.  $V_{cc (min)}$  is determined by the zener diodes,

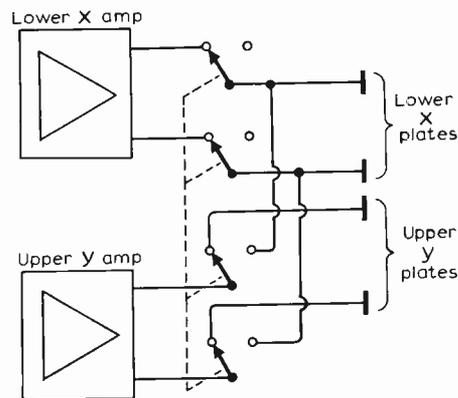
the use of those with the lowest available reference voltage setting a lower limit for  $V_{cc (min)}$  of about 7V. If a smallest value for  $V_{gk (min)}$  of 2V is assumed, a minimum value of 5V is established for  $V_{gg}$ . Use may be made of this offset voltage to provide a trace shift or picture centring facility as shown in the circuit diagram. The components shown provide a 460V peak-to-peak output swing for a 28V peak-to-peak input swing.

D. E. VAUGHAN,  
Christchurch,  
Hants.

1. P. Williams, "Letters to the Editor", *Wireless World*, p.456, Sept. 1966.
2. P. Williams, "Ring-of-two Reference", *Wireless World*, p.318, July 1967.

## Conversion of a double-beam 'scope for XY plotting

For those unable to buy an oscilloscope having identical X and Y amplifiers, the ability to do XY plotting is somewhat limited. The figure given illustrates a simple modification to a double-beam oscilloscope. The idle Y amplifier is made use of, and switched to the X plates,



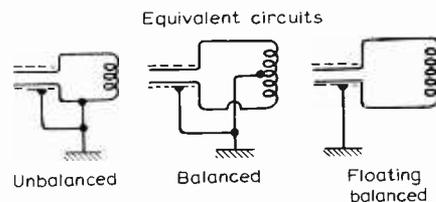
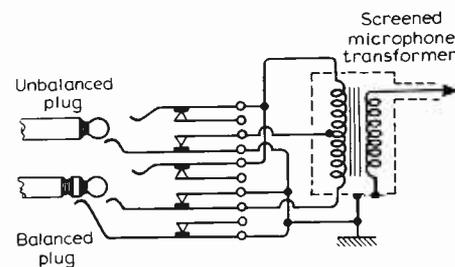
Switching for X Y plotter.

which in turn have merely been disconnected from their own amplifier. Leaving the spare beam disconnected at the upper Y plates usually means that it will appear near centre on the screen, but with the brilliance turned down, no difficulty should ensue. Where the output of the normal X and Y amplifiers is developed with respect to chassis, care should be taken to avoid reversals in the switching.

B. LANE,  
Bletchley,  
Bucks.

## Connecting microphones to transformers

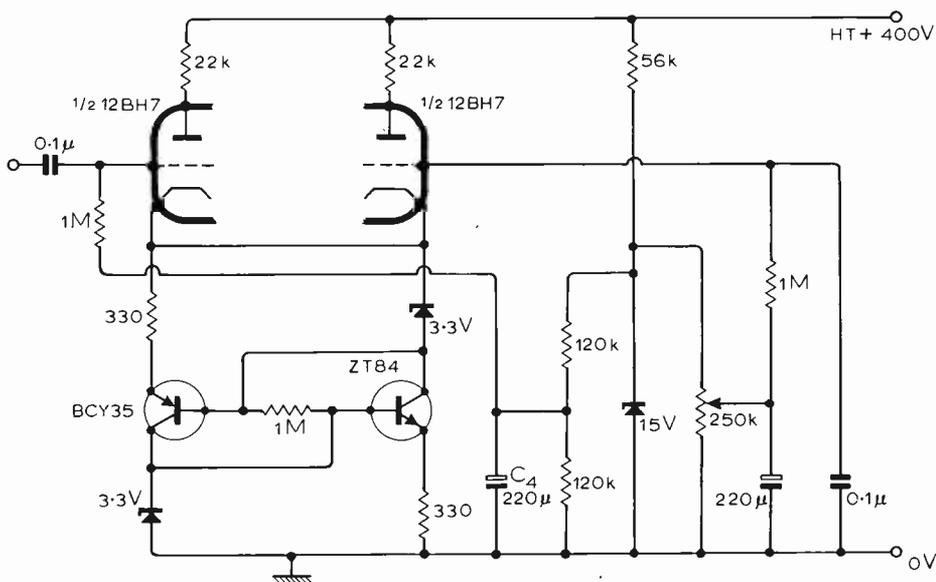
It is sometimes necessary to be able to connect either a balanced or unbalanced input plug to the primary of a microphone transformer. This can be done with the circuit shown which allows either to be plugged into its appropriate socket. The



Versatile microphone transformer arrangement.

jack sockets have normally closed contacts as shown, and the connections are arranged so that the whole of the primary winding is included and the appropriate points and cable screening are earthed in each case. A floating balanced input can also be obtained by inserting an empty plug into the unbalanced socket.

A. C. GOTT,  
Southall,  
Middx.



Transistors supply constant current to valve amplifier cathodes.

# The F.E.T. as a Class-A Audio Amplifier

## When to use and how to bias

by P. L. Matthews\*

In spite of the publicity given to field-effect transistors when they were introduced, they are still dominated by bipolar types in audio circuits. One of the main reasons for this is that present methods of manufacture lead to wide variations in their primary characteristics—the zero gate voltage drain current  $I_{dss}$ , pinch-off voltage  $V_p$ , and mutual conductance  $g_{mo}$ —which are approximately related by  $2I_{dss} = g_{mo} \cdot V_p$ .

Probably the most widely used f.e.t. is the 2N3819, with  $V_p$  and  $I_{dss}$  spreads of 0.5 to 7.5 V and 2 to 20 mA respectively. Without going into calculations it can be seen that if devices with extreme parameter values are to be incorporated into a conventional self-biased stage, the design will have to tolerate a drain current variation of the order of 10 to 1, which is obviously impracticable. The extra cost of a tightly specified selection of the 2N3819 makes it less of an economic proposition when a couple of cheap plastic bipolars will often do the job just as well. However, there are some instances in which an f.e.t. must be used, and this article aims to show which devices should be chosen for a given application, and how they should be biased.

### The perfect performance

In order to determine how bias variations alter the performance of an f.e.t. amplifier it is useful to consider the operation of a theoretically perfect device in an isolated self-biased stage. The circuit of Fig. 1 depicts an n-channel f.e.t. operated from a supply voltage of  $+V_{dd}$ , with load and bias resistors  $R_L$  and  $R_S$  respectively, when capacitor  $C$  is sufficiently large to bypass signal frequencies. The input shunting resistor  $R_g$ , which

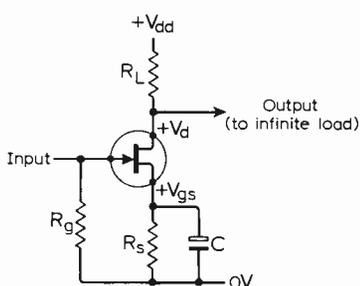


Fig. 1. Standard biasing circuit for f.e.t. audio stage.

	← b →							
	1/4	1/2	3/4	1	2	3	4	
1/4	0.25	0.38	0.48	0.54				
1/2	0.32	0.50	0.65	0.76	1.07			
3/4	0.33	0.57	0.75	0.90	1.33	1.60		
1	0.35	0.61	0.82	1.00	1.53	1.89	2.34	
2		0.70	0.98	1.22	2.00	2.59	3.06	
3			1.05	1.33	2.26	3.00	3.61	
4				1.41	2.44	3.28	4.00	

$$c = \frac{b}{2a} \left[ (4a+b) - \sqrt{b(8a+b)} \right]$$

Fig. 2. Values of c for various values of a and b, according to the equation.

would typically be about 1 MΩ, must nevertheless be small enough to ensure that  $R_g \cdot I_{dss} \ll V_{gs}$  and the gate terminal can then be considered to be at zero d.c. potential. In addition the primary characteristics of the f.e.t. are taken as  $V_p$ ,  $I_{dss}$  and  $g_m$ .

From the above it can be seen that, provided the input signal remains within the linear region, the maximum pk-pk output voltage swing in the linear region ( $V_{ds} > V_p$ ) is

$$\begin{aligned} & V_{dd} - [V_{ds(sat)} + V_{gs}] \\ &= V_{dd} - [(V_p - V_{gs}) + V_{gs}] \\ &= V_{dd} - V_p \end{aligned}$$

The voltage drop across  $R_L$  is half the swing, or  $\frac{V_{dd} - V_p}{2}$ , and this gives the optimum value of  $R_L$  as

$$R_L = \frac{V_{dd} - V_p}{2I_d}$$

But  $A_v = g_m \times R_L$

$$\begin{aligned} &= \frac{2I_{dss}}{V_p} \left( 1 - \frac{V_{gs}}{V_p} \right) \times \frac{V_{dd} - V_p}{2I_d} \\ &= \frac{V_{dd} - V_p}{V_p - V_{gs}} \text{ (with substitution for } I_d \text{).} \end{aligned}$$

Again, considering pk-pk signal voltage,

$$V_{in(max)} = \frac{V_{out(max)}}{A_v}$$

This gives  $V_{in(max)} = V_p - V_{gs}$ .

This result shows that no matter what other specifications the f.e.t. has, provided that the load resistance is substantially lower than the input impedance of the following stage, and that the drain voltage falls exactly at the centre of the output swing, an input signal of  $V_p - V_{gs}$  (pk-pk) gives the maximum output of  $V_{dd} - V_p$  (pk-pk). Consequently, a device with a low pinch-off voltage should be selected for use with a low supply voltage so that a larger output swing will be available. As a general rule, it is not worthwhile operating an f.e.t. from a supply voltage less than twice its maximum pinch-off voltage, so the 2N3819 would have to run off at least 15V. You have to be careful, of course, not to exceed the maximum voltage rating for the device—in this case it is 18 V.

It is now easy to calculate the harmonic distortion (predominantly second) produced by the above amplifier at maximum output.

$$D_2 = \frac{V_{in}}{8(V_p - V_{gs})} = \frac{1}{8} = 12\frac{1}{2}\%$$

It may seem remarkable that the above simple results should hold for any depletion mode f.e.t. but in practice a slight departure from the theoretical value would be expected due to variations in the specification of  $V_p$ , and to the fact that the assumed equations may only be approximately true.

### The problem of parameter spreads

The selection of suitable bias conditions for the f.e.t. is now considered. With a particular device, it can be seen that as  $V_{gs}$  is increased toward  $V_p$ , more voltage gain is obtained at the expense of output swing, and vice versa. A higher supply voltage increases both gain and output, but, as the designer is often tied to the supply of 12 V or so available in most equipment and because the drain-source breakdown voltage (which is only about 20 V for many popular devices) imposes limitations, this is not always a practicable proposition. Nevertheless, a quick calculation will show that quite a reasonable gain and output can be obtained with a typical f.e.t. but the problem of parameter spreads now becomes clear. If a circuit is set up with components selected to suit a device with a chosen  $V_p$  and  $I_{dss}$  substitution of a dissimilar device is

likely to cause severe bias problems. In particular, the variation in drain current will upset the vital centring of the drain voltage between  $V_{dd}$  and  $V_p$ , causing a considerable reduction in output voltage swing. Unfortunately this problem cannot be solved in general as simply as in the preceding calculations, and the best technique is to determine the maximum spreads of  $I_{dss}$  specified for the device in question, and then to calculate the optimum resistance values for a typical centre spread unit. As an example, in the case of the 2N3819, it would be best to take  $I_{dss} = 11$  mA and  $V_p = 4$  V, as these are the middle values. It also proves useful to specify  $V_{gs} = \frac{V_p}{2}$  in most cases, as

this places the input voltage swing safely in the centre of the permitted region.

Suppose, in the circuit of Fig. 1 that a device with parameters  $I_{dss}$  and  $V_p$  are inserted,  $R_S$  is adjusted to make  $V_{gs} = \frac{V_p}{2}$ , and  $R_L$  sets the drain voltage to the middle of the output swing. The drain current is therefore  $\frac{I_{dss}}{4}$ . If now the f.e.t. is removed and replaced by a device with parameters  $I_{dss'}$  and  $V_{p'}$ , where  $I_{dss'} = (a \cdot I_{dss})$  and  $V_{p'} = (b \cdot V_p)$  ( $a$  and  $b$  are small positive numbers) then the new drain current  $I_{d'}$  can be related to the original by  $I_{d'} = c \cdot I_d$ .

Substituting into the standard transfer equation,

$$I_{d'} = I_{dss'} \left( \frac{V_{p'} - V_{gs'}}{V_{p'}} \right)^2$$

giving

$$c I_d = a I_{dss} \left( 1 - \frac{c}{2b} \right)^2$$

and thus

$$c^2 \left( \frac{a}{b^2} \right) - c \left( \frac{4a}{b} + 1 \right) + 4a = 0.$$

The solution of this quadratic is

$$c = \frac{b^2}{2a} \left( \frac{4a+b}{b} - \sqrt{\frac{8a+b}{b}} \right),$$

and further simplification gives

$$c = \frac{b}{2a} [(4a+b) - \sqrt{b(8a+b)}].$$

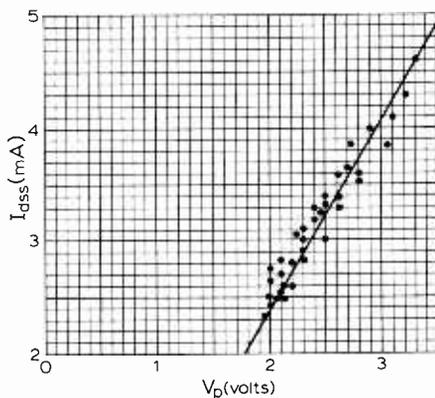


Fig. 3. Graph showing proportionality between  $V_p$  and  $I_{dss}$  for NKT80110 family—typical for most popular devices.

Approximate values of  $c$  for various values of  $a$  and  $b$  are given in Fig. 2.

This discussion assumes to a certain extent that the highest and lowest values of  $V_p$  and  $I_{dss}$  occur simultaneously, so that they are considered to be characteristic of an extreme device. In theory this is not necessarily the case, but the graph in Fig. 3 illustrates that  $V_p$  can be considered to be roughly proportional to  $I_{dss}$  for devices from the Newmarket NKT80110 family, and this can be shown empirically for most popular devices. In any event it is possible to allow for discrepancies of this nature merely by substitution of appropriate "worst cases" in the above equation.

### A practical example

An example will help to clarify the general procedure. Consider the circuit shown in Fig. 4(a) which incorporates a junction f.e.t. type NKT80212. The typical  $V_p$  and  $I_{dss}$  for this device are 700 mV and 200  $\mu$ A respectively, and setting  $V_{gs} = \frac{V_p}{2} = 350$  mV gives

a drain current of 50  $\mu$ A. The values of  $R_S$  and  $R_L$  can be calculated from this information to be 7 k $\Omega$  and 83 k $\Omega$  respectively and the nearest E12 preferred types have been specified in the diagram.

Consider now what happens when this typical device is replaced by a "lower spread" unit with  $V_p$  and  $I_{dss}$  of 500 mV and 100  $\mu$ A respectively as shown in Fig. 4(b). For this unit,  $a = \frac{1}{2}$ ,  $b = \frac{5}{7}$  and this gives  $c = 0.6$  (approximately) so the new drain current will be about 30  $\mu$ A. The source and drain voltage can now easily be calculated and it is seen that the drain voltage is above the output swing centre, causing clipping of the waveform unless its amplitude is reduced to 2.5 V pk-pk. A similar argument applies to the "upper spread" unit with  $a = 1\frac{1}{2}$ ,  $b = 1\frac{2}{7}$  and  $c = 1.35$  (approximately), giving  $I_d = 68 \mu$ A, but this time the drain voltage is too low and restricts the output to 2.5 V pk-pk. Thus the circuit will be able to yield an output of only 2.5 V pk-pk at most for any NKT80212 f.e.t. without individual circuit adjustment, as distinct from just over 8 V pk-pk for the typical device considered first.

The distortion level appears to be rather complicated to calculate, but it is sufficiently accurate to consider the ratio of available output to maximum output and multiply this by the previously determined value of 12.5%.

$$D_2 = \frac{2.5}{8} \times 12.5\% = 4\% \text{ (approximately).}$$

The justification for this calculation is understandable in the case of the typical device, as  $D_2$  is proportional to  $V_{im}$ , but this can be formally extended to cover the limit cases if desired.

### The effect of temperature

Variations in temperature, supply voltage, resistor values, etc., can readily be incorporated into the above argument, but, as the first of these can be very important, a brief outline of the method is given. The pinch-off voltage of an f.e.t. decreases with

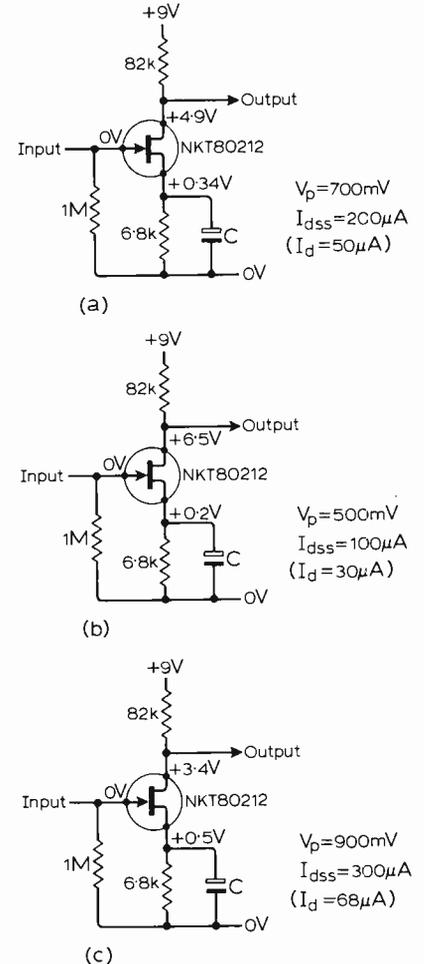


Fig. 4. Circuits illustrating the effect of parameter spreads in f.e.t.s.

temperature by a factor similar to that of a p-n junction, a typical value for diffused devices being  $-2$  mV/C°. Unfortunately it is not as easy to define a simple factor for  $I_{dss}$  as this depends on such things as carrier mobility and impurity concentrations of the particular device, but many manufacturers provide a graph of the relationship. As a guide, however, it can be estimated that  $I_{dss}$  will fall linearly with increase in temperature up to 75°C, when its value is  $\frac{3}{4}$  of that at 25°C. Conversely, the  $I_{dss}$  at  $-25^\circ$ C is  $1\frac{1}{4}$  times the value at 25°C. If the previously designed amplifier was required to operate from  $-25^\circ$  to  $+75^\circ$ C it would be necessary to consider the typical device at 25°C as before, the lower spread device at  $+75^\circ$ C and the upper at  $-25^\circ$ C. These would give a  $V_{p'}$  and  $I_{dss'}$  of 400 mV, 75  $\mu$ A and 1 V, 375  $\mu$ A for them, respectively, so  $a$ ,  $b$ , and subsequently  $c$  would be altered accordingly.

### Conclusion

"You pays your money, you takes your choice". Either you select an economical "full spread" device and accept its restricted usefulness, or pay more for a special selection with its corresponding advantages. It's not surprising that bipolar transistors are still the first choice for most audio circuits.

# Personalities

**Paul Adorian**, F.C.G.I., F.I.E.E., F.I.E.R.E., managing director of Rediffusion Ltd since 1966, is to retire at the end of October when he will be succeeded by **Hugh Dundas**, D.S.O., D.F.C., D.L., who has been on the board of the company since 1966. Mr. Adorian, who will be 65 in November, entered the field of radio communications as a student engineer with Standard Telephones and Cables. He joined Rediffusion in 1932 as a development engineer, becoming in succession assistant chief engineer and chief engineer before joining the board. He is also chairman of Redifon Ltd, manufacturers of flight simulators and communications equipment, and of Redifon-Astrodata Ltd and a director of the British Electric Traction Company Ltd. Mr. Dundas, his successor, joined Rediffusion's executive staff in 1961 from the Beaverbrook Press. He is also a director of Rediffusion's parent company, British Electric Traction, and of Thames Television.

Sinclair Radionics has bought a major shareholding in the AIM Associates Group. **Tim Eiloart**, founder of the group, has resigned from the position of chief executive but remains outside chairman of Cambridge Consultants Ltd, the research and development company of the AIM group, and **Richard Cutting** is appointed managing director. **Gordon Edge** and **Roy Hawkins**, who were joint managing directors of Cambridge Consultants, have left the company and been appointed to the Technical Division of PA Management Consultants Ltd. **David Southward**, another of the founder-directors of the company, remains managing director of AIM Electronics, AIM bioSciences and Cambridge Audio Laboratories, the Group's manufacturing subsidiaries. **Clive Sinclair**, managing director of Sinclair Radionics, which he founded eight years ago, has become chairman and chief executive of the AIM group. Mr. Sinclair has stated that the two organizations will operate independently "because of their very different fields of activity".

**Commander David W. Malim** has become chairman of Marconi Space and Defence Systems Ltd, one of the four systems companies within GEC-Marconi Electronics Ltd. Educated at the Royal Naval College, Keyham, he served as an officer in the Royal Navy throughout the war and was on the staff of the British Joint Services Mission in Washington from 1946 to 1949 when he went to the Admiralty as weapon engineer officer. On his retirement in 1959 Commander Malim became manager and director of Lancashire Dynamo Ltd, in Manchester, joining Elliott Automation Ltd in 1962 and becoming joint managing director of Elliott Space and Weapon Automation Ltd in 1963. English Electric bought Elliott Automation in 1968 and after the merger with GEC in 1969 all the electronics interests in the group were reorganized. Elliott Space and Weapon Automation became part of GEC-Marconi Electronics Ltd and Commander Malim was appointed joint managing director of GEC-Elliott Space and Weapon Systems with **Arthur S. Walsh**, M.A. (Cantab.), who now becomes managing director of Marconi Space and Defence Systems. Mr. Walsh, who is 44, was educated at Selwyn College, Cambridge, where, after service in the Royal Signals from 1944 to 1948, he graduated in natural sciences in 1951. He joined the GEC Laboratories at Stanmore in the radar microwave group and became a group leader in 1956. Mr. Walsh was appointed assistant manager of the Applied Electronics Laboratories at Stanmore in 1964, becoming manager a year later, and was technical director of GEC-AEI (Electronics) Ltd from 1966 until his appointment as joint managing director of GEC-Elliott Space and Weapon Systems Ltd in 1969.

**Leo G. Dive**, the senior assistant in the B.B.C. Engineering Information Department, is to be the Corporation's engineering representative on the B.R.E.M.A. commercial committee in succession to **Hugh Greatorex**, who

retired recently. Mr. Dive, who was from 1964-1966 senior engineer in the B.B.C.'s New York Office, has also taken over responsibility for the management and direction of the B.B.C.'s mobile colour demonstration unit which is at present on a summer tour of exhibitions and promotions. Enquiries about the unit should be addressed to Mr. Dive at the Engineering Information Department, B.B.C., Broadcasting House, London W1A 1AA.

**Eric J. Wightman** has been appointed engineering director of the Industrial Instrument Division of Smiths Industries Ltd. Mr. Wightman, who is 43, has spent a little over three years with the Industrial Instrument Division, first as chief engineer and latterly as technical manager. Before joining S.I. he spent two years as chief engineer, data systems, at Solartron and previously was with the Gyroscope Division of Sperry Rand for seven years.

**K. Milne**, Ph.D., M.I.E.E., has been appointed engineering manager of the Radar Equipment Division of Plessey Radar Ltd in succession to **R. L. Burr**, who has become technical co-ordinator for Plessey Radar. Dr. Milne began his career in 1946 as chief microwave aerial designer with Associated Electrical Industries Ltd. He was awarded his doctorate in 1951 for his thesis on wide-angle scanning properties of microwave lens aerials. In 1953 he became engineer-in-charge of systems analyses of radar systems, including c.w. and volumetric scanning radar. He joined Decca Radar Ltd in 1960. Particular projects with which he was concerned included satellite earth terminals and electronic scanning radars. He was appointed manager of Plessey Radar's Space Systems Department in 1966.

**J. W. V. Denton** is appointed national sales manager by Data Recognition Ltd, of Reading. Prior to joining D.R. he was manager, information systems, for Motorola Control Systems Ltd and before that was with Cossor Communications for four years as their regional sales manager. Mr. Denton received his training in communications and radar in the Royal Navy.

**Sir Robert Cockburn**, K.B.E., C.B., has been appointed chairman of the Council of the National Computing Centre. He succeeds **J. M. A. Smith**, who recently retired. Sir Robert, who is 61, was director of the Royal Aircraft Establishment, Farnborough, from 1964-1969. A graduate of London University, he engaged in research in communications, radar and atomic energy between 1937 and 1948 at R.A.E., the Telecommunications Research Establishment and the Atomic Energy Research

Establishment, respectively. He was the Scientific Adviser to the Air Ministry from 1948 to 1953 and between 1954 and 1959 was successively principal director of scientific research (guided weapons and electronics), deputy controller of electronics, and controller of guided weapons and electronics at the Ministry of Supply. Sir Robert, who received his knighthood in 1960, was chief scientist, Ministry of Aviation, from 1959 to 1964, and vice-chairman of the Space Committee, Ministry of Defence, from 1964-1965.

Transitron Electronic Corporation, of Wakefield, Mass., has announced the appointment of **Grahame F. Hazell** as vice-president for European Semiconductor Operations. Mr. Hazell, who is 36, is a native of Ipswich, Suffolk, and a graduate in physics of the University of Nottingham. For the past 10 years he has been employed by Texas Instruments, initially on various marketing assignments and for the past few years as operations manager of the TI facilities in Bedford and, more recently, Plymouth. The Transitron companies reporting to European Semiconductor Operations are in the UK, France, West Germany, Holland and Sweden.

**George Siddall**, who joined the Electrical Research Association as head of its Electronics Department in 1962, has been appointed assistant director technical to help Dr. B. C. Lindley, the director, in the formulation, co-ordination and control of the Association's technical policies and operational activities. He will have special responsibility for the Applied Sciences Division and for the technological planning unit.

**Robert W. Beattie** has resigned from the managing directorship of Electrofil Ltd and chairmanship of Miniature Electronic Components Ltd. He is succeeded in these positions by **John E. Carl**, B.Sc., a 42-year-old American who recently came to this country from the parent company Corning Glass Works. After graduating from Alfred University, New York, in 1951 with a degree in ceramic engineering he joined the research and development department of Corning. In 1968 he moved to the electronic components plant at Bradford, Pennsylvania, where he remained as plant manager until coming to the U.K. recently as production executive at Pallion, Sunderland.

## OBITUARY

**John Goodman**, assistant managing director of the Dubilier Condenser Co. (1925) Ltd, died recently at the age of 56. Mr. Goodman joined the company in 1932, and was appointed assistant managing director in 1966. His father was one of the founders of the company in 1912.

# World of Amateur Radio

## Awards and certificates

Although amateur operating proficiency awards and certificates have a long and respected history—for example, the “worked all continents” award dates back to the early days of the International Amateur Radio Union, founded in 1925—there are fears that the situation has rather got out of hand in recent years. As far as can be judged there are now between 800 and 1000 different awards issued by national and international societies and groups, local clubs, and in association with various amateur radio publications. While many of these do undoubtedly encourage useful activities and provide amateurs with valuable competitive yardsticks, there is a growing belief that unless care is exercised the rising flood of awards may bring the system into disrepute. The recent introduction of new awards, such as the “five-band DXCC” requiring some 500 QSL cards, valid only if of recent date, is threatening to overwhelm the amateurs in the “rarer” countries with requests for more and more cards. For several years some of these amateurs have appointed “QSL managers” to undertake the tremendous task of verifying thousands of brief radio contacts each year. But even so (and there are arguments against the system of QSL managers as this is open to abuse), it is becoming more and more difficult to obtain the rarer cards from overseas stations swamped by requests.

The R.S.G.B.—which has done much to uphold the continued value of proficiency awards—has recently announced new rules for all of its awards (details from R.S.G.B., 35 Doughty Street, London W.C.1), but one notes with some alarm that yet another major new award “The I.A.R.U. Region I Award” has been added to the list—this time at the request of the I.A.R.U. Region I Bureau.

## R.A.E. courses

Would-be amateur transmitters should note that a number of evening courses covering the syllabus of the Radio Amateurs Examination will be starting at local educational centres in many parts of the country during September. Typical of these is one at Birkenhead Technical

College where enrolment takes place from September 7 to 10, and classes are held on Thursday evenings. In this area, as in a number of others, Morse classes are held in conjunction with the local amateur radio society, in this case the Wirral A.R.S. (non-members enquiries to Alf Fisher, G3WSD, 34 Glenmore Road, Oxton, Birkenhead. We have been notified of courses at several London centres including Acton Technical College, Wembley Evening Institute and Gascoigne Recreation Centre, Barking. Readers in other parts of the country should make inquiries of their local education authority to discover if there are any local courses.

## Transceivers

Although Collins introduced an h.f. transceiver about 10 years ago, it is only quite recently that fairly substantial numbers of amateurs have swung over to the use of compact, combined transmitter-receivers.

While transceivers are generally regarded as fairly ambitious projects for home construction, many of the problems can be overcome by group construction. For example, the Nottingham Amateur Radio Club is planning a constructional project this winter under the guidance of Bob Sills, G3IQM, for a number of members to build their own five-band, largely solid-state, s.s.b. transceivers at a cost in the region of £30.

An interesting recent development in the field is the marketing in the United States of a compact 2-watt c.w.-only low-power transceiver for 3.5 and 7 MHz, for use as a fixed or vacation station. The key feature of this all-semiconductor equipment, which runs from dry batteries and is made by Ten Tec for sale at about \$55 (£23), is the use of its single variable-frequency oscillator to form the transmitter driver and a simple homodyne (synchrodyne) receiver based on a dual-gate m.o.s.f.e.t. heterodyne detector, and with a single integrated circuit providing all the a.f. amplification.

At the other end of the scale is the recent 300-watt p.e.p. CX7 transceiver by Signal/One, a subsidiary of the computer firm N.C.R. This makes full use of s.i.cs, including 16 digital and 14 linear types, 60

silicon transistors (including dual-gate f.e.t.s in the front-end) with one ceramic/metal power valve which has a beryllia coupler block to transfer anode heat to its own extruded heat sink and with many other features to put it into the *de luxe* class.

**In Brief:** Winner of the 1970 (33rd) annual B.E.R.U. Contest was R. J. Mills, VQ8CR, of Mauritius, who made 517 contacts in spite of very poor propagation conditions. Runner-up was D. M. MacVicar, VP7DX, while D. L. Courtier-Dutton, G3FPQ, was third and the leading British station. . . . A new v.h.f. beacon transmitter, GB3DM, is now operating from the I.T.A. transmitting site at Burnhope, Co. Durham. The 30-watt transmitter on 145.975 MHz feeds two four-element Yagi aerials beaming north and south, mounted at a height of 98 ft. The station can be received at good range (reports to D. Long, G3PTU, Croesor, Iveston Lane, Iveston, Leadgate, Consett, Co. Durham). . . . Among recent stations heard on h.f. bands have been FB8XX (Kergulen Islands), 4N2BR (a Yugoslav expedition to one of the Adriatic Islands), HS5ABD Chaing Mai, Thailand, 9Q5QR Kinshasha, Congo, and the Japanese EXPO '70 station JA3XPO. Also reported active recently have been CEOAE Easter Island, VPICP British Honduras, VR5LT Tonga Island and several CE9A stations on South Shetland Island. . . . An intense E-layer disturbance on July 6th resulted in long-range reception of many v.h.f. broadcasting stations on 70 and 95 MHz, and another opening to TF3EA in Iceland. . . . Among the mobile rallies being held in September are: R.S.G.B. Scottish Mobile Rally (19th) at the David Livingstone Memorial, Blantyre, Lanarkshire (details G. A. Hunter, GM3ULP, “The Bungalow”, Broomside Braes, Camp Road, Motherwell); Peterborough (20th) at Walton Senior School, Mountsteven Avenue off Lincoln Road, Peterborough; and Harlow (27th) at Magdalen Laver Village Hall (details B. G. Capper, G8CUA, 124 Peterswood, Harlow, Essex). . . . A special event station, GB3WAC, will be operating from the Sea Cadet's HQ, Scotch Yard, Tonypany, during the World Archery Championships (Sept. 10th-12th). . . . A special station, GB3CWR (or GB3CWI) will be run in connection with the Cumberland Federation of Women's Institutes “Golden Jubilee” celebrations (Sept. 6th-12th). . . . Contests during September include the V.H.F. National Field Day (6th) in conjunction with the international I.A.R.U. contest; “Worked all Europe” DX Contest (12th to 13th, phone section); 3.5-MHz Field Day (13th); and National Final of the R.S.G.B. D/F contest (20th, by Slade Radio). . . . A new world record for 13 cm is being claimed for a 249-mile contact in the United States (W4HHK and WA4HGN/P). . . . A 144-MHz moon-bounce contact has been made between New Zealand (ZL1AZR) and California (K6MYC).

PAT HAWKER, G3VA

# Literature Received

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

## ACTIVE DEVICES

Power microcircuits are the subject of some literature we have received from AEI Semiconductors, Carholme Rd. Lincoln.

- PM5A. Thyristor/rectifier diode combination, 800 V, 5A .....WW401  
 PM 6A. Diode/diode. 1.4kV. 6A .....WW402  
 PM 7A. Bridge rectifier. 1.4kV. 7A ..WW403

Motorola have produced a new journal called *Semiconductors* which is to be produced every 3 months. The first issue contains articles on integrated circuits for industry and computers, gives circuits for a 400MHz wideband amplifier, a 1Hz low-pass filter, and low-voltage inverters, and describes an integrated circuit f.m. stereo decoder ...WW404

A 96-page manual called "Power transistors for amplification switching and control" has been produced by RCA. It covers physical theory, structure, packaging, limiting factors, and the operation and requirements of power transistors in amplification, switching and in control circuitry. The price is \$2. RCA Solid State Division, Somerville, N.J.08876, U.S.A.

A range of logic modules employing, high threshold logic, d.t.l., t.t.l. and e.c.l. are the subject of a catalogue from Jasmin Electronics Ltd, 1 Meriden Close, Hainault, Ilford, Essex. The products consist of integrated circuits on printed circuit cards .....WW405

"Reliability Report—digital integrated circuits—May 1970" may be obtained from the National Semiconductor Corporation, 2900 Semiconductor Drive, Santa Clara, California 95051 .....WW406

"Planar Power Switching Transistors" is the title of a new Mullard publication for design engineers. E.E.D., Mullard Ltd, Mullard House, Torrington Place, London WC1E 7HD .....WW407

Marconi-Elliott Microelectronics Ltd, Witham, Essex, have recently started production of 54-74 series t.t.l. and have published a data sheet on their range .....WW408

## PASSIVE COMPONENTS

Bulletin 94033 from Brush Clevite Co. Ltd, Thornhill, Southampton, Hants, describes a 10.7MHz ceramic filter (type FM4) intended for use in f.m. i.f. strips. The component has a 3dB bandwidth of typically 235kHz (40dB, 900kHz max.) and an insertion loss of about 3.5dB .....WW409

An alarm annunciator capable of displaying, 12, 18 or 24 legends is described in a data sheet from Mimic Diagrams and Electronics Ltd, Maxim Rd, Crayford, Kent. The unit contains logic for alarm sequences .....WW410

Condensed catalogue 8010 from Penny and Giles Ltd, Mudeford, Christchurch BH23 4AT, Hampshire, deals with a range of precision conductive plastic potentiometers .....WW411  
 From the same company comes a fuller catalogue containing details of rectilinear and rotary potentiometers; pressure, force, acceleration and rotary transducers; and servo and signal conditioning equipment .....WW412

A wall chart devoted to wirewound trimming potentiometers may be obtained from Electrofil Ltd, Pallion, Sunderland, Co. Durham ..... WW 413

"Manual of inverter transformers and modules" has been published by Gardners Transformers Ltd, Christchurch, Hampshire BH23 3PN .....WW414

A pocket booklet describes the products of B & R Relays Ltd, Temple Fields, Harlow, Essex. ....WW415

Limit switches, microswitches and proximity switches together with various process timers are the subject of a new 20-page catalogue from Omron Precision Controls, 313 Edgware Rd, London, W.2. ....WW416

We have received the following literature concerned with audio equipment for professional use from Vitavox Ltd, Westmoreland Rd, London, N.W.9.

- B80 and B M100 microphones .....WW417  
 B50 series microphones .....WW418  
 B60 and B64 microphones .....WW419  
 Microphone stands .....WW420  
 Pressure units data sheet .....WW421  
 Type 190 circular horn .....WW422  
 Radial diffuser, lightweight hailer and 1000Hz horn .....WW423  
 Series 550 multicell horns .....WW424  
 Series 220 multicell horns .....WW425  
 Bitone loudspeaker systems (halls and cinemas) .....WW426  
 Mini-bitone speaker system (special effects in halls and cinemas) .....WW427  
 Dividing networks (cross-over) .....WW428  
 15-inch (380mm) ceramic magnet loudspeakers .....WW429  
 12-inch (305mm) ceramic magnet loudspeakers .....WW430  
 3-inch (84mm) WN350 loudspeaker unit .....WW431  
 Trade price list .....WW432

An integrated circuit patchboard which will house up to 14 packages (or more with a plug-in extension board) and which contains pulse generation, input and indication facilities is described in a leaflet from Elliott Instruments Ltd, Station Industrial Estate, South Woodham Ferrers, Nr. Chelmsford, Essex .....WW433

## APPLICATION NOTES

A leaflet "Use of 10.7MHz ceramic coupled mode filters in linear i.c. i.f. strips" is obtainable from the Brush Clevite Co. Ltd, Thornhill, Southampton, Hants .....WW434

"Power Microcircuit" describes the use of the PM5A, 6A and 7A devices mentioned in the Active Devices section. AEI Semiconductors, Carholme Rd, Lincoln .....WW435

Application report No. 6 from Brookdeal Electronics Ltd, Market St, Bracknell, Berkshire is called "Measurement of contact potential by the vibrating capacitor method" .....WW436

## EQUIPMENT

High-quality audio power amplifiers for use in the broadcasting and sound recording industries with outputs up to 100W are the subject of a leaflet from H/H Electronic, Industrial Site, Cambridge Rd, Milton, Cambridge CB4 4AZ .....WW437

The following catalogues of American equipment are available from Wessex Electronics Ltd, Stover Trading Estate, Yate, Bristol BS17 5QP.

- Wiltron Company. Sweep generators 0.1 to 18GHz, phase meters, vector network analysers, line stretchers, v.s.w.r. automatic testers, directional detectors and r.f. detectors .....WW438  
 Anzac Electronics. Broadband r.f. and microwave signal processing devices, 0.5MHz to 3GHz .....WW439  
 Wavetek Company. Function generators from sine, square and triangle manual instruments to fully programmable waveform synthesizers from 0.0015Hz to 10MHz .....WW440  
 Philco-Ford, Sierra Operations. High-power signal generators 50MHz to 3GHz, wattmeters, coaxial loads and attenuators .....WW441  
 Birtcher Corporation. Transistor and integrated circuit test equipment, computer controlled automatic test equipment .....WW442

The data sheets listed below were sent to us by Begle N.V., 718 Houba de Strooperlaam, Brussels 2.

- Rodec Fader, 22Hz to 32kHz .....WW443  
 Rodec Stereo Mixer, CU887. Four-channels with bass and treble controls, comprehensive switching facilities and twin VU meters .....WW444  
 Rodec Mixer, CU881. Four-channel stereo mixer .....WW445

Audio equipment, an amplifier (model 9000) and an f.m. tuner (model 1500), is described in literature from Bryans Amplifiers Ltd, 18 Greenacres Rd, Oldham, Lancs .....WW446

Two leaflets from Culan Electronics Ltd, By Ormiston, East Lothian, Scotland, describe a.c. power controllers up to 3kW .....WW447

SE Laboratories (Engineering) Ltd, North Feltham Trading Estate, Feltham, Middlesex have available a leaflet which briefly describes the test equipment they produce .....WW448

# New Products

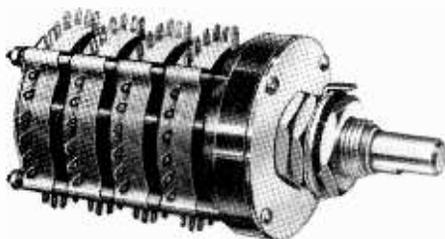
## Flying Spot Scanner Tube

A new screen phosphor is used in the Mullard, five-inch, flying spot scanner tube type Q13-110GU. The tube has magnetic focusing, a metal-backed screen, and a spark gap to prevent internal flashover between the anode and the grid. It operates with an anode voltage of 25kV and has a resolution better than 1000 lines. The new phosphor, a cerium activated yttrium aluminate, has an emission peak at 550nm and an extremely short decay time of less than 0.1 $\mu$ s. It is mixed with a blue phosphor (caesium activated yttrium silicate), which also has a short decay time. Because of the short decay time of the phosphors, the flying spot scanner tube can follow fast moving objects without blurr. Mullard Ltd., Mullard House, Torrington Place, London W.C.1.

WW 302 for further details

## Miniature Rotary Switch

Highland Electronics have announced a miniature rotary switch in the Highland/Grayhill range—series 53. The switches have the following features: up to

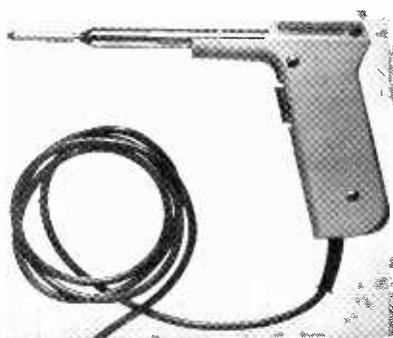


24 positions (15° indexing angle); up to 12 decks; up to 12 poles per deck; diameter over tags 1.35in; gold plated contacts. Panel and spindle seals are available. Highland Electronics Ltd, 33-41 Dallington Street, London E.C.1.

WW 303 for further details

## Quick-heating Iron

The Ersa Sprint quick-heating soldering iron, made in West Germany, is available from Home Radio (Components). Warm up time is less than 15 seconds. When the press switch is released the iron starts to



cool, but remains sufficiently hot to continue to melt solder for about 1 minute. The technique for using it therefore seems to be to press the switch for 15 seconds, then release it just at the point of starting to make the soldered joint. The switch could be held down for the whole time of soldering, particularly if there was rapid heat conduction from the joint, but this would cause the bit to oxidise more rapidly. The iron proper weighs less than 5 ounces (7 ounces with lead and plug), and when laid down on the bench after use it is balanced so that the bit does not touch the bench. Although the iron is marked 220V the suppliers state that it is suitable for all a.c. voltages from 220V to 250V and are prepared to guarantee it for use within this range. Spare parts are available and any part can be changed very quickly. Price £3 19s 6d. Home Radio (Components) Ltd, 234-240 London Road, Mitcham, Surrey, CR4 3HD.

WW329 for further details

## Op. Amp Dual Output Supply

A dual output supply to power operational amplifiers is available from Lambda Electronics. The outputs are  $\pm 12$  to 15V d.c. at 400mA for each line. The voltage difference between the lines is maintained to within 1% of absolute voltage or 0.1% change for all variations of line, load, and temperature. The unit, designated LXD-3-152, gives series connected dual outputs. Convection cooling is used and no external heat sinks or forced-air systems are required. Regulation is 0.1% of line or load; ripple and noise 1.5mV r.m.s., 5mV peak to peak. Remote sensing is provided. Current limiting is fixed and

current ratings at different operating temperatures are clearly specified. The unit measures 80 × 95 × 130mm. A 24 to 40V version is also available. Lambda Electronics, Marshland Road, Farlington, Hants.

WW 318 for further details

## Lockjaw Vice

A vice, called the Lockjaw, has been introduced which is suitable for industrial or domestic use and incorporates a number of novel features. The vice has 104mm (4 $\frac{1}{16}$  in) jaws, is 200mm (8 in) long and 100mm (4in) high and weighs about 1.75kg. The silicon metal jaws have indents and slots machined in them so that tubes and discs can be held without excessive pressure and therefore without damage. The jaws can be easily prised off and the rear jaw can be reversed (turned upside down). If this is done the rear jaw is free to pivot so that it automatically adjusts to the shape of any tapered objects that have to be clamped, again avoiding excessive damage. The vice as described above has a recommended retail price of 86s. For more delicate work rubber-faced jaws are available as an extra (14s a pair). There are three ways of mounting the vice. In its standard form it can be bolted to a bench in the normal way. A suction base can be purchased (30s) which allows the vice to be firmly attached to any flat



non-porous surface without damaging the surface in any way. Finally a substantial G-clamp is available (30s) which can be bolted to the vice so that the vice can be mounted on any convenient bench, girder, etc. Vice and Workholding Co. Ltd, 149a Crayford Rd, Crayford, Kent.

WW 301 for further details.

## Spot-frequency Marine Receivers

Two multi-channel, single-sideband receivers are introduced by Eddystone Radio. Both have crystal-control and operate on switch-selected spot frequencies. One of these models, type EC964/1, provides a choice of 52 spot frequencies in the medium- and high-frequency bands, while the other, type EC964/3 offers a choice of 28 spot frequency channels in the m.f. maritime band. The two receivers meet the British Post Office specifications TSC 102 and TSC105 respectively. The EC964/1 is primarily intended for use in ocean-going ships, while the EC964/3 is suitable for

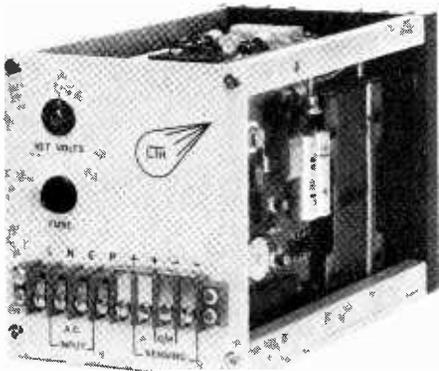


ships operating in coastal waters where the higher frequencies are not normally used. Both receivers cover the international distress and calling channel (2182 kHz), other frequencies being chosen by the customer before delivery. Channels are switch-selected to simplify operation. Reception facilities cover double-sideband and single-sideband voice transmission, upper-sideband being accepted in the latter mode. An integral monitor loudspeaker is fitted and outlets are provided for telephones and remote line circuits. Operation can be from any standard a.c. supply or from low-voltage d.c. using a G.P.O. approved d.c./a.c. converter type 978. GEC-Marconi Electronics, Eddystone Radio Ltd, Marconi House, Chelmsford, Essex.

**WW330 for further details**

## Modular Power Supplies

LTH Electronics have launched a series of compact, high specification stabilized power supply modules. Known as the LRA series, it is designed for installation into customers' equipment and is built as a 19in rack-mounting module. Both single and twin units are available with preset voltages in the range of 1-30V and 30-50V at 1, 2, 5 and 10A. The stability ratio is greater than 200,000:1 and typically 500,000:1. A fast acting, automatic-reset, over-current circuit affords complete protection against short circuit and overload. Remote sensing enables the correct voltage to be maintained at the load terminals and integral over-voltage units are available for the protection of



expensive external loads. The output resistance is less than  $0.0005\Omega$ . Ripple and noise is less than  $200\mu\text{V}$ . LTH Electronics Ltd, Eltelec Works, Chaul End Lane, Luton, Beds.

**WW327 for further details**

## Quartz-crystal Units

The McKnight Crystal Company supply a range of hermetically sealed, nitrogen filled, metal-cased AT-cut quartz-crystal units covering the frequency band 1400kHz to 20MHz. These units are available in several holder styles including miniature Def. types D, J and K. A wide range of frequency tolerances is available for oscillator or filter applications. Frequency calibration is to customers' requirements. McKnight Crystal Company, Unit 21, Shipyard Estate, Hythe, Southampton SO4 6DE.

**WW333 for further details**

## Function Generator

Model 142 HF VCG generator from Wavetek (available through Wessex Electronics) is a precision signal source with a frequency range of 0.0005Hz to 10MHz. In addition to sine, square and triangle waveforms model 142 offers a variable duty cycle on all output waveforms. This can be continuously adjusted from 5% through the usual 50% to 95%. This means that pulse outputs can be generated with on-off ratios of 1:19, 19:1 or anywhere between. A sawtooth



waveform with a rise-fall ratio of 1:19, 19:1 is also possible. In addition to the 15V pk-pk into  $50\Omega$ , the 60dB step attenuator allows clean signal levels as low as 15mV (pk-pk). An external sweep signal (either d.c. programming or a.c. modulation) can be applied to sweep the output over a 1000:1 ratio. Square-wave rise and fall time is less than 20ns. Wessex Electronics Ltd, Stover Trading Estate, Yate, Bristol BS17 5QP.

**WW332 for further details**

## Time Scale Generator

The Comark time scale generator, type 1401, provides a 'rule-scale' timing waveform from  $1\mu\text{s}$  to 10s with an accuracy of 0.005%. There are three simultaneously available waveforms. The rule-scale waveform consists of equispaced



rectangular pulses of three distinct amplitudes, every fifth and tenth being accentuated without change of duration. An 8-position switch selects the scale by specifying the least significant interval. The unscaled outputs are 1:4 mark/space ratio pulses from seven separate outputs with periods from  $1\mu\text{s}$  to 1s. The squarewave output has unity mark/space ratio and an interval of 10 times the periods indicated by the selector switch. The output stage has a rise time of 40ns and a fall time of 30ns. The internal 1MHz reference can be replaced by an external clock signal for increased accuracy or to permit generation of long time periods. Two instruments, used in cascade, will generate periods up to  $10^8$  sec. Comark Electronics Ltd, Brookside Avenue, Rustington, Littlehampton, Sussex.

**WW 324 for further details**

## 3.5-W Amplifier

A low-cost version of the General Electric (U.S.A.) PA246 5-W amplifier, the PA263, is available from Jermyn. Designed for supply voltages up to 30V it will deliver 3.5W r.m.s. continuously with about 9mV input. It may be used with various supply voltages, loads and inputs by adjusting external components. Price for quantities 1-24 is 33s (plus 2s 6d post and packing for small orders). Jermyn Industries, Vestry Estate, Sevenoaks, Kent.

**WW328 for further details**

## Dual Pulse Stretcher

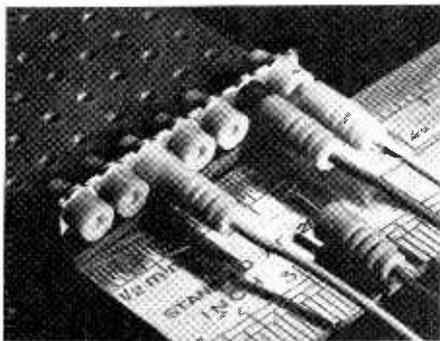
A noise-free pulse of almost any width can be generated by the type MC 675 pulse stretcher from Motorola. The width of the output pulse generated by this circuit is determined by the width of the input pulse and a time constant derived from an external capacitor and either an external or an internal resistor. Two modes of operation are made possible by the inclusion of a two-input NOR gate at the output. When the signal levels at both inputs of this gate are low and with the input pulse fed to the pulse-stretcher input terminal only, the unit operates as a

conventional pulse stretcher to generate a pulse the duration of which is related to the input pulse duration as described above. The unit can also operate as a monostable multivibrator. In this configuration, no output pulse is generated for an input noise pulse of a duration (in seconds) equal to 10 times the value of the external capacitor (in farads). Propagation delay is 110ns and the power dissipation is 180mW. Encapsulation is a plastic TO-116 package. The temperature range is  $-40$  to  $+75^{\circ}\text{C}$ . The price is 45s each for quantities of 100 and above, Motorola Semiconductors Ltd, York House, Empire Way, Wembley, Middx.

**WW331 for further details**

### Printed Circuit Sockets

Oxley Developments Company have added a subminiature socket, type 30S/093/PCB, to its range of miniature printed circuit sockets. Designed to accept the standard Oxley 30P/093 plug, the sockets mount on a standard 0.150 in (3.8mm) module printed circuit board. Plugs are inserted in a plane parallel to the



printed circuit board to allow compact board stacking. Single or multiple units with up to ten outlets can be supplied; p.t.f.e., insulating bushes are available in eleven colours to BS 2746; socket contacts are gold-plated brass. Oxley Developments Co. Ltd, Priory Park, Ulverston, Lancs.

**WW 313 for further details**

### 50-MHz Digital Frequency Meter

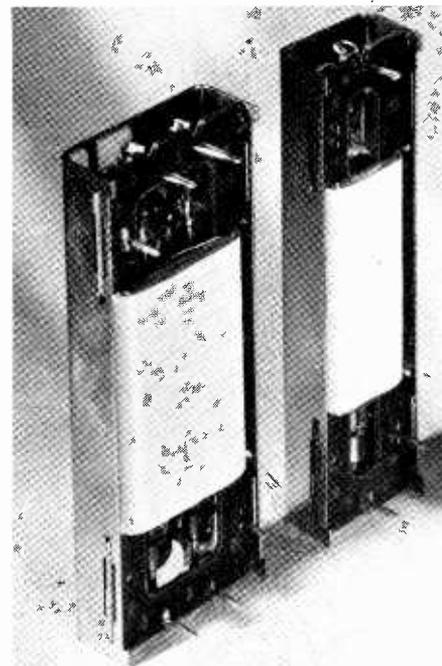
Orbit Controls have announced the first of a new family of electronic instruments for 19in rack mounting with a panel height of only  $1\frac{3}{4}$ in. Digital frequency meter type 71C 100 is a direct reading 5-decade instrument covering the spectrum 20Hz to

50MHz. Input sensitivity over the range is 10mV, and the dynamic range is better than 60dB. Three programmable gate times and four programmable display times are available. Selection of gate and display time is remotely programmed via a multipole socket on the rear panel. The instrument is designed so that it may be used to indicate the incoming frequency to a communications receiver by monitoring the local oscillator frequency. To provide direct reading, up to six frequency offsets are provided and the particular offset, equal to the receiver intermediate frequency, may be selected to add to or subtract from the local oscillator frequency as appropriate. Selection of frequency offset is, again, remotely programmed via a multipole socket on the rear panel. The front panel of the instrument is clear of controls other than a test button which enables the quartz crystal derived timing signal to be switched to the input circuit. Input, outputs, switch, etc., are located on the rear panel. The display module may, if required, be removed from the instrument and connected by an external cable to a further socket on the rear panel to provide a display remote from the instrument. An alternative version, type 71C 101, is also available, having gate and display times selected by means of front panel push-buttons. In this version the frequency offset, if required, is wired internally. In other respects the two instruments are identical. Orbit Controls Ltd, Alstone Lane Industrial Estate, Cheltenham, Glos. GL51 8JQ.

**WW 309 for further details**

### Low-cost Dry Reed Relays

A range of dry reed relays has been introduced by ITT Components Group Europe. The HRE 399, HRE 599, HRE 899 and HRE 831 are low-cost general-purpose industrial relays incorporating up to four "normally open" (make) switches. They are designed for printed-circuit mounting on boards up to 2.5mm thick, with the mounting lugs and electrical terminals being on a grid spacing of 2.54mm. The depth of the relays is 10.5mm, and magnetic and mechanical protection is provided by a metal shield. The HRE 399 relay has a maximum switching current of 0.6A a.c./d.c., maximum switching voltage of 220V a.c./d.c. and a maximum switching power of 12VA. Maximum switching current for the HRE 599 is 1A a.c./d.c.; the maximum switching voltage is 250V a.c.



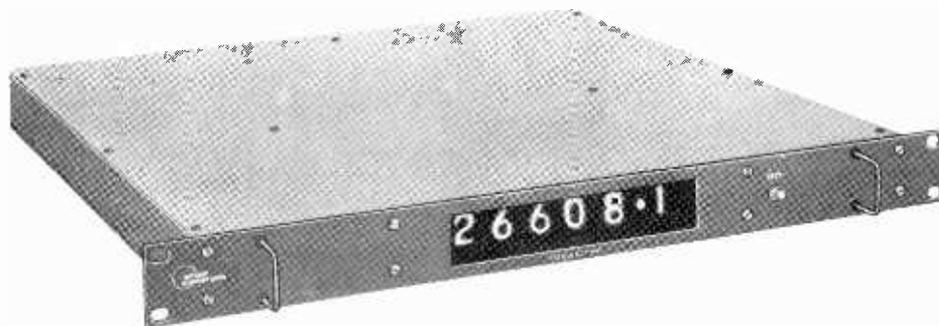
or 90V d.c. and the maximum switching power is 24VA. For the HRE 899 relay the maximum switching current is also 1A a.c./d.c., with the maximum switching voltage being 250V a.c. or 150V d.c. and the maximum switching power 60VA. The HRE 831 has the same performance as the HRE 899 relay. ITT Components Group Europe, Power Components Division, West Road, Harlow, Essex.

**WW 308 for further details**

### Signal Amplifier

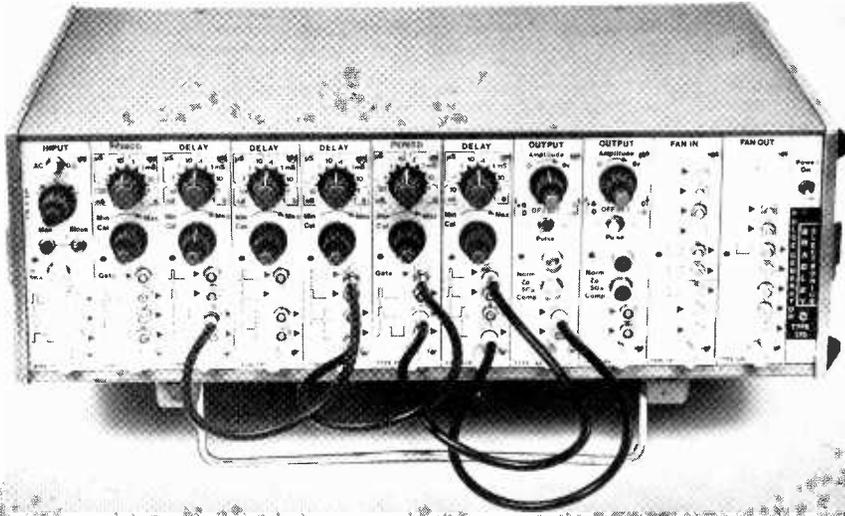
The Bournlea Dynamic d.c.-a.c. amplifier has a bandwidth from d.c. to 500kHz, 25V pk-pk output swing and employs f.e.t. input stages to provide a drift of less than  $50\mu\text{V}/^{\circ}\text{C}$  and a noise level of  $25\mu\text{V}$  r.m.s. at 60dB gain. Alternative overall gain settings of 0, 20 or 40dB are selectable by switch, the gain accuracy being 0.5dB. The  $1\text{M}\Omega$  input resistance is accurate within  $\pm 2\%$  and makes it possible to use the amplifier as an accurate high gain current to voltage converter down into the nA and pA region. Either a.c. or d.c. input coupling can be selected, the low frequency cut-off being at 1Hz in the a.c. mode. The output d.c. potential is adjustable by a single front panel control the setting of which is unaffected by the input source resistance. The output resistance is less than  $20\Omega$ . Operation is from self-contained batteries. The amplifier is available from The Cardon Instrument Co., Earls Colne, Colchester, Essex.

**WW 307 for further details**



### Modular Pulse Generator

The Bradley Modular Pulse Generator 176 is a 50 MHz instrument for generating various complex pulse patterns. The use of modules in a basic main frame provides flexibility—the modules can be arranged in any order and additional units added as required. The main frame which

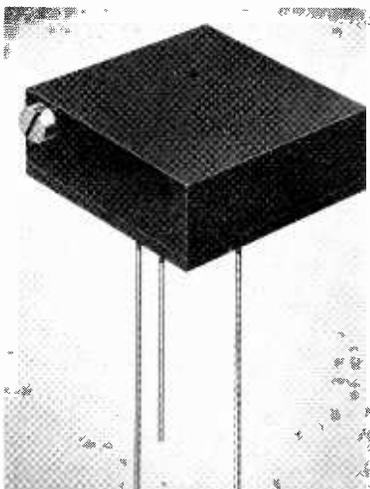


includes the stabilized power supply, can accommodate up to 11 modules. These are interconnected by coaxial cables. Six modules are currently available, the basic units being a period module capable of producing any p.r.f. from 1Hz to 50MHz, and a delay/width module providing pulse widths or delays from 10ns to 1s. Other modules include a high-impedance variable-level input unit, and an output module providing up to 6V and having a risetime of 2ns. Fan-in and fan-out units provide expansion, pulse-width subtraction, and inversion. Separate sockets are used for each interconnection, and all outputs are short circuit proof. G. & E. Bradley Ltd, Electral House, Neasden Lane, London, N.W.10.

**WW 326 for further details**

### Square Trimmer Resistor

Reliance Controls have introduced a new  $\frac{1}{2}$ -in square wirewound fully sealed trimmer. The trimmer is available in three versions, designated CW65, CW66 and CW67, dependent upon the pin configuration required. Suitable for printed circuit board mounting, the various styles allow the designer to make the maximum use of available space. Resistance range of the CW65/66/67 trimmers covers  $10\Omega$  to  $25k\Omega$ . Mechanical adjustment is 25 turns and temperature range  $-55$  to  $+155^\circ\text{C}$ . Wattage rating (whole element uniformly

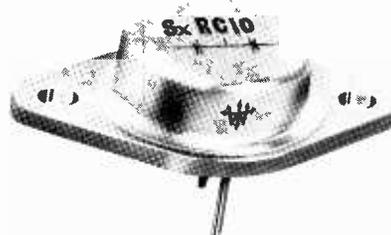


loaded) is 1W at  $20^\circ\text{C}$ , derating to zero to  $155^\circ\text{C}$ . Insulation resistance is  $1000M\Omega$  at 500V d.c. The wiper is of gold plated beryllium copper, and the terminals are gold plated. Reliance Controls Ltd, Drakes Way, Swindon, Wilts.

**WW 316 for further details**

### Centre-tap Silicon Diode Assemblies

The Semiconductor Division of Westinghouse Brake and Signal Co. have introduced a series of silicon double-diode rectifiers rated at 20A with voltage ratings of 100-600V. This series of centre-tap assemblies is designated



SxRC10 and SxRN10. Higher than usual overload to mean-current rating ratio is claimed. Housing is a standard TO-3 glass/metal package which permits mounting on normal transistor heat sinks. Westinghouse Brake and Signal Co. Ltd, 82 York Way, King's Cross, London N.1.

**WW 306 for further details**

### Thyristors for High-frequency Inverters

Two new families of thyristors available from Mullard have high  $di/dt$  and  $dv/dt$  ratings of  $100A/\mu\text{s}$  and  $200V/\mu\text{s}$  respectively with crest working voltages of 800, 1000, and 1,200V. Types BTW23 and BTW24, are p-gate, reverse blocking, avalanche devices intended for use in high-frequency inverters and motor-control circuits. The BTW23 thyristors have a maximum forward current rating of 70A and an avalanche rating of 40kW when a square pulse of  $10\mu\text{s}$  duration is applied and the junction temperature is  $25^\circ\text{C}$ . The thyristors have an encapsulation

similar to the TO-49 with an M12 thread, on the stud. The BTW24 thyristors have a forward current rating of 30A and an avalanche rating of 20kW ( $10\mu\text{s}$  square pulse when junction temperature is  $25^\circ\text{C}$ ). These thyristors are contained within TO-103 encapsulations. Mullard Ltd, Mullard House, Torrington Place, London W.C.1.

**WW 322 for further details**

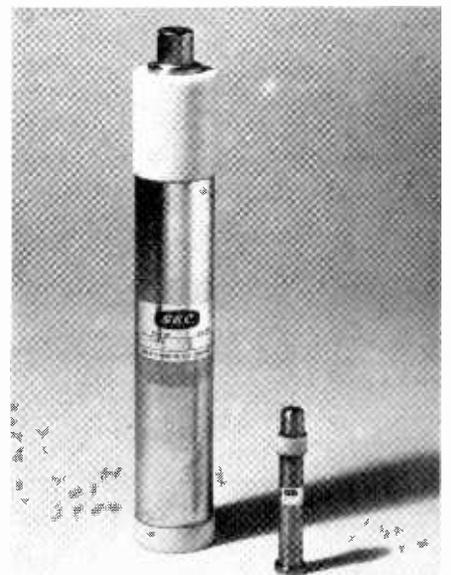
### 100-W Power Transistor

Microwave Associates have announced the first 100-W power transistor at 1GHz, designed specifically for pulse applications. The device will provide 10dB gain as an amplifier, and 60 watts output as an oscillator, at 1GHz. Microwave Associates Ltd, Cradock Road, Luton, Beds.

**WW 310 for further details**

### Corona Stabilizers

The M-O Valve Company has extended its range of metal/ceramic corona stabilizers with the introduction of the SC8 and SC9 series. The SC8 (the larger in the photograph) provides stabilized voltages in the range 25 to 50kV in six 5kV stages and the SC9 in the range 350 to 2000V in 11 stages of from 50 to 200V. Specific voltage types can also be made to

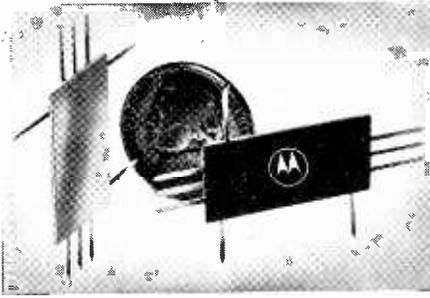


customers' special requirements. After one minute the voltage remains constant to within 0.25% of the initial value for at least two hours, and long-term stability is better than 1% per 1000 hours. The temperature coefficient of the SC8 is 0.005%/ $^\circ\text{C}$  while for the SC9 it is measured at 0.3V/ $^\circ\text{C}$  over the temperature range  $-40$  to  $+90^\circ\text{C}$ . The M-O Valve Co. Ltd, Brook Green Works, London W.6.

**WW 323 for further details**

### Microwave Duplexer

Type MCH5890 microwave duplexer from Motorola consists of two



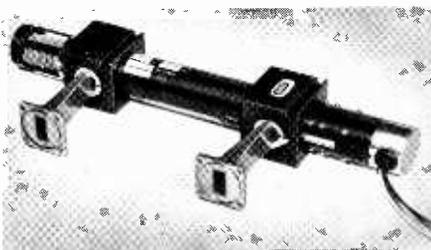
step-recovery diodes, one connected in series between the transmitter terminals and the receiver terminals, and the other one shunting both pairs of terminals. The device can accept a 40W input power. During transmission the insertion loss between aerial and transmitter terminals is only 0.1dB while the isolation between the aerial and receiver terminals is 25dB. Motorola Semiconductors Ltd, York House, Empire Way, Wembley, Middx. **WW 319 for further details**

### M.O.S. Arrays for Electronic Organs

Two m.o.s. arrays specifically designed for electronic organs are available from WEL. Array type MA70 is a  $12\sqrt{2}$  divider giving true semi-tones. Array type MA60 is a six-stage binary divider giving six outputs each one octave apart. (An electronic organ can be made with four MA70 circuits and twelve MA60s.) For organ designers requiring a free-phase system 30 MA70s could be used. Prices are about £3 10s. for the MA70 and 25s for the MA60 (for quantities in excess of 1,000 pieces). WEL Components Ltd, 5 Loverock Road, Reading, Berks. **WW 320 for further details**

### Lightweight X-band Travelling-wave Tube

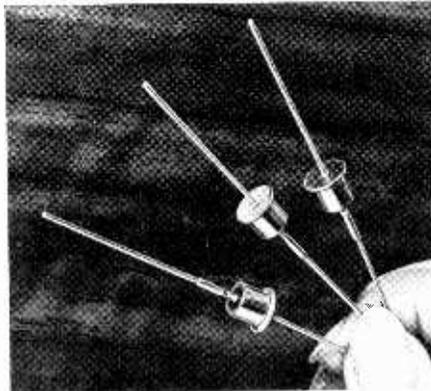
The M-O Valve Company has introduced a low-cost lightweight X-band travelling wave amplifier, type TWX34, giving a minimum gain of 35dB and a saturated power output of 1W over the frequency range 7.5 to 11 GHz. A typical application is in the ground station of a transportable satellite communications system where continuous operation in ambient temperatures of up to 60°C and ability to withstand shock, vibration and high humidity conditions are required. A low wattage oxide coated cathode has been incorporated and total power supply consumption under full r.f. drive conditions is less than 25W. Power supply connections are by flying leads, but other



types of connection can be provided on request. The M-O Valve Co. Ltd, Brook Green Works, London W.6. **WW 321 for further details**

### Switching Diode

A silicon planar, epitaxial, whiskerless diode, type BAV44, is announced by Mullard. It can rapidly switch currents up to 1A, and is primarily intended for use in servo amplifiers, digital voltmeters and oscilloscopes. Maximum continuous

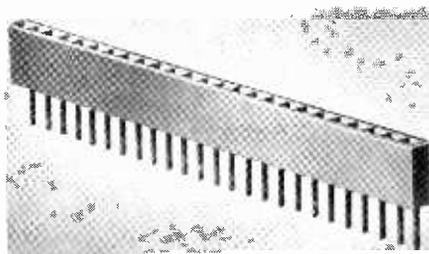


reverse voltage is 65V and the maximum voltage drop with a forward current of 1A is 1.25V. Switching time ( $t_{rr}$ ) from  $I_F = 1.0A$  to  $I_R = 1.0A$  and measured at  $I_{rr} = 100mA$  is 22ns. Diode capacitance is 7.5pF. Mullard Ltd, Mullard House, Torrington Place, London W.C.1.

**WW 325 for further details**

### Integrated Circuit Socket

Employing a new concept in socket design for integrated circuits and semiconductor devices, the A23/2033 now available from Jermyn, is a 25-contact single strip socket capable of accepting either flat or round

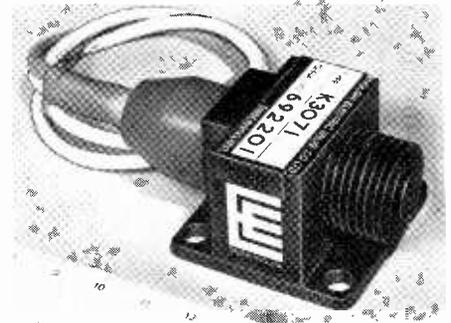


leads. The body of glass-filled nylon is fitted with gold flash phosphor bronze contacts, giving a life of up to 10,000 insertions with an electrical resistance of 15m  $\Omega$ . Jermyn Industries, Vestry Estate, Sevenoaks, Kent.

**WW 305 for further details**

### Oscillator Klystron

A forced-air cooled, fixed frequency, two cavity oscillator klystron (K3071), for operation in airborne Doppler and beacon radar equipment, has been introduced by English Electric Valve Co. The tube incorporates a heater design claimed to give a lower level of heater f.m. than

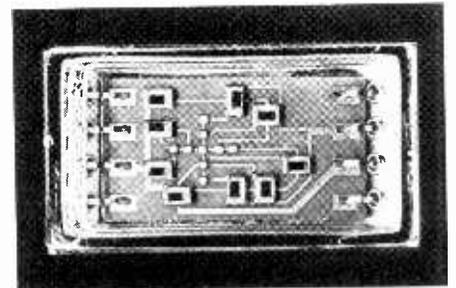


hitherto attainable. In addition, the sturdy construction results in a tube having low noise and low microphony. A further improvement is its longer life expectancy compared with earlier types. Operating frequency of the K3071 is  $8800 \pm 5MHz$  and a typical output power is 1.5W, but variants can be supplied for operation at any frequency in the 8 to 9.5 GHz range. Silicone rubber moulded connections are used for unpressurized high-altitude operation. English Electric Valve Co. Ltd, Chelmsford, Essex.

**WW 315 for further details**

### Solid-state Plus/Minus Sign

To indicate plus or minus information, a light-emitting diode display module has been added to Hewlett-Packard's numeric indicators. The model 5082-7018 plus/minus sign comes in the same package as the 5082-7000 series of numeric indicators. It operates at less than



5V. A plus or a minus is displayed by applying a drive voltage to one (minus sign) or two (plus sign) input leads. A third lead is the earth connection. Brightness can be varied by changing the d.c. drive between 1.6 and 4V. Hewlett-Packard Ltd, 224 Bath Road, Slough, Bucks.

**WW 317 for further details**

### Schmitt Trigger I.C.

SN7413N Schmitt trigger combines two 4-input positive nand gates. Each gate has different input levels for positive and negative going signals. Hysteresis (the difference between two threshold levels) is typically 800mV. Noisy pulses can be accommodated without false trigger regardless of change of temperature. The units also fire reliably with rise and fall times slower than 1V per second. The unit is housed in a 14-pin dual-in-line plastic package and costs 10s 1d each in quantities of 100. WEL Components Ltd, 5 Loverock Road, Reading, Berks.

**WW 311 for further details**

# Real and Imaginary

## “Have we eaten of the insane root that takes the reason prisoner?”

Now that the dust of the General Election has settled, with the computers, both electro-mechanical and human, duly confounded,\* we are now looking forward with differing degrees of trepidation to the delights the future holds under our new masters.

The political parties are unanimous in plumping for increased production for export as the prime means of salvation. This being so, I thought that for a few minutes we might do worse than to take a look at our own electronics industry to see whether anything could be done to improve existing performance.

The position of industry in general can be likened to that of a farmer who possesses twenty cows. Under Communism, the State takes the cows and sells some of the milk back to the farmer. Labour buys the milk from the farmer and pours it down the drain. The Conservative policy is to get the farmer to sell five cows and buy a bull. The Liberal outlook is much the same except that they would employ A.I. All, however, subscribe (by implication at least) to the premise that the bigger the organization the more efficient it is; so the trend has been towards the scooping of a multitude of little electronics concerns into a few gigantic ones.

We all know the arguments for mergers—streamlining, rationalization, the avoidance of duplication of effort, are all stock phrases—but, according to a recently published study,† most take-overs and mergers are made for the security and convenience of the management of the bidding company. Usually (it says) the major motives are to gain bigger shares of their markets, reduce competition or protect themselves from other predatory firms.

Be that as it may, the concept that the greater the size, the greater the efficiency, is rubbish, and those who argue for it take no account of human nature. As an instance, those of you who run your own small businesses won't need to be told that economies in small matters make the difference between extracting a living and going broke.

Not so in the big organization. To the clerk who is writing a letter about a £250,000 order, a second sheet of paper is too trifling a matter to be considered and it is far too easy to reach for a telephone to save the fag of writing.

In such circumstances the management's typical reaction is either nil, which is bad, or to create a Gestapo department to deal with it, which is often worse. Control departments of this character are frequently parasitic growths, sucking out an existence from the main stem of profits, for they can, all too easily, cost more to maintain than the savings they effect.

A typical example of the control system now in vogue is P.E.R.T. (the initials stand for Programme Evaluation and Review Technique). In essence this is a semi-diagrammatic method of ensuring that all the bits and pieces for a large contract come together at the right times and places so that the job flows smoothly to completion on schedule. It also sets out to keep tabs on costs and to aid the solution of various management problems. It is the sort of thing that no trendy company would dream of doing without, on the grounds that present-day systems orders are on so large a scale that it would be impossible to control them efficiently in any other way. But some while ago I was at a gathering which included several veteran engineers and I was amazed to hear from one of them of the size and complexity of some of the radio communication systems which were undertaken between the wars, and even back in the 1914-18 period. Nobody had ever heard of P.E.R.T. in those days, but the jobs got done in far quicker time than they would take today. At that time it was part of engineering training to be able to visualize the demands for materials well before they arose, and to order accordingly. The man who couldn't do that didn't become a senior or chief engineer or if he did, he didn't last long. He was sacked.

Now P.E.R.T. in principle is applied commonsense and, used rationally, is well enough. It is at its interface with human nature that it can fall down badly. Elevate it to the status of a department and it can so easily become a coterie of high priests whose main—although perhaps unconscious—aim is to preserve the mystique and to enlarge the sphere of influence of

the cult.

The computer is another control system which is wide open to misuse. Computers tend to be run by an alien race of high priests who, protected from close investigation by reason of the jargon of their calling, can easily let enthusiasm outweigh sober judgement and advocate the use of highly expensive machines for jobs that a desk calculator could do in less time and at a fraction of the cost.

A big combine tends to be riddled with control departments; all were instituted with the best of intentions; some, possibly, save the company money. But it would at any rate do no harm for such a firm to take a cool, hard look at all such areas to see whether they are costing more to maintain than the amounts they save. The grave danger, too, with efficiency-control systems is that they can easily become a cloak for managerial ineptitude and face-saving. When things go wrong their presence can make the difference between the personal admission of “I was to blame” and the shrugging-off comment “Unfortunately there was an undetected error in the computer programming”. Such an outlook leads by logical progression to the present prevalent practice of calling in an external firm of management consultants to advise on company reorganization. By definition a manager's function is to manage, and do so to such effect that he makes a profit for his company. If he cannot do this, then he should go.

Are we, in fact, making too much of a fetish of large-scale electronics groupings and business efficiency systems? These approaches of course are an aping of American techniques, but what is sauce for the American goose is not necessarily sauce for the British gander; it should not be forgotten that, in spite of its size and vaunted efficiency, the American electronics industry would collapse like a house of cards if disarmament became a reality and government-sponsored space programmes were stopped.

Now I come to think of it, the humble tea-break is, in its way, symptomatic of the whole business of pseudo-efficiency. Time was when the tea-lady and her trolley did the rounds twice daily, dispensing cheer to all. But, “Inefficient!” said the experts, and proceeded to prove on paper how much cheaper machines would be. “Splendid!” said management and so it came to pass that machines were installed and the tea-lady was out.

After the inevitable teething troubles, things go famously for a while and the revenue rockets. Management rubs its hands, overlooking the fact that a three-fold increase in takings signifies that a considerable proportion of the proletariat are now taking several tea-breaks *per diem* instead of the statutory two.

This bit of automation was originally an American idea which has been widely copied over here. But one world-famous firm has, to my certain knowledge, seen the light and has gone back to the once-derided trolley. I hardly like to mention this, but it's located in the U.S.A.

\* With one exception; see this page, May issue.

† (“Management and Merger Activity” by Gerald Newbould.)

# F. M. Tuners

## Outline details of some up-to-date units

It is fair to suggest that the poor relation of most hi-fi enthusiasts' systems is the radio tuner, if indeed a tuner is included at all.

While at any time the upper crust of the hi-fi fraternity are willing to enter into protracted and sometimes pretentious discussion of purely mechanical parameters such as wow and flutter, mass, compliance, trackability and so on, radio reception is hardly regarded by some as worthy of consideration. Yet this latter via the radio tuner is a truly electronic signal source that could be more actively utilized. Most of the country is now covered by v.h.f. transmitters so that it is possible for the majority of listeners to receive a reliable signal\*. If the transmission is a "live" one originating in a studio local to the transmitter, the output from a hi-fi system can be of superbly high quality, especially on stereo.

Hi-fi probably came into its own as a "following", with the introduction of the LP disc and thus made possible music quality in the home far superior to that supplied by long- and medium-wave a.m. radio. But medium-wave radio has nothing to do with hi-fi and it is only at v.h.f. with f.m. transmissions that radio, mainly because of better noise performance at those frequencies, can compete with the record. It is true that some manufacturers supply an a.m./f.m. tuner with medium-, long- and sometimes short-wave reception, in addition to the v.h.f. band. However, no one pretends that quality programmes are possible on the a.m. bands and these are usually included merely to give maximum coverage of the available transmissions, since the v.h.f. band provides only B.B.C. programmes Radio 2, 3 and 4, and some local radio. Also v.h.f. has limited area coverage and foreign programmes generally can only be received on a.m. bands.

### Importance of tuning

The distortion content of an f.m. transmission is potentially extremely small. One particular requirement to avoid distortion on f.m. is accuracy of tuning. Unlike the simple a.m. demodulator, if the i.f. signal is not centred on the linear portion of the f.m. discriminator

characteristic the demodulated audio signal will be non-linear. Again unlike a.m. reception it is not easy with an f.m. tuner for the listener to find the centre frequency by ear and most tuners feature visual and automatic electronic facilities to assist in tuning and to prevent oscillator drift with time.

### Sensitivity and noise

It is in the matter of audio dynamic range and signal-to-noise ratio that disc recordings could be said to be superior to that of broadcast signals. Because of the need to maintain the broadcast signal at a reasonably high average it is necessary for the B.B.C. to limit the audio dynamic range (the range from the softest to the loudest passage) to a particular ratio; 30-35dB having been quoted. Recordings have not the same limitations of dynamic range. On the question of noise, one big advantage of the f.m. system over a.m. is that extraneous signals which display an a.m. characteristic can be removed from the input signal by a limiter circuit. These include static and man-made interference such as that caused by ignition systems and electrical apparatus. By limiting the maximum amplitude of all signals, the discriminator is presented with a signal of constant amplitude, with variations in frequency only.

Random noise (white noise) contains a.m. and f.m. components and the f.m. when detected is heard as a background noise or hiss. Because of the nature of f.m. detection and the use of a.g.c. circuits the audio output from the detector is reasonably constant and the difference between strong and weak stations manifests itself by the amount of background noise present. To obtain good clean reception (and the worst is always cleaner than a.m.) it is desirable for the tuner to enjoy good sensitivity and low noise when the amplifying stages are working at high gain. This "usable" sensitivity is invariably quoted by tuner manufacturers as so many  $\mu\text{V}$  for so many dBs quieting, for example: 2  $\mu\text{V}$  for 30dB quieting being typical.

Noise increases as the audio frequency range is extended, and this is counteracted by emphasizing the high-frequency end of the audio range before transmission and

de-emphasizing by the same amount in the receiver. By this means the frequency response effectively remains level but the accompanying noise is attenuated. The de-emphasis figure is quoted as 50 $\mu\text{sec}$  which represents the time-constant of the de-emphasis circuit.

As has been stated then the greatest advantage of f.m. over a.m. is the virtual elimination of interference and this combined with transmissions at v.h.f. has allowed a greater audio bandwidth. Some programmes, however, which are routed over many miles of land-line networks before reaching the transmitter, suffer from attenuation of the high frequencies. The U.K. system bandwidth is 15kHz with a deviation frequency of  $\pm 75\text{kHz}$ . The ratio of deviation frequency to the highest audio frequency (deviation ratio) has a direct influence on noise performance†. The i.f. bandwidth of an f.m. tuner is typically 200kHz at the 6dB points. The response should be symmetrical, and the linear portion of the discriminator characteristic should cover at least 100kHz to prevent distortion. (Grundig claim for their RT100 tuner that the distortion factor is below 1% when it is detuned by 50kHz.) Although present-day tuners are very sensitive and can be operated from relatively crude aerial installations, distortion can arise as a result of multipath reception and for this reason alone it is wise to consider the erection of an efficient outdoor aerial preferably with some directional properties. All v.h.f./f.m. transmissions are horizontally polarized which means that even the simple dipole offers some rejection of reflected signals on a horizontal plane but "aircraft flutter" can be troublesome in some areas. A particularly unpleasant form of distortion can occur from reflected signals which makes piano music sound as if the speaker windings were dragging the magnet pole piece.

### Basic requirements

Having settled on a suitable aerial, all that is necessary for enjoyable reception on an existing hi-fi amplifier and speakers is a quite simple, well designed tuner. It

\* See "B.B.C. Band-two Broadcasting Stations", in the August issue, page 401.

† For further reading: "F-M Simplified" by Milton S. Kiver. Published by D. Van Nostrand Co. Inc., Princeton, New Jersey, U.S.A.

should have good sensitivity so that the limiter is always saturated, adequate bandwidth with good response, a stable oscillator and a discriminator with a high order of linearity. To save further on cost the tuner could be powered from the main amplifier if the amplifier power supply ratings allow but for convenience it is better to buy a tuner unit with its own mains power unit. Such a tuner can be obtained for a modest sum. If stereo reception is required the tuner must incorporate a stereo decoder. Most modern tuners are suitable for stereo

reception but if cost is a prime factor a "stereo ready" tuner could be purchased and used on mono. It could be converted to stereo at a later date by means of a plug-in decoder module available from the manufacturer.

Refinements on the more expensive tuners are extras which improve reception in weak-signal or difficult areas and electronic aids to relieve the user of a certain amount of guesswork. Among these are visual tuning indicators which may take the form of an ordinary meter movement, an electronic tuning eye or

even a system of coloured lights to indicate which side of the centre frequency the tuner is off-tune and when it is on-tune. Probably the largest single influence on good stereo quality is the decoder itself. Manufacturers favour different methods of extracting the left and right-hand channels from the composite signal but a point to watch out for here is the degree of channel separation. This should be typically 30dB at 1kHz.

In the early days of stereo transmissions some tuners gave a visual indication of when a stereo signal was present and it was then necessary to switch the tuner manually to stereo. Nowadays it is more usual for the stereo signal to switch-in the decoder automatically, at the same time lighting a pilot lamp to indicate that stereo is being received. Many tuners with automatic switching still retain a manual mono override switch because in fringe reception areas or situations where the stereo signal is very weak it may be preferable to hear the programme in mono with less background noise, which is the case when the decoder is muted. It should be mentioned that stereo transmissions in any case contain more noise than mono transmissions when received on a mono tuner because the audio information occupies slightly less of the carrier modulation depth.

To assist listeners in setting up their equipment correctly, the B.B.C. transmits special test signals at scheduled times. Details of these are set out in cols. 1 and 2 opposite.

If it appears that we are dwelling too long on the possibility that programmes are likely to be degraded by noise let us put things in perspective by saying that in the poorest conditions the noise on f.m. is less than is the norm on a.m., especially after dusk. With a "usable" signal, noise on f.m. is virtually inaudible.

### Use of new devices

Noise performance has again been improved as of late by the use of field effect transistors. These devices also make it easier to apply automatic gain control than do bipolar transistors and for these and other reasons many makers use an f.e.t. as an r.f. amplifier. Ceramic filters in place of conventional i.f. transformers are coming in and so too are i.c.s. The use of i.c.s no doubt eases production problems and ceramic filters can be designed with wideband characteristics and sharp cut-off to provide the necessary selectivity without the use of a large number of tuned circuits in the i.f. stages.

More and more manufacturers are now employing capacitance-diode tuning. This allows the ganged tuning capacitor to be dispensed with and tuning to be carried out by a single potentiometer. Sometimes four or more potentiometers are included, each with a separate tuning scale and press-button thus allowing the user to preset his tuner to four or more stations.

Oscillator frequency drift is corrected in most f.m. tuners by an automatic frequency control circuit (a.f.c.) which has

## Stereo test tone transmissions

To facilitate channel identification and adjustment of channel cross-talk a 250Hz tone is transmitted every day except Wednesday and Saturday in the left channel only from about four minutes after the end of Radio 3 until 23.55. This test may be interrupted from time to time. On Wednesday and Saturday the following test sequence is transmitted by the B.B.C.

Test No.	Time (Approx.)	Left channel (A)	Right channel (B)	Purpose
1	23.42	250Hz at zero level	440Hz at zero level	Identification of left and right channels and setting of reference level
2	23.44	900Hz at +7dB	900Hz at +7dB, antiphase to left channel	Adjustment of phase of regenerated subcarrier and check of distortion with signal wholly in the (A-B), i.e. S, channel
3	23.48	900Hz at +7dB	900Hz at +7dB, in phase with left channel	Check of distortion with signal wholly in the (A+B), i.e. M, channel
4	23.49	900Hz at +7dB	No modulation	Check of A to B cross-talk
5	23.50	No modulation	900Hz at +7dB	Check of B to A cross-talk
6	23.51.20	Tone sequence at -4dB: 60Hz 900Hz 5kHz 10kHz This sequence is repeated	No modulation	Check of A-channel frequency response and A to B cross-talk at high and low frequencies
7	23.52.20	No modulation	Tone sequences as for left channel on Test 6	Check of B-channel frequency response and B to A cross-talk at high and low frequencies
8	23.53.20	No modulation	No modulation	Check of noise level in the presence of pilot tone
23.55		Reversion to monophonic transmission		

The schedule is subject to variation or cancellation to accord with programme requirements and essential transmission tests.

The zero level reference corresponds to 40% of the maximum level of modulation applied to either stereophonic channel before pre-emphasis. All tests are transmitted with pre-emphasis. Periods of tone lasting several minutes are interrupted momentarily at one-minute intervals.

With receivers having separate controls of subcarrier phase and cross-talk, the correct order of alignment is to adjust first the subcarrier phase to produce maximum output from either the A or the B channel during test-2 and then to adjust the cross-talk (or 'separation') control on tests-4 and -5 for minimum cross-talk between channels.

With receivers in which the only control of cross-talk is by adjustment of subcarrier phase, this adjustment should be made on tests-4 and -5.

Adjustment of the 'balance' control to produce equal loudness from A and B loudspeakers, is best carried out when listening to the announcements during a stereophonic transmission, which are always made from a centre-stage position. If this adjustment is attempted during the tone transmissions, the results may be confused because of the occurrence of standing-wave patterns in the listening room.

The outputs of most receivers include significant levels of the 19kHz pilot tone and its harmonics. These components do not interfere with normal listening but do affect most signal-level meters. It is essential, therefore, to provide filters with adequate loss at these frequencies if instruments are to be used for the above tests.

Wireless World, September 1970

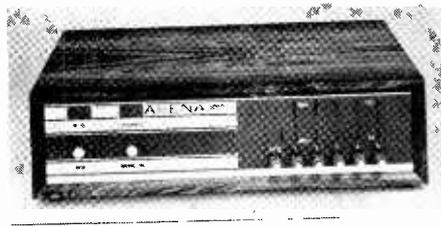
a pull-in range of some 150-200kHz. Provision is commonly included to switch-out the a.f.c. so that the correct tuning point can first be found without the masking effect of the automatic tuning, which is then switched-in to take care of drift. Some listeners may wish to receive an f.m. station in an adjacent transmission area or those living in south-east coastal regions may sometimes receive Continental f.m. stations. These transmissions are necessarily much weaker than the local station and it is useful to be able to switch-out the a.f.c. in this situation to prevent the tuner being "captured" by the strong local signal.

#### Available units

We circulated all known makers and suppliers of f.m. tuner units in the U.K. for details of their products and from each of those who replied we have selected one model for a short review in the following pages. We stipulated that the tuner must have a v.h.f./f.m. band but it could also cover a.m. bands. Unless stated otherwise the tuners mentioned are for a.c. mains operation. Tuner/amplifiers are excluded. Some specifications are suffixed (I.H.F.) where this has been given on the particular manufacturer's returns. It may well be however, that some unmarked specifications for tuners from other manufacturers are also to I.H.F. requirements but have not been so defined. I.H.F. are the initial letters of an American body, the Institute of High Fidelity, which lays down methods of measurement for audio equipment. In some cases it can provide for enhanced published performance figures.

Prices quoted are the suggested retail prices in force at the time of going to press, and include purchase tax.

#### Arena F211 (f.m. stereo)



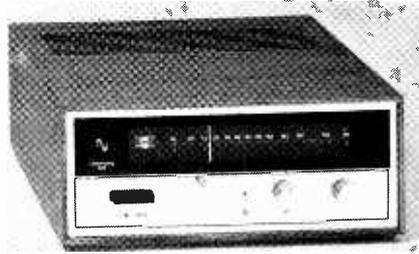
Sensitivity:  $3\mu\text{V}$  for 20dB quieting at 40kHz deviation.  
I.F. bandwidth: 250kHz.  
Discriminator bandwidth: 600kHz.  
A.M. suppression: better than 50dB, limiting from  $4\mu\text{V}$ .

Frequency response: 20-15000Hz.  
Channel separation: better than 30dB (250-6300Hz)  
Carrier suppression: better than 50dB.  
Price: 35gn.

Automatic stereo switching with indicator and mono override switch; switched a.f.c.; capacitance-diode tuning with five press-buttons and scales. U.K. agents: Highgate Acoustics, 184-188 Great Portland Street, London W.1.

#### Armstrong 524

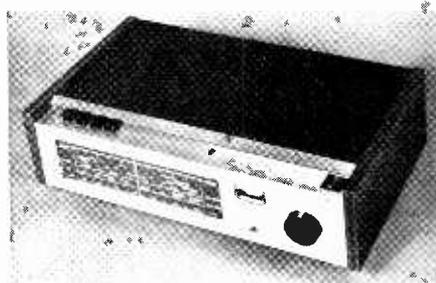
(f.m., decoder optional)



Sensitivity:  $1.5\mu\text{V}$  (mono),  $5\mu\text{V}$  (stereo) for 30dB s/n ratio at 75kHz deviation.  
Limiting: Full limiting at  $5\mu\text{V}$ .  
I.F. bandwidth: 220kHz at 6dB.  
I.F. rejection: 90dB.  
Aerial inputs: 70-80 $\Omega$  and 300 $\Omega$ .  
Output voltage: 300mV (average).  
Output impedance: 1k $\Omega$ .  
Price: £40 4s 6d.

When decoder is fitted, channel separation is 30dB at 1kHz, suppression at 38kHz is 40dB; automatic switching and stereo indicator; tuning meter and interstation noise suppression. Armstrong Audio Ltd, Warlters Road, London N.7.

#### Bush (a.m./f.m. stereo)



Sensitivity:  $3\mu\text{V}$  for 26dB s/n ratio (mono).  
Aerial input: not quoted.  
Output voltage: 2V (max).  
Output impedance: 1M $\Omega$ .  
Power supply: external from Bush stereo amplifier via 5-pin DIN type socket.  
Price: £36 15s.  
Tuner intended primarily for use with Bush stereo amplifier. Features a.f.c. on f.m. with switch; stereo indicator and tuning meter. Above details refer to f.m. section. Coverage on a.m. is long- and medium-wave bands with internal ferrite

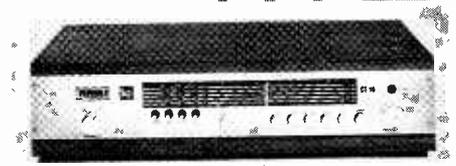
rod aerial. Rank Bush Murphy Ltd, Power Road, Chiswick, London W.4.

#### Beomaster 5000 (f.m. stereo)



Sensitivity:  $0.8\mu\text{V}$  for 20dB s/n ratio, 75kHz deviation.  
I.F. bandwidth: 200kHz at 3dB.  
Detector bandwidth: 1MHz.  
Crosstalk: 40dB at 1kHz.  
Aerial input: 75-300 $\Omega$ .  
Output voltage: adjustable between 55mV and 1V.  
Pilot and carrier suppression: 50dB.  
Price: £105 (teak), £106 (rosewood).  
Ceramic filters and f.e.t. r.f. amp. and mixer incorporated; a.f.c.; automatic stereo switching with level adjustable between 1 and 100 $\mu\text{V}$ ; interstation muting. Bang & Olufsen U.K. Ltd, Eastbrook Road, Gloucester GL4 7DE.

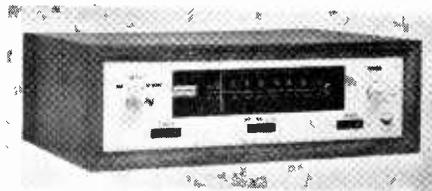
#### Dual CT16 (a.m./f.m. stereo)



Sensitivity:  $1.5\mu\text{V}$  for 26dB quieting at 22.5kHz deviation (mono).  
Image rejection: 50dB.  
I.F. bandwidth: 200kHz.  
Channel separation: better than 45dB.  
Pilot tone suppression: better than 50dB.  
Aerial input: 240 $\Omega$ .  
Output voltage: 0.8V for 30% modulation.  
Output impedance: 47k $\Omega$ .  
Price: £106.  
Automatic stereo switching and stereo indicator; audio response 40-15000Hz  $\pm 1.5\text{dB}$ . Above details refer to f.m. section. On a.m. frequency coverage is 150-350kHz (l.w.), 500-1650kHz (m.w.), 6.7-15.4MHz and 5.6-6.6MHz. Dual Electronic Industries, St. Georgen House, Mill Road, Stockenchurch, Bucks.

#### Eagle AFT60 (a.m./f.m. stereo)

Sensitivity:  $2\mu\text{V}$  for 20dB quieting (stereo).  
Channel separation: 28dB at 1kHz.  
Image rejection: 55dB.  
Aerial input: 75 $\Omega$  unbalanced.  
Output voltage: variable 0-280mV.  
Price: £53 18s 10d.  
Above details refer to f.m. section. Cover-



age on a.m. 600-1600kHz (m.w.) with sensitivity of 500 $\mu$ V. Teak cabinet; f.e.t. front end. U.K. agents: B. Adler & Sons (Radio) Ltd, Coptic Street, London W.C.1.

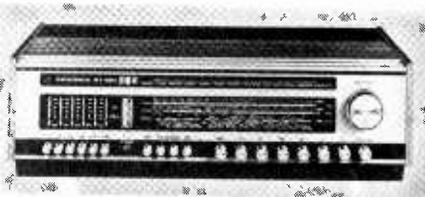
### Elizabethan System 4

(f.m. mono)



Sensitivity: 14 $\mu$ V for 3dB from limiting. Output voltage: 100mV. Price: £28. A.f.c.  $\pm$ 250kHz range. Part of the Elizabethan Coniston Suite. Lee Products (Great Britain) Ltd, 10-18 Clifton Street, London E.C.2.

### Grundig RT100 (a.m./f.m. stereo)



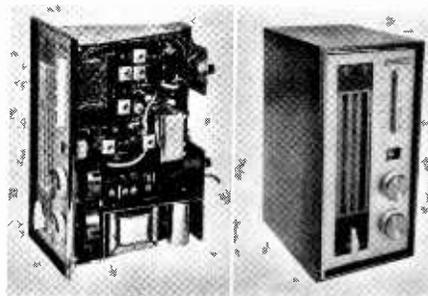
Sensitivity: 1.5 $\mu$ V for 26dB quieting at 15kHz deviation. Image rejection: 58-66dB. I.F. bandwidth: 160-200kHz. Discriminator bandwidth: 650kHz. A.M. suppression: better than 58dB at 1kHz. Pilot tone suppression: 40dB at 19kHz, 60dB at 38kHz. Channel separation: 35dB minimum at 1kHz. Aerial input: 240 $\Omega$ . Output voltage: 0.65V for 40kHz deviation. Output impedance: 2k $\Omega$  (lowest permissible load impedance 22k $\Omega$ ). Price: £181 11s 9d.

Automatic stereo switching with variable trigger level (6-60 $\mu$ V); override mono switch and indicator; f.e.t. front end with a.f.c.; tuning meter and light aids; variable-capacitance diode tuning with press-button selection of up to six stations. Above details refer to f.m. section. Frequency coverage on a.m.: 145-350kHz (l.w.), 510-620kHz (m.w.), 3.15-8.8 and 8.6-22.5MHz. Grundig (Great Britain)

Ltd, 15 Orchard Street, London W1H 9AE.

### Goodmans Stereomax

(a.m./f.m. stereo)

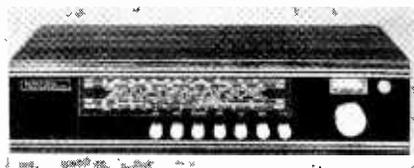


Sensitivity: 2 $\mu$ V for 30dB quieting. I.F. bandwidth: 300kHz at 6dB. Discriminator bandwidth: 600kHz. A.M. rejection: 40dB. Channel separation: 37dB at 1kHz. Pilot tone suppression: 50dB. Aerial input: 300 $\Omega$  balanced, 70 $\Omega$  unbalanced. Output voltage: 250mV for 30% modulation. Output impedance: 100k $\Omega$ . Automatic stereo switching and stereo indicator; switched a.f.c. (pull-in range 100kHz); muting; tuning meter. Above details refer to f.m. section. Frequency coverage on a.m. 545-1650kHz (m.w.). External power socket for feeding other units. Goodmans Loudspeakers Ltd, Axiom Works, Lancelot Road, Wembley, Middx.

### Heathkit K/AJ-14 (f.m. stereo)

Sensitivity: 5 $\mu$ V. Image rejection: 45dB. I.F. rejection: 80dB. Frequency response: 20-15000Hz at 3dB (I.H.F.). Aerial input: 300 $\Omega$  balanced, 75 $\Omega$  unbalanced. Output voltage: 0.7V for 1000 $\mu$ V input. Output impedance: 20k $\Omega$ . Channel separation: 30dB at 1kHz. Price of kit: £24 18s, post and packing 5s. Mono/stereo switch and stereo indicator; a.f.c.; walnut or teak cabinet available. Heath (Gloucester) Ltd, Gloucester GL2 6EE.

### Körting T500 (a.m./f.m. stereo)



Sensitivity: 3 $\mu$ V for 26dB s/n ratio at 12.5kHz deviation.

Bandwidth: approximately 140kHz.

Price: £79 15s.

Automatic stereo switching with indicator; tuning meter; frequency coverage on a.m. 145-355kHz (l.w.), 510-1620kHz (m.w.) and 5.85-7.4MHz. Special feature on a.m., automatic bandwidth (3-6kHz) dependent on input signal strength. U.K. agents: Europa Electronics Ltd, Howard Place, Shelton, Stoke-on-Trent ST1 4NW.

### Leak Stereofetic (f.m. stereo)

Sensitivity: 2.5 $\mu$ V for 30dB s/n ratio.

Image rejection: 72dB.

I.F. rejection: 80dB.

A.M. suppression: 50dB.

Aerial input: 75 $\Omega$  unbalanced.

Output voltage: 0.9V r.m.s. at 75kHz deviation.

Output impedance: 200 $\Omega$ .

Channel separation: better than 35dB at 1kHz.

Price: £68 1s 4d.

Switched a.f.c.; tuning indicator combined stereo indicator; f.e.t. front end and i.cs in i.f. stages and decoder; ceramic filter i.f. stages; automatic stereo switching with "mono lock" switch. Features "quasi-stereo", a method of progressively reducing noise while retaining some stereo effect. H. J. Leak & Co. Ltd, Bradford Road, Idle, Bradford, Yorks.

### L & H "Signalmaster" 6087

(f.m., decoder optional)

Sensitivity: 2.5 $\mu$ V for 20dB s/n ratio.

Image rejection: better than 55dB.

I.F. bandwidth: 250kHz.

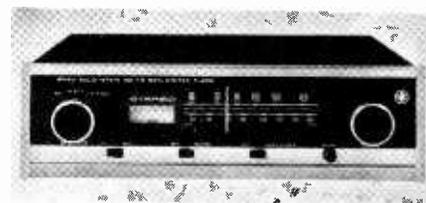
Output voltage: 200mV (nominal).

Power supply: 9V battery or 32V external.

Price: 30gn.

With decoder channel separation is better than 32dB at 1kHz; a.f.c. switch; stereo indicator; available in teak or rosewood. Britimpex Ltd, 8/12 Rickett Street, London S.W.6.

### Nikko FAM-12F (a.m./f.m. stereo)



Sensitivity: 1.8 $\mu$ V for 20dB quieting.

Image rejection: better than 45dB at 1MHz.

Channel separation: 40dB at 1kHz.

Output voltage: 0.5V at 30% modulation.

Price: £68 8s 3d.

Automatic stereo switching with indicator and mono override switch; tuning meter; switched a.f.c.; muting; noise filter; f.e.t.

Wireless World, September 1970

front end. Above details refer to f.m. section. Frequency coverage on a.m.: 530-1605kHz (m.w.). U.K. agents: Howland-West Ltd, 2 Park End, South Hill Park, London N.W.3.

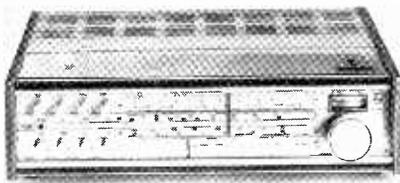
### Pioneer TX-900 (a.m./f.m. stereo)



Sensitivity:  $1.7\mu\text{V}$  (I.H.F.).  
Image rejection: 95dB.  
Selectivity: 65dB.  
S/N ratio: 60dB at 30% modulation.  
Harmonic distortion: 0.3% at 400Hz, 100% modulation.  
Aerial input:  $300\Omega$  balanced.  
Output voltage: 1V at 400Hz, 30% modulation adjustable on each channel.  
Channel separation: 38dB at 1kHz.  
Price: £154 18s 3d.

Front end f.e.t.; crystal filter i.f. stages; automatic stereo switching with mono override switch; adjustable stereo muting and interstation muting; switched a.f.c. Above details refer to f.m. section. Frequency coverage on a.m.: 525-1605kHz (m.w.). Shiro (U.K.) Ltd, Lynwood House, 24/32 Kilburn High Road, London N.W.6.

### Philips RH691 (a.m./f.m. stereo)



Sensitivity:  $7\mu\text{V}$  for 26dB s/n ratio at 15kHz deviation.

Distortion: less than 1% at 75kHz deviation.

Channel separation: 35dB at 1kHz.

Carrier suppression: 40dB at 38kHz (30dB at 19kHz).

Audio response: 20-15000Hz  $\pm$  3dB.

Output voltage: 1.4V at 40kHz deviation.

Output impedance:  $10k\Omega$ .

Price: £83.

Switched a.f.c.; automatic stereo switching with mono override switch and indicator; tuning meter; interstation muting. Above details refer to f.m. section. Frequency coverage on a.m.: 150-400kHz (l.w.), 525-1604kHz (m.w.) and 5.9-18.2MHz. Philips Electrical Ltd, Century House, Shaftesbury Avenue, London W.C.2.

### Quad FM (stereo)



Sensitivity:  $2\mu\text{V}$  for 30dB quieting.  
Crosstalk: better than 30dB at 1kHz.  
Suppression: better than 40dB at 38kHz.  
Aerial input:  $75\Omega$ .

Output voltage: 100mV.

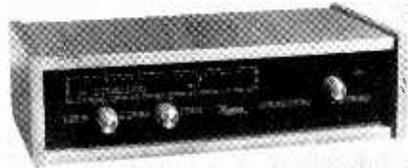
Output impedance:  $100k\Omega$  each channel ( $50k\Omega$  mono).

Price: £51.

Automatic switching and stereo indicator with override manual switch; neon tuning indicator; a.f.c.; fully tropicalized. Acoustical Manufacturing Co. Ltd, Huntingdon, Hunts.

### Radon 404 Mk2

(f.m., decoder optional).



Sensitivity:  $15\mu\text{V}$  (usable).

Bandwidth: 300kHz at 3dB.

I.F. bandwidth: 170kHz.

A.M. rejection: 26dB for 20mV input.

Aerial input:  $75\Omega$ .

Price: £39 18s with decoder fitted.

Switched a.f.c.; permeability tuning.

When decoder is fitted stereo switching is automatic with indicator. A Mark 3

version of this tuner has the stereo decoder fitted as standard. Radon

Industrial Electronics Co. Ltd, Brook-

lands Trading Estate, Orme Road,

Worthing, Sussex.

### Radford FMT.3

(f.m., decoder optional)

Sensitivity:  $2\mu\text{V}$  for 30dB quieting.

S/N ratio: 70dB.

Frequency response: 40-15000Hz  $\pm$  1dB.

Harmonic distortion: less than 0.6% at 75kHz deviation.

Detector bandwidth: 550kHz.

Aerial input:  $75\Omega$  and  $300\Omega$ .

A.M. suppression: 45dB.

Output voltage: 2V at 75kHz deviation.

Price: £60 plus p.t. (decoder fitted).

With decoder, channel separation is

better than 37dB at 1kHz; carrier suppression better than 60dB; auto-

matic stereo switching with mono override switch; switched a.f.c.; tuning meter; interstation muting; f.e.t. r.f. amplifier. Radford Audio Ltd, Ashton Vale Road, Bristol BS3 2HZ.

### Rogers Ravensbrook

(f.m. stereo)



Sensitivity:  $5\mu\text{V}$  (usable).

I.F. rejection: 85dB.

Image rejection: 70dB.

A.M. suppression: 50dB.

Channel separation: better than 30dB at 1kHz.

Output voltage: 200mV for 30% modulation.

Price: £45 plus case.

Front end f.e.t.; integrated circuit i.f.

strip; switched a.f.c.; automatic stereo

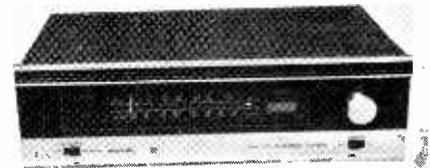
switching with indicator; tuning meter;

interstation muting. Rogers Develop-

ments (Electronics) Ltd, 4-14 Barmeston

Road, Catford, London S.E.6.

### Rotel 120-ST (a.m./f.m. stereo)



Sensitivity:  $2.5\mu\text{V}$  for 20dB quieting.  
Harmonic distortion: less than 1.5% at 1kHz

Channel separation: better than 35dB at 1kHz 100% modulation.

Output voltage: 1200mV at 100% modulation.

Price: £49 10s.

Automatic stereo switching with stereo

indicator; a.f.c.; tuning meter. Above de-

tails refer to f.m. Frequency coverage

on a.m.: 535-1605kHz (m.w.). Distribu-

tors: Pullin Photographic Rank Aldis,

P.O. Box 70, Great West Road, Brentford,

Middx.

### Sony ST-5100

(a.m./f.m. stereo)

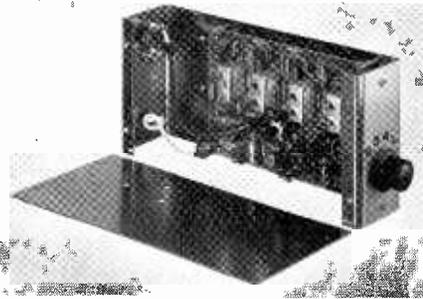
Sensitivity:  $1.8\mu\text{V}$  for 20dB s/n ratio.

Selectivity: 70dB (I.H.F.).

Image rejection: 90dB.  
 Spurious rejection: 100dB.  
 A.M. suppression: 50dB (I.H.F.).  
 Frequency response: 20Hz-15kHz  
 ± 1dB.  
 Aerial input: 300Ω balanced,  
 75Ω unbalanced.  
 Channel separation: better than 38dB  
 at 400Hz.  
 Carrier suppression: 60dB.  
 Price: £99 15s.

Front end f.e.t.; i.f. filters; tuning indicators; a.f.c. control; muting switch. Above details refer to f.m. section. Frequency coverage on a.m.: 530-1605kHz (m.w.). Sony (U.K.) Ltd, 11 Ascot Road, Bedfont, Feltham, Middx.

**S.N.S. FMT/9 (f.m. mono)**

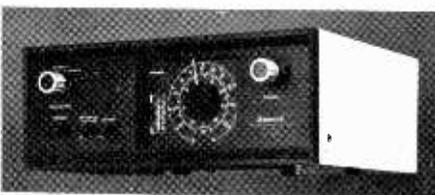


Sensitivity: 10μV for 30dB s/n ratio at 22.5kHz deviation.

Limiting: 10μV for full limiting.  
 Aerial input: 70-80Ω unbalanced.  
 Output voltage: variable 0-500mV.  
 Output impedance: 5kΩ.  
 Power supply: 9.1V d.c. or optional a.c. mains unit.  
 Price: on application.

This tuner is available either for single programme reception or in switched version for up to four preset stations. It has a crystal-controlled oscillator and in the four-station version the above sensitivity figures are slightly impaired. Designed specially for radio distribution systems. S.N.S. Communications Ltd, 851 Ringwood Road, West Howe, Bournemouth BH11 8LN.

**Sansui TU555 (a.m./f.m. stereo)**



Sensitivity: 2μV for 20dB quieting.  
 Image rejection: better than 50dB.  
 I.F. rejection: better than 60dB.  
 Channel separation: better than 35dB.  
 Aerial input: 300Ω balanced, 75Ω unbalanced.  
 Output voltage: more than 1.5V.

Output impedance: greater than 10kΩ.  
 Price: £77 9s 2d.  
 Signal strength meter and stereo indicator; stabilized oscillator supply with no a.f.c.; special noise cancelling circuit; f.e.t. front end. Above details refer to f.m. section. Frequency coverage on a.m.: 535-1605kHz (m.w.). U.K. importers: Brush Clevite Co. Ltd, Thornhill, Southampton SO9 1QX, Hants.

**Sugden R21 (f.m. stereo)**



Sensitivity: 2μV for 30dB quieting.  
 Frequency response: 30Hz-15kHz  
 ± 1dB.  
 I.F. rejection: 80dB.  
 Image rejection: 70dB.  
 A.M. suppression: 50dB.  
 Aerial input: 75Ω or 300Ω.  
 Output voltage: 0.5V.  
 Channel separation: better than 30dB.  
 Price: approximately £67.  
 Front end f.e.t.; variable-capacitance diode tuning with four preset station buttons in addition to continuous tuning; switchable stereo filter giving low noise with reduced separation; special low-pass filter with 55kHz cut-off; pilot tone and sub-carrier filters. Differently styled version (R51) available. J. E. Sugden & Co. Ltd, Bradford Road, Cleckheaton, Yorks.

**Sinclair System 3000**

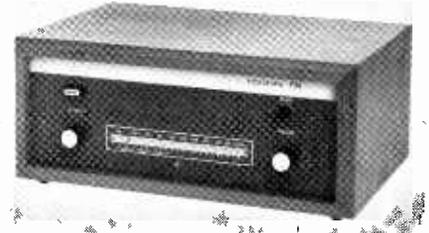
This f.m. tuner will be released in late autumn. The only information available at the time of going to press is that sensitivity is expected to be 5-10μV for 40dB quieting. The circuit will incorporate a phase-lock loop discriminator, variable-capacitance diode tuning and an i.c. stereo decoder. Sinclair Radionics Ltd, 22 Newmarket Road, Cambridge CB5 8DU.

**Teleton STQ-201X (f.m. stereo)**

Sensitivity: 2.5μV for 20dB quieting.  
 I.F. bandwidth: 240kHz (3dB).  
 Image rejection: better than 50dB.  
 S/N ratio: 45dB for 1mV input.  
 Aerial input: 300Ω balanced.  
 Channel separation: 30dB at 1kHz.  
 Price: £36.  
 Stereo indicator; a.f.c.; tuning meter.  
 Teleton Electro (U.K.) Co. Ltd, Teleton

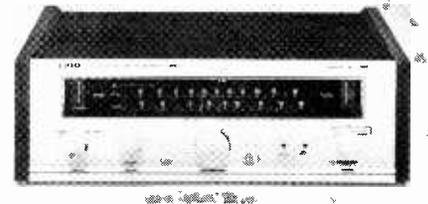
House, Robjohns Road, Widford, Chelmsford, Essex.

**Tripletone FM Mk2 (f.m. stereo)**



Sensitivity: 2-3μV for 20dB quieting.  
 Bandwidth: 210kHz.  
 Aerial input: 70-80Ω unbalanced.  
 Output voltage: 0.1V.  
 Channel separation: better than 30dB at 1kHz.  
 Price: £37 19s 10d (teak case), £35 1s 3d (chassis only).  
 Front end f.e.t.; a.f.c. (range 400kHz); automatic stereo switching and indicator. A mono version is available with provision for a plug-in decoder. The Tripletone Manufacturing Co. Ltd, 138 Kingston Road, Wimbledon, London S.W.19.

**Trio KT-7000 (a.m./f.m. stereo)**



Sensitivity: 1.5μV (usable).  
 Frequency response: 20-15000Hz - 2dB.  
 Harmonic distortion: less than 0.3% (mono) at 400Hz, 100% modulation.  
 S/N ratio: better than 70dB at 30μV input.  
 Image rejection: better than 100dB at 100MHz.  
 I.F. rejection: better than 100dB.  
 Channel separation: better than 35dB at 1kHz.  
 Carrier suppression: better than 50dB.  
 Aerial input: 300Ω balanced, 75Ω unbalanced.  
 Output voltage: 1.5V at 400Hz, 100% modulation.  
 Output impedance: 7000Ω.  
 Price: £125.  
 Three-f.e.t.s front end; crystal filter and integrated circuit i.f. stages; signal strength meter and tuning meter; automatic stereo switching and indicator; interstation muting; step-type output level control. Above details refer to f.m. section. Frequency coverage on a.m.: 540-1600kHz (m.w.). U.K. agents: Lasky's Radio Ltd, 3-15 Cavell Street, Tower Hamlets, London E.1.

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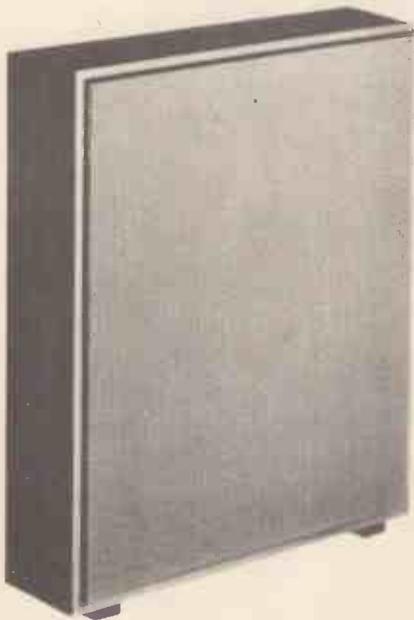
WW—006 FOR FURTHER DETAILS

# Stentorian

## SPEAKER SYSTEMS

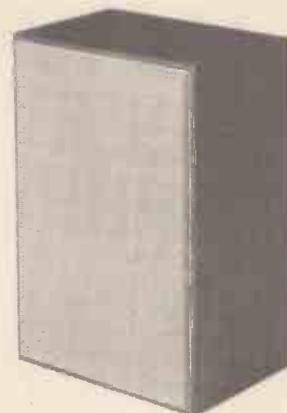
These superb new speaker systems make available even higher standards of performance in sound reproduction and uphold the high reputation gained by Whiteley Stentorian speakers throughout the world.

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### LC93

A 19" x 12½" x 8½" completely enclosed acoustically loaded cabinet housing a 9" graded melamine paper cone with siliconized cambric suspension giving a frequency response of 60Hz to 20KHz.

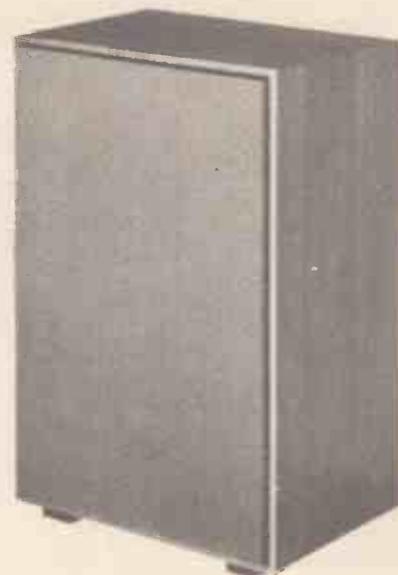


### LC94

A 29½" x 23¾" x 6⅛" acoustic Labyrinth enclosure fitted with acoustic resistance in the pipe, using the same highly efficient 9" speaker unit used in the LC 93. Frequency response 45Hz to 20KHz.

### LC95

The LC95 loudspeaker system is an acoustically loaded Bass Reflex cabinet, measuring 31½" x 20¾" x 13½", fitted with two loudspeakers and a crossover network. The bass loudspeaker being used is a newly developed 12" unit having a Melamine treated paper cone with a cambric surround. The middle and high frequency unit is a new 8" loudspeaker having a Melamine treated paper ribbed cone and surround.



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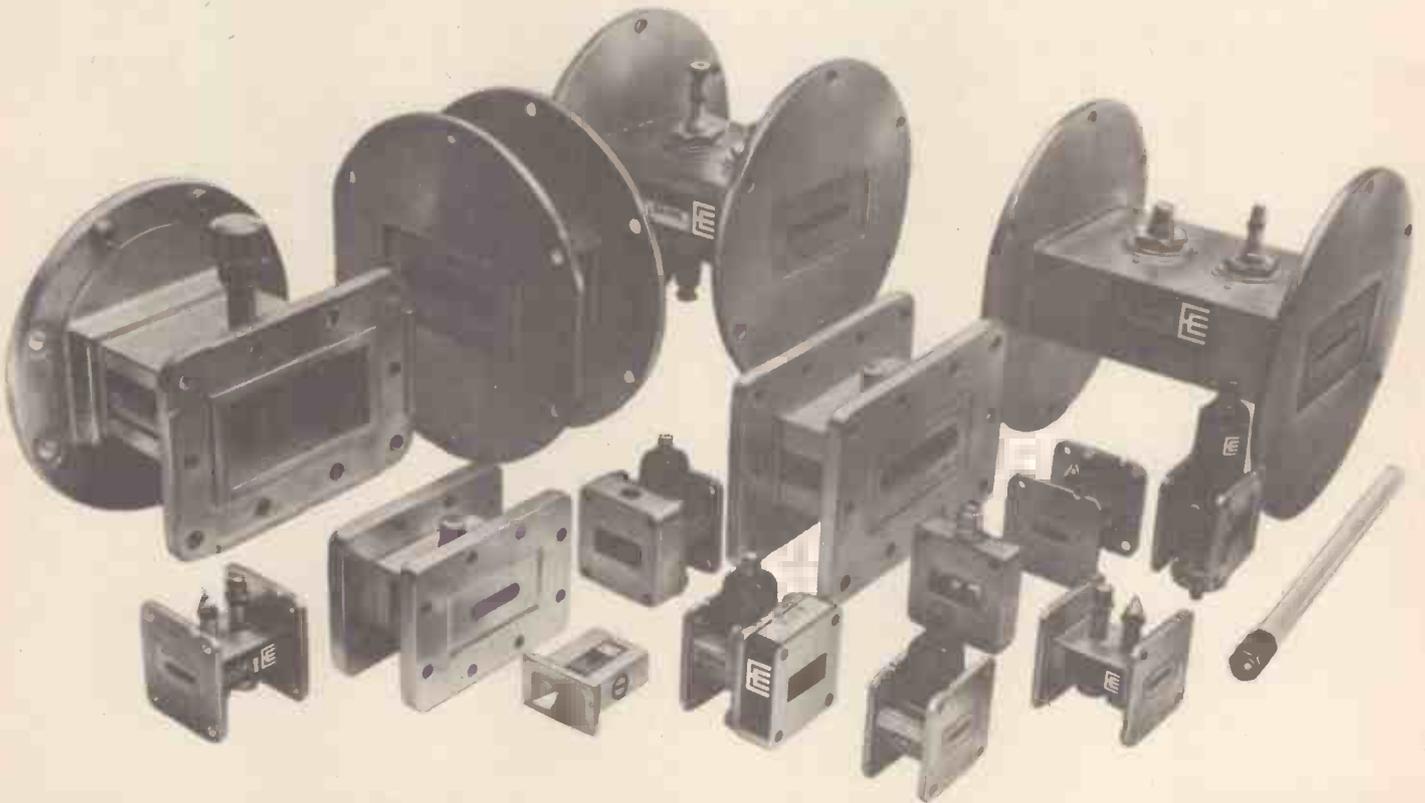
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	BS870	L	1240–1370	2500
TR cells	BS456	S	2850–3050	1250
	BS824	S	2700–3100	250
	BS856	C	5300–5700	250
	BS156	X	9000–9600	200
	BS452	X	9310–9510	100
	BS810	X	9250–9550	75
TB cell	BS310	X	9375	5–200
TR Limiter cell	BS814	X	9000–9700	200
Solid state microwave switches	BS392	S	2925–3075	0.5
	BS460	X	any 100 MHz	0.5

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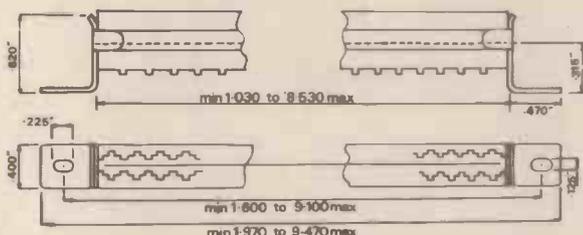
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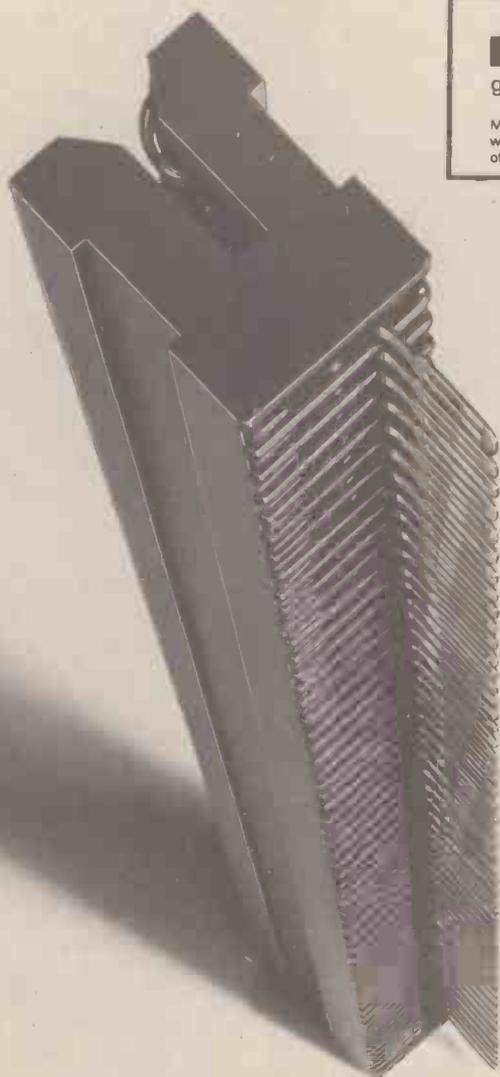
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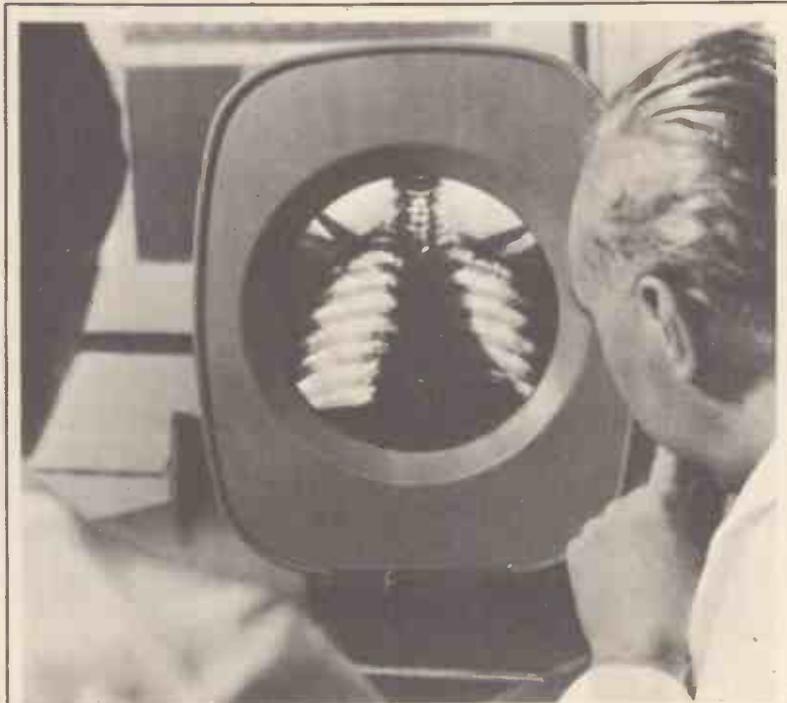
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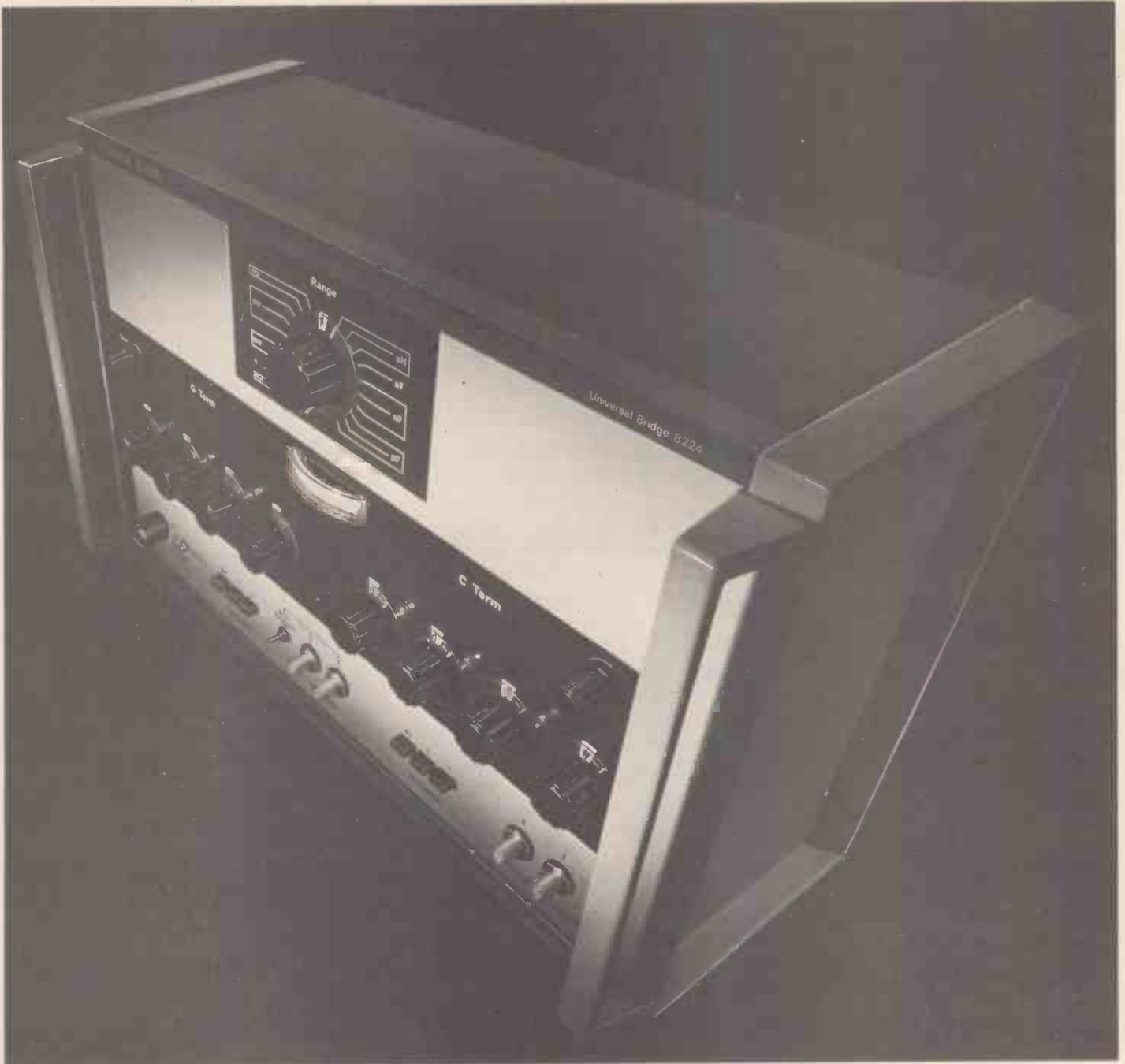
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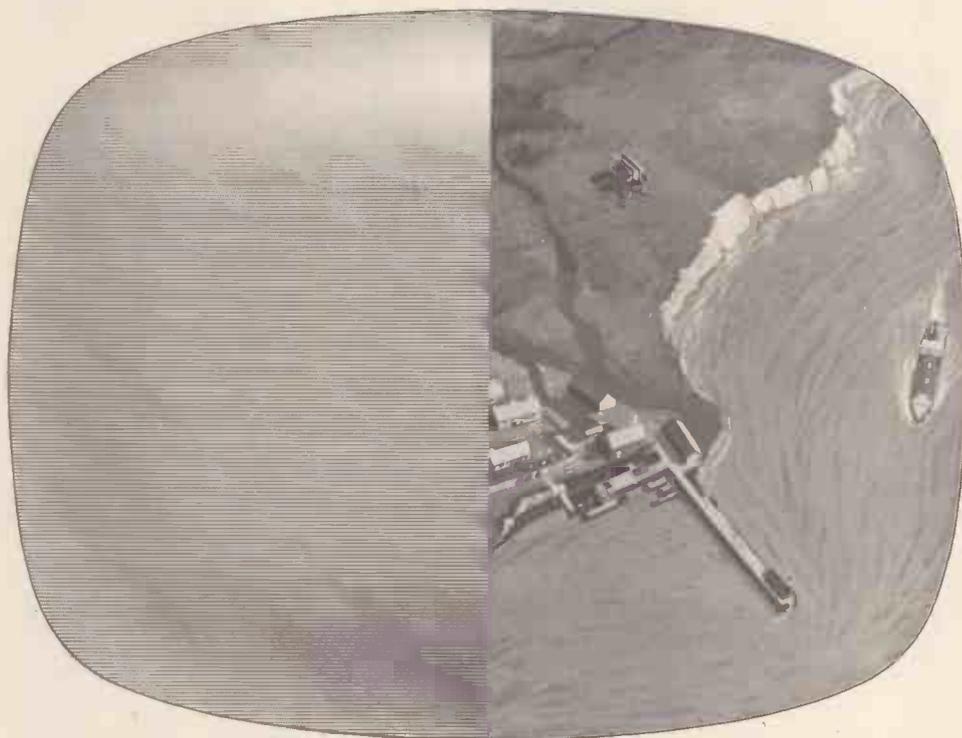
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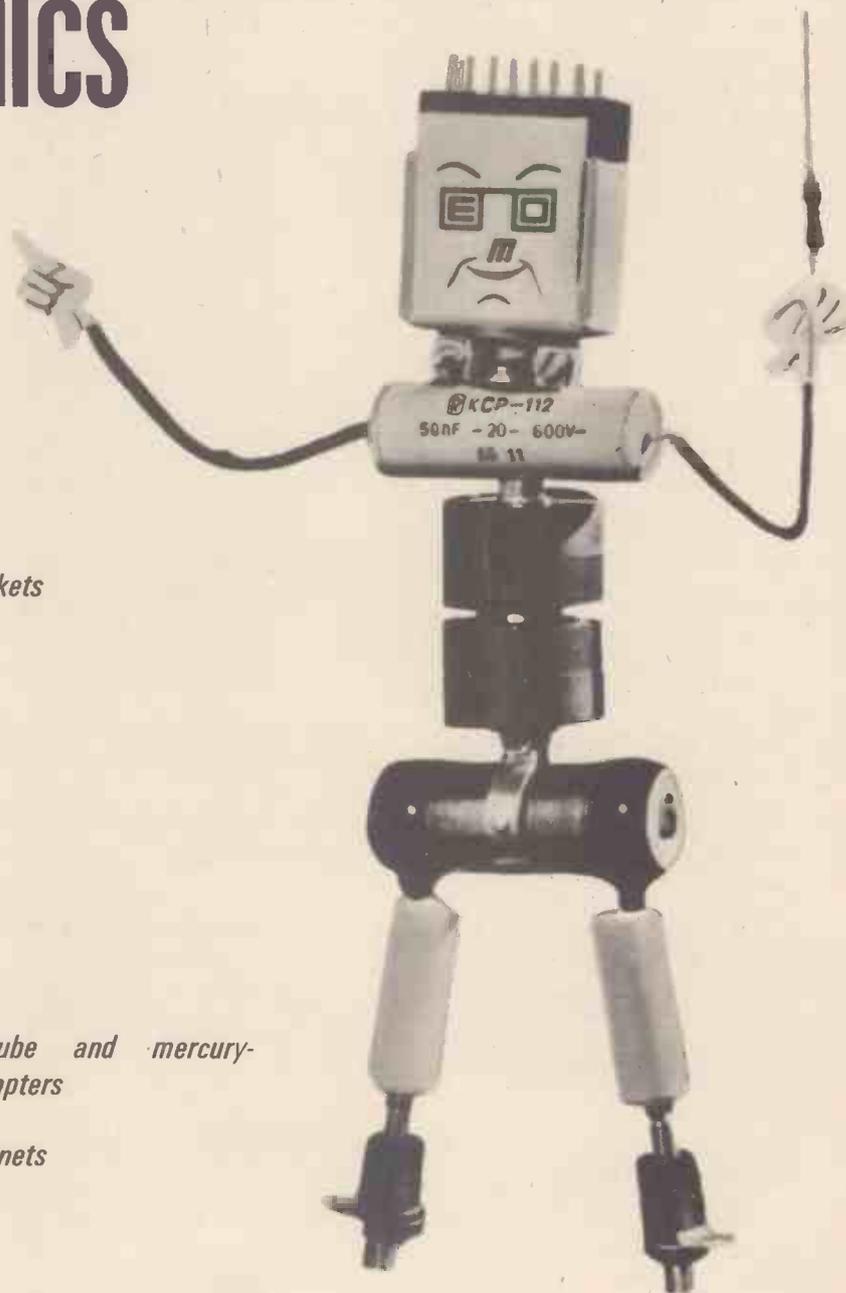
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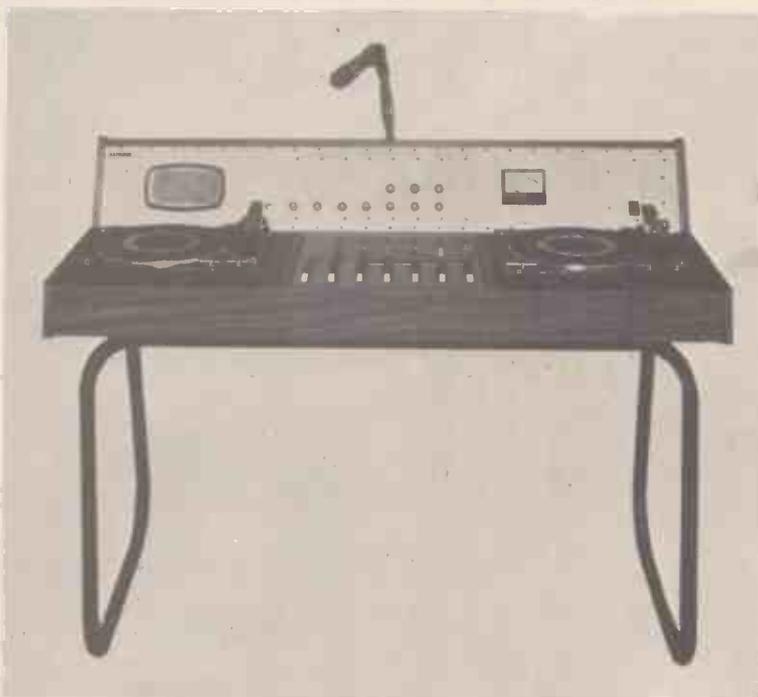
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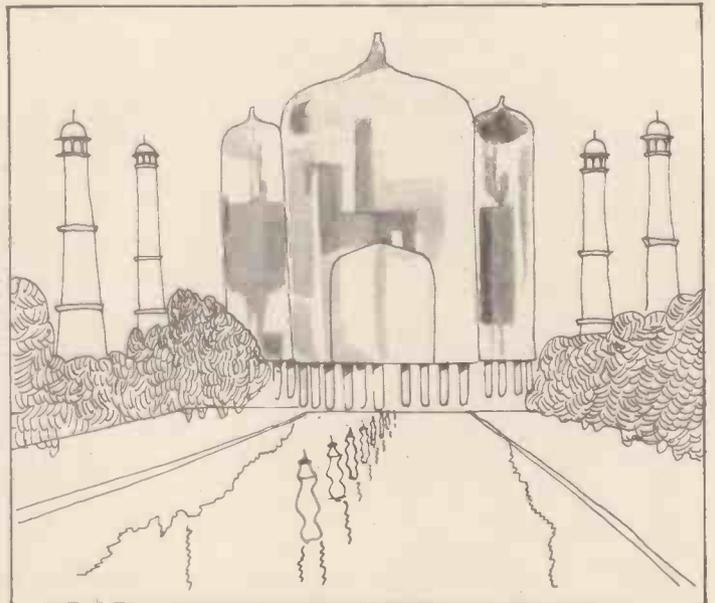
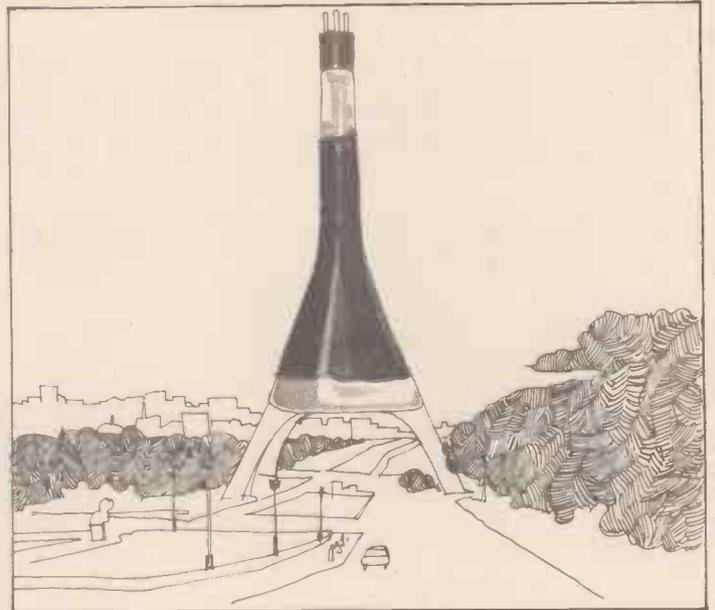
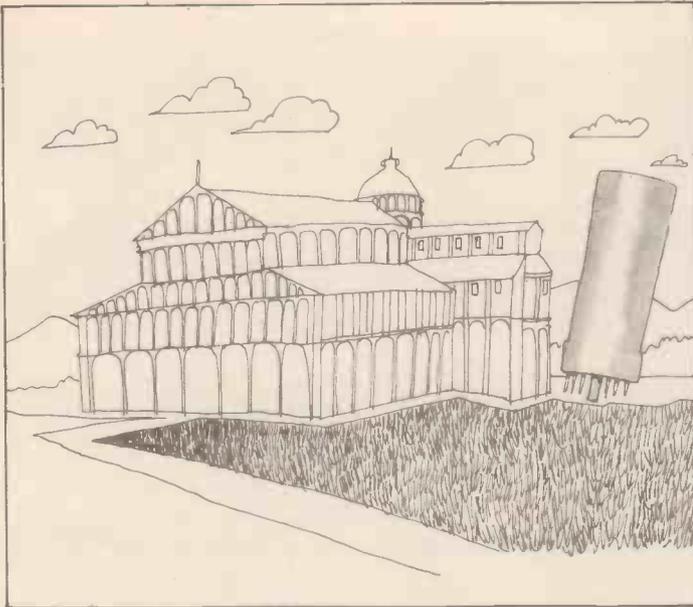
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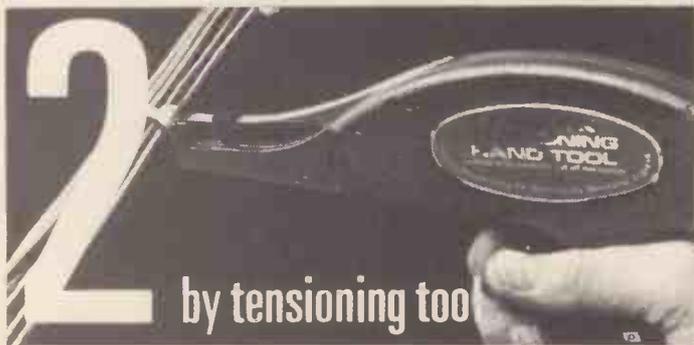
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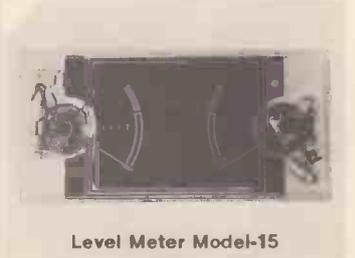
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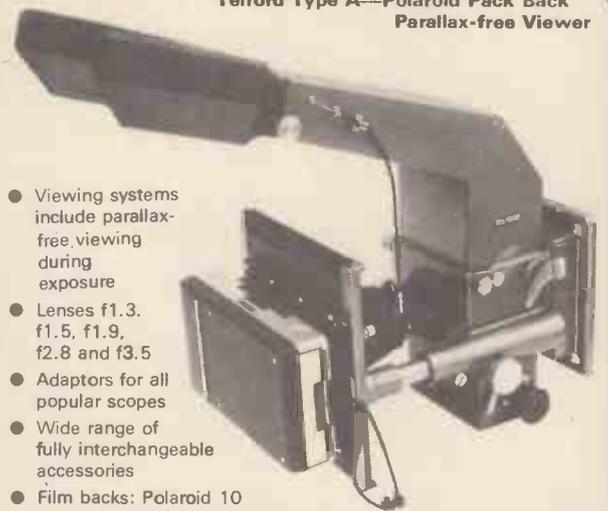
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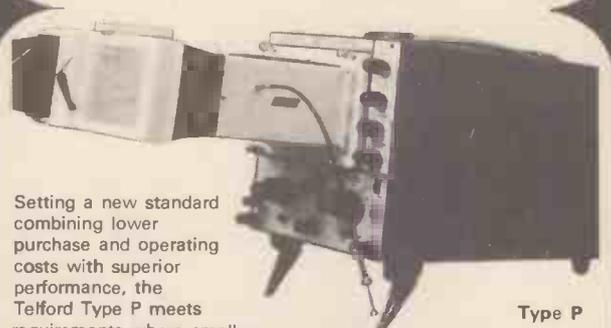


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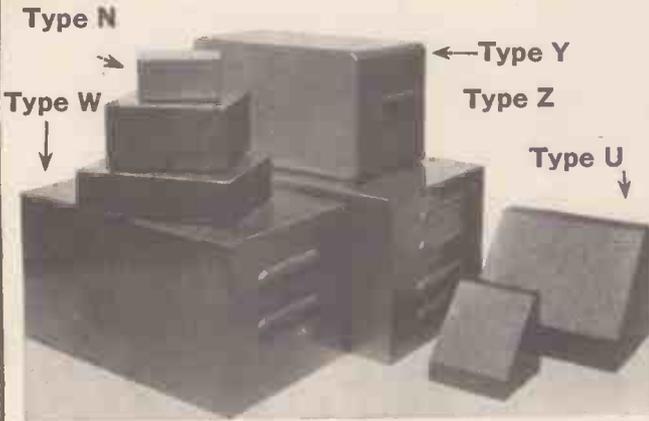
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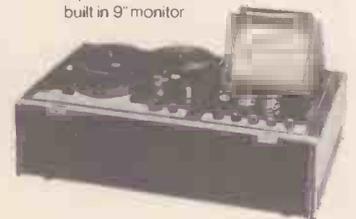
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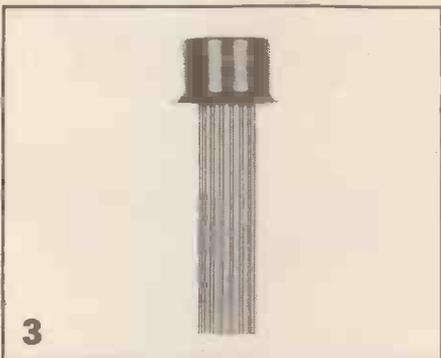
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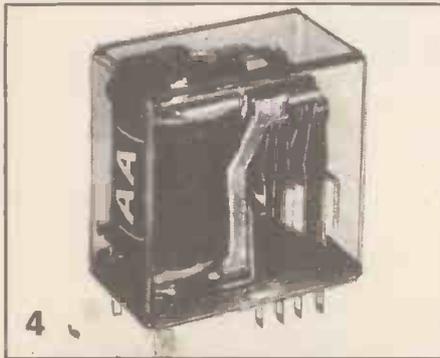
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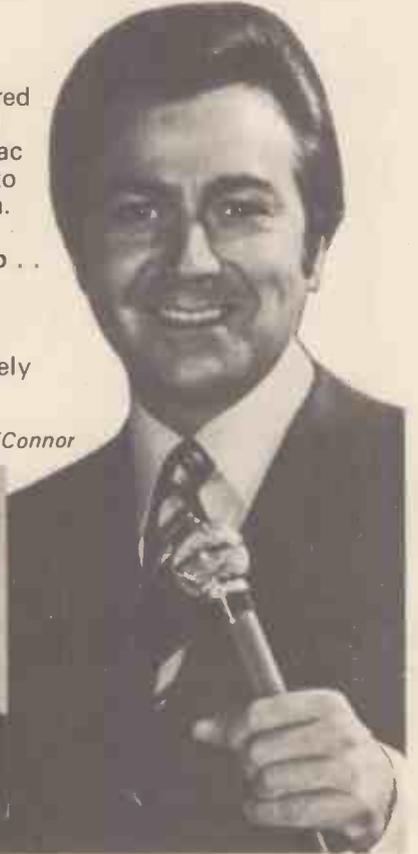
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# Voltmobile voltage regulators

# Rectifier Sets



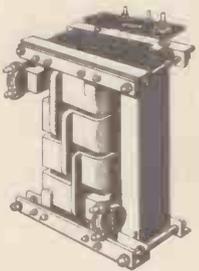
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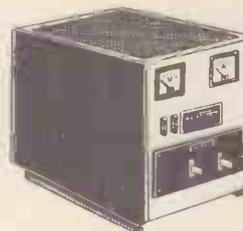
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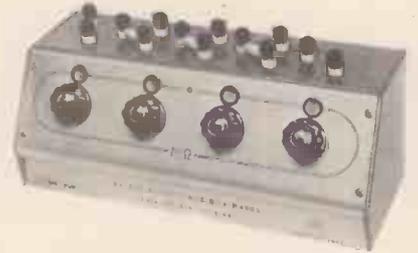
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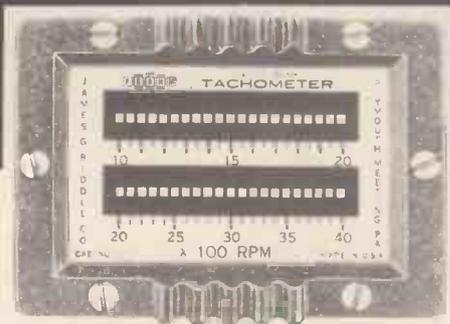
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71	2.0A	0-12V @ 1 Amp x 2	2 1/2 x 2 1/2 x 2 1/2	1 0	23/1 21/4
68	3.0A	0-12V @ 3 Amp	3 1/2 x 2 1/2 x 3 1/2	2 0	28/8 26/6
18	4.0A	0-12V @ 2 Amp x 2	3 1/2 x 2 1/2 x 2 1/2	2 4	32/4 29/11
85	5.0A	0-12V @ 5 Amp	3 1/2 x 2 1/2 x 3	3 2	36/11 34/1
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3	2.0A	"	3 1/2 x 2 1/2 x 3	3 2	31/10 29/4
20	3.0A	"	4 x 3 1/2 x 3 1/2	4 6	43/1 39/-
21	4.0A	"	4 x 3 1/2 x 3 1/2	6 0	51/3 47/5
51	5.0A	"	4 1/2 x 3 1/2 x 4	6 8	63/1 58/4
117	6.0A	"	4 1/2 x 3 1/2 x 4	12 4	75/10 70/1
89	8.0A	"	5 1/2 x 3 1/2 x 4 1/2	9 6	100/6 92/11
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103	1.0A	"	3 1/2 x 2 1/2 x 2 1/2	2 10	33/10 31/4
104	2.0A	"	4 x 3 1/2 x 3 1/2	5 0	46/8 43/3
105	3.0A	"	4 x 4 x 3 1/2	6 0	63/7 58/8
106	4.0A	"	4 1/2 x 4 1/2 x 4	9 4	84/- 77/8
57	5.0A	"	4 1/2 x 4 1/2 x 5 1/2	12 4	124/1 114/8
118	8.0A	"	5 1/2 x 4 1/2 x 4 1/2	18 9	162/- 149/10
119	10.0A	"	6 1/2 x 4 1/2 x 6 1/2	19 12	203/- 187/8

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126	1.0A	"	3 1/2 x 3 x 3	3 0	32/10 30/4
127	2.0A	"	4 x 3 1/2 x 3 1/2	5 6	51/3 47/5
125	3.0A	"	4 1/2 x 3 1/2 x 4	7 0	75/10 70/1
123	4.0A	"	4 1/2 x 3 1/2 x 4 1/2	10 6	100/6 92/11
40	5.0A	"	5 1/2 x 5 x 5 1/2	13 4	121/- 111/11
120	6.0A	"	5 1/2 x 4 1/2 x 4 1/2	16 12	145/7 134/7
121	8.0A	"	5 1/2 x 5 1/2 x 4 1/2	20 3	192/8 177/8
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62	250	194	3 1/2 x 5 x 4 1/2	12 4	100/11 93/3
55	350	195	5 1/2 x 5 1/2 x 4 1/2	17 6	137/4 127/-
63	500	196	6 1/2 x 4 1/2 x 6 1/2	27 0	194/8 180/1
96	750	197	7 1/2 x 6 1/2 x 6 1/2	31 0	277/8 256/9
92	1000	198	7 1/2 x 6 1/2 x 8 1/2	40 0	358/8 331/8
97	1250	199	7 x 7 x 8 1/2	47 0	440/8 407/7
128	2000	200	9 1/2 x 8 1/2 x 6	63 0	593/2 548/7
129	3000	201	8 1/2 x 8 1/2 x 8	84 0	927/7 857/11
120	6000	202	12 1/2 x 14 x 6 1/2	178 0	1,524/2 1,409/7

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4	150	0-115-200-220-240V	3 1/2 x 2 1/2 x 3	3	34/10 32/3
65	200	"	3 1/2 x 4 1/2 x 4	4	49/3 45/6
66	300	"	4 x 4 x 3 1/2	6 7	67/7 62/6
110	400	"	4 1/2 x 4 1/2 x 4	11	84/6 78/1
67	500	"	5 1/2 x 4 x 4 1/2	12 8	100/6 92/11
83	750	"	4 1/2 x 5 1/2 x 5 1/2	13 4	142/5 131/8
84	1000	"	4 1/2 x 5 1/2 x 5 1/2	16	182/5 168/8
93	1500	"	5 1/2 x 5 1/2 x 6 1/2	28 9	264/5 244/6
94	1750	"	5 1/2 x 6 1/2 x 6 1/2	31	297/3 274/11
95	2000	"	7 x 6 1/2 x 8 1/2	40	345/2 319/2
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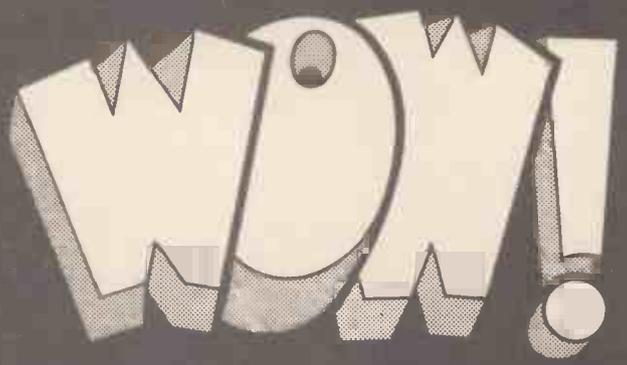
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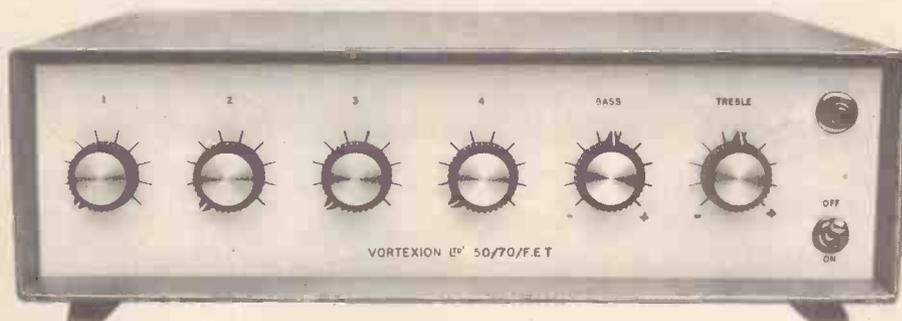
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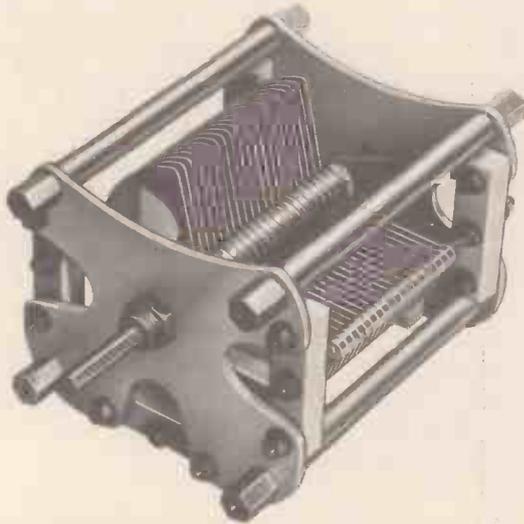
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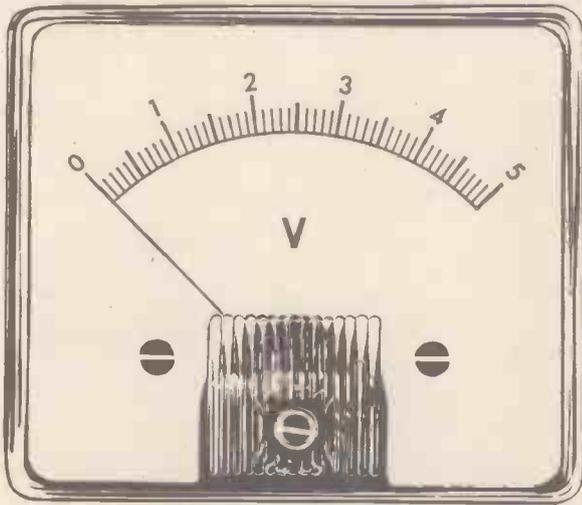
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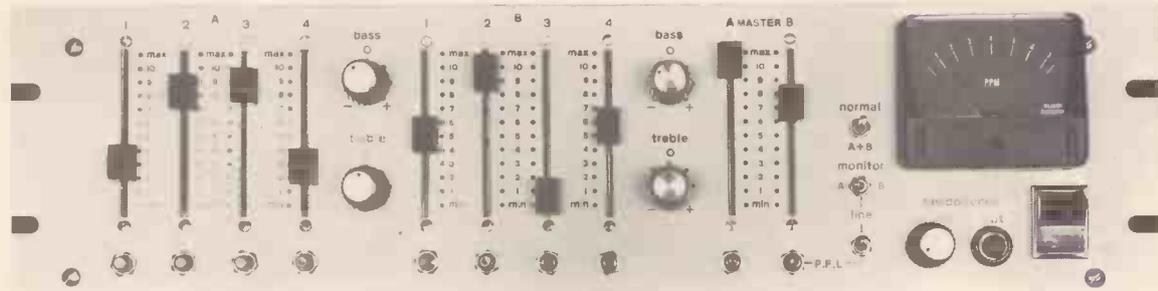
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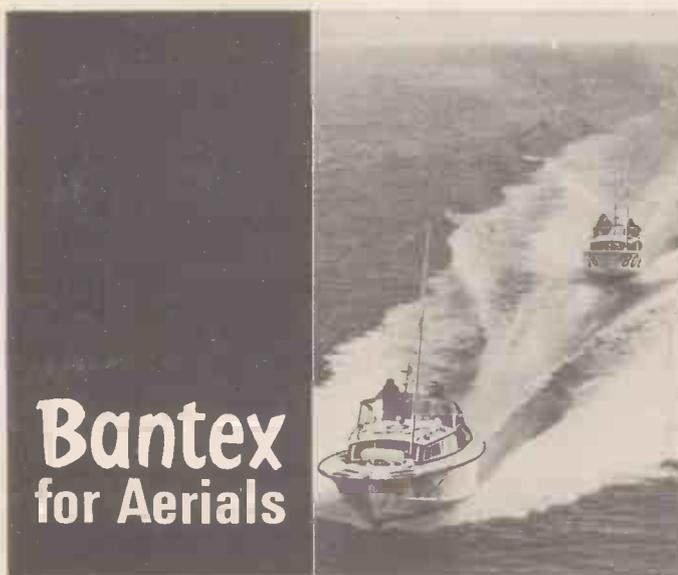
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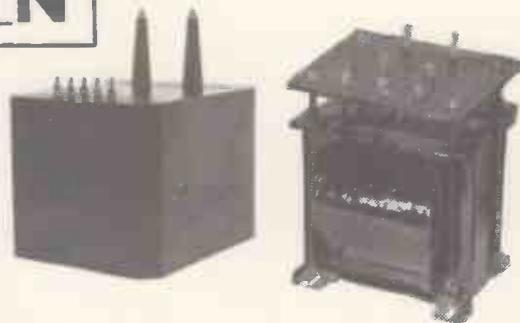
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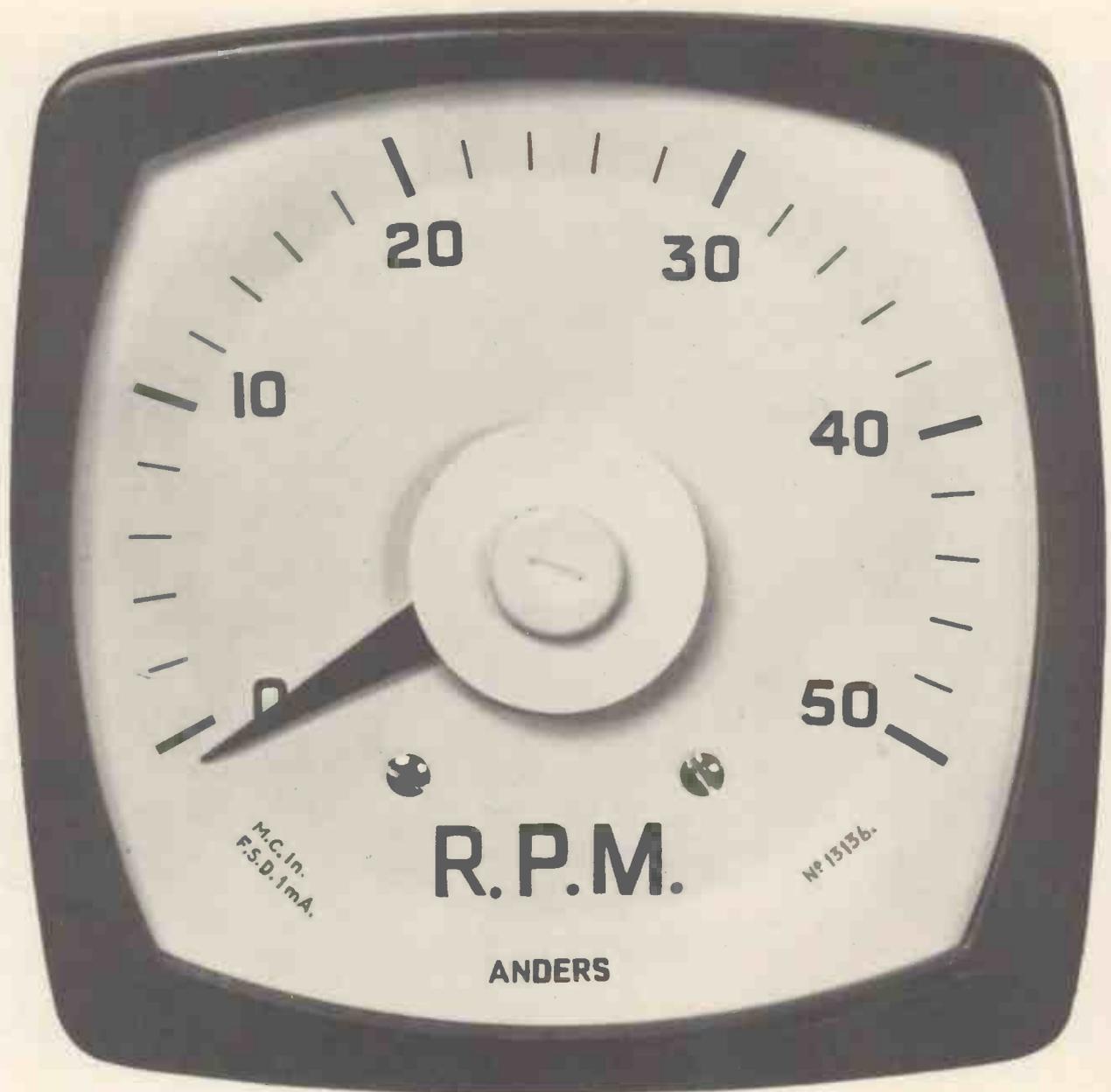
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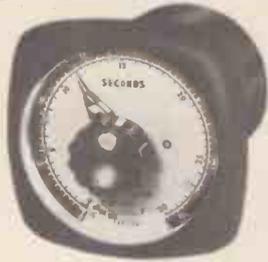
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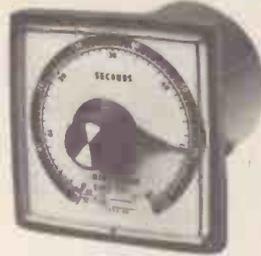
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GP73-1 .. .. .	6/6	9/6
GP73-2 .. .. .	6/6	9/6
GP79 .. .. .	2/6	7/6
GP81-1 .. .. .	2/6	7/6
GP91-1 .. .. .	6/6	9/6
GP91-2 .. .. .	6/6	9/6
GP91-3 .. .. .	6/6	9/6
GP91-1Sc .. .. .	6/6	9/6
GP91-3Sc .. .. .	6/6	9/6
HGP37 .. .. .	2/6	7/6

B.S.R.	Sapphire	Diamond
BSR CI (ST3) .. .. .	6/6	9/6
BSR TC8H .. .. .	2/6	7/6
BSR TC8M .. .. .	2/6	7/6
BSR ST8 .. .. .	6/6	9/6
BSR ST9 .. .. .	6/6	9/6
BSR ST10 .. .. .	—	9/6
BSR X1M .. .. .	6/6	9/6
BSR X1H .. .. .	6/6	9/6
BSR X3M .. .. .	6/6	9/6
BSR X3H .. .. .	6/6	9/6
BSR X5H .. .. .	6/6	9/6
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COLLARO	Sapphire	Diamond
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Collaro-Ronett TX88 .. .. .	2/6	7/6
Coliel SK1 .. .. .	2/6	7/6
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ELAC KST9 (PE10) .. .. .	6/6	9/6
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ERSMB .. .. .	6/6	9/6
ERSMX .. .. .	2/6	7/6
ERS SB .. .. .	6/6	9/6
ER60 Stereo .. .. .	6/6	9/6

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	Sapphire	Diamond
EV26 Stereo .. .. .	2/6	7/6
GC2 .. .. .	2/6	7/6
GC8 .. .. .	2/6	7/6
GCE12 .. .. .	2/6	7/6
GCS10/1 .. .. .	2/6	7/6
GCS10/2 .. .. .	2/6	7/6
S 1-2-3 .. .. .	6/6	9/6
TS1 .. .. .	6/6	9/6
TS2 .. .. .	6/6	9/6
TS3 .. .. .	6/6	9/6

GOLDRING	Sapphire	Diamond
CM50 .. .. .	2/6	7/6
CM60 .. .. .	2/6	7/6
MX1 .. .. .	2/6	7/6
MX2 .. .. .	2/6	7/6
Stereo CS80 .. .. .	2/6	7/6

PERPETUUM EBNER	Sapphire	Diamond
PE188 .. .. .	6/6	9/6

PHILIPS	Sapphire	Diamond
AG3016 .. .. .	2/6	7/6
AG3063 .. .. .	2/6	7/6
AG3306 .. .. .	6/6	9/6
AG3310/3306 .. .. .	6/6	9/6
AG3400 .. .. .	2/6	7/6

RONETTE BINOFUID	Sapphire	Diamond
BF40 .. .. .	2/6	7/6
DC284 .. .. .	2/6	7/6

SONOTONE	Sapphire	Diamond
2T .. .. .	6/6	9/6
3T .. .. .	6/6	9/6
8TA .. .. .	6/6	9/6
9TA .. .. .	6/6	9/6
9TA/HC .. .. .	6/6	9/6
19T .. .. .	2/6	7/6
20T .. .. .	2/6	7/6

## PERPETUUM EBNER

PE188 .. .. .

## PHILIPS

AG3016 .. .. .	2/6	7/6
AG3063 .. .. .	2/6	7/6
AG3306 .. .. .	6/6	9/6
AG3310/3306 .. .. .	6/6	9/6
AG3400 .. .. .	2/6	7/6

## RONETTE BINOFUID

BF40 .. .. .	2/6	7/6
DC284 .. .. .	2/6	7/6

## SONOTONE

2T .. .. .	6/6	9/6
3T .. .. .	6/6	9/6
8TA .. .. .	6/6	9/6
9TA .. .. .	6/6	9/6
9TA/HC .. .. .	6/6	9/6
19T .. .. .	2/6	7/6
20T .. .. .	2/6	7/6

The Diamond Tip is .007 in. radius, thus making it compatible to play stereo records on mono equipment without damage to the record; and of course full stereo.

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Suitable to replace TC8, etc.		As above
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Acos 104 1-10 .. .. .		41/10
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25-50 .. .. .		38/3
51-499 .. .. .		35/5

B.S.R.		
X3M .. .. .	S/S	27/9
X3H .. .. .	S/S	27/9
X5M .. .. .	S/S	27/9
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#### SELECTEST Super 50 Multirange Test Meter.

Tremendous value in multirange test meters, the SELECTEST has all the features you are likely to need for years to come.

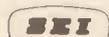
Reasonably priced at **£31.0.0.**

#### MINITEST pocket-sized Multirange Test Meter

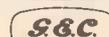
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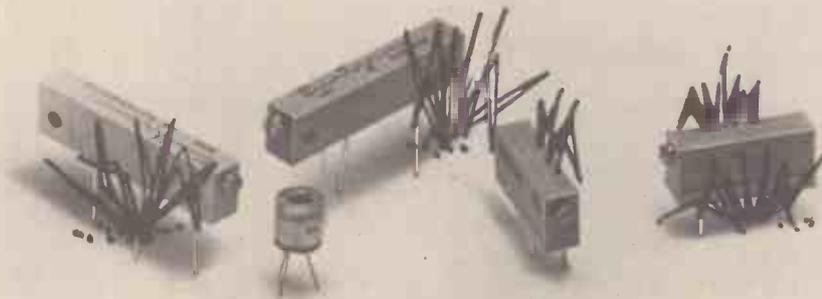
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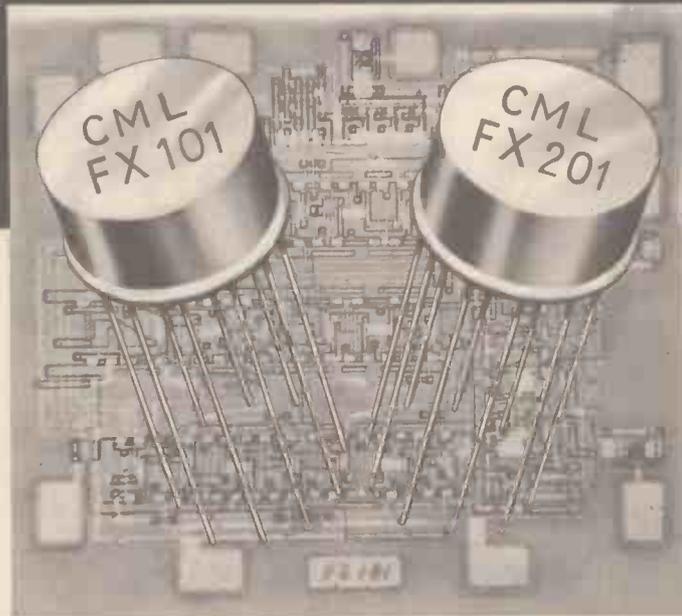
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The FX 101 switches an external load when the input lies above a given datum value or falls within a predetermined band. Applications include control, instrumentation, telemetry, telecommunications and entertainment systems. FX 201, comprising two separate 'band accept' flip-flop switches, each of which responds only to a signal within a predetermined frequency range, is primarily applicable to remote control systems using discrete 'tone' signals for command purposes.

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Power Ranges: 1W to 10kW.  
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GMS



**TRANSISTORISED FIELD STRENGTH METER  
TYPE MC16 BY PRESTEL**

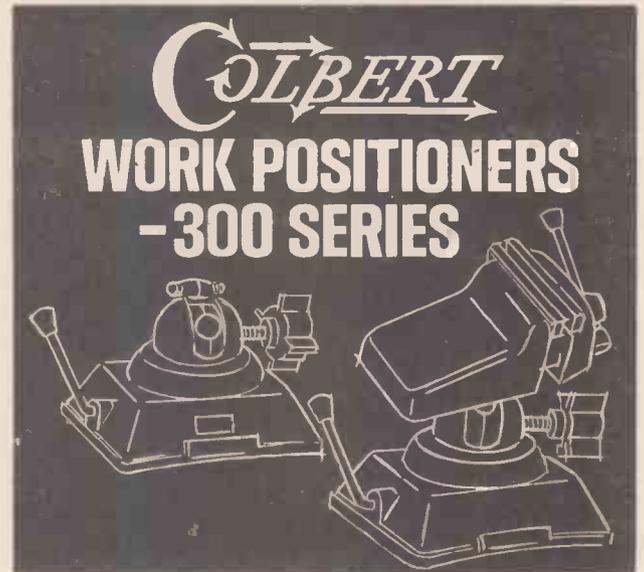
**SPECIFICATION:**

Frequency bands: three in VHF—40 to 60; 60 to 110; 110 to 230 Mc/s, one in UHF—470 to 900 Mc/s. Continuous separate UHF-VHF tuning with reduction gear (single control knob, 2-speed). Frequency accuracy: 2%. Intermediate frequency: 35 Mc/s. Transistors: 16. Diodes: 7. UHF-VHF sensitivity: 2.5  $\mu$ V. Measuring range: 2.5  $\mu$ V to 100 mV. 4 measuring scales: 100  $\mu$ V f.s. 1 mV f.s. 10 mV f.s. 100 mV f.s. and 1 Volt full scale, with auxiliary attenuator 20 dB. Two asymmetrical coaxial input terminals: 75 Ohms for UHF and VHF. Measuring accuracy:  $\pm 3$  dB;  $\pm 2$   $\mu$ V in UHF,  $\pm 3$  dB;  $\pm 2$   $\mu$ V in VHF. Power supply by 7 1.5 volt batteries, supplied Stabilized voltage by Zener diode. Incorporated loud-speaker. Detection can be switched on FM or AM. Pointer reset control. Battery charge checking device. Impedance matching transformer UHF-VHF 300 Ohms. Attenuator 20 dB. Leather bag. Technical manual. Dimensions: 280x100x150 mm. Weight: 3.5 Kg. Price: £95 Nett.

**PETER SEYMOUR, 410 BEVERLEY ROAD, HULL, YORKSHIRE.**

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Colbert Pana-Vise Work Positioners are specifically designed to quickly and easily achieve the most convenient, comfortable and time-saving work position.

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**OXLEY**

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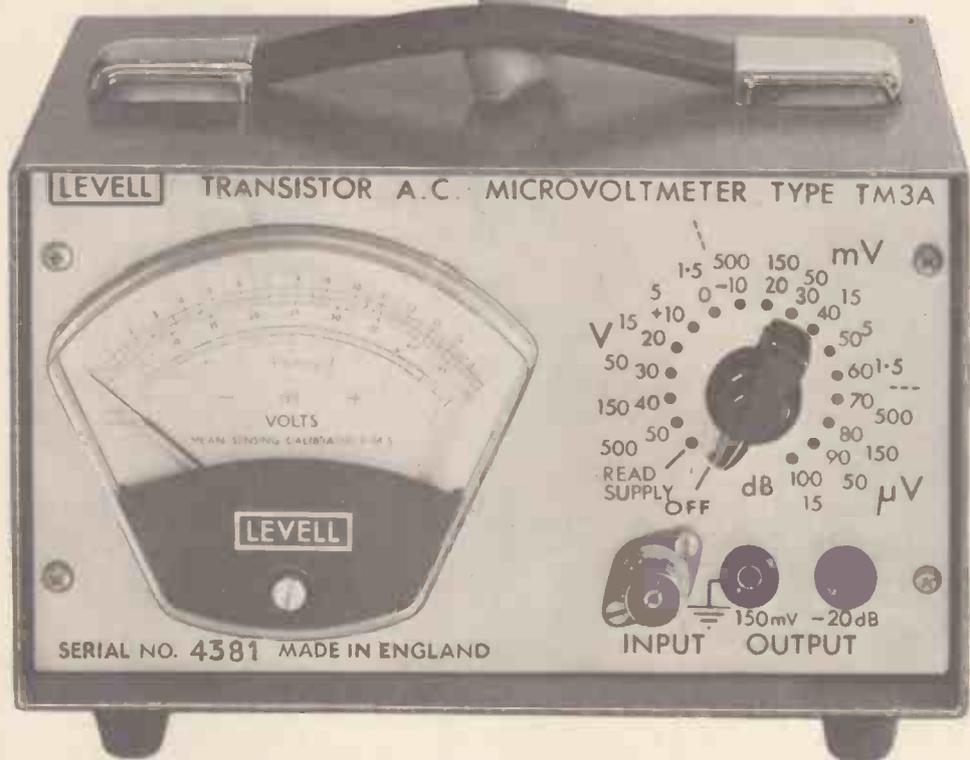
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**VOLTAGE & dB RANGES:** 15µV, 50µV, 150µV... 500V f.s.d. Acc. ± 1% ± 1% f.s.d. ± 1µV at 1kHz. - 100, - 90... + 50dB. scale = 20dB/+ 6dB rel. to 1mW/600 Ω.  
**RESPONSE:** ± 3dB from 1 Hz to 3MHz. ± 0.3dB from 4Hz to 1MHz above 500µV. Type TM3B can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

type **£49** type **£63**  
TM3A TM3B



**LEVELL**  
PORTABLE INSTRUMENTS

**D.C. MULTIMETERS**

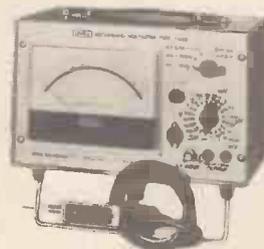
**VOLTAGE RANGES:** 3µV, 10µV, 30µV... 1kV. Acc. ± 1% ± 1% f.s.d. ± 0.1µV. LZ & CZ scales.  
**CURRENT RANGES:** 3pA, 10pA, 30pA... 1mA (1A for TM9BP) Acc. ± 2% ± 1% f.s.d. ± 0.3pA. LZ & CZ scales.  
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**RECORDER OUTPUT:** 1V at f.s.d. into > 1k Ω on LZ ranges.

type **£75** type **£89** type **£93**  
TM9A TM9B TM9BP

**BROADBAND VOLTMETERS**

**H.F. VOLTAGE & dB RANGES:** 1mV, 3mV, 10mV... 3V f.s.d. Acc. ± 4% ± 1% of f.s.d. at 30MHz. - 50dB, - 40dB, - 30dB to + 20dB. Scale - 10dB/+ 3dB rel. to 1mW/50 Ω. ± 0.7dB from 1MHz to 50MHz. ± 3dB from 300kHz to 400MHz.  
**L.F. RANGES:** As TM3 except for the omission of 15µV and 150µV.  
**AMPLIFIER OUTPUT:** Square wave at 20Hz on H.F. with amplitude proportional to square of input. As TM3 on L.F.

type **£85** type **£99**  
TM6A TM6B



Long battery life and large overload ratings are leading features of these solid state instruments. Mains units and leather carrying cases are optional extras. All A type instruments have 3 1/2" scale meters and case sizes 5" x 7" x 5", B type instruments have 5" mirror scale meters and case sizes 7" x 10" x 6".

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A Division of Tektronix U.K. Limited.

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# Wireless World

Electronics, Television, Radio, Audio

Sixtieth year of publication

September 1970

Volume 76 Number 1419

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## Wireless World

September 1970 3s 6d

Stereo decoder without coils  
Television wobbulator design



Our cover picture this month, which might be called "two kinds of digits", shows a five-by-seven array of light-emitting diodes made by Standard Telecommunications Laboratories. Display devices are discussed on page 444.

### IN OUR NEXT ISSUE

The first of a series of articles on the elements of linear i.c.s

Constructional details of a 100-watt quality amplifier

Review of some of the latest techniques in domestic sound and television receivers

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# Brimar's new catalogue talks tubes-in your language!



Data Display

Flying Spot Scanner

Monoscopes

Instrument Tubes

Our new catalogue is packed with technical information about the comprehensive Brimar range of industrial cathode ray tubes - abridged data on the tubes themselves, together with details of the wide choice of graticules, screen phosphors, etc. All designed to help you find the right tube, at the right price, in the right language - fast. Call, phone, or drop us a line - and we'll let you have your copy by return.

Radar & Compass Tubes

Standard Tubes

Screen Phosphors

**BRIMAR** Thorn Radio Valves and Tubes Limited  
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Telephone: 01-437 5233

# Sh-h-h don't make a noise!



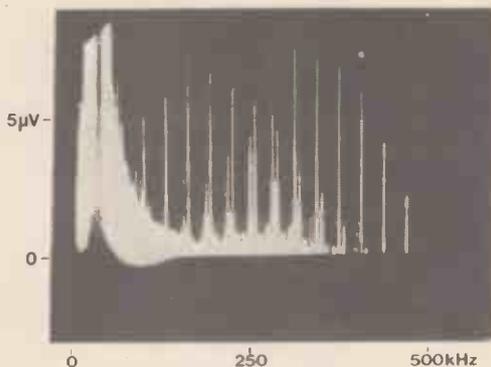
Well how much noise can a digital voltmeter make?

Some of them quite a lot.

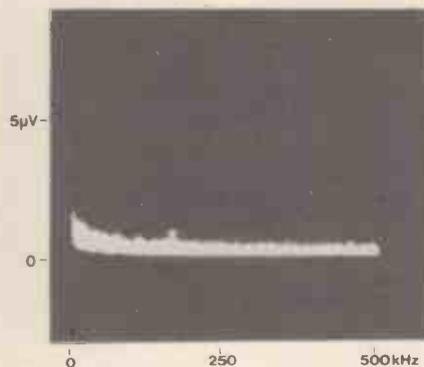
Spillback from the input terminals of a digital voltmeter can result in errors – errors often attributed to external noise – particularly in systems measuring low level inputs.

So down with spillback and welcome to the quiet one – the Racal 9075.

Still need convincing? Take a look.



"Spillback" from input terminals of a chopper stabilised digital voltmeter.



"Spillback" from Racal 9075 digital voltmeter.

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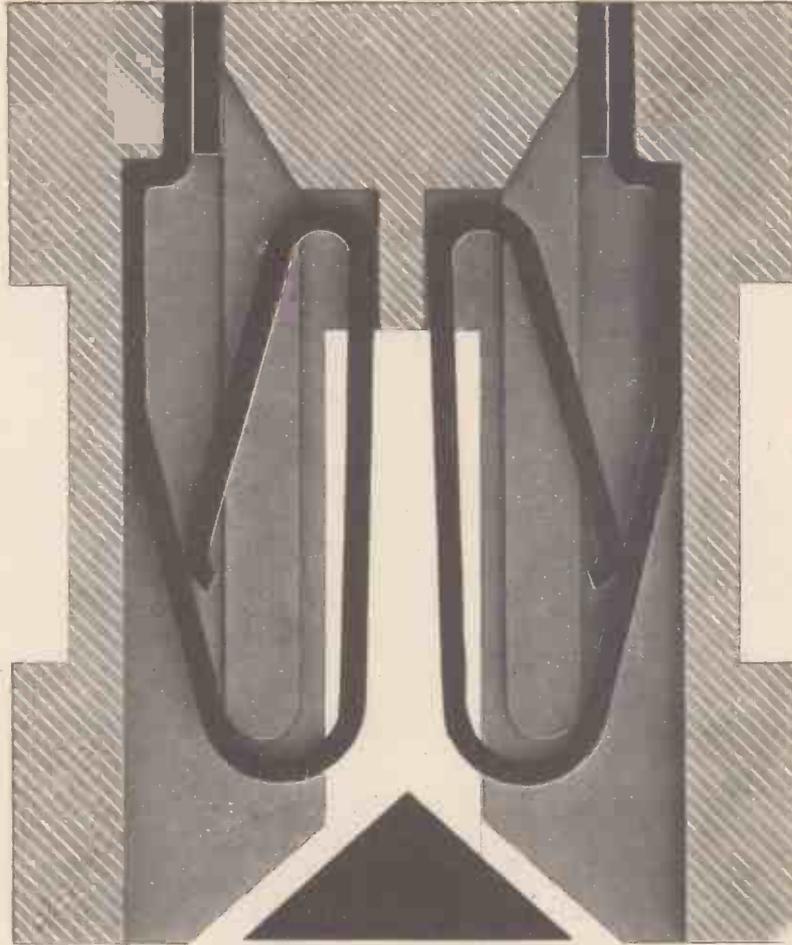
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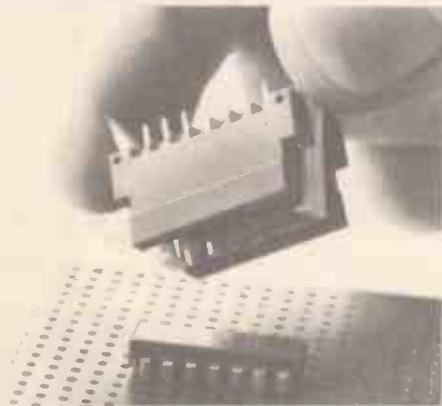
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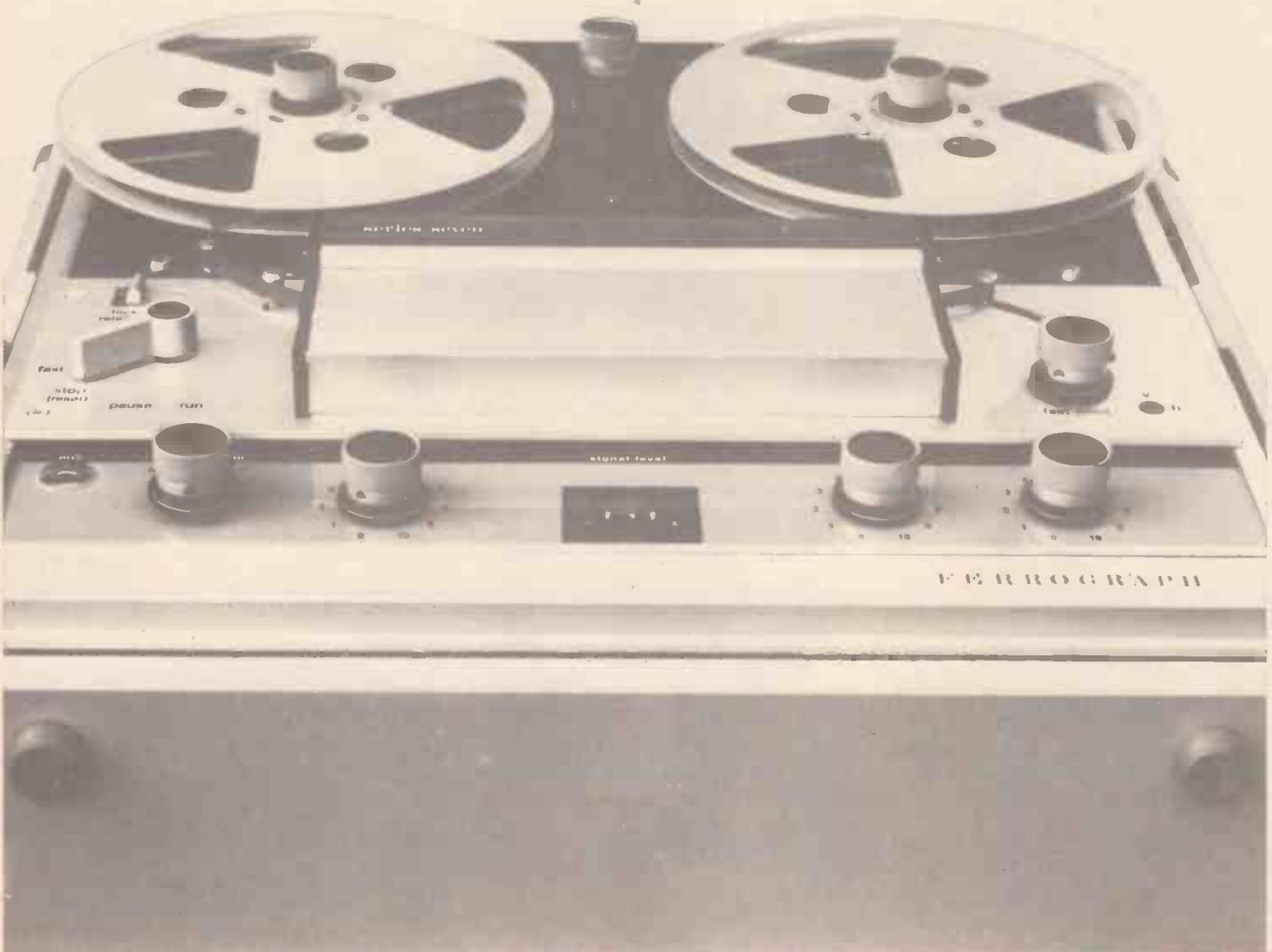
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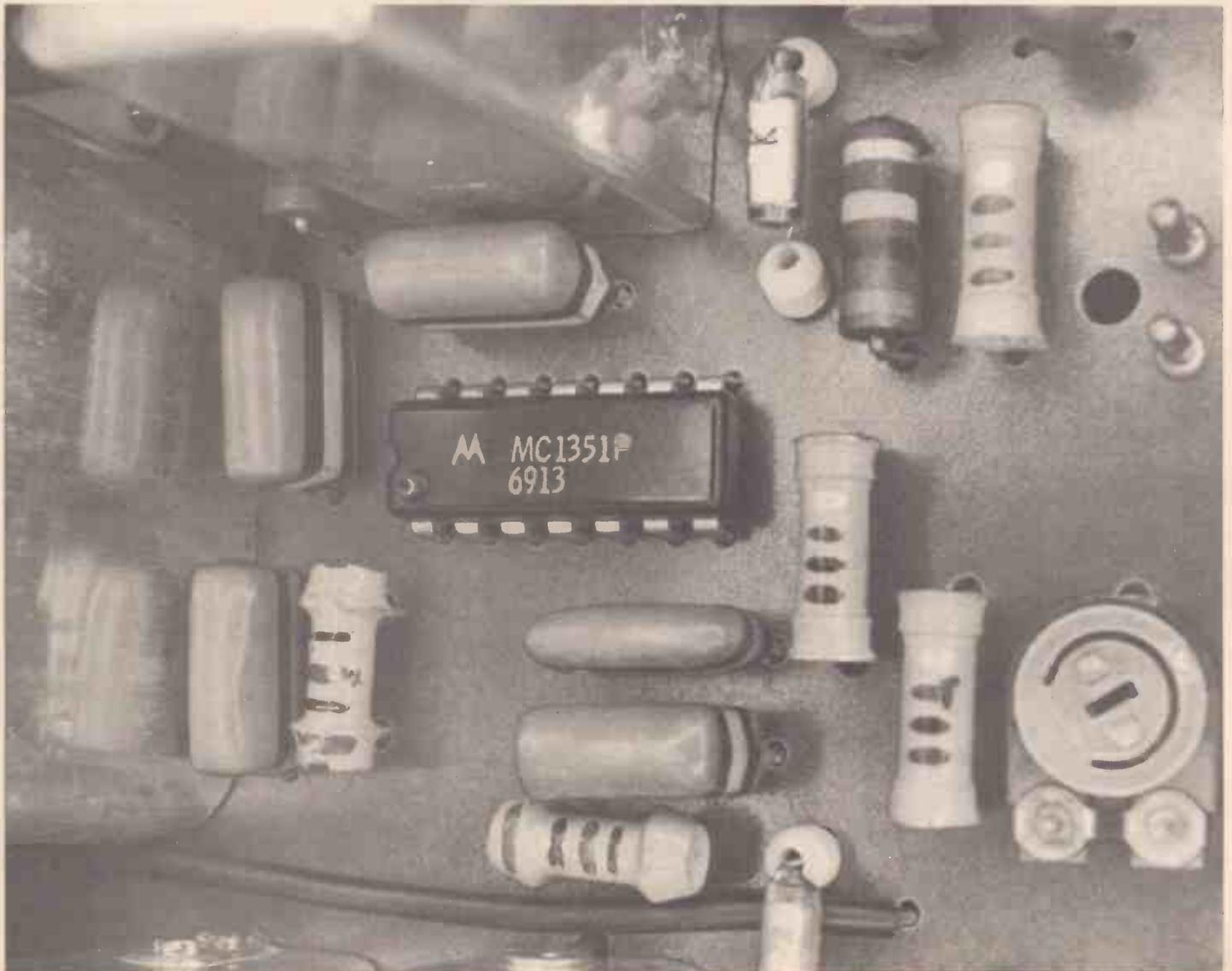
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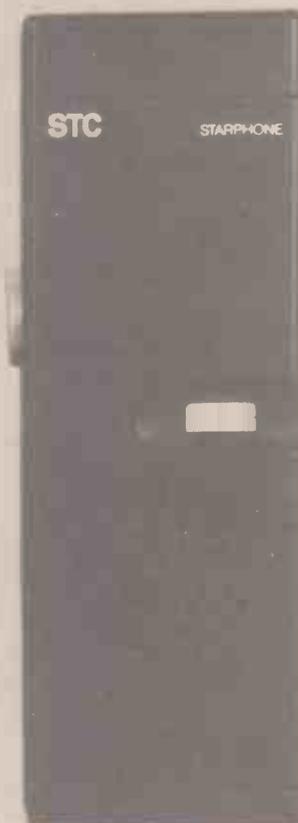
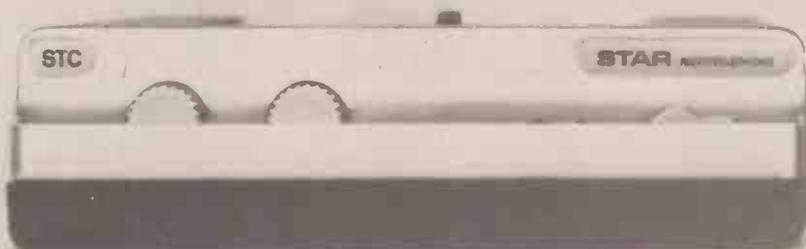
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It is an integrated stereo amplifier, built in the Ferrograph tradition to provide a unique combination of performance and facilities. Power output is 20 watts RMS per channel into a load of 8 ohms. Total harmonic distortion is less than 0.25% at 1 kHz at all levels up to its rated output. Silicon solid state devices are

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and output switching. The main controls are readily to hand on the front panels; all others are conveniently placed under a hinged flap.

In appearance, the F307 amplifier continues the uncluttered lines of the Ferrograph Series 7 recorder, the two making an ideal combination which is matched both visually and technically. But the amplifier is equally compatible with most other good recorders and hi-fi installations, suits innumerable

amateur and professional uses, blends with any decor, stands attractively on any bookshelf or room-divider.

When planning your hi-fi system the F307 deserves your serious consideration. Your local Ferrograph specialist will be pleased to demonstrate it to you. Alternatively, please write or ring for details and address of nearest stockist. The Ferrograph Co. Ltd, The Hyde, Edgware Road, Colindale, London NW9  
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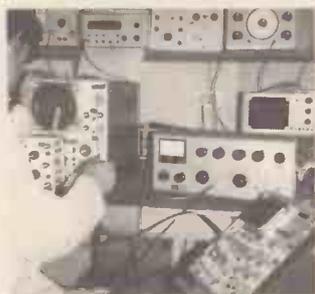
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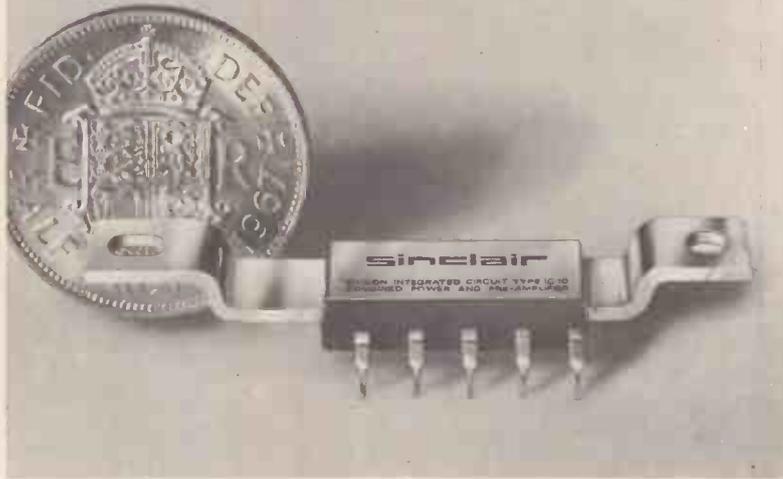
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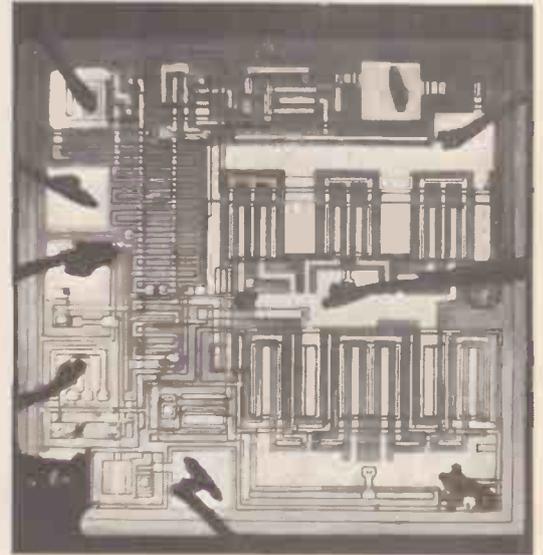


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# SINCLAIR IC-10



## MONOLITHIC INTEGRATED CIRCUIT AMPLIFIER AND PRE-AMP



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The IC-10 is primarily intended as a full performance high fidelity power and pre-amplifier, for which application it only requires the addition of such components as tone and volume controls and a battery or mains power supply. However, it is so designed that it may be used simply in many other applications including car radios, electronic organs, servo amplifiers (it is d.c. coupled throughout), etc. Once proven, the circuits can be produced with complete uniformity which enables us to give a full guarantee on every IC-10, knowing that every unit will work as perfectly as the original and do so for a lifetime.

MORE SINCLAIR DESIGNS ON PAGES FOLLOWING

### ■ SPECIFICATIONS

Output:	10 Watts peak, 5 Watts R.M.S. continuous
Frequency response:	5 Hz to 100 KHz $\pm$ 1dB
Total harmonic distortion:	Less than 1% at full output.
Load impedance:	3 to 15 ohms.
Power gain:	110dB (100,000,000,000 times) total.
Supply voltage:	8 to 18 volts.
Size:	1 x 0.4 x 0.2 inches.
Sensitivity:	5mV.
Input impedance:	Adjustable externally up to 2.5 M ohms.

### ■ CIRCUIT DESCRIPTION

The first three transistors are used in the pre-amp and the remaining 10 in the power amplifier. Class AB output is used with closely controlled quiescent current which is independent of temperature. Generous negative feedback is used round both sections and the amplifier is completely free from cross-over distortion at all supply voltages, making battery operation eminently satisfactory.

### ■ APPLICATIONS

Each IC-10 is sold with a very comprehensive manual giving circuit and wiring diagrams for a large number of applications in addition to high fidelity. These include stabilised power supplies, oscillators, etc. The pre-amp section can be used as an R.F. or I.F. amplifier without any additional transistors.

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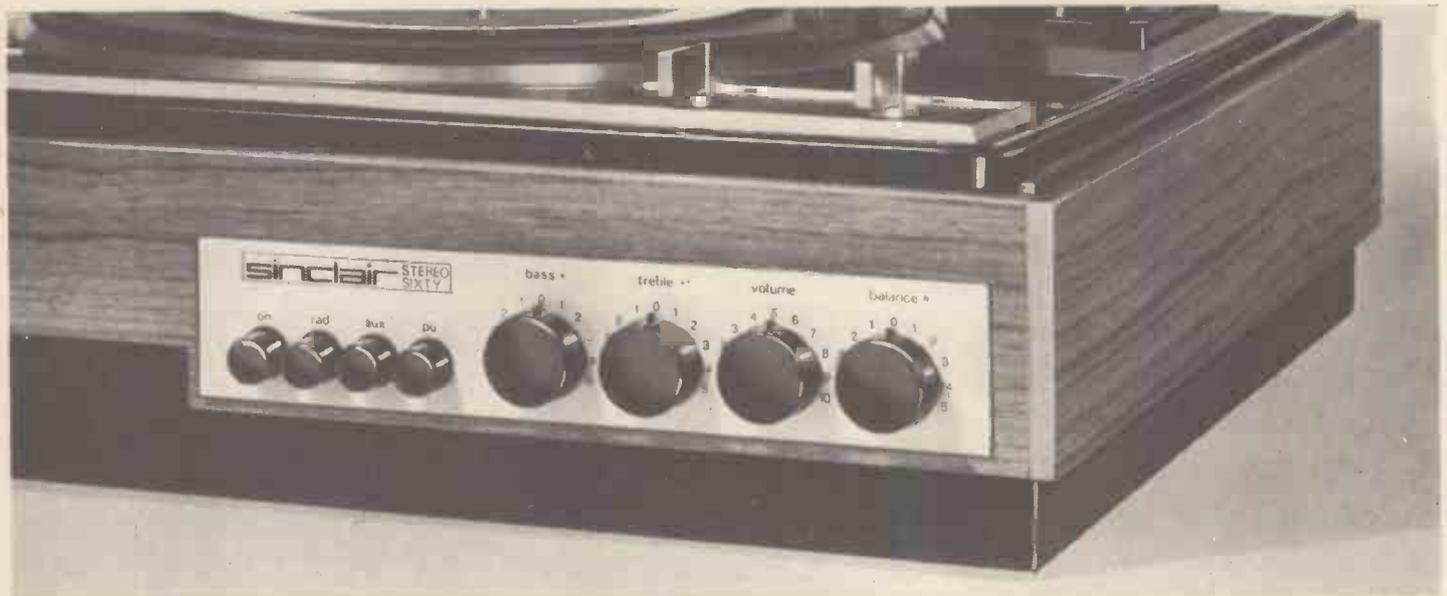
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The modules are: 1. The Z.30 and Z.50 high gain power amplifiers. 2. The Stereo 60 preamplifier and control unit. 3. The Active Filter Unit. 4. 4 supply units—PZ.5; PZ.6; PZ.7 and PZ.8. In a normal domestic application, there will be no significant difference between PZ.5 or PZ.6 unless loudspeakers of very low efficiency are being used, in which case the PZ.6 will be required. For assemblies using two Z.50's there is the PZ.8 supply unit to ensure maximum performance from these amplifiers. No skill or experience are needed to build your system and the Project 60 manual gives all the instructions you can possibly want, clearly and concisely. Perhaps the greatest beauty of the system is that it is not only flexible now but will remain so in the future as new additions are made to the range. A stereo F.M. tuner is next to come. These and all other modules introduced will be compatible with those already available and may be added to your system at any time. And because Sinclair are the largest producers of constructor modules in Europe, Project 60 prices are remarkably low.

System	The Units to use	In conjunction with	Your Project 60 Units will cost
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B Simple battery powered record player	Z.30	Crystal pick-up, 12 V or more battery supply and volume control	89/6
C Mains powered record player	Z.30 and PZ.5	Crystal or ceramic P.U. Vol. control etc.	£9.9.0
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K Stereo F.M. tuner	To be released shortly		

How to assemble and use Project 60 modules to best advantage in the above and other applications will be found in the fully descriptive Project 60 manual included with Project 60 systems. This 48 page manual is available separately, price 2/6d including postage.

# sinclair

SINCLAIR RADIONICS LTD., 22 NEWMARKET ROAD, CAMBRIDGE

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## Z.30 & Z.50 POWER AMPLIFIERS

The Z.30 together with the Z.50 are both 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 the Z.30 or Z.50 power amplifiers in your Project 60 system will depend on personal preference, but they are the same physical size and may be used with other units in the Project 60 range equally well. For operating from mains, for the Z.30 use PZ.5 for most domestic requirements, or PZ.6 if you have very low efficiency loudspeakers. For Z.50, use the PZ.8 described below.

**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 35V: 20 watts R.M.S. into 3 ohms using 30 volts.  
 Z.50 40 watts R.M.S. into 3 ohms from 40 volts: 30 watts R.M.S. into 8 ohms, using 50 volts.  
**Frequency response** 30 to 300,000 Hz  $\pm$  1 dB  
**Distortion** 0.02% into 8 ohms  
**Signal to noise ratio** better than 70 dB unweighted  
**Input sensitivity** 250mV into 100 Kohms.  
**For speakers** from 3 to 15 ohms impedance  
**Size** 3½ x 2½ x ½ ins.

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

**89/6**

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

**109/6**

Curve shows power versus distortion for Z.30 and Z.50.



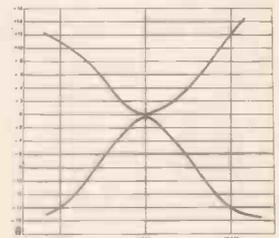
## STEREO 60 Pre amp/Control Unit

Designed for the 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  $\pm$  1dB: 20 to 25,000Hz. Ceramic p.u. – up to 3mV: up to 3mV.
- Output – 250mV.
- Signal-to-noise ratio – better than 70 dB.
- Channel matching – within 1 dB.
- Tone controls – TREBLE +15 to -15dB at 10kHz: BASS +15 to -15dB at 100Hz.
- Front panel – brushed aluminium with black knobs and controls.
- Size 8½ x 1½ x 4 ins.

Built, tested and guaranteed **£9.19.6**

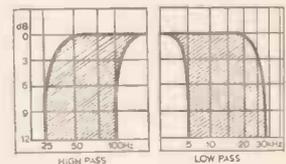


Curve to show bass and treble cut and boost.

## ACTIVE FILTER UNIT

For use between Stereo 60 unit and two Z.30s or Z.50s, the Active Filter Unit matches the Stereo 60 in styling and is as 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 Sinclair A.F.U. is suitable also for use with any other amplifier system.

Two stages of filtering are incorporated—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. Filter slope, both sections 12dB per octave. Distortion at 1kHz (35V supply) 0.02% at rated output.



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## POWER SUPPLY UNITS

The units below are designed specially for use with the Project 60 system of your choice. Illustration shows PZ.5 power supply unit to left and PZ.8 (for use with Z.50s) to the right. Use PZ.5 for normal Z.30 assemblies and PZ.6 where a stabilised supply is essential.

- PZ-5 30 volts unstabilised **£4.19.6** PZ-8 45 volts stabilised (less mains transformers) **£5.19.6**  
 PZ-6 35 volts stabilised **£7.19.6** PZ-8 mains transformer **£5.19.6**

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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.

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# Electro-Tech Sales

**NEW HYSTERESIS MOTORS BY WALTER JONES.** Type 14050/12, 240v. 50 c/s 1500 RPM cont. rating, output 2.0 oz./in. Size: Length (less spindle) 3 3/8". Width 2 1/4" x 2 1/4". Spindle 1" x 3/16". Weight 3 lb. Maker's price in region of £22.10.0. Our price £6.10.0 each. Carr. Paid.



**"Parvalux" Reversible 100 RPM Geared Motor.** Type S.D.14, 230/250v. A.C. 22 lb./in. Standard foot mounted, variable angle final drive. Removable 9-tooth chain spigot on 3/16" spindle. 1st class condition. £7.10.0 each. P. & P. 10/-. Also limited number only as above. Without spigot. Brand New. £12.10.0 each. P. & P. 10/-.



**NEW "CARTER ELECTRIC" 12 r.p.m. MOTOR.**—Non-reversible, 1/2" spindle. 240v. A.C. Open frame with cast aluminium cased gearbox. Stoutly constructed. Approx. 25 lbs./in. Overall size (approx.) 3" x 3" x 4" plus spindle. 45/- P. & P. 5/-.



**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 1/2", dia. 9/16" (including mount). Please state vertical or horizontal mount and voltage. £2.5.0 each. Carr. Paid.



**SPECIAL OFFER. Enclosed Relay, complete with base.** Brand New. Type MQ308 600Ω 24v. 4 c/o. Size 1 1/2" x 1 1/2" x 3/4", £5 per dozen. 12/- each. Type MQ508 10,000Ω 100v. 4 c/o. £5 per dozen. 12/- each. Type MQ108 40Ω 6v. 4 c/o. £6 per dozen. 13/6 each. Type MQ208 150Ω 12v. 4 c/o. £6 per dozen. 13/6 each. Carr. Paid.



**NEW "F.I.R.E." PLUG-IN RELAY.**—115v. Coil 50/60 c.p.s. 3 heavy duty silver change-over contacts. Very robust. 17/6. Carr. Paid.



**NEW DIAMOND "H" 240v. A.C. RELAY.**—3 heavy duty silver change-over contacts. 17/6. Carr. Paid.



**DIAMOND "H" SEALED RELAY** Type BR 115 C.I.T.—IC 26v. 150Ω 4 P.D.T. Completely encapsulated in heavy gauge brass case, glass sealed terminals, very robust. 17/6 each. Carr. Paid.

**SIEMENS HIGH SPEED RELAY, Type 89L.** 1,700Ω + 1,700Ω coil. New 15/- each. Carr. Paid.

**G.E.C. SEALED RELAY, Type M1492.** 670Ω 24v. Contacts: 4 c/o. Ex-chassis, but unused. 20/- Carr. Paid.

**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. 10/- each. 80/- per dozen. Special quotations for 100 or over. Reference Magnets available 1/6 each. Carr. Paid.



**SYLVANIA CIRCUIT BREAKERS** gas filled providing a fast thermal response between 80° and 180°C. Will withstand pressures up to 2,000 lb. sq./in. rated 10 amp. at 240v. continuous. Fault currents of 28 amps. at 120v. or 13 amp. at 240v. silver contacts. Supplied in any of the following opening temperatures (degs. cent.) 80, 85, 95, 100, 105, 110, 120, 125, 130, 135, 140, 145, 150, 155, 160, 170, 175. 10/- each or 80/- per dozen. Carr. Paid.



**THORN DIGITAL INDICATOR.** A modular unit easily read through a wide angle of view even under bright lighting. 12 characters, 0 to 9, decimal point and minus sign. Characters 13/16" high on acrylic, edge-lit by 1 watt midjet lamp. Front panel 4 3/8" x 1 1/8", depth overall 1", matt black finish. Supplied with 12 lamps. Choice of the following ratings—6v. 1A. or 12-14v. .08A. £4.0.0 each, spare lamps 24/- per dozen. Carr. Paid.



**PRECISION RESISTORS**

Electro-Thermal Precistor 2.4K ± 0.1% 10/- each. Shallcross 3400Ω ± 0.5% 6/- each. Alma 141.46K ± 0.1% 10/- each. Alma 50K ± 0.05% 15/- each. RIL Type 2, 6.666K ± 0.01% 20/- each. RIL Type 9, 560Ω ± 1% 2/6 each.

**SERVO POTENTIOMETERS**

Precision Line (USA). Size 15, 300Ω ± 5% ± 5% LIN. Continuous track plat. Wipers set at 180°. 75/- each. Carr. Paid.

Penny & Giles. Size 15, 500Ω. Type Q26201-72/1. Continuous track. 75/- each. Carr. Paid.

**PRECISION POTENTIOMETER**

Beckman. Type AS.506. 10 turn. Tol ± 1%. LIN Tol ± .07%. 40K. Long Spindle. 60/- each. Carr. Paid.

**VACTRIC.** Precision D.C. motor and gear head. Motor type 11P101 (size 11) 28 volts operation. 5000 RPM Torque 120G.C.M. 0.54 amp. Coupled to gear head, type 15H102 (size 15). Ratio 300:1. Max torque 100 lbs./ins. Original makers packing. £20. Carr. Paid. Quantity discounts on application.



**SYNCHROS**—in original makers packing. Muirhead receiver 23/TR4b 400 HZ 115/90v. £10.10.0. Muirhead control transformer. 18CT4b. 400HZ. 90/1V per degree £8.10.0.

Sperry A.C. tachogenerator. Type 11MGSL 400 HZ 115v. 0.5v/1000RPM. Lin. Range 0-600 RMP. £15.10.0.

Moore Reed synchro control differential transmitter VCDX18/27-4a. 400HZ. 90/90 volts. £10.10.0.

Moore Reed synchro control transmitter. VCX 23-36-46. 400HZ. 115/90 volts. £10.10.0.

Quantity discounts on application.

**New 75-0-75 Microammeter by Sifam.** 750 ohm movement, clear reading, 5µa divisions × 1/2"; plastic front, projection 1/2" (tapering forward). Size: 4 1/2" x 3 3/8", 57/6 each. Carr. Paid.



**ERIE.** Ceramicon capacitor. Type CHV411P. 500 P.F. 30KV. Size 1.5 in. dia. x 1.44 in. long 15/- each. Carr. Paid.

**PULLIN MOTOR.** Type PMIC. 28 Volts D.C. Original makers packing. £4.5.0. Carr. Paid.

**BERCO.** Rotary rheostat. Type L25. 100Ω. 25 watt. 1 1/2 in. dia. 1/2 in. spindle. 12/6 each. P.P. 2/6.

**TIME ELAPSED REGISTER.** This robust and accurate instrument functions on 24v. D.C. Has a 5 digit readout plus dial reading 1 hour (60 l min. div.) metering. Total of 99,999 hrs. Non-reset sealed unit, chrome bezel, through panel mounting. Size 2 1/8 in. dia. x 3 1/8 in. overall. 65/- Carr. Paid.



**ATLAS MIDJET PANEL LAMPS** unrivalled for indication purposes requiring a brilliant but tiny light source. Available with flange cap or wire ended in the following ratings: Capped: 6v. 1A and 12-14v. .08A Uncapped: 4v. .25A., 6v. 1A., 6v. 2A 24/- per dozen or boxes of 50 at 24 per box. **INDICATOR LAMP HOLDERS AND CAPS** for MIDJET PANEL LAMPS (as above) available red, green, blue, 2/6 each (complete) minimum order 4 units.



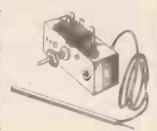
**ATLAS SUB-MINIATURE LAMPS** type L1122 and L1123—a high efficient light-source with excellent light-output and low power demand. Ratings 5v. 60 ma. .35 ± 25% lumens. Life expectancy 60,000 hours or at 6 v. 70 ma. .75 ± 25% lumens 5,000 hours. Dimensions: Uncapped 6.3 x 3.1 mm. leads 12.7 mm. capped 9.1 x 3.1 mm. Ideal for instrument lighting normally sold in excess of 12/- each, our price 30/- per dozen or boxes of 50 at £5 per box. Carr. Paid.



**CENTRIFUGAL BLOWER BY AIR CONTROL LTD.** 240v. AC. 9" dia. 2,850 RPM. 1/10th HP. Ideal for organ blowing, powerful, low noise level. 1st class condition. Photo on request. £12.10.0. Carr. Paid.

**WE WELCOME OFFICIAL ORDERS FROM ESTABLISHED COMPANIES, EDUCATIONAL DEPTS., ETC.**

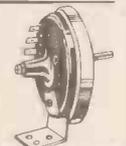
**"TEDDINGTON" CONTROLS STAT TYPE TBB.**—Adjustable between 75° and 100°C. A further internal adjuster takes the maximum up to 120°C. Circuit cuts in again at 3° below cut-out setting. 42" capillary and sensor probe. The thermostat actuates a 15 amp. 250v. c/o switch. A second single pole on/off switch is incorporated in the adjustment mechanism. 17/6. Carr. Paid.



**OMRON MICROSWITCH.** Type VV—15—1A. Single c/o 10 amp. at 250v. 1 1/2" x 3/8" x 3/8". 30/- per dozen. Carr. Paid.

**"HONEYWELL" MICROSWITCH.**—Single and double bank, manual-push. Ideal for vending machines, etc. Each bank comprises a change-over rated 15 amps. 240v. A.C. The through-panel mounting assembly is in heavy polythene surmounted by black knob. Neck dia. 3/8". Single 10/- each. Double 15/- each. Also few only 3 bank 20/- each. Carr. Paid.

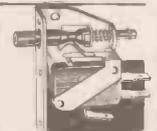
**"GOYEN" PRESSURE SWITCH.**—Incorporating differential adjustment between 2" and 12" water gauge (a max. of approx. 1/2 p.s.i.). A single pole change-over switch rated 15 amps. 250v. is actuated. Air inlet tube 1/8" dia. Projection 1 1/2". Overall size: dia. 3 1/2", depth 2" plus 1/4" (air tube). 25/- Carr. Paid.



**"HONEYWELL" V3 SERIES.**—Flush microswitch 10 amp. c/o. The side panel is insulated. End-plate size: 2" x 3/8". 30/- per doz. Carr. Paid.



**"HONEYWELL" TYPE 23AC-NE**—15 amp. change-over switch is fitted on angled metal mount with spring loaded plastic rod operating cam. 10/- each. Carr. Paid.



**"BONNELLA" 15 AMP. 240v. TOGGLE SWITCHES.**—Single pole change-over, 3" Long Dolly. Standard single hole mounting. 30/- per doz. (minimum 1/2 doz.). Carr. Paid.

**GARDNERS AUTO-TRANSFORMERS.** 110/115/200/250v. 1500 watts. Weight 23lb. Few only. £10.10.0. P. & P. 25/-.

**GARDNERS CASTLE SERIES.** Isolation transformer type CAS 934. 240v. fused. Primary 24v. 4 1/2 amps. out. These units are constructed for outside use with fitted 5' mains lead and 3 socket outlet with plug supplied. Brand New. Makers price £7.18.6. Our price £4.15.0 P. & P. 15/-.

**GARDNERS CHOKES**

Type C237 20H 180MA	30/-	5/- P.P.
Type C570 0.05H 3.5A	35/-	5/- P.P.
Type C549 0.1H 2.5A	20/-	5/- P.P.
Type C271 5H 500MA	37/6	7/6 P.P.
Type C576 0.05H 7.5A	50/-	10/- P.P.
Type C527 0.5H 4A	50/-	10/- P.P.
Type SK7486 35MH 3A D.C.	30/-	5/- P.P.
Type F9719 25H 60MA	8/6	3/6 P.P.

**PRECISION TRIMMER POTENTIOMETERS**

Painton Bourns Type 2005-1-502 5kΩ	12/-
Painton Bourns Type 2005-1-03 10KΩ	12/-
Painton Bourns Type 2005-1-501 500KΩ	12/-
Painton Bourns Type 200-51-503 50KΩ	12/-
Painton Bourns Type 224P-1-202 2KΩ	12/-
Painton Bourns Type 224S-1-102 1KΩ	12/-
Painton Bourns Type 200S-1-203 20KΩ	12/-
Painton Bourns Type 275-1-252 2.5KΩ	12/-
Ril Type 321 10KΩ	12/-
Morganite Type 80 1KΩ	12/-
Mec Type 025 (Tubular) 200Ω	12/-
Mec Type T20P 50Ω	12/-

All Carr. Paid.

**Ernest Turner 5" x 4" 0-1 Ma. meter** calibrated 0-10 in 50 divisions mirrored scale, handsome chrome escutcheon for flush mounting. A quality instrument. £4.5.0. Carr. paid.



**"DECCO" MAINS SOLENOID.**—Compact and very powerful. 16 lb. pull. 3/8" travel which can be increased to 1" by removing captive-end-plate. Overall size 2" x 2 1/2" x 2 1/2" high. 27/6. P. & P. 5/-.



**New "Magnetic Devices"** solenoid 240v. A.C. Type 42117, 1 to 3 lb. pull, frame size 1 1/2" x 1 1/2" x 1". 20/- each. Carr. Paid.



**K.L.G. Sealed Terminals.** Type TLSI AA, overall length 1 1/16", box of 100, 25s. Type TLSI BB, overall length 1", box of 100, 35s. Carr. Paid.



**Welwyn high value Resistors Type GA 36501.** Values between 9.4 and 10.9 kilo-ohm ± 1%, glass encapsulated 15/- Carr. Paid.

**WELWYN" RESISTORS.**—Type H12. One value only. 1 kilo-ohm ± 20%. 5/- each. (Min. order 2.) Carr. Paid.

**ALL ITEMS NEW AND UNUSED UNLESS OTHERWISE STATED**

PERSONAL CALLERS WELCOME.

**ELECTRO-TECH SALES**

**BUSINESS HOURS: 264 PENTONVILLE ROAD, LONDON, N.1**  
**9.30-6 (1 p.m. Sats.) (ONE MIN. FROM KINGS X STATION) Tel. 01-837 7401**

**SENSITIVE DC AMPLIFIERS TGA2**

Modular construction all solid state, gains up to 1,000 may be obtained impedance in the order of 10 M ohms 5 voltage gain ranges and variable control provides continuous adjustment over each range make these units very suitable for increasing the sensitivity of chart and pen recorders, offered brand new at only £15. P. & P. 4/6.

**ADVANCE VOLT STAT CV500/31**

Input 162-276 v. A.C., 50 c/s. 1 phase output 115 v. constant at 410 watt. Offered BRAND NEW at only £8. P. & P. 15/-. These items are double wound.

**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 £7.10 including earth bayonet TM8194.

**HIGH VOLTAGE TRANSFORMERS**

Input 240 v., output 2560 v. and 2820 v. at 1 amp. Weight 75 lb. Price £15.

**NICKEL-CADMIUM BATTERIES**

D.E.A.C. manufacture RS 3-5 rating 3-5 Ah 1-24 v. Size as British U2, fully rechargeable. Offered BRAND NEW 19/6 each. P. & P. 1/6.

**MARCONI TF 1073A RF ATTENUATOR**

Range 0-100 in 1dB steps. Frequency range d.c. to 100 MHz. Input 0.25 watts, accuracy each 1dB step 0.2dB. Offered perfect condition 75 ohm version £35 each.

**MATRIX SWITCH ASSEMBLY**

Five rows of 17 contacts (gold plated). Working voltage 250v between adjacent contacts current rating max in any one row 1 amp. Applications are many in Process Control data handling and card reading. Offered brand new at only 50/- each, P. & P. 3/6. Diode Pins 3/6 each.

**SPECIAL OFFER**

Temperature Compensated RF Power Meter, Model B831B, for the accurate measurement of CW or Pulsed RF power in six full scale ranges from .01 to 3.0 milliwatts. These measurements can be made over the frequency range from 0.01 to 40 GHz using a series 218 Thermistor Head. All measurements are read directly in milliwatts or DBM on the meter which has a mirror backed scale. These units are offered in as new condition, some of which have been used as demonstration models only. Price only £75, complete with wave guide type thermistor head and fully detailed manual.

**VSWR INDICATOR MODEL 812A**

Precision equipment used to measure VSWR and relative power, over the frequency range of 1 GHz to 220 GHz. The unit consists of three fundamental electrical parts, a high gain, tuned amplifier, a precision, attenuator and a precision meter, the tuned audio amplifier is tuned to a centre frequency of 1 kHz adjustable between 950-1050 cps. Band Width 20, 40 and 400 cps selectable. Sensitivity 0.1 micro volt for full scale deflection. Offered as new at only £45 each.

**A.E.I. MINIATURE UNISELECTOR SWITCHES**

No waiting, straight off the shelf and into your equipment the Catalogue Nos. are 2202A, 4/33A63/1; coil resistance is 250 ohms. Complete with base, and the price is £4.19.6. Limited quantity only available. Also: 2203A, 2200A, 2202A.



**FOSTER VOLTAGE REGULATING EQUIPMENT TYPE 12A80**

Input 250 A.C. max., input variation ±5-15% output 250 v. A.C. constant. Load 80A max. As new £65. Carr. £4.



**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 with battery ready to work. For 250 volt pressure only. List Price £19.10.0. Our Price £5.19.6 plus 4/6 post/packing.

- Rhode & Schwarz ESM300 UHF Receiver AM/FM 85MHz—300 MHz.
  - Rhode & Schwarz BN15031 Field strength test receiver AM/FM 90 MHz—470 MHz.
  - Rhode & Schwarz BN4151/2\*60 Noise generator 3 MHz—1000 MHz.
  - Rhode & Schwarz BN18042 Unbalanced standard Attenuator 0-100db 50 ohm 0 MHz—600 MHz.
  - Rhode & Schwarz BN33664/50 UHF Load resistor 100 watt 50 ohm 0 MHz—600 MHz.
  - Rhode & Schwarz BN4521 Vibration Meter 30Hz—12 KHz.
  - Rhode & Schwarz ZD Diagraph.
- Advance Q meter type T.1. 100 kHz—100 MHz.  
 Marconi Q meter type 329G 50 kHz—50 MHz.  
 Marconi Q meter type 886A 15 MHz—170 MHz.

- Marconi Impedance Bridge type TF936
- Marconi Universal Bridge type TF868/1
- Marconi Universal Bridge type TF868

**RHODE & SCHWARZ POLYSKOP (SWOB. 2)**  
 With accessories for sale or hire.

**RF GENERATORS**

- Marconi Standard Signal generator TF867 15 kHz—30 MHz ..... £200
- Marconi UHF signal generator TF762C 300—600 MHz ..... £75
- Marconi FM/AM Signal Generator 2-216 MHz TF995A/3 ..... P.U.R.
- Services type CT212 AM/FM signal generator 85 kHz—32 MHz ..... £45
- Services type CT211 AM/FM signal generator 20-80 MHz ..... £40
- Avo Signal generator portable 50 kHz—80 MHz ..... £15
- Hewlett Packard 616B 1-8 GHz—4 GHz, also special generators up to X band
- Marconi signal generator TF144H/4. Range 10 kHz to 72 MHz ..... P.U.R.
- Advance Model SLI. Range 300-1000 MHz ..... £150

**D.C./A.C. ELECTRONIC VOLTMETERS**

- Phillips GM6010 Sensitive D.C. Millivolt Meter 1MV/FSD to 300 volts in twelve ranges ..... £45
- Phillips GM6505 Transistor measuring test unit designed for labs' test departments etc. .... £125
- Advance VM77 wide range A.C. Valve Voltmeter 1 mv-300 v. .... £25
- Phillips GM6016 3 mv-1000 v. 1 kHz-30 MHz ..... £30
- Phillips GM6014 1 mv-300 v. 1 kHz-30 MHz ..... £25
- Rhode & Schwarz UHF Millivoltmeter type URV with insertion unit for measurements up to 2400 MHz ..... £95
- Hatfield Millivoltmeter LE48C 0-3 MV- 30 volts. Large eight inch scale indication balance and unbalanced inputs ..... £30

- CAMBRIDGE INSTRUMENT Co. Ltd. Precision test meters. Electrodynamic A.C. Ammeter 0 to 15 amps with test certificate ..... £35
- Dynamometer A.C. Ammeter range 0 to 15 amps ..... £45
- Cambridge Dynamometer A.C. test set 0-225 Watts/0-330 v./0-30 v. .... £55

- Tinsley Universal Shunt type 4309C ..... £5
- Tinsley Vernier Potentiometer type 4363E Auto ..... £95
- Foster Thermocouple potentiometer type DX ..... £75

- Digital Voltmeter Solartron LM902-2 four digit readout ..... £85
- Solartron A.C. Converter LM 903 matching unit for LM902 ..... £75
- Hewlett Packard DVM 405CR four digit readout auto polarity ..... £75
- Glouster DVM BIE 2123 A.C./D.C. transistor portable 0-1000 v. .... £75

- Frequency Counters Analogue/Digital
- Marconi TF1345/2 digital 10 Hz to 220 MHz C/W full complement plug in's ..... £300
- Racal Digital frequency meter type older valve model 10 Hz-300 kHz ..... £25
- Rank Cintel Counter/timer transistorised model 10 Hz-1 MHz ..... £45
- Venner Counter/timer type TS a3 Mains or portable Digital meter readout ..... £25
- U.S.A. BC221 Heterodyne frequency meter 125 kHz-20 MHz new or used from ..... £18
- U.S.A. TS175/U 85-1000 MHz Modulated, reception/emission CW, MCW, as new ..... £85
- U.S.A. TS186/D Heterodyne frequency meter 100-10,000 MHz CW, MCW, pulse ..... £95

**SOLARTRON VF252/NSL PRECISION AC MILLIVOLT METER**  
 Range 1.5 milli volt (for full scale deflection) to 15 volts in eight ranges input impedance 30 M ohms. The meters offered are of the very latest type not to be confused with the older models. Price only £75.

**LUCAS CAR RELAYS.** 12 v. Heavy duty make. Suitable for spotlights, horns, overdrives, etc. Brand new. Only 7/6. Special price for quantities.

**BARGAIN OFFER**  
 200-yard reels equipment wire, size 1/0/24, STC quality, various colours. Brand new reels only 15/-. P. & P. 2/6.

**MUIRHEAD DECADE OSCILLATOR MODEL 650B**

This Precision Instrument has an accuracy of 0.2 per cent with a frequency coverage of 1 cps to 111,100 KHz continuous. Max output 2 watts into 8k ohms harmonic content less than 1 per cent. Hourly stability 0.02 per cent. Offered in as new condition, list price £350. Our price £95.

**BRUEL & KJOER AUTOMATIC SWEEP FREQUENCY OSCILLATOR MODEL 1016**

Frequency 5 cps to 10 KHz. Offered in good used condition. Price £65, carriage at cost.

**GEC UNISELECTOR.** GPO pattern. 5 bank full wipe 5 bridging contacts. 25 position, 75 ohm. Coil 28-36 v. Brand new 50/-. P. & P. 4/6.

**R.D.O. UHF. RECEIVER.** 38-1000 mHz offered with 3 tuning units to cover full frequency range. Ideal communications receiver/or can be supplied with Pan-adaptor for laboratory work. £95.

**WATSON MARLOW ORBITAL LOBE PUMPS**

Specially designed for corrosive liquids etc. Rated output against 10 ft. head—110 G.P.H. direction of flow reversible. Supply 240 v. A.C. mains. Nett weight 14 lb. Supplied as new. Price £12.10.0 P. & P. 10/-. List £22.10.0.

**DOUGLAS No. 6 COIL WINDER**

With motor tailstock and special Swedish reel carrier, plus gears. Offered in good operative condition. Price £85.

**CAMBRIDGE SPOT GALVANO-METER.** Type 41153/1-3. Offered brand new with hand book. Price £22.

**CROYDON INSTRUMENTS**

Precision Kelvin Wheatstone Bridge, type KWI. Measurements can be made from 0.0001 of an ohm. 100,000 ohms contains insitu Sullivan Galvo, four decade ranges, four standards and six Kelvin divide/multiply ratios offered in excellent condition ready for use. Price £95.

**MARCONI 100 KHZ QUARTZ CRYSTAL** Type Qml20/F contained in B7G envelope with flying lead connections. Brand new only 20/- each.

**MORGANITE GLASS ENCLOSED RESISTORS** Value 2.5k. meg ohms, tolerance 10%. 25/- per carton of four.

**COMPLETE C.R.T. KIT** comprising 2API C.R.T. mumetal screen/tube base and grille. The lot 45/-. P. & P. 2/6.

**TMC MINIATURE KEY SWITCHES** Two change-overs, non-biased, two position offered. New, only 8/6 each.

**PAXOLIN PC BOARDS** contains five Mullard OC36 power transistors—made up as solenoid drive unit. Guaranteed. Brand new, only 30/- inc.

**PAXOLIN PC BOARD** contains ten GET113 transistors with polythene holders, ten miniature glass diodes and 25 1/2W. resistors. BRAND NEW 19/6. P. & P. 6d.

**SOLARTRON OSCILLOSCOPE 523S.2**

The best of the surplus scopes for £52, fully serviced and calibrated, compare the specification with others. Bandwidth DC-10MHz at 3dB. Sensitivity 1s 1MV/cm. Time Base 0.1 usec-1cm/sec in 7 decades with fine control on each range. Uses C Core mains transformers/4 in. High resolution flat face PDA CRT and many other features make this scope very suitable for colour television servicing and many other applications. Price £52 P. & P. 25/-.

**ADVANCE WIDE RANGE AC VALVE VOLTMETER VM77**

Range 0.001v to 300v in six decades, frequency range 15 cps to 4.5 MHz, the VM77 operates on 100-250v ac supply. Price £25, P. & P. Inclusive.

**SCHOMANDL FREQUENCY METER TYPE FD.1 AND CONVERTER UNIT TYPE FDM.1**

Range 1 KHz to 900 MHz an approved standard for telecommunications equipment. Offered calibrated to manufacturers specifications.

**P. F. RALFE**

**10 Chapel St London N.W.1**

Phone 01 - 723 8753

**ADMIRALTY B.40 RECEIVERS**



High quality 10 valve receiver manufactured by Murphy. Coverage in 5 bands 600 Kc/s-30 Mc/s. I.F. 500/Kc/s. Incorporates 2 R.F. and 3 I.F. stages, bandpass filter, noise limiter, crystal controlled B.F.O., calibrator I.F. output, etc. Built-in speaker, output for phones. Operation 150/230 volt A.C. Size 19 1/2 x 13 1/2 x 1 1/2 in. Weight 114lb. Offered in good working condition. £22/10/0, Carr. 30/-. With circuit diagrams. Also available B41 L.F. version of above. 15 Kc/s-700 Kc/s. £17/10/0. Carr. 30/-.

**RTC 249 4-TRACK TAPE DECK**

British made. Speeds 1 1/2 in., 3 1/4 in., 7 1/2 in. p.s. Marriot heads. 7 in. reel size. Push button controls, fully interlocking. Size 13 1/2 x 10 1/2 x 1 1/2 in. above unit plate, 4 1/2 in. below. Full instructions. £13.19.6. Carr. 7/6.



**TYPE 13A DOUBLE BEAM OSCILLOSCOPES BARGAIN**

An excellent general purpose D/B oscilloscope. T.B. 2 cps-750 Kc/s. Bandwidth 5.5 Mc/s. Sensitivity 33 Mv/cm. Operating voltage 0/110/200/250 v. A.C. Supplied in excellent working condition. £22/10/0. Carriage 30/-.



**MARCONI CT44 TF956 AF ABSORPTION WATTMETER**

1 μ/watt to 6 watts. £20. Carr. 20/-.



**CLASS D. WAVEMETERS**

A crystal controlled heterodyne frequency meter covering 1.7-8 Mc/s. Operation on 6 v. D.C. Ideal for amateur use. Available in good used condition £5.19.6 Carr. 7/6. Or brand new with accessories £7.19.6 Carr. 7/6.



**CLASS D WAVEMETERS No. 2** Crystal controlled. 1.2-19 Mc/s. Mains or 12v. D.C. operation. Complete with calibration charts. Excellent condition £12/10/0. Carr. 30/-.

**LELAND MODEL 27 BEAT FREQUENCY OSCILLATORS** 0-20 Kc/s. Output 5K or 500 ohms. 200/250 v. A.C. Offered in excellent condition. £12/10/0. Carriage 10/-.

**VOLTAGE STABILISER TRANSFORMERS.** 160-260v. Input. Output 230v. Available 150w or 225w. £12.10.0. Carr. 5/-.

**TO-2 PORTABLE OSCILLOSCOPE** A general purpose low cost economy oscilloscope for everyday use. Y amp. Bandwidth 2 CPS-1 MHz. Input Imp. 2 meg Ω. 25 PF. Illuminated scale. 2 tube. 115 x 180 x 230 mm. Weight 8lbs. 220/240v. A.C. Supplied brand new with handbook. £22/10/0. Carr. 10/-.



**TO-3 PORTABLE OSCILLOSCOPE. 3" TUBE** Y amp. Sensitivity 1v p-p/CM. Bandwidth 1.5 cps-1.5 MHz. Input Imp. 2 meg Ω. 25 PF. X amp sensitivity. -9v p-p/CM. bandwidth 1.5 cps-800 KHz. Input Imp. 2 meg Ω. 20 PF. Time base. 5 ranges 10 cps-300 KHz. Synchronization. Internal/external. Illuminated scale. 140 x 215 x 330 mm. Weight 15 1/2 lbs. 220/240 v. A.C. Supplied brand new with handbook. £37.10.0 Carr. 10/-.



**CRYSTAL CALIBRATORS NO. 10**

Small portable crystal controlled wavemeter. Size 7 in. x 7 1/2 in. x 4 in. Frequency range 500 Kc/s-10 Mc/s (up to 30 Mc/s on harmonics). Calibrated dial. Power requirements 300 V D.C. 10mA and 12 V D.C. 0.8A. Excellent condition. 89/6. Carr. 7/6.



**MARCONI TF885 VIDEO OSCILLATORS** 0-5 mc/s sine square wave £45. Carr. 20/-.

**MARCONI TF195M BEAT FREQUENCY OSCILLATORS** 0-40 kc/s. £20. Carr. 30/-.

**WS62 TRANCEIVERS**

Large quantity available for EXPORT! Excellent condition. Enquiries invited.

**UNR-30 4 BAND COMMUNICATION RECEIVER**

Covering 550 Kc/s-30 Mc/s. Incorporates BFO. Built-in speaker and phone jack. Metal cabinet. Operation 220/240 v. A.C. Supplied brand new, guaranteed with instructions. 13gns. Carr. 7/6.



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770R. 19-165 Mc/s. £150. Both types in excellent condition.

**LAFAYETTE SOLID STATE HA600 RECEIVER**



5 BAND AM/QW/SSB AMATEUR AND SHORT WAVE. 150 kc/s-400 Kc/s AND 550 Kc/s-30 Mc/s. F.E.T. front end • 2 mechanical filters • Huge dial • Product detector • Variable BFO • Noise limiter • 8 Meter • 24 1/2 in. Bandspeed • 230 v. A.C./12 v. D.C. neg earth operation • RF gain control. Size 15 1/2 x 9 1/2 in. x 8 1/2 in. Wt. 18 lbs. EXCEPTIONAL VALUE £45. CARR. 10/-. S.A.E. FOR FULL DETAILS.

**AVO CT471A MULTIMETER**

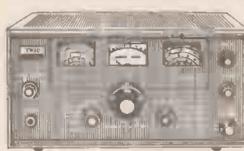
Battery operated, fully transistorised. Sensitivity 100 MΩ/v. Measures A.C./D.C. voltages 12mV. to 1,200 V. A.C./D.C. current 12uA. to 1.2 Amp. Resistance 12 ohm to 120 mΩ H.F., V.H.F., U.H.F. voltage with multiplier 4V. to 400V. up to 50 Mc/s., 40 mV. to 4V. up to 1,000 Mc/s. Offered in perfect condition. £55 each. Carr. 10/-.

**RUSSIAN G1-16 DOUBLE BEAM OSCILLOSCOPE**

5 mc/s Pass Band. Separate Y1 and Y2 amplifiers. Rectangular 5in. x 4in. C.E.T. Calibrated triggered sweep from 2 μ/sec. to 100 mill-sec. per cm. Free running time base 500 μ/sec. Built-in time base calibrator and amplitude calibrator. Supplied complete with all accessories and instruction manual. £37. Carr. paid.



**TRIO COMMUNICATION RECEIVER MODEL 9R-59DE**



4 band receiver covering 500 Kc/s to 30 Mc/s, continuous and electrical bandspread on 10-15, 20, 40 and 80 metres. 8 valve plus 7 diode circuit. 4/8 ohm output and phone jack. SSB-CW • ANL • Variable BFO • 8 meter. • Sep. Bandspeed dial • IF 455 Kc/s • audio output 1.5 w. • Variable RF and AF gains controls. 115/250 v. A.C. mains. Beautifully designed. Size 7 x 15 x 10 in. With instruction manual and service data. £42. Carriage paid Trio Communication Type Headphones. Normally £5.19.6. Our price £3.15.0 if purchased with above receiver.

**TRIO TS 510 Amateur Transceiver with speaker and mains P.S.U. £180**  
**TRIO JR 500SE 10-80 Metre Amateur Receiver £65**

**LAFAYETTE HA.800 SOLID STATE AMATEUR COMMUNICATION RECEIVER SIX BANDS 3.5-4, 7-7.3, 14-14.35, 21-45, 28-29.7, 50-54 Mc/s.**

Dual conversion on all bands. 2 x 455 Kc/s mechanical filters. Product detector. Variable B.F.O. 100 Kc/s crystal calibrator. '8' meter. Huge slide rule dial. Operation 230V AC or 12V DC. Size 16" x 9 1/2" x 8 1/2". Complete with instruction manual. £57.10.0. Carr. Paid. (100 Kc/s Crystal 39/6 extra.)



**TRIO JR-310 NEW AMATEUR BAND 10-80 METER RECEIVER IN STOCK £77.10.0**



**RCA COMMUNICATIONS RECEIVERS AR88D**

Latest release by ministry BRAND NEW in original cases. 110-250v. A.C. operation. Frequency in 6 Bands. 535 Kc/s-32 Mc/s continuous. Output impedance 2.5-600 ohms. Incorporating crystal filter, noise limiter, variable BFO, variable selectivity, etc. Price £85. Carr. £2.



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A completely new transistorised receiver covering 152-174 Mc/s. Fully tuneable or crystal controlled (not supplied) for fixed frequency operation. Incorporates 4 INTEGRATED CIRCUITS. Built-in speaker and illuminated dial. Squelch and volume controls. Tape recorder output. 75 Ω aerial input. Headphone jack. Operation 230 v. A.C./12 v. D.C. Neg. earth. £37/10/- Carr. 10/-.

**LAFAYETTE LA-324 STEREO AMPLIFIER**

A fine new Hi-Fi Amplifier at low cost. 12.5 watts B.M.S. per channel. -20-20,000 Hz ± db. Inputs for Mag or Cer Cartridge, Tuner and Auxillary. Output 4-16 Features Headphone Socket/ Tape output. Protected output stage. Finish simulated walnut vinyl clad metal case black and brushed anodised aluminium front panel. 10 1/2 x 3 1/2 x 8 1/2 in. £24. Carr. 7/6.

**SEW PANEL METERS**

Type MR.38P. 1 2 1/2 3/2 in. square fronts.

50μA	40/-	50mA	27/6	100V. D.C.	27/6
50-0-50μA	37/6	100mA	27/6	150V. D.C.	27/6
100μA	37/6	150mA	27/6	300V. D.C.	27/6
100-0-100μA	35/-	200mA	27/6	500V. D.C.	27/6
200μA	35/-	300mA	27/6	750V. D.C.	27/6
500μA	30/-	500mA	27/6	15V. A.C.	27/6
500-0-500μA	27/6	750mA	27/6	50V. A.C.	27/6
1mA	27/6	1 amp	27/6	150V. A.C.	27/6
1-0-1mA	27/6	2 amp	27/6	300V. A.C.	27/6
2mA	27/6	5 amp	27/6	500V. A.C.	27/6
5mA	27/6	3V. D.C.	27/6	8 meter 1mA	39/-
10mA	27/6	10V. D.C.	27/6	VU meter	42/-
20mA	27/6	20V. D.C.	27/6		

FULL RANGE OF OTHER SIZES IN STOCK—SEND SAE FOR LEAFLET

**POWER RHEOSTATS**

High quality ceramic construction. Windings embedded in vitreous enamel. Heavy duty brush wiper. Continuous rating. Wide range available ex-stock. Single hole fixing. 3/8 in. dia. shaft. Bulk quantities available. 25 WATT. 10/25/50/100/250/500/1000/1500/2300 or 5000 ohms. 14/6. P. & P. 1/6. 50 WATT. 10/25/50/100/250/500/1000/2500 or 5000 ohms. 21/-. P. & P. 1/6. 100 WATT. 1/5/10/25/50/100/250/500/1000 or 2500 ohms. 27/6. P. & P. 1/6.



**BELCO DA-20 SOLID STATE DECADE AUDIO OSCILLATOR**



New high-quality portable instrument. Sine 1 Hz to 100 KHz. Square 20 Hz to 20 KHz. Output max. +10 db (10 K ohms). Operation 220/240 v. A.C. Size 215 mm x 180 mm x 120 mm.

Price £27.10.0 Carr. 5/-.

**MARCONI TF.142E DISTORTION FACTOR METERS**

Excellent condition. Fully tested £20. Carr. 15/-.

**T.E.40 HIGH SENSITIVITY A.C. VOLTMETER**

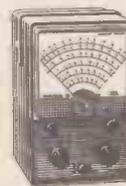


10 meg. input 10 ranges: .01/.03/.1/3/10/30/100/300 v. R.M.S. 4 cps. 1.2 Mc/s. Decibels -40 to +50 dB. Supplied brand new complete with leads and instructions. Operation 230 v. A.C. £17/10/0. Carr. 5/-.

**PLESSEY SL 403A**

3-watt. integrated amplifier circuit. 49/6 post paid.

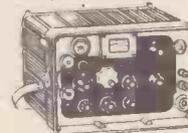
**TE-65 VALVE VOLTMETER**



High quality instrument with 23 ranges. D.C. volts 1.5-1,500 v. A.C. volts 1.5-1,500 v. Resistance up to 1,000 megohms. 220/240v. A.C. operation. Complete with probe and instructions £17/10/0. P. & P. 6/-. Additional Probes available: B.F. 35/- H.V. 42/6.

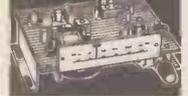
**COSSOR 1049 DOUBLE BEAM OSCILLOSCOPES** D.C. coupled. Band width 1 Kc/s. Perfect order. £25. Carr. 30/-.

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Oscillator Test No. 2. A high quality precision instrument made for the Ministry by Airmeq. Frequency coverage 20-80 Mc/s. AM/CW/FM. Incorporates precision dial, level meter, precision attenuator 1 μV-100 mV. Operation from 12 volt D.C. or 0/110/200/250 v. A.C. Size 12 x 9 1/2 x 8 in. Supplied in brand new condition complete with all connectors, fully tested. £45. Carr. 20/-.

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6 TRANSISTOR HIGH QUALITY TUNER. SIZE ONLY 6 in. x 4 in. x 2 1/2 in. 3 I.F. stages. Double tuned discriminator, ample output to feed most amplifiers. Operates on 9 volt battery. Coverage 88-108 Mc/s. Ready built ready for use. Fantastic value for money. £26/7/6. P. & P. 2/6.

**STEREO MULTIPLEX ADAPTORS, 99/6.**

**TE-16A TRANSISTORISED SIGNAL GENERATOR**



5 Ranges 400 KHz-30 MHz. An inexpensive instrument for the handyman. Operates on 9v. battery. Wide easy to read scale. 800 KHz modulation. 5 1/2" x 5 1/2" x 3 1/2". Complete with instructions and leads. £7/19/6. P/P 4/-.

**TRANSISTORISED L.C.R. A.C. MEASURING BRIDGE.**



A new portable bridge offering excellent range and accuracy at low cost. Ranges: R. 1 Ω-111 MEG Ω. 6 Ranges ± 1%. L. 1 μH-111 HENRIES. 6 Ranges ± 2%. C. 10PF ± 1110MFD. 6 Ranges ± 2%. TURNS RATIO 1:1/1000-1:11100. Operated from 9 volt. 100μA. Meter indication. Attractive 2 tone metal case. Size 7 1/2" x 5" x 2". £20. P. & P. 5/-.

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**G. W. SMITH & Co. (Radio) Ltd.**

ALSO SEE OPPOSITE PAGE

**BELCO AF-5A SOLID STATE SINE SQUARE WAVE C.R. OSCILLATOR**

Sine 18-200,000 Hz; Square 18-50,000 Hz  
Output max. +10 dB  
(10 K ohms). Operation  
internal batteries.  
Attractive 2-tone case  
7 1/2 in. x 5 in. x 2 in.  
Price £17.10.0  
Carr. 3/6



**TE-20RF SIGNAL GENERATOR**

Accurate wide range  
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120 kc/s-260 Mc/s.  
on 6 bands. Directly  
calibrated. Variable  
R.F. attenuator. Oper-  
ation 200/240 v. A.C.  
Brand new with instruc-  
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P. & P. 7/6. S.A.E. for details.

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Output impedance  
5,000 ohms. 200/  
250 v. A.C. opera-  
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new and guaran-  
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2 ohms-200 meg-  
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impedance turns  
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200/250 v. A.C.  
Brand New. £17.10  
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Kc/s. High and low impedance  
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6 volts. 220/240 volts A.C.  
Brand new with instructions.  
£16. Carr. 7/6. Size 210 x  
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Accurate wide range signal  
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120 Kc/s-600 Mc/s on  
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attenuator, audio output.  
Xtal socket for calibra-  
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**ADVANCE TEST EQUIPMENT**

Brand new and boxed in original sealed cartons.

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15 c/s to 50 Kc/s. Sine wave. Output 600 ohms  
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10 mV. 3v. Current 0.01 uA to 0.3 mA. Resistance  
1 ohm to 10 megohm. £125.0.0.

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Carriage 10/- per item.

**SOLARTRON CD 711S2 DOUBLE BEAM OSCILLOSCOPES**

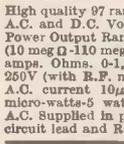
D.C. to 9 Mc/s. Perfect order. £85. Carr. 50/-.

**AVO CT.38 ELECTRONIC MULTIMETERS**

High quality 97 range instrument which measures  
A.C. and D.C. Voltage, Current, Resistance and  
Power. Output Ranges D.C. volts 250 mV, 10, 100V,  
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amps. Ohms. 0-1,000 meg ohm A.C. volt 100mV-  
250V (with R.F. measuring head up to 250 Mc/s)  
A.C. current 10uA-25 amps. Power output 50  
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A.C. Supplied in perfect condition complete with  
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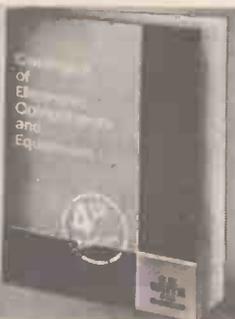
Compact and panel mounting.  
Ideal for control of lamps,  
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Input 230/240 v. A.C. Output  
continuously variable from  
20 v.-230 v. Model MR 2306  
5 amp 68 x 46 x 43 mm.  
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Hi Fi solid state pre-amplifier and control unit incorporating  
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Amplifier but full instructions are supplied to enable it to be  
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OUR PRICE £4.19.6. P. & P. 3/.



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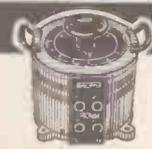
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High quality construction. Input 230 v. 50-60 cycles.  
Output full variable from 0-260 volts. Bulk quantities available.  
1 amp.—£5/10/-; 2.5 amp.—£6/15/-; 5 amp.—£9/15/-;  
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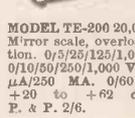
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**TE-800 20,000Ω/VOLT GIANT MULTIMETER**  
Mirror scale and over-  
load protection. 6in.  
full view meter. 2  
colour scale. 0/2.5/10/50/  
250/1,000/5,000 v. A.C.  
0/25/12.5/10/50/  
250/1,000/5,000 v. D.C.  
0/50μA/110/1.1/500μA/10  
amp. D.C. 0/2K/  
200K/20 MEG. OHM.  
£15/- P. & P. 5/-.



**MODEL TE-70. 30,000 O.P.V.**  
0/3/15/60/300/600/1,200 v.  
D.C. 0/5/30/120/600/1,200 v.  
A.C. 0/30μA/3/30/300mA.  
0/15K/160K/1.6M/16 MEG. Ω.  
£5/10/- P. & P. 3/-.



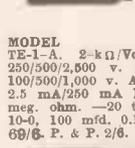
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Mirror scale, overload protec-  
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0/10/50/250/1,000 V.A.C. 0/50  
μA/250 MA. 0/60K/6 meg.  
+20 to -62 db. 75/-  
P. & P. 2/6.



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V.A.C. 0/30μA/6mA/60mA/  
300mA/600mA. 0/8K/80K/  
800K/8 meg. —20 to +65 db.  
£5.19.6. P. & P. 3/.



**TE-51. NEW 20,000Ω/VOLT MULTIMETER**, with  
overload protection and  
mirror scale, 0/6/60/120,  
1,200 v. A.C. 0/3/30/60/300/  
600/3,000v. D.C. 0/60μA/12/  
300mA D.C. 0/60K/6 meg.  
ohm. 92/6. P. & P. 2/6.



**MODEL TE-1 -A. 2-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.  
69/6. P. & P. 2/6.**



**MODEL FT-34. 1,000  
O.P.V. 0/10/50/250/  
500/1,000V. a.c. and  
d.c. 0/100 K Ω 39/6.  
P. & P. 1/6.**



**LAFAYETTE 57 Range Super  
50K Ω/V. Multimeter. D.C.  
volts 125mV-1000V. A.C.  
volts 1.5V-1000V. D.C. Cur-  
rent 25μA-10 Amp. Ohms  
0-10 Meg Ω. D.B.—20 to  
+81 db. Overload protection.  
£12/10/- P. & P. 3/6.**

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**SPECIAL OFFERS**

Garrard SP25 Mk II fitted Goldring G800  
cartridge and wooden plinth. Total list  
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**OUR PRICE £19.15.0.** Carr. 10/-  
Plastic Cover 25/- extra  
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Project 60. Package Offers  
  
2 x Z30 amplifier, stereo 60 pre-amp, PZ5  
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power supply. £21.0.0. Carr. 7/8. 2 x Z50  
amplifier, stereo 60 pre-amp, PZ8 power supply.  
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extra. Add to any of the above £4.17.6 for active  
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All other Sinclair products in stock: 2,000 amplifier,  
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Low cost high perform-  
ance stereo headphones.  
Foam rubber ear cups.  
Adjustable headband.  
8 ohm impedance. 25-  
18,000 Hz. With lead and  
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39/6. P. & P. 2/6.

**B.C. 221 FREQUENCY METERS**

Latest release 125 KHz-20 MHz. Excellent  
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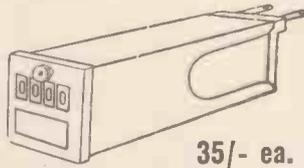
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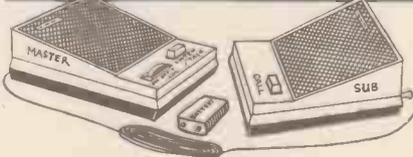
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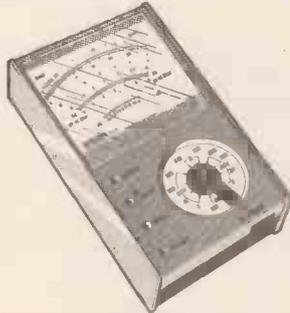
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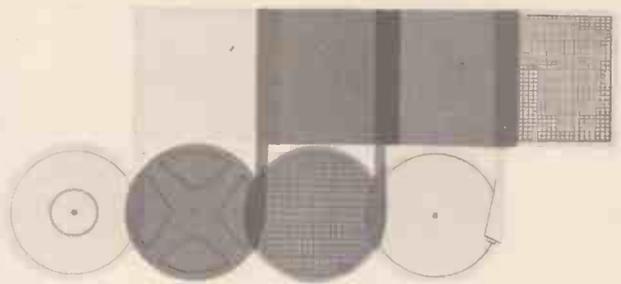


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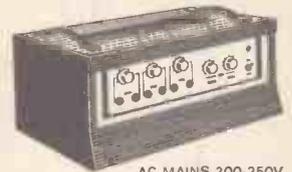
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50µA	69/6	50V. D.C.	59/6
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500µA	62/6	5 amp. D.C.	59/6
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80 mm. square fronts

50µA	62/6	50V. D.C.	49/6
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500µA	52/6	5 amp. D.C.	49/6
1mA	49/6	300V. A.C.	52/6
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**Type MR.85P. 4 1/2 in. x 4 1/2 in. fronts.**

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200µA	57/6	1 amp.	52/-
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1mA	52/-	20V. D.C.	52/-
1-0-1mA	52/-	50V. D.C.	52/-
5-0-1mA	52/-	150V. D.C.	52/-
		300V. D.C.	52/-
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		8 Meter 1mA	57/6
		VU meter	72/-
		1 amp. A.C.*	52/-
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200mA	27/6	15V. D.C.	27/6
300mA	27/6	20V. D.C.	27/6
500mA	27/6	100V. D.C.	27/6
750mA	27/6	150V. D.C.	27/6
1 amp.	27/6	15V. A.C.	27/6
2 amp.	27/6	30V. A.C.	27/6
5 amp.	27/6	150V. A.C.	27/6
10 amp.	27/6	300V. A.C.	27/6
3V. D.C.	27/6	8 Meter 1mA	27/6
10V. D.C.	27/6	VU meter	27/6
15V. D.C.	27/6	1 amp. A.C.*	27/6
20V. D.C.	27/6	5 amp. A.C.*	27/6
100V. D.C.	27/6	10 amp. A.C.*	27/6
150V. D.C.	27/6	20 amp. A.C.*	27/6
500µA	40/-	30 amp. A.C.*	27/6
50-0-50µA	37/6		
100µA	37/6		
100-0-100µA	35/-		
200µA	35/-		
500µA	30/-		
500-0-500µA	27/6		
1mA	27/6		
1-0-1mA	27/6		
2mA	27/6		
5mA	27/6		
10mA	27/6		
20mA	27/6		
50mA	27/6		
100mA	27/6		
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**Type MR.45P. 2 1/2 in. square fronts.**

50µA	45/-	5 amp.	30/-
50-0-50µA	42/-	10V. D.C.	30/-
100µA	42/-	20V. D.C.	30/-
100-0-100µA	37/6	50V. D.C.	30/-
200µA	37/6	300V. D.C.	30/-
500µA	32/-	15V. A.C.	30/-
500-0-500µA	30/-	300V. A.C.	30/-
1mA	30/-	8 meter 1mA	37/6
5mA	30/-	VU meter	45/-
10mA	30/-	1 amp. A.C.*	30/-
50mA	30/-	5 amp. A.C.*	30/-
100mA	30/-	10 amp. A.C.*	30/-
500mA	30/-	20 amp. A.C.*	30/-
1 amp.	30/-	30 amp. A.C.*	30/-

**Type MR.52P. 2 1/2 in. square fronts.**

50µA	42/-	10V. D.C.	40/-
50-0-50µA	52/-	20V. D.C.	40/-
100µA	52/-	50V. D.C.	40/-
100-0-100µA	47/6	300V. D.C.	40/-
500µA	45/-	15V. A.C.	40/-
1mA	40/-	300V. A.C.	40/-
5mA	40/-	8 Meter 1mA	42/-
10mA	40/-	VU Meter	42/-
50mA	40/-	1 amp. A.C.*	40/-
100mA	40/-	5 amp. A.C.*	40/-
500mA	40/-	10 amp. A.C.*	40/-
1 amp.	40/-	20 amp. A.C.*	40/-
5 amp.	40/-	30 amp. A.C.*	40/-

**Type MR.65P. 3 1/2 in. x 3 1/2 in. fronts.**

50µA	67/6	10V. D.C.	42/-
50-0-50µA	55/-	20V. D.C.	42/-
100µA	55/-	50V. D.C.	42/-
100-0-100µA	52/-	150V. D.C.	42/-
200µA	52/-	300V. D.C.	42/-
500µA	47/6	15V. A.C.	42/-
500-0-500µA	42/-	50V. A.C.	42/-
1mA	42/-	150V. A.C.	42/-
5mA	42/-	300V. A.C.	42/-
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5 amp.	42/-	200mA A.C.*	42/-
10 amp.	42/-	500mA A.C.*	42/-
20 amp.	42/-	1 amp. A.C.*	42/-
30 amp.	42/-	5 amp. A.C.*	42/-
50 amp.	42/-	10 amp. A.C.*	42/-
5V. D.C.	42/-	20 amp. A.C.*	42/-
		30 amp. A.C.*	42/-

### "SEW" BAKELITE PANEL METERS

**Type MR.65. 3 1/2 in. square fronts.**

50µA	70/-	500mA	35/-
50-0-50µA	47/6	1 amp.	35/-
100µA	45/-	5 amp.	35/-
100-0-100µA	45/-	15 amp.	35/-
500µA	42/-	30 amp.	35/-
1mA	35/-	60 amp.	35/-
5mA	35/-	5V. D.C.	35/-
10mA	35/-	10V. D.C.	35/-
50mA	35/-	20V. D.C.	35/-
100mA	35/-	50V. D.C.	35/-
500mA	35/-	150V. D.C.	35/-
1 amp.	35/-	300V. D.C.	35/-
5 amp.	35/-	15V. A.C.	35/-
10 amp.	35/-	30V. A.C.	35/-
20 amp.	35/-	50V. A.C.	35/-
30 amp.	35/-	150V. A.C.	35/-
50 amp.	35/-	300V. A.C.	35/-
100mA	35/-	500mA A.C.*	35/-
		1 amp. A.C.*	35/-
		5 amp. A.C.*	35/-
		10 amp. A.C.*	35/-
		20 amp. A.C.*	35/-
		30 amp. A.C.*	35/-
		50 amp. A.C.*	35/-
		VU meter	62/-

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### EDGWISE METERS

**Type PE.70. 3 17/32 in. x 1 15/32 in. x 2 1/2 in. deep.**

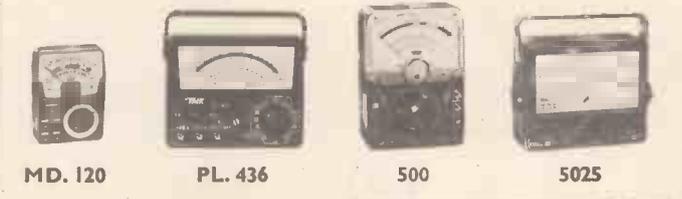
50µA	80/-	500µA	52/-
50-0-50µA	57/6	1mA	47/6
100µA	57/6	300V. A.C.	47/6
100-0-100µA	55/-	VU meter	65/-
200µA	55/-		

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**MD.120**      **PL.436**      **500**      **5025**

**LAB TESTER**      **TW. 50k**

**MODEL TW 20CB**  
FEATURES RESETTABLE OVERLOAD BUTTON

Normally only found on meters costing over £25.

Sensitivity: 20kΩ/Volt D.C. 5kΩ/Volt A.C. D.C. Volts: 0-0.5, 2.5, 10, 50, 250, 1,000V. A.C. Volts: 0-2.5, 10, 50, 250, 1,000V. D.C. Current: 0-0.05, 0.5, 5, 50, 500mA-10 amp. Resistance: 0-5K, 50K, 0-500K. 5 MEGΩ. Decibels: -20 to +22db. Plastic case with carrying handle. Size 5 1/2 in. x 4 in. x 2 1/2 in. approx.

£11.10.0 p/p 3/6

★ All models fitted overload protection and supplied with batteries, prods and instructions.

**MODEL MD-120** Features Mirror Scale, Low Loss Switch and Robust Movement. Sensitivity: 20kΩ/Volt D.C. 10kΩ/Volt A.C. D.C. Volts: 30, 60, 300, 600, 3,000V. A.C. Volts: 6, 120, 1,200V. D.C. Current: 60µA, 12, 300mA. Resistance: 60K, 6 MEGΩ. Decibels: -20 to +83db. Rugged High Impact Plastic Case, size 3 1/2 in. x 4 1/2 in. x 1 1/2 in.

**MODEL PL 436** Features Mirror Scale and Wood Grain Finish Front Panel. Sensitivity: 20kΩ/Volt D.C. 8kΩ/Volt A.C. D.C. Volts: 6, 3, 12, 30, 120, 600V. A.C. Volts: 3, 30, 120, 600. D.C. Current: 50, 600µA, 60, 600mA. Resistance: 10K, 100K, 1MEG, 10MEGΩ. Decibels: -20 to +46db. Rugged High Impact Plastic Case with Handle, size 5 1/2 in. x 4 1/2 in. x 2 1/2 in.

**MODEL TW-50K** Features 46 ranges, mirror scale. Sensitivity 50kΩ/Volt D.C. 5kΩ/Volt A.C. D.C. Volts: 125, 25, 1.25, 2.5, 5, 10, 25, 50, 125, 250, 500, 1,000V. A.C. Volts: 1.5, 3, 5, 10, 25, 50, 100, 250, 500, 1,000V. D.C. Current: 25, 50µA, 2.5, 5, 25, 50, 100, 250, 500, 1,000V. Resistance: 10K, 100K, 1MEG, 10MEGΩ. Decibels: -20 to +81db. Plastic case with carrying handle. Size 4 1/2 in. x 2 1/2 in. x 6 1/2 in.

**MODEL 500** Features Mirror Scale and Buzzer Short Circuit Check. Sensitivity: 30kΩ/Volt D.C. 15kΩ/Volt A.C. D.C. Volts: 25, 1, 2.5, 10, 25, 100, 250, 500, 1,000V. A.C. Volts: 2.5, 10, 25, 100, 250, 500, 1,000V. D.C. Current: 50µA, 5, 50, 500mA. Resistance: 2K, 10K, 100K, 1MEG, 10MEGΩ. Decibels: -20 to +85db. Plastic Case with Carrying Handle, size 6 1/2 in. x 2 1/2 in. x 5 1/2 in.

**MODEL 100,000 O.P.V. LAB TESTER** Features Unique Range Selector, 6 1/2 in. Scale Buzzer Short Circuit Check. Sensitivity: 100,000 Ω/Volt D.C. D.C. Volts: 5, 2.5, 10, 50, 250, 1,000V. A.C. Volts: 3, 10, 50, 250, 500, 1,000V. D.C. Current: 10, 100µA, 10, 100, 500mA, 2.5, 10 amp. Resistance: 1K, 10K, 100K, 10MEG, 100MEGΩ. Decibels: -10 to +49db. Plastic Case with Carrying Handle, size 7 1/2 in. x 6 1/2 in. x 3 1/2 in.

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0B2	6/	6BW6	14/3	6Y6GT	6/6	20L1	20/	306	13/	DL84	5/9	ECH83	5/9	EZ80	4/8	PCF86	10/	R19	7/6	U76	4/9	AA23	3/8	BCY33	4/8	GET119	4/	OC24	7/8		
0Z4	4/8	6BW7	13/	6X4	4/3	20P1	17/6	807	11/9	DL96	7/	ECH84	7/6	EZ81	4/8	PCF87	16/	R19	11/9	U78	4/3	AC107	3/8	BCY38	4/8	GET120	7/8	OC25	7/8		
1A3	4/8	6C04	5/	6X5GT	5/	20P3	18/	956	2/	DM70	6/	ECL80	7/6	EZ90	4/3	PCF200	13/3	R52	7/6	U87	10/18	AC113	5/	BCY38	4/8	GET127	8/6	OC26	5/		
1A6	5/	6C08	3/8	6Y6G	6/	20P4	18/6	1821	10/8	DM71	7/6	ECL82	6/	GZ30	7/	PCF801	7/	RK34	3/8	U93	6/9	AC127	4/3	BCY39	4/8	GET128	19/	OC28	9/		
1A7GT	7/3	6C09	14/6	6Y7G	12/6	20P5	20/	8763	10/	DW4/350	7/6	ECL83	9/	GZ33	12/6	PCF802	14/	RK34	3/8	U94	7/6	AC127	13/	BC106	9/	GET129	14/	OC29	9/		
1C5	4/9	6C17	12/6	7B6	10/9	25A6G	5/9	6060	5/6	ECL84	12/	HW3	8/6	GZ34	10/	PCF806	11/6	SP42	12/6	U92	8/	AC154	5/	BC113	5/	GET130	23/6	OC38	7/8		
1D5	7/6	6C26G	23/	7B7	7/	25L6G	6/6	7193	10/6	DY86/7	5/9	ECL85	14/	GZ37	14/6	PCF806	14/6	SP61	3/3	U301	11/	AC156	4/	BC116	5/	GET132	10/	OC38	9/		
1D6	9/6	6C26H	7/	7C8	6/	25Y6	6/6	7475	14/	DY802	6/6	ECL86	9/	HALC80	8/6	PCH200	12/3	TH4B	10/	U329	14/6	AC165	5/	BC118	4/6	GET138	4/6	OC41	10/		
1FD1	6/6	6C26L	8/6	7F8	12/6	25Y6G	8/6	A1834	20/	ES0F	24/	ECLL80	30/	HALC80	8/6	PCH200	12/3	TH4B	10/	U329	14/6	AC165	5/	BC118	4/6	GET138	4/6	OC42	12/6		
1FD9	4/3	6C3W4	12/	7H7	8/6	25Z4G	8/6	A2134	18/6	E83F	24/	30/	KT8	34/6	PCL82	7/3	TH233	7/	U499	6/6	AC165	5/	BC211	3/6	GET139	4/6	OC44	2/6			
1G6	6/	6D3	7/6	7R7	13/	25Z5	8/	A2042	15/	E83G	12/	EP22	12/6	HL42DD	9/	PCL83	10/	TH233	7/	U499	6/6	AC165	5/	BC211	3/6	GET139	4/6	OC44	2/6		
1H5GT	7/	7H5GT	3/	7V6	6/	25Z6G	8/6	AC2PEN	E180F	19/	EP36	3/6	KT44	20/	HL42DD	9/	PCL83	10/	TH233	7/	U499	6/6	AC165	5/	BC211	3/6	GET139	4/6	OC44	2/6	
1I4	2/6	6F1	12/6	9B6W	7/	30C1	6/6	AC2PEN	E180F	19/	EP36	3/6	KT44	20/	HL42DD	9/	PCL83	10/	TH233	7/	U499	6/6	AC165	5/	BC211	3/6	GET139	4/6	OC44	2/6	
1LD5	6/	6F6	12/6	9D7	16/6	30C1S	13/	AC2PEN	E1148	10/6	EP39	5/	KT63	5/	PL200	11/9	UCH81	6/6	U120A	12/	AD162	9/	BY105	3/6	OA5	5/6	OC81D	2/			
1LN6	8/	6F6G	5/	10C1	25/	30C1T	16/	AC2PEN	E1148	10/6	EP39	5/	KT63	5/	PL200	11/9	UCH81	6/6	U120A	12/	AD162	9/	BY105	3/6	OA5	5/6	OC81D	2/			
1NS0T	7/9	6F12	3/3	10C2	10/	30C1L	14/	AC2PEN	E1148	10/6	EP39	5/	KT63	5/	PL200	11/9	UCH81	6/6	U120A	12/	AD162	9/	BY105	3/6	OA5	5/6	OC81D	2/			
1K5	5/8	6F13	3/6	10D1	14/	30F5	16/	AC2PEN	E1148	10/6	EP39	5/	KT63	5/	PL200	11/9	UCH81	6/6	U120A	12/	AD162	9/	BY105	3/6	OA5	5/6	OC81D	2/			
1S4	4/9	6F14	15/	10D2	14/7	30F1L	13/	AC2PEN	E1148	10/6	EP39	5/	KT63	5/	PL200	11/9	UCH81	6/6	U120A	12/	AD162	9/	BY105	3/6	OA5	5/6	OC81D	2/			
1S5	4/3	6F15	10/	10F1	9/	30FL2	15/	AC2PEN	E1148	10/6	EP39	5/	KT63	5/	PL200	11/9	UCH81	6/6	U120A	12/	AD162	9/	BY105	3/6	OA5	5/6	OC81D	2/			
1U4	5/9	6F16	7/6	10P9	15/	30FL2	15/	AC2PEN	E1148	10/6	EP39	5/	KT63	5/	PL200	11/9	UCH81	6/6	U120A	12/	AD162	9/	BY105	3/6	OA5	5/6	OC81D	2/			
2D21	6/6	6F23	14/3	10P18	7/	30FL4	14/	AC2PEN	E1148	10/6	EP39	5/	KT63	5/	PL200	11/9	UCH81	6/6	U120A	12/	AD162	9/	BY105	3/6	OA5	5/6	OC81D	2/			
3A4	4/	6F24	13/6	10L11	8/3	30L11	8/3	AC2PEN	E1148	10/6	EP39	5/	KT63	5/	PL200	11/9	UCH81	6/6	U120A	12/	AD162	9/	BY105	3/6	OA5	5/6	OC81D	2/			
3A6	10/	6F25	13/	10P13	13/	30L15	13/9	AC2PEN	E1148	10/6	EP39	5/	KT63	5/	PL200	11/9	UCH81	6/6	U120A	12/	AD162	9/	BY105	3/6	OA5	5/6	OC81D	2/			
3B7	5/	6F26	5/3	10P14	20/	30L17	15/8	AC2PEN	E1148	10/6	EP39	5/	KT63	5/	PL200	11/9	UCH81	6/6	U120A	12/	AD162	9/	BY105	3/6	OA5	5/6	OC81D	2/			
3C6	3/9	6F28	14/	12A6	12/6	30P4	12/	AC2PEN	E1148	10/6	EP39	5/	KT63	5/	PL200	11/9	UCH81	6/6	U120A	12/	AD162	9/	BY105	3/6	OA5	5/6	OC81D	2/			
3Q4	7/6	6H6GT	3/	12A6C	7/6	30P4MR	ATP	2/3	EBC91	5/6	EP92	2/6	MHL400/14/9	PL509	29/9	U10	10/6	X101	30/6	AF179	13/6	PSY18A	4/6	OA200	1/	OC202	4/6				
3Q5GT	6/1	6J5G	3/8	12AD6	7/6	30P12	17/6	A1	8/	EBC90	6/6	EP97	10/6	MHL412/8	PL509	29/9	U10	10/6	X101	30/6	AF179	13/6	PSY18A	4/6	OA202	2/	OC203	4/6			
384	5/9	6J6	3/	12AE6	12/6	30P12	17/6	A231	9/6	EBC93	6/6	EP98	10/6	MHL512/8	PL509	29/9	U10	10/6	X101	30/6	AF179	13/6	PSY18A	4/6	OA210	1/	OC204	5/6			
3V4	6/3	6J7G	4/9	12AT6	4/6	30P11	13/9	A241	10/6	EBC94	6/6	EP99	10/6	MHL512/8	PL509	29/9	U10	10/6	X101	30/6	AF179	13/6	PSY18A	4/6	OA210	1/	OC204	5/6			
3R4GY	10/6	6K7G	4/6	12AT7	3/6	30P11	13/9	B13	9/6	EBC95	6/6	EP99	10/6	MHL512/8	PL509	29/9	U10	10/6	X101	30/6	AF179	13/6	PSY18A	4/6	OA210	1/	OC204	5/6			
3C4G	6/6	6K7G	2/	12AU6	4/6	30PL13	15/6	C13	18/6	EBC95	12/6	EH90	7/6	N78	40/3	YV60	6/	U113	3/6	Z49	14/3	AF179	13/6	PSY18A	4/6	OA210	1/	OC204	5/6		
5V4G	7/6	6K7GT	4/6	12AV7	4/6	30PL14	15/6	CV8	10/6	EC54	10/	EK90	4/6	N108	27/10	YV61	6/3	U11N	9/	Transistors	AY27	8/6	GD9	4/	OA220/10/6	OC812	8/				
6Y3GT	6/6	6K8G	4/	12AV6	5/6	30PL15	15/6	CV988	3/	EC70	4/9	EL32	3/6	N119	6/6	YV62	5/3	U121	9/6	and diodes	AY28	6/6	GD10	4/	OA220/9/6	OC812	8/				
5Z3	9/	6L1	19/6	12AX7	4/6	35A3	30/	CV10	10/6	EC96	12/6	EL33	12/	N123	9/6	YV63	5/9	U14	7/6	IN1124	10/6	AY29	10/6	GD11	4/	OA220/9/6	OC812	8/			
5Z4G	7/	6L6GT	7/6	12AX7	9/6	35A5	15/	CV31	7/6	EC98	6/6	EL37	17/3	N154	6/6	YV68	9/9	U16	9/6	IN2404	8/	AY100	26/	GD12	1/	OA220/9/6	OC812	8/			
6/3012	12/	6L7GT	12/6	12BA6	6/	35D8	12/6	D63	5/	EC92	6/6	EL37	17/3	N308	27/6	YV91	12/6	U10	9/	2N3963	10/	AY100	26/	GD12	1/	OA220/9/6	OC812	8/			
6A8G	6/6	6L18	8/	12BB6	5/6	35L6GT	8/6	D77	2/3	EC93	15/6	EL41	11/	N329	6/6	YV90	21/6	U12/4	7/6	2N1756	10/	AY100	26/	GD12	1/	OA220/9/6	OC812	8/			
6AC7	3/	6L19	27/6	12BB7	6/	35W4	4/6	DAC32	7/	EC93	4/6	EL42	10/6	N339	25/	YV90	21/6	U12/4	7/6	2N1756	10/	AY100	26/	GD12	1/	OA220/9/6	OC812	8/			
6A05	4/	6L20	9/6	12E1	17/	35Z3	10/6	DAF91	4/3	EC93	31/6	EL41	10/6	N339	25/	YV91	6/6	U17	5/	2N2297	4/6	BA116	5/	GET111	15/6	OC224/18/6	Y43	3/6			
6AK5	5/	6N7GT	6/6	12K7	10/	35Z4GT	4/9	DAF96	6/6	EC94	11/	EL43	7/6	N379	6/6	ZQ30	9/6	U19	34/6	2N2369A	4/3	BA129	2/6	GET113	15/6	OC224/18/6	Y43	3/6			
6AK6	6/	6P1	12/	12K7GT	10/	35Z5GT	6/6	DC90	10/	EC94	11/	EL43	7/6	N379	6/6	ZQ30	9/6	U19	34/6	2N2369A	4/3	BA129	2/6	GET113	15/6	OC224/18/6	Y43	3/6			
6AL5	2/3	6P25	12/	12K7GT	6/6	35D8	12/6	DD30	10/	EC94	11/	EL43	7/6	N379	6/6	ZQ30	9/6	U19	34/6	2N2369A	4/3	BA129	2/6	GET113	15/6	OC224/18/6	Y43	3/6			
6AM4	16/6	6P28	12/	12Q7GT	6/	50C5	6/3	DF33	7/8	EC94	6/3	EL46	4/	PBC80	7/6	U17	5/	2N2297	4/6	BA116	5/	GET111	15/6	OC224/18/6	Y43	3/6					
6AM6	3/	6P28	25/	12SA7GT	6/	50C6D	44/3	DF91	2/9	EC94	6/3	EL46	4/	PBC80	7/6	U17	5/	2N2297	4/6	BA116	5/	GET111	15/6	OC224/18/6	Y43	3/6					
6AQ5	5/6	6Q7G	6/	8/	50L6GT	9/	DF96	6/6	EC95	5/6	EL46	5/3	PC88	10/3	PC88	10/3	PC88	10/3	PC88	10/3	PC88	10/3	PC88	10/3	PC88	10/3	PC88	10/3	PC88	10/3	
6AR6	20/	6Q7GT	8/6	12B07	5/	72	6/6	DF97	10/	EC98	8/	EM80	7/6	PC87	8/6	PC87	8/6	PC87	8/6	PC87	8/6	PC87	8/6	PC87	8/6	PC87	8/6	PC87	8/6	PC87	8/6
6AT6	4/	6R7G	7/	12B07	4/6	85A2	8/6	DE63	6/	EC9																					

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AAZ13	3/2	B2M	12/6	BF181	12/6	NKT12	5/5	NKT231	5/5	NKT13329	3/11	TIS45	3/3	2N911	10/-	2N3402	5/6	2N5172	3/-	BY127	2/3
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AC126	5/-	B108	8/-	BF185	8/-	NKT42	6/-	NKT237	5/9	NKT16229	8/5	TIS47	3/3	2N918	8/5	2N3404	7/6	2N5175	10/6	BYX10	3/-
AC127	4/-	BA111	6/-	BF194	3/6	NKT43	6/-	NKT238	4/-	NKT20329	6/6	TIS48	3/3	2N929	5/3	2N3414	5/6	2N5176	9/-	BYX36/150	2/6
AC127Z	9/6	BAX13	1/6	BF195	3/6	NKT72	3/9	NKT239	3/9	NKT20339	6/4	TIP31A	14/10	2N930	6/-	2N3415	6/-	2N5232	5/6	BYX36/300	2/10
AC128	4/-	BC107	2/9	BF200	10/6	NKT73	3/7	NKT240	3/10	NKT25219	15/9	TIP32A	14/10	2N931	6/11	2N3416	7/6	2N5249	13/6	BYX36/600	3/9
AC176	5/-	BC108	2/9	BF274	5/-	NKT101	6/-	NKT241	3/9	OC19	5/-	V205	20/-	2N932	7/9	2N3436	15/-	2N5249A	13/6	BYZ21	25/-
AC187	12/-	BC109	2/9	BFX13	5/-	NKT102	6/-	NKT242	3/11	OC20	19/6	V405A	9/3	2N933	3/7	2N3525	21/9	2N5305	7/6	BYZ24	26/3
AC188	12/-	BC113	5/-	BFX29	6/2	NKT103	6/-	NKT243	12/-	OC22	8/-	40250	10/9	2N934	3/7	2N3526	19/-	2N5306	8/-	BYZ25	31/9
ACY17	5/9	BC116	8/-	BFX44	8/-	NKT104	6/-	NKT244	3/11	OC22	8/-	40309	6/6	2N935	4/11	2N3528	5/6	2N5309	12/6	BYZ142	3/9
ACY18	4/-	BC118	5/-	BFX84	5/2	NKT105	6/-	NKT245	3/-	OC24	8/-	40310	9/-	2N936	4/11	2N3607	4/6	2N5354	5/6	BYZ10	9/-
ACY19	4/-	BC125	11/-	BFX85	6/9	NKT106	6/-	NKT246	4/3	OC25	7/6	40311	6/9	2N937	6/-	2N3702	2/6	2N5355	5/6	BYZ12	6/-
ACY20	3/10	BC126	11/-	BFX86	4/11	NKT107	6/-	NKT262	4/3	OC26	6/6	40312	9/6	2N938	6/-	2N3703	2/5	2N5356	10/6	BYZ13	5/-
ACY21	3/10	BC134	5/-	BFX87	5/9	NKT108	6/-	NKT263	4/8	OC27	12/-	40313	7/3	2N939	6/-	2N3704	3/2	2N5357	10/6	CG65	4/-
ACY22	3/9	BC135	6/-	BFX88	5/3	NKT109	6/-	NKT264	4/3	OC29	15/-	40315	7/3	2N940	6/3	2N3705	2/8	2N5358	10/6	CG66	4/-
ACY27	3/6	BC136	8/-	BFY18	15/-	NKT121	10/6	NKT265	5/6	OC35	9/-	40316	9/3	2N941	4/5	2N3706	2/3	2N5359	12/6	EA403	3/6
ACY28	3/8	BC137	8/6	BFY50	4/6	NKT122	10/6	NKT270	6/-	OC36	12/6	40317	7/3	2N942	5/11	2N3707	2/10	2N5360	15/-	EA401	5/6
ACY29	7/6	BC138	12/-	BFY51	3/9	NKT123	9/6	NKT271	2/10	OC41	4/6	40319	10/9	2N943	16/3	2N3708	1/10	2N5361	15/-	EA402	4/8
ACY30	7/6	BC140	13/3	BFY52	4/6	NKT124	9/6	NKT272	2/10	OC42	4/6	40320	7/3	2N944	12/6	2N3709	2/1	2N5362	15/-	EA403	4/8
ACY31	4/7	BC147	2/9	BFY53	3/2	NKT125	4/6	NKT273	3/8	OC43	4/6	40323	6/6	2N945	14/9	2N3710	2/3	2N5363	15/-	EA404	4/8
ACY34	3/5	BC148	3/3	BFY90	24/6	NKT126	4/-	NKT274	2/10	OC44	3/-	40324	9/3	2N946	5/5	2N3711	2/6	2N5364	17/6	EA405	3/6
ACY35	3/6	BC149	3/3	BFW57	6/-	NKT127	10/6	NKT275	3/4	OC45	3/-	40326	7/3	2N947	11/4	2N3712	5/19	2N5365	19/6	EA406	3/8
ACY36	3/9	BC154	12/6	BFW58	5/6	NKT128	10/6	NKT276	3/6	OC70	2/6	40329	4/9	2N948	6/5	2N3819	7/10	2N5366	20/6	EA407	1/8
ACY39	12/-	BC167	3/9	BFW59	5/6	NKT129	8/6	NKT279A	2/6	OC71	3/-	40344	5/3	2N949	8/4	2N3820	18/9	2N5367	25/104	EA408	1/8
ACY40	3/7	BC168	4/6	BFX60	4/6	NKT135	6/11	NKT281	5/-	OC72	4/6	40347	7/6	2N950	7/2	2N3826	6/-	2N5368	25/104	EA409	1/8
ACY41	3/7	BC169	3/9	BLY47	3/3	NKT137	6/11	NKT301	18/6	OC74	8/-	40348	10/3	2N951	10/3	2N3854	5/6	2N5369	25/104	EA410	1/8
ACY44	8/-	BC171	2/9	BS05	10/6	NKT141	10/6	NKT302	12/3	OC75	4/6	40360	8/6	2N952	3/4	2N3854A	5/6	2N5370	10/6	EA411	1/8
AD140	11/-	BC182L	2/3	BSX19	3/3	NKT142	10/6	NKT303	17/6	OC76	2/6	40361	9/6	2N953	3/11	2N3855	5/6	2N5371	12/6	EA412	1/8
AD149	11/6	BC183L	1/10	BSX20	3/3	NKT143	9/6	NKT304	9/10	OC77	2/6	40362	11/6	2N954	7/6	2N3855A	5/6	2N5372	15/6	EA413	1/8
AD161	6/-	BC184L	6/-	BSX21	7/6	NKT144	8/-	NKT351	10/-	OC81	4/6	40370	6/-	2N955	4/-	2N3856	6/-	2N5373	9/-	EA414	1/8
AD162	6/-	BC185L	12/7	BSX22	12/7	NKT151	6/-	NKT352	17/6	OC81D	3/-	40406	11/3	2N956	10/-	2N3856A	6/-	2N5374	6/-	EA415	1/8
AD170	12/6	BC190	10/6	BSX61	7/11	NKT153	6/-	NKT361	20/-	OC82	8/-	40408	10/3	2N957	10/3	2N3904	9/9	2N5375	25/104	EA416	1/8
ADZ11	32/-	BCY12	12/-	BSX76	4/-	NKT154	6/-	NKT362	20/-	OC82D	3/-	40462	11/3	2N958	9/9	2N3904A	9/9	2N5376	10/6	EA417	1/8
ADZ12	39/-	BCY30	5/-	BSX77	6/-	NKT161	6/-	NKT401	14/6	OC83	4/6	40467	16/6	2N959	12/11	2N3959	5/6	2N5377	8/6	EA418	1/8
AF102	12/6	BCY31	5/6	BSX78	6/6	NKT162	6/-	NKT402	15/-	OC84	5/-	40468A	7/-	2N960A	15/1	2N3959A	6/3	2N5378	11/4	EA419	1/8
AF106	7/6	BCY32	10/-	BSY27	4/-	NKT163	6/6	NKT403	14/9	OC123	7/-	40602	8/-	2N960B	8/10	2N3860	6/-	2N5379	12/6	EA420	1/8
AF114	5/-	BCY33	4/-	BSY29	3/9	NKT164	6/6	NKT404	11/6	OC139	15/-	1N3713	30/-	2N960C	10/10	2N3866	25/-	2N5380	26/6	EA421	1/8
AF115	5/-	BCY34	5/-	BSY32	5/-	NKT165	6/-	NKT405	11/6	OC140	7/-	1N3717	30/-	2N961	10/10	2N3866A	25/-	2N5381	26/6	EA422	1/8
AF116	5/-	BCY38	6/-	BSY36	5/-	NKT201	6/-	NKT406	9/11	OC170	5/-	15100	3/2	2N962	4/-	2N3877A	9/6	2N5382	25/-	EA423	1/8
AF117	5/-	BCY40	10/-	BSY95	3/2	NKT202	6/-	NKT420	28/11	OC171	6/-	15107	6/6	2N963	3/6	2N3900	10/6	2N5383	8/6	EA424	1/8
AF118	8/10	BCY42	4/-	BSY95A	2/11	NKT204	6/-	NKT451	9/11	OC200	6/3	15410	5/1	2N964	2/-	2N3900A	11/6	2N5384	11/6	EA425	1/8
AF121	6/-	BCY43	4/-	BZ14	33/3	NKT205	6/-	NKT452	9/6	OC201	9/6	15410R	3/9	2N965	2/-	2N3903	7/6	2N5385	7/6	EA426	1/8
AF124	4/2	BCY54	7/6	BY245	33/3	NKT206	6/-	NKT453	9/6	OC202	9/6	2G302	5/1	2N966	2/-	2N3904	7/6	2N5386	10/6	EA427	1/8
AF125	4/2	BCY70	3/10	C111	18/-	NKT208	4/2	NKT603F	4/8	OC203	7/6	2G339A	5/1	2N967	2/-	2N3905	7/6	2N5387	13/9	EA428	1/8
AF126	3/6	BCY71	7/8	C11E	12/-	NKT210	4/2	NKT613F	5/2	OC204	8/-	2G371	3/-	2N968	2/-	2N3906	7/6	2N5388	15/3	EA429	1/8
AF127	3/6	BCY72	3/6	C246	8/3	NKT211	3/9	NKT654F	4/2	OC205	9/-	2G371B	3/-	2N969	2/-	2N4037	15/3	2N5389	14/6	EA430	1/8
AF139	15/-	BCY87	8/6	CRI-051C	8/-	NKT212	3/9	NKT675	6/8	OC206	10/6	2G374	5/-	2N970	2/-	2N4058	3/4	2N5390	10/6	EA431	1/8
AF178	9/6	BCZ11	7/6	CRI-401C	10/-	NKT213	4/7	NKT676	5/-	OC207	7/6	2G381	5/-	2N971	2/-	2N4059	5/4	2N5391	13/9	EA432	1/8
AF179	11/6	BD119	19/-	D13T1	10/-	NKT214	3/5	NKT677	3/10	OC271	19/6	2N174	16/-	2N972	12/1	2N4060	3/4	2N5392	17/6	EA433	1/8
AF180	12/6	BD121	18/-	FST3/8AF	5/-	NKT215	3/7	NKT703	8/-	ORP12	9/6	2N385A	9/6	2N973	3/9	2N4061	4/-	2N5393	4/-	EA434	1/8
AF186W	9/6	BD123	12/6	GET16	12/6	NKT216	7/6	NKT713	3/10	ORP60	8/-	2N388A	3/1	2N974	4/5	2N4062	4/6	2N5394	5/6	EA435	1/8
AF186G	9/6	BD124	12/6	GET102	6/-	NKT217	9/-	NKT717	5/10	ORP61	8/-	2N404A	4/6	2N975	12/6	2N4284	3/4	2N5395	5/6	EA436	1/8
AF239	7/6	BDY20	20/8	GET103	5/-	NKT218	6/-	NKT734	4/11	ORP63	9/-	2N696	3/7	2N976	15/6	2N4287	3/4	2N5396			

# R.S.T. VALVE MAIL ORDER CO.

## BLACKWOOD HALL, 16A WELLFIELD ROAD STREATHAM, S.W.16

A61 9/8	ECL82 7/-	PL82 8/8	XH8/100	7Y4 8/8	2G401 5/-
ACT9 500/-	ECL83 10/3	PL84 7/-	300/-	10F1 14/8	2G402 6/-
ARF38 18/-	ECL86 9/-	PL508 29/-	XR13/200	11E3 70/-	2G414 8/-
AZ31 10/-	ECLL800	PL509 29/-		12A0C 10/-	2G415 6/-
BT19 60/-		PL802 18/8		12AD6 11/-	2G416 6/8
BT79 57/-	EF9 20/-	PT15 15/-		12A7 9/8	2G417 6/-
B789 67/-	EF37A 7/-	FX4 24/-		12AT8 9/8	2N247 9/8
CIO 20/-	EF39 8/-	FX25 27/8		12AT7 6/-	2N655 12/8
CBL31 18/-	EF41 10/-	PY32 10/9		12AU7 5/9	AC107 5/8
CCH35 15/-	EF50 5/-	PY33 10/9		12AX7 6/3	AC127 5/8
CV5 95/-	EF82 25/-	PY81 5/3		12BA6 6/-	AC128 4/8
CV74 80/-	EF80 4/8	PY82 5/9		12BE6 6/3	ACV19 5/8
CV82 50/-	EF86 6/8	PY83 7/-		12E1 20/-	ACV20 5/-
CV315 30/-	EF89 5/8	PY500 18/8		12K7GT 7/-	ACV21 4/8
CV354 110/-	EF91 3/8	PY800 9/6		12K8GT 8/-	AD140 8/-
CV370 300/-	EF92 2/6	PY801 9/6		12Q7GT 6/-	AF114 5/-
CV372 57/-	EF98 15/0	PZ30 10/-		13E1 190/-	AF115 5/-
CV404 28	EF183 6/8	QF41 40/-		20P4 20/-	AF116 4/8
CV408 50/-	EF184 7/-	QQV02/6		2E26 20/-	AF117 7/-
CV428 85/-	EF84 21/-	QQV02/6		2K25 160/-	BY100 4/8
CV429 350/-	EFPP0 10/-	QQV03/10		2525GT 8/-	GET571 5/-
CV450 25/-	EH90 7/6	27/8		25Z6GT 8/8	GET875 6/-
CV1144 60/-	EL33 12/6	QQV03/20		27M1 72/6	NKT211 6/8
CV1385 140/-	EL34 10/8	105/-		3B24 29/-	NKT214 4/4
	EL38 22/8	QQV04/10		3B240M	NKT216 6/4
	EL41 11/-	105/-		30F5 17/-	NKT217 8/4
	EL42 11/6	100/-		3B241M	NKT218
	EL81 9/-	100/-		3B24 110/-	
	EL84 4/8	100/-		3B24 29/-	
	EL85 7/9	90/-		3C24 60/-	
	EL88 8/3	90/-		3C45 65/-	
	EL90 6/3	90/-		3D21A 35/-	
	EL95 7/-	90/-		3E29 70/-	
	EL360 24/-	90/-		4X150A	
	EL820 8/-	20/-		4X150B	
	EL821 7/8	20/-		4X150C	
	EL822 16/-	20/-		4X150D	
	EL823 16/-	20/-		4X150E	
	EL824 16/-	20/-		4X150F	
	EL825 16/-	20/-		4X150G	
	EL826 16/-	20/-		4X150H	
	EL827 16/-	20/-		4X150I	
	EL828 16/-	20/-		4X150J	
	EL829 16/-	20/-		4X150K	
	EL830 16/-	20/-		4X150L	
	EL831 16/-	20/-		4X150M	
	EL832 16/-	20/-		4X150N	
	EL833 16/-	20/-		4X150O	
	EL834 16/-	20/-		4X150P	
	EL835 16/-	20/-		4X150Q	
	EL836 16/-	20/-		4X150R	
	EL837 16/-	20/-		4X150S	
	EL838 16/-	20/-		4X150T	
	EL839 16/-	20/-		4X150U	
	EL840 16/-	20/-		4X150V	
	EL841 16/-	20/-		4X150W	
	EL842 16/-	20/-		4X150X	
	EL843 16/-	20/-		4X150Y	
	EL844 16/-	20/-		4X150Z	
	EL845 16/-	20/-		4X150AA	
	EL846 16/-	20/-		4X150AB	
	EL847 16/-	20/-		4X150AC	
	EL848 16/-	20/-		4X150AD	
	EL849 16/-	20/-		4X150AE	
	EL850 16/-	20/-		4X150AF	
	EL851 16/-	20/-		4X150AG	
	EL852 16/-	20/-		4X150AH	
	EL853 16/-	20/-		4X150AI	
	EL854 16/-	20/-		4X150AJ	
	EL855 16/-	20/-		4X150AK	
	EL856 16/-	20/-		4X150AL	
	EL857 16/-	20/-		4X150AM	
	EL858 16/-	20/-		4X150AN	
	EL859 16/-	20/-		4X150AO	
	EL860 16/-	20/-		4X150AP	
	EL861 16/-	20/-		4X150AQ	
	EL862 16/-	20/-		4X150AR	
	EL863 16/-	20/-		4X150AS	
	EL864 16/-	20/-		4X150AT	
	EL865 16/-	20/-		4X150AU	
	EL866 16/-	20/-		4X150AV	
	EL867 16/-	20/-		4X150AW	
	EL868 16/-	20/-		4X150AX	
	EL869 16/-	20/-		4X150AY	
	EL870 16/-	20/-		4X150AZ	
	EL871 16/-	20/-		4X150BA	
	EL872 16/-	20/-		4X150BB	
	EL873 16/-	20/-		4X150BC	
	EL874 16/-	20/-		4X150BD	
	EL875 16/-	20/-		4X150BE	
	EL876 16/-	20/-		4X150BF	
	EL877 16/-	20/-		4X150BG	
	EL878 16/-	20/-		4X150BH	
	EL879 16/-	20/-		4X150BI	
	EL880 16/-	20/-		4X150BJ	
	EL881 16/-	20/-		4X150BK	
	EL882 16/-	20/-		4X150BL	
	EL883 16/-	20/-		4X150BM	
	EL884 16/-	20/-		4X150BN	
	EL885 16/-	20/-		4X150BO	
	EL886 16/-	20/-		4X150BP	
	EL887 16/-	20/-		4X150BQ	
	EL888 16/-	20/-		4X150BR	
	EL889 16/-	20/-		4X150BS	
	EL890 16/-	20/-		4X150BT	
	EL891 16/-	20/-		4X150BU	
	EL892 16/-	20/-		4X150BV	
	EL893 16/-	20/-		4X150BW	
	EL894 16/-	20/-		4X150BX	
	EL895 16/-	20/-		4X150BY	
	EL896 16/-	20/-		4X150BZ	
	EL897 16/-	20/-		4X150CA	
	EL898 16/-	20/-		4X150CB	
	EL899 16/-	20/-		4X150CC	
	EL900 16/-	20/-		4X150CD	
	EL901 16/-	20/-		4X150CE	
	EL902 16/-	20/-		4X150CF	
	EL903 16/-	20/-		4X150CG	
	EL904 16/-	20/-		4X150CH	
	EL905 16/-	20/-		4X150CI	
	EL906 16/-	20/-		4X150CJ	
	EL907 16/-	20/-		4X150CK	
	EL908 16/-	20/-		4X150CL	
	EL909 16/-	20/-		4X150CM	
	EL910 16/-	20/-		4X150CN	
	EL911 16/-	20/-		4X150CO	
	EL912 16/-	20/-		4X150CP	
	EL913 16/-	20/-		4X150CQ	
	EL914 16/-	20/-		4X150CR	
	EL915 16/-	20/-		4X150CS	
	EL916 16/-	20/-		4X150CT	
	EL917 16/-	20/-		4X150CU	
	EL918 16/-	20/-		4X150CV	
	EL919 16/-	20/-		4X150CW	
	EL920 16/-	20/-		4X150CX	
	EL921 16/-	20/-		4X150CY	
	EL922 16/-	20/-		4X150CZ	
	EL923 16/-	20/-		4X150DA	
	EL924 16/-	20/-		4X150DB	
	EL925 16/-	20/-		4X150DC	
	EL926 16/-	20/-		4X150DD	
	EL927 16/-	20/-		4X150DE	
	EL928 16/-	20/-		4X150DF	
	EL929 16/-	20/-		4X150DG	
	EL930 16/-	20/-		4X150DH	
	EL931 16/-	20/-		4X150DI	
	EL932 16/-	20/-		4X150DJ	
	EL933 16/-	20/-		4X150DK	
	EL934 16/-	20/-		4X150DL	
	EL935 16/-	20/-		4X150DM	
	EL936 16/-	20/-		4X150DN	
	EL937 16/-	20/-		4X150DO	
	EL938 16/-	20/-		4X150DP	
	EL939 16/-	20/-		4X150DQ	
	EL940 16/-	20/-		4X150DR	
	EL941 16/-	20/-		4X150DS	
	EL942 16/-	20/-		4X150DT	
	EL943 16/-	20/-		4X150DU	
	EL944 16/-	20/-		4X150DV	
	EL945 16/-	20/-		4X150DW	
	EL946 16/-	20/-		4X150DX	
	EL947 16/-	20/-		4X150DY	
	EL948 16/-	20/-		4X150DZ	
	EL949 16/-	20/-		4X150EA	
	EL950 16/-	20/-		4X150EB	
	EL951 16/-	20/-		4X150EC	
	EL952 16/-	20/-		4X150ED	
	EL953 16/-	20/-		4X150EE	
	EL954 16/-	20/-		4X150EF	
	EL955 16/-	20/-		4X150EG	
	EL956 16/-	20/-		4X150EH	
	EL957 16/-	20/-		4X150EI	
	EL958 16/-	20/-		4X150EJ	
	EL959 16/-	20/-		4X150EK	
	EL960 16/-	20/-		4X150EL	
	EL961 16/-	20/-		4X150EM	
	EL962 16/-	20/-		4X150EN	
	EL963 16/-	20/-		4X150EO	
	EL964 16/-	20/-		4X150EP	
	EL965 16/-	20/-		4X150EQ	
	EL966 16/-	20/-		4X150ER	
	EL967 16/-	20/-		4X150ES	
	EL968 16/-	20/-		4X150ET	
	EL969 16/-	20/-		4X150EU	
	EL970 16/-	20/-		4X150EV	
	EL971 16/-	20/-		4X150EW	
	EL972 16/-	20/-		4X150EX	
	EL973 16/-	20/-		4X150EY	
	EL974 16/-	20/-		4X150EZ	
	EL975 16/-	20/-		4X150FA	
	EL976 16/-	20/-		4X150FB	
	EL977 16/-	20/-		4X150FC	
	EL978 16/-	20/-		4X150FD	
	EL979 16/-	20/-		4X150FE	
	EL980 16/-	20/-		4X150FF	
	EL981 16/-	20/-		4X150FG	
	EL982 16/-	20/-		4X150FH	
	EL983 16/-	20/-		4X150FI	
	EL984 16/-	20/-		4X150FJ	
	EL985 16/-	20/-		4X150FK	
	EL986 16/-	20/-		4X150FL	
	EL987 16/-	20/-		4X150FM	
	EL988 16/-	20/-		4X150FN	
	EL989 16/-				

# BI-PRE-PAK LIMITED

### FULLY TESTED AND MARKED

AC107	3/-	OC170	3/-
AC126	2/6	OC171	4/-
AC127	3/6	OC200	3/6
AC128	2/6	OC201	7/-
AC176	5/-	2G301	2/6
ACY17	3/-	2G303	2/6
AF114	4/-	2N711	10/-
AF115	3/6	2N1302-3	4/-
AF116	3/6	2N1304-5	5/-
AF117	3/6	2N1308-7	6/-
AF239	12/6	2N1308-9	8/-
AF186	10/-	2N3819 F.E.T.	9/-
AF139	10/-	Power	
BFY50	4/-	Transistors	
BSY25	7/6	OC20	10/-
BSY26	3/-	OC23	10/-
BSY27	3/-	OC25	8/-
BSY28	3/-	OC26	5/-
BSY29	3/-	OC28	7/6
BSY95A	3/-	OC35	5/-
OC41	2/6	OC36	7/6
OC44	2/6	AD149	10/-
OC45	2/6	2S034	10/-
OC71	2/6	2N2287	20/-
OC72	2/6	2N3055	15/-
OC73	3/6	Diodes	
OC81	2/6	AA42	2/-
OC81D	2/6	OA95	2/-
OC83	4/-	OA79	1/9
OC139	2/6	OA81	1/9
OC140	3/6	IN914	1/6

### ANOTHER SCOOP FOR BI-PRE-PAK

JUST RELEASED FROM STOCK, A.E.I. INTEGRATED CIRCUITS  
These are brand new genuine surplus stocks, marked and guaranteed to full makers specification and not remarked rejects.

NE808A	Single 8 I/P Nand Gate TTL	7/-
NE816A	Dual 4 I/P Nand Gate TTL	7/-
NE825A	D.C. Clocked J-K Flip-Flop TTL	17/6
NE840A	Dual 4 I/P Exclusive DR Gate TTL	7/-
NE855A	Dual 4 Power Gate TTL	7/-
NE870A	Triple 3 I/P Nand TTL	7/-
NE880A	Quad 2 Nand TTL	7/-
SP616A	Dual 4 Nand Gate DTL	7/-
SP631A	Quad 2 I/P Gate Expander DTL	7/-
SP670A	Triple 3 Nand Gate DTL	7/-
SP806A	Dual I/P Expander TTL	7/-
SP808A	Single 8 I/P Nand Gate TTL	7/-
SP816A	Dual 4 I/P Nand Gate TTL	7/-
SP825A	D.C. Clocked J-K Flip-Flop TTL	17/6
SP840A	Dual 4 I/P Exclusive OR Gate TTL	10/-
SP855A	Dual 4 Power Gate TTL	7/-
SP870A	Triple 3 I/P Nand TTL	7/-
SP880A	Quad 2 I/P Nand TTL	7/-
NE500K	Video Amplifier	40/-
NE501K	Video Amplifier 40 MHz	40/-
NE806J	Dual 4 I/P Expander TTL	7/-
NE808J	Single 8 I/P Nand Gate TTL	7/-
NE816J	Dual I/P Nand Gate TTL	7/-
NE825J	D.C. Clocked J-K Flip-Flop TTL	17/6
NE840J	Dual 4 I/P Exclusive OR Gate TTL	7/-
NE855J	Dual 4 Power Driver TTL	7/-
NE880J	Quad 2 I/P Nand TTL	7/-
ST620A	J-K Flip-Flop DTL	17/6
ST659A	Dual 4 Buffer/Driver DTL	7/-

Suffix: A = DIP 14 lead K = 10 lead TO.5  
J = Flat Pack

### NEW TESTED & GUARANTEED PAKS

B79	4	1N4007 Sil. Rec. Diodes. 1.000 P.I.V. 1 amp. Plastic.	10/-
B81	10	REED SWITCHES MIXED TYPES LARGE & SMALL	10/-
B89	2	5 SP5 LIGHT SENSITIVE CELLS LIGHT RES. 400 Ω DARK 1 M Ω	10/-
B92	4	NPV SIL. TRANS. AO6=BSX20, 2N2369, 500MHz. 360mW	10/-
B93	5	GET113 TRANS. EQUIV. TO ACY17-21 PNP GERM.	10/-
B96	5	2N3136 PNP SIL. TRANS. TO-18 HPE100-300 IC. 600mA, 200MHz	10/-
B98	10	XB112 & XB102 EQUIV. TO AC126 AC156, OC81/2, OC71/2, NKT271, ETC.	10/-
B99	200	CAPACITORS, ELECTROLYTICS, PAPER, SILVER MICA, ETC. POSTAGE ON THIS PAK 2/6.	10/-
H4	250	MIXED RESISTORS POST & PACKING 2/-	10/-
H7	40	WIREWOUND RESISTORS MIXED TYPES & VALUES. POSTAGE 1/6	10/-
H8	4	BY127 Silicon Recs. 1000 P.I.V. 1 amp Plastic. Replaces the BY100	10/-
H9	2	OC71 LIGHT SENSITIVE PHOTOTRANSISTORS	10/-

**FREE!**  
PACKS OF YOUR OWN CHOICE UP TO THE VALUE OF 10/- WITH ORDERS OVER £4

**Return of the unbeatable P.1 Pak.**  
Now greater value than ever

Full of Short Lead Semiconductors & Electronic Components, approx. 170. We guarantee at least 30 really high quality factory marked Transistors PNP & NPN, and a host of Diodes & Rectifiers mounted on Printed Circuit Panels. Identification Chart supplied to give some information on the Transistors.

Please ask for Pak **P.1.** Only **10/-**  
2/- P & P on this Pak.

**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. **20/- each** counter for any car.

**FREE CATALOGUE AND LISTS for:-**

**ZENER DIODES  
TRANSISTORS, RECTIFIERS  
FULL PRE-PAK LISTS  
& SUBSTITUTION CHART**

MINIMUM ORDER 10/- CASH WITH ORDER PLEASE. Add 1/- post and packing per order. OVERSEAS ADD EXTRA FOR AIRMAIL.

**P.O. RELAYS** 8 for  
VARIOUS CONTACTS AND COIL RESISTANCES. NO INDIVIDUAL SELECTION. POST & PACKING 5/- **20/-**

### LOOK! TRANSISTORS ONLY 6d EACH

**TYPE A  
PNP SILICON ALLOY  
TO-5 CAN**

Spec:-  
ICER AT VCE = 20v  
1mA MAX.  
HFE, 15-100  
These are of the 29300 type which is a direct equivalent to the OC200/205 range.

**TYPE B  
PNP SILICON  
PLASTIC ENCAPSULATION**

Spec:-  
ICER AT VCE = 10v  
1mA MAX.  
HFE, 10-200  
These are of the 2N3702/3 and 2N4059/62 range.

**TYPE E  
PNP GERMANIUM**

FULLY MARKED AND TESTED. STATE R.F. OR A.F. WHEN ORDERING.

### NEW UNMARKED UNTESTED PAKS

B78	12	INTEGRATED CIRCUITS, DATA & CIRCUITS OF TYPES, SUPPLIED WITH ORDERS	10/-
B80	8	DUAL TRANS. MATCHED O/P PAIRS NPL-SIL INTO-5 CAN.	10/-
B82	10	OC45, OC81D & OC81 TRANS. MULLARD GLASS TYPE	10/-
B83	200	200 TRANSISTORS. MAKERS REJECTS. NPN-PNP. SIL & GERM.	10/-
B84	100	SILICON DIODES DO-7 GLASS EQUIV. TO OA200, OA202 HIGH QUALITY GERM.	10/-
B66	150	DIODES MIN. GLASS TYPE SIL. DIODES SUB. MIN. IN914 & IN916 TYPES	10/-
B86	50	GERM. PNP TRANS. EQUIV. TO OC44, OC45, OC81, ETC.	10/-
B87	100	SIL TRANS. NPN, PNP, EQUIV. TO OC200/1, 2N706A, BSY95A, ETC.	10/-
B88	50	7 WATT ZENER DIODES. MIXED VOLTAGES	10/-
B60	10		10/-
H5	16	1 AMP. PLASTIC DIODES 50-1000 VOLTS	10/-
H6	40	250mW. ZENER DIODES DO-7 MIN. GLASS TYPE	10/-

**SPECIAL OFFER  
GERMANIUM BRIDGE  
RECTIFIERS  
GEX 541 FINNED**

SINGLE PHASE 12 AMP 48 VOLTS  
THREE PHASE 18 AMP 74 VOLTS

IDEAL FOR BATTERY CHARGERS OR POWER UNITS

OFFERED AT FRACTION OF MAKERS COST

ONLY **12/6** EACH  
POST & PACKING 2/6

**FREE! A WRITTEN GUARANTEE WITH ALL OUR TESTED SEMICONDUCTORS**

**BI-PRE-PAK LTD** DEPT. B, 222-224 WEST ROAD, WESTCLIFF-ON-SEA, ESSEX  
TELEPHONE: SOUTHEND (0702) 46344

**CURRENT RANGE OF BRAND NEW L.T. TRANSFORMERS, FULLY SHROUDED (\*excepted) TERMINAL BLOCK CONNECTIONS. ALL PRIMARIES 220/240v**

No.	Sec. Taps	Amps	Price	Carr.
1A	25-33-40-50	15	£10 10 0	12/6
1B	25-33-40-50	10	£7 12 6	9/6
1C	25-33-40-50	6	£6 15 0	9/6
1D	25-33-40-50	3	£4 0 0	7/6
2A	4-16-24-32	12	£7 2 6	8/6
2B	4-16-24-32	8	£5 7 6	8/6
2C	4-16-24-32	4	£3 12 6	7/6
3A	4-16-24-32	2	£2 7 6	5/-
3B*	25-30-35	20	£16 10 0	12/6
3C*	25-30-35	10	£10 5 0	10/6
3D	25-30-35	5	£7 5 0	8/6
3E	25-30-35	2	£4 2 6	7/6
4A*	12-20-24	30	£13 0 0	12/6
4B	12-20-24	20	£8 5 0	9/6
4C	12-20-24	10	£4 5 0	8/6
4D	12-20-24	5	£3 12 6	7/6
5A	3-12-18	30	£9 12 6	9/6
5B	3-12-18	20	£7 2 6	8/6
5C	3-12-18	10	£4 5 0	7/6
5D	3-12-18	5	£2 17 6	7/6
6A	48-56-60	2	£3 12 6	6/6
6B	48-56-60	1	£2 12 6	6/6
7A*	6-12	50	£10 7 6	10/6
7B	6-12	20	£6 2 6	8/6
7C	6-12	10	£3 17 6	7/6
7D	6-12	5	£2 15 0	6/6
8A	12-24	1	£1 12 6	6/6
9A*	17-32	8	£6 5 0	8/6
10A*	9-15	2	£1 9 6	6/6
11A	6-3	15	£2 10 0	7/6
12A	30-25-0-25-30	2	£3 12 6	6/6

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	2 1/2 lb	£1 19 6	5/6
2	150	4 lb	£2 12 6	6/6
3	300	6 1/2 lb	£3 12 6	6/6
4	500	8 1/2 lb	£5 2 6	8/6
5	1000	15 lb	£7 2 6	9/6
6*	1500	25 lb	£9 15 0	10/6
7*	1750	28 lb	£14 15 0	12/6
8*	2250	30 lb	£17 17 6	15/-

\* Completely enclosed in beautifully finished metal case fitted with two 2-pin American sockets, neon indicator, on/off switch, and carrying handle.

**DOUBLE WOUND STEP DOWN TRANSFORMERS**

240/110v. completely shrouded. Fitted with 2-pin American sockets or terminal blocks. 150 watts, £4.2.6, P. & P. 8/6. 300 watts, £5.15.0, P. & P. 9/6. 500 watts, £8.5.0, P. & P. 10/6. 1000 watts, fitted in metal case, with twin 2-pin American socket, neon indicator, on/off switch, £17.17.6, carriage 15/-.

**ISOLATION TRANSFORMERS**

PRI 240v. Sec 120-0-120v. 2kVA conservatively rated, built into strong metal cases. Size 1 1/2 x 9 x 8 inches. £27.10.0. Carr. 30/-.

**Samson's**  
(ELECTRONICS) LTD.

9 & 10 CHAPEL ST., LONDON, N.W.1  
01-723-7851 01-262-512

**HEAVY DUTY L.T. TRANSFORMERS**

Twickenham PRI 220, 235, 255v. Secs 55v 24a, 14v. 10a, 22v. 2a, 25v. 1a. Panel terminal block connections. Conservatively rated. £15.0.0. Carr. 17/6.  
 PRI 220-240v. Sec tapped 7, 8 9v., 45a. Open Frame Type. Heavy terminal connections. £8.10.0. Carr. 12/6.  
 Parmeko Neptune Series. PRI 200, 220, 240v. Sec. tapped 3, 8, 12, 18v. 5a. Potted C core type. Conservatively rated. 59/6. Carr. 8/6.  
 PRI 230v. Sec. 20v. 4a. Open Frame Type. 45/- P. & P. 5/-.  
 Special Clearance Offer. 95, 110, 120v. Primary only. Sec. 46v. 25a. Very conservatively rated. Size 10 1/2 x 8 x 8 inches. £8.10.0. Carr. 15/-.

**SPECIAL OFFER OF GRESHAM CHOKES**

15H 300mA 50 ohm. "C" Core Potted Type. 62/6. Carr. 10/-.  
 10H 300mA 60 ohm. "C" Core Potted Type. 55/- P. & P. 10/-.  
 15H 180mA 200 ohm. "C" Core Potted Type. 45/- P. & P. 8/6.  
 20H 350 mA. 200 ohm. "C" Core Potted Type. 69/6. Carr. 12/6.  
 1H 1a. 15 ohm, 69/6. Carr. 15/-.  
 Swinging Chokes. 20H 100mA-10H 450mA. 55/- Carr. 10/-.  
 All Chokes supplied new and guaranteed.

**PARMEKO CHOKES—NEPTUNE SERIES**

10H. 180M/A., 25/- P. & P. 5/-, 10H. 120M/A., 12/6. P. & P. 4/-.  
 10H. 75M/A., 15H. 75M/A., 15H. 50M/A., 5H. 120M/A., 5H. 60M/A., 50H. 25M/A., all types, 8/6 each, P. & P. 3/6. 0.7H. 450M/A. 12/6. P. & P. 4/-.  
 1H. 300M/A. 10/6 P. & P. 4/6. 5H. 150M/A. 17/6.

**JUPITER SERIES SWINGING CHOKE**

34H. 60M/A.-70H. 35M/A., 2.8kv., D.C. Wkg. 25/- P. & P. 6/-.

**E.H.T. TRANSFORMERS**

Parmeko Neptune, Pri. 115-230v. Sec. 2000v. 5 m/a. 4v. 1a. 47/6. P. & P. 5/-.  
 Gardners Pri. 200-240v. Sec. 2250v. 22 m/a. 75/- P. & P. 7/6. Pri. 200-240v. Sec. 1650v. 25 m/a. 75/- P. & P. 7/6. Pri. 200-240v. Sec. tapped 3000-3300v. 10 m/a. 4-6-3v. 1-5a. 3kv. wkg. 2-4v. 2a. 3kv. wkg. £419.6. Carr. 10/-.

**PARMEKO C CORE TRANSFORMERS**

Pri. tapped 110-200-240v. Sec. 1 250v. 197 m/a. Sec. 2 161v. 110 m/a. Sec. 3 152v. 76 m/a. Sec. 4 124v. 25 m/a. Sec. 5 28v. 0-4a. Sec. 6 6-4v. 6-2a. 6-3v. 3-25a. 6-3v. 1-4a. Table top connections. Size 5 x 4 x 4 ins. Brand new boxed. 35/- P. & P. 7/6. Special prices for qty's.

**MAGNETIC DEVICES 6v. D.C. CONTACTORS**

3 Heavy Makes contacts. Size 2 x 1 1/2 x 1 in. 8/6. P. & P. 2/-.



**PULLEN SHUNT WOUND 24. D.C. REVERSIBLE MOTORS**

Type 610 H.P. 1/75 r.p.m. 3,500 Cont./R. New and boxed. 15/- P. & P. 3/6.

**BURGESS MICRO SWITCHES**

Type MK 38R/74. Norm closed or Norm open. 1/2 in. raised Press Button. 8/6 for three. P. & P. 2/6.



HONEYWELL 250v. 10A. A.C. Lever operated. Make or break (3 tags). Three for 12/6. P. & P. 2/- Many other types available.

**NEWMARK SYNCHRONOUS MOTORS**

220-240v. 50 cycles, 3 watts 8 r.p.m. Overall size 2 x 2 x 2 ins. 10/6. P. & P. 1/6



LONDEX 220-240v. A.C. RELAYS  
 Open frame type 12 heavy make contacts. 27/6. P. & P. 5/-.

**VENNER SYNCHRONOUS BIO-DIRECTIONAL MOTORS**

220-240v. 50 cycles 40 r.p.m. automatically reverses wherever spindle stop is placed overall size 2 1/2 x 2 x 2 ins. Spindle length 1/2 in. dia. 1/16th. An ideal motor for display, giving a forward and reverse motion. 12/6. P. & P. 2/6.

**CROUZET SHADED POLE MOTORS**

A.C. 115/230v. 10 watts, 1 r.p.m. Overall size 2 1/2 in. dia. depth 2 ins. Spindle 1/2 in. dia. 1/16th. P. & P. 2/6.

**GARDNERS HT TRANSFORMERS ALL PRIMARIES TAPPED 200-250v.**

Sec. 500-0-500v. 250 m/a. 6-3v. 4a. 6-3v. 4a. 6-3v. 3a. 5v. 3-5a. Fully shrouded. £6.10.0. Carr. 10/-.  
 Sec. tapped 350-360-370-380-390-400v. 350 m/a. 15v. 2a. 6-3v. 3a. x 3. 6-3v. 2a. 6-3v. 1a. Fully shrouded. £419.6. Carr. 8/6.  
 Sec. 350-0-350v. 60 m/a. 4-6-3v. 4a. 4-5v. 2-5a. Fully shrouded. 27/6. P. & P. 5/-.  
 Sec. 500-0-500v. 80 m/a. 6-3v. 2a. 6-3v. 2a. 5v 2a. Fully shrouded. 47/6. P. & P. 5/-.  
 Sec. 63v. 1-6a. 24v. 0-8a. 6-3v. 1a. Open type. Table top connections. 65/- P. & P. 7/6.  
 Sec. 12v. 1a. Twice open type T.T. connections. 17/6. P. & P. 3/6.  
 Sec. 3-75v. 9a. 6-3v. 0-5a. Fully shrouded. 17/6. P. & P. 3/6.  
 Sec. 7v. 5a. 6-4v. 4a. 6-4v. 2-2a. 6-4v. 2-2a. 5v 2-8a. 4v. 1a. Oil-filled potted type. 50/- Carr. 8/6.  
 Sec. 370-390-410v. 6 m/a. Open 'C' core type. 12/6. P. & P. 2/6.  
 Sec. 12v. 6a. and 15-6v. 1-5a. Fully shrouded. 57/6. P. & P. 7/6.  
 Sec. tapped 20-40-700-760v. 50 m/a. 6-3v. 1-5a. Fully shrouded. 17/6. P. & P. 4/6.  
 Sec. 300v. 37.5 m/a. 4kv. D.C. wkg. Twice. 4v. 1a. 4v. 0-3a. 19/6. P. & P. 4/6.  
 600 watts auto tapped 200-210-220-230-240-250v. Open type. T.T. connections. 45/- P. & P. 5/-.

**NO EXCUSES! NO DELAYS! FROM STOCK! VARIABLE VOLTAGE TRANSFORMERS**

**INPUT 230 v. A.C. 50/60 OUTPUT VARIABLE 0/260 v. A.C.**

BRAND NEW. Keenest prices in the country. All Types (and spares) from 1/2 to 50 amp. available from stock.

0-260 v. at 1 amp. ....	£5 10 0
0-260 v. at 2.5 amps. ...	£6 15 0
0-260 v. at 5 amps. ....	£9 15 0
0-260 v. at 8 amps. ....	£14 10 0
0-260 v. at 10 amps. ...	£18 10 0
0-260 v. at 12 amps. ...	£21 0 0
0-260 v. at 15 amps. ...	£25 0 0
0-260 v. at 20 amps. ...	£37 0 0
0-260 v. at 30 amps. ...	£72 0 0
0-260 v. at 50 amps. ...	£92 0 0

**20 DIFFERENT TYPES AVAILABLE FOR IMMEDIATE DELIVERY.**

**Double Wound Variable Transformers**

Fully isolated, low tension Secondary winding. Input 230 v. A.C. OUTPUT CONTINUOUSLY VARIABLE 0-36 v. A.C.

0-36 v. at 5 amp. £9.12.6—  
 p. & p. 8/6  
 0-36 v. at 20 amp. £21.0.0—  
 15/- p. & c.

These fully shrouded Transformers, designed to our specifications, are ideally suited for Educational, Industrial and Laboratory use.

**INSULATION TESTERS (NEW)**

**500 VOLTS, 500 megohms. Price £28 carriage paid.**

**1,000 VOLTS, 1,000 megohms, £34 carriage paid.**

**VAN DE GRAAF ELECTROSTATIC GENERATOR**

fitted with motor drive for 230 v. A.C. giving a potential of approx. 50,000 volts. Supplied absolutely complete including accessories for carrying out a number of interesting experiments, and full instructions. This instrument is completely safe, and ideally suited for School demonstrations. Price £77/-, plus 4/- P. & P. L't. on req.

**OPEN TYPES**  
 Designed for Panel Mounting.  
 Input 230 v. A.C. 50/60 Output variable.  
 0-260 v.  
 1 amp. .... £3 18 6  
 1 amp. .... £5 10 0  
 2 1/2 amp. .... £6 12 6  
 P. & P. 7/6

**SANWA MULTI RANGE TESTERS**

**NEW MODEL U-50D MULTI TESTER, 20,000 O.P.V. MIRROR SCALED WITH OVERLOAD PROTECTION.** Ranges: D.C. volts: 100mV, 0.5 v., 5 v., 250 v., 1,000 v. A.C. volts: 2.5 v., 10 v., 50 v., 250 v., 1,000 v. D.C. current: 50µA, 0.5 mA, 5 mA., 50 mA., 250 mA. Size: 5 1/2 x 3 1/2 x 1 1/2 in. Complete with batteries and test prods. £7.5.0

Post paid

**'AVO' MODEL 48A**  
 Ex-Admiralty in good condition with instructions, leads, plus D.C. Shunts for 120 Amp and 480 Amp. A.C. Transformer for 60 Amp and 240 Amp. Multiplier for 3600 volt. Complete outfit in fitted case. £15/0/0, P. & P. 10/-.

**LATEST TYPE SOLID STATE VARIABLE CONTROLLER**

Ideal for lighting and heating circuits, compact panel mounting. Built in fuse protection. CONTINUOUSLY VARIABLE.

Input 230v AC output 25-230v AC  
 5 amp model £8. 7. 6  
 10 amp model £13. 5. 0

230 v. A.C. SOLENOID. Heavy duty type. Approx. 3lb. pull. 17/6 plus 2/6 P. & P. 12 v. D.C. SOLENOID. Approx. 1lb. pull. 10/6, P. & P. 1/6. 50 v. D.C. SOLENOID. Approx. 1lb. pull. 10/6, P. & P. 1/6. 50 v. D.C. SOLENOID. Approx. 2lb. pull. 12/6, P. & P. 1/6.

**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.**

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 40/- p. & c.

**SERVICE TRADING COMPANY**

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## RING TRANSFORMER

Functional Versatile Educational



This multi-purpose Auto Transformer, 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. @ 12Amp., 4V. @ 25Amp. or 2V. @ 50Amp., etc. Price: RT.100VA 3.18 turns per volt. £2 5 0 + 3/6 p. and p. RT.300VA 2.27 turns per volt. £4 4 0 + 5/6 p. and p. RT.1KVVA 1.82 turns per volt. £6 10 0 + 6/6 p. and p. RT.2KVVA 1.5 turns per volt. £10 10 0 + 9/6 p. and p. RT.3KVVA 1.5 turns per volt. £14 0 0 + 10/- p. & p.

## L.T. TRANSFORMERS

All primaries 220-240 volts.	Type No.	Sec. Taps	Price	Carr.
1	12 v. at 5A		£1 17 6	5/6
2	30, 32, 34, 36 v. at 5 amps.		£4 13 6	6/-
3	30, 40, 50 v. at 5 amps.		£6 17 6	6/6
4	10, 17, 18 v. at 10 amps.		£4 19 0	4/6
5	6, 12 v. at 20 amps.		£6 8 6	6/6
6	17, 18, 20 v. at 20 amps.		£7 5 6	6/6
7	6, 12, 20 v. at 20 amps.		£6 17 6	7/6
8	24 v. at 10 amps.		£5 4 6	5/6
9	4, 6, 24, 32 v. at 12 amps.		£7 3 0	6/6

**AUTO TRANSFORMERS.** Step up, step down. 110-200-220-240 v. Fully shrouded. New. 300 watt type £3/12/6 each, P. & P. 4/6. 500 watt type £5/2/6 each, P. & P. 6/6. 1,000 watt type £7/2/6 each, P. & P. 7/6.

## 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 25/- plus 2/6 P. & P. ORP. 12 and Circuit 12/6 post paid.



## 220/240 A.C. MAINS MODEL

incorporates mains transformer rectifier and special relay with 2 x 5 amp. mains c/o contacts. Price inc. circuit 47/6; plus 2/6 P. & P.

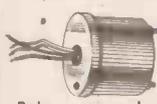
## LIGHT SOURCE AND PHOTO CELL MOUNTING

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 £2/15/0 plus 3/6 P. & P.



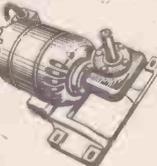
## SOLID STATE INTERVAL TIMER

24-30v. D.C. operation. Stabilised unijunction Timer and S.C.R. (30v. 1Amp.), encapsulated in metal core. Timing interval adjustable from a fraction of a second to several minutes by means of external resistor or pot. By adding a 24v. Relay many other complex timing Functions are possible. Price: 16/6 incl. circuit, p. & p. 2/6. Suitable relay 9/6. P. & P. 1/6.



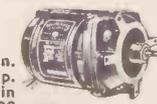
## PARVALUX TYPE SDI9 230/250 VOLT AC REVERSIBLE GEARED MOTORS

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 gns. P. & P. 10/-.



## 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 £3.3.0 plus 6/6 P. & P. or less transformer £2.2.6 plus 4/6 P. & P. These motors are ideal for rotating aerials, drawing curtains, display stands, vending machines etc.



## 230/240V 10 RPM MOTOR (Non Reversible)

Extremely powerful. Continuously rated. Offered at the low price of 35/- post paid.



## MOTORISED SWITCHING UNIT (Ex-W.D.)

Powerful, precision-made, ex-W.D., 12 v. D.C., reversible motor, drives multiple gear train with outputs approx. 4 r.p.m. and 5 r.p.m. Price 25/- P. & P. 4/6.



## POWER RHEOSTATS

(NEW) Ceramic construction, winding embedded in Vitreous Enamel, heavy duty brush assembly designed for continuous duty. AVAILABLE FROM STOCK IN THE FOLLOWING II 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 3 3/4 in. Shaft length 3 in. dia. 3/8 in., 27/6. P. & P. 1/6. 50 WATT 1/5/10/25/50/100/250/500/1K/1.5K/2.5K/5K ohm. All at 21/-, P. & P. 1/6. 25 WATT 10/25/50/100/250/500/1K/1.5K/2.5K ohm. All at 14/6, P. & P. 1/6. Black Silver Skirted knob calibrated in Nos. 1-9. 1 1/2 in. dia. brass bush. Ideal for above Rheostats, 3/6 each.

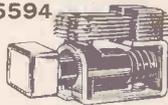
## MOTOROLA MACII/6 PLASTIC TRIAC 400 PIV 8 AMP

Now available EX STOCK supplied complete with full data and applications sheet. Price 21/- plus 1/6 P. & P.

## T.M.C. ILLUMINATED

### LATCHING PUSH BUTTON KEY SWITCH No. S525594 LOCK 4 c/o

Complete with mounting bracket, Push Knob and Lenses (GREEN, AMBER, RED or CLEAR - state colour preference). PRICE 14/6 each excluding bulb, Post Paid. Discount for quantities of 200 or over.



## 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 £5.5.0 plus 5/- 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 9 gns. 7/6 P. & P.

★ **HY-LIGHT 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 foles. Price £10.17.6. P. & P. 7/6.

★ **FINCH POLISHED REFLECTOR.** Ideally suited for above Strobe Kits. Price 10/6 and 2/6 P. & P. or post paid with kits.

## ELECTRONIC ORGAN KIT

Ideal present for Electronically minded boy. Easy to build, solid state. Two full octaves (less sharps and flats). Fitted hardwood case, using two penlite 1 1/2 v. batteries. Complete set of parts including speaker, etc., together with full instructions and 10 tunes. Have all the pleasure of building this instrument and finish with a functional, instructive gift for any boy or girl. Price £3.0.0. P. & P. 4/6.

## 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 £7.15.0. P. & P. 6/-.

## 10 in 1 PROJECT KIT

10 easy to build Projects including: Radio, Morse Oscillator, L F Oscillator etc. A Solar Cell is included in this Kit as alternative power for some of the circuits also a 14-page step by step instruction leaflet. Price £3.17.6. P. & P. 4/6.



## MINIATURE UNISELECTOR

3 banks of 11 positions, plus homing bank. 40 ohm coil. 24-36 v. D.C. operation. Carefully removed from equipment and tested. 22/6 plus 2/6 P. & P.

## UNISELECTOR SWITCHES NEW 4 BANK 25 WAY FULL WIPER

25 ohm coil, 24 v. D.C. operation. £5.17.6, plus 2/6 P. & P.

## 6 BANK 25 WAY FULL WIPER 25 ohm coil, 24 v. D.C. operation. £6.10.0, plus 2/6 P. & P.

## 8-BANK 25-WAY FULL WIPER 24 v. D.C. operation. £7.12.6, plus 4/- P. & P.



## RELAYS

NEW SIEMENS PLESSEY, etc. MINIATURE RELAYS AT A HIGHLY COMPETITIVE PRICE.



COIL	WORKING D.C. VOLT	CONTACTS	PRICE
52	6-9	6M	12/6
170	9-12	4 c/o H.D.	14/6
170	9-12	3 c/o + 1 H.D. c/o	12/6
230	6-12	2 c/o	12/6
280	6-12	2 c/o incl. base	14/6
700	16-24	4M 2B incl. base	12/6
1250	36-45	6M	12/6
2500	36-45	6M	12/6
5800	80-85	4 c/o	12/6
9000	40-70	2 c/o incl. base	10/-

H.D. = Heavy Duty POST PAID

## MINIATURE RELAYS

9-12 volt D.C. operation. 2 c/o 500 M.A. contacts. Size only 1 in. x 1/2 x 3/4 in. Price 11/6 Post paid. 30-36 v. D.C. operation. 2 c/o 500 M.A. contacts. 3,200 ohm coil. Size only 1 x 1/2 x 3/4 in. 8/6 post paid.

## SPECIAL OFFER

Relay 18/24 v. D.C. 2 c/o 3 Amp contacts. 400 ohm coil. NEW. 9/6 P. & P. 1/6 or 3 for 30/- post paid.

TYPE A.G.C. 1M 1B 12v. A.C. 3 amp contacts. NEW 9/6 + 1/6 p. & p. or 3 for 30/- post paid.



## RECHARGEABLE NICKEL CAD. BUTTON CELLS.

2 x 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 9/6 each plus 1/6 p. & p. or 2 units for £1 post paid.



## COMPLETE NI. CAD. BATTERY OUT-FIT (EX W.D.)

2 metal carrying cases each containing 10 x 1.2 volt 7AH (12v) batteries, also 10 x 1.2v 22 AH (12v) batteries (40 batteries in all). 1 Dual voltage, dual meter, thyristor controlled charging unit. Designed for charging the 7AH and 22AH batteries simultaneously. Input voltage can be adjusted between 100-250v AC. Built to ministry specification. Ideal power supply for field work. Offered at fraction of makers price. 2 sets of batteries, 1 charging unit. The set £45 c. & p. 30/-.



## NICKEL CADMIUM BATTERY

1.2 v. 35 AH. Size 8 1/2 high x 3 x 1 1/4. 30/- each, plus 4/- P. & P. Sintered Cadmium Type 1.2 v. 7AH. Size: height 3 1/2 in., width 2 1/2 in. X 1 1/2 in. Weight: approx. 13 ozs. Ex-R.A.F. Tested 12/6. P. & P. 2/6.

## NEW MODEL HIGH FREQUENCY TRANSISTORISED MORSE OSCILLATOR

Adjustable tone control. Fitted with moving coil speaker, also earpiece for personal monitoring. Complete with morse key. 45/- plus 3/6d. p. & p.

## SEMI-AUTOMATIC "BUG" SUPER SPEED MORSE KEY

7 adjustments, precision tooled, speed adjustable 10 w.p.m. to as high as desired. Weight 2 1/2 lb. £4/12/6 post paid.



## INSULATED TERMINALS

Available in black, red, white, yellow, blue and green. New 2/- each.



## Ex. W.D. MINIATURE BLOWER UNIT

18-24 v. D.C. operation, overall length 3 1/2 in. Blower 2 1/2 x 2 1/2 in., 20/- P. & P. 2/6.

ALL MAIL ORDERS. ALSO CALLERS AT:

57 BRIDGMAN ROAD, LONDON, W.4. Phone: 995 1560 Closed Saturdays.

# SERVICE TRADING CO.

SHOWROOMS NOW OPEN AMPLE PARKING

PERSONAL CALLERS ONLY

9 LITTLE NEWPORT STREET, LONDON, W.C.2. Tel.: GER 0576

# ELECTRONIC BROKERS LTD

## DIGITAL VOLTMETERS



**DM2004.** For DC measurement from 1mV to 1 kV. Scale 1999 in two manually selected states of 0-999 and 100-1999. Input impedance Range 1: 1M ohms; Ranges 2, 3 and 4: 10M ohms. Accuracy 0.1% of reading. Price £95

**DM2010.** Scale 109999. For DC measurement of 10 microvolt to 1.1K volt. Input Z greater than 25000M ohms. Accuracy 0.001% F.S.D. C.M.R. DC 160 dB. Parallel B.C.D. output (not isolated). Price £500

**LM902.2.** Scale 1599 in 7 ranges from 0.1V to 1,000V. Input Z 0-1,000V 100M ohms. Accuracy 0.5%. Print out facility two 50-way sockets for Printer or remote display. 6V DC 300 mA maximum combined output. Price £50

**LMI420.2.** For DC measurement from 0.1-1,000V in 6 Ranges. Input Z not less than 10M ohms. Accuracy 0.05% of Indication, Calibration, Internal Voltage Cell. C.M.R. greater than 150 dB. Can be used as a counter or as a simple stop watch or to determine the frequency or period of unknown events. O/P modified B.C.D. Price £300

**DM2020.** Scale 19999, 10 microvolt resolutions. Accuracy 0.01%. B.C.D. output. Price £325

**DM2001.** Scale 19995. DC. Accuracy 0.05%. Range 50 microvolt to 2kV. I/P impedance greater than 10,000M ohms. Parallel B.C.D. output or Decimal (not isolated). Price £250

### AC-DC CONVERTERS TYPE 2140/AI-BI and 2140/A3-B3

A flexible modular system for use with a DVM for accurate mean (RMS) or true (RMS) Voltage measurements. Module AI LF Amplifier X 0.1 to X 1,000. Module A3 LF Amplifier X 0.1 to X 100.

2140/AI-BI 1,000V True RMS Converter. Price £175  
2140/A3-B3 200V Mean (RMS CALIBRATED) Converter. Price £150

## HIGH GRADE COMPONENTS

### AVO TRANSISTOR ANALYSER CT 446

A portable direct-reading instrument capable of giving accurate transistor measurements in the grounded emitter configuration. Battery power unit 1.5V to 10.5V in 5 steps. Base current 0-1 mA. 1.40 mA. Collector current 250 mA. Size: 15 1/2 x 9 1/2 x 5 ins. Weight with batteries: 15 lbs. Price £42.10.0. Carriage extra.



### MINIRACK MULTICHANNEL OSCILLOGRAPH. MUR 12

The multichannel oscillograph is a 12 crt. oscilloscope with recording facilities. The instrument consists of two units. The trolley mounted recording unit comprising 12 crts. with their respective controls and a 120 mm. continuous feed camera. The electronic console contains the appropriate amplifiers, time marker, time base, and associated power supplies. Price and full details on application.



### OSCILLOSCOPE CAMERAS

Consor. Model 1431. Complete with motor, auto transformer and capacitor unit. Price. . . . £49.10.0 plus carriage  
Langham Thompson 200 Type B. Price. . . . £55. 0.0 plus carriage  
New Telford Polaroid. Type 'A'. As illustrated. Price. . . . £99.10.0 plus carriage  
Viewing head to suit Type 'A' camera. Price. . . . £25.10.0 plus carriage



### VOLSTATS

Type	I/P	Freq.	O/P	Load	Price
CV 25E	190/260	50	6	25 W.	£3.10.0
MT 161E	190/260	50	6	50 W.	£5.10.0
MT 161F	190/260	50	12	50 W.	£8.10.0
MTZ 161A	190/260	50	30	50 W.	£7.10.0
CV 500/27	95/130	50	85	4 Amp	£15. 0.0
CV 50J	190/260	50	290	50 W.	£4. 0.0
CV 150/98	110/220	50	230	150 W.	£5.10.0
MT 267A	190/260	50	290	250 W.	£10.10.0
MT 161ADA	190/260	40	230	50 W.	£4. 0.0
MT 140A	190/260	50	230	150 W.	£7. 0.0
MT 202XA	190/260	50	230	500 W.	£25. 0.0
MT 140	190/260	50	230	150 W.	£6.10.0
MT 202A	190/260	50	230	500 W.	£25. 0.0
30MB790	210/250	50	230	2.61 Amps	£25. 0.0
CVH 60A	190/260	50	240	60 W.	£10.10.0
CV 50D	95/130	50	240	50 W.	£3.10.0
CV 1000A	190/260	50	240	1000 W.	£35.10.0
CVN 500H	190/290	50	220	500 W.	£35. 0.0

### GALVANOMETERS (PENCIL TYPE) SPECIFICATIONS

Adaptors available to suit all types of recorders.

Type No.	Natural Frequency	Nominal Terminal Resistance	Galvanometer sensitivity for a 30cm optical path	Price
EB/20	20 cps	85	0.4 Micro A/cm	£33
EB/35	35	75	0.67 Micro A/cm	£33
EB/40	40	95	0.43 Micro A/cm	£33
EB/40c	40	45	2.1 Micro A/cm	£33
EB/60	60	80	0.7 Micro A/cm	£33
EB 100c	100	60	0.1 Micro A/cm	£33
EB/100	100	75	2.7 Micro A/cm	£33
EB/160	160	70	5 Micro A/cm	£33
EB/200	200	70	21 Micro A/cm	£33
EB/300	300	120	25 Micro A/cm	£33
EB/450	450	120	50 Micro A/cm	£33

High Frequency Types	Price
EB/1,000	£33
EB/1,400	£33
EB/1,600	£33
EB/2,200	£33
EB/2,500	£33
EB/3,300	£33
EB/4,000	£33
EB/5,000	£33
EB/8,000	£33
EB/10,000	£33
EB/20,000	£50

## BRAND NEW HIGH CAPACITY ELECTROLYTIC CAPACITORS at a fraction of original prices by MALLORY or SPRAGUE

Capacity In Microfarads	Working Voltage	Surge Voltage	Price
3,500	25	35	10/-
5,000	55	61	20/-
7,750	10	15	10/-
20,000	30	45	25/-
25,000	25	40	15/-
25,000	50	65	30/-
27,000	15	20	20/-
30,000	32	35	25/-
35,000	15	20	10/-
37,000	15	20	20/-
40,000	10	12	10/-
46,000	25	30	25/-
55,000	15	20	20/-
90,000	10	14	20/-

P. & P. 5/- on single item.

### (No. 5) IMPEDANCE BRIDGE TYPE TF33

Measures L & C at 80 Hz, 1K Hz or 10 KHz. Measures R at DC, AC Bridge volts monitored and variables. Automatic detector sensitivity control. Rugged pan-climatic construction. Measures L from 1 microH to 100H. C from 1 pF to 300 microF and resistance from 0.1 ohm to 100M ohm. Price. . . . £95 carriage extra.



## MOTORS

### HIGH PRECISION MAINS MOTOR - 3 Phase - 1 Phase

230V 50 Hz 1/8 h.p. continuously rated. 3000 r.p.m. Made by Croxford Engineering. Model KA 60 JFB. Suitable for capacitor motor. Size 8 in. long, 4 1/2 in. diameter with 6 in. diameter flange and 4 fixing holes. £4/10/0 each. P. & P. 25/-.



### LOW TORQUE HYSTERESIS MOTOR MA21

Ideal for instrument chart drives. Extremely quiet, useful in areas where ambient noise levels are low. High starting torque enable relative high inertia loads to be driven up to 6-oz/in. Available in the following speeds and ranges: 240V 50 Hz 4 r.p.m., 2 r.p.m., 1 1/2 r.p.m., 1 r.p.m., 1/3 r.p.m., 1/5 r.p.m., 1/10 r.p.m., 1/12 r.p.m., 1/20 r.p.m., 1/40 r.p.m., 1/60 r.p.m., 1/75 r.p.m., 1/120 r.p.m., 1/360 r.p.m., 1/720 r.p.m., 1/20, 1/45 r.p.m., 1/20V 50 Hz 1/6 r.p.m., 1/15 r.p.m., 1/16 r.p.m., 1/20 r.p.m., 1/24 r.p.m., 1/30 r.p.m., 1/60 r.p.m., 1/120 r.p.m., 1/240 r.p.m., 1/300 r.p.m., 1/720 r.p.m., 1/1440 r.p.m. 25/- each. P. & P. 3/-.

### HYSTERESIS REVERSIBLE MOTOR

Incorporating two coils. Each coil when energised will produce opposite rotation of output shaft. 240V 50 Hz 1/2 r.p.m., 1/3 r.p.m., 1/6 r.p.m., 1/8 r.p.m., 1/20V 60 Hz, 1/10 r.p.m., 30/- each. P. & P. 3/-.

### SYNCHRONOUS MOTORS

Model S 71 r.p.h. and 1/80 r.p.h. Self starting complete with gearing shaft 1/2 in. dia. in. long. 200/250V 50 Hz. New condition Equipment. 40/- P. & P. 3/-.

### DATA TRANSMISSION - SYNCHROS

A selection from our wide range

Type	Maker	Voltage	Hz	Price £ s. d.
Torque Receiver	11TR4a	Sperry	90/115v	400 7 10 0
Torque Receiver	ACN 1550C	Smith	26,12,3	400 7 10 0
Torque Receiver	11TR4a	Pullin	90/115v	400 7 10 0
Control Transformer	11CT4A	Muirhead	90v	400 9 10 0
Control Transformer	98CT4	Muirhead	26v	400 9 10 0
Control Transformer	11CT4A	Sperry	90v	400 9 10 0
Control Transformer	11CX 4a	Pullin	26v	400 6 10 0
Control Transformer	11CX 4	Ketay	115/90v	400 9 10 0
Torque Transmitter	AC8/AE	Smith	115/90v	400 6 10 0
Torque Transmitter	11M13	Muirhead	26v	400 9 10 0
Torque Transmitter	10M1B	Muirhead	115/90v	400 9 10 0

CARRIAGE EXTRA

### EVERSHED & VIGNOLES SPLIT FIELD SERVO MOTOR

Type PBA-A1/B 1/2 in. keyed shaft. Price £12/10/0 each.

## SYNCHRONOUS MOTOR WITH GEARBOX

Motor 11M83 gearbox type 11H21. This unit is an 8000 r.p.m., 116v., 400Hz motor fitted with concentric cyclo gear reduction gearbox of 9.92/1. Motor torque 6 oz.in. length c/w gearbox 2 5/8 in. x 1 in. diameter.



### RAGONOT MOTOR

220V 3-phase 50Hz 1/20 HP, 1500 RPM. Precision EX-COMPUTER TAPE DRIVES. Rotar moves 1 in. axially on "Switch on" to take up drive and on "Switch off" is spring returned to disengage drive. 45/- each. P. & P. 10/-.

## GENERATORS

### AVO SIGNAL GENERATOR CT 378

2-225 M Hz in 7 ranges on Fundamentals up to 450 M Hz on Harmonics. Scale calibration accuracy ± 1%. Output 1 micro volt to 25 mV continuously variable into 75 ohm. 1 micro volt to 12.5 mV into 50 ohm using fixed attenuator pad. Modulation facilities. A/F o/p facility. O/p level meter. Force o/p facility. Size 15 1/2 in. x 9 1/2 in. x 1 1/2 in. Weight 25 lbs. Price £45. Carriage extra.



## OSCILLATORS & SIGNAL GENERATORS

- (12) CRYSTAL CONTROLLED OSCILLATOR STC. 16-LXU-52A Mk. II. 0-20 MHz. Sweep facilities. O/p attenuation 0-70 dB. Complete with power supply unit 14-LXU-52B. Price £85
- (1104) NEW AUTOMATIC CYCLING OSCILLATOR. ACOS 1. P.YE. Range 5 Hz-3 KHz. Sweep mode 1 Ctr/min. O/p. 0-10V. Mains supply. Price £99.10.0
- (1108) LOW FREQUENCY DECADE OSCILLATOR D-635-A KUIBHEAD. Range 0.1 Hz-2.12 KHz. O/p 0-50V. Mains supply. Max. O/p 1W in 500Ω above 30 Hz. Price £45
- (1109) DECADE OSCILLATOR D-650-B. Range 1 Hz-111 KHz. Max. O/p 2W into 8KΩ above 20 Hz. O/p 0-150V. Price £45
- (1110) L.F. OSCILLATOR G 420 FURZEHILL. Range 1.4 Hz-15 KHz. Viewing CRT. Price £15
- (113) E.C. OSCILLATOR AND AUTOMATIC FREQUENCY MONITOR-SMITHS. Oscillator range 10 Hz-100 KHz. Price 20/-
- (1130) AUDIO FREQUENCY OSCILLATOR-PYE. Range 20 Hz. O/p. 0-20V. Mains operated. Price £15
- (149) GAUGE OSCILLATOR M 700L SOUTHERN INSTRUMENTS. Price £15
- (118) SIGNAL GENERATOR CT218. Range 85-90 MHz. O/p. Facilities include crystal calibrator, modulation. Price £85
- (115) AUDIO FREQUENCY GENERATOR. Type J2. ADVANCE. Range 15 Hz-50 KHz. O/p. 0-40V. Price £25
- (183) SIGNAL GENERATOR CT 480 SANDERS. Range 7 KHz-12 KHz. O/p. 0-±50V. Attenuation range -10 to +100 dB. Price £85
- (179) WOBULATOR GM 2877/02 PHILLIPS. Price £65
- (142) NOISE GENERATOR CT 410 WAYNE KERR. Frequency Range: 15 Hz-160 MHz. Timer 0-8 mins. Drive current 0. dB. at 5mA to +13 dB at 100mA. Price £50
- FM/AM SIGNAL GENERATOR. Type 8G. 63D. ADVANCE. Range 4 MHz-100 MHz. O/p. 1 microV-100mV. Sweep facility and line FM deviation ± 100 KHz. Price £55
- (1105) SIGNAL GENERATOR Mod. 68A TAYLOR. Range 100 KHz-240 MHz. O/p. 0-10V R.F. O/p. and attenuation 0 to -80 dB in 4 steps. Price £15

### D.C. TACHOGENERATOR

Type 9c/108 16v. at 1000 r.p.m. Drive shaft dia. 3/16 in. 3/8 in. long. Price £16/10/0.



### A.C. MOTOR GENERATOR

Type G1005 Motor Spec. 6000 r.p.m. Torque 25gm/cm. Control winding 20v., 400Hz. Ref. Winding 26v., 400Hz. Generator Spec. Ref. Winding 26v., 400Hz. O/PO 4v/1000r.p.m. Length 2 1/2 in., dia. 1 in. Price £7/10/0 p. & p. 5/-.



49-53 PANCRAS ROAD, LONDON, N.W.1. Tel: 01-837 7781/2. Cables: SELELECTRO

**MEASURING INSTRUMENTS AND RECORDERS**



(R3) SINGLE PEN. DC MILLIAMMETER. 0-1mA. Chart width 3 1/2 in. Speed 1 in. and 6 in./hr. Alarm contacts. Mains power supply. Price £52.10.0  
 (R4) SINGLE PEN. DC MILLIAMMETER. 0-1mA or 0-500 micro amp. Chart width 3 in. Speed 1 in. and 6 in./hr. Fitted alarm contacts. Terminal Resistance 400 ohms (0-1mA) 1.5K ohms (0-500 micro A). Mains power supply. Price £49.10.0  
 (R24) SINGLE PEN. DC MILLIAMMETER. 0-2mA. Chart width 4 1/2 in. Speed 1 in. and 6 in./hr. and 1 in. and 6 in./min. Clockwork drive 8-day movement. Terminal Resistance 2,900 ohms. Price £30

(R8) 2 PEN. DC MILLIAMMETER. 0-15mA. Chart width 8 in. Speed 6 in. and 12 in./hr. Mains supply. Price £75  
 (R9) UNIVERSAL MULTIPOINT. 1-24 point suitable quantities with slow rate of change. Chart width 12 in. Speed: 3 ranges, 6/1 ratio. Sensitivity 0-100°C based on 0-75mV FSD using Thermocouple pick up. Price £80  
 (R10) NEW MULTIPOINT RECORDER. 100-0-100mV. Chart width 6 1/2 in. Speed: 20 and 720 min./hr. Also available 0-100, 0-400°C using Thermocouple pick ups. Price £79.10.0

(R11) CAMBRIDGE TEMPERATURE RECORDER SINGLE PEN. Circular Scale. Uses either bulb and capillary tube. Range: 50-300°C. Chart dia. 1 1/2 in. (24-hr. markings). Mains supply. Price £45  
 (R12) MERSTED TEMPERATURE RECORDER. Two Pen 0-200°C. c/w bulbs and capillary tubing. Mains supply. 24 hr. Chart dia. 1 1/2 in. Price £65  
 (R13) FIDDEN Mk. II SERVOGRAPH. Single point fitted with turret head to enable conversion to 4 point. Uses capacitive sensing input. Chart dia. 1 1/2 in. Speed: 1 rev./hr. Sensitivity 50 micro Amp. Resistance 1,950 ohms. Mains supply. Price £95

(R14) KENT Mk. II SINGLE POINT. Chart width 9 1/2 in. Speed: 1 in., 2 in., 3 in./hr. Sensitivity approx. 10mV FSD. Various scales, k.e. 0-600°C, 0-1,000°C, -50 to -200°C, 0-100°C. Also available: multipoint. General purpose slow response suitable Temperature, Humidity, etc. Response 33 secs. for FSD. Supply: 115V 50 Hz. 230V Autotransformer available. Price £49.10.0  
 (R25) SINGLE PEN. DC MILLIAMMETER. 0-1mA. Chart width 4 1/2 in. Speed 3 in./hr. Mains supply. Price £28.10.0  
 (R27) SINGLE PEN. DC MILLIAMMETER. 15-0-5mA. Oil damped movement. Chart width 7 in. Speed: 1 in./hr. Clockwork drive 8-day. Terminal Resistance 100 ohms. Price £29

(R39) SINGLE POINT. DC MILLIAMMETER. 4-0-4mA. Chart width 2 in. Speed: 6 in./hr. Uses typewriter ribbon marker. Mains supply. Terminal Resistance 240 ohms. Price £25  
 (R52) PHILLIPS 0-10mA 6-CHANNEL DC. Chart width 5 in. Two-speed motor. Mains supply. Price £75  
 (R61/1) TWO PEN. DC MILLIAMMETER. 0-2mA. Chart width 8 in. Speed: 1 in./hr. Clockwork drive. Terminal Resistance 1,687 ohms. Price £25  
 (R5) SINGLE PEN. SERVOITER MODEL FWS. Chart width 1 1/2 in. slow speed. Response time 24 secs. for FSD. Suitable Temperature, Humidity, etc. Price £75

(R7) PORTABLE SINGLE AND FOUR PEN. Suitable recording quantities with high rate of change. Speeds: Single pen 60 in./min. and 240 in./min.; Four pen 1, 2, 4 and 16 cms./sec. Electric pens. Mains supply amplifiers to suit. Price... Single pen c/w Amp. £99; Four pen c/w Amp. £149  
 (R56) SINGLE PEN. DC MILLIAMMETER. 0-5mA. Chart width 8 in. Speed: 1 in./hr. Mains supply. Price £30  
 (R57) SINGLE PEN. DC MILLIAMMETER. 0-0.5mA. Chart width 8 in. Speed: 1 in. and 6 in./hr. Terminal Resistance 4,500 ohms. Price £35

(R8) SINGLE PEN. DC MILLIAMMETER. 0-2mA. Chart width 6 in. Speed: 1 in./hr. Mains supply. Price £30  
 (R60/1) AC RECORDING WATTMETER MURDAY SYSTEM. 0-7kW. Chart width 4 in. Clockwork drive. 8-day movement. Maximum current: 38 amps. Price £28  
 (R34) CAMBRIDGE SINGLE PEN STRIP CHART RECORDER COMPLETE WITH CONTROL UNIT. A general purpose potentiometric recorder for quantities such as temperature, moisture, etc. Specifications: Chart width 8 in. Chart speed 1/4, 1/2, 1, 2, 3, 6 in./min. Power supply 200/250V 50 Hz. Dimensions: Width 16 1/2 in., height 3 1/2 in., depth 10 1/2 in. Price £65

(R35) ARKON PRESSURE RECORDER-SINGLE PEN TYPE 1800. Manufactured by Walker Crosswell & Co. Ltd. Specifications: Range -0 to +6 in. w.g.; Chart width 7 in.; Chart speed 1/2 in./hr.; Chart drive, synchronous motor, 200/250V 50 Hz. Dimensions: Width 18 1/2 in., height 21 in., depth 17 1/2 in. Weight 50 lb. Price £75  
 (R36) FOXBORO FLOW INDICATOR TYPE ECC IND MAG FLOW DYNALOG MODEL M9600B. Specifications: Range 0-40 litres/min. Curve uniform. Power supply 240V 50 Hz. Weight 52 lb. Dimensions: Width 14 1/2 in., height 17 in., depth 13 in. Price £35

(R37) FOSTER STRIP CHART RECORDER TYPE 3490Y. Uses a six-colour half-inch ribbon and mechanical chopper principle to record data on to a 6 in. chart. Specifications: Chart width 6 in.; Chart speed 1 1/2 in./hr. Dimensions: Width 16 1/2 in., Height 22 in., depth 13 in. Weight 60 lb. Price £90

**METERS**

(1517) VIBRON ELECTROMETER. Mod. 33B. Electronic Inst. Range 0-10V. O/p. ± 1mA into 1.5 KΩ. Price £85  
 (1514) pH METER, CAMBRIDGE. Price £12.10.0  
 (1508) AC/DC VOLT METER. WINSTON ELECTRONIC. Voltage range -7.5 to 15V. Price £12.10.0  
 (1508) FLUX METER Type 15A/AP. T.L.G. ELECTRIC. Range 90-12 gauge. In wooden case. Price £10  
 (1504) VERNIER POTENTIOMETER. Type 4363. A. TINSLEY. Accuracy x 0.0001. Price £75  
 (1513) WATTMETER. S 67. SANGAMO WESTON. Range 0-15W; 150-300V; 0.25-0.5A. Price £29.10.0

(1117) WIDEBAND MILLIVOLTMETER. TP 1371 MARCONI. Range 3mV-300mV; -10 to +3 dB, complete with probe. Flat response 30 Hz-30 MHz. Reading in mV, dB. Price £20  
 (1121) PORTABLE POTENTIOMETER. Type LI92928 CAMBRIDGE. Fitted with standard cell and thermometer. Price £45  
 (1122) POTENTIOMETER AND GALVO. Type P.3-CROYDON PRECISION. Accuracy .0001V. Price £35  
 (1123) SLIDE WIRE POTENTIOMETER. CAMBRIDGE. Voltage range 0.01 : 0.1 : 1.0. Fitted with Galvo. Key. Absolute voltage 0-1.7V in 18 steps. Price £35  
 (1182) DECADE INDUCTOMETER. Type 230A. DAWE. Range 1 microH at 100 mHz. in 40 steps. Price £25  
 (1114) MILLIVOLTMETER. Type 284. AIRMEC. Range 0-300 mV. Complete with amplifiers and 75Ω probe. Price £20  
 (1111) VALVE VOLTMETER. Type 712. AIRMEC. Range AC 0-150V; DC 0-500V. Price £25

(1119) ABSORPTION WATTMETER A.F. No. 1 MR 4. Power Ranges. 200 microW-6W. Scaled in watts and dB. Impedance 2.5Ω-20KΩ. Price £15  
 (1112) STANDARD FREQUENCY CHANGER. Type 203. AIRMEC. Range Volts 0-2.0V. Filters 100 KHz; 500 KHz; 1 MHz. Freq. 1 MHz-50MHz. Price £25  
 (104) DYNAMOMETER. Type 3206. TINSLEY. Price £45  
 (105) AC/DC VOLT METER. Mod. 32. TURNER. Range Voltage 0-300V, 230V/Volt. 5 in. moving coil with mirror scales, in wooden carrying case. Price £15  
 (108) PHASE METER. Type K159. SOUTHERN INST. 0-100° with Invert and direct switching. Price £35  
 (102) PHASE METER. Type IT. 1-3. McMICHAEL RADIO. 0-90° with reverse O/p. switching. Price £20  
 (106) MICROAMMETER. CA 138. Range 0-60 microA. Price £10  
 (181) FREQUENCY METER 1176-A. GENERAL CAMBRIDGE RADIO. Range 200 Hz-60 KHz. Input 25-150V. Price £30  
 (180) AC/DC VOLT METER. S72.16. SANGAMO WESTON. Range Voltage 0-300V. Price £29.10.0

(169) FREQUENCY METER. ENGLISH ELECTRIC. Range 380-410 Hz. Input Voltage: 115 and 208V. Price £5  
 (172) TUNING FORK FREQ. METER. 4 volts. 275. 3877. SMITHS. Fitted with clock 1-12 hrs. Freq. 50 cycles. Price £25  
 (151) MILLIAMMETER. CAMBRIDGE. Range 0-200mA. Freq. error less than 0.5%. 6 1/2 mirror scale. Price £10  
 (1519) PRECISION PHASEMETER. Model 901-MAXSON. Facilities include: phase lag, phase lead; fine, medium and coarse reference; balance and multiplier; meters. Price £85  
 (16) DYNAMOMETER. M.I.P. Voltage range 0-±4V; 0-200 V. 5 1/2 mirror scale. FSD 220V at 400 Hz in wooden case with carrying handle. Price £35  
 (112) R & Q METER. Type 299 XTE. SMITH. Reference and quadrature reading, also readings in radians: 0-360° head/lag phase readings 1/p 0-15V. Price £115  
 (190) VALVE VOLTMETER. Type 6. MARCONI. Range 0-150V. Mains operated. Price £25.10.0

(150) AC/DC METER. Model 44. E.I.L.L. Range Voltages: 0-20V. AC/DC. Resistance 0-1,000Ω. Current 1mA-10A. Power 1mW-4W. -10 to +19 dB. Price £15  
 (143) VERNIER POTENTIOMETER-CAMBRIDGE. Accuracy 0.00001V. Standard Cell voltage selection. Price £55

**CLOSED CIRCUIT TELEVISION SYSTEM**  
 Consisting of a FARVIBRON Compact Camera fully transistorised printed circuitry, 625 lines. Dimensions: 11x24x7 in. Weight 7 lb. AMPEX Video Monitor Type VM-9A. All solid state. Dimensions: Height 11 1/2 in., width 9 1/2 in., depth 6 in. Weight 14 lb  
 SIEMENS Monitor Type IF 8008E, two tripods and all interconnecting cables, c/w handbook. This equipment is offered in excellent condition at a bargain price of £120  
 We can also offer a TV pattern generator by Video Circuits Model PG162 for checking out the above system, c/w handbook. Very good condition. Price £45

**SPECTRUM ANALYSERS**  
 Marconi. OA. 109A. Spectrum Analysers. 3 to 30 M Hz. optional low frequency extension unit, 100 Hz-3 M Hz. Display continuously variable up to 30 K Hz. Spectrum scan time variable from 0.1 to 30 secs. Long persistence CR tube. Complete with trolley and power supplies. Price £750.

**FENLOW LOW FREQUENCY ANALYSER**  
 0.3 Hz to 1 K Hz. Power density 0-10. Bandwidth switching range .06: 0.3: 1.5: 7.5: 37.5 Hz. Price £275.

**MICOVAC ELECTRONIC TEST METER**  
 By E.I. Ltd. Model 22B this is a precision portable instrument with a wide range of facilities. D.C. volts. 0-2.4, 4.8, 24, 48, 240, 480, volts PSD with facility for centre zero measurement. A.C. volts, similar range to D.C. with frequency coverage from 20 Hz-20 M Hz. Probe increases range from 10K Hz-200 M Hz. Resistance Ranges 0-1 K, 10 K, 100 K, 1 M ohm and 10 M ohms. Fitted with mains P.S.U. adaptor. Metal case. Price £40. Carriage extra.

Amplifier X 0.1 to X 1000. Module A3 LF Amplifier X 0.1 to X 100. 2140/A1-B1 1000 V Mean RMS Converter. Price £175.  
 2140/A3-B3 200 V True (RMS CALIBRATED) Converter. Price £150.

**PLATINUM RESISTANCE THERMOMETER PROBES**  
 SOLARTHER Type NT 1198/c and NT 1687. Accuracy ±1°C. Probes in stainless steel case. 1 in. diameter. Temp. range NT 1198/C-50°C to +250°C. Price £12.10 each. P. & P. 3/6.

**MINIATURE PRECISION POTENTIOMETERS**  
 New 10-turn precision potentiometers consisting of potential in one extremely compact assembly. A very active unit finished in black plastic with white dial. Available in 100K, 20K, 5K, 1K, 1/2W. Resistance tolerance 5%. Accuracy correlation of dial reading to O/P 0.5%. Weight 0.6 oz., overall length 1 1/16 in., diameter 1/2 in. New price £7.15.0 each. Our price £4.10/0. P. & P. 2/6.

**NUMERICATORS**  
 Cold cathode gas-filled, in-line 0-9 digital display tubes. Long life expectancy. Minimum striking voltage 180v. Slide reading type XN 13 and XN3 amber filter. Price 18/8 each. P. & P. 2/6.

**MERCURY WETTED RELAYS**  
 Type HG4B1007 relay is capable of an operating time as short as 5 milliseconds. A BILLION OPERATIONS! Small chassis space required. Convenient mounting. Environment-free. Tamper-proof. High sensitivity.

Type	Coil Resistance	Control Rating	Contact
HG2B 1004	5000 ohm	5 amp.	2 PDT
HG2B 1006	1300 ohm	5 amp.	2 PDT
HG2B 1010	1300 ohm	5 amp.	2 PDT
HG4B 1065	1300 ohm	5 amp.	4 PDT
HG4B 1007	1300 ohm	5 amp.	4 PDT

Ex-equip. £110/0. P. & P. 6/.

**INKWELL OPERATION**  
 20 and 40 channel Multiplex (Projecting Pattern) Recorder. Driven from a 24V supply. Chart width 9 in. Electro-magnet pens. Voltage range 6-125V. Price £65.

**VIBRATION EQUIPMENT**  
 Goodmans Vibration Control Amplifier E50L. Price £65  
 Goodmans Vibration Phase Shifter. E 566. Price £89  
 Goodmans Power Oscillator 5V.A. Price £59.10  
 Savage Acceleration Control Unit. SGC1. 12Hz-10K Hz. Input impedance 1MΩ. Output impedance 600Ω. Price £45  
 Pye Ling. Power Amplifier. 50V.A. Price £80

**PHOTOMULTIPLIER VMPII/44 (CV 2317)**  
 by 20th Century Electronics  
 Cathode sensitivity 40μA/L. Operating volts for 10 A/L 1100 volts. DARK current 0.004A. £9/10/0.  
 E.M.I. 6097 and 20th Century CV 2317 £9/10/0. P. & P. 5/.

**ANIMAL SONARAY**  
 Type 1803B by Dawes  
 An instrument for measuring the thickness of fat on an animal by the use of ultrasonics using the pulse echo principle. The animal sonaray was specifically designed for the measure of back fat thickness for use under field conditions. Fully portable weighing only 26 lb. With handbook, price: £149/10/0.

**CRYSTAL OVENS**  
 Redfern. Fitted Bi-Metal Strip 75°C 5°C. Octal Base Type A 4260 EDN°C 6V AC and 12V AC or DC. Price £4/10/0 P. & P. 2/6.  
 Type A 4260 EDN"A" 12V/24V AC/DC. Price £4/10/0. Marconi Type F 3006-01 £12/10/0. P. & P. 2/6.

**VARIABLE VOLTAGE TRANSFORMERS**  
 Various types available, including single- and three-phase manual or motor drive. Contact us by phone or letter for stock appraisal and delivery.

**SYNCHRONOUS CHOPPERS**  
 Base B-8. Coll 6.3 v., 50-60 Hz. Proportion of time contacts are closed 45%. Also available 100 Hz and 400 Hz. Price £6/10/0. P. & P. 5/.

**NEW COMPLETE TELEPHONE DIAL ASSEMBLIES**  
 Clear Perspex dials-no markings. 20/- each. P. & P. 5/.

**LINEAR THYRISTOR CONTROLLED LIGHT DIMMER**  
 600w. module. Ideally suitable for photofood or speed controller, etc. Will mount into standard socket boxes. Our price 59/6. P. & P. 3/.

**AUTOMATIC CRYSTAL THICKNESS SORTING MACHINE**  
 Fully automatic dice gauging and sorting system, eliminates all manual operations. This instrument is of extreme interest to manufacturers of semiconductor. It is offered in good condition at a quarter of its original list price. It is suitable for the sorting of germanium and silicon dice. The unit can sort up to 2,400 pieces an hour. Our price £450. Further information available on request. Complete with manual and spares.

All orders accepted subject to our trading conditions a copy of which may be inspected at our premises during trading hours or will be sent on application through the post.

TELEPHONES. Two-tone grey. Brand new boxed. Current type. £5.50 each. P. & P. 5/-.

MULLARD MX I15 GM TUBE with holder. Plat app 300 volts. 30/- ea. P. & P. 3/6.

PHOTOMULTIPLIERS. EMI 6097X at £8/10/- ea. TRANSISTOR OSCILLATOR. Variable frequency 40 c/s to 5 kc/s. 5 volt square wave o/p, for 6 to 12V DC input. Size 1 1/2 x 1 1/4 x 1 1/4 in. Not encapsulated. Brand new. Boxed. 11/6 ea.

RACAL Diversity unit. £10 each. Carriage £1.

PYE RADIO TELEPHONES. 50W Base. Ranger 20A final and 3/10. Prices less valves from £5. Complete, tested and working. from £8. Callers please!

CRAMER TIMER 28V DC Sweep 1/100th sec & sweep 60 c/s. 4" dial. Remote control stop/start reset £6.10.0.

RELAYS Omron/Schrack octal based plug-in relays. 2 pole c/o 5A, 6V only. Brand new. Boxed. 7/6 each. G.E.C. 4 pole c/o 6/12V operation 180 ohms. Platinum contacts. Brand new. Boxed. 10/- each.

Miniature STC Plug in relays Plastic dust cover, 4 pole c/o 7.5-18 v. operation. 185 Ohms 8/- each. 6/- each per 100.

S.T.C. sealed 2 pole c/o, 2,500 ohms. (okay 24v) 2/6 ea.; 12v—7/- ea.

CARPENTERS polarised Single pole c/o 20 and 65 ohm coil as new, complete with base 7/6 ea. Single pole c/o 680, 1,110 and 1,570 ohm coil. As new 6/6 ea. Single pole c/o 14 ohm coil 6/6 ea.; Single pole c/o 45 ohm coil 6/6 ea.

Brand New. Single Pole c/o (type 5A2), 2 x 1200 ohms. 8/6 ea. E.M.I. PhotoChopper type ACPL1. Size 1 1/2 x 1 1/4". £1 each. P. & P. 2/6.

POTENTIOMETERS COLVERN Brand new. 5; 10; 50; 100; 250; 500 ohms; 1; 2.5; 5; 10; 25; 50k all at 2/6 ea. Special Brand new MORGANITE 250K 1 in. sealed. Normal price 9/-, our price 3/6 ea.

INSTRUMENT 3" Colvern. 5; 25; 100 ohms. 7/- ea. TRIM POTS. Paignton-solder lugs 5, 10 & 25K at 3/- each; Plus 10; 20; 50; 100; 200; 250; 500 ohms; 2.5 and 25K at 7/- each.

ALMA precision resistors 100K; 40K; 497K; 998K; 1 meg—0.1% 5/6 each; 3.25K—0.1% 4/- each; 1 meg—0.05% 7/- each.

DALE heat sink resistors, non-inductive 50 watt. Brand new. 15 ohms—6/6 ea.; 8.2K 4/6 ea. Excellent dummy load.

Wheatstone Bridge by TINSLEY type 1138 £60.

CAPACITORS ERIE feed through ceramic 2200 pf—9d. ea. Sub-min. TRIMMER 1 square. 8, 5pf. Brand new 2/6 ea. Concentric TRIMMER 3/30 pf. Brand new 1/6 ea.

ELECTROLYTICS. Brand new. 250 mfd 70V 4/6 ea.; 2000 mfd 16V 7/- ea.

EHT 2 mfd 5 KV. Brand new £2 each.

VISCONOL EHT. Brand new 0.0005 25 kV, 16/- ea. E.H.T. 0.02mfd 8KV- 6/- ea.; 0.5mfd 5KV—11/- ea.; 0.5mfd 2.5KV 7/- ea.

DECADE DIAL UP SWITCH. Finger-tip. Engraved 0/9. Gold plated contacts. Size 2 1/2" high, 2 1/2" deep 1" wide. 30/- ea. Bank of 4 with escutchin plates etc. 2 1/2" high 2 1/2" deep, 2 1/2" wide. £5.

PHOTOCELL equivalent OCP 71 2/6 ea.

Photo-resist type Clare 703. (T05 Case) 10/- each.

BURGESS Micro Switches V3 5930. Brand new 2/6 ea.

PANEL mounting lamp holders. Red. Brand new 2/3 ea.

TRANSISTORS BC 114—NPN Low noise high gain audio, etc.; BC 116—PNP General purpose 200 mc/s. Ex brand new equipment. Guaranteed perfect. Good lead length. 2/- ea.

BRAND NEW BC114 TRANSISTORS. 5/- each; 4/3 each per 100; 3/6 each per 1,000.

MINIATURE SPEAKERS 15 ohm 2" diameter. Brand new. 7/- each. P. & P. 2/6 each.

NUCLEONIC INSTRUMENTS SCALER type 1000 by Dynatron. Suitable Beta/gamma counts. Built in test signal. Calibrated adjustable discriminator. Read out 2 decade neon and 4 digit counter. Supplied in as new condition at £5 ea. Carr. 30/-.

As above but with resettable counter £8 ea. Carr. 30/-.

Few only RATEMETER type 1161B Complete with built in EHT supply. Separate metering EHT and Count. EHT available for external equipment 0 to 3 kv. As new £35. Carr. 30/-.

Portable Geiger Counter in haversack, complete £5 ea. P. & P. 10/-.

100 CHANNEL PULSE HEIGHT analyser type 1368B. As new £75. As above but type 1363C. £120.

ECKO PULSE HEIGHT ANALYSER type N101 £25. Carr. 30/-.

CINTEL Transistorised Nucleonic Scaler with adjustable discriminator. 6 meter display 0-9 giving count of 10 to the 5. New Condition. Now ONLY £18. Carr. 15/-.

PULSE Generator type 1147A. £6. Carr. 30/-.

SPECIAL. SGS Fairchild Silicon Epitaxial Transistor. NPN. 30 V; 300 MW. Complementary to BC116. Guaranteed Brand New. Full Length leads. NOT rejects. Perfect. Spec. Sheet supplied. 1/- each, minimum order £1. P. & P. 2/-.

AMPEX TV CAMERA CC3324. As new £250. New 2 1/2" dual standard Marconi TV modified for above. If required £50.

### TEST GEAR

OSCILLOSCOPES E.M.I. WM 2 DC—13 mc/s £30 E.M.I. WM 8—£80 SOLARTRON 711S.2 D.B. DC—9 mc/s. In fine condition £50.

SOLARTRON 643 DC—15 mc/s NOW only £65. SOLARTRON DC—10 mc/s. CD513—£35, 513.2—£40, CD523—£45 COSSOR 1035 DB. £20 COSSOR 1049; 1049 Mk. 3. DB. £22/10 and £30

HARTLEY 13A DB. £18/10/- All carefully checked and tested. Carriage 30/- extra.

MARCONI TF 958 (CT44) Audio Freq. Wattmeter £15. Carr. 10/-. TF 886 Magnification Meter £45 Carr. £1 TF 869 N. 5 Impedance Bridge £35 Carr. 30/- TF 144G Signal Generator. Serviceable. Clean £15 In exceptional condition £25. Carr. 30/- TF 885 Video Oscillator Sine/Square £35 Carr. 30/- TF 195M Sine wave oscillator 0/40kc/s £12 Carr. £1 TF 1343/2 'X' Band Gen. £35 Carr. 30/- TF 428B/1 Valve voltmeter £4 Carr. 10/- TF 428B/2 Valve voltmeter £8 Carr. 10/- Type 801 Sig. Gen. £35. Carr. 30/- TF 934/2 FM Deviation Meter £25. Carr. 30/- TF 791B Carrier Deviation Meter £35. Carr. 30/-

SOLARTRON Pulse generator POS 100C 50 c/s—1 mc/e £18 Carr. £1 Laboratory amplifier AWS51A. 15c/s—350kc/s £35 Carr. £1

Stabilised P.U. SRS 151A £20 Carr. 30/- Stabilised P.U. SRS 152 £1 Carr. 30/- Stabilised P.U. AS 616 & AS 517 £3, £6 Carr. 10/- Calibration Unit type AT203. £25. Carr. 30/- Process Response Analyser. Fine Condition. £250 Oscillator type OS 101. £30. Carr. 30/- D.C. Amplifier type AA900. £30. Carr. £1.

AVO AVO TRANSISTOR ANALYSER—£75 only. Testmeter No. 1 £14 Carr. 15/- Electronic Testmeter CT 35. Complete £18 Carr. £1

TWO only TELEQUIPMENT DB Oscilloscopes type D38R. £70 each. Carr. £1.

CINTEL Wide Range Capacitor Bridge £25 Carr. 15/- Sine and Pulse Generator type 1873 £25 Carr. 15/-

AIRMEC Valve Millivoltmeter type 264. 3MV-1V £20 Carr. £1 Counter type 865. 6 decades. Bright Vertical display gate facilities. Very good condition £25. Carr. 30/- Klystron Power Supply 695B £25 Carr. £1 Signal Generator type 701. £35. Carr. 30/-

OSCILLOSCOPE CAMERA. Shackman 25ft. Exp 270 frames. Times from 1/250 to 1 sec. auto. Dalmere Fl. 9 Focal 1 1/4 in. with standard 4in. to sin. fitting. £30.

BRADLEY ATTENUATORS 0/500 meg cycles. 0/12 db and 0/120 db—£25 per pair.

BECKMAN MODEL A. Ten turn pot complete with dial. 100k 3% Tol 0.1% only 52/6 ea.

E.H.T. Base B9A in Polystyrene holder with cover. Brand new. 2/6 ea.

ZENITH E.H.T. Tester, with Probes. Metered 0-3.5 kv. £25 Carr. 30/-.

DVM & RATIOMETER BIE 2116 by Blackburn £60 each.

DENCO S band low noise travelling Wave amplifier £25. Carr. 30/-.

FREQUENCY Meter LM 14. Modulated version of BC 221 with charts and covers. Brand new £30. Carr. 30/-.

SPECIAL. FURZEHILL V200A Valve millivolt meter. 10 mv. to 1 kv. £20. Carr. £1.

FURZEHILL Valve Voltmeter type 378B/2. Range 0-80 db to 10 millivolts to 100 Volts in 5 ranges. Size 11 x 8 1/2 x 7". £10. Carr. 15/-.

Low Ohm SAFETY METER 12 ma 5 ohms. £7.10.0 each. P. & P. 10/-.

MIC-O-VAC type 22 (CT54) Volts; Ohms. DC to 200 mc/s with probe, leads, circuits etc. As new £8.10.0. P. & P. 10/-.

HEWLETT PACKARD 5" oscilloscope tube with built-in graticule 10 x 10 cm. Length 16 1/2". Brand new, boxed. £12 each. Carr. 30/-.

3 CM Wave Guide, some flex; Sanders Attenuators; Decca Waveguide Switches; Delay lines, etc. Phone or call.

DISTRIBUTED AMPLIFIER type 2C/3 50 c/s 100 mc/s Gain 300. £30 each.

Type 2C 50 c/s to 100 mc/s £16 each.

DAVE Wide Range oscillator type 400A. 20 cs to 20 kc/s Sine wave. 500, 600 and 2000 ohm. Fine condition. £20. Carr. 30/-.

PAIGNTON ATTENUATORS 0.1 db. to 100 db. in 3 decades, 600 ohm. 19" rack mounting. £20 ea. Carr. 15/- PISTON ATTENUATOR in carrying case. 30-140 mc/s calibrated 0/70 db. £10 ea. Carr. £1

Precision THERMISTOR by YSI. 100 k. at 25°C. Range: 40°C. to 150°C. Supplied with charts giving ohms for each degree over entire range. Brand new. 30/- each.

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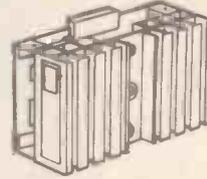
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FREE COMPLETE LIST ON REQUEST no. 16/17.

## HI-FI equipment to suit EVERY POCKET

### ★ PA AND DISCOTHEQUE EQUIPMENT

Complete range now in stock ready to use and modular equipment

\*Complete systems and individual units at special low prices—choose from 100 selected stereo systems.

Call in for a demonstration when in London.

\*Free 12-page stock/systems List No. 16/17.

### LOW CASH AND CREDIT/HP PRICES

(Credit terms for purchases from £30—callers only.)



## ELECTRONIC ORGANS

★MODERN ALL BRITISH TRANSISTORISED DESIGNS AVAILABLE AS KITS OR READY BUILT

★VENEERED CABINETS FOR ALL MODELS

★49 NOTE, 61 NOTE SINGLE MANUAL DESIGNS ALSO TWO MANUAL 49 NOTE

★KITS AVAILABLE IN SECTIONS AS REQUIRED

★HP and CREDIT SALE FACILITIES

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★LET US quote for all your organ component requirements.

**VISIT THE NEW DEMONSTRATION ROOMS (see below)**

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309 EDGWARE ROAD LONDON W.2  
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# ELECTROVALUE

EVERYTHING BRAND NEW AND TO SPECIFICATION • LARGE STOCKS

## BARGAINS IN NEW SEMI-CONDUCTORS

ALL POWER TYPES SUPPLIED WITH FREE INSULATING SETS

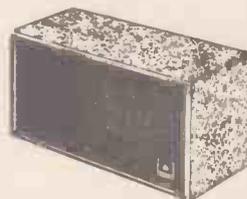
1N914	1/3	2N3706	3/3	40512	45/6	BC147	3/6	BFY51	4/3
1N3754	4/-	2N3707	4/-	40602	9/6	BC148	3/3	BSX20	3/9
1N4148	1/9	2N3708	3/-	AC107	14/6	BC149	3/6	BY164	10/-
1N5054	4/-	2N3709	3/-	AC126	6/6	BC153	10/-	BY238	3/6
1S940	1/-	2N3710	3/6	AC127	6/-	BC154	11/-	CI06B1	14/6
2N696	5/6	2N3711	3/11	AC128	6/-	BC157	3/9	MC140	5/-
2N697	5/6	2N3731	24/-	AC176	11/-	BC158	3/6	MJ480	21/-
2N706	2/9	2N3794	3/3	ACY22	3/9	BC159	3/9	MJ481	27/-
2N1302	4/-	2N3819	8/6	ACY40	4/-	BC167	2/6	MJ491	30/-
2N1303	4/-	2N3820	25/6	AD140	19/-	BC168	2/3	MPP102	7/6
2N1304	4/6	2N3904	7/6	AD142	14/3	BC169	2/6	NKT403	15/6
2N1305	4/6	2N3906	7/6	AD149	17/6	BC177	6/3	NKT405	15/-
2N1306	6/9	2N4058	5/3	AD161/AD162	16/-	BC178	5/8	OA47	1/9
2N1307	6/9	2N4059	4/-	(matched)	16/-	BC179	6/-	OA90	1/3
2N1308	8/9	2N4060	4/3	AFI14	7/-	BC182L	4/3	OA91	1/3
2N1309	8/9	2N4061	4/3	AFI15	7/-	BC183L	2/3	OA95	1/3
2N1613	6/-	2N4062	4/3	AFI16	6/6	BC184L	2/6	OA99	3/-
2N1711	7/-	2N4284	3/3	AFI17	6/6	BC186	8/6	OA200	1/11
2N2147	18/9	2N4286	3/3	AFI24	7/6	BC121L	5/-	OA202	2/-
2N2218	9/3	2N4289	3/3	AFI27	7/-	BC213L	5/-	OC71	5/6
2N2270	12/9	2N4291	3/3	AFI39	9/6	BC214L	5/3	TIP31A	17/6
2N2484	13/6	2N4292	3/3	AFI80	18/6	BCY70	5/6	TIP32A	23/9
2N2646	10/9	2N4410	4/9	AFZ39	9/9	BD121	18/-	TIS43	10/6
2N2904	11/-	2N5062	12/3	ASY26	6/6	BD123	24/3	ZTX300	3/6
2N2924	4/-	2N5163	5/-	ASY27	8/3	BD124	16/-	ZTX301	3/6
2N2925	4/6	2N5192	25/-	ASY28	6/6	BF167	8/6	ZTX302	4/6
2N2926	2/3	2N5195	28/3	BS041	15/-	BF178	10/6	ZTX303	4/6
2N3053	5/6	2N5457	9/9	BA102	9/-	BF180	12/-	ZTX304	6/9
2N3054	14/3	2N5458	9/9	BA115	4/-	BF194	7/-	ZTX500	5/-
2N3055	16/-	2N5459	9/9	BA130	4/6	BF195	7/6	ZTX501	5/-
2N3325	10/9	40250	14/3	BA145	5/6	BFX29	10/9	ZTX502	6/-
2N3663	11/6	40361	12/6	BC107	2/9	BFX84	7/5	ZTX503	5/6
2N3702	3/6	40362	16/6	BCI08	2/6	BFX85	8/3	ZTX504	12/-
2N3703	3/3	40406	16/3	BCI09	2/9	BFX87	8/6	ZTX530	5/5
2N3704	3/9	40408	14/6	BCI25	12/-	BFX88	6/9	ZTX531	6/9
2N3705	3/5	40430	37/-	BCI26	12/-	BFY50	4/6		

## PEAK SOUND PRODUCTS ENGLEFIELD CABINET KITS



Build it  
12+12  
or  
25+25

Stereo amplifier in modular kit form 12 watts per channel £38/9/-; 25 watts £58/15/-.  
Cabinet kit only £6. These prices nett.  
As recently reviewed in Hi Fi Sound.



## BAXANDALL SPEAKER SYSTEM

Designed by Peter Baxandall. Superb reproduction for its size. Handles 10 watts with ease. Uses ELAC 15Ω 59RM109 speaker unit. Kit £13/12/- nett; built £19/8/6 nett.

## STEREO AMPLIFIER SA.10-10.



Developed from the very successful SA.8-8 amplifier giving first-class stereo amplification featuring separate volume controls for each channel, bass and treble controls. 10 watts per channel into 5 to 8 Ω. Kit £19/7/6 nett; built £24/16/8 nett. Suitable 8Ω wide range speakers available £13/15/- each nett.

## MAINLINE AMPLIFIER KITS

RCA/SGS designed main amplifier kits. Input sensitivity 500-700mV for full output into 8Ω.

Power	Kit price including components	Suitable unreg. power supply kit
12W	168/- nett	92/-
25W	190/- nett	N/A
40W	210/- nett	115/1
70W	252/- nett	138/10

## 30 WATT BAILEY AMPLIFIER PACK

Special summer reduction (to Sept. 30th 1970 only)  
Sensitivity 1.2V for full output into 8Ω.  
Transistors for one channel £7/5/6 hist, £6 only nett.  
Transistors for two channels £14/11/- hist, £11 only nett.  
Capacitors and resistors (metal oxide), 30/- per channel nett.  
Complete unregulated power supply pack, 87/6 nett.

## INTERGRATED CIRCUITS

PLESSEY SL403A 3 watts into 7.5 ohms. Data book supplied FREE when two of these units are purchased. Price per unit, nett 48/6.

SINCLAIR IC.10 as advertised, complete with instructions and applications manual 59/6 nett.  
Components pack for stereo inc. mains transformer, controls, etc., nett £4/15/0.

## S-DeCs PUT AN END TO BIRDS NESTING

Components just plug in—saves time—allows re-use of components. S-Dec (70 points), 30/-.  
Complete T-Dec, may be temperature-cycled (208 points), 50/-  
Also μ-Decs and 1C carriers.

## ELECTROVALUE CATALOGUE

48 pages and cover well printed and excellently illustrated. Thousands of items fully detailed. POST FREE 2/-. Overseas, post free by surface mail, add 4/- if sent airmail.

## COMPONENT DISCOUNTS

10% on orders for components for £5 or more.  
15% on orders for components for £15 or more.  
(No discount on nett items)

## POSTAGE AND PACKING

Free on orders over £2. Please add 1/6 if order is under.  
Overseas orders welcome: carriage and insurance charged at cost.

## RESISTORS

Code	Power	Tolerance	Range	Values available	1 to 9 (see note below).	10 to 99	100 up
C	1/20W	5%	82Ω-220KΩ	E12	18	16	15
C	1/8W	5%	4.7Ω-330KΩ	E24	2.5	2	1.75
C	1/4W	10%	4.7Ω-10MΩ	E12	2.5	2	1.75
C	1/2W	5%	4.7Ω-10MΩ	E24	3	2.5	2.25
C	1W	10%	4.7Ω-10MΩ	E12	6	5	4.5
MO	1/2W	2%	10Ω-1MΩ	E24	9	8	7
WW	1W	10% ± 1/20Ω	0.22Ω-3.9Ω	E12		15d. all quantities	
WW	3W	5%	12Ω-10KΩ	E12		15d. all quantities	
WW	7W	5%	12Ω-10KΩ	E12		18d. all quantities	

Codes: C = carbon film, high stability, low noise.  
MO = metal oxide, Electrofilm TRS, ultra low noise.  
WW = wire wound, Plessey.

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.

ZENER DIODES 5% full range E24 values: 400mV; 2.7V to 30V, 4/6 each; 1W: 6.8V to 82V, 9/- each; 1.5W: 4.7V to 75V, 12/- each.  
Clip to increase 1.5W rating to 3 watts (type 266F), 9d.

CARBON TRACK POTENTIOMETERS, long spindles. Double wiper ensures minimum noise level.

Single gang linear 220Ω to 2.2MΩ, 2/6; Single gang log, 4.7KΩ to 2.2MΩ, 2/6; Dual gang linear, 4.7kΩ to 2.2MΩ, 8/6; Dual gang log, 4.7KΩ to 2.2MΩ, 8/6; Log/antilog, 10K, 47K, 1MΩ only 8/6; Dual antilog, 10K only, 8/6. Any type with 1/2A D.P. mains switch, extra 2/3.  
Please note: only decades of 10, 22 and 47 are available within ranges quoted.

## CARBON SKELETON PRE-SETS

Small high quality, type PR, linear only: 100Ω, 220Ω, 470Ω, 1K, 2K2, 4K7, 10K, 22K, 47K, 100K, 220K, 470K, 1M, 2M2, 5M, 10MΩ. Vertical or horizontal mounting, 1/- each.

COLVERN 3 watt Wire-wound Potentiometers. 10Ω, 15Ω, 25Ω, 50Ω, 100Ω, 250Ω, 500Ω, 1K, 1.5K, 2.5K, 5K, 10K, 15K, 25K, 50K, 5/6 each.

ENAMELLED COPPER WIRE even No. SWG only: 2 oz. reels: 16-22 SWG 4/3; 24-30 SWG 5/-; 32, 34 SWG, 5/6; 36, 38 SWG, 6/3.  
4 oz. reels: 16-22 SWG only 7/6.

## TYGAN SPEAKER MATERIAL

7 designs, 36 x 27 in. sheets, 31/6 sheet.  
Pattern book, S.A.E. plus 6d. stamp.

## MULLARD polyester C280 series

250V: 20%; 0.01, 0.022, 0.033, 0.047 8d, each; 0.068, 0.1, 9d, each; 0.15, 11d., 0.22, 1/-; 10%; 0.33, 1/5; 0.47, 1/8; 0.68, 2/3; 1μF, 2/9; 1.5μF, 4/2; 2.2μF, 4/9

## MULLARD SUB-MIN ELECTROLYTICS

C426 range, axial lead... 1/3 each  
Valves (μF/V): 0.64/64; 1/40; 1.6/25; 2.5/16; 2.5/64; 4/10; 4/40; 5/64; 6.4/6.4; 6.4/25; 8/4; 8/40; 10/2.5; 10/16; 10/64; 12.5/25; 16/40; 20/16; 20/64; 25/6.4; 25/25; 32/4; 32/10; 32/40; 32/64; 40/16; 40/2.5; 50/6.4; 50/25; 50/40; 64/4; 64/10; 80/2.5; 80/16; 80/25; 100/6.4; 125/4; 125/10; 125/16; 160/2.5; 200/6.4; 200/10; 250/4; 320/2.5; 320/6.4; 400/4; 500/2.5.

## LARGE CAPACITORS

High ripple current types: 1000/25, 5/6; 1000/50, 8/2; 1000/100, 16/3; 2000/25, 7/4; 2000/50, 11/4; 2000/100, 28/9; 2500/64, 15/5; 2500/70, 19/6; 5000/25, 12/6; 5000/50, 21/11; 5000/100, 58/3; 10000/15, 17/-; 10000/25, 24/6; 10000/50, 44/-; 10000/70, 61/-.

## MEDIUM RANGE ELECTROLYTICS

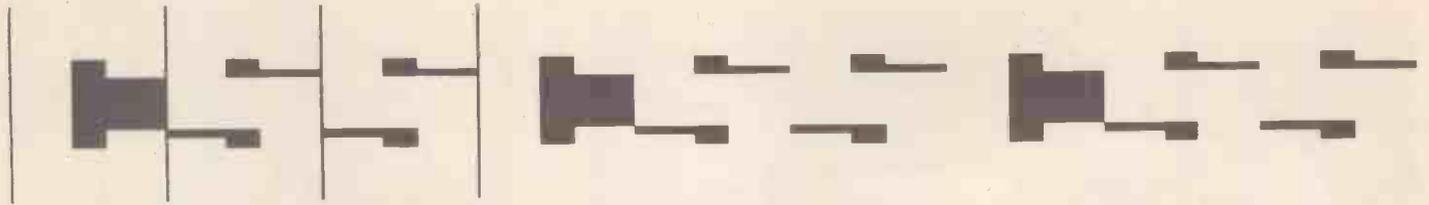
Axial leads: 50/50, 1/9; 100/25, 1/9; 100/50, 2/6; 220/25, 2/3; 250/25, 2/6; 250/50, 3/9; 500/25, 3/9; 500/50, 4/6; 1000/25, 4/-; 1000/50, 6/-; 2000/25, 6/-.

## SMALL ELECTROLYTICS

Axial leads: 4.7/10, 4.7/25, 5/50, 1/- each; 10/10, 10/25, 10/50, 33/10, 50/10, 1/- each; 22/25, 25/50, 47/25, 100/10, 220/10, 1/3 each.

# ELECTROVALUE

DEPT. WW.907, 28 ST. JUDES ROAD, ENGLEFIELD GREEN, EGHAM, SURREY,  
Hours: 9-5.30, 1.0 p.m. Saturdays. Phone: Egham 5533 (STD 0784-3) Telex 264475

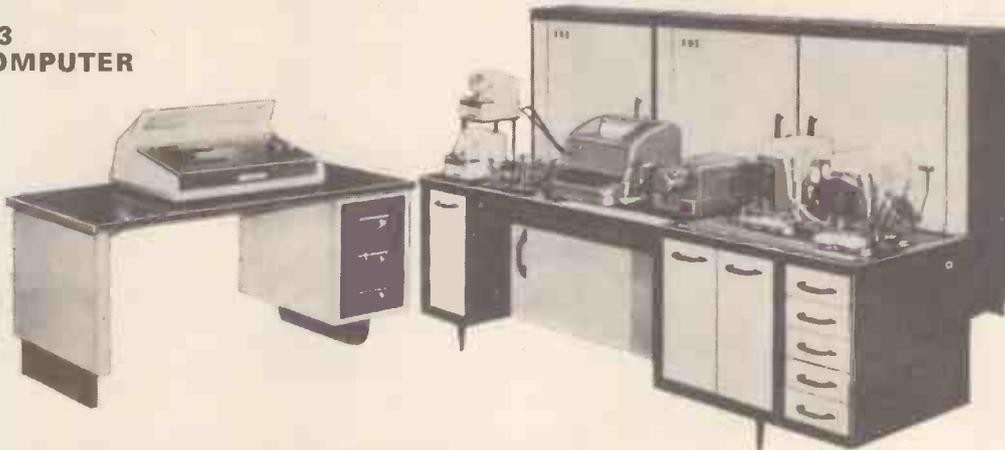


# COMPUTER SALES AND SERVICES

49-53 PANCRAS RD., LONDON, N.W.1. Tel: 01-278 5571

*(low cost computers and peripherals)*

## ELLIOTT 803 DIGITAL COMPUTER



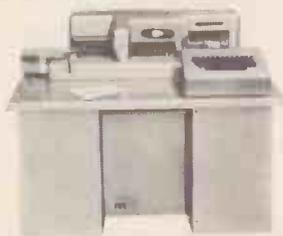
This is a well proved solid state digital computer, with well over 200 systems sold in the UK and abroad. Reliability has been proved by long periods of operation. It has many advantages, such as low running costs, compact design, automatic programming, extensive libraries of programmes available and a wide variety of input and output devices and auxilliary equipment can be coupled making this system suitable for use in all classes of work.

### Typical Configuration:

Central Processor with 4096 Core Store. Type 3 Paper Tape Station. One Tape Reader 500 characters per sec. (Elliott TS/93). One Tape Punch 100 characters per sec. (Teletype BRPE E11). Keyboard console and associated desk. Creed Teleprinter. Automatic Floating Point Unit.

## PART USED COMPUTERS AVAILABLE SHORTLY

ICL 1500; PDP 8F; IBM 1440; IBM 1401; SDS 930; ELLIOTT 803; EMIDEC 1100; HONEYWELL 200; NCR 400.

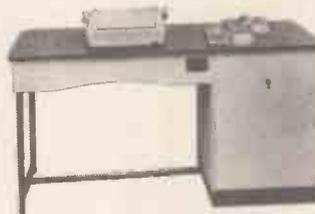


### ICT HOLLERITH Type 029.80 column Punch

A well-proven electro-mechanical card punch, with duplicating, spacing, and skipping facilities. Two types of keyboard are available for this model Alpha/Numeric and Alphabetic. The alphabetic largely resembles a typewriter keyboard, enables alpha punching by the operation of one key. Supplies 110v. D.C. mains for card feed motor. **FEATURES:** Motor cut-out switch for clearing card jams. Stop Lever for stopping card at the 80th column. Also available H129 card verifiers.

## KODATRON PAPERTAPE PREPARATION UNIT

Consisting of:  
IBM Typewriter  
Keyboard;  
Addo 8-Hole  
papertape  
Perforator;  
Addo 8-Hole  
papertape  
Reader;  
Control Panel.



## FRIDEN 6010

A Solid State digital computer designed for business applications which require accurate high-speed computations. Input/output unit consists of a Friden Flexowriter Model 6011. Storage: Has both variable and fixed storages. Programming: Removable programme panel for change of instructions.



## IBM 151 NUMERICAL VERIFIER

Has been designed for use on a table. It can be used in conjunction with the 011 Electrical Punch. Uses an electric Keyboard. Cards being fed, and removed manually. A Skip Bar can be fitted to control skipping over card areas which need no verification. Alphabetic and special character information can be verified using a multiple punch procedure.



## MAGNETIC TAPE

COMPUTER QUALITY  
MAGNETIC TAPE  
CERTIFIED 550 B.P.1.  
800 B.P.1. ON 2,400-ft. REELS. GUARANTEED  
REPLACEMENT IF FAULTED. £6.10.0



3/4 in. Highest grade 2,400 ft. .... £3. 0.0  
1/2 in. 10 1/2 in. dia. spool and cassette. .... £1.10.0  
1/2 in. 8 1/2 in. dia. spool and cassette. .... £1.10.0  
1 in. metal 10 1/2 in. dia. spool and cassette. .... £2.10.0  
3/2 in. N.A.B. centres 10 1/2 in. spool only. .... £1. 0.0

## HAND PUNCHES—80 COLUMN

### The Punch

Is a table-mounted model punch. For the Serial Punching of alpha-numeric Data, Alpha or Multi Hole Punching is made by depressing two or more keys simultaneously.



**COMPLETE AIR CONDITIONING SYSTEM AVAILABLE BY WORTHINGTON U.S.A. COST OVER £8K WHEN NEW. P.O.A.**

## FRIDEN FLEXOWRITERS

Flexowriter programmatic automatic writing machine for automatic letter writing, Data preparation work, invoice format paper work, edge punching cards, cutting continuous cards, preparing unit cards, preparing stub cards, reading edge punched cards, reading/copying punched tape. Price £175.



## DATA DISK

The Mark IV Data Disk Handler is a self-contained magnetic disc memory unit designed for integration with small computers or other digital systems. The handler's salient features include: random access; high density contact recording; interchangeable disc cartridges; write lock-out; air filtration in critical areas. The mechanical assembly, alone, can be supplied for rack mounting or custom installation.



**COMPUTER MULTI-CORE CABLES**

12, 14/0076 copper cores, each one insulated by coloured P.V.C. then separately screened, the 12 metal braided cores laid together and P.V.C. covered overall making a cable just under 1/4 in. dia. but quite pliable. Price 7/6 per ft. Any length cut. Other sizes available 7 core 5/- ft., 6 core 4/- ft., 4 core 3/6 ft.

**AC FAN**

Small but very powerful mains motor with 5 in. blades. Ideal for cooling equipment or as extractor. Silent but very efficient. 17/6, post 4/6. Mounts from back or front with 4BA screws.



**Double Leaf Contact**

Very slight pressure closes both contacts. 1/3 each. 12/- doz. Plastic push-rod suitable for operating. 1/- each, 9/- doz.

**PAPST MOTORS**

Est. 1/20th h.p. Made for 110-130 volt working, but two of these work ideally together on our standard 240 volt mains. A really beautiful motor, extremely quiet running and reversible. 30/- each. Postage one 4/6, two 6/6.



**E.M.I. MOTOR**

230v. 50Hz. Capacitor start. Reversible. Normal construction. Size: 3 1/2 in. dia. x 2 in. deep. Approx. 1/40th h.p. 32/6 with Condenser, plus 4/6 post and insurance.

**INSTRUMENT KNOBS**

1/4 in. dia. head with 3/8 in. shank for flatted 1/8 in. spindle. 9d. each. 3/- dozen. Ditto but with metal disc, 1/- each, 11/- dozen.



**MIDGET OUTPUT TRANSFORMER**

Ratio 140 : 1. Size approx. 1 1/4 in. x 1/2 in. x 1/2 in. Primary impedance 450 Ohm. Connection by flying leads. 4/6 each. 48/- doz.



**MIDGET OUTPUT TRANSFORMER**

Ratio 80 : 1. Size approx. 1 1/4 in. x 1/2 in. x 1/2 in. Primary impedance 132 Ohm. Printed circuit board connection. 5/6 each. 43/- doz.

**CHART RECORDER MOTOR**

Small (2 in. diameter approx.) instrument motor with fixing flange and spindle (1/4 in. long, 1/8 in. diameter); integral gear-box given 1 rev. per 2 hours. 19/6.

**IGNITION (E.H.T.) TRANSFORMER**

Made by Parmeko Ltd. Primary 240v. 50 c.p.s. Secondary 5Kv at 23mA. Size approx. 4 1/2 in. x 3 1/2 in. x 2 1/2 in. thick. Price 29/6 + 4/6.



**12-VOLT EXTRACTOR FAN BY DELCO**

Ideal for ventilation in caravan, car or boat. 6-bladed 5 in. diameter fan inside heavy duty cylinder with 3-point fixing flange. 5 1/2 in. diameter fixing hole. Length approx. 8 1/2 in. Exceptional bargain. 27/6 plus 5/6 post and insurance.



**4-PUSH SWITCH**

Ideal to control fan heater, etc. 3 on switches and 1 off. Contacts rated at 15 amp on all switches. Price 4/6 each. 48/- dozen.

**MAINS TRANSISTOR POWER PACK**

Designed to operate transistor sets and amplifiers. Adjustable output 6v., 9v., 12 volts for up to 500mA (Class B working). Takes the place of any of the following batteries: PP1, PP3, PP4, PP6, PP7, PP9, and others. Kit comprises: mains transformer rectifier, smoothing and load resistors, condensers and instructions. Real snip at only 18/6, plus 3/6 postage.



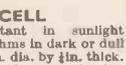
**3 DIGIT COUNTER**

For Tape Recorder or other application. Re-settable by depressing button. Price 5/6.



**ISOLATION SWITCH**

20 Amp D.P. 250 Volts. Ideal to control Water Heater or any other appliance. Neon Indicator shows when current is on. 4/6; 48/- per dozen.



**LIGHT CELL**

Almost zero resistance in sunlight increases to 10 K. Ohms in dark or dull light. Epoxy resin sealed. Size approx. 1 in. dia. by 1/2 in. thick. Rated at 500 MW. Wire ended. 8/6. Min. dist. circuits.



**5A 3-PIN SWITCHED SOCKETS**

An excellent opportunity to make that bench dia board you have needed or to stock up for future jobs. This month we offer 6 British made (Hicraft) bakelite flush mounting shuttered switch sockets for only 10/- plus 3/6 post and insurance. (20 boxes post free.)



**MOTOR WITH GEARBOX**

Very powerful 7 r.p.m., operates from standard A.C. mains. 29/6, plus 3/6 P. & P.



**230 VOLT SOLENOID**

1/2 in. stroke. Size 2 1/4 in. x 2 in. x 1 1/2 in.. 14/6, postage 2/9.



**TRANSDUCER**

Made by ACS, reference No. 1.D.1001. For measuring vibration, etc., to be used in conjunction with "G" Meter. Regular price 25. Our price 49/6. Brand new and unused.

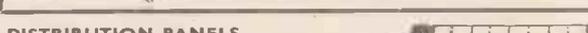


**THERMOSTAT**

Continuously variable 30°-90°C. Has sensor bulb connected by 33 in. of flexible tubing. On operation 15 amp 250 volt switch is opened and in addition a plunger moves through approx. 1/2 in. This could be used to open valve on ventilator etc. 29/6 plus 4/6 p. & ins.

**230 VOLT MAINS OPERATED KLAXON HORN**

This is small (about 10 in. long) but has a very piercing and effective tone hence it would make good Fire Alarm or Works stop and start Siren. Also useful for instance to scare birds off crops. Made for the G.P.O. so obviously best quality. Slightly used but OK. 39/6 plus 1/6 p. p.



**DISTRIBUTION PANELS**

Just what you need for work bench or lab. 4 x 13 amp sockets in metal box to take standard 13 amp fused plug and on/off switch with neon warning light. Supplied complete with 7 feet of heavy cable. Wired up ready to work. 39/6 less plug; 45/- with fitted 13 amp plug; 47/6 with fitted 15 amp plug, plus 4/6 P. & I.



**STANDARD WAFER SWITCHES**

Standard size 1/2 wafer—silver-plated 5-amp contact, standard 1/4 spindle 2" long—with locking washer and nut.

No. of Poles	2 way	3 way	4 way	5 way	6 way	8 way	9 way	10 way	12 way
1 pole	6/6	6/6	6/6	6/6	6/6	6/6	6/6	6/6	6/6
2 poles	6/6	6/6	6/6	6/6	6/6	6/6	6/6	10/6	6/6
3 poles	6/6	6/6	6/6	6/6	10/6	10/6	10/6	10/6	14/6
4 poles	6/6	6/6	10/6	10/6	14/6	14/6	14/6	14/6	22/6
6 poles	6/6	10/6	10/6	10/6	14/6	14/6	14/6	26/6	26/6
7 poles	6/6	10/6	10/6	14/6	18/6	18/6	18/6	30/6	30/6
8 poles	10/6	10/6	10/6	14/6	18/6	18/6	18/6	34/6	34/6
9 poles	10/6	10/6	14/6	14/6	22/6	22/6	22/6	38/6	38/6
10 poles	10/6	10/6	14/6	18/6	22/6	22/6	22/6	42/6	42/6
11 poles	10/6	14/6	14/6	18/6	26/6	26/6	26/6	46/6	46/6
12 poles	10/6	14/6	14/6	18/6	26/6	26/6	26/6	50/6	50/6



**VARIAC CONTROLLERS**

With these you can vary the voltage applied to your circuit from zero to full mains without generating undue heat. One obvious application therefore is to dim lighting. We offer a range of these. Any equipment but little used and in every way as good as new. Ex-not so, will be exchanged or cash refunded. 2 amp £4.19.6. 4 amp £8.19.6. 8 amp £8.10.0. Carriage extra

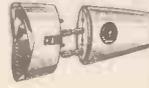
**THIS MONTH'S SNIP**

**25 Amp Electrical Programmer**  
Learn in your sleep! Have Radio playing and kettle boiling as you awake—switch-on lights to ward off intruders—have warm house to come home to. All these and many other things you can do if you invest in an Electrical Programmer. Made by the famous Smiths Instrument Company. This is essentially a 230/240 volt mains operated Clock and a 20 amp Switch, the switch-off time of which can be delayed up to 12 hours (continuously variable not stepped). Similarly the switch-on time can be delayed. This is a beautiful unit, size 5 1/2 x 3 1/4 x 2 1/4 in. deep. Metal encased, glass fronted with chrome surround. Offered at 47/6 plus 3/6 postage and insurance.



**RE-CHARGEABLE TORCH**

Neat flat torch, fits unobtrusively in your pocket, contains 2 Nicad cells and built-in charger. Plugs into shaver adaptor and charges from our standard 200/240 volt mains. American made, sold originally at over 4 dollars. Our price only 19/6 each.



**VARYLITE**

Will dim incandescent lighting up to 600 watt from full brilliance to out. Fitted on M.K. flush plate, same size and fixing as standard wall switch so may be fitted in place of this, or mount on surface. Price complete in heavy plastic box with control knob £3.19.6.



**BARGAIN OF THE YEAR**

**MICROSONIC RADIOS**  
7 transistor Key chain Radio in very pretty case, size 2 1/2 x 2 1/2 x 1 1/2 in.—complete with soft leather zippered bag. Specification: Circuit: 7 transistors superheterodyne Frequency range: 530 to 1600 Kcs. Sensitivity: 5 mv/m. Intermediate frequency: 465 Kcs, or 495 Kcs. Power output: 40mW. Antenna: ferrite rod. Loud-speaker: Permanent magnet type. In transit from the East, these sets suffered slight corrosion as the batteries were left in, but when this corrosion is cleared away they should work perfectly—offered without guarantee except that they are new. 24/6 plus 2/6 post and insurance. Less batteries. Six for £7, post free.



**OUT OF SEASON BARGAIN**

**TANGENTIAL HEATER UNIT**  
This heater unit is the very latest type, most efficient and quiet running. It is fitted in a cover and blower heaters costing £15 and more. We have a few only. Comprises motor, impeller, 2kW. element and 1kW. element allowing switching 1, 2 and 3kW. and with thermal safety cut-out. Can be fitted into any metal line case or cabinet. Only need control switch. 59/6, 2kW. Model as above except 2 kilowatt 39/6. Postage and insurance 6/6. Don't miss this.



**HI FI BARGAIN**

**FULL FI 12-INCH LOUDSPEAKER.** This is undoubtedly one of the finest loudspeakers that we have ever offered, produced by one of the country's most famous makers. It has a die-cast metal frame and is strongly recommended for Hi-Fi loud and Rhythm Guitar and public address. Flux Density 11,000 gauss—Total Flux 44,000 Maxwell—Power Handling 15 watts R.M.S.—Cone moulded fibre—Freq. response 30-10,000 c.p.s.—specify 3 or 15 ohms—Main resonance 60 c.p.s.—Chassis Diam. 12in.—12 1/2 over mounting lugs—Baffle hole 11in. Diam.—Mounting holes 4, holes 1/2 in. diam. on pitch circle, 1 1/2 in. diam.—Overall height 5 1/4 in. A £6 speaker offered for only £3.19.6 plus 7/6 p. & p. 12" 40w £8.19.6. Carr. 8/6. 15in. 25 watt £7.19.6 Carr. 10/6. 18in. 100 watt £19.10.0. Carriage, etc., 30/-.



**CONTROL DRILL SPEEDS**

Electronically changes speed from approximately 10 revs. to maximum. Full power at all speeds by finger-clip control. Kit includes all parts, case, everything and full instructions. 19/6 plus 2/6 post and insurance. Made up model also available 37/6 plus 2/6 p. & p.

**INTEGRATED CIRCUITS**

A parcel of integrated circuits made by the famous Plessey Company. A once in a lifetime offer of Micro-electronic devices well below cost of manufacture. The parcel contains 5 ICs all new and perfect. First grade device definitely not sub-standard or second. The ICs are all single silicon chip General Purpose Amplifiers. Regular price of which is well over £1 each. Full circuit details of the ICs are included and in addition you will receive a list of 50 different ICs available at bargain prices 5s. upwards with circuits and technical data of each. Complete parcel only £1 post paid or List and all technical data.

Where postage is not stated then orders over £5 are post free. Below £5 add 2/9. Semi-conductors add 1/- post. Over £1 post free. S.A.E. with enquiries please.

**MAINS TRANSFORMERS**

Note all these are first grade Transformers and all have normal 200/240 volt 50 cycle primary.  
**Mains Transformer Type No. 56786**  
Upright mounting, size approx. 2 1/2 x 2 in. approximately 2 secondaries one 28 volt 1 amp and the other 5.5 volt 1.5 amp. Earth screen between primary and secondaries—this transformer will power a 5-5 watt stereo amplifier (circuit diagram available, price 2/6). Suitable output transformer is type 56787 described below. Our price 17/6. Plus 4/6 post.  
**Mains Transformer Type No. 56733**  
Chassis mounting type, size approximately 3 x 2 1/4 x 3 in., 2 secondaries one 230 volt at 60 mA and other 6.3 volts 1.5 amp. Earth screen between primary and secondaries. This will power a 5 watt amplifier (circuit available 2/6). Matching OPT. is 56734 described below. Price 16/6 plus 4/6 post.  
**Mains Transformer Type No. 56695**  
Upright mounting, size approximately 4 x 3 x 2 1/4 in. 2 secondaries 275-0-275 at 90 mA and 6.4 volts at 3.1 mA. There is a screen between primary and secondaries. This is a partner to output transformer 56694 described below. Price 19/6 plus 4/6 post.

**OUTPUT TRANSFORMERS**

**OPT. ref. 56894**  
Chassis mounting—size 2 x 2 x 2 in. approximately 7 watts. A push pull transformer for matching 2/EL84 or similar valves to 15 ohm Loud Speaker. 14/6 no extra for post if ordered with Transformer 56695. Circuit diagram of amplifier available, price 2/6.  
**OPT. ref. 56787**  
Upright mounting, size approximately 2 1/2 x 2 x 2 in. Matching impedance 60 ohms to 15 ohms. 5 watts output using transistor type AD140 (Circuit diagram available price 2/6). Price 8/6 each, no extra for postage if ordered with mains transformer type 56786.  
**OPT. ref. 56804**  
Upright mounting, size approximately 2 x 2 1/2 x 2 in. Primary impedance 60 ohm, secondary impedance 3 ohm, otherwise this is as 56787. Price 8/6.  
**OPT. ref. 56734**  
Chassis mounting, size approximately 2 1/2 x 2 x 1 1/4 in. Primary 500 ohm centre tapped. Ratio 27/1, 5 watts output using twin EL88 or similar. Price 12/6. No extra for postage if ordered with 56733.

**HEAVY DUTY MAINS TRANSFORMER**  
30V. 37A. Primary tapped 200/240 in 10v. steps. A really beautiful "C" core transformer. Made by Parmeko, impregnated and varnished. Weight approx. 50 lb., size approx. 8in. wide 6 1/2 in. deep and 8 1/4 in. high. Metal framed for free standing and fitted with E.S. screen. Probably priced £40-£50 from Parmeko. E.S. equipment, but perfect. £17.10 each, plus carriage at cost.

**50 CYCLE TO 60 CYCLE INVERTERS**  
For operating American instruments and other equipment Made for 60 cycles 115 v. from 230/240 50 cycle mains. These units have an output of 115 volts A.C. and will handle a load of up to 100 watts. These are precision made and have a reed type frequency meter which vibrates when the frequency is exactly 60 c.p.s. Adjustment of the frequency is by a knob on control panel. Input by 3 core output from 3 pin socket. Original cost of this in excess of £60. A limited quantity available £17/10 each.

**MAINS OPERATED CONTACTOR**  
220/240V. 50 cycle solenoid with laminated core so very silent in operation. Closes 4 circuits each rated at 10 amps. Extremely well made by a German Electrical Company. Overall size 2 1/2 x 2 in. 39/6 each.

**SIMMERSTAT CONTROL SWITCH**  
Combed on-off switch and "heat on" regulator intended for automatic temperature regulation of electric hot plates up to 3kW. Official rating 15A 200-250V A.C. size 2 x 1 1/2 x 2 in. deep. Single hole fixing 12/6. Knob 4/6 extra.

**ELECTRIC BLANKET BARGAIN**  
Famous Nordic blanket claimed to be the most reliable in Britain. We offer at less than wholesale price "Corona double bed" model, this has flame resistant super safe element—durable bed size 60 x 48 in., with control switch giving choice of three heat—in presentation box showing regular price £9.9—we offer at £4.19.6 post and ins. paid.

**TOGGLE SWITCH**  
3 amp 250v. with fixing ring. 1/6 each 15/- doz

**AUTO-ELECTRIC CAR AERIAL**  
with dashboard control switch—fully extendable to 40in. or fully retractable. Suitable for 12v positive or negative earth. Complete control switch giving fitting instructions and ready wired dashboard switch. £5.18.6 plus 5/- post and ins.

**MICRO SWITCH**  
5 amp. changeover contacts. 1/9 each 18/- doz. 15 amp model 2/- ea. or 21/- doz.  
**MINIATURE EAR PIECE**  
As used with imported pocket radios. 1/6 each 15/- doz.

**15/20 AMP CONNECTORS**  
Polythene insulated 12-way strip. 2/6 each 24/- doz.

**13 AMP FUSED SWITCH**  
Made by G.E.C. For connecting water heater etc., into 13 amp ring main. Flush type 3/6 each 30/- doz. Metal boxes for surface mounting 1/6 each 15/- doz.

**13 AMP SPUR UNIT**  
By G.E.C. for connecting clock, etc., to ring main. Pull-out fuse. Flush mounting. Cream. 2/6 each; 24/- doz.

**MAINS MOTOR**  
Precision made—as used in record decks and tape recorders—ideal also for extractor fans, blower, heater, etc. New and perfect. Snip at 9/6. Postage 3/- for first one then 1/- for each one ordered. 12 and over post free.

**MINIATURE WAFER SWITCHES**  
2 pole, 2 way—4 pole, 2 way—3 pole, 3 way—4 pole, 3 way—2 pole, 4 way—3 pole, 4 way—2 pole, 6 way—1 pole, 12 way. All at 3/6 each. 36/- dozen, your assortment.

**MINIATURE SLIDE SWITCH**  
3 pole change-over. 3/- each 30/- doz.

# R.S.C. HIGH FIDELITY STEREO 'PACKAGE' OFFERS

Matching as recommended for optimum performance. Compare prices with equipment and cabinets purchased individually.

- ★ Super 30 Amplifier (15+15Watt) in veneered housing.
- ★ Goldring Transcription Turntable on Plinth.
- ★ Shure or Goldring Magnetic Pick-up Cartridge.
- ★ Pair of Stanway II Loudspeaker Units.

Special total price. Four fully wired units ready to 'plug-in'. Really superb performance. Send S.A.E. for leaflet.

**86 Gns.**  
Carr. 30/-

**EXTREMELY ATTRACTIVE PLINTHS** finished in Teak or Afrormosia veneer. Tinted Transparent Plastic cover.



'Package' prices apply providing all individual units are purchased from any branch within 3 months (see leaflet).



- ★ TA 12 6+5+6-5W Amplifier in veneered housing.
- ★ Pair of Dorchester Loudspeaker Units.
- ★ Garrard SP25 Mk II 4-speed Player on Plinth.
- ★ Goldring CS90 Ceramic P.U. Cartridge with diamond Stylus. Special total price. **53 Gns.** Carr. 25/-

Transparent Plastic cover **3 gns** extra  
Terms Dep. £7 and 9 monthly payments **£62.8** (Total 59Gns.) Carr. 25/-

**PACKAGE:** As above but with Garrard 3000 and Sonotone 9TA cartridge in lieu of SP25 and CS90. Special total price **£47 1/2 Gns.** Transparent cover 3 gns. extra. Terms: Dep. £6/0/0 and 9 monthly payments **£51/1/5** (Total 256/2/0). Carr. 25/-

**AUDIOTRINE HIGH FIDELITY LOUSPEAKERS** 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 15 ohms.

WHEN ORDERING PLEASE STATE IMPEDANCE  
HF 80LD 8W 54/3 HF 120 12 15W 79/9  
HF 100D 10 10W 67/11 HF 120D 12 15W 89/9  
HF 100D 10 15W 24/10/9 HF 128 12 15W 25/15/-  
HF 105DL 10 10W 26/6/0 HF 128D 12 15W 25/15/-

**HIGH FIDELITY LOUSPEAKER UNITS** Cabinets of latest styling Teak or Afrormosia veneer. Acoustically lined or filled with acoustic damping material. Ported where appropriate. Credit terms available.

- Dorchester Size 16 x 11 x 9in. Appr. Range 45-15,000 c.p.s. Rating 8-10 watts. Fitted High flux 13 x 8in. **£8.19.9**
- Stanway II Size 20x10x9in. Appr. Rating 10 watts. Including 13x8in. speaker with highly flexible cone surround, long throw voice coil and 11,000 line magnet. High flux tweeter. Handsome Scandinavian design cabinet. Range 35-20,000 c.p.s. Impedance 15 Ohm. Gives smooth realistic sound output. Inc. carr. **16Gns.**

**R.S.C. TA6 6 Watt High Fidelity Solid State Amplifier**

200-250v. A.C. mains operated Frequency Response 20-20,000 c.p.s. -2dB. Harmonic Distortion 0.3% at 1,000 c.p.s. Separate Base and Tone 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. 9 1/2 x 2 1/2 x 3 1/2 in. Attractive brushed silver finish fascia plate 10 1/2 x 3 1/2 in. and matching knobs. Complete kit of parts with full wiring diagrams and instructions. Carr. 7/6. **7 Gns.**  
OR FACTORY BUILT WITH 12 months' g'tee. **£8.19.9**

**HIGH QUALITY R.S.C. COLUMN LOUSPEAKERS**

Covered in Rexine and Vynal, ideal for vocalists and Public Address. 15 ohm matching. TYPE C488, 30 watts. Fitted four 8in. high flux 13 w. speakers. Or Dep. £3 and 9 monthly payments of 16 Gns. Carr. 10/-  
TYPE C4128, 50 watts. Fitted four 12in. 11,000 lines 15 watt speakers. Or Dep. £21 and 9 monthly payments of 26 Gns. Carr. 10/-  
TYPE C4129, 100 watts. Fitted four 12in. 18 x 10 in. approx. Gauss 10,000 lines. Finish as above. 15 months' payments of 58/8 (Total £30/8/0). Carr. 15/-

**R.S.C. BATTERY/MAINS CONVERSION UNITS**

Type BM1. All-dry battery eliminator. Size 5 1/4 x 4 1/2 in. 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 59/9, or READY FOR USE, 69/9.

**R.S.C. SUPER 30 Mk II HIGH FIDELITY STEREO AMPLIFIER**

**HIGH GRADE COMPONENTS. SPECIFICATIONS COMPARABLE WITH UNITS COSTING CONSIDERABLY MORE**  
Employing Twin Printed Circuits 200/250v. A.C. mains operation.  
TRANSISTORS: 9 high-quality types per channel.  
OUTPUT (Per channel): 10 Watts R.M.S. continuous into 15 Ohm 16 Watts R.M.S. continuous into 8 Ohm.  
INPUT SENSITIVITIES: P.U. 4 mV. Ceramic P.U. 35 mV. Tape Amp. 400 mV. Aux. 100 mV. Mic. 6 mV. Tape Head 2.5 mV.  
FREQUENCY RESPONSE: ±2 dB 10-20,000 c.p.s.  
TREBLE CONTROL: +17 dB to -14 dB at 10 Kc/s.  
BASS CONTROL: +17 dB to -15 dB at 50 c/s.  
HUM LEVEL: -80 dB.  
HARMONIC DISTORTION: 0.1% at 10 Watts 1,000 c.p.s.  
CROSS TALK: 52 dB at 1,000 c.p.s.

**AUDIOTRINE HI-FI SPEAKER SYSTEMS**

Consisting of matched 12in. 11,000 line 15 watt ohm high quality speaker, cross-over unit and tweeter. Smooth response and extended frequency range ensure surprisingly realistic reproduction. Carr. 5/9  
Or SENIOR 15 WATT Inc. HF 126 15,000 line Speaker 28/15. Carr. 6/6.

**HI-FI LOUSPEAKER ENCLOSURES** Teak or Afrormosia veneer finish. Modern design. Acoustically lined. All sizes approx. Carr. 7/6 extra. JEB Size 16x11x9in. Pressurised. Gives pleasing results with any 8in. HI-FI speaker. Carr. 15/10  
SE3 For optimum performance with any 8in. HI-FI speaker. 22 x 15 x 9in. Ported. SE10 For outstanding results with HI-FI 10in. speaker. 24 x 15 x 10in. Ported. **£5.19.9**  
SE12 For high performance with 12in. HI-FI speaker and Tweeter. Size 25 x 16 x 10 1/2 in. Pressurised. **£6.19.9**

**THE 'YORK' HIGH FIDELITY 3'SPEAKER SYSTEM** Moderate size (approx. 25 x 14 x 10 in.). Range 30-20,000 c.p.s. Complete kit 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 x 5 in. high flux middle range speaker. (4) High efficiency tweeter. (5) Appropriate quantity acoustic damping material. (6) Teak veneered cabinet. (7) Circuit and full instructions. **REMARKABLE VALUE HEAR IT AT ANY BRANCH 20 Gns.** Carr. 12/6

**R.S.C. G66 6+6 WATT HIGH QUALITY STEREO AMPLIFIER**

Individual Ganged controls: Bass, Treble, Volume and Balance. Printed circuit construction employing 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 fascia plate and matching control knobs. Complete kit of PARTS INCLUDING FULL WIRED PRINTED CIRCUIT and comprehensive wiring diagram and instructions OR FACTORY BUILT in Teak veneered cabinet as illustrated £12/10/0. Carr. 7/9. Or Deposit 37/6 and 9 monthly payments of 29/2 (Total £15).

**PACKAGE OFFER SAVE £3.** Above G66 assembled in cabinet plus pair DORCHESTER L/SPEAKER UNITS £27/9/6 Carr. £1. Or Deposit £5 and 9 monthly payments 57/6 (Total £30/17/6).

**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, EP86, 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. mains. For 3 & 15 ohm speakers. Complete kit parts wiring diag., instructions. Twin-handled perforated cover 35/-, Or factory built with EL34 output valves and 12 months' guarantee for 18 gns. Tech. figs. apply to factory built units. Carr. 12/6. **15 Gns.**  
TERMS: Deposit £3.0 and 9 monthly payments of £2 (Total £21/9/0). Send S.A.E. for leaflet.

**R.S.C. TFM1 SOLID STATE VHF/FM RADIO TUNER**

★ High-sensitivity. ★ 200-250v. A.C. Mains operation. ★ Sharp A.M. Rejection. ★ Drift-free reception. ★ Output ample for any amplifier (approx. 500 m.v.). ★ Output for feeding Stereo Multiplexer. ★ Tuner head using silicon Planar Transistors. ★ Designed for standard 80 ohm co-axial input. Visually matching our Super 15 and 30 amplifiers. Printed circuitry. A quality product at considerably less than the cost of comparable units. **FACTORY BUILT 18 gns.** Or in Teak finished cabinet as illus. **21 gns.** Terms: Deposit £8/1/- and 9 monthly payments £2/12/- Total £24/19/- STEREO VERSION 23 1/2 gns. or in Cabinet 26 1/2 gns. All units carriage 9/6 extra.

**TA12 MK III 6+5+6-5W 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 20-20,000 c.p.s. -2dB ★ Harmonic Distortion 0.3% at 1000 c.p.s. Hum and noise -70dB ★ Sensitivities (1) 20 mV (2) 400 mV (3) 100 mV (4) Handsome finish Facia Plate and Knobs. Output rating I.H.F.M. Complete kit of parts with full wiring diagrams and instructions 13 1/2 GNS. Carr. 7/9.  
FACTORY BUILT with 12 mth. g'tee. 17 GNS. Or Dep. £3 and 9 mthly pymts. 38/10 (Total 19 1/2 GNS). Or in Teak or Afrormosia veneer housing 20 1/2 GNS. or Dep. 3 GNS. and 9 mthly. pymts. 46/8 (Total 23 GNS.).  
SELENIUM RECTIFIERS. F.V. Bridged 6/12v. D.C. Output Input Max. 18v. A.C. Ia. 4/3; 2a. 6/11; 3a. 9/9; 4a. 12/9; 6a. 15/9.

**INTEREST CHARGES REFUNDED**  
On Credit Sales settled in 3 months

**R.S.C. MAINS TRANSFORMERS**

FULLY GUARANTEED. Interleaved and Impregnated. Primaries 200-250v. 50c/s. Screened MIDGET CLAMPED TYPE 2 1/2 x 2 1/2 in.

250 v. 60 mA. 6.3 v. 2a.	17/11
250-0-250v. 60mA. 6.3v. 2a.	18/11

FULLY SHROUDED UPRIGHT MOUNTING

250-0-250v. 60mA. 6.3v. 2a. 0-5-6.3v. 2a.	24/9
250-0-250v. 100mA. 6.3v. 4a. 0-5-6.3v. 3a.	39/9
300-0-300v. 100mA. 6.3v. 4a. 0-5-6.3v. 3a.	39/9
300-0-300v. 150mA. 6.3v. 4a. c.t. 6.3v. 1a.	39/9

For Mullard 510 Amplifier

350-0-350v. 100mA. 6.3v. 4a. 0-5-6.3v. 3a.	47/11
350-0-350v. 150mA. 6.3v. 4a. 0-5-6.3v. 3a.	47/9
425-0-425v. 200mA. 6.3v. 4a. c.t. 6.3v. 3a.	49/9
425-0-425v. 200mA. 6.3v. 4a. 0-5-6.3v. 3a.	49/9
400-0-450v. 230mA. 6.3v. 4a. c.t. 6.3v. 3a.	93/9

TOP SHROUDED DROP-THROUGH TYPE

250-0-250v. 70mA. 6.3v. 2a. 0-5-6.3v. 2a.	23/9
250-0-250v. 100mA. 6.3v. 3.5a.	27/9
250-0-250v. 100mA. 6.3v. 2a. 6.3v. 1a.	28/9
350-0-350v. 80mA. 6.3v. 2a. 0-5-6.3v. 2a.	29/11
250-0-250v. 100mA. 6.3v. 4a. 0-5-6.3v. 3a.	39/9
300-0-300v. 100mA. 6.3v. 4a. 0-5-6.3v. 3a.	39/9
300-0-300v. 130mA. 6.3v. 4a. 0-5-6.3v. 1a.	39/9

Suitable for Mullard 510 Amplifier

350-0-350v. 100mA. 6.3v. 4a. 0-5-6.3v. 3a.	46/9
350-0-350v. 150mA. 6.3v. 4a. 0-5-6.3v. 3a.	46/11

FILAMENT OR TRANSFORMER POWER PACK Types

6.3 v. 3A. 8/9; 6.3v. 2A. 9/9; 6.3v. 3A. 13/9; 6.3v. 6A. 22/9; 12v. 1A. 9/11; 12v. 3A. or 24v. 1.5A. 23/9; 0-8-18v. 1 1/2A. 19/11; 0-12-25-42v. 2A. 31/9.	
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CHARGER TRANSFORMERS 0-6-10v. 1 1/2A. 18/9; 2 1/2A. 19/11; 3A. 21/11; 5v. 25/11; 6A. 29/9; 8A. 36/9.

AUTO (Step UP/STEP DOWN) TRANSFORMERS

0-110/120v-200-230-250v. 50-80 watts	105/9
160 watts. 33/6; 250 watt 40/9; 500 watts 139/9	

OUTPUT TRANSFORMERS

Standard Pentode 5,000 Ohm or 7,000 Ohm to 3 Ohm	8/9
Push-Pull 8 watts EL34 to 3 Ohm or 15 Ohm	14/9
Push-Pull 10 watts EL34 to 3 Ohm or 15 Ohm	24/9
Push-Pull EL34 to 3 or 15 Ohm 12 1/2 watts	25/9
Push-Pull EL34 Linear for Mullard 510, etc.	39/9
Push-Pull 16-18 watts, sectionally wound 6L6	

KT66, etc., for 3 or 15 Ohm quality sectionally wound EL34, 6L6, KT66, etc. to 3 or 15 Ohm 59/9

SMOOTHING CHOKES

150mA. 7-10H. 250 Ohm 12/9; 100mA. 10H. 200 Ohm 10/9; 80mA. 10H. 350 Ohm 8/9; 60mA. 10H. 400 Ohm 4/11	
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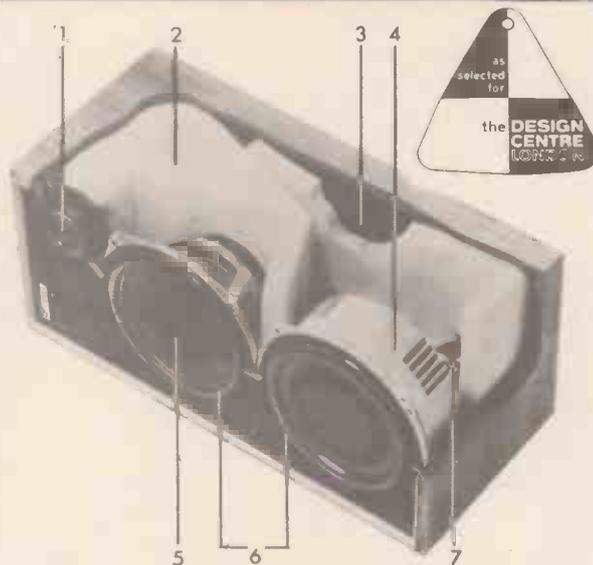
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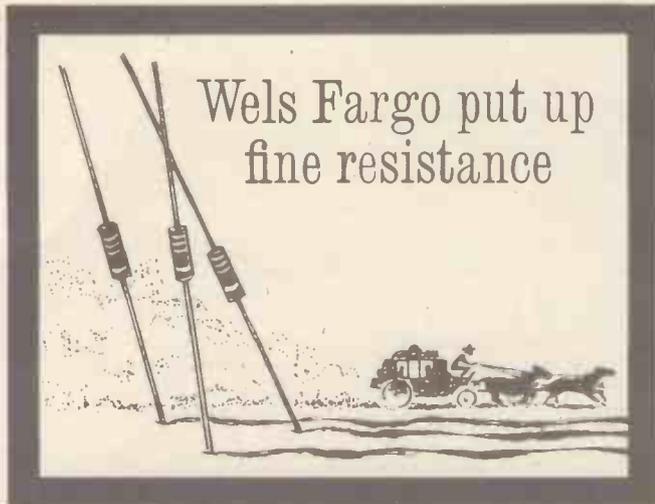
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64	—	—	—	—	PA424	47/-

Data Sheets all 1/- per type except L900/  
914/923 and Plessey 2/6.  
8 Pin To-5 I.C. Holders, 10/6  
14 Pin Dual-in-Line I.C. Holders, 11/-  
16 Pin Dual-in-Line I.C. Holders, 12/6

Post and Packing 1/6d. per order. Data sheet free if ordered with ICS. Send 2/6d. for catalogue

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01-452 0161  
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CALLERS WELCOME 9-5.30 SATURDAY 9-5  
SEE OUR MAIN ADVERTISEMENT ON PAGE 73 FOR SEMICONDUCTORS

# AERO SERVICES LTD



## INTEGRATED CIRCUIT AMPLIFIERS

CA3005 RF amplifier, 100mc/s bandwidth...	27/-
CA3012 Wide Band Amplifier for IF applications...	22/-
CA3020 350mW Audio Amplifier	30/-
CA3036 Two super-alpha pairs for stereo pick-up systems	19/-
CA3052 Latest addition to RCA range. Four-in-one amplifier	42/-
PA222 1.2 watt Audio Amplifier	65/-
PA234 1 watt Audio Amplifier	27/6
PA237 2 watt Audio Amplifier	40/-
MC17090—G.P. operational Amplifier	40/-
TAA263 3-stage direct coupled Amplifier	15/-
TAA293 3-stage direct coupled Amplifier	20/-
TAA320 MOST input + bi-polar stage	13/-
TAD100 All active components required to construct an AM receiver	45/-
SL403A 3 watts Audio Amplifier	49/6

## ZENER DIODES

BZY88 series, from 3.3V to 9.1V ± 5% 400mW	3/6 each
BZY94 series, from 10.0V to 12.0V ± 5% 400mW	4/1 each
D814 series, from 7.5V to 13.0V ± 10% 340mW	3/- each
D815 series, from 4.7V to 18.0V ± 10% 8 Watts	7/6 each
D816 series, from 22V to 47V ± 10% 5 Watts	7/6 each
D817 series, from 56V to 100V ± 10% 5 Watts	7/6 each

Outlines: BZY series—miniature—wire ended  
 D814—'Top Hat' type  
 D815-D817—stud mounted, supplied complete with hardware  
 Please state voltage required—nearest standard voltage will be supplied.

## TRANSISTORS

2N404 3/6	ABY74	AC125 6/6	ASY77 7/7	BY27 5/6
2N410 3/6	18/1	AC126 5/4	ASY82 4/4	BY28 5/5
2N412 3/6	2N2923 3/3	AC127 5/6	ASY86 4/6	BY265 4/6
2N444 5/2	2N2924 3/3	AC128 4/6	BC107 3/3	BSY95A
2N696 4/6	2N2926 5/5	AC132 7/6	BC108 3/3	
2N697 4/6	3/3	AC153 5/5	BC109 4/4	D29A4 3/6
2N698 8/8	2N2926 5/5	AC154 3/3	BC113 8/8	OC16 15/15
2N705 15/15	3/3	AC157 4/4	BC118 8/8	OC22 13/13
2N706 3/3	2N2926 5/5	AC159 2/2	BC147 4/6	OC23 12/6
2N708 3/6	3/3	AC176 6/6	BC148 3/3	OC25 15/15
2N753 4/6	2N2926 5/5	AC188 6/6	BC149 3/6	OC25 7/6
2Y16 8/8		ACY17 6/6	BC152 3/2	OC26 6/6
2N929 6/6	2N2926 5/5	ACY18 4/4	BC175 5/6	OC28 14/6
2N930 6/6	3/3	ACY19 4/6	BC187 6/6	OC29 14/9
2N987 6/6	2N3059 6/3	ACY21 3/11	BCY31 5/1	OC30 15/15
2N1131 8/8	2N3059 15/15	ACY22 2/8	BCY33 5/1	OC36 12/6
2N1132 9/6	3/3	AD140 16/16	BCY34 5/1	OC42 6/6
2N1184 25/25	2N3133 7/7	AD149 12/6	BCY39 5/1	OC44 4/4
2N1301 7/7	2N3134 8/6	AD161 9/9	BCY72	OC45 3/6
2N1302 7/6	2N3134 8/6	AD192 3/10		OC71 3/6
2N1304 4/6	2N3392 2/2	AP102 15/6	BC211 7/6	OC72 5/5
2N1305 4/6	2N3393 2/6	AP114 6/6	BD121 18/18	OC73 7/6
2N1306 5/6	2N3394 2/6	AP115 6/6	BD123 25/25	OC75 5/5
2N1307 3/3	2N3395 3/6	AP116 5/6	BF115 4/9	OC76 5/5
2N1309 7/6	2N3402 5/6	AP117 4/6	BF167 5/5	OC78 5/5
2N1709 9/6	2N3403 5/6	AP125 6/6	BF181 6/6	OC78D 3/3
2N1711 6/6	2N3404 6/6	AP126 5/3	BF184 7/6	OC81 4/6
2N1756 15/15	2N3414 4/4	AP127 5/3	BF185 4/9	OC81D 3/3
2N2147 14/9	2N3415 6/6	AP128 12/6	BF194 3/6	OC83 4/6
2N2160 23/23	2N3416 4/6	AP186 11/11	BF195 3/3	OC83 13/13
2N217 6/6	2N3702 5/2	AP239 10/10	BF440 5/5	OC139 7/6
2N219 7/9	2N3702 5/6	APY19 8/8	BF197 4/6	OC140 9/6
2N2219 8/6	2N3703	APZ18 22/8	BFY88 5/4	OC170 5/5
2N2369A 4/6	3/10	APZ11 9/9	BFY17 8/6	OC201 5/6
2N2704 5/6	2N3704 5/6	APY26 6/6	BFY18 5/5	OC200 4/4
2N2707 4/4	2N3707 4/4	APY27 6/6	BFY19 5/5	OC201 10/10
2N2477 12/6	2N3709 3/5	APY28 6/6	BFY40 5/5	OC202 13/13
2N2646 12/6	2N3710 3/3	APY29 6/6	BFY61 4/6	OC203 6/6
2N2919 12/6	2N3819 12/12	APY54 6/6	BFY62 10/10	OC204 6/6
2N2919 12/6	2N3906 6/6	APY73		OC205 13/13
2N2905 10/10	AC113 3/3	10/10	BSY26 4/10	OC206 14/14

## TWO NEW OSCILLOSCOPES FROM RUSSIA



**CI-5 SINGLE BEAM OSCILLOSCOPE**  
 10 mc/s passband, triggered sweep from 1 μ sec. to 3 milli-sec. Free running time base from 20 c/s to 200 kc/s. Built-in time marker and amplitude calibrator, 8-in. cathode ray tube with telescopic viewing hood. £39.00

## CI-16 DOUBLE BEAM OSCILLOSCOPE

5 mc/s passband. Separate Y1 and Y2 amplifiers, rectangular 5 in. x 4 in. cathode ray tube. Calibrated triggered sweep from 0.2 μ sec. to 100 milli-sec. per cm. Free running time base 50 c/s to 1 mc/s. Built-in time base calibration and amplitude calibrator ..... £87/10/0  
 Full details on request. Full servicing facilities and spares available.



WHEN ORDERING BY POST PLEASE ADD 2/6 IN £ FOR HANDLING AND POSTAGE.

NO C.O.D. ORDERS ACCEPTED  
 ALL MAIL ORDERS MUST BE SENT TO HEAD OFFICE AND NOT TO RETAIL SHOP.

0A2 6/6	5R4GY 11/11	6BS7 26/26	6SL7GT 6/6	12AV6 6/6	30FL14 15/6	723A/B 140/140	CBL1 16/16	E186F 24/24	ECL86 8/6	EN11 70/70	HL94 8/8	QJ37 30/30	UCL81 11/11
0A3 9/9	5U4G 7/6	6BW6 16/16	6SN7GT 6/6	12AV7 9/9	30L15 17/17	811A 20/20	CBL3 17/17	E188C 19/6	ECL89 30/30	EN32 30/30	KT8 40/40	QV03-12 13/13	UCL82 7/7
0A4G 22/22	5U4GB 7/6	6BX6 16/16	6X4 6/6	12AX4GTB 30L11 7/7	30L17 7/7	817 9/9	CL4 12/12	E280R 4/2	EF9 9/9	EY51 6/6	KT44 8/8	R10 20/20	UCL83 12/12
0B2 6/6	5V4G 8/8	6BX6 16/16	6X4 6/6	12AX7 9/9	30L17 7/7	807 7/7	CLY 3/3	E10F 57/6	EF39 9/9	EY80 9/9	KT48 30/30	R18 9/9	UF11 10/10
0C2 17/17	5X8 10/10	6BZ6 6/6	6X4 6/6	12AX7 13/6	30P12 7/7	829B 6/6	DA4 85/85	E40 4/4	EF40 10/10	EY81 8/8	KT66 27/6	R03-250A 14/14	UF41 10/10
0C3 7/7	5Y3GT 6/6	6C4 6/6	6X4 6/6	12BA4 10/10	30P19 15/15	837 15/15	DAF91 10/10	E42 9/9	EF42 14/14	EY83 11/11	KT71 8/8	R18 14/14	UF42 12/12
0D3 6/6	5Z3 9/9	6C6 6/6	6X4 6/6	12BA6 6/6	30P19 15/6	866A 14/14	DAF92 9/6	EF401 9/6	EF40 14/14	EY84 10/10	KT76 8/8	R18 14/14	UF45 11/11
1A3 5/5	5Z4G 7/7	6C6 6/6	6X4 6/6	12BE6 6/6	30PL13 13/13	872A 10/10	DAF93 7/6	EF43 10/10	EF43 10/10	EY85 6/6	KTW63 6/6	R18 14/14	UF45 11/11
1A3GT 5/6	5Z4GT 8/8	6C6 6/6	6X4 6/6	12BE7 6/6	30PL14 13/13	889A 8/8	DC9 9/9	EB91 3/3	EF56 7/7	EY88 8/8	LL4 9/9	RL18 14/14	UF45 11/11
1A7GT 7/6	6J30L2 15/15	6C6 6/6	6X4 6/6	12C06 15/15	30P19 15/6	927 5/5	DF91 4/6	EB93 9/9	EF56 6/6	EY88 8/8	ME91 8/8	R18 14/14	UF45 11/11
1B3GT 7/6	6A8G 6/6	6C6 6/6	6X4 6/6	12C06 15/15	30P19 15/6	927 5/5	DF96 7/6	EB93 9/9	EF56 6/6	EY88 8/8	MH4 8/8	R18 14/14	UF45 11/11
1C5G 6/6	6AB4 6/6	6C6 6/6	6X4 6/6	12C06 15/15	30P19 15/6	927 5/5	DF96 7/6	EB93 9/9	EF56 6/6	EY88 8/8	MH4 8/8	R18 14/14	UF45 11/11
1G4GT 8/6	6AC7 4/6	6C6 6/6	6X4 6/6	12C06 15/15	30P19 15/6	927 5/5	DF96 7/6	EB93 9/9	EF56 6/6	EY88 8/8	MH4 8/8	R18 14/14	UF45 11/11
1G6GT 7/6	6AC7A 9/6	6C6 6/6	6X4 6/6	12C06 15/15	30P19 15/6	927 5/5	DF96 7/6	EB93 9/9	EF56 6/6	EY88 8/8	MH4 8/8	R18 14/14	UF45 11/11
1HG7 7/6	6AG5 8/8	6C6 6/6	6X4 6/6	12C06 15/15	30P19 15/6	927 5/5	DF96 7/6	EB93 9/9	EF56 6/6	EY88 8/8	MH4 8/8	R18 14/14	UF45 11/11
1L4 3/6	6AG7 7/6	6C6 6/6	6X4 6/6	12C06 15/15	30P19 15/6	927 5/5	DF96 7/6	EB93 9/9	EF56 6/6	EY88 8/8	MH4 8/8	R18 14/14	UF45 11/11
1NG6T 8/6	6AR6 10/10	6C6 6/6	6X4 6/6	12C06 15/15	30P19 15/6	927 5/5	DF96 7/6	EB93 9/9	EF56 6/6	EY88 8/8	MH4 8/8	R18 14/14	UF45 11/11
1Q6T 10/10	6A78 5/9	6C6 6/6	6X4 6/6	12C06 15/15	30P19 15/6	927 5/5	DF96 7/6	EB93 9/9	EF56 6/6	EY88 8/8	MH4 8/8	R18 14/14	UF45 11/11
1R4 7/6	6AK5 9/9	6C6 6/6	6X4 6/6	12C06 15/15	30P19 15/6	927 5/5	DF96 7/6	EB93 9/9	EF56 6/6	EY88 8/8	MH4 8/8	R18 14/14	UF45 11/11
1R5 7/6	6AK5W 9/9	6C6 6/6	6X4 6/6	12C06 15/15	30P19 15/6	927 5/5	DF96 7/6	EB93 9/9	EF56 6/6	EY88 8/8	MH4 8/8	R18 14/14	UF45 11/11
1R2 6/6	6AK6 11/6	6C6 6/6	6X4 6/6	12C06 15/15	30P19 15/6	927 5/5	DF96 7/6	EB93 9/9	EF56 6/6	EY88 8/8	MH4 8/8	R18 14/14	UF45 11/11
1R4 5/6	6AK7 6/6	6C6 6/6	6X4 6/6	12C06 15/15	30P19 15/6	927 5/5	DF96 7/6	EB93 9/9	EF56 6/6	EY88 8/8	MH4 8/8	R18 14/14	UF45 11/11
1R5 5/6	6AL3 8/6	6C6 6/6	6X4 6/6	12C06 15/15	30P19 15/6	927 5/5	DF96 7/6	EB93 9/9	EF56 6/6	EY88 8/8	MH4 8/8	R18 14/14	UF45 11/11
1T4 4/6	6AL5 3/3	6C6 6/6	6X4 6/6	12C06 15/15	30P19 15/6	927 5/5	DF96 7/6	EB93 9/9	EF56 6/6	EY88 8/8	MH4 8/8	R18 14/14	UF45 11/11
1T9GT 8/6	6AM6 5/6	6C6 6/6	6X4 6/6	12C06 15/15	30P19 15/6	927 5/5	DF96 7/6	EB93 9/9	EF56 6/6	EY88 8/8	MH4 8/8	R18 14/14	UF45 11/11
1U4 8/6	6AM6 4/6	6C6 6/6	6X4 6/6	12C06 15/15	30P19 15/6	927 5/5	DF96 7/6	EB93 9/9	EF56 6/6	EY88 8/8	MH4 8/8	R18 14/14	UF45 11/11
1U5 9/6	6AN8 10/6	6C6 6/6	6X4 6/6	12C06 15/15	30P19 15/6	927 5/5	DF96 7/6	EB93 9/9	EF56 6/6	EY88 8/8	MH4 8/8	R18 14/14	UF45 11/11
1V2 9/6	6AQ6 6/6	6C6 6/6	6X4 6/6	12C06 15/15	30P19 15/6	927 5/5	DF96 7/6	EB93 9/9	EF56 6/6	EY88 8/8	MH4 8/8	R18 14/14	UF45 11/11
1X2B 7/6	6AQ6 10/6	6C6 6/6	6X4 6/6	12C06 15/15	30P19 15/6	927 5/5	DF96 7/6	EB93 9/9	EF56 6/6	EY88 8/8	MH4 8/8	R18 14/14	UF45 11/11
2A3 7/6	6AR5 6/6	6C6 6/6	6X4 6/6	12C06 15/15	30P19 15/6	927 5/5	DF96 7/6	EB93 9/9	EF56 6/6	EY88 8/8	MH4 8/8	R18 14/14	UF45 11/11
2C26A 10/10	6AN5 7/7	6C6 6/6	6X4 6/6	12C06 15/15	30P19 15/6	927 5/5	DF96 7/6	EB93 9/9	EF56 6/6	EY88 8/8	MH4 8/8	R18 14/14	UF45 11/11
2C29A 14/6	6AR6 16/16	6C6 6/6	6X4 6/6	12C06 15/15	30P19 15/6	927 5/5	DF96 7/6	EB93 9/9	EF56 6/6	EY88 8/8	MH4 8/8	R18 14/14	UF45 11/11
2C40 8/6	6AT6 6/6	6C6 6/6	6X4 6/6	12C06 15/15	30P19 15/6	927 5/5	DF96 7/6	EB93 9/9	EF56 6/6	EY88 8/8	MH4 8/8	R18 14/14	UF45 11/11
2C51 8/6	6AD6 5/6	6C6 6/6	6X4 6/6	12C06 15/15	30P19 15/6	927 5/5	DF96 7/6	EB93 9/9	EF56 6/6	EY88 8/8	MH4 8/8	R18 14/14	UF45 11/11
2C53 7/6	6AV6GTA 6/24	6C6 6/6	6X4 6/6	12C06 15/15	30P19 15/6	927 5/5	DF96 7/6	EB93 9/9	EF56 6/6	EY88 8/8	MH4 8/8	R18 14/14	UF45 11/11
2C64 10/10	6AN5 7/7	6C6 6/6	6X4 6/6	12C06 15/15	30P19 15/6	927 5/5	DF96 7/6	EB93 9/9	EF56 6/6	EY88 8/8	MH4 8/8	R18 14/14	UF45 11/11
2D21 6/6	6AR6 16/16	6C6 6/6	6X4 6/6	12C06 15/15	30P19 15/6	927 5/5	DF96 7/6	EB93 9/9	EF56 6/6	EY88 8/8	MH4 8/8	R18 14/14	UF45 11/11
2E24 5/6	6AWA11 1/1	6C6 6/6	6X4 6/6	12C06 15/15	30P19 15/6	927 5/5	DF96 7/6	EB93 9/9	EF56 6/6	EY88 8/8	MH4 8/8	R18 14/14	UF45 11/11
2E26 30/30	6AX4GTB 6K6 12/12	6C6 6/6	6X4 6/6	12C06 15/15	30P19 15/6	927 5/5	DF96 7/6	EB93 9/9	EF56 6/6	EY88 8/8	MH4 8/8	R18 14/14	UF45 11/11
2K25 140/140	6A 9/4	6C6 6/6	6X4 6/6	12C06 15/15	30P19 15/6	927 5/5	DF96 7/6	EB93 9/9	EF56 6/6	EY88 8/8	MH4 8/8	R18 14/14	UF45 11/11
2X2 7/7	6AX6GT 6J50T 6/6	6C6 6/6	6X4 6/6	12C06 15/15	30P19 15/6	927 5/5	DF96 7/6	EB93 9/9	EF56 6/6	EY88 8/8	MH4 8/8	R18 14/14	UF45 11/11
3A4 4/4													

# APPOINTMENTS VACANT

**DISPLAYED SITUATIONS VACANT AND WANTED:** £7 per single col. inch.

**LINE advertisements (run-on):** 8/- 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 5/-.

**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., 10th SEPT., for the OCTOBER issue, subject to space being available.

## Electrical & Electronic Engineering Assistants

As a civilian Engineering Assistant in the Naval Production Pool you'd procure, inspect and test electronic equipment for radio communications, sonar, radar, and missile and weapon control.

The job includes preparing production specifications and working closely with contractors to maintain standards. Offices are located in London, Slough and Copenacre, near Bath.

To apply, you should have an ONC or equivalent. The grade you start at depends on the qualifications and experience you have, as there are two levels of entry. Most of the openings, though, are at Grade II. That grade pays £1,643-£1,897. Grade III pays £1,092 at 21, rising to a maximum of £1,643. (£125 a year more on all appointments in London.) There is also a non-contributory pension.

Prospects of promotion to posts paying over £3,000 are good, and career planning means you'd work on more than one location.

Interested? Write for details and an application form (to be returned by 8th September) to: The Civil Service Commission, Alencon Link, Basingstoke, Hampshire. Please quote S/625/MOD(N)/M.

## A CIVILIAN CAREER IN NAVAL ENGINEERING



INDEPENDENT TELEVISION NEWS LIMITED

### SENIOR ENGINEER—VTR

At the new ITN facilities centre in London. The post is in a small section working with the latest colour equipment and handling the recording, editing and playback of news items received from the U.K. and abroad via Eurovision and Satellite links. The work also involves some colour film recording.

Several years' experience of operation and maintenance of quadruplex VIDEO TAPE RECORDERS is required, preferably under broadcast conditions.

*Commencing salary £2,461 per annum (ACTT Category B)*

*Contributory Pension Scheme and Free Life Assurance.*

*Please telephone the Personnel Office 01-637 2424 for an application form.*

## RADIO OPERATORS

There will be a number of vacancies in the Composite Signals Organisation for experienced Radio Operators in 1971 and in subsequent years.

Specialist training courses lasting approximately nine months, according to the trainee's progress, are held at intervals. Applications are now invited for the course starting in January, 1971.

During training a salary will be paid on the following scale:

Age 21	£848 per annum
" 22	£906 "
" 23	£943 "
" 24	£981 "
" 25 and over	£1,023 "

Free accommodation will be provided at the Training School.

After successful completion of the course, operators will be paid on the Grade 1 scale:

Age 21	£1,023 per annum
" 22	£1,087 "
" 23	£1,150 "
" 24	£1,214 "
" 25 (highest age point)	£1,288 "

then by six annual increases to a maximum of £1,749 per annum.

Excellent conditions and good prospects of promotion. Opportunities for service abroad.

Applicants must normally be under 35 years of age at start of training course and must have at least two years' operating experience. Preference given to those who also have GCE or PMG qualifications.

Interviews will be arranged throughout 1970.

Application forms and further particulars from: Recruitment Officer, Government Communications Headquarters, Oakley, Priors Road, CHELTENHAM, Glos., GL52 5AJ Telephone No. Cheltenham 21491, Ext. 2270

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## ELECTRONICS SERVICE ENGINEER

is required to service a range of Electronic Desk Calculators at the Sanyo Sales and Service centre in London.

Basic Qualifications: C. & G. Electronics Service Certificate or equivalent. Consideration would be given, however, to previous experience in this field.

Salary Range: £1,350 to £1,500 per annum, according to qualifications and/or experience.

Write or phone in first instance to:

E. J. Landon, Esq.,  
Calculator Division Service Manager,

SANYO MARUBENI (U.K.) LTD.,  
Bushey Mill Lane, Watford, Herts.

Tel.: WATFORD 25354

738

709

711

# CONTINUOUS EXPANSION

Standard Telephones & Cables, Microwave and Line Division based at Basildon are growing fast. In order to keep pace with this consistent growth rate we require the following

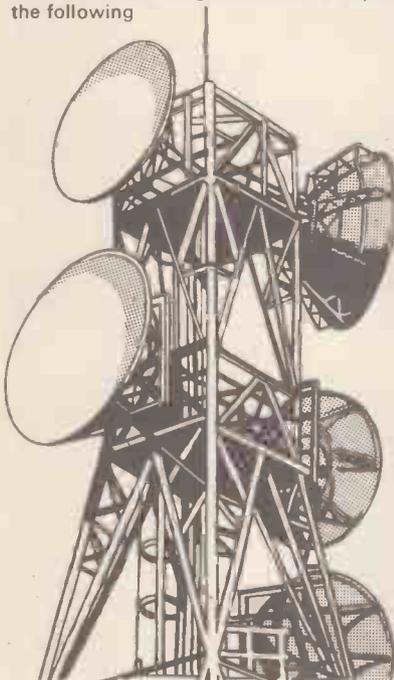
## Installation Engineers Technicians & Testers

Ref. 25720

To test and commission Multiplex, Co-axial Line and Microwave Radio Systems.

Ideal candidates will be less than 45 years of age with practical experience on some of the above equipment. These challenging posts call for drive, initiative and common sense. It is necessary for applicants to be prepared to work anywhere in the U.K.

*Applications should be addressed to  
The Personnel Officer,  
STC Chester Hall Lane,  
Basildon, Essex.*



## Test Technicians

Ref. 27221

The diversity of products manufactured at the Basildon Plant demands experienced testing staff for work on complex transmission systems.

Candidates should hold an ONC in electrical engineering and be able to offer considerable practical experience in the field of testing and fault clearing all types of land-unit, pcm and microwave equipment.

# STC

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# BROADCASTING ENGINEERS UGANDA

- ★ Salary £2,010—£2,506 according to experience.
- ★ Low Taxation.
- ★ 25% Gratuity.
- ★ Contract 21-27 months.
- ★ Subsidised accommodation.
- ★ Education Allowances.

The officer will undertake senior operational duties including the maintenance of broadcasting equipment in transmitting stations in remote districts.

Candidates should possess City and Guilds Final Certificate in Telecommunications (with Radio) or equivalent and have wide practical experience of technical broadcasting equipment particularly high power M.F. transmitting equipment.

Apply to CROWN AGENTS; 'M' Division, 4 Millbank, London, S.W.1., for application form and further particulars stating name, age, brief details of qualifications and experience and quoting reference M2K/690995/wf



# Go places as a Computer Service Engineer

Men under 35 with experience in light engineering and electronics can build excellent careers in ICL servicing computers.

We want qualified men with HNC or C & G in electronics engineering, or a Forces training in electronics. Or, perhaps, you have a similar qualification which proves you have the serious interest in the subject necessary for further specialist training.

We pay realistic salaries while you train—about six months—on ICL equipment, learning how to sort out operational problems and maintain computers in peak condition.

You will have to take responsibility for highly sophisticated and expensive equipment, so if you have a worthwhile career in mind, here is the chance to apply your expertise and initiative to the full. Career progression and promotion are limited only by your ability.

On top of your basic salary we pay generous overtime and shift rates, plus travelling expenses. Working conditions in ICL are well above the average in industry.

Write giving brief details of your career, quoting reference WW 103 C.  
A. E. Turner, International Computers Limited,  
85/91 Upper Richmond Road, Putney, London SW15.

International Computers

ICL

## If you can put a 'Yes' in every box, you might just make a RADIO TECHNICIAN in Air Traffic Control

An all-consuming interest in telecommunications

At least one year's practical experience in telecommunications, preferably with 'ONC' or 'C and G' technical qualifications

A highly developed sense of responsibility

Willingness to undergo a rigorous programme of training

Aged 19 or over

**To the right man, the National Air Traffic Control Service offers the prospect of an interesting and steadily developing career as a Radio Technician in air traffic control.**

The work involves the installation and maintenance of some of the very latest electronic equipment at civil airports, radar stations and other specialist establishments all over the country. Important today, the job will become increasingly vital as Britain's air traffic continues to grow, and prospects for promotion are excellent. Starting salary varies from £1,044 (at 19) to £1,373 (at 25 or over). Scale maximum £1,590 (higher rates at Heathrow). The annual leave allowance is good, and there is a non-contributory pension for established staff.

If you feel you can meet the demands of this rather special job—and you have a strong determination to succeed—you are invited to complete the coupon below.

Send this coupon for full details and application form  
To: A. J. Edwards, C Eng, MIEE,  
The Adelphi, Room 705, John Adam Street, London WC2,  
marking your envelope "Recruitment".

Name.....

Address.....

WWT/G2

Not applicable to residents outside the United Kingdom

**NATCS**  
National Air Traffic Control Service

## Sea-going Radio Officers can now make sure of a shore job and good pay.

If you'd like a job ashore, at a United Kingdom Coast Station, the Post Office will start you off on £965—£1,215, depending on age, with annual rises up to £1,650 (salaries are under review) and good prospects of promotion to higher posts.

You will need to be 21 or over, with a 1st Class Certificate of Competence in Radiotelegraphy issued by the Postmaster General, or the Ministry of Posts and

Telecommunications, or an equivalent certificate issued by a Commonwealth administration or the Irish Republic.

Find out more by writing to:—

The Inspector of Wireless Telegraphy,  
External Telecommunications Services,  
Wireless Telegraph Section ( ww ),  
Union House,  
St. Martins-le-Grand,  
London, E.C.1.

**Post Office**  
Telecommunications

691

# ASSISTANT ENGINEER GRADE II (BROADCASTING) BOTSWANA

- ★ Salary up to £2,387
- ★ Low taxation
- ★ Appointments grant £100 or £200 in certain circumstances
- ★ 25% gratuity on basic salary
- ★ Contract 24 – 36 months
- ★ Subsidised Accommodation
- ★ Education Allowances

The Posts and Telecommunications Department requires an officer to undertake operational duties including the installation and maintenance of broadcasting equipment in transmitting stations and to assist with the training of junior engineering staff.

Candidates must possess the City and Guilds Intermediate Certificate (Telecommunications) or equivalent and have had five years relevant practical experience, (additional to any period of approved training) of technical broadcasting equipment including M.F. and H.F. transmitting equipment up to 10 KW.

Apply to CROWN AGENTS, 'M' Division, 4 Millbank, London, S.W.1., for application form and further particulars stating name, age, brief details of qualifications and experience and quoting reference number M2K/690420/WF.

SCIENCE RESEARCH COUNCIL

RADIO AND SPACE RESEARCH STATION  
**OPERATIONS SUPERVISOR—**  
 FALKLAND ISLANDS

An Operations Supervisor is required for service at the European Space Research Organisation Satellite Telemetry Station at Stanley, Falkland Islands. He will be responsible to the Station Director for planning the operation and maintenance of the radio telemetry equipment used for the reception of data from satellites. The grade will be that of Experimental Officer and the post carries a responsibility allowance. The tour of duty will be of three years duration. A hostel is available for single staff and married staff will be accommodated, rent free, in a modern, well furnished, centrally-heated bungalow.

**Qualifications** Aged 26 or over with a University degree, H.N.C. or equivalent. Experience in the operation and maintenance of electronic equipment and in the management of a small group of staff would be advantageous.

**Salary** Between £1725 and £2177 p.a. To this scale will be added an allowance of £125, together with a responsibility allowance of £100 and an overseas allowance.

A car and baggage within certain limits will be transported free of charge.

Apply: The Secretary,  
 Radio and Space Research Station,  
 Ditton Park,  
 Slough,  
 Bucks  
 Telephone: SLOUGH 24411

Closing date 18 September, 1970

729



have vacancies in Cardiff for Technical Assistants/Assistant Engineers in Telecine/VTR and Electronic Maintenance Departments.

Applicants should have basic theoretical and practical electronic and broadcasting experience.

Salary as ACTT. Grade H/E as appropriate.

Apply in writing to:  
**The Personnel Department**  
**HTV Television Centre**  
**CARDIFF CF1 3JG**

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**TELECOMMUNICATIONS ENGINEERS**  
**WEST AFRICA**

Qualified Telecommunications Engineers are required for servicing and maintenance of radiotelephone equipment and associated items in tropical West Africa.  
 Qualifications: HNC or higher.  
 Contract: One year plus leave extensible.  
 Salary: According to age, experience and qualifications. Commencing at not less than equivalent £2000 sterling. Free accommodation and passages. Preference for bachelors with tropical experience but not essential.

Interested? Apply for application form to:

**C.O.D.E.C.O.**  
 2b - Sussex Road - New Malden - Surrey  
 635



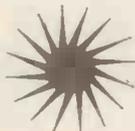
**RADIO & TELEVISION SERVICING**  
**RADAR THEORY & MAINTENANCE**

This private College provides efficient theoretical and practical training in the above subjects. One-year day courses are available for beginners and shortened courses for men who have had previous training.

Write for details to: The Secretary, London Electronics College, 20 Penywern Road, Earls Court, London, S.W.5. Tel.: 01-373 8721.

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**REDIFFUSION**



**ENGINEER — COLOUR TELEVISION**

We are growing even bigger in colour television and our factories at Chessington and Bishop Auckland are now producing hundreds of colour sets every week. The next few years will see us growing even more, as colour television spreads throughout the country. Our modern Engineering Department at Chessington, which designs our colour and monochrome receivers as well as all the specialised test equipment, needs two Engineers who are interested in television and wish to join an expanding organisation. The right applicants will have obtained their HNC or equivalent but consideration will be given to day release for those still studying.

Assistance with removal expenses will be given if required.

Replies please to:

The Chief Engineer  
 Rediffusion Vision Limited  
 Fullers Way South  
 Chessington  
 Surrey

735

**ST. BARTHOLOMEW'S**  
**HOSPITAL,**  
**LONDON E.C.1**

**Computing Unit for**  
**Medical Sciences**

**PROGRAMMER**

required in the Computing Unit for Medical Sciences which has been set up by St. Bartholomew's Hospital and Medical College. The aim of this science-based Unit is to help enlarge and develop the use of computer technology in medicine, especially in the area of patient monitoring in operating theatres and wards. In this and other applications it is expected that interactive computer graphics will play an important role. The Unit has also an educational commitment. A large-configuration Honeywell DDP-516 is due for installation in the very near future, and will be the latest addition to the computing facilities already available in various departments of both Hospital and College. Applicants should have programming experience, against a background of electronics, physics or a biological subject. A degree or equivalent qualification is desirable.  
 Salary scale: £1,100 to £1,400 per annum.  
 Applications, accompanied by a full curriculum vitae and naming two referees, should be sent to the Clerk to the Governors by 3rd September, 1970, quoting reference ASC/2589.

712

# Electronics Maintenance Engineers

There are excellent opportunities in the Installation and Maintenance Division of U.K. Electronics and Industrial Operations of E.M.I. Ltd., at Hayes, Middlesex, for engineers to carry out maintenance work on a wide variety of electronic equipments including laboratory test gear and trans-mitters.

Candidates should be between 21 and 45 years of age and have some experience in this type of work. Consideration will be given to experienced Radio and Television servicing technicians and to ex service personnel.

Commencing salaries of up to £1,500 per annum will be paid and staff conditions include contributory pension scheme and free life assurance.

*Please apply in writing giving brief personal and career details to:*

**J. J. Sweetman, Personnel Department,  
U.K. Electronics & Industrial Operations,  
E.M.I. Ltd., Blyth Road,  
Hayes, Middlesex.  
Tel: 01-573 3888, Ext. 411.**



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## radio..electrical.. electronics engineers

You probably don't realise that your experience and training could put you in line for a key job in the computer world. Right now, you could be a T.V. or telephone maintenance engineer, an ex-Serviceman with an electronics background or simply have an electrical or electronics qualification providing you have the ability and ambition we'll help you mould your talents into a specialised skill.

Burroughs, one of the largest international electronics companies will train you to become a

member of a highly experienced team of Electronics Field Engineers—men who install and maintain some of today's most advanced computer systems. You can work in your own home area, and at the same time find variety through working with our many clients in the course of your job. And, of course, you will earn a good salary. But, most important of all, you will have true career prospects—because we believe in quickly rewarding talent. . . . Promotion to senior management is purely dependent upon ability.

The opportunity is here—if you have the will then we have the way. The rewards are undoubtedly high and we offer a number of excellent employment benefits, including a special company-assisted car purchase scheme.

Here are the brief facts—but you can find out more by writing with details of your age, qualifications and experience to:

Geoff Lewis,  
Personnel Manager,  
**Burroughs Machines Ltd.**, Dept. WW/S,  
Heathrow House, Cranford,  
Hounslow, Middlesex.

**B** Burroughs

# Glaxo

## ELECTRONICS TECHNICIAN

### Chemical Research

The Physical Chemistry Unit of Glaxo Research Limited requires an electronics technician who will be primarily concerned with the design and building of electronic devices for chemical research. The work will also involve the maintenance and evaluation of modern electronic instruments.

Candidates should preferably possess 'A' level chemistry and physics and have attained HNC standard in electronics, or be studying for HNC. Further training will be given in the laboratories and day release for further studies is available.

Glaxo offers generous salary scales, holiday and sick pay allowances and welfare and social facilities



Applicants should write giving brief details and quoting reference ZH185 to the Personnel Officer (MRG), Glaxo Laboratories Limited, Greenford, Middlesex.

## SENIOR TECHNICIAN (Grade III)

with electrical and preferably some mechanical experience to maintain Therapeutic X-Ray equipment at the Royal Marsden Hospital, Fulham Road, London, SW3.

The successful candidate will also have the opportunity to develop new equipment.

Minimum qualifications, O.N.C. in Electrical Engineering, and not less than 3 years' technical experience, to obtain salary on scale £1,270 to £1,590 per annum.

Applications, with details of experience and names of two referees, to the Administrator, the Royal Marsden Hospital, Fulham Road, London, SW3.

717

## THE UNIVERSITY OF MANCHESTER EXPERIMENTAL OFFICER

Experimental Officer required in the Department of Engineering to assist in development and use of high-speed data logging equipment for application to research on internal combustion engines and on fluid mechanics. The equipment will be based upon commercially available units. Principal duties are the initial assembly of the equipment, the preparation of control programs, the development of the completed facility, and the supervision of maintenance. Applicants must have knowledge of and experience in electronic technology. Experience of digital computers and some knowledge of programming desirable, but an applicant judged able to learn could be accepted. Appointment initially for up to three years. Salary £1,370-£1,555 p.a. Further details and forms of application (returnable by August 28th) from the Registrar, The University, Manchester, M13 9PL. Quote ref: 166/70/VVV.

718

## ELECTRONIC ENGINEERS

Service Engineers required for Offices, throughout the United Kingdom, of well-known Company manufacturing Electronic Desk Calculating Machines. Applicants should possess a sound knowledge of basic Electronics with experience in Electronics, Radar, Radio and T.V. or similar field. Position is permanent and pensionable. Comprehensive training on full pay will be given to successful applicants. Please send full details of experience to the Service Manager, Sumlock Comptometer Ltd., 102/108 Clerkenwell Road, London, E.C.1.

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## JUNIOR TECHNICAL OFFICER

required for permanent post to assist with commissioning, operation and development of a whole body counter equipped with on line computer processing. Some experience of electronics essential. Age under 30. Two Science 'A' levels, or if over 21 H.N.C. or pass degree. Salary according to age and experience. Write stating full details to Director, Medical Research Council Cyclotron Unit, Hammersmith Hospital, London, W.12.

696

# Test Engineers

Due to further expansion we offer excellent opportunities for Test Engineers to make a rewarding career with excellent prospects testing a wide range of complex electronic navigational equipment.

Applicants with a background of T.V. and Radio Servicing, Electronic Control Circuitry and Computers circuits should apply as soon as possible giving details of past experience. An H.N.C. would be an asset.

Conditions of service and salaries are excellent.

# DECCA



Apply to: The Personnel Officer,  
The Decca Navigator Company Limited,  
88 Bushey Road,  
Raynes Park,  
London, S.W.20.

Tel. No: 946 8011.

## TECHNICAL ASSISTANT

A vacancy occurs in the Medical Electronics Department, St. Thomas' Hospital, for a technical assistant, aged 18 to 26.

The work is concerned with the construction and testing of experimental electronics equipment. Some workshop experience is necessary, and wiring/assembly experience would be an advantage. Salary on scale £683-£1,454 plus £125 London Weighting. This is a Medical School appointment but applicants should write in the first instance to the Personnel Officer, St. Thomas' Hospital, London, S.E.1, quoting ref. L/28.

698

## UNIVERSITY OF BRADFORD AUDIO VISUAL AIDS UNIT TELEVISION ENGINEER

Applications are invited for superannuable appointment as (Ref: AVA/E1/Z)

to be responsible for all aspects of the operation and maintenance of closed circuit television equipment including studio practice. The person appointed will possess wide and detailed knowledge and experience of the field of television, including cameras and videorecorders. He will probably be a graduate or possess an appropriate H.N.C., H.N.D. and/or corporate membership of I.E.E. or I.E.R.E.

Five-day week. Salary on scale rising to £2,427 dependent upon qualifications and experience.

Further particulars and application forms (to be returned as soon as possible) from the Personnel Officer, University of Bradford, Bradford, Yorkshire, BD7 1DP.

695

**BBC**

have a vacancy for an

**ENGINEER**

in the Designs Department

Candidates for this post will be engaged in the design of new systems, equipment and test apparatus for use at radio frequencies including both television and audio applications.

Applicants must possess a University degree or equivalent qualification. Experience of transmitter and receiver techniques is desirable, together with a good knowledge of circuit theory.

Salary, depending upon experience, would be initially between £2,395 and £2,625 p.a. rising to a maximum of £2,970 p.a. Candidates with limited experience will also be considered but may be appointed on a salary scale from initially £2,150 to £2,346 p.a. rising to a maximum of £2,640 p.a.

Applicants should be citizens of, and permanently resident in, the United Kingdom.

Requests for application form to

The Engineering Recruitment Officer,  
BBC, Broadcasting House,  
London W1A 1AA

quoting reference YO.E.22 53. W.W.



708

**Microwave  
Installation  
Controller**

This high-level appointment carries responsibility for planning and controlling the installation and commissioning of 7GHZ and 11GHZ systems. ITA, the BBC, the Post Office and HM Government are among the organisations purchasing this equipment.

Resulting from expanded operations in this sphere, the position demands a professional approach based on several years experience in the broad-band field—and proven success in major microwave projects.

Salary will amply reflect the considerable degree of responsibility involved. Excellent fringe benefits are another attraction—but perhaps the most important factor is that present large-scale Pye Telecom growth is creating tremendous opportunities.

Pye Telecom is an ideal Company for ambitious people. If your background suits you for this job, write now, giving career and present salary details, to: M. W. Timmins Esq.,



**Pye Telecommunications Ltd**



Newmarket Road, Cambridge.

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**UNIVERSITY RESEARCH  
ASSISTANT**

Post for Electronic Engineer available for development and maintenance of electron micro-analyser and other specialised equipment. Thorough knowledge of both linear and digital transistor or circuitry essential. H.N.C. standard or equivalent experience required. *Full details from:*

**Dr. E. T. HALL**

Research Laboratory for Archaeology

6 Keble Road, Oxford Interviews starting 14.9.70

728

**SOUTHAMPTON GROUP HOSPITAL  
MANAGEMENT COMMITTEE**

AND

**BOURNEMOUTH AND EAST DORSET  
GROUP HOSPITAL MANAGEMENT  
COMMITTEE**

Applicants should be suitably qualified for the following posts in the Electronics Department at Southampton General Hospital or Poole General Hospital:

(i) **ELECTRONICS TECHNICIAN I** (qualifications: H.N.C., City and Guilds Final or equivalent qualification);

(ii) **ELECTRONICS TECHNICIAN IV** (qualifications: O.N.C. or H.N.C. or membership of the Society of Radiographers);

(iii) **STUDENT TECHNICIAN**

Salary Scales: (i) £1,800 by five annual increments to £2,100;

(ii) £1,020 by eight annual increments to £1,310;

(iii) Salary applicable to age.

This department is 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 Senior Medical Staff.

Applications giving full details—including qualifications, experience and names of two referees—to the Group Engineer, Southampton Group H.M.C., Coxford Road, Southampton, SO1 6JW, by the 21st August, 1970.

741

**GEC-Marconi Electronics****TECHNICIANS AND  
ENGINEERS FOR ST. ALBANS  
AND LUTON****QUALIFIED OR NOT!**

**VACANCIES** exist for work on testing and calibrating valve and solid-state electronic measuring equipments embracing all frequencies up to u.h.f. in Production, Service and Calibration departments.

**APPLICATIONS** are invited from people of all ages with experience or formal training in electronics and from ex-Armed Services technicians.

**HIGHLY COMPETITIVE SALARIES**, negotiable and backed by valuable fringe benefits.

**RE-LOCATION EXPENSES** available in many instances.

**CONDITIONS** excellent; free life assurance, pension schemes, canteen, social club.

37½-hour, 5-day, office-hours week.

**WRITE** or phone Personnel Department stating age, details of previous employment, training, qualifications, approximate salary required, quoting WW 6



**MARCONI INSTRUMENTS LIMITED,**  
Longacres, St. Albans, Herts.

Tel: St. Albans 59292

Luton Airport, Luton, Beds.

Tel: Luton 31441.

A GEC-Marconi Electronics Company



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## A real opportunity for all Service and Calibration Engineers

Are you capable of working on sophisticated electronic telecommunications equipment?—If you are read on, as Our Technical Service Department has vacancies for Service and Calibration Engineers with at least 3 years experience in the Industrial repair and calibration fields.

Ideally the right men will possess either H.N.C., C. & G. Full Tech., D.N.C. or equivalents. Salaries will be related to experience and qualifications whilst excellent prospects for promotion exist for the right man. Informal discussion will be held at our main offices, write giving full details to:

**Manager,  
Technical Services Department,  
Aveley Electric Ltd.,  
Arisdale Avenue,  
South Ockendon,  
Essex.**

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**WE KNOW YOU WANT A BETTER JOB  
and what is more WE WILL HELP YOU FIND IT.**



Experienced engineers in Design and Development, Systems Test, Technical Sales, Production Engineering, Field Service or Technical Writing should

**Contact Electronics Appointments Ltd.**  
and we will help you.

Our placement service is professional, specialised and completely confidential. We are in consultation with over 800 companies on all aspects of electronics engineering.

Phone or write at any time quoting WW 101.

**NORMAN HOUSE · 105/109 STRAND · LONDON · W.C.2**  
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## REDIFFUSION

### COLOUR TELEVISION FAULTFINDERS & TESTERS

We have a number of vacancies in our Production Test Departments for experienced faultfinders and testers.

Knowledge of transistor circuitry and experience with Colour Receivers together with R.T.E.B. Final Certificate or equivalent qualifications required.

These will be staff appointments with all the expected benefits.

Applications to:

**Works Manager,  
Rediffusion Vision Service Ltd.,  
Fullers Way South,  
Chessington, Surrey (near Ace of Spades).  
Phone: 01-397 5411**

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### MEDICAL ENGINEERING IN HOSPITALS MEDICAL ELECTRONICS TECHNICIAN

required in the  
Northampton Group of Hospitals

to service, repair and calibrate a wide range of electronic equipment used in hospitals for medical, surgical and engineering purposes.

Candidates should have good practical experience in radio/telecommunications, pulse generation, automatic control systems or electro-medical equipment. Possession of HNC or HND in electronics or a comparable qualification would be an advantage. Opportunities for further study and training available. Salary scale £1,180-£1,500.

If you are interested in receiving further details of this opportunity, please write to the Group Secretary, Northampton and District Hospital Management Committee, General Hospital, Northampton, NN1 5BD. 697

### UNIVERSITY OF DURHAM DEPARTMENT OF APPLIED PHYSICS AND ELECTRONICS

#### EXPERIMENTAL OFFICER

Applications are invited for the post of EXPERIMENTAL OFFICER in ELECTRONICS from 1 October, 1970. Applicants should be experienced in Instrumentation, Circuit Design, or Semiconductor Devices. The person appointed will assist in the design and development of electronic circuits for applications in the Department, and will be given an opportunity to take part in teaching.

Salary on the scale: £1,145 x £55—£1,310 x £65—£1,505 per annum with F.S.S.U.

Applications (3 copies), together with the names and addresses of three referees, should be sent by Friday, 28 August, 1970, to the Registrar & Secretary, Old Shire Hall, Durham, from whom further particulars may be obtained.

745

#### SITUATIONS VACANT

**A FULL-TIME** technical experienced salesman required for retail sales; write giving details of age, previous experience, salary required to—The Manager, Henry's Radio, Ltd., 303 Edgware Rd., London, W.2. [67]

**APPLICATIONS** are invited for the post of Technician in the Department of Psychology. The vacancy is for either a Workshop Technician with experience in metal working and general workshop techniques or an animal technician. The salary will be on the scale £935-£1,303 p.a. and the exact point of entry will depend on qualifications and experience. Apply in writing, quoting T.25, to Assistant Bursar (Personnel), University of Reading, Whitenights, Reading RG6 2AH. [722]

**ARE YOU INTERESTED IN HI FI?** If so, and you have some experience of selling in the Retail Radio Trade, an excellent opportunity awaits you at Telesonic Ltd., 92 Tottenham Court Road, London, W.1. Tel. 01-387 7467/8. [21]

**A SENIOR** Transformer/Rectifier design Engineer is required for varied and interesting projects associated with equipment up to 150/kVA/KW. We are an expanding Company of Manufacturing Electrical Engineers located in South Herts. Box W.W. 97 Wireless World.

**AUDIO ENGINEER** required by specialist Importer Distributor for work on Hi Fi equipment. Should have a keen interest in Hi-Fi and experience in this field. Excellent position with good prospects. Mr. Ruppin, Howland-West Ltd., 2 Park End, South Hill Park, London, N.W.3. Tel.: 01-794 6033. [703]

**REDIFON LTD.** require fully experienced TELECOMMUNICATIONS TEST ENGINEERS and ELECTRONICS INSPECTORS. Good commencing salaries. We would particularly welcome enquiries from ex-Service personnel or personnel about to leave the Services. Please write giving full details to—The Personnel Manager, Redifon Ltd., Broomhill Road, Wandsworth, S.W.18. [26]

### BALANCE ENGINEER

with Multi Trade Operating experience,  
required for large London Studio, phone  
437 2130

713

**UNIVERSITY OF OXFORD**, Department of Nuclear Physics, has a vacancy for a Senior Technician to join a group designing, building and maintaining advanced experimental electronic equipment for use by researchers in nuclear structure employing a twenty million volt accelerator. Experience in electronics is essential and a formal qualification an advantage. Salary on a scale rising to £1,592 with six weeks' paid leave per year. Write to T. L. Green, Nuclear Physics Laboratory, Keble Road, Oxford. Mentioning reference A.133. [725]

**UNIVERSITY OF LONDON KING'S COLLEGE**, Faculty of Education Mobile Recording Unit. **TECHNICAL ASSISTANT** required for the Mobile Recording Unit and for the organisation and maintenance of audio-visual aids within the Faculty. Applicants should have had experience in the maintenance of electronic equipment. The salary will be in accordance with the scales of College technicians and will be within the range £1,235-£1,403 per annum, including London Weighting. The appointment will be for one year in the first instance. Application forms and further particulars from the Head Clerk, King's College London, Strand, WC2R 2LS. Closing date for applications: 21st August, 1970. [726]

**UNIVERSITY OF SURREY. DEPARTMENT OF ELECTRONIC AND ELECTRICAL ENGINEERING. TECHNICIAN AND SENIOR TECHNICIAN** required in the Electronic and Electrical Engineering Department to service a wide range of electronic equipment and to build specialised electronic research apparatus. Applicants for the senior position should have had sufficient experience in the electronics field to enable them to work with the minimum of supervision. Appointments will be made on one of the following salary scales: Technician: £935-£1,303 per annum. Senior Technician: £1,278-£1,586 per annum. Applications in writing should be sent to the Staff Officer, University of Surrey, Guildford, Surrey, from whom application forms may be obtained. [736]

#### SITUATIONS WANTED

**SIGNALS OFFICER, MALAYSIAN GOVERNMENT**, whose post is being Malaysianized, seeks employment from the end of the year. Five years head of signals section with staff of 150 radio operators, technicians and administrative personnel engaged in operating and maintaining large rural HF/VHF communications network. Sound experience in the design, equipping and operation of a system comprising Collins, Racal, Redifon and Marconi equipment. This experience includes the preparation and general supervision of maintenance programmes and training of junior staff. Administrative interest and ability gained from being responsible for control of staff, budget, estimates, administration and technical details of Department communications. Knowledge of government bureaucracy and versed in the writing of reports. Able to conduct official correspondence in nearly fluent Malay. Age 28 and single. Presently resident Malaysia. Seeking employment in the telecommunications field. Nature of work and opportunities for promotion of more consideration than salary. Reply to Box WW 740, Wireless World.

#### ARTICLES FOR SALE

**BRAND NEW ELECTROLYTICS**, 15/16 volt, 0.5, 1, 2, 5, 8, 10, 20, 30, 40, 50, 100 mfd., 8.5d. Mullard 25 volt 6.4, 12.5, 25, 50, 80 mfd., 10d. 5% E12 series resistors—Carbon Film 1/2 watt 10 ohms to 1 Megohm, 1.5d., Wirewound 5 watt 15 ohms to 15,000 ohms, 10d. Postage 1/- per order. The C.R. Supply Co., 127 Chesterfield Road, Sheffield, S8. [99]

**BUILD IT** in a DEWBOX quality plastics cabinet. 2 in. X 2 1/2 in. X any length. D.E.W. Ltd. (W), Ringwood Rd., FERNDOWN, Dorset. S.A.E. for leaflet. Write now—Right now. [76]

**COLOUR T.V.** large-screen projectors, Cintel Model 20630. 6 ft. picture from R.G.B. Video inputs. Dismantled for storage. Two available. £100 each as seen. Phone 01-948 1414. [706]

**FOR SALE.** Panels, Units, Components, Meters, Special Valves, Avo's. Many more items. S.A.E. Lists. Mr. Frear, 1 Newton Street, Ulverston, Lancs. [715]

**FOR SALE:** 5 KVA 220 to 110 volt 50 HZ Transformer, £30 o.n.o. Box W.W. 720 Wireless World.

**HI-FI EQUIPMENT**—Radio Tape Recorders, complete systems supplied and installed. Spares & components. Radio and T.V. valves. First class repair service. Telephone Farnborough (Hants) 42590/49101. [705]

**MOBILE RADIO TELEPHONE EQUIPMENT.** The following used 25 kHz channelled low band radio telephone equipment are for sale. 1 Ultra T5A0, 41 Ultra 4A6 and 49 Ultra 4A4 (all with conversion kits for 12.5 kHz channelling), also 1 Murphy TR 1000, 9 Murphy TR 1005, 35 Murphy 960, 12 Murphy 821, 2 GEC BRT 192 and 4 GEC BRT 175. Offers should be made to The Purchasing Officer, The East Midlands Electricity Board, 398 Coppice Road, Arnold, Nottingham NG8 7EX, from whom further details may be obtained. [699]

**MUSICAL MIRACLES.** Send S.A.E. for details of Cymbals and Drum Modules, versatile independent bass pedal unit for organs, pianos or solo, musical novelties, waa-waa kits (49/-). Also bargain components list reed switches etc. D.E.W. Ltd., 254 Ringwood Road, Ferndown, Dorset. [95]

**NEW CATALOGUE** No. 18, containing credit vouchers value 10/-, now available. Manufacturers' new and surplus electric and mechanical components, price 4/6, post free. Arthur Sallis Radio Control Ltd., 28 Gardner Street, Brighton, Sussex. [94]

**SALE.** Wireless World (1930-1939). 29/6 dozen, WW1, 43 Dundonald Road, Colwyn Bay. [701]

**STC** Star Radiotelephone, single channel UHF, complete car installation, almost new, offers? Box W.W. 716 Wireless World.

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# Test Technicians

Our test department is expanding. It is responsible for the testing of magnetic storage devices, high-speed printers, punched-card and paper-tape equipment.

For people with experience in electronics, opportunities exist immediately. Further vacancies will arise over the next few months. Training will be given to those who do not have previous computer experience.

Applicants must have worked on the testing, maintenance or repair of electronic equipment, and preference will be given to those qualified to ONC (Elect.) or C & G Final.

Locations: Kidsgrove and Winsford. Both are situated in rural surroundings bordering on the Cheshire Plain. Housing is available at attractive prices, and assistance with mortgage can be arranged.

Write giving details of age, qualifications, and experience, to: Brian Buckley, Personnel Manager, International Computers Limited, Kidsgrove, Stoke-on-Trent, quoting reference WW498M.

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## TEST ENGINEERS

EKCO AVIONICS (A Division of Pye Telecommunications Ltd.) urgently require a number of Test Engineers for their expanding production lines.

They will be employed on the test and diagnosis of VHF equipment and a City and Guilds Radio and TV Servicing or Intermediate Telecommunications Certificate qualification would be preferred.

Salary commensurate with experience and qualifications. Excellent working conditions in very pleasant surroundings. Good fringe benefits and opportunities for promotion.

Write, Phone or Call: The Personnel Manager

**EKCO AVIONICS**

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We require a Technician grade 1 to assist in the maintenance and commissioning of our equipment. Knowledge of comprehensive modern testing procedures, appropriate maintenance experience and the ability to work alone to effect site repairs are essential. A current driving licence is required.

Initial salary £1,365-£1,725 p.a. with excellent conditions of employment including progression to Senior Technician and up to £1,968 p.a. on proven ability.

Please apply quoting ref. WW/A90 to the Senior Personnel Officer (Headquarters), West Midlands Gas Board, 5 Wharf Lane, Solihull, Warwickshire.



743

# TELECOMMUNICATIONS ENGINEER

A Telecommunications Engineer is required by a company manufacturing H.F. antennas. It is anticipated that the successful applicant has C. & F. full certificate, H.N.C. or degree, and preferably has some installation or similar experience in telecommunications.

The applicant will be expected, after training, to be able to prepare quotations, customer liaison, design minor modifications, supervise our workshop, liaise with suppliers and occasional supervision of installations.

The anticipated age range is 25 to 35. Salary negotiable. For proven results generous annual bonus on profits will be given and also the opportunity of becoming a Director of the company.

Contact the Managing Director.

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S. M. House, Osborne Road, Totton, Southampton, Hants.  
Telephone: Totton 4930

704

# ELECTRONICS TECHNICIANS

## Department of Physics

Senior Technician required to join a small team carrying out research into the applications of nuclear science, concerned with a wide variety of electronic counting and measuring equipment. Candidates should possess good experience and preferably qualifications in the design, construction and maintenance of modern electronics. Some experience of computer interfacing an advantage. Ref.: 113/B/447. Senior Technician/Technician required for the construction and maintenance of advanced electrical equipment. Qualifications and/or experience in pulsed digital equipment desirable. Ref.: 113/B/448.

Salary ranges:

Senior Technician .. £1,278 to £1,586  
Technician .. £935 to £1,303

Apply: Assistant Secretary (Personnel), Personnel Office, University of Birmingham, P.O. Box 363, Birmingham, B15 2TT.

719

# TECHNICIANS

The Margaret McMillan College of Education requires the following:

**AUDIO VISUAL AIDS TECHNICIAN—GRADE 2** —to be responsible for the maintenance and repair of audio visual aids equipment. Candidates should preferably possess City and Guilds Radio and Television Servicing Intermediate Certificate.

**JUNIOR TECHNICIAN—GRADE 1**—to assist in the maintenance of equipment and making of teaching aids. An interest in craft, e.g. woodwork, would be an advantage and candidates should preferably have 3 G.C.E. ('O' level) passes in appropriate subjects.

Salaries are in accordance with the N.J.C. Technicians' Grades, namely:

Grade 2—£942 to £1,089  
Grade 1—£429 to £942

Plus a qualification allowance of either £30 or £50 per annum where appropriate.

Application forms and further details of the posts may be obtained from the Senior Administrative Officer, Margaret McMillan College of Education, Trinity Road, Bradford 5, and should be returned within 14 days of the appearance of the advertisement.

744

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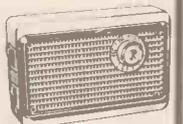
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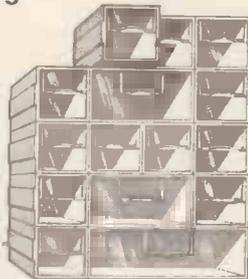
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