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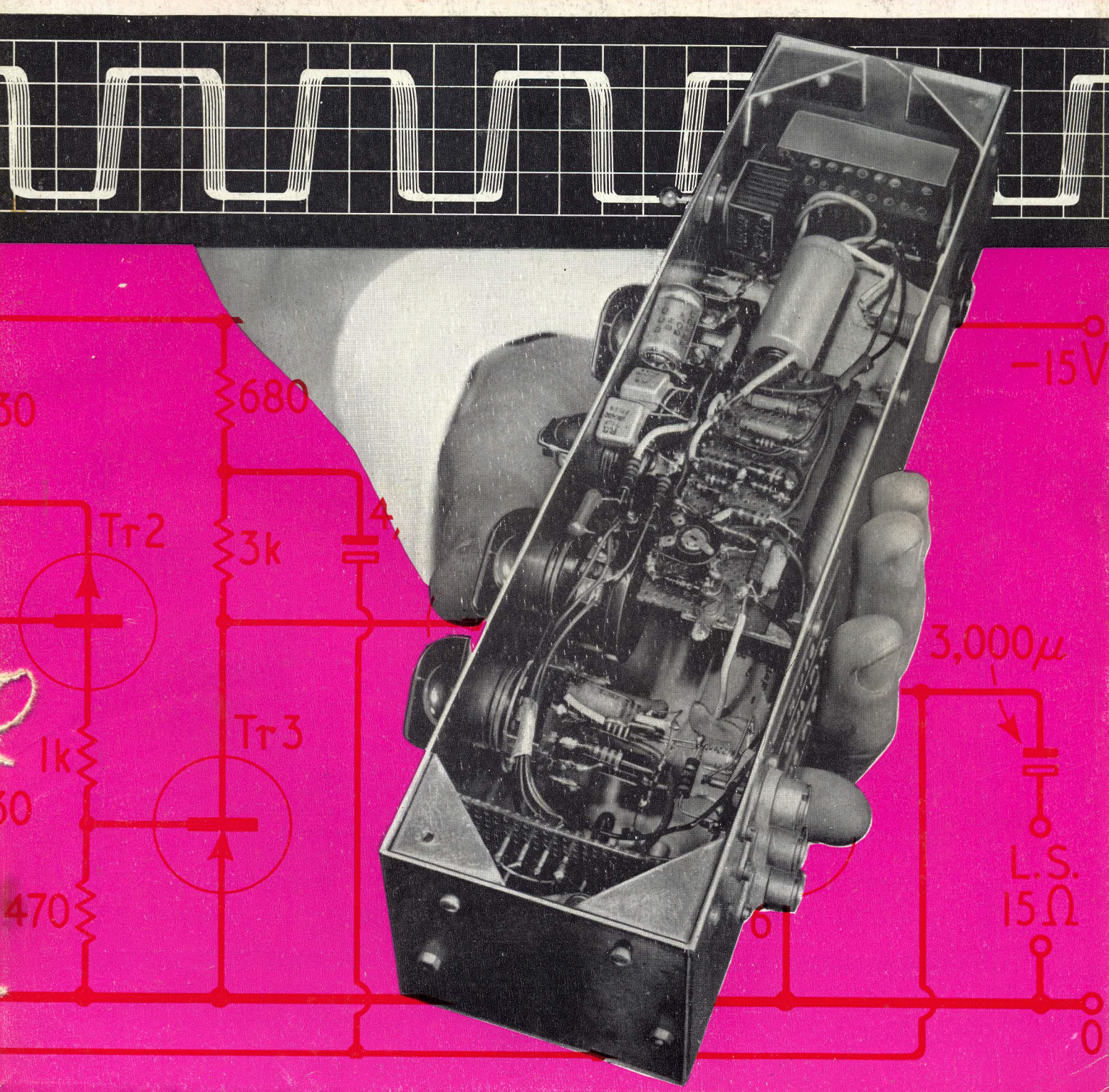

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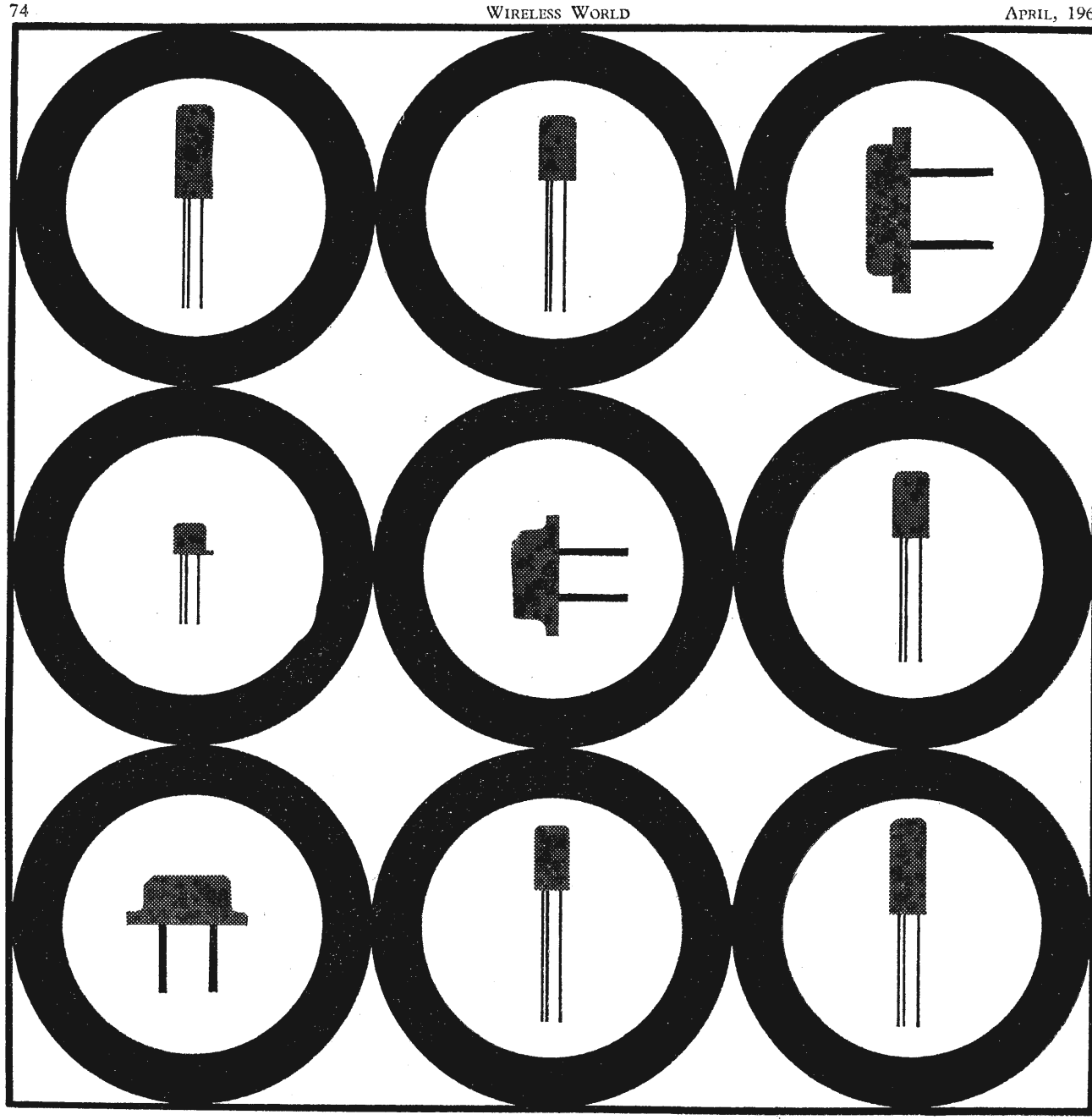

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## Audio Topics

WHAT will be the topics of conversation (occasionally of declamation) to be heard among the knots of enthusiasts as they move from floor to floor of the Audio Festival and Fair demonstrations at the Russell Hotel in London this month? Headphones *versus* loudspeakers, cross-field magnetic recording? Almost certainly transistor amplifiers of every class from A to D (pulse width modulated).

The choice of circuitry for transistor high-quality amplifiers is wider than ever and we foresee much argument between the devotees of what must now be regarded as the tried basic conventional designs of Toby and Dinsdale, Tharma and Osborne, and the modulated pulse amplifiers stimulated by D. R. Birt's article in this journal two years ago and represented in this issue by the design described by G. F. Turnbull and J. M. Townsend.

The advent of the transistor has reopened argument about the power ratings of amplifiers. This interests us not only because it is a frequent cause of wrangles between advertisers and customers (in spite of the fact that most of our readers are sufficiently well informed to apply the principle of *caveat emptor* effectively) but because it has shown how our attitudes and judgments in matters of this kind are conditioned by precedent.

Power in electrical engineering is the root-mean-square power of a sine wave. What more natural, then, than to rate an amplifier on the same basis, even though it is not normally used to boil an egg, make tea or even to reproduce sine waves?

No one is going to argue that an amplifier which will be called upon to reproduce music at a satisfying level in an average living room is any the worse for being able to sustain indefinitely an undistorted sine-wave power of, say, 10 watts r.m.s. which, incidentally, means that 20 watts peak power will be touched twice in every cycle. On music it will be called upon to touch peak power less than 1% of the time and the average power will be 20 dB below this, or 200 milliwatts if one is a purist and insists on preserving the dynamic range of the original sound. But the B.B.C. and the gramophone recording companies are not giving you the original peak powers anyway. If they did their service areas would shrink and the record groove walls would break down; both know to a nicety just how to fit good sound between the limits of background noise and overmodulation.

Thinking like electrical engineers in terms of sine-wave power has hitherto done no one any harm because valve amplifiers are robust pieces of equipment, at least in the sense that if you don't drop them you can abuse them in the matter of occasional overloading and mishaps with bias and in ninety-nine times out of a hundred get away with it with no more to show than a slight brightening of the glow of the anodes.

Habits of thought induced by long experience with valves are likely not only to be wrong but costly when applied to transistor amplifiers. Basically the difference is in the size and accessibility of the heat generating surfaces in valves and solid-state devices; the semiconductor solids are poor conductors, the junctions are buried and are also more vulnerable to heat. So the limiting factor is the junction temperature and the temperature gradients between it and the heat sinks. While the junction may be capable of handling the normal quota of peaks met with in music it may not survive sustained sine-wave power at the full output. Allowing generously for compression of dynamic range at the source, a ratio of 10dB between peak and average power could mean that a 10 watt (peak) amplifier might be required to run (and be tested) at the equivalent of a sustained sine-wave r.m.s. power of only 50 milliwatts. It all depends on the type of circuit and the rating of the transistors used.

Clearly there is a need for rethinking on the rating of transistor amplifiers and the old single figure accepted for valve amplifiers may no longer be sufficient. For class A and B transistor amplifiers we can still give one (possibly small) figure for sustained power performance at a specified distortion level, but the question of testing for distortion at peak powers is one which still needs to be settled.

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# A Feedback Pulse Width Modulated

By G. F. TURNBULL,* M.Sc., and J. M. TOWNSEND,* M.Sc.

THE advantages of on-off control systems, that is systems in which the power is controlled by a two-state switch, have been recognized for a long time in industrial applications, but only recently has serious consideration been given to the possibility of audio power amplification using the technique, the main problem being the difficulty of obtaining a suitable switch capable of operation at a high enough frequency.

The biggest advantage possessed by systems of this type is that large powers can be controlled by switches which themselves dissipate only a small amount of power. The overall power efficiency of the amplifying system is thus increased compared with the conventional (i.e. continuous control) type of power amplifier. Other advantages of the on-off type of system, compactness for example, stem from this principal fact, which enables heat dissipating surfaces of large physical size to be dispensed with.

The switching frequency of such systems must be several times higher than the highest frequency to be amplified, which may be taken as 20kc/s for audio work. Mechanical switches are therefore completely impracticable.

It has recently become possible to use both transistors and valves as switches at these frequencies but with valves the voltage and current values for a given power are not suitable to enable them to be coupled directly to a loudspeaker unless a special loudspeaker having a voice coil resistance of about 1kΩ is used and these are relatively expensive. Transistors, however, are basically high current, low voltage devices which makes them ideal for coupling directly to the low impedance of a loudspeaker.

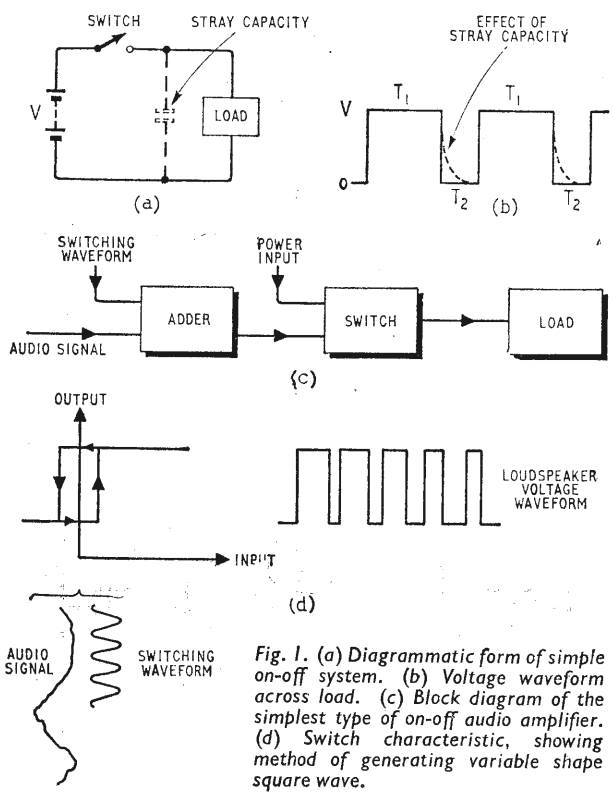



*Fig. 1. (a) Diagrammatic form of simple on-off system. (b) Voltage waveform across load. (c) Block diagram of the simplest type of on-off audio amplifier. (d) Switch characteristic, showing method of generating variable shape square wave.*

This article describes the development of a transistor low power feedback audio amplifier which employs on-off control of the loudspeaker and has a simple circuit which is not particularly critical on component tolerances, and is quite simple to set up to the required operating conditions.

A simple form of on-off control of a loudspeaker is shown in Fig. 1(a), where the loudspeaker is connected by a switch to a voltage source. The voltage waveform appearing across the loudspeaker is shown in Fig. 1(b). The average value of the loudspeaker voltage is given by:—

$$V_L = \frac{VT_1}{T_1 + T_2}$$

where $T_1$ and $T_2$ are respectively the times for which the switch remains closed and for which it remains open. The mean level of the loudspeaker voltage can thus be varied by alteration of the ratio of the times $T_1$ and $T_2$. In an audio amplifying system this variation will be produced by the audio signal. The general form of the amplifier will thus be that shown in Fig. 1(c), where the switch is operated by a signal derived by addition of the audio signal and the switching waveform which is a continuous oscillation. This is shown graphically in Fig. 1(d). The switch is shown as possessing a certain amount of hysteresis (i.e. the point at which it changes state is dependent upon the direction of the change). This is a necessary feature of a two-state switch in order to ensure positive changes of state at well defined points on the characteristic.

For a fixed switching waveform it is possible to draw a curve relating the mean level of the load voltage to the instantaneous value of the audio signal. This curve can then be considered as the input *versus* output curve for the non-linearity (in this case the switch) modified by the switching waveform.

The exact shape of the modified non-linearity will depend upon the particular switching waveform used and it is possible to calculate the curve for any waveform. The best switching waveform to use is that which gives a linear input *versus* output curve, since any curvature of the amplifier characteristic will cause harmonic distortion of the audio signal. It can be shown that a switching waveform which is a symmetrical triangle will give a modified non-linearity which is exactly linear between two limits which are set by the ratio of the hysteretic width of the switch ($2\delta$) to the pk-pk height ($\triangle$) of the triangular switching waveform (see Appendix 1). The modified non-linearity for a hysteretic switch for two

*Electrical Engineering Laboratories, Manchester University.

# Audio Amplifier

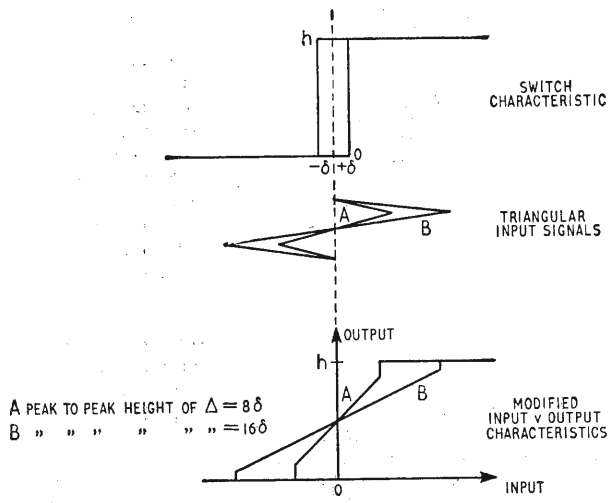



*Fig. 2. Modified input versus output curves for a hysteretic switch operated by triangular waves of different sizes.*

values of $\Delta$ is shown in Fig. 2. As can be seen, for $\Delta = 8\delta$ the effective gain through the modified non-linearity is greater than for $\Delta = 16\delta$, but the range of control is reduced because of the effect of the hysteresis of the switch. In order to obtain both high gain and full range of output level, the hysteretic width must be made very small. The most direct implementation of on-off control would thus use a switch with very low hysteresis, switched by a waveform generated by the addition of a very small triangle and the audio signal.

Before a system can be designed, however, it is necessary to decide upon the exact form to be taken by the switch. In general, the simple type of switch shown in Fig. 1(a) suffers from several disadvantages. The biggest of the disadvantages arises from the fact that when the system is operating at the centre of the linear region, as would be the case, for example, when no audio signal were present, there is a mean current V/2R flowing in the load, since $T_1 = T_2$. This results in the loudspeaker being displaced from its normal equilibrium position and may alter the loudspeaker characteristics and introduce distortion of the audio signals. A further disadvantage of the simple system is that stray capacity across the load will cause the square wave to be asymmetrical. This is shown dotted in Fig. 1(b). This asymmetry will cause curvature of the modified non-linear characteristic and, therefore, distortion to the audio signal which is again undesirable.

The disadvantages of the simple switch are largely overcome in the double switch system shown in Fig. 3(a). The practical implementation of this system can be achieved by following a simple switch (operated by the triangular waveform) by the arrangement shown in Fig. 3(b). Since the load is driven in both directions from a low impedance source the effect of stray capacity is very much reduced, and is approximately the same on both edges. The square wave across the load, when $T_1 = T_2$, has a mean level of zero and since in audio applications the d.c. component of the audio signal is always zero, the loudspeaker load can in fact be driven *via* a capacitor. In this case the battery supply need not be centre tapped, the load being returned to either the positive or the negative end of the supply. As stated earlier, the frequency of operation of the switch must be greater than 20 kc/s in an audio system, and at these frequencies the effect of extra capacitance in all parts of the switch cannot be neglected. Due to imperfections in the driving waveform and stray capacity at the output the edges of the square wave will in fact occupy a finite time and although use of a double switch makes the edges more nearly symmetrical, the finite slopes of the edges will cause a certain amount of curvature of the modified non-linearity, mainly at the ends of the linear range, since it is there that the output wave will depart most from the ideal. The time occupied by the change over from one state to the other will have a further effect since during this time the product of voltage and current in the switching transistors is not zero. The power dissipated in the switching transistors will therefore increase as the proportion of the total time occupied by the edges of the square wave is increased. It is apparently most important therefore to ensure that the edges of the square wave occupy only a very small portion of the duration of the square wave, in order to keep both distortion and power dissipation to a low level. The actual power dissipated in each output transistor is calculated in Appendix 2.

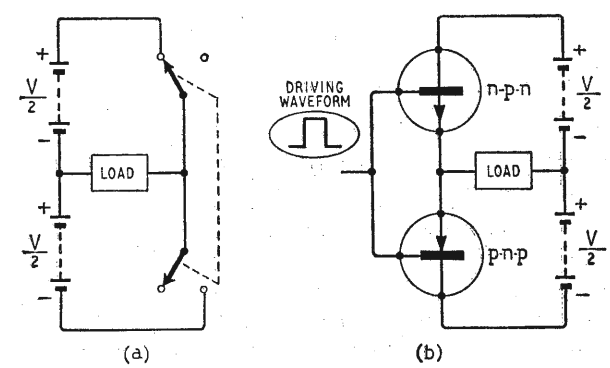
## Amplifier Design

In order to ascertain the potentialities of the on-off type of audio system a small, low power system was constructed to the following specification:

(1). Power output 2 watts r.m.s. into a 15 ohm loudspeaker.
(2). Frequency response within $\pm$ 3dB from 50 c/s to 20 kc/s.
(3). Amplifier sensitivity such that 100mV r.m.s. input signal shall produce full output.
(4). Input impedance approximately 10k$\Omega$.

The specification was chosen so that the system would be comparable with low power amplifiers of more con-

*Fig. 3. (a) Double switch on-off system. (b) Practical implementation of (a) using two transistors.*



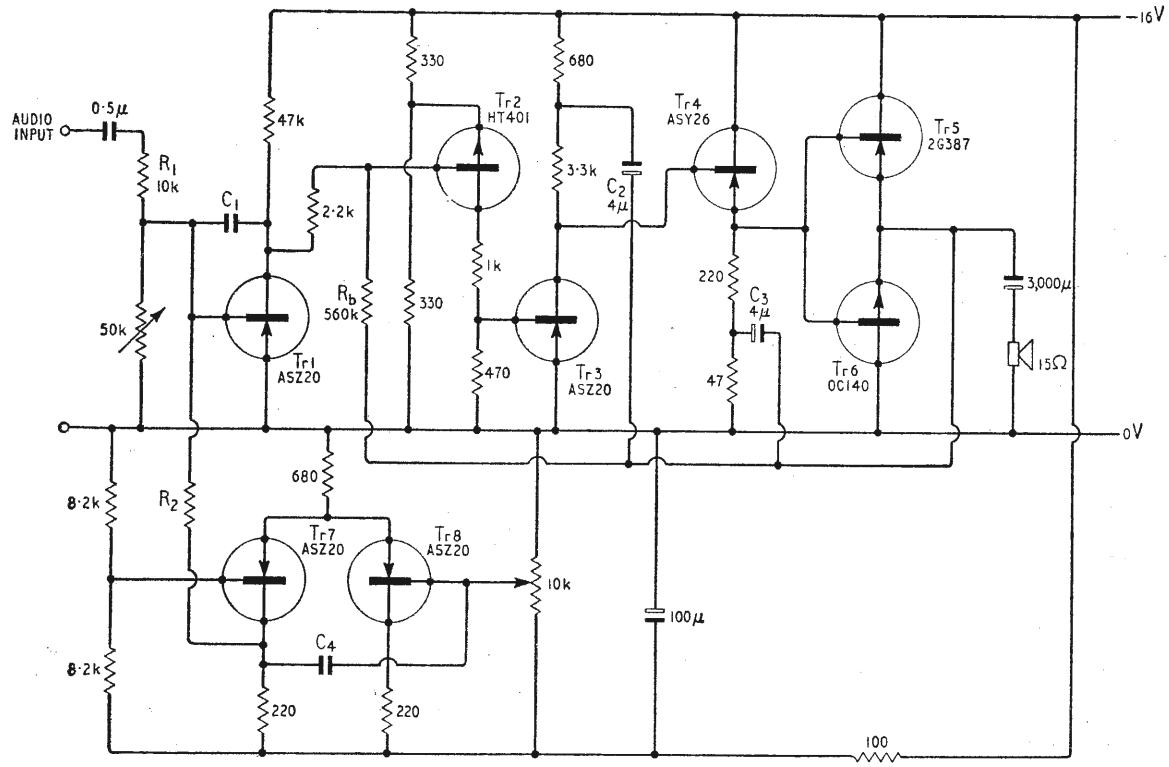



*Fig. 4. Circuit diagram of the open-loop audio amplifier.*

ventional design. Various aspects of the design procedure will now be considered.

## Design of the Switch

Neglecting the bottoming potentials the maximum power in the loudspeaker (see Fig. 3(b)) will be given by

$$(P_o)_{max} = \frac{V^2}{8R}$$

so that the output square wave should have a pk—pk height of about 16V. Thus the supply to the system is fixed at 16V. The peak load current will then be approximately 0.5A, so that the output switching transistors must be capable of handling this current. With the arrangement of Fig. 3(b) it is necessary to ensure that sufficient base current can be provided to hold the output transistors sufficiently well bottomed. The switch is shown in Fig. 4. In order that the triangle generator (Tr1) shall not be heavily loaded, the switch is made up of three current gain stages (Tr2, Tr4 and Tr5/Tr6) and one stage of voltage gain (Tr3). Positive feedback is provided of a magnitude just sufficient to ensure that the switch has only two states, thus keeping the hysteretic width of the switch characteristic to a minimum.

Tr5 and Tr6, the output switching transistors, are driven from the emitter follower transistor Tr4 which has one of its emitter resistors bootstrapped *via* $C_3$ to enable it to hold Tr6 fully bottomed during the positive half of the square wave. $C_3$ must be large enough to provide an almost constant potential during the period that Tr6 remains bottomed, and the emitter resistor is chosen so that it can supply the necessary base current to hold Tr6 bottomed whilst the collector current of Tr6 is 500mA. Tr4 is driven from a positive gain amplifier Tr2/Tr3 which has a load resistor bootstrapped by $C_2$ to ensure that Tr4 and Tr5 are well bottomed during the negative half cycle of the square wave. The positive feedback is taken *via* the resistor $R_b$ to the base of Tr2 from the output. In the design $R_1$ is set to 560kΩ. Values larger than this give a region of continuous variation in output potential which during normal operation will only slow the edges of the output square wave and possibly the subsequent increase in power could be tolerated. Even so this is surely to be avoided if possible and furthermore, under freak conditions (e.g., removal of the triangle), the output could attain potentials between the two supply lines with probable excessive dissipation in the output stage.

## Switching Waveform Generator

The triangular switching waveform is obtained by integrating a square wave, which is obtained from a multivibrator circuit. The minimum permissible oscillation frequency of the switch is about 50 kc/s and the actual one used is 100 kc/s. An emitter-coupled multivibrator produces a good square wave at this frequency provided the transistors are not allowed to bottom. The multivibrator comprises transistors Tr7 and Tr8 (Fig. 4) and Tr1 is connected as a feedback summing integrator. The frequency of the square wave is set by varying $C_4$, and the 10kΩ potentiometer on the base of Tr8 is used to adjust the shape of the square waves at the collectors to be symmetrical, that is to have a mark to space ratio of

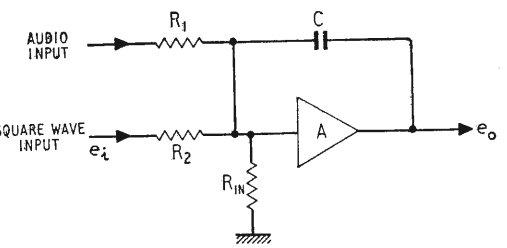



*Fig. 5. Circuit of summing integrator with imperfect amplifier.*

unity. Referring to Fig. 5, the transfer function of an amplifier of gain A, with input impedance $R_{in}$, connected as an integrator, is:-

$$\frac{e_o}{e_i} = \frac{R_c.A}{R_2} \cdot \frac{1}{1+pCR_c(1+A)},$$

where $R_c$ is the parallel resistance of $R_1$, $R_{in}$ and $R_2$. To obtain this transfer function it is necessary to consider the audio input point to be earthed (since the audio signal is normally derived from a low impedance source).

This equation may now be used in the design of the integrator. Before this can be done, however, it is necessary to decide on the distribution of the gain between the integrator and the modified switch. The overall audio voltage gain required is about sixty times. If it is attempted to obtain all this gain from the modified switch, then even a very small hysteretic width can restrict the extent of the linear region quite appreciably, and in addition the effect of a small drift in the output stages of the switching circuit will cause the operating point of the modified non-linearity to move from the centre of the linear region by a large amount, this obviously being undesirable. If the gain of the modified non-linearity is set to be approximately 3 then with the value of hysteresis chosen the linear region extends over almost the whole range of possible mean levels of the output, and at the same time drift effects are reduced. Having decided upon the gain through the switch to the audio signal the pk—pk height of the triangle must be $16/3 \approx 5$ V and the integrator must have an output swing capable of accommodating this size of triangle. The emitter of Tr2 is held at the mid-point of the supply by a low impedance resistance chain, and since the switch has only a very small hysteresis the mid-point of the triangle, and thus the mean level of the collector of Tr1 will be at this potential. Under conditions of peak drive, the triangle will not intersect with the switch operating point and thus the integrator must be capable of accommodating a swing of $\pm 5$ V at the output.

As previously stated, the integrator transistor is used for the dual purpose of generating the triangular waveform, and adding the audio waveform to it. The input resistor ($R_1$) for the audio signal is a 10kΩ resistor to obtain the required input impedance. If we make the collector current in Tr1 when the collector potential is at the centre of the supply, about 200 μA, this will allow sufficient current to charge the feedback capacitor and operate the switch, and at the same time give an input impedance at the base of Tr1 of about 10kΩ. In the equation for the transfer function of the integrator to the audio signal (obtained by replacing $R_2$ by $R_1$ in the previous equation) we therefore have:—

$R_c \approx 5\text{k}\Omega$ and $R_1 = 10\text{k}\Omega$ (assuming $R_2 >> 5\text{k}\Omega$)

The measured value of A was found to be approximately 40, so that the d.c. gain through the integrator will be about 20 to both the triangle and the audio signal. The gain to the audio signal will remain within 3dB of the d.c. gain up to a frequency given by:—

$$f = \frac{1}{2\pi R_c C_1(1+A)}$$

this frequency must be greater than at least 20kc/s. Substitution of the above values leads to a maximum value for $C_1$ of approximately 25pF. With this value of feedback capacity and with $R_2 = 27\text{k}\Omega$ the square wave required to produce a triangle of 5 V pk—pk is about 0.7 V pk—pk. $R_2$ must not be made too large since this will reduce the gain of the integrator as far as the square wave is concerned. This will cause exponential curvature of the triangles and consequent distortion of the modified non-linear characteristic. With $R_2$ set to 27kΩ, the square wave height is adjusted by variation of the collector resistors of Tr7 and Tr8 to obtain the 5 V pk—pk of the triangular waveform at the integrator output.

## Test of the System

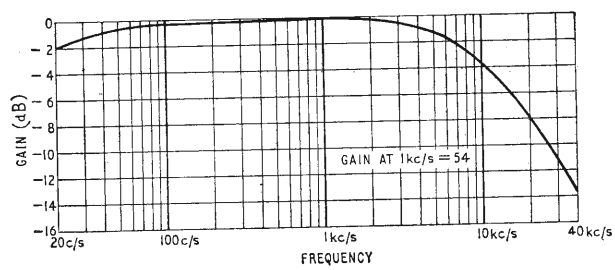
The system constructed according to the above design procedure was tested for frequency response and distortion. The frequency response curve is shown in Fig. 6 and the distortion terms at certain points in the system are given in Table 1. Both frequency response and distortion were measured at an output swing of 2 V r.m.s. across a simulated loudspeaker load of 15Ω and 5 mH in series. The low frequency fall-off in frequency response is due to the coupling capacitor on the input, and can be varied to suit particular requirements. The high frequency fall-off is wholly due to the integrator, since it was found that the integrator frequency response and the overall frequency response were identical in shape. The combined effect of the feedback capacitor, the miller capacitance of the transistor and stray capacitance, has apparently doubled the effective integrator time constant since the 3dB point is at 9kc/s rather than the 20kc/s designed for.

The distortion figures show that a large part of the

**TABLE I**
**Distortion in open-loop amplifier at 2V r.m.s. across loudspeaker**

| POINT IN SYSTEM | f (=1kc/s.) | 2f | 3f | 4f |
|---|---|---|---|---|
| Input | 40mV (0dB) | −52dB | −54dB | >−60dB |
| Integrator Output | 0.7V (0dB) | −34dB | −50dB | >−60dB |
| Loudspeaker | 2V (0dB) | −31dB | −40dB | >−60dB |
| | **f (=10kc/s.)** | **2f** | **3f** | **4f** |
| Input | 60mV (0dB) | −52dB | −52dB | >−60dB |
| Integrator Output | 0.7V (0dB) | −33dB | −50dB | >−60dB |
| Loudspeaker | 2V (0dB) | −36dB | −50dB | >−60dB |

*Fig. 6. Amplitude—frequency response of open-loop amplifier.*



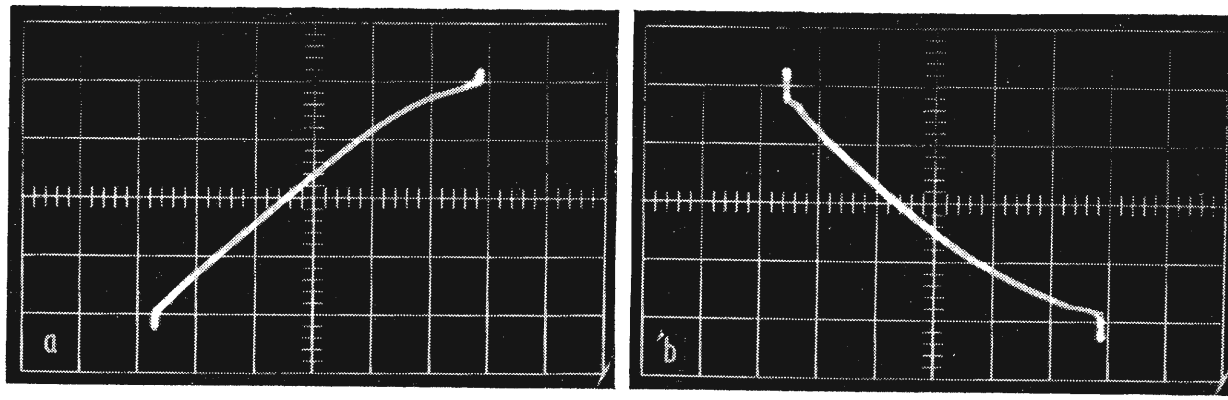



*Fig. 7. Characteristics of open-loop amplifier. (a) Relay input v. relay output. (Input 1V/cm, output 2V/cm.) (b) Overall input v. output characteristic. (Input 50mV/cm, output 2V/cm.)*

distortion of the amplifier occurs in the integrator stage. This must be due to the large swings which are required at the integrator output.

The input *versus* output characteristics of various parts of the system were displayed on an oscilloscope and photographed; these are shown in Fig. 7. The curvature of the input-output characteristic for the switch shows that there is significant distortion through this element as well as through the integrator.

Since the system functions as a modulator, sidebands will be produced. For large audio inputs at high frequencies these sidebands can be quite large and, more important, they can be frequencies which are in the audio spectrum and can thus be heard as unwanted high frequency outputs. In the system tested with large input signals at 10 kc/s these sidebands could both be heard and measured with a wave analyser and were found to be rather obtrusive.

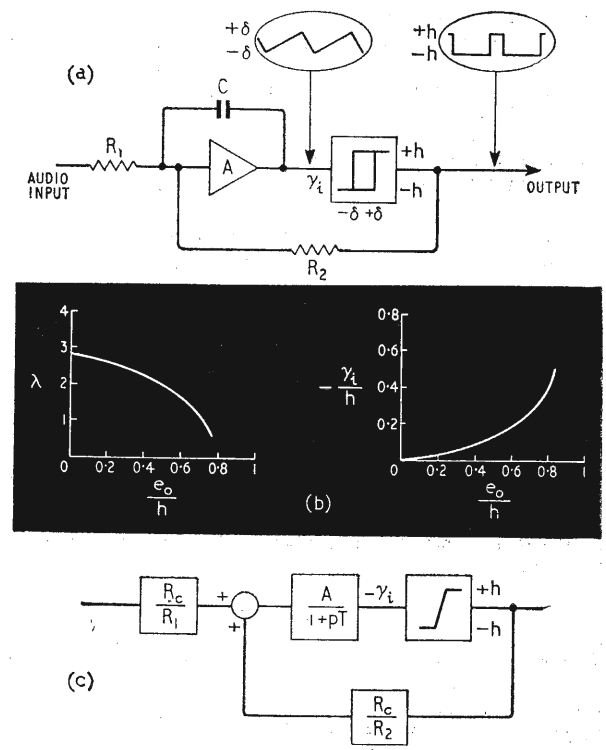
The system so far described has a performance which is rather mediocre, particularly in respect of its distortion figures. It does, however, have the main advantages of on-off systems in general, notably low power dissipation. However, it is a relatively complex system since to produce the switching waveform a square wave generator must be built. This generator has no function as far as the audio signal is concerned. A further disadvantage found in practice during tests on the system was that the operating point tended to move by quite large amounts away from the centre of the linear region. This effect is caused by relative drift between the operating point of the switch and the mean level of the triangle. It produces undesirable asymmetrical limitation of the output swing and increased distortion.

Various means may be employed to improve the system performance. The distortion can be reduced by improving the integrator design. This will improve the shape of the triangular waveform and thus improve the linearity of the modified switch characteristic, whilst at the same time it will possibly reduce the distortion through the integrator to the audio signal. The improved integrator will almost certainly require extra transistors.

The audio signal could be applied direct to the switch, thus eliminating one source of distortion from the audio path. This would waste potential audio gain and further increase the complexity of the system since additional amplifying stages would then be required to obtain the desired audio gain.

Without increasing the complexity of the system, the only alternative seems to be to attempt to reduce the triangle size, possibly even to the point where the audio signal can be applied directly to the switch. To maintain the same gain would require a triangle height of 260mV pk—pk. This would require that both the relative drift and the hysteretic width be well below this figure. These extremely stringent conditions mean that the optimum design for the present configuration and the specification

*Fig. 8. Characteristics of an oscillating loop. (a) Block diagram of the loop. (b) Oscillation frequency of the loop and the d.c. input to the switch as function of the mean level of the output. (c) Low frequency equivalent circuit of the loop.*



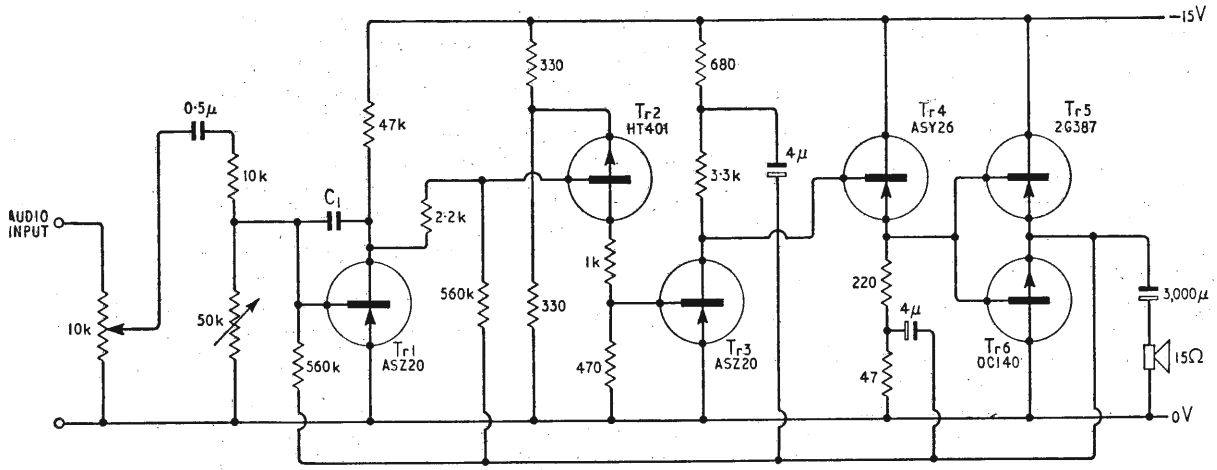



*Fig. 9. Circuit diagram of the closed-loop on-off audio amplifier.*

adopted is probably somewhere between this solution and the system described.

The square wave generator could be dispensed with altogether merely by connecting the loudspeaker driving point (i.e. the emitters of Tr5 and Tr6) to the integrator input base by a resistor. This causes a negative feedback oscillation to be set up due to the phase shift around the loop, resulting in a square wave oscillation across the loudspeaker, whose mean level is controlled by the audio input signal in such a way that the average input signal into the integrator base is approximately zero. It is important to note that in this oscillating system there is inherent negative feedback to the audio signal. This has certain advantages just as feedback has advantages in more conventional systems. It can reduce distortion due to the amplifier, and it can increase the system bandwidth. The overall gain of the system is better defined and the requirements for ripple in a mains derived power supply are reduced. It reduces the output impedance of the amplifier, thus driving the loudspeaker from a low impedance source which is necessary to damp out loudspeaker resonances at low frequencies.

## Theoretical Aspects of the Closed-loop System

As noted previously the closed loop system functions in a totally different way from the open loop system. The pk-pk height of the triangle is now constant at $\delta$, and different values of the mark-space ratio of the output square wave are obtained by varying the slope of the sides of the triangle (see Fig. 8(a)). The limitations of the integrator performance will cause the triangle sides to be part of exponential curves, and will thus modify the effective input *versus* output curves for the switch. It is possible to analyse the closed loop system which is shown in Fig. 8(a).* The integrator here has the transfer function:—

$$\frac{e_o}{e_i} = \frac{K}{1+pT}.$$

The hysteretic width of the switch is $2\delta$ and its two output levels are $\pm h$. For this system it is found that:—

$$\frac{2hK}{\delta} = \coth\frac{B}{\lambda} + \coth\frac{\pi-\beta}{\lambda}$$

$$\frac{\gamma_i \pi}{2hK} = \frac{\pi}{2}\left[1 - \frac{\sinh\frac{\pi-\beta}{\lambda}}{\sinh\frac{\pi}{\lambda}}\right]$$

where $\lambda = 2\pi T \times f_{osc}$ ($f_{osc}$ being the oscillation frequency of the loop), $\gamma_i$ is the switch d.c. input, i.e. the mean level of the switching waveform, and $\frac{\beta}{\pi-\beta} = \frac{T_1}{T_2}$ (comparing Fig. 8(a) and Fig. 1(b)). From these results it is possible to draw curves relating oscillation frequency and d.c. input to the switch ($\gamma_i$) with the mean level of the output. These are shown in Fig. 8(b) for the case when $K = 1$ and $\delta/h = \frac{1}{2}$. Examination of the curve for $\gamma_i$ shows that the switch behaves as a gain of about 5 over a large region of the characteristic which has considerable curvature over its full range. The oscillation frequency can be seen to vary considerably over the full range of output. Both oscillation frequency and gain are dependent on the ratio of $\delta/h$ (being high when $\delta/h$ is small) and also on the integrator d.c. gain K. The bigger the value of K the higher the gain through the switch to the d.c. signal. (For $K = \infty$, $\gamma_i$ is always zero.)

So far as the audio input and output are concerned, we may represent the system to that shown in Fig. 8(c) which is a feedback loop containing a saturating amplifier. The frequency response of a self-oscillating loop of this type can be calculated although the calculation is laborious. Theoretical results indicate that the frequency response is almost flat up to about one half of the oscillation frequency provided that the gain K is large.

## Design Details of the Closed-loop System

The main elements of the closed loop system, notably the switch and the integrator are common to both systems, and in order to allow a fair comparison to be made between the two systems, the same switch and the same integrator were used as for the open loop system, the only difference is that the square wave from the

*"A Method for the Theoretical Analysis of Relay Amplifiers." G. F. Turnbull, D. P. Atherton and J. M. Townsend, to be published in *Proc. I.E.E.*

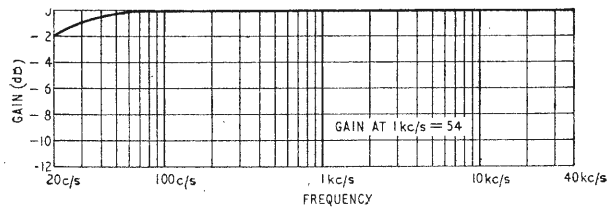



*Fig. 10. Amplitude—frequency response of closed-loop amplifier.*

output is taken to the integrator *via* a 560kΩ resistor. This defines the gain to the audio signal as 560/10 = 56. The feedback capacitor round the integrator was adjusted to make the oscillation frequency when $T_1 = T_2$ about 100 kc/s. With zero input signal the square wave was initially set to be symmetrical by adjustment of a 50kΩ potentiometer between base and emitter of the integrator transistor. The practical circuit is shown in Fig. 9.

## Test of the Closed-Loop System

The closed loop system described was tested in the same way as the open-loop system described previously, and the results are shown in Fig. 10 and Table 2. One factor immediately apparent from Fig. 10 is that the

**TABLE 2**
**Distortion in closed-loop amplifier at 2V r.m.s. across loudspeaker**

| POINT IN SYSTEM | f (= 1kc/s.) | 2f | 3f | 4f |
|---|---|---|---|---|
| Input | 40mV (0dB) | −52dB | −54dB | > −60dB |
| Loudspeaker | 2V (0dB) | −40dB | −52dB | −50dB |
| | **f (= 10kc/s.)** | **2f** | **3f** | **4f** |
| Input | 40mV (0dB) | −52dB | −54dB | > −60dB |
| Loudspeaker | 2V (0dB) | −40dB | −52dB | −50dB |

frequency response of the closed-loop system is rather better than that of the open loop system, in spite of the fact that the integrator capacitor was about five times as large in the closed-loop system as it was in the open-loop system. Comparison between Table 1 and Table 2 also shows that the overall distortion is very much reduced in the closed-loop case. Photographs of the overall input *versus* output and switch input *versus* output characteristics of the amplifier were taken and are shown in Fig. 11. The effect of the feedback in improving the distortion in a non-linear system is clearly seen. Measurement of the signals at the input and output of the switch indicated that the gain through the switch to small signals was about 200, thus giving a low frequency open-loop gain of about 75 (the integrator d.c. gain (A) being about 40, as before). Fig. 12(a) shows the shape of the switching waveform and the output waveform from the switch in the closed-loop amplifier. Fig. 12(b) shows the same waveforms in the open-loop

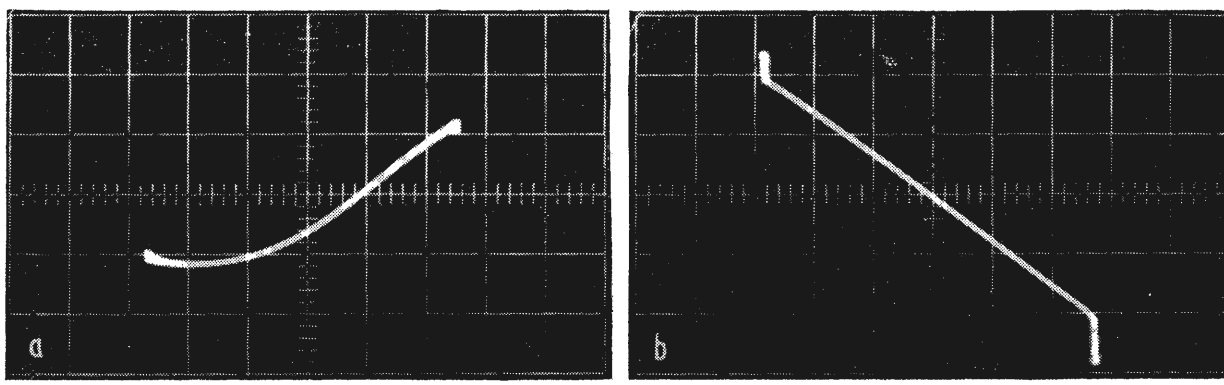



*Fig. 11. Characteristics of the closed-loop amplifier. (a) Relay input v. relay output. (Input 50mV/cm, output 2V/cm.) (b) Overall input v. output. (Input 50mV/cm, output 2V/cm.)*

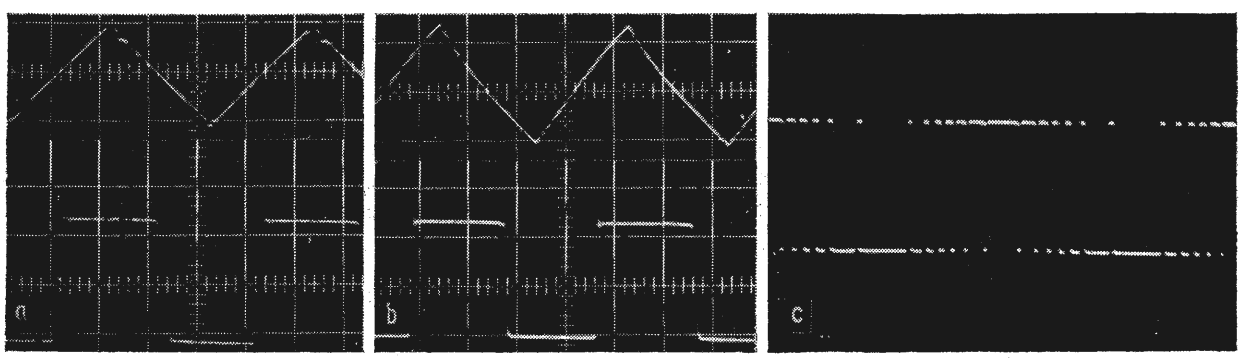



*Fig. 12. (a) Switching and output waveforms in the closed-loop amplifier. (Top 100mV/cm, 2μsec/cm; bottom 5V/cm, 2μsec/cm.) (b) Switching and output waveforms in the open-loop amplifier. (Top 2V/cm, 5μsec/cm; bottom 5V/cm, 5μsec/cm.) (c) Loudspeaker driving waveform for closed-loop amplifier driven with 6 kc/s signal.*

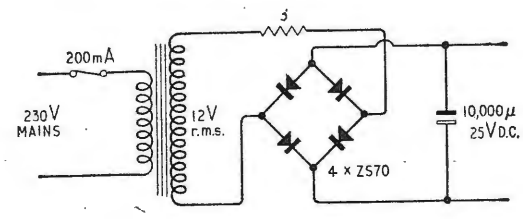



*Fig. 13. Mains power supply.*

amplifier, and Fig. 12(c) is included since it illustrates the principle of operation of the on-off type of system, being a photograph of the output waveform as a function of time when the system is modulated by a sinusoidal signal.

The sideband components at the output of the system mentioned earlier in the tests on the open-loop amplifier represent spurious signals. These should be reduced by the negative feedback over the audio region when the negative feedback is operative. It was found during tests that this was indeed the case; over the audio range there was almost complete suppression of these unwanted signals.

The frequency change measured in the amplifier as a function of mean output level was very close to that theoretically predicted for the case when $K=\infty$ which is

$$\lambda=\lambda_0\left[1-\left(\frac{e_0}{h}\right)^2\right]$$

where $\lambda_0$ is the maximum oscillation frequency, so that the frequency change over the working range of the amplifier is not so great as is suggested by Fig. 8(b)."

## Conclusions

Two types of on-off audio amplifier have been described and the performance of the two systems using the same principal components has been compared in a way which was considered to be the most fair to both systems. Whilst it is obviously possible to construct an open-loop system to give an extremely good performance it would appear that a closed-loop system can be made to give the same performance with every much less complexity, and thus at a lower cost. In the systems described every attempt was made to use transistors of minimum cost throughout and no transistor used cost more than ten shillings.

The output power achieved in the circuits described may be considered rather low. The decision to keep to a low power circuit was taken because it was desired to achieve small size and low cost, and there appears to be a dearth of cheap transistors in small cans which will handle collector currents of greater than 500mA, particularly in the npn category. Higher output can, however, be obtained by uprating everything in the circuit, once suitable output transistors have been obtained. An alternative solution would be to use parallel operation of the output transistors. It would be advisable under these circumstances to include a small resistor in each emitter lead to ensure equal current sharing between the transistors. It is also possible to use four transistors in a bridge circuit for the output stage, with an increase of a factor of four in the power output for a given supply This system has the disadvantage that the loudspeaker is " floating " relative to the supply so that it is extremely difficult to employ the circuit in a closed loop system. It also uses twice as many transistors in the output stage since the current rating of the transistors still needs to be

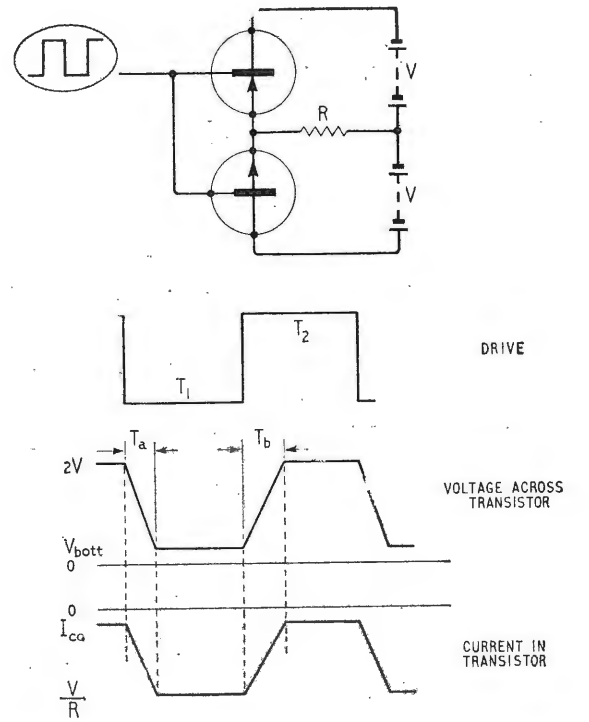



*Fig. 14. Approximate conditions in the output stage during change of state.*

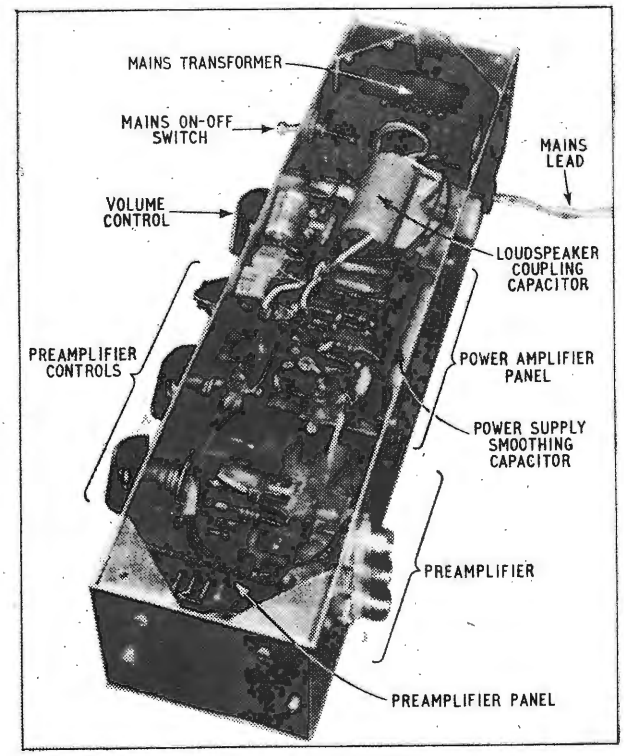



*Fig. 15. Closed-loop amplifier with pre-amplifier and power supply.*

the same as in the case when the supply voltage is doubled, to obtain the higher power output.

One disadvantage of on-off systems running at 100 kc/s which is brought out by practical tests is that of radiation. The circuit whether open or closed loop, is a prolific source of radiated harmonics and this is a serious disadvantage if it is to be driven from a medium wave tuner. Radiation can, however, be reduced very greatly by screening the amplifier. No interference has been caused to neighbouring equipment working in anything but the long and medium wave bands, and the field of radiation from an enclosed system does not appear to extend more than a few feet.

Comments on the actual power efficiency are contained in Appendix 2.

## Power Supply

The circuit of a mains power supply suitable for driving the amplifier is shown in Fig. 13. The value of the smoothing condenser is large enough to give a hum level at the output of the amplifier which is about −80dB relative to full output. There is insufficient smoothing to give a satisfactory hum level in the open-loop amplifier.

Fig. 15 shows a photograph of the prototype closed-loop audio system with an input pre-amplifier equalised for f.m. radio, l.p. and standard play recordings, etc. The system is sensitive enough to be driven from a magnetodynamic pick-up. The whole system including the mains power supply is contained in an aluminium box 11in. × 3in. × 2in., and the majority of the space in the box is taken up by the potentiometers and the 10,000$\mu$F smoothing condenser in the power supply.

### APPENDIX 1

#### Calculation of the Modified Switch Characteristic

Referring to Fig. 2, assume that the triangular switching waveform is displaced to the right by an amount $\gamma_i$ This corresponds to the situation which occurs in the open-loop system (Fig. 1 (c) ) when the audio input signal has an instantaneous value $+\gamma_i$.

Denoting $T_2$ in Fig. 1 (b) by $T_2 = t_2 - t_1$, where $t_2$ and $t_1$ are the times at which the switch operates measured from the zero on the triangle in Fig. 4:—

$$t_1 = \pi + \frac{\pi}{\Delta}(\gamma_i + \delta)$$

$$t_2 = 2\pi - \frac{\pi}{\Delta}(\gamma - _i \delta)$$

i.e. $$t_2 = \pi - \frac{2\pi}{\Delta}\gamma_i$$

Thus the mean level of the output is given by:—

$$e_o = h(\tfrac{1}{2} + \gamma_i/\Delta)$$

The characteristic $e_o$ *versus* $\gamma_i$ does not extend over the whole range from 0 to h, since some value of $e_o$ are physically unrealizable because the triangle does not intersect with the relay operating point. This occurs when

$$|\gamma_i + \delta| \geq \frac{\Delta}{2}$$

The limiting values on the characteristic are thus

$$e_o = h(1 - \frac{\delta}{\Delta})$$

and $$e_o = h(\frac{\delta}{\Delta})$$

The fraction of the total characteristic actually covered by the linear region is $\left(1 - \frac{2\delta}{\Delta}\right)$, and the gain in the linear region of the modified characteristic is $h/\Delta$.

With the values used in the open-loop system described (i.e. h = 16 volts) $\Delta$ = 5 volts and $\delta$ = 100 mV) the percentage of the range covered is $100\left[1 - \frac{200}{5000}\right] = 96\%$ and the gain is 16/5 = 3.4.

### APPENDIX 2

#### Calculation of the Power Dissipation in the Output Transistors

Referring to Fig. 14, the power (P) dissipated in each output transistor is obtained by considering each of the four regions in turn, each region being integrated separately.

$$P = \frac{1}{T}\int_0^T V.I\,dt$$

$$\therefore P = \frac{1}{T_1+T_2}\left[\int_0^{T_a}\left[2V - (2V\text{-}V_{bott})\frac{t}{T_a}\right]\frac{V.t}{RT_a}dt + \int_0^{T_1-T_a} V_{bott}\cdot\frac{V}{R}dt + \int_0^{T_b}\left[V_{bott} + (2V\text{-}V_{bott})\frac{t}{T_b}\right]\left[\frac{V}{R} - \frac{Vt}{RT_b}\right]dt + \int_0^{T_2-T_b} 2V\,I_{co}\,dt\right]$$

Thus the total power in each transistor is

$$P = \frac{1}{T_1+T_2}\left[\frac{VV_{bott}(3T_1-2T_a+T_b) + V^2(T_a+T_b) + 6RVI_{co}(T_2-T_b)}{3R}\right]$$

In the design described,

$T_1 + T_2 = 7.5\ \mu$sec.

$T_a = 0.4\ \mu$sec, $T_b = 0.5\ \mu$sec.

$V_{bott} = 0.3$V, $I_{co} = 1$mA (maximum)

V = 8V, R = 15 ohms

giving P approximately 250 mW in each transistor.

This gives an efficiency of $\frac{200}{2.5} = 80\%$. If the oscillation frequency were reduced to 50 kc/s, making $(T_1+T_2) = 20\ \mu$sec. then this increases the efficiency to almost 90%. With this frequency of oscillation the frequency response of the closed loop system is still very good. The use of higher frequency transistors can, of course, increase the efficiency even more.

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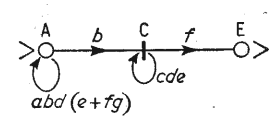
## "Signal Flow Diagrams"

In W. Grant's article in the February issue, the mathematical working in Theorem 2g.1 (page 96) should end as

$$C = \frac{ac + b}{1 - cd}$$

Also, the right-hand diagram in Example 3d.2 (page 97) is incorrectly annotated. It should be:



# MATRIX ALGEBRA

## 2. – ITS APPLICATION TO CIRCUIT ANALYSIS

By G. H. OLSEN,* B.Sc. A.M.I.E.R.E.

READERS of last month's article on matrix algebra will recall that many arrangements of linear components may be regarded as four-terminal networks such networks being represented by a " black-box " as in Fig. 1.

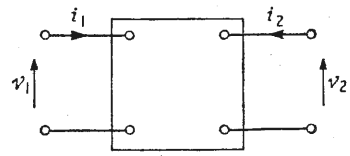



Fig. 1

With circuit arrangements that can be reduced to two-terminal networks we find it very convenient to describe such a network by the simple expression R + jX. Unfortunately such a simple expression is inadequate for four-terminal networks because of the increased number of variables involved. However, we saw that a two-by-two matrix is a sufficiently simple and adequate expression to describe four-terminal networks, the elements of such a matrix giving valuable information about the network's behaviour.

The four independent variables $v_1$, $i_1$, $v_2$, $i_2$ may give rise to six different ways of describing the external behaviour of the network. For our purpose we need only consider four of these ways.

The first, discussed in detail in the previous article may be expressed by the two equations :—

$$v_1 = a_{11}\, v_2 - a_{12}\, i_2 \quad .. \quad .. \quad .. \quad .. \quad (1)$$

$$i_1 = a_{21}\, v_2 - a_{22}\, i_2 \quad .. \quad .. \quad .. \quad .. \quad (2)$$

which in matrix form reduces to :—

$$\begin{pmatrix} v_1 \\ i_1 \end{pmatrix} = [A] \begin{pmatrix} v_2 \\ -i_2 \end{pmatrix}$$

The elements of the A-matrix describe the particular network involved; and by applying certain rules we saw how combinations of networks in cascade could be described by a single matrix, the latter being obtained by multiplying together the individual matrices of the networks making up the combination (see Fig. 2).

The transfer function of the composite network was one of the most valuable items of information obtained from a consideration of the elements of [A].

Circuits are not always, however, made up of networks connected in cascade as above. We may have networks connected in parallel (e.g. the parallel-T filter) or in series at their inputs and outputs; or we may have the inputs in series and the outputs in parallel. In such cases the A-matrix may not be the best description available. Other matrices are possible and, especially for certain transistor work, these alternatives have distinct advantages over the A-matrix. For those readers who are just starting on transistor work it is hoped that this article will show how some of the parameters associated with transistors arise; and perhaps they will then take some comfort in the fact that some order does indeed exist among the bewildering number of parameters that can be used.

The A-matrix and other matrices are all obtained by using one central idea or theme. From the quantities $v_1$, $i_1$, $v_2$, $i_2$ in Fig. 1 we may regard any pair as known and the other pair as unknown. With $v_2$ and $i_2$ known, $v_1$ and $i_1$ can be expressed as in equations (1) and (2). From these equations the A-matrix is defined. Similarly the following matrices may be obtained:

$$i_1 = y_{11}\, v_1 + y_{12}\, v_2 \quad .. \quad .. \quad .. \quad .. \quad (3)$$

$$i_2 = y_{21}\, v_1 + y_{22}\, v_2 \quad .. \quad .. \quad .. \quad .. \quad (4)$$

which in matrix form is

$$\begin{pmatrix} i_1 \\ i_2 \end{pmatrix} = \begin{pmatrix} y_{11} & y_{12} \\ y_{21} & y_{22} \end{pmatrix} \begin{pmatrix} v_1 \\ v_2 \end{pmatrix} = [Y] \begin{pmatrix} v_1 \\ v_2 \end{pmatrix} \quad .. \quad .. \quad (5)$$

The elements of the y-matrix are known as the y-parameters since each has the dimensions of an admittance. The matrices are particularly useful when analysing circuits consisting of two networks in parallel at their input and output terminals (Fig. 3).

The overall matrix is given by $[Y] = [Y_1] + [Y_2]$ i.e. the elements in corresponding positions in $[Y_1]$ and $[Y_2]$ are merely added. An example of an analysis using this technique is given later.

If we take as our starting point

$$v_1 = z_{11}\, i_1 + z_{12}\, i_2 \quad .. \quad .. \quad .. \quad .. \quad (6)$$

$$v_2 = z_{21}\, i_1 + z_{22}\, i_2 \quad .. \quad .. \quad .. \quad .. \quad (7)$$

which in matrix form is

$$\begin{pmatrix} v_1 \\ v_2 \end{pmatrix} = \begin{pmatrix} z_{11} & z_{12} \\ z_{21} & z_{22} \end{pmatrix} \begin{pmatrix} i_1 \\ i_2 \end{pmatrix} = [Z] \begin{pmatrix} i_1 \\ i_2 \end{pmatrix} \quad .. \quad ..$$

we obtain the z-matrix for the network. The z-matrices are most useful in the analysis of networks arranged in series as in Figure 4.

The overall matrix is given by $[Z] = [Z_1] + [Z_2]$

The individual elements of a z-matrix all have the dimensions of an impedance.

The last matrix we need consider is the h-matrix. It is this matrix that is most useful when considering transistors. The individual elements of this matrix are the

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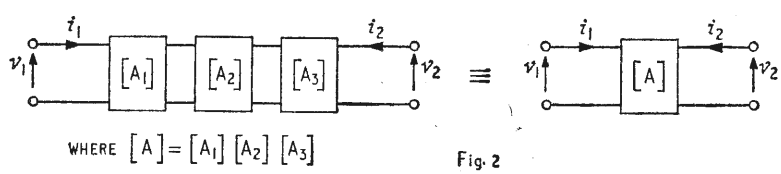



Fig. 2

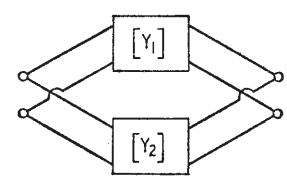



Fig. 3

hybrid or h-parameters often quoted by manufacturers of transistors. The matrix is defined from the following equations:—

$$v_1 = h_{11}\, i_1 + h_{12}\, v_2 \quad .. \quad .. \quad .. \quad .. \quad (8)$$

$$i_2 = h_{21}\, i_1 + h_{22}\, v_2 \quad .. \quad .. \quad .. \quad .. \quad (9)$$

which in matrix form is:—

$$\begin{pmatrix} v_1 \\ i_2 \end{pmatrix} = \begin{pmatrix} h_{11} & h_{12} \\ h_{21} & h_{22} \end{pmatrix} \begin{pmatrix} i_1 \\ v_2 \end{pmatrix} = [H] \begin{pmatrix} i_1 \\ v_2 \end{pmatrix}$$

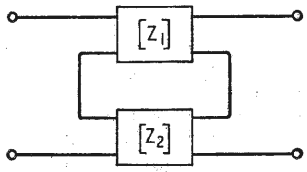



Fig. 4

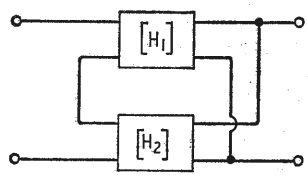



Fig. 5

In circuit analysis the h-matrices are most useful in the configuration of Fig. 5.

The overall h-matrix is given by $[H] = [H_1] + [H_2]$.

Consider now the transistor manufacturer's dilemma when wishing to publish design data on his products. The matrices described so far each have their advantages when applied to suitable circuit configurations; but from the manufacturer's point he wishes to describe his transistors with parameters that can easily be measured accurately and unfortunately the z- and y-parameters do not permit of easy determination because of the way in which they are defined. An examination of the h-parameters shows that they can all be determined easily and accurately. This is why the h-parameters are now widely used in manufacturers' data sheets, in textbooks and articles. D. N. Tilsley in the May 1964 issue of the *Wireless World* (p229) has described the parameters in detail and it is thus unnecessary to go over the same ground again. It is essential however to point out that it will be necessary to be able to convert the h-parameters into the corresponding z-, y- and A-parameters depending upon the particular circuit arrangement it is wished to examine. Since no one can rapidly convert one set into another from first principles every time a conversion is required it is usual to refer to a table. There is nothing complicated about the use of the tables. Like the log. tables with the trig. ratios etc., and the tables of Laplace transforms, the tables of matrix conversions should be readily available to all electronic engineers especially in examinations. Such a table is given in Table 1. Only one symbol used has not been defined so far, and that is the one used for the determinant of a matrix. Taking the A-matrix as an example we have

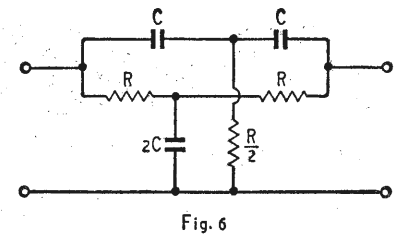



Fig. 6

$$[A] = \begin{pmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{pmatrix} \text{ and det. A (written } |A|) = a_{11}a_{22} - a_{12}a_{21}.$$

## Applications

When using matrices in circuit analysis we must first determine the most useful matrix form to use. As an example let us take the case of the parallel twin- T network shown in Figure 6.

To obtain the overall matrix of this configuration we

**TABLE 1**

| CONVERSION FROM | To | | | |
|---|---|---|---|---|
| **A-Matrix parameters** | $z_{11} = \frac{a_{11}}{a_{21}}$ $z_{12} = \frac{\|A\|}{a_{21}}$ <br> $z_{21} = \frac{1}{a_{21}}$ $z_{22} = \frac{a_{22}}{a_{21}}$ | $y_{11} = \frac{a_{22}}{a_{12}}$ $y_{12} = \frac{-\|A\|}{a_{12}}$ <br> $y_{21} = \frac{-1}{a_{12}}$ $y_{22} = \frac{a_{11}}{a_{12}}$ | $h_{11} = \frac{a_{12}}{a_{22}}$ $h_{12} = \frac{\|A\|}{a_{22}}$ <br> $h_{21} = \frac{-1}{a_{22}}$ $h_{22} = \frac{a_{21}}{a_{22}}$ | $\|A\| = a_{11}a_{22} - a_{12}a_{21}$ |
| **z-parameters** | $a_{11} = \frac{z_{11}}{z_{21}}$ $a_{12} = \frac{\|z\|}{z_{21}}$ <br> $a_{21} = \frac{1}{z_{21}}$ $a_{22} = \frac{z_{22}}{z_{21}}$ | $y_{11} = \frac{z_{22}}{\|z\|}$ $y_{12} = \frac{-z_{12}}{\|z\|}$ <br> $y_{21} = \frac{-z_{21}}{\|z\|}$ $y_{22} = \frac{z_{11}}{\|z\|}$ | $h_{11} = \frac{\|z\|}{z_{22}}$ $h_{12} = \frac{z_{12}}{z_{22}}$ <br> $h_{21} = \frac{-z_{21}}{z_{22}}$ $h_{22} = \frac{1}{z_{22}}$ | $\|z\| = z_{11}z_{22} - z_{12}z_{21}$ |
| **y-parameters** | $z_{11} = \frac{y_{22}}{\|y\|}$ $z_{12} = \frac{-y_{12}}{\|y\|}$ <br> $z_{12} = \frac{-y_{21}}{\|y\|}$ $z_{22} = \frac{y_{11}}{\|y\|}$ | $a_{11} = \frac{-y_{22}}{y_{21}}$ $a_{12} = \frac{-1}{y_{21}}$ <br> $a_{21} = \frac{-\|y\|}{y_{21}}$ $a_{22} = \frac{-y_{11}}{y_{21}}$ | $h_{11} = \frac{1}{y_{11}}$ $h_{12} = \frac{-y_{12}}{z_{11}}$ <br> $h_{21} = \frac{y_{21}}{y_{11}}$ $h_{22} = \frac{\|y\|}{y_{11}}$ | $\|y\| = y_{11}y_{22} - y_{12}y_{21}$ |
| **h-parameters** | $z_{11} = \frac{\|h\|}{h_{22}}$ $z_{12} = \frac{h_{12}}{h_{22}}$ <br> $z_{21} = \frac{-h_{21}}{h_{22}}$ $z_{22} = \frac{1}{h_{22}}$ | $y_{11} = \frac{1}{h_{11}}$ $y_{12} = \frac{-h_{12}}{h_{11}}$ <br> $y_{21} = \frac{h_{21}}{h_{11}}$ $y_{22} = \frac{\|h\|}{h_{11}}$ | $a_{11} = \frac{-\|h\|}{h_{21}}$ $a_{12} = \frac{-h_{11}}{h_{21}}$ <br> $a_{21} = \frac{-h_{22}}{h_{21}}$ $a_{22} = \frac{-1}{h_{21}}$ | $\|h\| = h_{11}h_{22} - h_{12}h_{21}$ |

first note that two T-networks are connected in parallel at their input and output terminals. The y-parameters are therefore used since simple addition of the y-elements for each T-network gives us the overall y-matrix. If only the A-matrix parameters are known we would proceed as follows:—

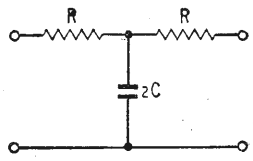



Fig. 7

The A-matrix of the T-network can be found from the individual matrices of the components as shown in the last article. The result (see Fig. 7) is given by

$$[A_1] = \begin{pmatrix} 1 + 2j\omega CR & 2R + 2j\omega CR^2 \\ 2j\omega C & 1 + 2j\omega CR \end{pmatrix} = \begin{pmatrix} \alpha & \beta \\ \gamma & \alpha \end{pmatrix} \text{ say.}$$

(It should be noted in passing that $|A| = 1$, a property of the A-matrices of passive linear symmetrical networks). Using the conversion table

$$[Y_1] = \begin{pmatrix} \frac{\alpha}{\beta} & -\frac{1}{\beta} \\ -\frac{1}{\beta} & \frac{\alpha}{\beta} \end{pmatrix}$$

Similarly the A-matrix of the network of Fig. 8 is given by

$$A_2 = \begin{pmatrix} 1 + ZG & 2Z + Z^2G \\ G & 1 + ZG \end{pmatrix} \text{ where } Z = \frac{1}{j\omega C}$$

and $G = 2/R$

$$= \begin{pmatrix} \alpha' & \beta' \\ \gamma' & \alpha' \end{pmatrix}$$

Thus

$$[Y_2] = \begin{pmatrix} \alpha'/\beta' & -1/\beta' \\ -1/\beta' & \alpha'/\beta' \end{pmatrix}$$

The overall y-matrix for the parallel T-network is therefore

$$[Y_3] = \begin{pmatrix} \frac{\alpha}{\beta} + \frac{\alpha'}{\beta'} & -\left(\frac{1}{\beta} + \frac{1}{\beta'}\right) \\ -\left(\frac{1}{\beta} + \frac{1}{\beta'}\right) & \left(\frac{\alpha}{\beta} + \frac{\alpha'}{\beta'}\right) \end{pmatrix}$$

From Eqn. (3) + (4) the transfer function is $-y_{21}/y_{22}$ i.e. $(\beta + \beta')/(\alpha\beta' + \alpha'\beta)$. For infinite attenuation $\beta + \beta' = 0$.

This occurs when $\omega = \omega_0$ say.

$$\therefore 2R + 2j\omega_0 C R^2 + \frac{2}{j\omega_0 C} - \frac{2}{\omega_0^2 C^2 R} = 0$$

$$\therefore \omega_0 = \frac{1}{CR}$$

Infinite attenuation therefore results at a frequency $f_0 = 1/(2\pi CR)$.

Before looking at the application of matrix algebra to transistor circuit analysis let us consider the symbol conventions used since we need to be quite clear about the interpretation of any symbol. As the h-parameters appear in the conversion table they apply to transistors used in the grounded-base mode of operation. When considering the grounded-emitter mode the same expressions are used except that all the h's are primed thus, $h'_{11}$, $h'_{12}$ etc. By considering the defining equations (8) and (9) we see that $h_{21} = \alpha$ (when $v_2 = 0$ i.e. the output is short circuited to a.c.); $h_{21}$ is therefore the current gain in the grounded base mode of operation. $h'_{21} = \alpha' = \beta$ i.e. the current gain of a grounded-emitter transistor. We also have the conventional symbols described by D. N. Tilsley where $h'_{11} = h_{ie}$; $h'_{12} = h_{re}$; $h'_{21} = h_{fe}$ and $h'_{22} = h_{oe}$.

The matter of conventions is not yet settled and many writers still go by preference. This writer prefers the numeral subscripts since the position in the matrix requires no effort on the part of the memory; additionally, the letter subscripts refer to English words such as "forward" and "reverse" and these are not likely to be adopted by non-English-speaking countries.

With many important practical circuits we often need to know one or more of the following: input impedance, voltage gain, current gain, power gain and output impedance. All of this information is available in compact form when using matrices. Take as an easy example a straightforward transistor amplifier, Fig. 9(a) and its matrix equivalent, Fig. 9(b).

Regarding this as two four-terminal networks in cascade we find it convenient to use A-matrices. The overall A-matrix will give the information we need; but let us say that only the h-parameters are available from the manufacturer's data. We first convert the h-parameters to A-parameters, using the table; then multiply the matrix by that representing the load. The overall matrix [A] is given by

$$[A] = \begin{pmatrix} \frac{-|h'|}{h'_{21}} & \frac{-h'_{11}}{h'_{21}} \\ \frac{-h'_{22}}{h'_{21}} & \frac{-1}{h'_{21}} \end{pmatrix} \begin{pmatrix} 1 & 0 \\ G_L & 1 \end{pmatrix} \text{ where } G_L = \frac{1}{R_L}$$

The required information can then be easily extracted.

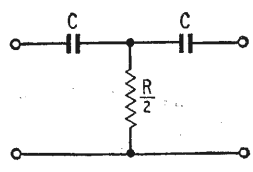
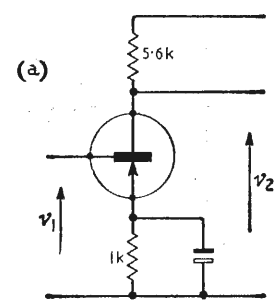
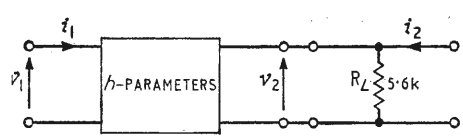



Fig. 8




(b)

Fig. 9

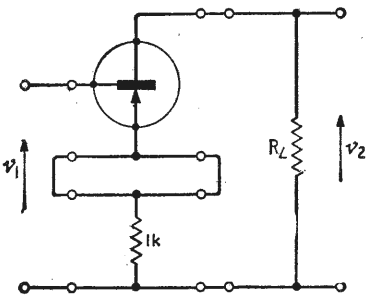


Fig. 10

For example the voltage gain will be given by the reciprocal of the $a_{11}$ element of [A]

i.e. $\dfrac{-h'_{21}}{|h'| + Gh'_{11}}$

Suppose therefore that $h'_{11} = 1k\Omega$, $h'_{12} = 3 \times 10^{-4}$ $h'_{21} = 50$ and $h'_{22} = 50\mu\mho$ then $|h'| = 50 \times 10^{-3} - 150 \times 10^{-4} = 35 \times 10^{-3}$. The voltage gain is therefore $-50/(35 \times 10^{-3} + G_L \times 10^3)$. For a 5.6k load resistor the voltage gain is therefore 235. The input resistance is found from equations (1) and (2) to be $a_{11}/a_{21}$ of [A] ($i_2$ being zero for the cascaded pair). This turns out to be

$$R_{in} = \frac{h'_{11} + |h'| R_L}{1 + h'_{22} R_L} = 930 \text{ (approx.)}$$

If feedback is introduced by omitting the by-pass capacitor across the emitter resistor (= 1k$\Omega$ say) we have Fig. 10 as a four-terminal equivalent.

The procedure here would be to notice that since the transistor and emitter resistor networks are in series at their inputs and outputs we require the z-parameters of each network. Addition gives the overall z-matrix which can then be converted to the A-matrix and multiplied by the A-matrix for the load resistor. It will be found that the intermediate working becomes rather cumbersome if symbols are retained so, if the configuration includes a transistor and emitter resistor with known parameters it is better to work out the numerical values of the matrix elements as one goes along. Once the overall A-matrix is obtained the voltage and current gains, and input and output impedances are readily determined. Provided the writer has done his homework satisfactorily readers should find that the gain is now $\approx$5.5 and the input resistance about 39k$\Omega$.

Although matrix algebra is not the answer to every problem of circuit analysis, it is a powerful tool that ought to be more widely used. Criticism that precise formulations are a waste of time with transistor circuits (because of the wide spread of transistor parameters) is not likely to be permanently valid. As manufacturing techniques improve better control of parameters will be effected. In any case some attempt should be made at analysing the circuits we use; and it is hoped that these articles have gone some way in encouraging readers to adopt matrix methods where appropriate.

# THIS MONTH'S CONFERENCES & EXHIBITIONS

**LONDON**

Apr. 11-14 — Chelsea Coll. of Science
**Educational Requirements for the Professional Inspection & Quality Engineer**
(Instn. of Engineering Inspection, 616 Grand Buildings, Trafalgar Sq., W.C.2.)

Apr. 21-30 — Olympia & Earls Court
**International Engineering Exhibition**
(F. W. Bridges & Sons, 1-19 New Oxford St., W.C.1.)

Apr. 22-25 — Hotel Russell
**International Audio Festival & Fair**
(C. Rex-Hassan, 42 Manchester St., W.1.)

Apr. 30 & May 1 — Royal Hotel
**Technical Publications & Aids to Technical Publications**
(Technical Publications Assoc., 17 Bluebridge Ave., Brookmans Park, Herts.)

**BIRMINGHAM**

Apr. 5-7 — The University
**Conference on Elementary Particles**
(Inst. Phys. & Phys. Soc., 47 Belgrave Sq., S.W.1)

**BRISTOL**

Apr. 7-9 — The University
**Stress Analysis Conference**
(Inst. Phys. & Phys. Soc., 47 Belgrave Sq., S.W.1)

**MANCHESTER**

Apr. 5-8 — Col. of Science & Tech.
**Physics Exhibition**
(Inst. Phys. & Phys. Soc., 47 Belgrave Sq., S.W.1.)

**NOTTINGHAM**

Apr. 6-9 — The University
**Automatic Control Convention**
(Inst. Mechanical Engineers, 1 Birdcage Walk, S.W.1)

**OVERSEAS**

Apr. 5-10 — Paris
**Symposium on Memory Techniques**
(Société Francaise d'Electroniciens et des Radioélectriciens, 10 avenue Pierre-Larousse, Malakoff (Seine))

Apr. 8-13 — Paris
**Electronic Components Exhibition**
(F.N.I.E., 16 rue de Presles, Paris 15e)

Apr. 8-13 — Paris
**Audio Equipment Exhibition**
(F.N.I.E., 16 rue de Presles, Paris 15e)

Apr. 12-17 — Los Angeles
**Technical Conference**
(S.M.P.T.E., 9 East 41st St., New York 17, N.Y.)

Apr. 13-15 — Houston
**Telemetering Conference**
(R. W. Towle, Advanced Technology Labs., 369 Whisman Rd., Mountain View, Cal.)

Apr. 14-15 — Cincinnati
**Electronics and Instrumentation Conference**
(J. R. Ebbeler, Avco Corp., 2630 Glendale-Milford Rd., Cincinnati)

Apr. 20-22 — New York
**Symposium on System Theory**
(Polytechnic Institute of Brooklyn, 333 Jay St., Brooklyn 1, N.Y.)

Apr. 20-22 — Atlantic City
**Frequency Control Symposium**
(M. F. Timm, U.S. Army Electronics Labs., Fort Monmouth)

Apr. 21-23 — Pittsburgh
**Optimization Techniques**
(I.E.E.E., Box A, Lenox Hill Station, New York 21, N.Y.)

Apr. 21-23 — Washington
**Nonlinear Magnetics**
(Dr. E. W. Pugh, IBM Building, 703-2, Poughkeepsie, N.Y.)

Apr. 24-May 2 — Hanover
**Hanover Fair**
(Schenkers Ltd., 13 Finsbury Sq., London, E.C.2)

**"Simple Transistor Power Supply":**—In Fig. 4, page 139 of the March issue, the resistances assume a meter resistance of 1450$\Omega$ (0.5 mA, f.s.d.). In the second paragraph, left-hand column, page 140 the reference is to Fig. (a) (not (b)) and in the performance table the ripple should be in *milli*volts.

# MANUFACTURERS' PRODUCTS

## NEW ELECTRONIC EQUIPMENT AND ACCESSORIES

### *Plug-in Component Module*

A NEW component board unit consisting of a twenty-two way plug-in base (identical to that used for the Keyswitch P33 relay) and a circuit component board enclosed in a transparent dust-proof cover has been introduced by Keyswitch Relays Ltd., of 120-132 Cricklewood Lane, London, N.W.2. The component mounting area is $3{\cdot}125 \times 2{\cdot}218 \times 1{\cdot}093$ in and as a demonstration of what can be achieved, Keyswitch have successfully built into a standard unit a ring counter stage complete with power pack. This included 11 trigger tubes, 11 diodes, 65 resistors and 35 capacitors.

Longitudinal copper strips 0·0015 in thick and spaced at 0·2 in intervals are bonded to the board which is pierced with a regular matrix of holes. The maximum working voltage between adjacent copper strips is 500 volts d.c. The price of the Type 304 plug-in component board unit is 30s.

**4WW 301 for further details**

### *Cold-cathode Indicator Diode*

AMBIENT illumination does not interfere with the operation of the new ZA1004 cold-cathode indicator tube from Mullard Ltd. This tube is primarily intended as a display device for medium/low voltage transistor circuits and a prominent feature is that the control voltage is less than 10 volts and in certain circuits may be kept as low as 3.5 V. The tube has a breakdown voltage of 93.5 V maximum, an extinction voltage of 83.5 V minimum, and a preferred cathode current of 1 mA. Minimum illumination at a distance of 2 mm from the bulb surface is 45 lux. The makers claim a life expectancy of 2,500 hours when the tube is operated at a constant cathode current of 1 mA and a bulb temperature of 35° C.

**4WW 302 for further details**

### *Temperature Gauge*

A COMPACT portable temperature gauge suitable for measuring temperatures to an accuracy of 1% from −20°C to +120°C has been introduced by Startronic Ltd., of 117a-119a Malden Road, New Malden, Surrey. The instrument has two scales covering −20 to +55 and +50 to +120°C and can be located some distance away from the probe without seriously affecting the accuracy. In fact, a lead resistance of 2Ω only introduces ¼°C error at 100°C.

A selection of matched thermistors are available for the measurement of surface temperatures and a selection of probes can be supplied for the measurement of gas or liquid temperatures. Other accessories include a ten-way selector box and a selection of leads. The instrument weighs 4 lb and measures (case size) $2\frac{3}{4} \times 5\frac{1}{4} \times 7\frac{3}{8}$ in. The price is £31.

**4WW 303 for further details**

### *Capacitance Bridge*

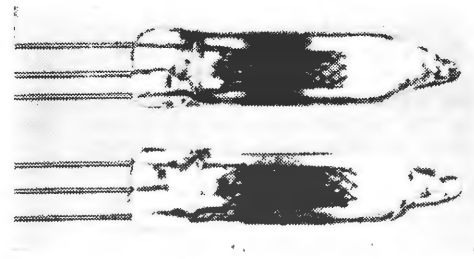
A THREE-TERMINAL 100 kc/s capacitance bridge able to measure 0.0002 to 110.000 pF with a basic accuracy of 0.1% has been developed by the Boonton Electronics Corporation, of New Jersey. This instrument, known as the Model 74D, may also be used for the measurement of conductance, from 0.0001 to 1,000 micromhos, and shut resistance, from 1,000Ω to 1,000 MΩ.

Features of the Model 74D include a continuously variable test signal from 1 mV to 4 V, an internal bias adjustable from −7 V to +144 V, provision for external bias up to ±400 V, negligible warm-up drift, and less than 0.001 pF capacitance drift in 24 hours.

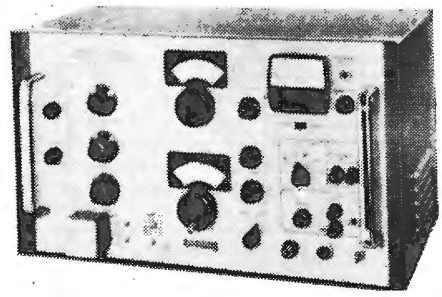
The Model 74D may also be used as a comparison bridge or for "go"-"no-go" testing, as a d.c. output proportional to the bridge unbalance is provided.

This instrument is obtainable in the United Kingdom through Livingston Laboratories Ltd., of 31 Camden Road,

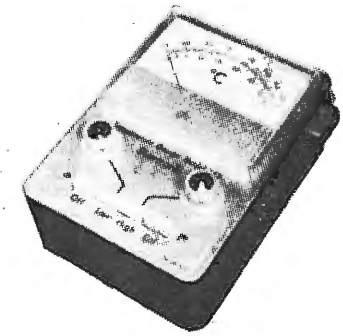

*Plug-in component board unit from Keyswitch Relays Ltd.*



*Two Type ZA1004 cold-cathode indicator diodes from Mullard.*



*Wide-range three terminal capacitance bridge manufactured by the Boonton Electronics Corp.*



*Battery-operated Model 142 temperature gauge from Startronic Ltd. It covers the range −20° to +120°C.*

London, N.W.1. The price, excluding duty, is £568.

**4WW 304 for further details**

## Professional Tape Recorder

A PORTABLE tape recorder that weighs less than 11 lb inclusive of batteries is announced by EMI Electronics Ltd., of Hayes, Middx. Features of the new machine include provision for a fourth magnetic head for film and television synchronization, two tape speeds —$3\frac{3}{4}$ and $7\frac{1}{2}$ in/sec—with a run-up time of less than one second, a remote stop-start control which can be embodied in one of the microphones and microphone mixing facilities.

This machine, which should be of interest to those in the broadcast, audio and industrial fields, is designated Type L4. Two microphone amplifiers are incorporated, each with separate volume controls, and require less than 50 microvolts for peak recording level. An EMI motor is used in the machine and speed stability (measured on either speed at a constant 14 volts) is better than 0.2 % of the mean speed from start to finish of a $4\frac{1}{4}$ in spool (maximum size). Wow and flutter is quoted to be better than 0.2 % at both speeds when played back on the same machine. At the higher speed the overall response is within 2 dB from 50 c/s to 12,000 c/s and at $3\frac{3}{4}$ in/sec within 2 dB from 50 c/s to 5,000 c/s.

Separate record and replay amplifiers are housed within the main chassis with a monitor amplifier (provided with a 3 in speaker for checking the information on the tape on replay only) and oscillator unit which operates, with variable bias, at approximately 60 kc/s. The 14 volt battery for this machine is rechargeable.

**4WW 305 for further details**

## Wall Speaker Unit

AN inexpensive sound reinforcement loudspeaker unit, Type BG, that can be fitted into a wall is announced by K.L.B. Electric Ltd., of 335 Whitehorse Road, Croydon, Surrey. A seven by four-inch speaker with a three-watt power-handling capacity is fitted as standard although speaker size can be varied to customer requirements.

The unit requires a wall area of 9×6 in and can easily be accommodated after the removal of two bricks. Alternative fixings are provided for mounting in a standard builder's "knock-out box." The price of the unit complete with 100 volt line transformer is £2 17s 6d.

**4WW 306 for further details**

## Digital Circuit Modules

INTENDED for applications up to 10 kc/s are the new Series 10A (open) and 10B (potted) digital modules from the electronic services division of Standard Telephones and Cables Ltd. The Series so far includes two- to five-input gates; low-, medium- and high-power inverters; low-, medium- and high-power buffers; and several multi-stable and peripheral equipment circuits. Module design is characterized by very sharp pulse edges ensuring positive response and immunity from noise. These units are designed to have a life span of at least twenty years and will operate within the temperature range −10° to +70° C. The division's address is Edinburgh Way, Harlow, Essex.

**4WW 307 for further details**

## Nanovolt Source

PRIMARILY designed to function as a secondary standard for calibrating low-voltage ranges on instruments, the Model 260 nanovolt source manufactured by Keithley Instruments Inc., of Cleveland, Ohio, is simple to operate and may be set with a three-digit resolution for any value from one nanovolt to one volt. Separate take-off points are provided for nanovolts, microvolts and millivolts. A source resistance of 1 Ω is quoted for the two lower ranges and 100 Ω for millivolt outputs. Long-term accuracy is specified to be within 0.25 % to 0.75 %, according to the range in use.

The Model 260, which can also be used to provide an accurate voltage source for zero suppression, potentiometric measurements and the like, is available in the United Kingdom through Livingston Laboratories Ltd., of 31 Camden Road, London, N.W.1.

**4WW 308 for further details**

## D.C. Multimeter

THIRTEEN voltage, thirteen current and sixteen resistance ranges are provided on the Millivac Type MV-77B d.c. multimeter. This instrument features a floating input, an output suitable for connection to a recorder, and a six-inch mirror-scale meter with taut-band suspension.

As a voltmeter it covers 1 mV to 1,000 V full scale in 13 ranges, each of which has individual calibration controls. The accuracy is quoted to be within 3% on the 1 mV range, 2% on the 2·5 mV to 10 mV ranges and within 1% on all ranges from 25 mV up to 1,000 V. Input impedance is 10 MΩ on the ranges up to 100 mV, 25 MΩ on the 250 mV range and 100 MΩ on all higher ranges.

The accuracy of the instrument in the current mode is within 2% on all ranges, except on the lowest, where it is 3%. Shunt resistances range from 1 kΩ on the lowest range to 0·01Ω on the highest, thus keeping the voltage drop to below 10 mV full scale over the entire range from 1 μA to 1 A.

The first 13 resistance ranges, from 1 Ω to 1 MΩ full scale, utilize the voltage scales which are linear and provide an accuracy of ± 2%. The terminal voltage on these ranges never exceeds 10 mV, thus making the instrument suitable for testing microminiature electronics, such as thin films. The three other resistance ranges, which have their own logarithmic scales, extend the measurement range up to 100 MΩ with a 5% accuracy and up to 5,000 MΩ at ±10%.

Overall dimensions of the instrument are 13×8½×11 in and it weighs 25 lb. A rack-mounted version, designated Type RM-77B, is also available in the United Kingdom through the instruments division of Claude Lyons Ltd., of 76 Old Hall Street, Liverpool, 3 (Southern offices Hoddesdon, Herts.). The price, excluding Government charges, is £148 2s 6d.

**4WW 309 for further details**

## Spark Eroder

BROKEN taps and drills of minute dimensions—down to 12 B.A.—can be

**INFORMATION SERVICE FOR PROFESSIONAL READERS**

To expedite requests for further information on products appearing in the editorial and advertisement pages of *Wireless World* each month, a sheet of reader service cards is included in this issue. The cards will be found between advertisement pages 48 and 51.

We invite readers to make use of these cards for all inquiries dealing with specific products. Many editorial items and all advertisements are coded with a number, prefixed by 4WW, and it is then necessary only to enter the number(s) on the card.

Readers will appreciate the advantage of being able to fold out the sheet of cards enabling them to make entries while studying the editorial and advertisement pages.

Postage is free in the U.K. but cards must be stamped if posted overseas. This service will enable professional readers to obtain the additional information they require quickly and easily.

removed with the "Arc-out" spark eroder developed by Watton Electronic Ltd., of Welwyn Garden City. The cores of taps and drills from any metal down to 12 B.A. size can be removed, claim the manufacturers, without damage to the thread or hole. The "Arc-out" can also be used for machining hardened metals, and any shape of hole is possible.

Apart from a normal a.c. mains supply (consumption 2 A to 240 V a.c.), it requires only a small flow of water. Two models of the "Arc-out" are available, the Model 1A which has a height clearance of 10 in and the 1B which has a 16 in clearance. Both models are supplied complete with electrode clamp nut, two electrode adaptors, a tubular electrode, five different sized insulated wire electrodes, and a water hose. The Model 1A is priced at £65 15s 0d and the 1B at £69 17s 6d.

These units are available through Roberts Electronics Ltd., of 17 Hermitage Road, Hitchin, Herts.

**4WW 310 for further details**

## Sub-miniature Electrolytics

SOLID electrolytic tantalum capacitors comparable in size to lighter flints—a typical example is 4 mm long by 1·8 mm diameter—are being produced by the dielectric and magnetic division of Plessey-UK Ltd., at Towcester, Northants. Designated Type M, the capacitance range of the new series is from 0.047$\mu$F to 10$\mu$F at d.c. working voltages from 1·5 to 50 V. Other characteristics include a temperature range of $-55°C$ to $+85°C$, a power factor of 25% of maximum at 120 c/s, leakage current not greater than two microamps at 20°C and a surge voltage rating of 16% above the rated working voltage.

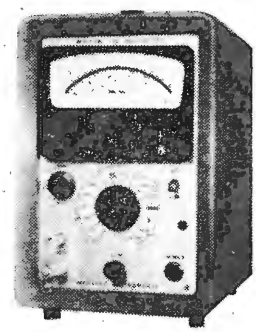
These polarized units are designed to operate with a d.c. bias and to avoid reverse polarity, the peak value of any a.c. component must not exceed the applied d.c. bias. Also, the sum of the d.c. bias voltage and the peak value of any a.c. component must not exceed the rated working voltage of the capacitor.

Tinned nickel contact leads of 0·010 in diameter are welded to the anode and soldered to the cathode. Each unit is metallic coated and encapsulated in epoxy resin.

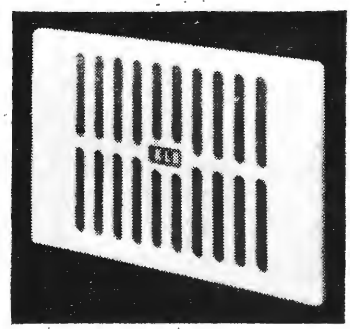
**4WW 311 for further details**

## Logic Circuit Elements

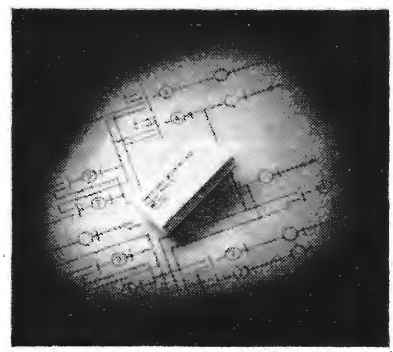
THREE new series of logical switching elements presented in rectangular encapsulations are announced by Ferranti Ltd. The 400 Series, an alternative to the current 300 Series, employ sili-



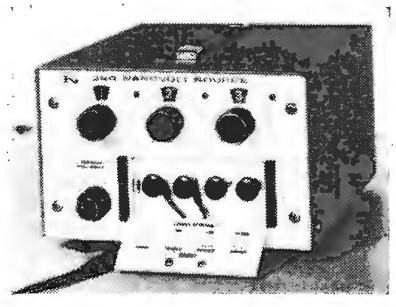
*Millivac d.c. multimeter obtainable through Claude Lyons Ltd.*



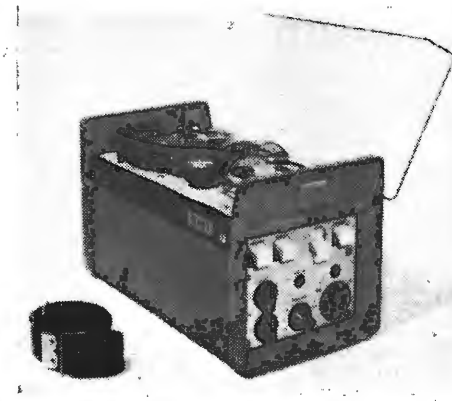
*Wall loudspeaker unit from K.L.B. Electric Ltd. It can be fitted in place of two bricks.*



*Type 10B potted circuit module for control and data systems from S.T.C. This unit measures $2\frac{1}{2} \times 1 \times 1$ in, excluding connections.*



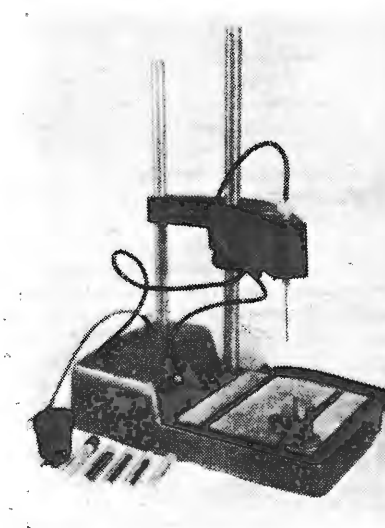
*Model 260 nanovolt source made by Keithley Instruments Inc.*



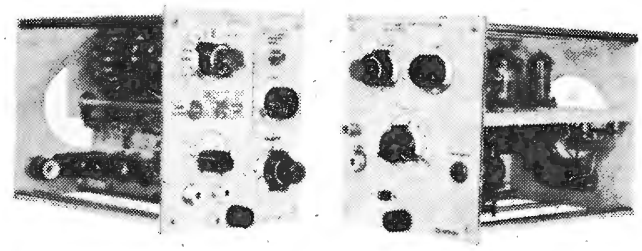
*EMI Electronics Type L4 portable tape recorder. Full and half track versions are available.*

*Plessey Type M "Castanet" tantalum capacitor shown against a cigarette lighter.*

*Watton "Arc-out" spark eroder for removing small broken taps and drills. It is suitable for use down to 12 B.A.*

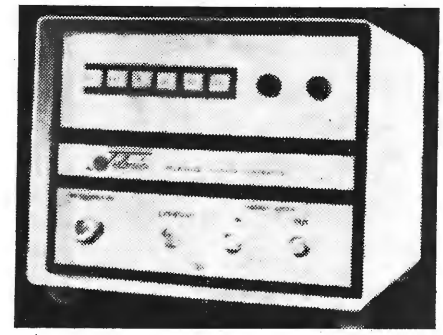


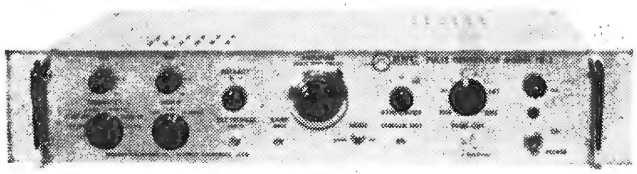
*Ferranti 700 Series of logic circuit elements. They weigh less than 10 gm.*



*Two new plug-in units for Solartron oscilloscopes. A high-gain differential amplifier is shown on the left and a wide-band amplifier on the right*

*Telonic microwave marker generator. It features push-button controls.*





*Sliding pulse generator from Berkeley Nucleonics.*

con active elements and have switching speeds in excess of 3 Mc/s; temperature range is from −40° to +100°C. Switching speeds in excess of 5 Mc/s are quoted for the 500 Series, which contain silicon transistors and gold-bonded germanium diodes.

The other new modules, the 700 Series, have been developed primarily for industrial applications and have switching speeds in excess of 1 Mc/s. Operating temperature range for this series and the 500 Series is from −20° to +90°C.

All circuits operate on standard supply rails of +12 V and −6 V, with a nominal tolerance on all rails of ±0.5 V. Logic levels for the new modules are similar to those specified for the current Ferranti range, and all electrical outlets are in the form of flying leads; the maximum number is 14. These modules measure 1.48×0.45×0.55in, and in many cases can be provided mounted on printed circuit boards to fulfil standard functions such as decade counters, shift registers, adders, decoders, etc.

**4WW 312 for further details**

## Sliding Pulse Generator

CAPABLE of producing a train of linearly increasing pulses suitable for testing differential linearity in amplifiers, pulse height analysers and analogue-to-digital converters is the Model PB-2 generator from Berkeley Nucleonics Co., of California. Transistors are used throughout the PB-2 which can also be used as a conventional precision pulse generator.

Pulse height linearity and stability are stated to be better than 0·1%. Repetition rate is adjustable from 1 c/s to 1 Mc/s and the output amplitude is calibrated from 1 mV up to 10.1 V. Coarse adjustment is by a step attenuator and fine adjustment by a 10-turn potentiometer. The rise time is adjustable from 0.05 to 2 μsec and pulse width from 0.3 to 100 μsec.

The Model PB-2 is available in the United Kingdom through High Volt Linear Ltd., of 1 Cardiff Road, Luton, Beds.

**4WW 313 for further details**

## Microwave Marker Generator

DESIGNED to provide marker intervals on swept frequency displays is the Model TMS-1 microwave marker generator from Telonic Engineering Incorporated. This instrument will operate on any frequency within the range 5 Mc/s to 10 Gc/s and provide 5, 10, 50 or 100 Mc/s markers accurate to ±0.001%. Other markers between 2 and 200 Mc/s may be generated by feeding the instrument with a signal of the appropriate frequency. The TMS-1 is marketed in the United Kingdom by Livingston Laboratories Ltd., of 31 Camden Road, London, N.W.1. The price, excluding Government charges, is £646.

**4WW 314 for further details**

## Plug-in Scope Units

TWO new plug-in units for the Solartron Type CD1212 (CT484) and CD1220 oscilloscopes are announced. One of these, a high-gain differential amplifier designated CX1258 features a high d.c. sensitivity (100 μV/cm), high in-phase rejection (80 dB) and very low drift. The maximum bandwidth of this amplifier is 200 kc/s making it suitable for a wide range of general purpose applications. The sensitivity of the amplifier is adjustable from 100 μV/cm to 2 V/cm in 14 calibrated ranges and maximum sensitivity is quoted to be 100 μV from d.c. to 50 kc/s, 200 μV from d.c. to 100 kc/s and 500 μV from d.c. to 200 kc/s. Maximum in-phase voltage is ±25 V peak from 100 μV/cm to 20 mV/cm and ±250 V peak from 20 mV/cm to 2 V/cm. Calibration accuracy is 3%.

The other unit, the CX1259, is a wide-band amplifier and has a similar performance to the CX1256, but includes an additional x10 d.c. coupled transistor amplifier providing a maximum sensi-

tivity of 5 mV/cm at a bandwidth of d.c. to 24 Mc/s. With the additional amplifier out of circuit, the sensitivity of the CX1259 is 50 mV/cm from d.c. to 40 Mc/s. Both of these units are available from the Solartron Electronic Group Ltd., whose address is Farnborough, Hampshire.

**4WW 315 for further details**

## Slip Clutches & Couplings

A RANGE of precision slip clutches and couplings for use in servomechanisms and small mechanical devices are now available from Bowmar Instrument Ltd., of Sutherland Road, London, E.17. Two sizes of slip clutches are being offered which can be pre-set to slip at torques between 2 oz/in and 20 oz/in. Various combinations of shaft sizes can be accommodated from 0.120 to 0.250 in and these are clamped by means of two set screws in the hub. These should be found particularly useful for the protection of multi-turn precision potentiometers in servo systems.

The precision couplings are also in two sizes, one for transmitting up to 8 oz/in torque without backlash, the other for 16 oz/in. Shaft sizes are also from 0.120 to 0.250 in and are held in position by either a set screw in the hub or a split collet type of hub.

**4WW 316 for further details**

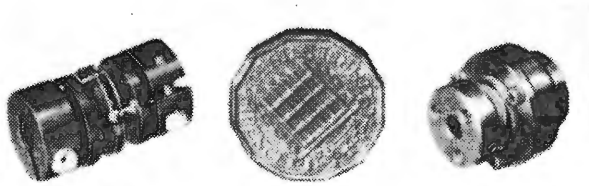
## Frequency Selective Amplifier

A PORTABLE frequency selective amplifier covering 10 c/s to 100 kc/s has recently been introduced by H. Tinsley & Co., of Werndee Hall, South Norwood, London, S.E.25. Four ranges are used to cover the spectrum, and frequency is selected by decade switches. A "Q" factor of better than 30 is quoted.

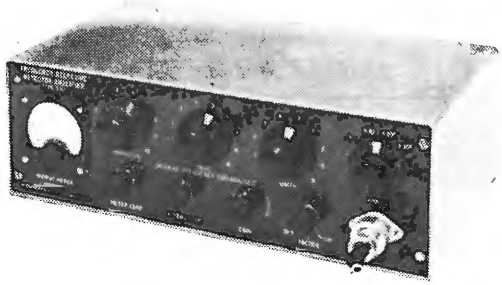
Three stages of amplification are incorporated in the Model 5710 providing voltage gains of the order of $10^6$. The input impedance of the instrument, which can handle signals from 1 $\mu$V to 10 V, varies according to the amount of internal attenuation. This may be adjusted from 10 to 120 dB and will cause the input impedance to vary from 10 k$\Omega$ for a 10 $\mu$V signal to 1 M$\Omega$ for larger signals requiring more than 50 dB attenuation.

The dimensions of the Model 5710 are 12 × 4 × 8½ in and it weighs 5lb. An alternative model, designated 5711, calibrated in angular frequency is also available. Both instruments use transistors throughout.

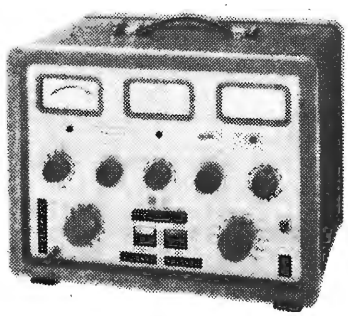
**4WW 317 for further details**



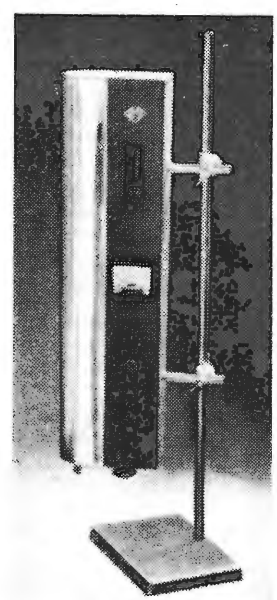
*A precision coupling (shown on the left) and slip clutch from Bowmar Instrument Ltd.*



*Frequency selective amplifier covering 10c/s to 100kc/s made by H. Tinsley & Co.*



*Philips transistor analyser Model PM6505A. It can measure leakage currents down to 10 nA f.s.d.*



*Machine for producing ultra-pure hydrogen (Johnson, Matthey & Co.) It weighs less than 15 lb.*

## Ultra-pure Hydrogen Machine

A SIMPLE-TO-OPERATE machine for producing ultra-pure hydrogen by the silver-palladium diffusion method is announced by Johnson, Matthey & Co. Ltd., of 73-83 Hatton Garden, London, E.C.1. This unit, known as the A.1 diffusion unit, should be of particular interest to those in research and development laboratories as it will give an ultra-pure output of up to 1.5 cu ft/hr. Connection to a hydrogen source is made by a steel coupling pipe and the output points are rust-protected to allow plastic tubing to be used.

The unit will operate from any 220-250 volt a.c. supply, via a power regulator—such as the Variac Duratrack—and requires only 600 watts when operating at the maximum temperature (400° C). The average working temperature of the instrument is 350° C, providing an output level of 1 cu ft/hr. This diffusion unit is housed in an aluminium case and is mounted on a laboratory retort stand.

**4WW 318 for further details**

## Transistor Analyser

THE latest transistor analyser from Philips, the Model PM6505A, which is an improved version of the PM6505, has a 10 nanoamps f.s.d. range for leakage currents.

A continuously adjustable collector voltage source, a base current supply, a tuned 1 kc/s oscillator for dynamic measurements, and an adjustable half-wave voltage source for the display of breakdown voltage characteristics are provided. All of these supply circuits are protected against accidental short-circuiting, and all with the exception of the half-wave source are fully stabilized. The measurements that may be made are: collector-emitter short-circuit test; collector-emitter, emitter-base and collector-base leakage currents; collector current as a function of base current and also as a function of base-emitter volt-

age; knee voltage; short-circuit impedance $h_{ie}$; and short-circuit current gain $h_{fe}$. The collector voltage is adjustable from 0 to 60 volts with a maximum collector current of 3 amps. The h parameters are measured at 1 kc/s, $h_{ie}$ covering the range 0 to 30 kΩ and $h_{fe}$ 0 to 1,000.

The analyser, which is a mains-operated unit and weighs 42 lb, can also be used for selecting and matching transistors. Its dimensions are 13 × 16 × 11½ in, and it is obtainable in the U.K. through the M.E.L. Equipment Company, 207 Kings Cross Road, London, W.C.1.

**4WW 319 for further details**

## Portable 2-12Mc/s Transceiver

A NEW "Manpack" transmitter-receiver that covers the frequency range 2-12 Mc/s in 1 kc/s steps is being manufactured by the communications division of Redifon Ltd., of Broomhill Road, London, S.W.18. Although this s.s.b. is being manufactured under licence from the Hughes Aircraft Company, of California, it has full a.m. capability—making it suitable for use with existing military and civil equipment—and better sensitivity figures than the original Hughes version.

A frequency synthesizer is used to obtain the 10,000 channels in the frequency range 2-12 Mc/s. This, of course, does away with the need for "netting" and enables the equipment to be operated by relatively unskilled personnel. A typical frequency tolerance for the equipment, designated GR 345, is quoted to be ±25 c/s, and never greater than ±50 c/s under any combination of extreme conditions.

The power output of the transmitter is 15 W p.e.p. on c.w. and s.s.b., and 3.75 W carrier (minimum) on a.m. with 100 % modulation. Receiver sensitivity is quoted to be 1.4 μV (3.0 μV on a.m.) for a 10 dB signal plus noise to noise ratio. The basic transmitter-receiver including the power pack—which is one of the six modules—weighs 22 lb. Many accessories are available for the GR 345.

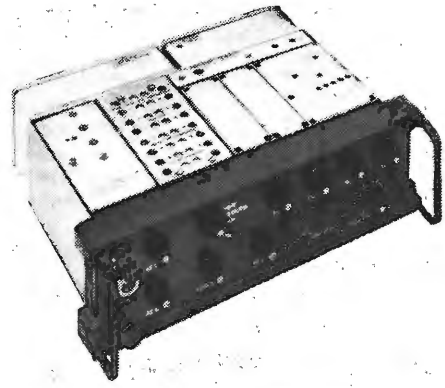
**4WW 320 for further details**

## Solid State Process Timers

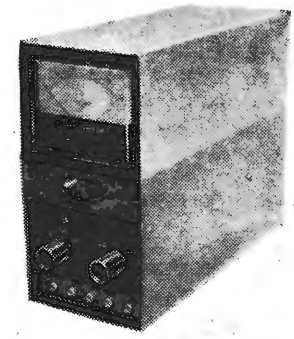
A NEW range of solid state process timers for industrial applications is announced by Kent Precision Electronics Ltd., of Vale Road, Tonbridge, Kent. These instruments, which are suitable for timing over the range 10 msec to 15 sec with an overall accuracy of ±1 %, can also be supplied with pulsed outputs; to fire thyristor circuits for the control of power circuits. They are housed in panel-mounting instrument cases and consist basically of a stable resistive-capacitive timing circuit and a transistor voltage threshold detector which fires the thyristor output circuit. For relay operation a low-power thyristor is used to operate an internal relay.

A feature of these instruments is that two units can be housed in the same case enabling the instruments to be interconnected. This allows one instrument to be initiated after the first has elapsed, etc. Alternatively, a dual instrument may be used as two separate timers with concentric controls.

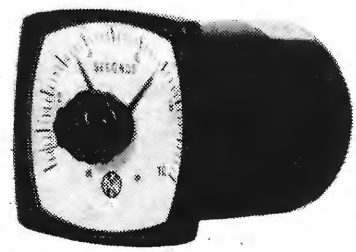
**4WW 321 for further details**



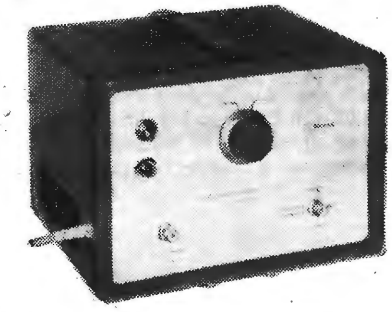
*Redifon Type GR 345 10,000-channel 2-12 Mc/s portable transmitter-receiver.*



*In-circuit transistor leakage tester made by Transition Inc.*



*Industrial solid state process timer being made by Kent Precision Electronics Ltd. Range is from 10 msec to 15 sec.*



*Add-on unit from Advance Electronics Ltd to extend the frequency range (to 100 Mc/s) of electronic counters.*

## In-circuit Transistor Tester

AN instrument designed for in-circuit measurement of transistor leakage current, which was developed by the IIT Research Institute, of Chicago, is now being manufactured and marketed by Transition Incorporated, of 10 W 35th Street, Chicago, Illinois. Collector-to-base leakage currents from 1 μA to 2.5 mA with a collector resistance down to 100 Ω can be measured with this instrument, which is claimed to be simple to operate and not to damage other circuit components.

The accuracy for transistor leakage between collector and base with emitter and collector junctions reverse biased is quoted to be within 1 % for collector resistances greater than 500 Ω with full scale meter readings. For collector resistances between 100 Ω and 500 Ω accuracy is within 5%.

**4WW 322 for further details**

## Counter Add-on Unit

ABLE to extend the range of most electronic counters now commercially available to 100 Mc/s is the new add-on unit Advance Electronics Ltd. have introduced. Designated TCD100, the new instrument provides division factors of 100 or 20 and has an input sensitivity of 50 mV (into 50 Ω). Both the input and output parameters are flexible to accommodate a wide range of input sources and the instrument will provide output pulses at 3 V peak-to-peak (50 Ω) from 10 kc/s to 1 Mc/s on the divide by 100 setting and from 50 kc/s to 5 Mc/s on the ÷ 20 setting. The manufacturers claim that the accuracy of the basic counter is not affected by the divider unit.

Transistors and tunnel diodes are used in the instrument which measures 6½ × 9½ × 8¼ in and weighs 8¼ lb. The price of the TCD100 is £195 and it is available from the company's headquarters in Roebuck Road, Hainault, Ilford, Essex.

**4WW 323 for further details**

## The Computer Industry

A FLOURISHING British computer industry and a rapid increase in the use of computers and computer techniques in industry and commerce are considered essential by the Government, and plans to serve these ends were announced by the Minister of Technology, Mr. Frank Cousins, on March 1st.

A Computer Advisory Unit within the Ministry of Technology to advise on computer requirements over the whole public sector is to be formed. All proposals for computers required by Government Departments for civil purpose and those to be purchased with public monies by universities, colleges and research councils will be referred to this unit for objective technical appraisal before purchases are authorized.

The Government has also initiated a full-scale review of the computer requirements of universities, colleges and research councils so that a new five-year programme of procurement can be planned. The Government proposes to start this five-year programme at a rate of £2M a year.

Further programmes of research into computer techniques and the development of new equipment within industry, the universities and in Government research establishments and in the Post Office will be initiated. In addition, the National Research Development Corporation will be greatly expanding its work in this field, and in this connection is to invest £5M in a series of joint projects with International Computers and Tabulators Ltd.

The Minister is also exploring with the industry and with users the possibilities of establishing a National Computer Programme Centre in which they would be partners with the Government.

## Reciprocal Amateur Operation

THE Postmaster-General announced on March 16th that in future he will, subject to certain conditions being met, grant licences to engage in amateur transmissions in Great Britain to nationals of countries which are prepared to grant similar facilities to United Kingdom licensed radio amateurs.

The U.S. Federal Communications Commission has, with effect from March 27th, also adopted rules to carry into effect the "reciprocal operating" provisions included in the U.S. Communications Act. A permit will be issued to those who hold a valid amateur transmitting licence in their own country, if there is a bilateral agreement between the U.S. and that government for reciprocal operation as now provided for in the U.K.

America is therefore the first country with which we have this reciprocal arrangement. It will be necessary to negotiate with other countries to make similar arrangements although, of course, not with countries within the Commonwealth.

## Dutch Nationalized Relay System

THE success of the Dutch P.T.T's experiments with a central aerial system to provide a four-programme piped-television service together with ten v.h.f. sound programmes to 2,200 homes in a district in the Hague has prompted the government to make plans to introduce the system on a national scale. The P.T.T. will be responsible and the investment cost is estimated at the equivalent of about £16M. The subscription is expected to be about 8s per month.

In the Hague experiment subscribers have had the choice of television programmes from Belgium, France and Germany as well as the Dutch service. Normal receivers can be linked to the system.

## Subscription TV in the U.S.

AFTER nearly three years' experimental operation of its "over-the-air" subscription television system in Hartford, Conn., the Zenith Radio Corporation has asked the Federal Communications Commission to authorize subscription TV on "an extended nation-wide basis." Analysis of the first two years' operation of the pilot scheme, using the Phonevision system and serving 4,775 homes, shows that a little over 5% of viewing time was devoted to subscription television. Charges for programmes ranged from 25 cents to $3.

In the Phonevision system the vision signal is scrambled by inverting the picture polarity, shifting picture information relation to sync by some 3% of the width of the picture on alternate strips of seven lines and by varying the vertical position of these displaced strips in each field. Sound is also scrambled. Each programme is coded and in the subscriber's "box" is a punched tape with sets of holes for some 2,000 different programme numbers. When the appropriate number has been selected and the switch set to "buy" a programme the tape is marked for subsequent payment of the fee.

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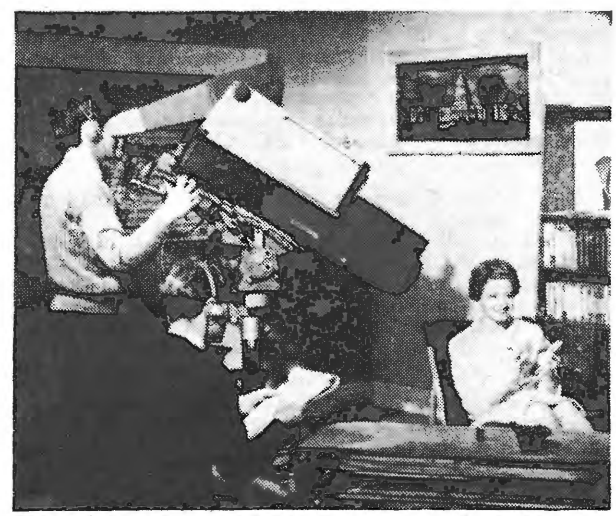
An international conference on **u.h.f. television** covering receiver and transmitter design, propagation, receiving and transmitting aerials, parametric amplifiers, and test equipment, is to be held in London on September 1st and 2nd—during the Radio Show. The sponsoring bodies are the I.E.E., I.E.E.E., I.E.R.E. and the Television Society. The venue is not yet decided. It is hoped that technical visits will take place on the day immediately after the conference. Details of these, and of the registration fee, will be available later from the Joint Conference Secretariat, 8-9, Bedford Square, London, W.C.1.



***Ease and flexibility of operation** characterize Marconi's small and light transistorized 4½-inch image orthicon television camera, Mark V. A single zoom lens, with means for preselecting under servo control any of four fixed zoom positions, eliminates the restrictions imposed by a number of separate lenses of fixed focal length. Controls for the camera electronics have been transferred to the associated equipment racks, and a tilting viewfinder enables the operator to view comfortably at any camera angle.*

For the next two years the **Physics Exhibition** will be held in London but at a new venue—Alexandra Palace. The dates are March 28th-31st, 1966, and April 17th-20th, 1967. The organizers, the Institute of Physics & Physical Society, say that the following two exhibitions may be held in the Provinces.

**Three exhibitions** to be held simultaneously at Earls Court, London, from June 15th to 19th will all have items of interest to some readers of *Wireless World*. They are: the first Noise and Vibration Reduction Exhibition (NAVREX), the second Church and School Equipment Exhibition (CASEX) and the first Pumping Exhibition. The organizers are Iliffe Exhibitions Ltd., Dorset House, Stamford Street, London, S.E.1, from whom tickets are obtainable free for NAVREX and the pumping show. Admission to CASEX will cost 2s 6d.

Next year's conference on **solid state physics,** organized by the Institute of Physics & Physical Society, will be held in Manchester instead of Bristol as in the past. The date will be January 4th-7th and the place, the Renold Building, Manchester College of Science and Technology.

"**Microwave applications of semiconductors**" is the title of the joint I.E.R.E.-I.E.E. symposium being arranged for June 30th to July 2nd at University College, London. The six main sessions will cover microwave properties of semiconductor devices, generators, p-i-n diode circuits, tunnel diode circuits and mixers, low-noise devices and systems. Further information and registration forms are obtainable from the I.E.R.E., 8-9 Bedford Square, London, W.C.1.

**A British Joint Computer Conference** is to be held at the Congress Theatre, Eastbourne, Sussex, from May 3rd to 5th, 1966, under the aegis of the United Kingdom Automation Council. Participating organizations include the I.E.E., I.E.R.E. and the British Computer Society. Further details and registration forms will be available in due course from the conference secretariat, I.E.E., Savoy Place, London, W.C.2.

"The challenge of improving the exports of the electronics industry" is to be the theme of the second **Exports Day** to be held by the Radio & Electronic Component Manufacturers' Federation. The conference, which is to be on May 11th at the Federation's headquarters at 11 Hanover Street, London, W.1, will be attended by representatives from the 200 or more member firms of R.E.C.M.F.

**V.H.F./U.H.F. Convention.**—The eleventh international v.h.f./u.h.f. convention organized by the Radio Society of Great Britain, will be held at Kingsley Hotel, Bloomsbury Way, London, W.C1, on April 10th. It opens at 11.0 with a trade exhibition and in the afternoon there will be a lecture programme. Tickets, costing 4s 6d (convention only) or 30s (convention and dinner), are obtainable from F. E. A. Green (G3GMY), 48 Borough Way, Potters Bar, Middx.

**Microelectronics.**—A symposium on the applications of microelectronics is to be held at Southampton University from September 21st to 23rd. It is under the joint sponsorship of the Southern Sections of the I.E.E. and I.E.R.E. in association with the Department of Electronics at the University, from which registration forms are obtainable.

The eighth **International Instrument Show** to be staged by B & K Laboratories will this year be held at Grosvenor House, Park Lane, London, W.1, from May 17th to 21st. The second Environmental Engineering Symposium will also be held during the same period. Tickets for both are obtainable by bona-fide engineers and designers from B & K Laboratories, 4 Tilney Street, London, W.1.

This year's **Fleming Memorial Lecture** of the Television Society is being given at the Royal Institution, Albemarle Street, London, W.1, at 7.0 on April 29th, by Dr. R. D. A. Maurice, assistant head of the B.B.C.'s Research Department. His subject is "The specification of an adequate television signal." Admission is by ticket obtainable from the Society at 166 Shaftesbury Avenue, London, W.C.2.

**E.E.A. Officers.**—At the annual general meeting of the Electronics Engineering Association on March 16th R. Telford, of the Marconi Company, was elected chairman in succession to W. D. H. Gregson (Ferranti) who held the office for two years. The new vice-chairman is R. J. Clayton (G.E.C. Electronics).

**B.B.C. in West Africa.**—In order to extend the coverage of the B.B.C.'s transmissions in West Africa arrangements have been made for a new medium-wave transmitter in Monrovia to relay programmes for 10 hours every day. The Liberian Broadcasting Corporation, for which Rediffusion provides commercial and technical management, will be responsible for the operation and maintenance of the transmitter and for the reception, recording and relaying of programmes. The agreement is the first of its kind that the B.B.C. has made in Africa involving a commercial organization.

**Baird Scholar.**—The Television Society invites applications for the third award of the John Logie Baird Travelling Scholarship. Valued up to £200 it is open to post-graduate students (in United Kingdom educational establishments) who are concerned with television engineering or an allied technology. The Scholarship is intended to assist the successful applicant in undertaking a period of investigation abroad of approximately 6-8 weeks. Application forms, which must be returned by April 17th, are obtainable from the Society at 166 Shaftesbury Avenue, London, W.C.2.

**Oscar III** the translator satellite for amateur use, was launched by the U.S. Army on March 9th at 18.30 G.M.T. into an orbit with a period of 103½ minutes. The orbit is circular, with a height of 502 miles and an inclination of 70°. The beacon and translator are reported to be functioning. Information regarding Oscar III may be obtained from W. H. Allen, 24 Arundel Road, Tunbridge Wells, Kent, who wrote on the project in our January issue.

A southern section of the **Society of Electronic and Radio Technicians** has been formed in the Portsmouth-Southampton area bringing the total to nine. The others are in Birmingham, Bristol, Glasgow, Leeds, London, Manchester, Newcastle upon Tyne and Nottingham. The Society's membership had grown to 366 in ten weeks.

**Radio and Television Servicing Film.**—A 16 mm colour film showing how a radio and television service engineer is trained and what his work involves was made for the British Radio Equipment Manufacturers' Association and shown for the first time at last year's National Radio and Television Show. The 14-minute sound film is now available on free loan from the Central Film Library, Central Office of Information, Hercules Road, London, S.E.1, and also from Sound Services Ltd., Wilton Crescent, Merton Park, S.W.19.

The twelfth **International Spectroscopy Colloquium** is to be held under the auspices of the British Spectroscopists Coordinating Committee and the Institute of Physics & Physical Society in the University of Exeter, from July 12th-17th. Information and registration forms may be obtained from Mrs. C. E. Arregger, 1 Lowther Gardens, London, S.W.7.

**R.E.C.M.F. Directory.**—A list of the member firms of the British Radio and Electronic Component Manufacturers' Federation, together with a list of trade names and buyer's guide, has been produced. It is available free from the R.E.C.M.F., 6 Hanover Street, London, W.1.

Admiral of the Fleet the **Earl Mountbatten of Burma,** K.G., P.C., has been elected to honorary membership of the Institution of Electrical Engineers "for his distinguished services to the United Kingdom and Commonwealth in war and peace, and for his contributions to the progress of electrical and electronic

*Earl Mountbatten*

science and engineering." Lord Mountbatten, who is Chief of the Defence Staff, joined the Royal Navy in 1913, and during his early naval career specialized in wireless and wrote two handbooks for the Navy on wireless telegraphy. He has retained his interest in radio and electronics and has been vice-patron of the Institution of Electronic & Radio Engineers (formerly Brit. I.R.E.) since 1948. He became chairman of the newly formed National Electronics Research Council last July.

**C. L. G. Fairfield,** M.A.(Cantab.), M.I.E.E., Barrister at Law, has been appointed assistant managing director of Submarine Cables Ltd. (owned jointly by A.E.I. and B.I.C.C.). He joined the board of the Company in 1958. Mr. Fairfield was with Mullard from 1948 to 1953 first as assistant to the directors on technical matters and later as manager of the valve division. He was also a director of Mullard Equipment Ltd. He joined the Telegraph Construction & Maintenance Co. —a subsidiary of B.I.C.C.—in 1953 and was appointed to the board in 1958.

**Graham Miller,** B.Sc., who joined Wayne Kerr in 1959 and for the past three years has been sales manager of the Company's American subsidiary in Philadelphia, has been appointed general sales manager of the parent company. Mr. Miller graduated in physics at Swansea University after studying electronics at the Manchester College of Technology and was for two years head of the Ferranti Standards Laboratory before joining Wayne Kerr.

The forty-third award of the Faraday Medal of the Institution of Electrical Engineers is to be made to **Dr. Vladimir K. Zworykin** "for his notable scientific and industrial achievements, including the invention of the iconoscope, and for his important role in medical electronics." Dr. Zworykin, who is honorary vice-president of the Radio Corporation of America, was born in Murom, Russia, in 1889, went to the United States in 1919, and was naturalized in 1924. He holds the degrees of Ph.D. (University of Pittsburgh) and D.Sc. (Polytechnic Institute of Brooklyn). After research work with Westinghouse Electrical and Manufacturing Company, Dr. Zworykin was, from 1929 to 1942, director of electronics research at the R.C.A. Manufacturing Company. Since 1942 he has devoted himself to the activities of R.C.A. Laboratories.

**Group Captain E. Fennessy,** C.B.E., B.Sc., M.I.E.E., has resigned as managing director of Decca Radar Ltd., and also his directorships of other companies in the Decca Group. He has joined the Plessey Group which, as reported elsewhere, has acquired the ground radar and data-handling divisions of Decca. Gp. Capt. Fennessy, who is a graduate of London University, was a member of the original radar research team under Sir Robert Watson Watt at Bawdsey and in 1940 was commissioned in the R.A.F.V.R. and worked on the planning, construction and operation of radar systems both in this country and abroad. After the war he joined the board of the Decca Navigator Company and became managing director of Decca Radar when the company was formed in 1950.

**Peter H. Parkin,** B.Sc., A.M.I.E.E., acoustics scientist at the D.S.I.R. Building Research Station, has received the 1964 Wolfe Award "for his work on acoustic design in buildings and his invention of 'assisted resonance' for modifying and improving hearing conditions in auditoria." The £500 award is made under the terms of the Wolfe bequest for research workers in D.S.I.R. who make an outstanding contribution to the Department's research during the previous year. Mr. Parkin was in the Admiralty during the war working on counter-measures to magnetic, acoustic and pressure mines. He has been at the Building Research Station, near Watford, since 1946 where he latterly devised the system of "assisted resonance," or electronic-controlled reverberation time, which has recently been introduced in the Royal Festival Hall. He was concerned with the original design of the Hall and he devised the speech reinforcement system installed in St. Paul's Cathedral in 1951.

**Sir Albert Mumford,** K.B.E., B.Sc., M.I.E.E., engineer-in-chief at the Post Office since 1960, retired on March 19th. Sir Albert, who is 62, entered the Post Office in 1924 after graduating at Queen Mary College (London University), of which he is a Fellow. He was for some time in the Radio Laboratories of the Dollis Hill Research Station before joining the Radio Branch staff at Headquarters, where in the early post-war years he led the U.K. delegations to a number of international radio conferences. Sir Albert was president of the Institution of Electrical Engineers last year. The new engineer-in-chief is **D. A. Barron,** C.B.E., M.Sc., M.I.E.E., who graduated at Bristol University and joined the Post Office in 1927 at the age of 20. He has been in the Telephone Branch of the Engineering Department since 1940 and played a major part in the introduction of the Subscriber Trunk Dialling system and in

*D. A. Barron*

the development of electronic telephone exchanges. He has been deputy engineer-in-chief since 1960 and is succeeded by **J. H. H. Merriman,** O.B.E., M.Sc., A.Inst.P., M.I.E.E., who became an assistant e.-in-c. in 1963. Mr. Merriman graduated at King's College, London, and did post-graduate work on non-linear oscillations to gain his M.Sc. He joined the Post Office in 1936, and worked at Dollis Hill Research Station on measurement of the arrival angles of short-wave pulses from the U.S.A. At the outbreak of war he set up and ran radio laboratories at Castleton, near Cardiff, working on v.h.f. for multi-channel telephony and television. In 1949 he returned to London to work on the planning and provision of radio links.

**Peter Lowry,** A.M.I.E.E., A.M.I.E.R.E., until recently assistant technical manager, television, with Rank Cintel, has joined Elliott Brothers as chief engineer of the airborne display division.

The Prince Philip Medal of the City & Guilds of London Institute for 1964 is being presented to **Derek A. Rush,** A.M.I.E.E., C.G.I.A., engineering manager at the Basingstoke Branch of the Aviation Division of S. Smith and Sons, by His Royal Highness on March 31st at Buckingham Palace. The medal, which is awarded annually in recognition of outstanding promise or achievement in the promotion, theory or practice of science and technology, is restricted to those who have "travelled the City and Guilds path." Mr. Rush, who is 41, began his career at the Post Office Research Station, Dollis Hill, and between the years 1941 and 1946 he gained nine C. & G. certificates in telecommunication subjects. He was

*D. A. Rush*

awarded the City and Guilds Insignia Award in Technology (C.G.I.A.) in the field of electronic equipment in 1959. He entered industry in 1946 and was for three years with Sperry Gyroscope before going to Sydney in 1951 to join Amalgamated Wireless Australasia. He later returned to Sperry where he was concerned with gunfire control systems. He joined Smith's in 1955 as project officer for guided weapons.

**W. A. Penkman,** who has been in charge of the Marconi International Marine Company's service organization since 1953, latterly as service and supplies manager, has been appointed to the new post of equipment controller. Mr. Penkman began his career with the company's shore staff in 1918. Two years later he joined the sea-going staff as a radio operator. He then joined the Radio Communication Company which in 1928 was amalgamated with Marconi Marine and he rejoined his original company. He became deputy manager of the service division in 1952. The new service and supplies manager is **J. S. E. Riddle** who has been with the company since 1940. He was a sea-going radio officer for six years. In 1956 he became an inspector and later was marine manager of the company's Norwegian associates, Norsk Marconi-kompani. He has been manager, service department, at Chelmsford since last August.

**Professor T. Kilburn,** D.Sc., Ph.D., M.A., M.I.E.E., who is the first incumbent of the chair of computer engineering established at Manchester University in 1960, has been appointed a Fellow of the Royal Society "for his contributions to the development, design and engineering of electronic digital computers and high speed computer components." Dr. Kilburn was at the Telecommunications Research Establishment (now R.R.E.), Malvern, from 1942 until 1946 when he joined the staff at the University as reader in electronics. In collaboration with Professor F. C. Williams, head of the Electrical Engineering Laboratories, he built the University's first computer.

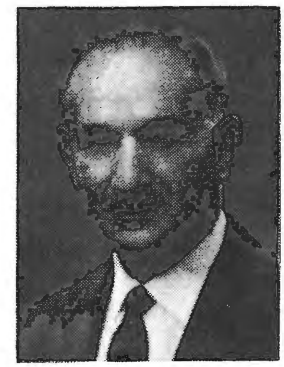
**J. R. Tillman,** B.Sc., Ph.D., A.M.I.E.E., has been appointed deputy director of research at the Post Office Research Station, Dollis Hill. Dr. Tillman was a Beit Research Fellow, 1934-36, and with P. B. Moon discovered the thermal neutron and the selective absorption of slow neutrons. He joined the Post Office Research Station in 1936. Dr. Tillman has latterly concentrated on solid state research and on the reliability of transistors for submarine cable repeaters. He is joint author with F. F. Roberts of the book "Theory and practice of the transistor."

**Robert Telford,** B.A.(Cantab.), M.I.E.E., the new chairman of the Electronic Engineering Association, joined Marconi's in 1937 at the age of 22 as a management trainee and in 1940 became manager of the Hackbridge Works where he was responsible for the production of airborne and portable radio equipment. He was appointed managing director of Marconi Brasilera in 1946 and on his return to this country four years later became assistant to the general manager at Chelmsford. He was appointed general manager of the company in 1961 and has been a director since 1963.

**Charles A. R. Pearce,** M.Sc., M.I.E.E., has been appointed deputy managing director of Ericsson/Etelco a principal operating company of the Plessey Group. Mr. Pearce joined Ericsson/Etelco in 1958 as controller of engineering. His earlier experience included engineering development and research with D.S.I.R. and with the London Telecommunications Region of the G.P.O. He was chief factories engineer to the Post Office from 1948 to 1951. Mr. Pearce, who is 53, received his technical education at the City and Guilds Engineering College and London University.

**Richard C. Norwood,** who has been deputy to the managing director of A. C. Cossor since February last year, has been appointed a managing director. **Professor C. L. Calosi,** who has been a managing director since January, 1964, has relinquished his appointment, but will continue as a director of the company in addition to his vice-presidency of Raytheon Company.

**H. S. Payman,** B.Sc.Tech., B.Sc. (Eng.), M.I.E.E., A.Inst.P., managing director of B. & R. Relays, has been co-opted a director of the parent company, Gas Purification & Chemical Co. Ltd. Mr. Payman, who is a graduate



*H. S. Payman*

of both Manchester and London Universities, joined B. & R. Relays in 1958, having been general manager of Suflex for the previous three years. Earlier he was with A.B. Metal Products as deputy director of component production.

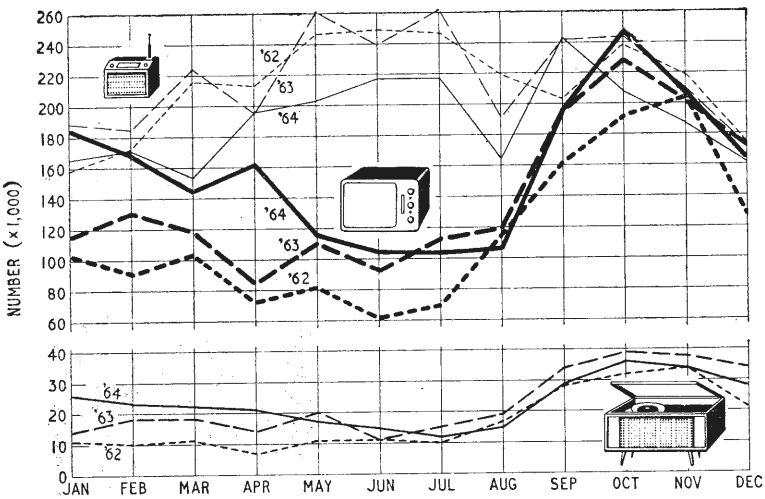
**R. H. W. Burkett,** B.Sc., M.I.E.E., has been appointed managing director of Welwyn Electric Ltd. Mr. Burkett, who has been 19 years with Welwyn, was appointed to the board as technical director in 1958 and has been general manager since December, 1963.

## OUR AUTHORS

**G. F. Turnbull,** M.Sc., and **J. M. Townsend,** M.Sc., who describe a pulse width modulated amplifier in this issue, are both on the staff of the electrical engineering laboratories of Manchester University. Mr. Turnbull graduated at the University in 1959 and did a year's post-graduate research obtaining his masterate in 1960. He was appointed assistant lecturer in electrical engineering in 1961 and was promoted to lecturer the following year. Mr. Townsend graduated at the University in 1961 and after a year's research was appointed assistant lecturer. He obtained his M.Sc. in 1963.

**J. M. Firth,** author of the article on an audio warning circuit in this issue, has recently gone to Canada to work with RCA Victor on the scientific satellite which is to succeed *Allouette.* After reading mechanical sciences at Cambridge from 1954-58 he spent three years with Smith's Aircraft Instruments, Cheltenham. From 1961 until last year he worked for the Radio Astronomy Group at the Cavendish Laboratory, Cambridge, on equipment for the scientific experiments included in the UK-2 satellite. This work took him to Washington for 15 months.

# NEWS FROM INDUSTRY




**Manufacturers' Despatches to the Home Market** for the past three years are shown above. This graph was compiled from monthly figures issued by the British Radio Equipment Manufacturers' Association. They are net figures of deliveries by manufacturers to the home market and include those despatched to the specialist rental and relay companies. Car radios are included in the sound receiver curves.

**Plessey Buy Part of Decca.**—Agreement has been reached whereby the ground radar and data handling divisions of Decca Radar Ltd. at the Isle of Wight and Tolworth are to be transferred to the Plessey Company at the end of March. This transfer, which is to cost Plessey approximately £4M—payable in cash—does not include any trade mark rights and there are no restraints on the future activities of either company.

**Audio Fidelity Ltd.**—Radio Supply Co. (Leeds) Ltd., which was incorporated as a private limited company in 1952 and has had several changes in name in recent years, is in future to be known as Audio Fidelity Ltd. It is also announced that the company has made application to the London Stock Exchange for permission to deal in, and for quotation of all their Ordinary Shares. Audio Fidelity Ltd. have a controlling interest (75%) in Fane Acoustics Ltd., the manufacturers of audio equipment.

The **specialized components division** of the Marconi Company, which was formed in July 1962, has moved from Writtle into new headquarters at Billericay, Essex. The address is Billericay Works, Radford Crescent, Billericay, Essex. (Tel.: Billericay 3431.)

**JFD Electronics Corporation,** of New York, have opened a European sales office in Paris. Correspondence should be addressed to JFD Electronics, Europe SA, 7 rue de Rocroy, Paris 10.

**Clarke & Smith.**—Electric & Musical Instruments Ltd. have relinquished their 49% interest in the Clarke & Smith Group.

**Two Million Transistor Order.**—International Computers and Tabulators Ltd. have placed an order for two million silicon planar epitaxial transistors with SGS-Fairchild Ltd. These semiconductors are for use in the I.C.T. 1900 Series of computers, which were introduced last October.

**Digital Airborne Data Recorder.**—High accuracy recording equipment for use in the assessment trials of aircraft navigational systems has been installed in a Comet 4C belonging to the Experimental Navigation Division of the Ministry of Aviation, Aeroplane and Armament Experimental Establishment at Boscombe Down. The recorder is designed to record flight data on punched tape and will replace the photographic methods previously used by the Aeroplane and Armament Experimental Establishment.

Weymouth Radio Manufacturing Co. Ltd. is in future to be known as **Weyrad (Electronics) Ltd.** The address remains the same: Regent Factory, Weymouth, Dorset.

**No Patent Infringement.**—At the end of February, the Honourable Mr. Justice Lloyd-Jacobs dismissed two actions brought by AMP Incorporated, of Pennsylvania, who sought an injunction to restrain Hellermann Ltd. and Hellermann Terminals Ltd. from infringing their Letters Patent 661,192, which relates to a hand crimping tool.

**Webb's Radio,** of 14 Soho Street, Oxford Street, London, W.1, are discontinuing their business with effect from 31st March, 1965. They have, for many years, carried an extensive range of Eddystone receivers.

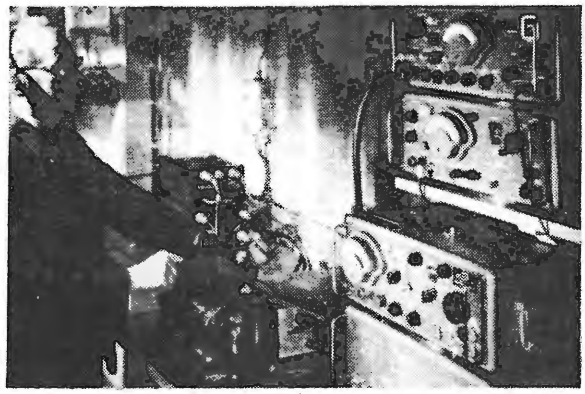
**English Electric 1964 Results.**—Turnover for the English Electric Group in 1964 amounted to £227M and represented an increase of £18M on the previous year's result. Group profit after tax charges of £4.8M as against £4.3M in 1963, depreciation of £4.8M (£4.4M) amounted to £6,743,000. This represents an increase of £2,948,000. The Marconi Company and its subsidiaries contributed £35.7M (£32.3M) to the Group's record turnover figure and £3M (£1.7M) to the Group's £19M pre-tax profit. More than 50% of the Company's output was exported in the year under review.

An associated company to the English Electric Group, the **Marconi International Marine Company,** reports a profit for 1964 of £734,401, which represents an increase of £65,544 over the previous year. Profit after taxation amounted to £416,145 (£315,625).

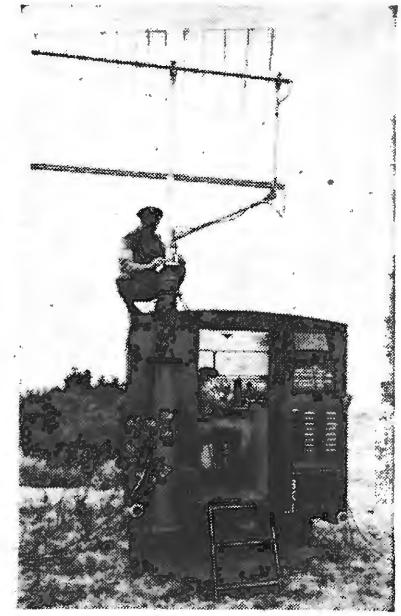
**Westinghouse.**—After deduction of the loss of £800,271 incurred by Gresham & Craven Ltd. (who are not in the electronics field) and general interest charges of £345,296, the group profit of the Westinghouse Brake and Signal Company for the year to 3rd October was £1,078,152. This shows a substantial improvement on the previous year when Westinghouse suffered a deficit of £863,559. Net taxation for the year under review was £220,915, leaving a profit after tax of £857,237.

**Advance Electronics Ltd.** group pre-tax profit for 1964 amounted to £236,347 and represents an increase of £49,128 over the 1963 result. After taxation, profits for the year totalled £121,347 as against £89,396 in 1963. This is the first financial year under the company's new name (formerly Advance Components Ltd.).

**Telegraph Condenser Co.**—Group trading profit of the Telegraph Condenser Company for 1964 amounted to £506,846 and shows an increase of £85,064 on the previous year's result. After deductions, including £156,335 (£156,991) for depreciation and £107,811 (£92,171) for taxation, the net profit rose from £114,323 in 1963 to £181,845.



**Interference.**—*New screened rooms, extra staff, new equipment and facilities for on-site testing have been added to the measurement and suppression of radio interference service offered by Standard Telephones and Cables to industry. This service covers aircraft, marine and industrial equipment and installations.*



**Mobile u.h.f. radio relay equipment,** *known as the Type C50, which has recently been undergoing field trials, has now been accepted for use by the British Army. The equipment, which was developed as a private venture by the Automatic Telephone & Electric Company, is frequency modulated and provides six spot frequencies in the 225-400 Mc/s band. Extra channels can easily be obtained by the inclusion of a Plessey frequency synthesizer. The power rating of the transmitter is 250 watts.*

## From overseas

**Canada**

**A closed circuit television system** that enables "downtown business houses" to monitor the quotation boards of the Vancouver stock exchange recently went into service. Eight cameras are used in the system, which was designed by the British Columbia Telephone Company and produced by Sylvania Electric Products Inc.; both subsidiaries of the General Telephone & Electronics Corporation.

**El Salvador**

G.E.C. (Telecommunications) Ltd. have received a contract, valued at £350,000, for a **microwave radio relay system** for the Central American republic of El Salvador. The system will have a capacity of 300 telephone channels, operate in the 7 Gc/s band and will connect the towns of San Miguel, Santa Ana, Sonsonate and Usulatan with the capital, San Salvador.

**Finland**

The Finnish Department of Telegraphs and Posts have ordered a six-target **surveillance and precision approach radar simulator,** Type SY2027, from the Solartron Electronic Group. This simulator is to be installed at Jyväskylä airfield and will be used to train air traffic controllers.

**Hong Kong**

Marconi Self-Tuning (MST) high-frequency **radio communications equipment** has been ordered by Cable and Wireless Ltd. for their Hong Kong transmitting station.

**Pakistan**

Sui Northern Gas Pipelines Ltd., of Karachi, have awarded the Marconi Company a contract, worth over £500,000, for the supply and installation of **instrumentation, telemetry and telecommunications equipment** for the first phase of a new natural gas pipeline to be laid in the northern part of West Pakistan.

Marconi Sixty Series of **airborne radio communications and navigation equipment** has been ordered for three Hawker Siddeley Trident aircraft shortly to enter service with the Pakistan International Airlines Corporation.

**South America**

The Bank of London & South America and English Electric-Leo-Marconi Computers Ltd. have formed a company to provide computer services in Latin America. The new company is named Intercontinental Data Services Ltd. and a KDF 8 computer will be installed in Buenos Aires at the end of this year.

**Spain**

Ten 13,000 ton cargo vessels now under construction in Spanish shipyards are to be fitted with Marconi Marine **navigation and communications equipment.** This order, which was placed through Empresa Nacional Radio Maritima, is valued at over £110,000.

**U.S.A.**

A "Certificate for Instrument Operations" approving the **Decca Navigator system** has been issued to New York Airways, who operate large passenger helicopters in and around the greater New York area. This certificate allows the Decca Navigator system to be used in all weather operations as a primary navigational aid. This is the first time that a passenger helicopter has received such a certificate for route as well as terminal area operations. The helicopter equipment consists of a dual Mark 8 installation with twin flight logs and will operate from the New York chain of Decca stations which has been in operation since January, 1958.

## Agencies and agreements

The M-O Valve Company has reached a licensing agreement with the **Microwave Electronics Corporation,** of California, under which they will manufacture and market in the United Kingdom M.E.C. low-noise metal/ceramic travelling-wave tubes.

**Federal Electronics,** of California, have appointed Forinco Ltd., of 52 Broad Street, Worcester (Tel.: Worcester 28171), as distributors of their valves and semiconductors.

The **Telectric Corporation** have appointed Britec Ltd., of 17 Charing Cross Road, London, W.C.2 (Tel.: WHItehall 3070), to act as U.K. distributors for the aeronautical equipment they manufacture in Switzerland. It includes an automatic tester for aircraft marker beacon receivers.

High Volt Linear Ltd., of 1 Cardiff Road, Luton (Tel.: Luton 23816), now represent **Oak Ridge Technical Enterprises Corporation,** of Tennessee, who manufacture surface barrier semiconductor detectors and associated equipment for use in nuclear research.

The electronic tube division of **Westinghouse,** New York, have appointed Ad. Auriema Ltd., of 125 Gunnersbury Lane, London, W.3 (Tel.: ACOrn 8762), as U.K. distributors for their receiving valves and microwave tubes and devices.

**Klein and Hummel,** the West German manufacturers of audio amplifiers, tuners and studio loudspeakers, have appointed The High-Fidelity Centre, of 61 West Street, Dorking, Surrey (Tel.: Dorking 4229), to act as U.K. agents.

# Physics Exhibition

FOR the first time since the Physical Society started its series of exhibitions in 1905, this year's—the 49th—is to be held outside London. Another change is in its title which is simply "The Physics Exhibition." Now organized by the Institute of Physics and the Physical Society, which amalgamated under their joint names in 1960, this year's exhibition opens at the Manchester College of Science and Technology on April 5th for four days. Admission is by ticket obtainable free from the secretary at 47 Belgrave Square, London, S.W.1. Applicants are asked to send a stamped addressed envelope. The exhibition will be open from 10 a.m. to 8.30 p.m. (5.30 p.m. on the last day) but admission before 2 p.m. on the first day is restricted to members and invited guests.

We give below a list of the 125 exhibitors. In addition to universities, colleges, and research laboratories there are some 90 U.K. manufacturers who will be showing new instruments, apparatus and materials of special interest to physicists in their work in research, development or in teaching. We hope to give in our next issue a report of some of the more outstanding exhibits, the majority of which will be in the research or development stage.

A.W.R.E.
Admiralty
Airflow Developments
Associated Electrical Industries
Associated Engineering
Atomic Power Constructions
Automatic Telephone & Elec. Co.
Aviation, Ministry of

Baldwin Instrument Co.
Barr & Stroud
Beck, R. & J.
Bell & Howell
Birmingham University, Electronic & Elect'l. Eng'g. Dept. Physics Dept.
Boulton Paul Aircraft
Bradford Inst. of Technology
Bradley, G. & E.

Bristol Siddeley Engines
Bristol University
Brit. Nat. Com. for High Speed Photography
British Oxygen Co.
British Railways
Brunel College
Bryans

Cambridge Instrument Co.
Cambridge University
Central Office of Information
College of Aeronautics

D.S.I.R.
Data Laboratories
Dawe Instruments
Deakin Phillips Electronics
Decca Radar
Defence, Ministry of
Devices
Digital Measurements
D-mac

E.M.I. Electronics
Edwards High Vacuum
Electronic Associates
Electronic Instruments
Elliott-Automation
Enfield College of Technology
Ether Langham Thompson
Evans Electroselenium

Fairey Engineering
Ferranti
Frigistor Laboratories

General Electric Co.
Genevac
Goethean Science Foundation
Grubb, Parsons & Co.
Gulton Industries

Haigh & Hochland
Hilger & Watts

Imperial Chemical Industries
Agricultural Div.
Central Instrument Lab.
Fibres Div.
Mond Div.
Nobel Div. (Instrument & Electronics)
Plastics Div.
Imperial College
Industrial Instruments
Instrom
International Research & Dev. Co.
Isotope Developments

Joyce, Loebl & Co.

King's College, London

Labgear
Lan-Electronics
London Hospital Medical College

Manchester College of Science & Technology
Manchester University
Mechatronics (London)
Mercury Electronics (Scotland)
Metals Research
Microwave Instruments
Middlesex Hospital Medical School
Mullard

Nat. Inst. of Agricultural Eng'g.
Newcastle University
Newport Instruments
Nuclear Enterprises (G.B.)

Optec Reactors
Optical Works
Oxford Instrument Co.

Panax Equipment
Perkin-Elmer
Planer, G.V.
Plessey Co.
Post Office Research Station
Pye, W. G., & Co.

Rainbow Radio
Rank Nucleonics & Controls
Research Electronics
Research & Engineering Controls
Research & Industrial Instruments Co.
Research Instruments
Royal College of Advanced Technology, Salford
Dept. of Elect'l. Eng'g.
Dept. of Pure & Applied Physics
Royal Military College of Science

Safety in Mines Research Establ.
Sangamo Weston
Scientifica
S.E. Laboratories (Eng'g.)
Smith, S., & Sons
Solartron Electronic Group
Standard Telephones & Cables
Strathclyde University

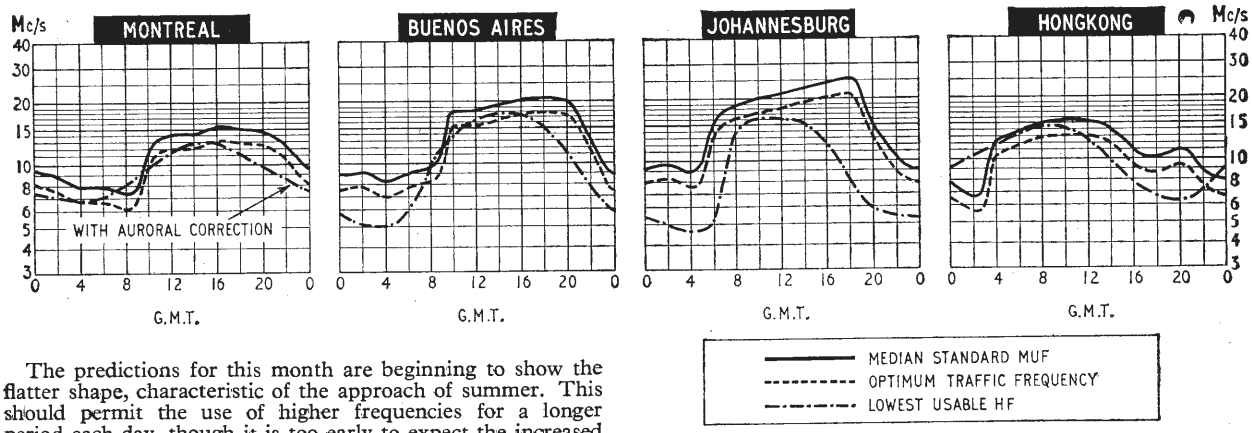
Techne (Cambridge)
Technology, Ministry of
Telequipment
Telford Products
Telsec Instruments
Tinsley, H., & Co.
20th Century Electronics

U.K.A.E.A.
Unicam Instruments
United Power Co.
University College, London

Vacuum Generators
Venner Electronics

Wareham (Measuring Systems)
Wayne Kerr Laboratories
Wild Barfield

# H. F. PREDICTIONS — APRIL




The predictions for this month are beginning to show the flatter shape, characteristic of the approach of summer. This should permit the use of higher frequencies for a longer period each day, though it is too early to expect the increased sunspot number to have any effect yet. Circuit working will still prove difficult, notably on the relatively short Montreal-London route, and little advantage can be expected due to Sporadic-E ionization. The reverse path London-Montreal might prove somewhat easier, due to lower LUF.

The curves show the median standard MUF, optimum traffic frequency and the lowest usable frequency (LUF) for reception in this country. Unlike the standard MUF, the LUF is closely dependent upon such factors as transmitter power, aerials, and the type of modulation. The LUF curves shown are those drawn by Cable & Wireless Ltd. for commercial telegraphy and assume the use of transmitters with a power of several kilowatts and rhombic type aerials.

# AUDIO FAIR PREVIEW

## GUIDE TO NEW EQUIPMENT EXHIBITED

ON April 22nd the International Audio Festival & Fair opens at the Hotel Russell, London, W.C.1, for four consecutive days. This preview of the Fair is compiled from information supplied by exhibitors in response to our request. Some manufacturers, however, did not wish to release information on their latest products before the opening date of the show. We hope, none the less, that in the following few pages readers will find a useful guide to most of the new equipment to be seen at the Fair.

We plan to include in our June issue our usual review of some of the outstanding exhibits seen at the Fair.

The reports are arranged alphabetically under trade names or abbreviated company title. Where, however, the trade name bears no relation to the manufacturer's name it is given in square brackets after the firm's name in the list of exhibitors below. At the end of reports on overseas companies' exhibits we give the name and address of the U.K. agents.

Plans are being made for the B.B.C. to provide demonstrations of pilot-tone stereo transmissions during the Fair. On the last day of the Fair and also on the Monday, record manufacturers are providing a series of demonstrations as well as displays of their discs at the nearby Royal Hotel.

The Fair will open each day at 11.0 but admission on the first day until 4.0 is restricted to invited guests. It will close at 9.0 (Sunday 8.0). Tickets (admitting two) are available from exhibitors, dealers or the editorial office of *Wireless World*. Please send a stamped addressed envelope.

### A.D.C.

The full range of cartridges made by the Audio Dynamics Corporation is to be shown. The Point-Four and Point-Four/E cartridges will be featured in A.D.C. Pritchard tone arms fitted to Thoren Type TD 124 turntables, and the ADC-770 cartridge in a Goldring Type GL70 transcription unit.

*Agents: K.E.F. Electronics Ltd., Tovil, Maidstone, Kent.*

### A.K.G.

In addition to their existing range of dynamic and condenser microphones a number of new types will be shown. The DX11 reverberation microphone announced last year has now reached the production stage. The D19C range has been extended with the introduction of the D119CS which incorporates a bass-cut switch and windshield. A high-low impedance switch and an on-off switch are included in the new D14S. The D77 stereo microphone has been superseded by the D66. A smaller version of the C12 condenser microphone has been introduced (the C12A) using a Nuvistor amplifier, a directional pattern switch and stabilized power unit.

*Agents: Politechna (London) Ltd., Eardley House, 182 Campden Hill Road, London, W.8.*

### AGFA

The complete range of Agfa magnetic recording tapes is to be shown, including the Novodur library storage cassette, which is available with several different size reels as an alternative to the more usual swivel type cassettes.

*Agfa Ltd., 27 Regent Street, London, S.W.1.*

### AKAI

Pullin Photographic, now part of the Rank Audio Visual Aids Division, will be displaying four new Japanese Akai tape recorders. All models are suitable for stereo operation and incorporate some novel features. The M-8 and X-4 (illustrated) use a cross-field head which results in higher frequency response at low tape speeds. The M-8 also includes a vertically directed supplementary loudspeaker system. The ST-1, being shown for the first time in this country, is a two-speed portable model with a transistor pre-amplifier. Other exhibits include the 345 recorder and the SS-110 stereo loudspeaker system.

*Agents: Pullin Photographic, 11 Aintree Road, Perivale, Middlesex.*

### AMPEX

A new magnetic tape recording equipment on show will be the MR-70, for making master recordings. The main advances over previous designs are a 10dB improvement in signal/noise ratio, to take advantage of low-noise tapes now available, a better frequency response and improved control of tape motion. Domestic tape recorders to be seen will include the 2,000 Series which feature automatic threading, automatic reverse, automatic shut-off and ability to operate in horizontal or vertical positions.

*Ampex Great Britain Ltd., 72 Berkeley Avenue, Reading, Berkshire.*

### LIST OF EXHIBITORS

A K G
Acoustical Manufacturing Co. [see Quad]
Agfa
Akai
*Amateur Tape Recording Magazine*
Ampex Great Britain
Armstrong Audio
Audio Dynamics Corp.

BASF Chemicals
B.M.B. Sales
Bang & Olufsen
Beyer Elektrotechnische Fabrik
Boosey and Hawkes [see Jordan-Watts]
Braun
Brenell Engineering Co.
Brown, S. G.
Butoba

Celestion
Clarke & Smith Mfg. Co.

Decca Record Co.
Decca Radio & Television Co.
Derritron Radio [see Chapman]
Design Furniture
Dual Electronics A/S

E.M.I. Tape
Elcom (Northampton)

Fane Acoustics
Ferrograph Co.
Field, N. & S. B. [see Record Housing]
Fi-Cord International

G.K.D.
Garrard Engineering
Goldring Mfg. Co.
Goodmans Industries
Grampian Reproducers
*Gramophone, The*

Hammond, C. E., & Co.

Ilford

K.E.F. Electronics
Kelly Speakers
Kodak

Leak, H. J., & Co.
Link House Publications
Long Playing Record Library
Loewe-Opta AG
Lowther Manufacturing Co.
Lustraphone

Mallory Batteries
Mastertape (formerly MSS)
Minnesota Mining & Mfg. Co.
Mullard

Ortofon A/S

Peto-Scott
Philips Electrical
Planet Projects
Print & Press Services
Pye

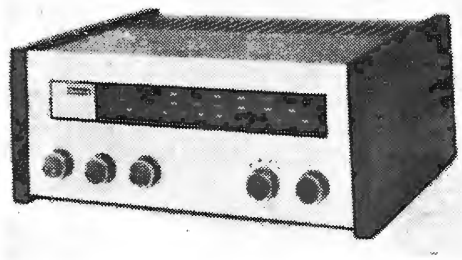
Radford Electronics
*Records and Recording*
Reslosound
Rogers Developments
Revox-Studer A/S

S.M.E.
Saba Electronics
Scandinavian Radio & TV Cie. [see S.R.T.]
Scott, H. H. Inc.
Shure Electronics
Sonotone
Sony Corp. of Japan
Standard Telephones & Cables
Sugden & Co. [see Connoisseur]
Svenska Hogtalfabriken [see S.H.B.]

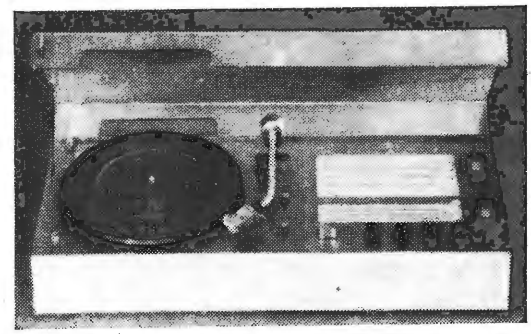
Tandbergs Radiofabrik A-S
Tannoy Products
Telefunken
Thorens, S.A.
Trio
Truvox

Vortexion

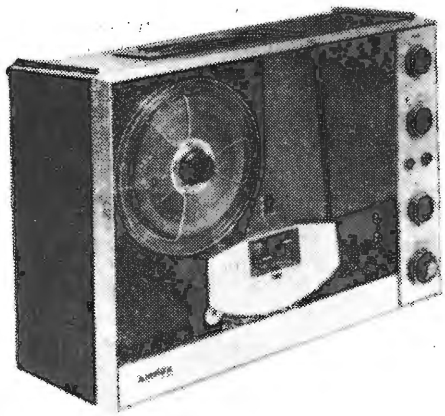
Wharfedale Wireless Works
Whiteley Electrical Radio Co.
Williman, K. H., & Co.
Wilmex
Wilson Stereo Library
*Wireless World & Wireless Trader*



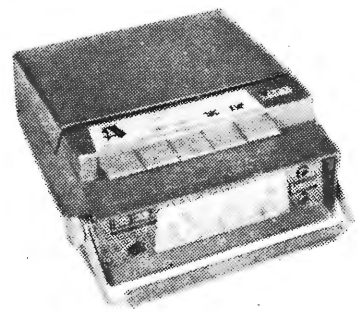
Armstrong 127M tuner-amplifier.



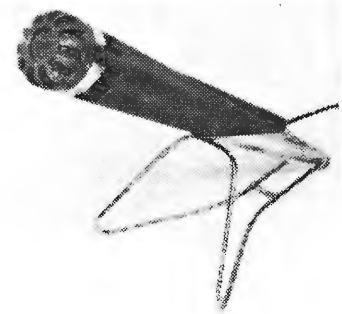
Braun Audio 2 Hi-Fi Stereo Combination.



Ampex Model 2000 tape recorder.



Akai X-4 battery/mains tape recorder with cross-field head.



Dual function microphone by S. G Brown.

#### ARMSTRONG

Designed for users requiring lower power outputs (5 watts) than those provided in the main Armstrong range are the 127 stereo tuner-amplifier and the 127M mono tuner-amplifier. Each unit will receive a.m. and f.m. broadcasts and can be used as an amplifier for tape recording or for reproducing records. The stereo model has provision for addition of a multiplex decoder for reception of f.m. stereo broadcasts.

*Armstrong Audio Ltd., Warlters Road, London, N.7.*

#### BASF

Visitors will be invited to listen to tape recorded talks on subjects of their own choice, and at the same time copy tapes will be made for them to take away free. Details of the range of BASF tapes, library boxes, spools and other accessories will be available. The company makes tapes with playing times up to 90 minutes at 7½ ins/sec (and correspondingly for lower speeds).

*BASF Chemicals Ltd., 5a Gillespie Road, London, N.5.*

#### B.M.B.

More than 70 types of sapphire and diamond styli will be exhibited for the first time by B.M.B. (Sales) Ltd. These are manufactured by the Stylus Division of British Manufactured Bearings Company.

*B.M.B. (Sales) Ltd., Crawley, Sussex.*

#### BANG & OLUFSEN

A wide range of B. & O. equipment is available in this country. It includes portable and table radios, stereograms, tape recorders, record players and accessories—from pickup cartridges to loudspeaker units.

*Agents: Debenhams Electrical & Radio Distribution Company, Eastbrook Road, Eastern Avenue, Gloucester.*

#### BEYER

A number of new microphones manufactured by Beyer Elektrotechnische Fabrik are to be shown. This includes the Beyer M 80 cardioid with a frequency response of 50 to 16,000 c/s and the Type M 110 dynamic directional microphone with a frequency response of 60 to 12,000 c/s.

*Agents: Fi-Cord International Ltd., 40a Dover Street, London, W.1.*

#### BRAUN

Reception of f.m. stereo broadcasts and medium-, long- and short-wave stations, as well as mono and stereo reproduction of disc and tape records, is provided for in the transistorized Audio 2 Hi-Fi Stereo Combination. Two other recent introductions will be the PS 400 stereo record player with counterbalanced tubular pickup arm and lowering system, and the CE 16 tuner covering f.m. stereo and m.w. broadcasts.

*Agents: Argelane Ltd., 251 Brompton Road, London, S.W.3.*

#### BRENELL

The well-known Mark 5 range of equipment is now into Series 3 and includes a tape deck, amplifier and tape recorder. These will be on show together with the Type M tape recorder, which has separate record and playback heads and amplifiers, and the Mark 510 recorder which will accommodate reels up to 10½in dia. A stereo tape recorder (STB/5/2) will also be on view, with a monitor amplifier and loudspeakers as optional extras.

*Brenell Engineering Co. Ltd., 231 Liverpool Road, London, N.1.*

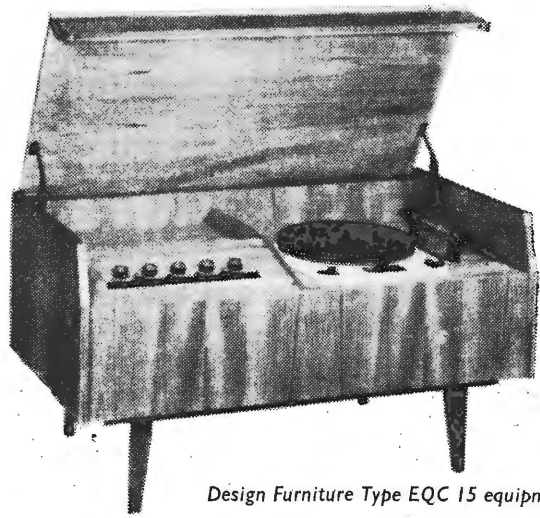
#### BROWN

Most audio products will be demonstrated, including the new dual function microphone (illustrated) which is transformed into a differential microphone by operation of a shutter. The Universal handset will be shown, with built-in pre-amplifier, as used for communication in aircraft. The recently announced miniature headset, developed for use in Mercury space craft, will also be on view.

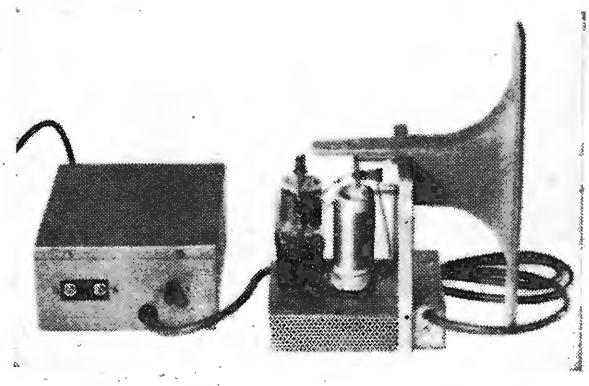
*S. G. Brown Ltd., King George's Avenue, Watford, Herts.*

#### BUTOBA

The latest tape recorder to be introduced is the three-speed portable model MT22. It has remotely controlled rewind and pause, a digital tape counter, an automatic tape stop, a recording level meter,



Design Furniture Type EQC 15 equipment cabinet.



Fane Acoustics "Ionofane" loudspeaker.

a 7-inch circular loudspeaker and transistor electronic circuits. Also on show will be the MT5 recorder, notable for its robust construction.

*Agents: Denham & Morley, 173/175 Cleveland Street, London, W.1.*

### CELESTION

The new Ditton 10 wide-range loudspeaker system with a power handling capacity of 10 watts r.m.s. will be featured together with existing models CX1512 and CX2012.

*Celestion Ltd., Ferry Works, Thames Ditton, Surrey.*

### CHAPMAN

The range of tuners to be shown includes an f.m. model; an a.m./f.m. type giving also long, medium and short wavebands; an a.m. bandspread receiver covering the 11, 13, 16, 19, 25 and 31 metre bands in bandspread ranges; and a similar bandspread receiver covering also f.m. at 87.5-108 Mc/s.

Amplifiers on view will include the 306 Stereo, an 8+8 watt integrated equipment with a frequency response claimed to be flat within 0.2dB from 30 c/s to 20 kc/s. Inputs are selected by push-button switches.

*Derritron Radio Ltd., 24 Upper Brook Street, London, W.1.*

### CLARKE & SMITH

Although no details of the exhibits to be shown by this firm were available at the time of going to press it is reasonable to assume that they will include high-quality amplifiers and sound reproducing equipment.

*Clarke & Smith Manufacturing Co. Ltd., Melbourne Road, Wallington, Surrey.*

### CONNOISSEUR

Two transcription turntables in the Connoisseur Craftsman series (one a two-speed and the other a variable three-speed unit) are to be shown by the manufacturers—Sugden. The units are very similar and have identical wow (0.15%) and flutter (0.1%) characteristics. Hum level is less than 80 dB and rumble is 50dB down on both machines. The Craftsman series of loudspeaker enclosures, which are available with and without speakers, and a selection of pickup arms and cartridges are also to be shown.

*A. R. Sugden & Co. (Engineers) Ltd., Market Street, Brighouse, Yorkshire.*

### DECCA

The *ffss* Mark III pickup will be demonstrated with a new magnetic bias adjuster. This fits on to the pivot pillar of all Decca pickup arms and magnetically neutralizes the lateral bias force. A new *ffss* Deccadec includes a non-ferrous turntable and a pickup arm to take all *ffss* heads except those with elliptical stylus. The current TSA range of "budget stereo" equipment will also be demonstrated, including the TSA33 transistor stereo amplifier and the Deccadec with the Deram ceramic cartridge.

*Decca Radio & Television Ltd., Albert Embankment, London S.E.1.*

### DESIGN FURNITURE

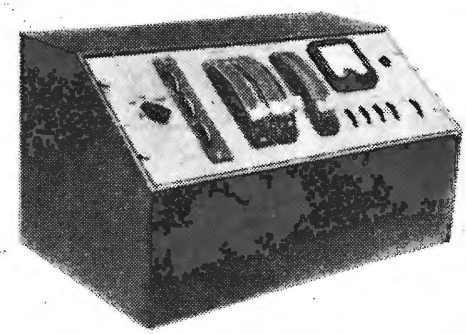
Two new equipment cabinets with motor mounting boards that are adjustable in height are to be featured. The motor mounting board in the larger of the two cabinets, the EQC 14, can be stepped in height if required. A record storage cabinet and a loudspeaker enclosure, containing Celestion speakers, are also to be featured.

*Design Furniture Ltd., Calthorpe Manor, Banbury, Oxon.*

### DUAL

Of this range of German equipment, the 1009 turntable and pickup arm will be shown with the CV2 transistor integrated stereo amplifier and loudspeaker unit CL3. The 1009 turntable, which weighs 7½ pounds, has a fine speed control which uses a conical motor drive pulley. The tracking weight is adjustable and, incidentally, it is claimed that the pickup will track with a tilt of 45° and a tracking weight of 1 gram. The unit provides for automation operation with a tracking weight of ½ gram.

*Agents: Celsa Electric Company Ltd., Kelway Place, London W.14.*



Elcom transistorized sound studio unit.

### E.M.I.

In addition to showing current tape recorders, EMI Electronics will present their new L4 portable professional recorder. This two-speed model with remote control and mixing facility includes a fourth magnetic head for sound sync. EMI Tape Ltd. will also be showing their range of recording tapes, film and blank discs.

*EMI Electronics, Hayes, Middlesex.*

### ELCOM

Transistorized sound equipment for recording and broadcasting studios will be displayed. The units are available in portable or console form and facilities include input switching, tone equalization, channel and group fading by quadrant faders, mid-lift units and pre-fade listen. Separate modules, available as plug-in units, will include line amplifiers, microphone amplifiers, compensating units, faders and peak programme meter units.

*Elcom (Northampton) Ltd., Weedon Road, Industrial Estate, Northampton.*

### FANE

The new Ionophone loudspeakers should create much interest since they have no mechanical moving parts and

(*Continued on page* 189)

*Duette equipment cabinet from GKD which can be used as a room divider.*

use ionized air to propagate sound. The Ionofane 601 frequency response extends from 3 kc/s-30 kc/s and is claimed to have a better transient response than conventional loudspeakers. The 602 model includes the 601 unit and a mid-range unit, and in the 603 model a 15in bass unit is added to the 602.

*Fane Acoustics Ltd., Hick Lane, Batley, Yorkshire.*

#### FERROGRAPH

An addition to the range of well-known equipment will be shown, but at the time of going to press details had not been released.

*The Ferrograph Company Ltd.,* 84 *Blackfriars Road, London S.E.*1.

#### FI-CORD

A new tape recorder, the Fi-Cord 202A, is to be introduced at the Fair. This machine is to replace the 202, which was first seen three years ago. At the higher of the two speeds ($7\frac{1}{2}$ in/sec) the frequency response of this portable machine is quoted to be within 3 dB from 50 to 12,000 c/s. Other features include a re-designed control panel and a new Vu-meter. Fi-Cord will also be showing the first two microphones of their own make. Both are of studio quality and use the moving coil principle.

*Fi-Cord International Ltd., 40a Dover Street, London, W.*1.

#### GKD

The Huntingdon and Anglian series of cabinets have been completely redesigned and will now accommodate almost any manufacturer's equipment. A number of modifications have also been made to the remainder of the G K D range, but without change to styling.

*G K D Ltd., 74 Langley Street, Luton, Beds.*

#### GARRARD

In addition to the present range of products, the new Model SP25 single-disc player will be displayed. This unit has a calibrated stylus pressure adjustment, a bias compensator and a pickup arm lowering device. An unusual feature for a single player is the automatic arm return. The unit also has a balanced non-magnetic die-cast turntable with a dynamically balanced rotor.

*Garrard Engineering Ltd., Swindon, Wilts.*

#### GOLDRING

A four-speed turntable unit with a fine speed adjustment of ± 10% on each speed will be introduced. Designated G 66, the unit has a built-in lowering device coupled with the on/off switch, and the pickup arm is wired for stereo. The idler wheel is automatically disengaged as the unit is switched off. Also on show will be the Pickering V 15 cartridge and a range of three transcription units, GL58, GL70 and GL88.

*Goldring Manufacturing Co. (Gt. Britain) Ltd.,* 486-488 *High Road, Leytonstone, London, E.*11.

#### GOODMANS

Loudspeakers from eight to eighteen-inches in diameter are to be shown. Included in the selection of high-fidelity speakers is to be the 12-in Axiom which incorporates several new design features, such as a new pressure die-cast chassis. The small Maxim reproducer ($10\frac{1}{2} \times 5\frac{1}{2} \times 7\frac{1}{4}$in), which was introduced at last year's festival is also to be shown.

*Goodmans Industries Ltd., Axiom Works, Lancelot Road, Wembley, Middx.*

#### GRAMPIAN

A selection of their range of microphones, amplifiers and loudspeakers will be shown, including three new amplifiers and a new 12in loudspeaker.

*Grampian Reproducers Ltd., Hanworth Trading Estate, Feltham, Middlesex.*

#### HAMMOND

A custom built sound system will be introduced, containing an a.m./f.m. tuner with stereo decoder, a stereo amplifier giving 12 watts per channel, a Garrard A70 transcription turntable with magnetic cartridge, and loudspeakers. A new condenser microphone, a redesign of the Microkit model, includes an encapsulated pre-amplifier, balanced low-impedance output and a regulated power supply. Also new are two loudspeaker units, the Europa with four drive units and the L.7 with a double-cone wide-range loudspeaker.

*C. E. Hammond & Co. Ltd.,* 90 *High Street, Windsor, Berks.*

#### ILFORD

Zonatape magnetic recording tape, which is specially manufactured for amateur tape recording, is to be shown. It is available in several grades on spools up to $8\frac{1}{4}$in diameter, which are colour-coded to indicate the grade of tape. Diacetate, p.v.c. and polyester based tapes are featured in the Zonatape range.

*Ilford Ltd., Ilford, Essex.*

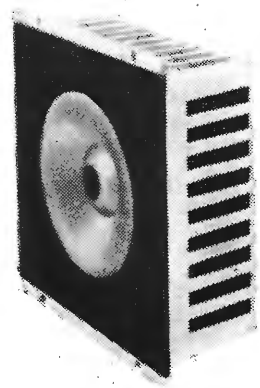
#### JORDAN-WATTS

Five examples of the Jordan-Watts modular loudspeaker design will be demonstrated. The Mini 12, with a single module, has a power handling capacity of 12 watts and a frequency response claimed to be level down to 80 c/s. The A 12, also one module, has a response level down to 40 c/s. A more advanced domestic system is the A 25, in which the radiation pattern is tailored to reduce spurious effects of room acoustics. The B50 is similar in performance but has four modules in distributed line source array and handles 50 W. Radiation pattern control techniques used in the A 25 and B 50 are adapted in the DPS 100 to provide a more precise stereo image.

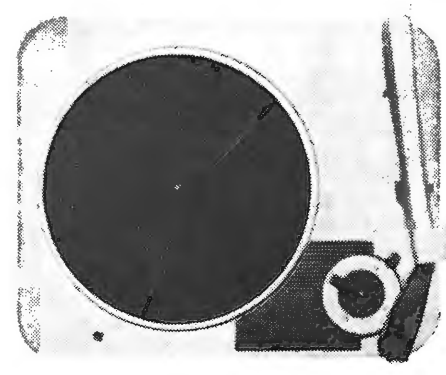
*Boosey & Hawkes (Sales) Ltd., Sonorous Works, Deansbrook Road, Edgware, Middlesex.*

#### KEF ELECTRONICS

The T.15 tweeter unit has been redesigned and is now claimed to provide an additional octave at the top end of its frequency response and a smoother response over its whole range. Floor-mounted and suspended versions of the B.B.C. monitoring loudspeakers will be



*Jordan-Watts modular loudspeaker.*



*Goldring Model G66 turntable unit.*

demonstrated. The company will also introduce a loudspeaker system in an 0.8 cu.ft cabinet which they say comes halfway between their existing Celeste and Duette models. This is their contribution to the Group 4 venture, which aims to offer genuine hi-fi equipment in attractive cabinets.

*KEF Electronics Ltd., Tovil, Maidstone, Kent.*

### KELLY

Kelly loudspeakers (now marketed by Decca) will include an improved version of the well-known Mini and a larger enclosure operated with an "acoustic lens" high-frequency diffusion technique. The Mini loudspeaker will be demonstrated in conjunction with the latest turntable unit, the *ffss* Deccadec, which has a magnetic pickup, a pickup arm extension/adaptor with standard *ffss* head fitting and a non-ferrous turntable.

*Decca Record Co. Ltd., 9 Albert Embankment, London S.E.1.*

### KODAK

A wide range of sound recording tapes are to be featured, including the Kodak P.400 quadruple-play tape which is claimed to be particularly good at slow speeds. This tape is now available on 3-, 3¼- and 4-in spools.

*Kodak Ltd., Kodak House, Kingsway, London, W.C.2.*

### L.P. RECORD LIBRARY

The Long Playing Record Library will be publishing volume 3(1) of its "Guide to the Bargain Classics" and also a new edition of its "Classical Catalogue & Handbook" specially for the Fair. Details will also be available of the Professional Stereo Record Library.

*The Long Playing Record Library Ltd., Squires Gate Station Approach, Blackpool, Lancs.*

### LEAK

Demonstrations of the Stereo 30 two-channel transistor amplifier together with the Sandwich loudspeaker system will be given. In the amplifier, the power section following the tone control pre-amplifier in each channel is a directly coupled transformerless push-pull circuit with over 60 dB of negative feedback, giving an output of 10 watts into a 15-Ω load or 15 watts into a 4-Ω load. The Sandwich loudspeaker system comprises a treble unit and a bass unit, both with rigid, lightweight cones to give improved piston action and freedom from cone break-up. The cone is constructed as a "sandwich" of two skins of thin aluminium enclosing a ⅜-in thick core of light expanded plastics material.

*H. J. Leak & Co. Ltd., Brunel Road, Westway Factory Estate, London, W.3.*

### LOEWE-OPTA

Receivers, radiograms and tape recorders will be exhibited, including the recently announced Optacord 408 tape recorder. The two-speed Optacord 416 will be on display for the first time in this country.

*Agents: Highgate Acoustics, 71 Great Portland Street, London, W.1.*

### LOWTHER

This company is well known for its range of loudspeakers using a single high-flux twin-cone drive unit in a horn-loaded enclosure. These include the Acousta folded-horn enclosure (14in × 18in × 33in); corner reproducers; and a twin enclosure for stereo reproduction. A feature of the drive unit is a central stabilizer plug which spreads the high frequency radiation and provides horn loading of the inner cone, thereby smoothing the response. Also on view will be the company's range of power amplifiers, control units and f.m. tuners, and a battery-powered a.f. test oscillator for setting up sound reproducing equipment.

*The Lowther Manufacturing Company, Lowther House, St. Mark's Road, Bromley, Kent.*

### LUSTRAPHONE

A wide range of microphones including dual-head stereo types, studio ribbon velocity microphones and moving-coil units, will be displayed together with floor and table stands, booms, flexible positioning tubes and other accessories. A folding mobile floor stand is a new addition to the range.

Also on show will be a microphone and radio transmitter combination, called the Radiomic System, which has received Post Office type and specification approval. Single- and multi-channel receivers are available for the system.

*Lustraphone Ltd., St. George's Works, Regent's Park Road, London, N.W.1.*

### 3M

All "Scotch" magnetic tapes to be shown, excluding the acetate-based standard type, will have the recently introduced Superlife protective coating, claimed to increase tape life up to fifteen times. Also displayed will be a tape machine that records and plays tapes in cartridge form, both mono and stereo. Up to 20 tape cartridges may be stacked on the loading platform, giving up to 15 hours playing time. Recording, replaying and cartridge changing are all automatic. Accessories on show will include a self-threading reel.

*Minnesota Mining & Manufacturing Co. Ltd., 3M House, Wigmore Street, London, W.1.*

### MALLORY

The full range of cells and batteries of particular value in audio equipment will be displayed. The 1.5V manganese-alkaline dry cells have been improved to give a lower internal impedance.

*Mallory Batteries Ltd., Crawley, Sussex.*

### MASTERTAPE

Four grades of magnetic recording tape are featured. These are available on five reel sizes—from 3 to 7 in—and are to be shown with a new splicing kit and a wide range of accessories for the recordist. Other items to be featured include the "Min-voice letter" and the "Senda-message" ultra-lightweight postal pack on a miniature reel.

*Mastertape (Magnetic) Ltd. [formerly MSS Recording Co.], Poyle Trading Estate, Colnbrook, Slough, Bucks.*

### MULLARD

Valves, capacitors, new transistor equipment circuits and the new range of transistors will be shown. The range of transistors comprises complementary output pairs: the AD128/AC176 for 3 watt class B stages and the AD161/AD162 for 6 watt stages. The AD149 can give 5 watts class A and is supplied in matched pairs for higher power stages. Also shown is a silicon planar epitaxial transistor, BC107, for high gain, low noise input stages and pre-amplifiers.

*Mullard Ltd., Torrington Place, London W.C.1.*

### ORTOFON

A stereo moving-coil pickup cartridge with the high compliance of $10 \times 10^{-6}$ cm/dyne and an equivalent mass at the stylus point of 1 mgm will be exhibited. Without a transformer (type SPU) it weighs 8gm, and has an impedance of 2Ω and an output of 0.05 mV/cm/sec. With a transformer (type SPU-T) it has an output impedance of 15kΩ and an output of 2 mV/cm/sec. The stylus is diamond and three versions are available—for stereo only, for stereo/mono, and elliptical-point for stereo/mono.

*Agents:—Metro-Sound (Sales) Ltd., Bridge Works, Wallace Road, Canonbury, London, N.1.*

### PETO SCOTT

The range of Philips professional sound recording equipment is to be shown this year, along with a new video tape recorder, Type EL 3400.

*Peto Scott Electrical Instruments Ltd., Addlestone Road, Weybridge, Surrey.*

### PHILIPS

A variety of tape recorders and accessories will be shown, including a four-speed stereo model (EL3534) and the cartridge loading model (EL 3300). Other models to be shown are EL 3548, EL 3549 and EL 3552.

*Philips Electrical Ltd., Century House, Shaftesbury Ave., London, W.C.*

### PLANET PROJECTS

A continuously operating magnetic tape transport mechanism, type C.D.2, will be shown. Designed to provide continuous music, the mechanism automatically reverses when the end of either reel is reached and electrically selects the appropriate one of the two heads. Using standard ¼-inch tape, it operates at either 1⅞ in/sec or 3¾ in/sec and is available for ½ or ¼ track mono replay or stereo replay only. The deck accepts 7-inch reels (or smaller if required) and the normal international recording direction is used.

*Planet Projects Ltd., Goodman Works, Belvue Road, Northolt, Middx.*

### PYE

A transistorized version of the well known "Black Box" mono record reproducer is to be shown along with the "Achoic Box" stereo record reproducer which was first seen at last year's Radio Show. The current range of "Brahms" hi-fi equipment, which is available either as a complete unit or separate chassis, will also be shown.

*Pye Ltd., Radio Works, Cambridge.*

### QUAD

A multiplex decoder for reception of stereophonic broadcasts on the pilot-tone system is now available, but for export only at present. Designed for use with the Quad f.m. tuner and Quad 22 control unit, the unit recovers the stereo information signal (difference between left- and right-hand channels) and combines it with the sum signal, so that the original two channels are obtained separately.

In addition, the well-known range of power amplifier, control unit, a.m. and f.m. tuners and electrostatic loudspeakers will be displayed.

*The Acoustical Manufacturing Co. Ltd., Huntingdon.*

### RADFORD

Items on show this year include the Series 3 Super Bookshelf loudspeaker unit with a response of 80 c/s—14 kc/s ± 3½ dB and handling up to 25 watts r.m.s. A new transistor control unit will be on display—the SC22—and f.m. tuners will be introduced with facilities for interstation noise suppression and multiplex stereo output. If the B.B.C. multiplex stereo transmissions are suitably timed it is hoped to demonstrate the stereo f.m. tuner. Other established Radford items will also be shown.

*Radford Electronics Ltd., Ashton Vale Estate, Bristol 3.*

### RECORD HOUSING

Most of the range of 20 cabinets will be on show, including the new Hi-Flex units which can be placed together, vertically or horizontally, to form a continuous cabinet. The system comprises an equipment unit, a record unit and a 12 in loudspeaker unit. The Nordyk range has been extended to include a Hi-Rak which is used for a shelf-mounting system. Changes in style have been made to the Lowflex and the Lowline-Two—both will be on show.

*N. & S. B. Field & Co., Brook Road, London, N.22.*

### RESLOSOUND

The complete range of Relso ribbon and dynamic microphones are to be shown with a comprehensive range of accessories, including floor-stands, table-stands, adaptors, etc.

*Reslosound Ltd., 24 Upper Brook Street, London, W.1.*

### REVOX

The model 736 stereo tape recorder, exhibited at last year's Audio Fair, will be on show. This two-speed model accepts up to 10½-in spools and incorporates equalization time-constants to the latest C.C.I.R. standard of 70 μsec and 140 μsec. An automatic transparency projector unit—the Slide-o-Matic—will be demonstrated working in conjunction with the Revox tape recorder.

*Agents: C. E. Hammond & Co. Ltd., 90 High Street, Windsor, Berks.*

### ROGERS

The latest version of the "eighty-eight" stereo amplifier and an f.m. receiver are to be shown for the first time. The receiver covers the frequency range 88 to 108 Mc/s and has a sensitivity of 1.5 μV. Other items to be shown include several amplifiers, f.m. tuners, speaker systems and equipment cabinets.

*Rogers Developments (Electronics) Ltd., 4-14 Barmeston Road, Catford, London, S.E.6.*

### S.R.T.

Two transcription units and a record player made by the Scandinavian Radio & Television Company are to be shown. An eight-inch diameter speaker, driven by a 2.5-watt amplifier, is incorporated in the four-speed record player. Distortion is claimed to be less than 1% at 2.5 watts. The transcription units also have four speeds and one is fitted with transistor pre-amplifiers.

*Agents: Denham & Morley Ltd., Denmore House, 173-175 Cleveland Street, London, W.1.*

### S.H.B.

Loudspeaker units manufactured by Svenska Hogtalfabriken are to be shown. These units are quite small (i.e. a unit of 10×5¾×7 in has a power handling capacity of 8 watts undistorted) and are hermetically sealed.

*Agents: Metro-Sound (Sales) Ltd., Bridge Works, Wallace Road, Canonbury, London, N.1.*

### S.M.E.

The Series II range of precision pickup arms and accessories will be on view, and a new addition this year will be a light-weight stainless steel lifting handle.

*S.M.E. Ltd., Steyning, Sussex.*

### S.T.C.

Two new microphones are to be shown by Standard Telephones and Cables. A field effect transistor head amplifier is incorporated in the Type 4126 capacitor microphone. The price of this unit, which is also available with a cardioid insert, is around £120. The other new microphone, Type 4119, is a tubular unit with a ribbon insert that has narrow cardioid characteristics. It has a spherical woven-wire windshield and a tubular bass chamber. A novel collapsible microphone floor stand is to be shown.

*Standard Telephones and Cables Ltd., 29-30 Glasshouse Yard, Aldersgate Street, London E.C.1.*

### SABA

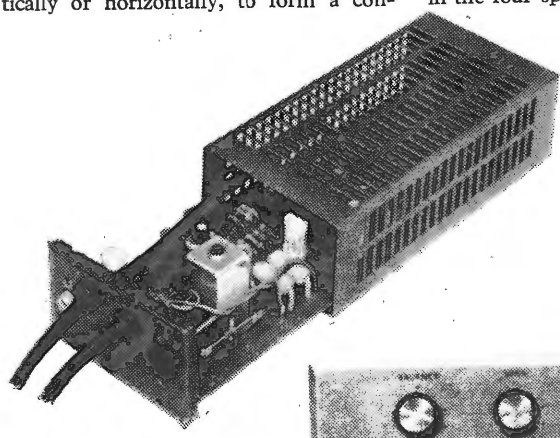
Two tuner amplifiers will be shown for the first time, the Stereo Studio T II with 24 watts output and the Stereo Studio T III with bandspreading, automatic tuning and 70 watts output. Both are transistorized and cover long-, medium- and short-wave and v.h.f./f.m. bands. Also on show will be the TK 230s stereo tape recorder, incorporating two loudspeakers.

*Saba Electronics Ltd., Eden Grove, Holloway, London, N.7.*

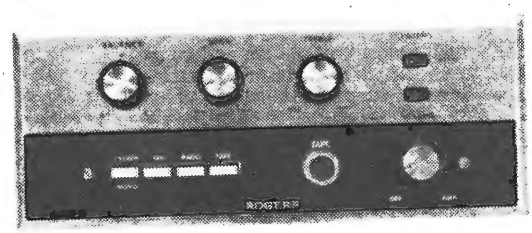
### SCOTT

The American company H. H. Scott will be exhibiting their 299 stereo valve amplifier, rated at 32 watts r.m.s. per channel at 0.8% harmonic distortion with a bandwidth of 20 c/s-20 kc/s ± 1 dB. This amplifier can also drive a third centre loudspeaker, the signal being derived from both left and right channels. Two new amplifiers will be on show this year for the first time, the model 200 rated at 12 watts r.m.s. per channel at 0.8% harmonic distortion (I.H.F.M. power band: 25 c/s—15 kc/s) with the derived centre channel and the model 260, a solid state design with silicon-output transistors and rated at 30 watts per channel.

*Agents: A. C. Farnell Ltd., Hereford House, North Court, Vicar Lane, Leeds.*

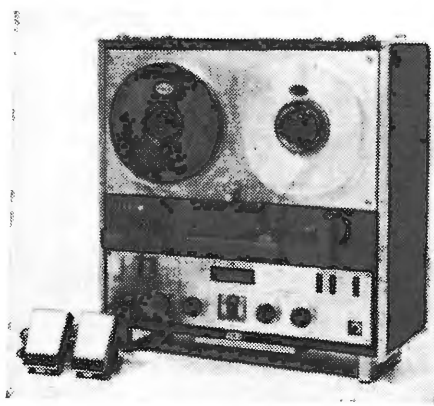


*Quad multiplex decoder for stereo reception.*



*Rogers Cadet III stereo amplifier and control unit.*

*Tannoy "Lancaster" corner loudspeaker unit.*



*Sony TC 600 four-track tape recorder.*

### SHURE

An addition to the Dynetic range of stereo cartridges will be the M44-C, intended for use with record reproducers requiring a tracking pressure of 3-5gm, and the M55-E, with elliptical stylus for use with transcription unit arms tracking at $\frac{3}{4}$-$1\frac{1}{2}$gm. All types in the range are compatible, allowing stereo and mono records to be played through stereo or mono equipment. Microphones not previously shown include the 550S omnidirectional dynamic type.

*Shure Electronics Ltd., 84 Blackfriars Road, London, S.E.1.*

### SONOTONE

Two stereo pickup cartridges are to be shown. The Type 9TA has a sensitivity of 80-120 mV/cm/sec at 1,000 c/s and a compliance of $5.3 \times 10^{-6}$ cm/dyne. Tracking weight is 2-4 gm, and response is within 3 dB from 30 to 15,000 c/s. The other ceramic cartridge, the 9TAHC, has a similar specification and both have average channel isolation figures of better than 20 dB. An electrical load of 2 MΩ and 100 pF is quoted for both cartridges.

*Agents: Metro-Sound Manufacturing Company, Bridge Works, Wallace Road, Canonbury, London N.1.*

### SONY

Four tape recorders along with a precision stereo tape transport and a complete stereo record pre-amplifier are to be shown. The tape recorders are multi-track machines suitable for mono and stereo applications, with the exception of the TC 777A, which is a professional twin-track recorder. The record pre-amplifier has been designed primarily to be used with the new tape transport.

*Agents: Debenhams Electrical & Radio Distribution Company, Eastbrook Road, Eastern Avenue, Gloucester.*

### TANDBERG

Two cabinet loudspeakers will be shown for the first time, the Model 8 and the Model Hi-Fi. They have an impedance of 4 ohms and are suitable for use with the company's transistorized amplifiers, tape recorders and Huldra receivers. The Huldra receivers provide f.m. and a.m. reception and include stereo amplifiers and loudspeakers for record reproduction. Mono tape recorders Series 8 and Series 9 will be introduced, in two-track and four-track versions.

*Agents: Elstone Electronics Ltd., Edward Street, Templar Street, Leeds.*

### TANNOY

The new range of Lancaster loudspeaker units will be shown in addition to the complete range of high-fidelity equipment. The corner Lancaster enclosure (illustrated) is available as a reflex unit with a 12 in loudspeaker and as an aperiodic unit with a 15 in loudspeaker.

*Tannoy Products Ltd., Norwood Road, London S.E.27.*

### TELEFUNKEN

Two a.m./f.m. tuner-amplifiers are featured this year. Both of these cover four wavebands and are fitted with multiplex decoders. Other exhibits are to include two four-speed transcription units, a 30+30 watt amplifier and speaker units.

*Agents: Welmec Corporation Ltd., 27 Chancery Lane, London, W.C.*

### THORENS

A selection of transcription units, including one combined with an automatic record changer, are to be shown. This novel unit, designated TD 224, does not carry a stack of records on the central spidle of the turnable, but selects records (up to eight) from a separate stack at the side of the turntable. When the record on the turntable is finished, it is automatically returned to the bottom of the stack and another from the top is selected and placed on the turntable.

*Agents: Metro-Sound (Sales) Ltd., Bridge Works, Wallace Road, Canonbury, London, N.1.*

### TRIO

F.M. tuners, stereo amplifiers and combined tuner-amplifiers with this Japanese trade name are to be shown. A stereo multiplex adaptor which is suitable for all Trio tuners and can be used on many other makes of tuner is also to be featured.

*Agents: Winter Trading Ltd., 95-99 Ladbroke Grove, London, W.11.*

### TRUVOX

Amongst equipment that will be demonstrated is a new stereo system, the details of which had not been announced at the time of going to press.

*Truvox Ltd., Neasden Lane, London, N.W.10.*

### VORTEXION

The C.B.L. professional tape recorder aims to provide a versatile twin-channel equipment for mono work as well as stereo recording and playback. Mixing is provided on both channels for microphone and gram/radio inputs. Cross-channel mixing allows special effects in monophonic work, such as a singer or musician accompanying himself. Echoes may be introduced and a monitoring facility allows comparison of the original and recorded sounds.

*Vortexion Ltd., 257-263 The Broadway, Wimbledon, London, S.W.19.*

### WHARFEDALE

Two new products which will be on show are the Dalesman and Dovedale enclosures, both with 5in and 12in loudspeakers. The Dalesman can handle 10 watts r.m.s., has an impedance of 10-12 ohms and the 12in loudspeaker uses a ceramic magnet. The larger and wider range Dovedale enclosure houses a bass loudspeaker with an open-baffle resonance of 15-18 c/s, and a Neoprene suspension. The 5in high-frequency unit uses a ceramic magnet with cloth suspension. The impedance of the Dovedale is 12-15 ohms; it can handle 15 watts r.m.s. and incorporates a treble volume control.

*Wharfedale Wireless Works Ltd., Idle, Bradford, Yorks.*

### WHITELEY

Loudspeakers, f.m. tuners, amplifiers and ready-to-assemble bass reflex cabinets are to be shown by the Whiteley Electrical Radio Company. The speakers vary in diameter from $1\frac{3}{4}$ in to 18 in and are available with several different cone constructions, speech coil impedances and magnetic flux densities.

*Whiteley Electrical Radio Company, Radio Works, Mansfield, Notts.*

### WILLIMAN

Overseas visitors will have the opportunity of seeing a selection of British audio equipment available to them through K. H. Williman & Co. This includes products from Armstrong, Kelly, Planet and Rogers, for whom Willimans are exclusive exporters.

*K. H. Williman & Company, Blackford House, Sutton, Surrey.*

### WILMEX

As an export house, Wilmex will be showing several makes of audio equipment, placing emphasis on Ferrograph.

*Wilmex Ltd., 151 Clapham High Street, London S.W.4.*

### WILSON STEREO LIBRARY

The latest edition of the Stereo Index will be exhibited. The book includes reviews of classical and popular stereo records by well-known critics.

*The Wilson Stereo Library Ltd., 463 Streatham High Road, London, S.W.16*

# LETTERS TO THE EDITOR

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

## The Colour Situation

MAY I correct two wrong impressions which may be given by the article on pages 30, 31, of your March issue.

In the BREMA Home Viewing Trials no overall assessment was made of compatibility, but, as the heading to the overall histogram in our report shows, a question was asked on the "Impairment of the monochrome picture (on a colour receiver) due to a colour cast." The sole purpose of this was to assess the effect that any convergence or misregistration errors in the shadow-mask tubes would have on the quality of the colour picture, and no conclusions on dot patterns can be drawn from the results.

These trials were conducted solely to assess whether the average non-technical viewer was capable of adjusting N.T.S.C. receivers so as to obtain good quality pictures, and any other results were incidental. The fact that this was the only supporting evidence given with our statement in favour of the N.T.S.C. system does not mean that supporting evidence for the other claims is not available, but that this aspect was thought to be of such importance as to warrant a special investigation, with a summary of the results being included as an appendix to our statement.

London, W.C.1. D. P. DOO,
Technical Secretary,
British Radio Equipment Manuf. Assoc.

## "Applications of Metal Oxide Silicon Transistors"

MR. F. Butler, in his article in the February issue has provided an introductory survey of possible uses of field effect transistors. I would like to point out what I regard as some significant omissions and to comment on one or two of his statements which seem to me to be misleading.

He writes, "In view of the very high input impedance, the amplifier noise figure is exceptionally low, . . .". In fact, the noise behaviour of the device is related only indirectly to the input impedance. A number of theories of the origin of noise prevail, including the effect of high electric fields in the pinch-off region, channel noise, leakage noise, etc. It is beyond the scope of this letter to discuss the pertinent device physics. I think that Mr. Butler means, "Even when coupled to sources having an internal impedance of several megohms, the noise figure is exceptionally low, . . .".

In my evaluation of some ten dozen f.e.ts of United States manufacture while I was actively engaged at de Havilland Aircraft of Canada, I found that m.o.s. f.e.ts exhibited noise performance in the audio range much inferior to p-channel planar diffused silicon junction f.e.ts. However, at radio frequencies, the reverse is said to be true.

This leads to another point of contention. The m.o.s. f.e.t. really comes into its own in high-frequency (r.f.) applications. A good m.o.s.t. should have a noise figure under 3dB at 100 Mc/s and a neutralized power gain of, say, 10dB. The applications illustrated by Mr. Butler can be carried out by junction f.e.ts and do not require a wait for the availability of m.o.s. devices. An excellent summary of the unique features of m.o.s. devices and their relation to junction f.e.ts is contained in a recent feature series[1].

Does Mr. Butler seriously advocate using bias resistors as high as 50 megohms. Leakage currents, sufficient to bias a device into cut-off (or hard on) can arise so unexpectedly, as when a "good" blocking capacitor at the input of an amplifier passes a few nanoamperes of current from, say, an infra-red detector biased at 100 volts when the entire assembly is subjected to a 125°C ambient environment. Further, to maintain good noise performance, carbon resistors cannot be used (even though ideal performance should be achieved as the current to cause current-noise is infinitesimal); wirewound resistors are bulky, costly and pick up noise through their inductive properties; metal film resistors would have to be used in large quantity.

Mr. Butler advocates bootstrapping. Experience shows that the transconductance of f.e.ts is not high enough for this method to provide much increase in the input impedance. At the moment, one of the facts of life is that the purchase price of these devices soars with the gain. Then, too, the valve boys will dig out their mildewed texts and show us that the drain resistive load (plate load) reduces the effective $\mu$ available for bootstrapping.

The answer to the dilemma of attaining a high input impedance with components of a reasonable size and securing low noise performance is provided in exploiting positive and negative feedback together in just the manner that Mr. Butler described for bipolar transistors in *Wireless World*[2], and others have described elsewhere. In a recent paper[3] I described the advantages of a hybrid design in which input impedance multiplication is achieved by greater-than-unity-gain drive for the bootstrap connection. The two-transistor amplifier there cited has an input impedance at the input end of a length of shielded cable of hundreds of megohms in parallel with 6pF of capacitance and an output impedance of less than three-hundred ohms at a stabilized voltage gain of ten. It maintains its performance over a wide temperature range and is independent of device differences.

London, S.W.7. IAN H. ROWE,
Imperial College of Science & Technology.


(1) *Electronics*, Vol. 37, No. 30, November 30th, 1964.

(2) F. Butler. "Analysis of the Bootstrap Follower," *Wireless World*, January, 1963.

(3) I. H. Rowe. "Design of Low Noise, High Impedance Amplifiers Using F.E.Ts," *Electronics and Communications* (Canada), March, 1963.


*The author replies:—*

Since I wrote this paper a number of articles on the basic physics of field effect transistors have appeared and there have also been one or two accounts of practical applications, including a bulletin by Mullard which contains useful information. One cannot track down and read everything and I fear that I missed seeing Mr. Rowe's own contribution. American literature deals mainly with junction-type f.e.ts. as distinct from the insulated-gate type. Both devices are equally suitable for many applications and I chose to discuss the Mullard transistor because of its novelty and topical interest.

Many American papers deal with choppers, low-noise amplifiers and voltage-controlled resistances. Application notes of U.S. manufacturers (Crystalonics, Fairchild and Texas Instruments), tend to cover the same ground, whereas my chief concern was with a broader field of more general interest.

As regards noise figures, I accept Mr. Rowe's correction to my sentence beginning "In view of the very high input impedance, the amplifier noise figure is very low . . " His version is more nearly what I meant to convey, as should be apparent from the context.

I should also like to comment on the spectral distribution of noise power in f.e.ts. I said that the $1/f$ component seems to be absent or abnormally low but now doubt very much if this is true. Everybody seems to agree that the spectrum of f.e.t. noise is not the same as normal transistor noise but much more work is required by physicists and device manufacturers before the facts are fully known. I suspect that some of the noise is inherent in f.e.ts and some

is capable of reduction by improved manufacturing techniques.

Mr. Rowe's remarks on f.e.t. noise figures at high frequencies are irrelevant to the subject of my paper. Since he has raised the point it should be said that a low noise figure is only one of many design requirements for a tuned r.f. amplifier. Others, perhaps of greater consequence, are linearity (absence of intermodulation), ease of applying a.g.c. and the possibility of wideband neutralization or unilaterization.

I am taken to task for suggesting the use of a 50 megohm bias resistor. Mr. Rowe will therefore be horrified to see the elegant and original electrometer circuit described by Mr. C. J. Mills in the letters on p. 141 of the March issue of *Wireless World*. In this a resistance of 100 kilomegohms is shown, though naturally one would not put a 100-volt d.c. supply in series with it through a blocking capacitor. For normal supply voltages, many modern plastic-foil capacitors have sufficiently good insulation for use in this type of circuit. There is another point. My circuits, and that of Mr. Mills, provide automatic source bias which will do something to offset the effects of capacitor leakage. Furthermore, there is a simple trick for eliminating or greatly reducing the effect. Connect two input capacitors in series and from the junction point connect another high resistance to ground. At d.c. the double CR network gives a potential-dividing effect, causing resistive attenuation of the leakage current.

Mr. Rowe has a point concerning the noise power in carbon resistors, or any other resistors for that matter but he cannot expect me to fight the laws of nature. The r.m.s. noise voltage across a 100 megohm resistor at 17°C in a bandwidth of 100 kc/s is around 400 microvolts. For a carbon resistor carrying d.c. the figure is much worse. The situation is inescapable and the f.e.t. is not to blame.

Because I gave the circuit diagram of a bootstrap amplifier it does not follow that I endorse or advocate the general use of this arrangement. In the past, Mr. G. W. Short and I have pointed out some of the disadvantages of this connection. Moreover I am well aware of the effect of the device transconductance on the performance. Almost the sole merit of the circuit is that its input impedance can exceed the physical resistances of the bias network.

The point about the use of combined positive and negative feedback to give a high input impedance has no relevance to the subject of my article, but while I am writing I would like to correct an error in Fig. 9 of my paper. The high tension line should be marked positive, not negative as shown. Next, I learn from Mullard Ltd. that the substrate lead, left floating in all my circuits, should preferably be connected to the source terminal. If desired, this lead may be used for a.g.c. purposes or for oscillator injection if the transistor is used as a mixer. Another point to note is that in later samples of the 95 BFY device, two electrode leads have been transposed. The base connections shown in my Fig. 1 apply only to early samples. There is also a mistake in Fig. 5. The middle resistance of the three at the bottom of the diagram should be 560 ohms, not 560 kΩ.

To conclude I would like to make a further comment on the electrometer amplifier described by Mr. Mills and on the interesting hybrid circuit noted by Mr. Short. One of the drawbacks of the f.e.t. is Miller feedback through the gate-to-drain capacitance. It is neatly avoided by using the source-follower connection. However, if the source load is capacitive there is some risk of instability as there can be with the ordinary cathode follower, though this cannot happen in the circuit described by Mr. Mills which, incidentally, has almost ten times the bandwidth of more conventional arrangements. The high input impedance makes possible a convincing demonstration of the piezoelectric effect in quartz merely by sandwiching a plate or bar between foil electrodes, adding two insulating outside sheets and compressing the assembly with a pair of pliers. Gentle pressure with a measuring micrometer is enough to show a perceptible reading on an output voltmeter. Screening is required to prevent hum pick-up.

Mr. Short's circuit* is new to me though I believe a similar arrangement was described in the Hewlett Packard Journal for April, 1961. It seems ideally suited for use with f.e.ts and could probably be used as a relaxation oscillator as well as the controlled negative resistance or sinusoidal oscillator which he suggests.

F. BUTLER

[* In G. W. Short's letter (March, p.141, the expression $-\alpha/g_m$ should be $-1/\alpha\, g_m$—Ed.]

## Units

MR. D. F. Gibbs' letter (p. 85 February issue) illustrates, I believe, more a continuing defect in mathematical pedagogy than any crankiness in Mr. Gibbs. "Cathode Ray" is fully justified in his strictures on the matter of Mr. Gibbs' letter, yet the fault may properly lie with the latter's teachers. It is, and has been for many decades, fashionable (and ego-flattering) to claim that mathematics, which ought properly to be called arithmetic is *the* school subject that demands thought. That claim has no foundation.

Until computers became common no self-evident rebuttal of the claim was available. Computers do not think, they *do!* The fact that they do faster than man-moved pencils is irrelevant. The man behind the pencil need think no more than the computer, he need only remember and do.

"Thinking" leads to the class of error demonstrated by Mr. Gibbs, viz., the overlooking of the principle that each arithmetical discipline becomes meaningless when any "foreign" axiom is allowed to creep in. There is no single, complete and exclusive set of axioms to link the c.g.s. electrostatic and electromagnetic systems. The systems touch, but do not coincide. Each is true *within the boundaries set by its own axioms* and, in practice, a change of scale at the proper place permits transfer from one system to the other and from both to the m.k.s. systems.

"Cathode Ray" has explained at length in several of his articles that these scale changes are numerical and dimensional, and that the axioms of the m.k.s. systems are preferable to those of the c.g.s. system. It is an interesting (although potentially mischievous) thought that the preference might have been made explicit by calling the new systems c.g.s. (Giorgi).

To make explicit the implications of the above, may it be suggested that our educationists strive towards improving our memories without ruining our ability to think. Thought can be a time-wasting substitute for memory, and is wastefully productive without accurate memory of a fair "quantity" of information.

Glasgow. W. GRANT

THE m.k.s.A system may well be the most suitable for present engineering purposes, and knowing how easily strong feelings are aroused, I was careful to make no direct criticism of it in my letter published in your February issue. "Cathode Ray," as I had feared, sees the matter as a battle between the reactionaries and the progressives. It was rather tempted on reading his reply to pick up the gauntlet and act out the villainous but not altogether unsympathetic part thrust upon me, no doubt disappearing down the trap in the final scene, to the accompaniment of red fire and hisses, my end delayed but not prevented. But I would prefer to stick to my original purpose, which was to emphasize the arbitrary nature of units and dimensions, and to refute suggestions that the c.g.s systems are unsound.

There is little disagreement on the main observations in experiments in classical electricity and magnetism. Having discovered certain proportionalities, we refer some of the quantities measured to existing standards, such as the metre, and define certain new quantities, such as electric charge. When we have a system which we find consistent and convenient, we all too easily assume that all other systems must contain some essential flaw. We are liable to feel that there "must" be some "true" dimensions for every physical quantity. I believe on the contrary that our systems are largely man-made, like a monetary system, or about as arbitrary as our habit of doing arithmetic in the decimal system. It is, of course, possible to devise systems which are self-contradictory, but between the many which are not, we can hardly choose with any degree of objectivity. In classical mechanics, for example, the conventional choice of mass length and time

as "fundamental" dimensions is not a necessity, one may perfectly well regard force as fundamental and mass as derived.

Perhaps "Cathode Ray's" insistence that volume must be of dimension $L^3$ demonstrates his own unwillingness to consider an unfamiliar system. I might measure volumes with reference to a standard pot, and decide that volume is an independent dimensional quantity, related to my standard of length by having dimensions $kL^3$, where k is a dimensional constant. The unit of volume in this system would resemble the ampere in the m.k.s.A system.

The misunderstanding about the dimensions of $\epsilon$ and $\mu$ is probably mainly verbal. In the context in which they were defined, I would indeed deny that "$\epsilon$ and $\mu$ possess (separately) certain dimensions." By this denial I mean that they are (separately) dimensionally indeterminate, not that they are both pure numbers. The indeterminacy results from our introduction of two constants instead of one, and the further arbitrary assignment of a magnitude and dimension to one of them results in one of the many systems which seem to cause us so much worry.

The analogy between the mass and volume of a quantity of sugar and the electrostatic and electromagnetic measures of an electric charge still seems to me a fair one. We perform different operations in each case, and our resultant measures differ in magnitude and dimensions unless we insert dimensional constants in our definitions. I cannot see why it should be loose and unscientific to speak of a quantity of sugar if it is not equally so to speak of a quantity of electric charge. Why should electric charge be the same thing no matter how it is measured, while sugar is not? I would say they both remain the same no matter how measured, but methods of measurement may differ.

I cannot, alas, claim any originality in expressing electrical quantities in terms of mechanical ones, for that we must thank such giants as Gauss and Weber. I do not know why "Cathode Ray" says this is in contradiction to Maxwell. In his "Treatise on Electricity and Magnetism," Part IV, Chapter X, the first sentence is "Every electromagnetic quantity may be defined with reference to the fundamental units of Length, Mass and Time." Some users of m.k.s. systems say explicitly that they regard the introduction of a fourth dimensional quantity as a matter of convention and convenience, but some, like "Cathode Ray" and your correspondent Mr. Frank Smith, seem to think it a matter of necessity, often giving as their reasons the avoidance of fractional indices, and of the appearance of different dimensions for different measures which they feel should be the same. The different dimensions may be reconciled, if desired, by the use of dimensional constants in the definitions. I do not understand why fractional indices are considered objectionable. While the matter cannot be settled by appeal to authority, I would sincerely recommend anyone interested in the fundamentals of the subject to read "Dimensional Analysis" by P. W. Bridgman (Yale University Press).

Mr. W. M. Wrigley's letter illustrates the difficulties in discussing this subject. I have carefully searched Condon and Odishaw's "handbook" for the passage which he implies shows that zero dimensions cannot be ascribed to $\epsilon_0$, and I do not even get the impression that this is the author's belief! To be pedantic, I agree with Mr. Wrigley that one cannot ascribe zero dimensions to $\epsilon_0$ "any more than to the velocity of light for instance," but the latter is indeed possible, and is a fairly common practice among certain theoreticians. The resultant equations can be numerically and dimensionally correct. If it is objected that the units used are not practical, that may be true, but it depends on your practice, and in this age of radar and space travel it is not self-evident.

I had read Mr. Bigg's paper, having as a matter of fact been a subscriber to the journal mentioned since its inception, but I take leave to doubt his predictions. As for being "forward-looking"; when I hear that word I reach for my revolving chair. I like to look all round.

Bristol. D. F. GIBBS

"CATHODE Ray" does well to advise us to use the SI system of units. There is little doubt as to the wisdom of his advice, but I wonder if I may comment on the reasons he has given in his article and in the reply (Feb. issue) to Mr. Gibbs? For it is not immediately clear from the article that there are two related issues involved; the need in electricity for 1. an arbitary unit of measurement, and 2. a fourth fundamental magnitude for dimensional analysis.

"Cathode Ray" does not define what he means by "dimensions" (an unusual omission), and perhaps as a result, is less than fair to the gravitational system of units. I take it that the dimensions of a physical quantity show how its numerical value will change when a change is made in the magnitude of the primary units. For the British gravitational system convenient primary magnitudes are those of length (ft), time (sec), and force (lbf). Retaining the pound, mass can be assigned the dimensions [F $L^2$ $T^4$]. The dimensions of energy are [F L] and so are the dimensions of $\frac{1}{2}m.g.v.^2$. The point is that there need be nothing wrong dimensionally with the gravitational system, even in this curious form; though it is true that people are thoughtless in its use. The reasons against accepting the gravitational system for scientific work are experimental, not dimensional; the standard mass—as a lump of material—is more accurately reproducible than the standard force defined gravitationally. Surely it is for similar experimental reasons that the ampere is chosen as the arbitrary electrical unit.

If, for example, we take as the independent experimental equations the Coulomb laws and the expression for the force on a free pole due to a current element

$$F = \frac{1}{\epsilon_0} \cdot \frac{q_1.q_2}{r^2}$$

$$F = \frac{1}{\mu_0} \cdot \frac{m_1.m_2}{r^2}$$

$$F = \frac{1}{A} \cdot \frac{m.I.\delta s.\sin\theta}{r^2}$$

and for good experimental reasons assume the identity $I = \frac{dq}{dt}$ we have five quantities and three equations. It is not possible to proceed without some assumption. In the SI system, A is taken to be unity leaving $\mu_0$ to be defined. By setting $\mu_0 = 4\pi \times 10^{-7}$ (and thereby defining the magnitude of the force in the definition of the ampere) the SI system obtains as its "absolute" units those found to be of a convenient size for "practical" use. Is it not this simplification which is the great virtue of SI units in electricity?

In dimensional analysis, however, the choice of fundamental magnitudes is—in theory—arbitary, ranging from one to the total number of quantities used. In any problem the number of fundamental magnitudes are chosen to extract the maximum information by dimensional means. Maxwell seems to have believed that all phenomena were ultimately reducible to mechanical terms and so derived dimensional equations for electrical units in terms of the fundamental magnitudes of mass, length, and time. This leads to inconsistency between the e.s. and e.m. system of units, but this reflects only the different way in which the quantities are defined. An alternative treatment to Maxwell's was given by Rucker in 1889 and from this basis generally used dimensional analyses in terms of mass (or energy), length, time, and electric charge, have developed. There are other alternatives for the fundamental magnitudes: mass, length, time, and resistance; length, time, current, and resistance; length, time, charge, and magnetic flux—all have been used for particular problems. The important thing is that these methods use a primary magnitude other than M, L, and T. Dimensional analysis—in practice—has regard for the "physics of the situation". Perhaps in this light Mr. Gibbs is seen to be defending a theoretical position while "Cathode Ray" maintains an experimental one. Certainly even given the generally felt need for an independent electrical unit, we do not necessarily have to use the unit which is defined practically as the fourth fundamental magnitude for dimensional analysis.

All of this may be dismissed as academic nicety, but from the point of view of the teacher it represents a serious practical problem. Efforts to introduce m.k.s. units in schools are often associated with independent ideas for reform in the theoretical structure of electricity courses. It seems to me that this is a

tactical mistake. The SI system represents a convenient and internationally acceptable method of simplifying units in physics and engineering—for this reason alone, there is every advantage in adopting it. Whether or not we decide to retain magnetic poles in teaching is, by comparison, of minor importance. Unfortunately, theoretical problems similar to those above seem to have obscured what is fundamentally a simple issue.

"Cathode Ray" complains also of mental inertia in other fields. I sympathize. I listen hopefully to B.B.C. weather forecasts; someday they may change to degrees Celsius instead of degrees Centigrade. Of course it is early yet, the recommendation was only made in 1948.

Uppingham. D. G. F. EASTWOOD

*The author replies:—*

If I believed that there could be only one right system of units I would not have said in my article that two possibilities exist for a coherent f.p.s. system and then gone on to point out that mass and force are alternative fundamental quantities —as Mr. Gibbs now also does. That is not in dispute. What Mr. Gibbs has to do, but so far has not even attempted, is to show why the c.g.s. systems should be retained, when:

(1) Abandoning them in favour of the m.k.s.A. system reduces the number of systems from three to one.

(2) C.g.s. electrical units differ from those in common use.

(3) Their magnitudes are in some cases quite unrelated to practical or even scientific purposes; e.g., the farad is admittedly rather too large, but the e.m.u. unit of capacitance is one-thousand-million times larger still.

(4) The c.g.s. systems conceal the fundamental difference between H and B, to the confusion of students and sometimes their elders.

(5) In dimensional formulæ they involve fractional indices, which are repugnant to common sense.

(6) The constant $\pi$ occurs where it is inappropriate and is missing where it would be appropriate.

Since the m.k.s.A. system is free from all these disadvantages the term "reactionary" that Mr. Gibbs puts into my mouth for those who, like him, spring to the defence of the c.g.s. systems would seem to be not altogether undeserved.

And is their case really strengthened by the arguments used by Mr. Gibbs? I said that any method of measuring volume that gave it dimensions other than $L^3$ would have to be looked at rather carefully. Does Mr. Gibbs deny that? If he chooses to introduce a dimensional constant $k$ let him, but I think he would have some difficulty in justifying it, let alone persuading others to follow his example. There is no difficulty on either count as regards the ampere.

Then how does he define "quantity" of sugar? If he defines it so as to make it dimensionally the same as mass, then unit "quantity" would always comprise the same number of molecules. If he defined it in terms of volume, it would not. A "quantity" of electric charge always gives consistent results in terms of, say, electrons. If we found that equal surpluses of electrons appeared to provide unequal charges, some investigation would seem to be desirable. Certainly the mass-defined "quantity" of sugar could be measured by measuring the volume, but density has to be brought in, which converts the result to mass, so there is no dimensional difference between the two measures.

In Art 2, of Maxwell's "Treatise" he says "The dimensions of each term of . . . an equation, with respect to each of the fundamental units, must be the same. If not, the equation is absurd, and contains some error." And in Art. 623, after giving equations connecting the various electric and magnetic quantities, he says, "In order to deduce the dimensions of the twelve units involved, we require one additional equation. If, however, we take either $e$ or $m$ as an independent unit, we can deduce the dimensions of the rest in terms of either of these." He, then, required an independent unit as well as length, mass and time.

I now gather that Mr. Gibbs protested against my saying "nobody knows what the dimensions of $\epsilon$ and $\mu$ are" instead of "nobody can know. . . ." But, of course, if "nobody can know" my statement must be true! If he can give incontrovertible reasons why "nobody *can* know" and my substituting "can know" for "knows" makes him any happier I would willingly do so.

I do not know why Mr Eastwood thinks I was unfair to gravitational systems. I wrote not a word of criticism of them and acknowledged the foot-pound(force)-second as a coherent system. My criticism was directed at the British mixture of two systems, in which the same name is used for the unit of mass and the unit of force.

I am well aware of the fact that other independent units than the ampere could have been chosen as the fourth in SI; in fact, until the CGPM had made up its collective mind, $\mu_0$ and Q were among those being considered.

I had rather Mr Smith (March issue) did not credit me with the sugar analogy; Mr Gibbs must bear that burden alone. And does he (Mr Smith) deny that electric charge is the same kind of thing no matter how it is measured? That was all I said about it in the letter he criticizes.

My surprise that physicists have, contrary to Mr Gibbs' impression, so largely gone over to m.k.s.A. units was due to the general feeling when they were introduced that if we were lucky they might be adopted by all electrical engineers within about a generation, but pure scientists could hardly be expected to make the change. I am glad that this forecast has proved to be too pessimistic. The progressive reduction of the partition between pure and applied scientists may well have contributed to the result. I am obliged to Mr Wrigley (March) for substantiating my statement that the c.g.s. systems are rapidly moving into past history.

"CATHODE RAY"

## Darlington-Cascode Trio

I WAS very interested to read F. Butler's article in the March issue on transistor cascade amplifiers and their various forms that "people keep re-inventing."

I was rather surprised to find that one permutation that I have often used myself, and which I feel is a bit "obvious," did not appear.

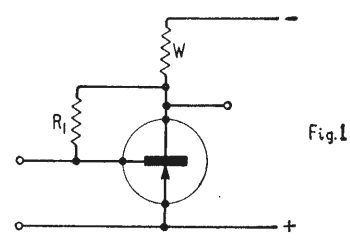


Fig. 1

It derives logically from the feedback stabilized transistor (Fig. 1) which is well known.

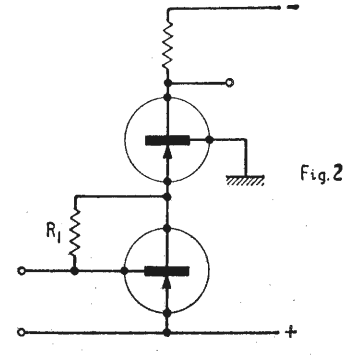


Fig. 2

Substitute a transistor for W and there appears the simple cascode, (Fig. 2) also stable.

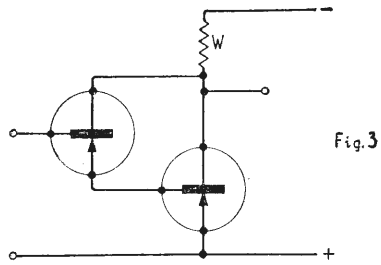



Fig. 3

Substitute a transistor for $R_1$ instead, and there appears the Darlington Pair in its stable form.

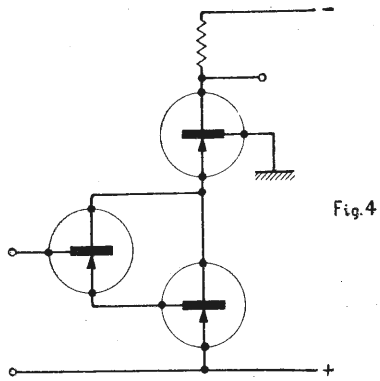



Fig. 4

Substitute *both* and there arrives that chamber-music ensemble, the "Darlington-Cascode Trio"!

Both have a high imput impedance (especially 5(b)) and this is useful for r.f. purposes where the input may well be

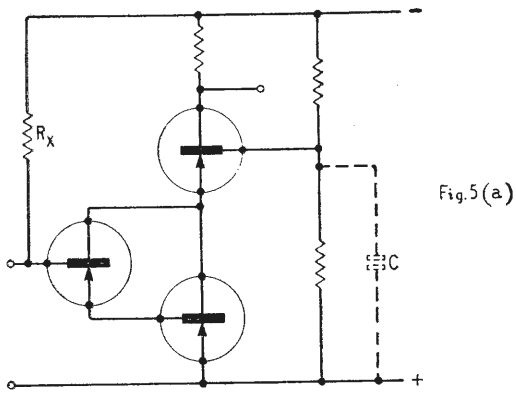



Fig. 5(a)

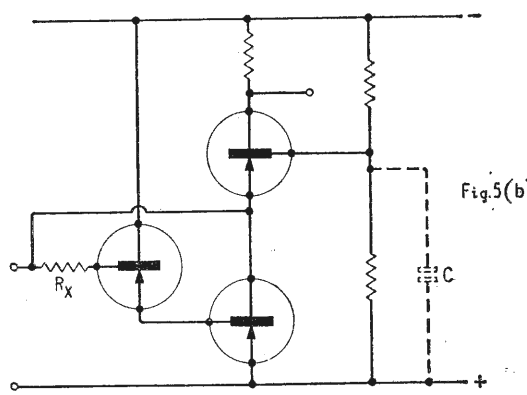



Fig. 5(b)

a tuned circuit that must not be damped too much. Gain is better than with a simple cascode (especially 5(b)) and although I have not had the opportunity of checking its band-width quantitatively, it gives, empirically good results and, minus C, might well give a fairly linear response.

Perhaps Mr. Butler will favour me with one of his scholarly analyses in a future issue of "*W.W.*"

The value of $R_X$, by the way, needs a rather careful estimate, especially for the 5(b) configuration. In a practical circuit it is high, in the $\frac{1}{2}$MΩ neighbourhood.

Nottingham. D. B. PITT

## Transistor High-quality Audio Amplifier

THE surge of joy with which I read, in the article by Mr. Dinsdale (January issue), that the signal-to-noise ratio of a transistor amplifier could be improved by introducing a low resistance from the base of the first transistor to earth, was, I'm afraid, quickly damped. It is not true. It is true that the noise output from a transistor in common-emitter will usually decrease as the resistance from base to earth is decreased; but this resistance will inevitably attenuate the signal to at least the same extent. In the circuit of Mr. Dinsdale's Fig. 6(a), I estimate that the removal of the 1 kΩ resistor (with appropriate adjustment of the frequency compensation) would improve the signal/noise ratio by about 10 dB.

This is not a serious criticism of the design, as the signal-to-noise ratio with the resistor included, assuming maximum output from the crystal pickup, should still be greater than 70 dB.

It is fairly safe to assume, in general, that for the highest signal-to-noise ratio (1) resistances in parallel with the signal path should be as large as possible. (2) resistances in series with the signal path should be as small as possible.

Such resistances would (a) attenuate the signal at least as much as they might reduce the noise output, and (b) introduce their own thermal noise.

Maxims (1), (a) are neatly illustrated by the examples in Mr. Johnson's letter in the same issue, in which the thermal noise of the resistances is evidently neglected. Maxims (1), (2), (b) are illustrated by the fact that with a low-noise valve such as the EF86 the thermal noise of resistors $R_1$ and $R_g$, in Mr. Johnson's second example, would form the major part of the noise in the circuit, and the improvement due to changing $R_g$ would be, not 17 dB, but about 10 dB.

The feedback, incidentally, has a negligible effect on the noise performance; the same figures would apply if the 10 MΩ resistor were removed.

Accra. F. HIBBERD

University of Ghana, Department of Physics.

## National Certificate Courses

IS it not time for the professional institutes and the Ministry of Education to take a more liberal attitude over the entry standards for the Higher National Certificate?

I speak for the thousands who drift into electronics with "A" level qualifications. Even with three "A" levels we still have to start at the beginning of the O.N.C. if we don't have the correct "O" levels.

In my case I have three "A" levels. I have been working in electronics for seven years and I earn £1,400 a year purely because of my knowledge of electronics. Yet I can't study for an H.N.C. I can get £16 per week grant if I study for an H.N.D., a Dip.Tech. or a degree, but it seems that an H.N.C. is in a more exclusive class.

The really annoying thing is that professional institutes accept the H.N.C. as an exemption for their intermediate examinations. This means technical colleges do not run courses for these intermediate examinations. Just to help things along, the professional institutes won't accept candidates who have not taken these non-existent courses. The last time I pointed this out I was informed that I could take an external degree to exempt me from part 1 of the Grad.Inst.P. examination.

London, N.W.5. I. LESLIE

# ELECTRONIC LABORATORY INSTRUMENT

## 4.—MEASUREMENT OF ALTERNATING VOLTAGE AND CURRENT

IN any good electronics laboratory nowadays you will find a range of instruments for measuring alternating voltages and currents at frequencies from 10 c/s to 1,000 Mc/s. Such instruments, on whatever principle they work, pose two main problems for the user: how to check calibration easily, and how to avoid "waveform errors."

Calibration checking, as we saw in an earlier article, is not too difficult with d.c. measurements because d.c. standards of voltage and resistance (and hence current) are not too hard to come by. But no a.c. primary reference standards exist, and a.c. meters have to be calibrated from a d.c. standard by means of some "transfer instrument." Such an instrument responds equally to a.c. and d.c., so that readings for a.c. can be taken and compared with readings from a d.c. standard.

The other practical difficulty with a.c. measuring instruments is that readings can vary with the waveform of the applied signal. Depending on its principle of operation, an a.c. meter may have a response (i.e., give a reading) proportional to the average, the effective (i.e., r.m.s.) or the peak value of a signal. Most a.c. meters, however, are scaled to read the r.m.s. voltage of an assumed sinewave signal, irrespective of their real response law. "True r.m.s. reading" instruments (i.e., with an r.m.s. response law), should show a correct reading, whatever the waveshape. On the other hand, average-reading or peak-reading instruments, when scaled to read r.m.s., may display large errors if the waveform departs materially from a sinewave. In general, average-reading meters are likely to give more accurate "r.m.s." readings than peak-reading ones. It can be shown in theory that for average-reading meters the error may vary from $-100\%$ to $+11\%$, and for peak-reading meters from $-100\%$ to $+0\%$.

There you have, then, the two main practical difficulties that beset the measurement of alternating current or voltage—the difficulty of calibrating, and the difficulty of measuring non-sinusoidal waveforms. Keeping these in mind, you are now faced with the problem of "what to use to measure what?"

### A.C. Meter Types

Some a.c. meters primarily measure voltage, and others current. The distinction is not important, however, because you can always use a current meter to measure voltage by measuring the current through a series resistor, or a voltage meter to measure current by measuring the voltage drop across a shunt resistor.

Over the years, many different types of instruments have been used to make measurements of alternating voltage or current. Those which you may possibly come across in an electronics laboratory are:

(1) Dynamometer, (2) moving-iron meter, (3) rectifier meter, (4) thermocouple meter, (5) valve voltmeter, (6) digital voltmeter, (7) electrostatic meter, (8) oscilloscope, (9) a.c. potentiometer, and (10) heterodyne-mixer meter.

Of these ten types, you will find three used in almost every laboratory: (3) rectifier meter, (5) valve voltmeter, and (8) oscilloscope. It is, however, useful to know something of the other types, particularly where the all-important problem of calibration arises. We will therefore take a look at all of them before we go on to the practical aspects of "ordinary" a.c. measurements.

### Dynamometers

The dynamometer (also known as the "electrodynamometer") is the basic instrument for a.c. measurements, just as the permanent-magnet moving-coil meter is the basic instrument for d.c. measurements. The dynamometer comprises a movable coil, with a pointer attached, suspended in the field of another fixed coil. The current to be measured passes through both coils in series and the deflection of the pointer indicates the value of current measured. The instrument responds to d.c. as well as a.c. and is therefore a basic transfer instrument for calibrating. It has an r.m.s response, and the a.c. reading for any deflection can be checked by applying known d.c. to give the same deflection.

The main limitations of the dynamometer are:

(1) Not having a strong fixed permanent magnet, it is much less sensitive than the moving-coil meter, and its lower current limit tends to be in the mA rather than the $\mu$A region.

(2) While accuracies as high as 0.1% can be achieved with a precision dynamometer at frequencies up to a few hundred cycles per second, it is normally not of much use above 1,000 c/s since its accuracy falls off rapidly with rising frequency. (A special form of r.f. dynamometer has been developed for use into the r.f. range but

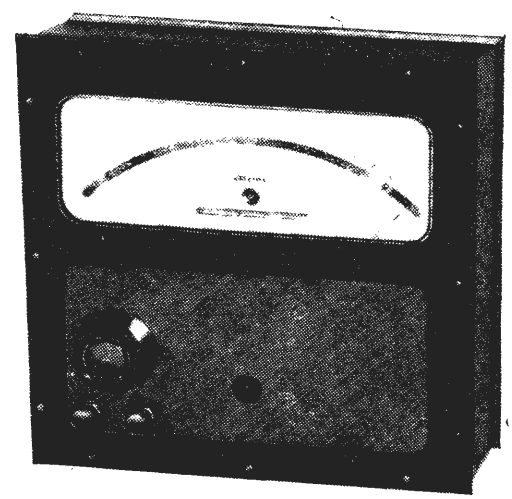


*Fig. 21. Typical commercial example of a.c./d.c. dynamometer: Sangamo Weston S93 dynamometer-type ammeter.*

# PRACTICE

By T. D. TOWERS,* M.B.E., A.M.I.E.E., A.M.I.E.R.E.

it is not likely that you will come across this in the ordinary laboratory.)

Dynamometers you will meet are likely to come from one of the following firms: Cambridge Instruments, Elliott's, Pullin, Salford and Sangamo Weston. Fig. 21 shows a typical good example, the Sangamo Weston, S93 dynamometer type ammeter. With a guaranteed accuracy of 0.1 f.s.d. from 25 to 2,500 c/s and a maximum sensitivity of 1A f.s.d., this instrument has a 12-in scale, is magnetically shielded, has a self-contained thermometer, and is provided with a spirit-level and levelling feet.

## Moving-iron Meters

Another class of instrument widely used for a.c. measurements is the moving-iron meter (also called iron-vane meter). This comprises a single fixed coil and a soft-iron movable vane with a pointer attached to it. When current is passed through the coil, it deflects the iron vane and thus the pointer.

This meter responds to both d.c. and a.c. Its response to a.c. is r.m.s. Without a permanent magnet, sensitivity again tends to be low compared with a moving-coil meter —only about 10 mA at best.

As the moving system carries no current, the moving-iron meter can be used for measuring higher currents than the dynamometer. Also since the moving parts can be designed without considerations of current carrying, the meter can be more ruggedly constructed and is not so easily liable to damage by overload. Finally, because a wide range of instruments can be constructed with the same moving system merely by changing the coil, the moving-iron meter tends to be relatively inexpensive. In summary, moving-iron meters are cheaper, sturdier and less accurate than electrodynamic meters.

Eddy currents and coil inductances can cause frequency and waveform errors in moving-iron instruments. Ordinary voltmeters and ammeters of this type are calibrated at a single frequency, usually between 25 and 125 c/s. Compensated instruments are available also for use up to 2,500 c/s, but it is at mains frequency that the moving-iron meter is most commonly used.

The accuracy of a moving-iron instrument can vary from several per cent on robust portable units down to 0·5% on the best lab. standards.

Among the companies marketing moving-iron meters are Pullin, Salford, Sangamo Weston, Taylor, Turner and Weir. No illustration of a moving-iron meter is given, because they look externally very similar to the dynamometer types discussed immediately above.

## Rectifier Meters

Dynamometers and moving-iron a.c. meters generally are low in sensitivity, they load circuits unduly, and are limited in frequency response to a few hundred cycles per second. Improvement in these respects can be achieved by using the inherently more sensitive moving-coil d.c. meter in conjunction with an a.c. rectifier to produce the a.c. "rectifier moving-coil meter" or simply "rectifier meter."

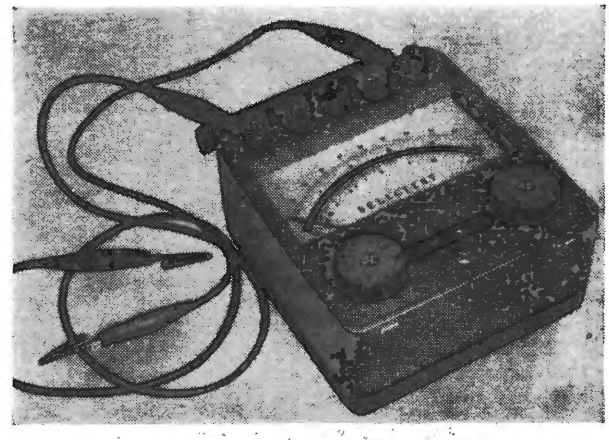


*Fig. 22. Typical multimeter exemplifying use of rectifier meter arrangement in a.c. ranges: Salford Selectest 50.*

The moving-coil meter indicates the average value of the rectified a.c. signal. Usually, however, the scale is calibrated in terms of r.m.s. for a sinewave. Measurement of non-sinusoidal waveshapes is accompanied by an error varying with the form factor (which was theoretically not present with the dynamometer and moving-iron meters).

Rectifier meters can be basically more sensitive than the others, and can be obtained with current sensitivities as high as 100μA f.s.d. a.c. or with voltage sensitivities as high as 2·5 V f.s.d. a.c.

The input impedance of the rectifier meter is about ten times higher than for dynamometers or moving-iron meters, typically 1,000 ohms per volt, compared with 100 ohms per volt.

The modern rectifier meter is reasonably accurate up to about 10,000 c/s as compared with a limit of 1,000 c/s for the other two types.

The B.S.I. Standard Specification No. 89/1954 for industrial grade portable moving-coil instruments specifies ±2¼% f.s.d. on a.c. ranges. This is a little over twice as wide a tolerance as the d.c. specification for the same type of instrument. In practice, when an instrument has been in use for a little time, it is prudent not to expect much better than a 5% accuracy on an a.c. rectifier meter.

The main advantages of the rectifier meter are ruggedness, resistance to overloads, long life, small size and no requirement for external power supply. Its main disadvantages are that its accuracy is somewhat low except at normal room temperature and for low-frequency pure sinewaves. You should look on rectifier meters as excellent general-purpose instruments but not ideally suited to precision work.

The a.c. ranges of general-purpose multimeters use the rectifier meter basic arrangement. Rectifier meters are also available separately as single-purpose instruments. In a laboratory you may thus come across rectifier meters in instruments of such firms as Avo, Daystrom, Philips, Pullin, Salford, Sangamo Weston, Smith, Taylor and Turner. Fig. 22 illustrates one example in the well-

* Newmarket Transistors, Ltd.

*Fig. 23. Example of commercial a.c. thermocouple meter: Taylor "Clarity" Model 42.*

known Salford Selectest Super 50 multimeter with an a.c. range of voltage down to 2.5 V f.s.d. and current down to 25 mA f.s.d.

## Thermocouple Meters

Another class of a.c. instrument which may be met with (although a little uncommon) is the thermocouple meter. In this, the current to be measured is passed through a thermocouple (or through a wire in close proximity to a thermocouple) and the resultant heat produces a thermal e.m.f which is measured. Since it is the heating effect only which is significant, either a.c. or d.c. may be measured.

Such types of meters can cover from d.c. to 100 Mc/s, and find their principal use as transfer instruments from high frequency a.c. to d.c. The usual current ranges are from 3 mA to 300 A f.s.d. Accuracies are of the same order as other a.c. meters, i.e. about 2% for panel instruments, and up to 0.5% for the more expensive portable standard instruments when used in the lower frequency ranges.

A major disadvantage of the thermocouple meter is its susceptibility to overload damage. Permissible overloads range only from 50% to 200% at maximum.

Among the companies supplying thermocouple meters are Pullin, Sangamo Weston and Turner. Fig. 23 shows a typical example in the Taylor Clarity range with a f.s.d. of 100 mA capable of operation with $\pm 2\%$ accuracy.

## Valve Voltmeters

Probably the commonest way nowadays to measure an alternating signal voltage or current in the laboratory is to use an a.c. valve voltmeter. Like the rectifier meter, this functions by rectifying the alternating signal and reading the result on a d.c. meter. The main difference is that the valve voltmeter uses amplification either by an a.c. amplifier before rectification or by a d.c. one after rectification.

Valve voltmeters can be used at low frequencies as an alternative to rectifier or other type meters, but they come into their own for higher frequency measurements. Instruments can be obtained to operate up to 1,000 Mc/s.

In the lower frequency ranges, the valve voltmeter has a very high input impedance, normally between 0·5 and 100 MΩ, typically 10-20 MΩ. Input capacitances as low as 1 pF are possible, but 20-30 pF is more usual. Generally the input impedance decreases considerably as the frequency rises.

Valve voltmeters are usually scaled in terms of r.m.s. Since the diode rectifier responds basically to peak voltage, errors can occur when non-sinusoidal waveforms are measured. The errors may be positive or negative and can vary in amount with the phase of the harmonic content of the measured waveshape. There is also a polarity effect in that the positive and negative peaks may not be equal. When very short pulses are measured, a very large error can occur. You should always look carefully at the reading of a valve voltmeter and consider whether the waveshape can have any significant effect on it.

Fig. 24 shows two good examples of commercial a.c. valve voltmeters in common laboratory use. (A) is the Marconi TF 2600 with 1 mV f.s.d. in its most sensitive range and a 5% accuracy bandwidth of 10 c/s - 5 Mc/s. (B) is the Advance VM78, which is transistorised. This, too, has a most sensitive range of 1 mV f.s.d. and a 3% accuracy range of 1 c/s-1Mc/s. Apart from Advance and Marconi, some other names in the a.c. valve volt-

(*Continued on page 201*)

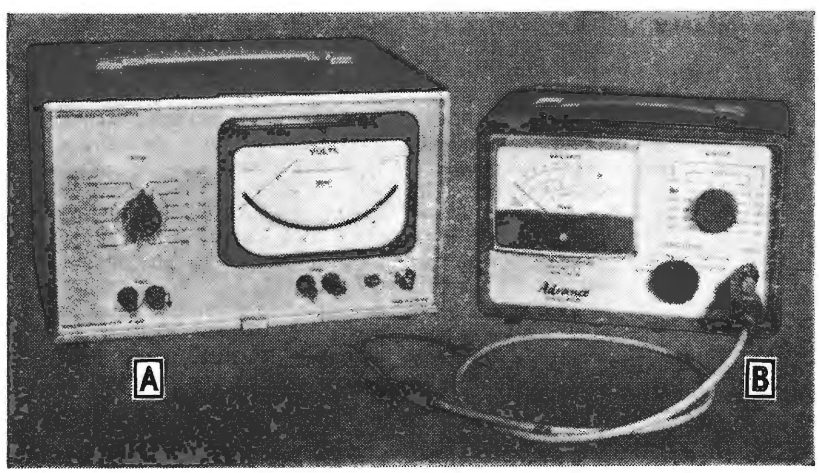



*Fig. 24. A.C. valve-voltmeters: (A) Marconi TF2600; (B) Advance VM78 (transistorised).*

meter field are Airmec, Avo, Dawe, Daystrom, Furzehill and KLB (Paco).

## A.C. Digital Voltmeters

The digital voltmeter (d.v.m.) is essentially a d.c. measuring instrument. However, by using an a.c.-to-d.c. converter, the d.c. d.v.m. can be turned into an a.c. one.

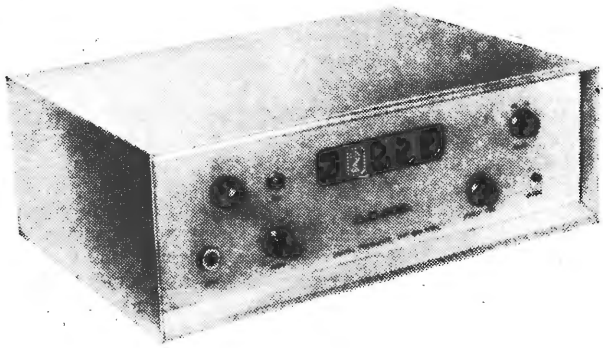


*Fig. 25. A.C./D.C. digital valve voltmeter: Applied Developments 1055.*

The converter can be a separate unit, or can be incorporated in the main d.v.m. to give the a.c./d.c. type of d.v.m. that is now becoming common. Fig. 25 illustrates a typical example, the Applied Developments Type 1055. Instruments of this type are capable of 0.3% accuracy on a.c., but for this order of accuracy are normally used only in the audio and supersonic frequency ranges. At reduced accuracy, or for accurate differential measurements, it can be used out to the megacycle range however. Other manufacturers supplying a.c. d.v.ms are Digital Measurements, EAL, Gloster, Hewlett-Packard, Roband and Solartron.

## Electrostatic Voltmeters

Electrostatic attraction or repulsion forces are used in a type of instrument known as the electrostatic voltmeter. This is capable of measuring voltages, d.c. or a.c., up to megacycles, from millivolts to hundreds of kilovolts. As the d.c. and a.c. responses are alike when the meters are suitably constructed, they may be used as transfer instruments. With proper design they can also be used as primary standards in the measurement of high voltage.

Electrostatic voltmeters have high input resistances, often of the order of $10^{15}$ ohms. On d.c. there is thus practically no current drawn. However, input capacitance causes a small current drain in a.c. instruments, and this is the limiting factor in the upper frequency range.

The full-scale deflection in commercial units can be as low as 120V or as high as 100kV. One practical point is that the input capacitance tends to increase with deflection and can range from a few picofarads up to several hundred.

A good commercial example of the electrostatic voltmeter, the W. G. Pye Type 11314, is illustrated in Fig. 26. This instrument gives direct readings of up to 40kV, d.c. or r.m.s. a.c., with an absolute accuracy of ±10% full-scale deflection, regardless of waveform. When special mounting precautions are taken the accuracy of comparative readings can be of the order of 0.1% and the d.c./a.c. transfer characteristic even better. It finds particular application in measuring the high voltages encountered in work on cathode-ray tubes.

## Oscilloscopes

The oscilloscope can be used for measuring alternating voltage and current. It has the basic advantage that the waveform can be seen and consequently waveform errors estimated.

The usual method of measurement is to apply the voltage to be measured at the Y-amplifier input terminals. Where the oscilloscope has been calibrated at its main sensitivity control, the peak voltage can be read immediately. Oscilloscopes afford the most accurate method of making true pulse peak measurements.

Calibration can be by means of an a.c. signal source of known amplitude operating within the known bandwidth of the signal of the oscilloscope, or by a known d.c. voltage. The more common method is the d.c. approach, where you apply a known d.c. to the Y-amplifier (direct coupled) and note the vertical shift difference necessary to return the trace to its original position. You then apply the a.c. signal to be measured, and measure the peak-to-peak voltage by Y-shift on the calibrated shift control. Cathode-ray tubes can be used as precision transfer instruments.

Instead of calibrating by comparison, a slide-back technique may be applied with a d.c. 'scope. This uses a variable d.c. source in series with the unknown voltage to bring the peak deflection back to the zero point.

A.c. measurements on an oscilloscope can be accurate over the frequency range of the Y-amplifier. The oscilloscope can be used beyond these limits but separate calibrations will have to be made at the frequencies to be measured.

We have been discussing so far the measurement of alternating voltage signals on the oscilloscope, but clearly current may be measured by shunting the oscilloscope input with a known standard resistor.

In standard oscilloscopes, the input impedance is generally greater than 1MΩ, making it possible to measure alternating voltages in circuits of fairly high impedance. The input impedance of the oscilloscope

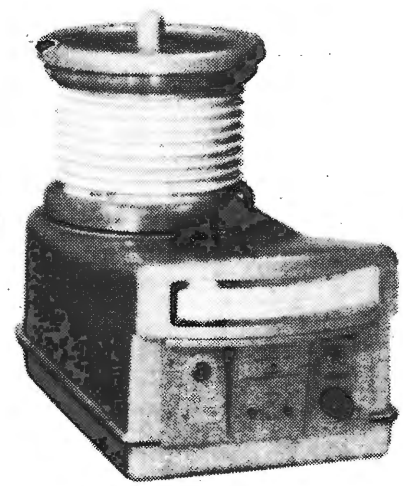


*Fig. 26. Commercial electrostatic a.c./d.c. voltmeter: W. G. Pye 11314.*

can be much greater if the signal is applied directly to the deflection plates rather than to the amplifier input.

## A.C. Potentiometers

In a.c. work the potentiometer is not as widely used as in d.c. work for the accurate comparative measurement of voltage. This is because in the a.c. case it is necessary to balance phase as well as magnitude, to take stray pick-up and coupling into account, and to consider the effect of harmonics on one or other of the voltages being compared. Also, for a.c. there is no standard voltage source for reference corresponding to the d.c. standard cell. Generally a transfer technique has to be applied to establish an a.c. reference voltage. Despite these difficulties, however, a.c. potentiometers are available commercially. A good example of this is the Cambridge Instruments A.C./D.C. Comparator illustrated in Fig. 27. This is designed to measure r.m.s. value of currents and voltages to an accuracy of $\pm 0.05\%$ over a frequency range of 25c/s to 20kc/s. The instrument contains its

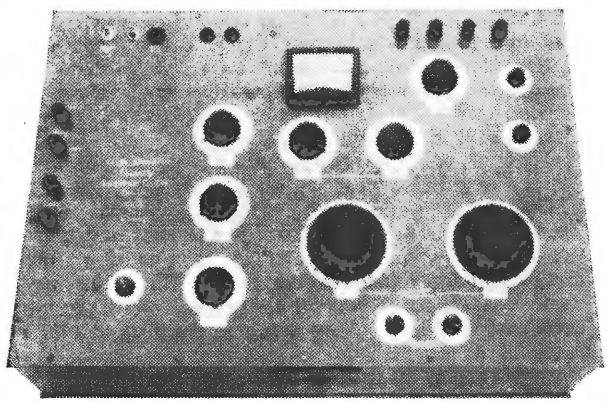


*Fig. 27. AC/DC potentiometer: the Cambridge Instruments AC/DC Comparator.*

own potentiometer circuit, and the only external units required are a standard cell and a suitable reflecting galvanometer. A meter is incorporated so that the approximate value of the unknown signal can be determined before the setting of the controls. This reduces the probability of overloading the vacuo-junction which is used as an internal a.c./d.c. transfer standard. The comparator has eight voltage and current ranges from 0.5V to 300V full scale and from 5mA to 300A respectively.

## Heterodyne-mixer Meter

A linear mixer can be employed to reduce measurements over a range of high frequency to measurements at a single low frequency. A known fraction of the unknown signal is applied to a mixer together with an auxiliary local-oscillator signal of a much greater magnitude. The resulting intermediate frequency passes through a standard attenuator to a meter. A single calibration point is established at each frequency by feeding a known signal into the input. Provided signal linearity is maintained by keeping the unknown signal sufficiently small, the change in attenuation necessary to keep the meter at its reference level is an indication of the desired measurement value. The heterodyne-mixer type of a.c. meter is not commonly used in ordinary laboratories.

## Special Problems of V.H.F. and U.H.F. Measurements

In general the measuring instruments described so far have been primarily for frequencies below 150 Mc/s. Above 150 Mc/s difficulties creep in. In the v.h.f./u.h.f. range, voltages and currents often have to be measured in tuned circuits, and it becomes extremely difficult to make measurements without disturbing the circuit unduly. Apart from this, circuit elements can no longer be treated as lumped, so that it becomes difficult to locate two specific circuit points across which a voltage, for example, can be measured. Because of this, you very often find that at v.h.f. and higher frequencies you do not make a voltage or a current measurement so much as a power measurement. The power measurement is usually made by looking at the temperature rise in some indicator due to the dissipation of the r.f. power. This implies the use of some thermal meter such as a thermocouple unit.

The other major difficulty is that at v.h.f. and higher frequencies, the input impedance of the meter becomes complex and varies with frequency; this can lead to calibration difficulties.

Some specially developed versions of the basic instruments referred to earlier for lower frequencies have been developed to operate into the v.h.f. range. In general, however, in the normal laboratory, voltage (and derived current) a.c. measurements above 150 Mc/s or so are normally made with some form of valve voltmeter, at least up to 1,000 Mc/s. Above 1,000 Mc/s the field becomes very specialized and bolometer or other thermal-type meters are normally used.

## Practical Points on the Use of A.C. Meters

(1) Always follow the "good-practice" precautions for instruments generally outlined in previous chapters. In a.c. measurements some of the precautions take on a special importance, however. For example, always look extra carefully to the earthing of the equipment under test and the measuring instrument. Earth loops can easily give rise to inaccurate readings, particularly at radio frequencies.

(2) Watch out for mains hum or other spurious frequencies getting on to the signal you are testing. Mains hum is particularly difficult at very low level a.f. measurements, i.e. in the millivolt r.m.s. region.

(3) Always adopt some standard procedure in recording measurements. Do not use r.m.s., average, peak, peak-to-peak interchangeably at random. Over the years I have built up a consistent habit of recording the signals for linear amplifiers in terms of r.m.s. (i.e. in effect assuming a sinusoidal waveshape), and for non-linear circuits (pulse, or large-signal sinewave with some clipping) in terms of peak (i.e. half peak-to-peak) because this can be read off so easily from an oscilloscope.

(4) Always consider the frequency of the a.c. signal you are measuring, and check that it falls within the specified bandwidth capabilities of your measuring instrument. A common failing in this is to try to measure signals at say 10 Mc/s with a valve voltmeter not capable of accurate measurement over say 1 Mc/s. This may seem very elementary, but it is surprising how often you

find quite competent bench engineers doing this without thinking.

(5) At r.f. always look to see that the circuit disturbance introduced by your measuring instrument is fully taken into account.

(6) Where you are using an instrument, such as an Avo multimeter, with floating input, i.e. with no specified earth terminal, always as a precaution reverse the leads and take a second reading. If this does not agree with the first reading, something is wrong. This is a useful practical step which soon becomes a reflex action with a good engineer. It is just another illustration of always trying to cross-check everything you do.

(7) Where you are trying to measure the voltage or current of an unknown waveshape, try if possible to display it on an oscilloscope at the same time, so that you can interpret the meter reading properly.

(8) Don't rely on the mains voltage to help you with calibrating an a.c. instrument except as a rough check. Nowadays, a nominal mains voltage of 230 V a.c. can lie at any time anywhere between 200 and 250 V. It is not uncommon to find the mains even lower than 200 V on occasion.

(9) Don't forget that a multimeter in its a.c. range has a certain d.c. input resistance. It is not capacitor-isolated and so may affect the d.c. bias conditions of the circuit being tested. This is important in the new-generation direct-coupled audio power amplifiers. Always look to see if you should d.c.-isolate the meter in its a.c. ranges by means of a large coupling capacitor. In other terms, don't forget that if a multimeter in its a.c. range is connected into circuit with a standing d.c. voltage on it, the a.c. meter reading can be inaccurate because of the spurious d.c. imposed.

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# BOOKS RECEIVED

**Transistor Ignition Systems Handbook,** by Brice Ward. A short, down-to-earth American text, including a good deal of material on commercial systems already in use in the U.S.A. but with a sufficiently general treatment to interest the British reader (who is warned of possible dangers in a British foreword). Pp. 128. W. Foulsham & Co. Ltd., Yeovil Road, Slough, Bucks. Price £1.

**Simplified Modern Filter Design,** by Philip R. Geffe. Nearly half of this 182-page book consists of tables and associated diagrams, compiled to enable the circuit engineer to design filters without the use of higher mathematics. In addition to the usual filter configurations, the book describes measurement techniques and the design of practical high-Q inductors. Published in Great Britain by Iliffe Books Ltd., Dorset House, Stamford Street, London, S.E.1. Price £2 10s.

**Wireless for Beginners,** 5th edition, is an old book (by C. L. Boltz and first published in 1933) completely revised by Thomas Roddam, who is well known to *Wireless World* readers. The original material on television has been expanded and includes colour television. Transistors, sound reproduction and frequency modulation are dealt with. Pp. 232. George G. Harrap & Co. Ltd., 182 High Holborn, London, W.C.1. Price 18s.

**Automatic Voltage Regulators and Stabilizers,** 2nd edition, by G. N. Patchett, Ph.D., B.Sc.(Hons. Lond.), M.I.E.E., M.I.R.E., M.Brit.I.R.E. New material on the Zener diode, transistor circuits, tap changers on large power transformers and alternator voltage regulators has been added to the original text, first published in 1954. There are now 80 pages of references, indexed! Pp. 468. Price £3 5s. Sir Isaac Pitman & Sons Ltd., Pitman House, Parker Street, Kingsway, London, W.C.2.

**Writing Technical Reports,** by Bruce M. Cooper. A Pelican paper-back, drawing on the author's experience of conducting report-writing classes for scientists and engineers. Numerous extracts from typical reports are provided and analysed, and there is a section on illustrating technical writing. Pp. 188. Penguin Books Ltd., Harmondsworth, Middx. Price 3s 6d.

**Elementary Particles,** by A. A. Sokolov. English translation of a short Russian guide to the more recently identified elementary particles, their prediction and discovery (the positron, nucleons and pions, the neutrino, muons, resonons, etc., together with the various anti-particles). Pp. 75. Pergamon Press Ltd., Headington Hill Hall, Oxford. Price 10s.

**Introduction to Semiconductor Devices,** by M. J. Morant, B.Sc.(Eng.), Ph.D. Intended to bridge the gap between applications books and books on pure semiconductor physics. This concise work (pp. 126) is about equally divided between the physics of the subject and semiconductor devices considered as active elements of electrical networks. Level: second year of a degree course in electrical engineering. George G. Harrap & Co. Ltd., 182 High Holborn, London, W.C.1. Price 18s.

**Gas-Discharge Tubes,** by H. L. van der Horst. A comprehensive review of the most important tubes in common use, intended to assist technicians in application problems. Some of the tubes described are now being superseded by semiconductor devices, but others, such as counter and indicator tubes and mercury vapour rectifiers, are still in wide use. Pp. 318. Philips Technical Library. Distributed in U.K. and Eire by Macmillan & Co. Ltd., 10-15 Martin's Street, London, W.C.2. Price £2 17s 6d.

**ABC's of Boolean Algebra,** by Allan Lytel, explains symbolic logic and how electronic circuits perform logical functions. The translation of algebraic expressions into practical switching circuits is dealt with, and numbering systems are discussed in order to explain how logic circuits can be combined to perform calculations. Pp. 112. W. Foulsham & Co. Ltd., Yeovil Road, Slough, Bucks. Price 16s.

**Design of Low-Noise Transistor Input Circuits,** by William A. Rheinfelder. The first half of the book discusses the general characteristics of noise, the noise factor concept and measurement of noise figure, while the second half deals with the design of particular classes of circuits: above 100 Mc/s; receiver front ends below 100 Mc/s; and audio circuits. Pp. 160. Published in Great Britain by Iliffe Books Ltd., Dorset House, Stamford Street, London, S.E.1. Price £1 10s.

**Elementary Electrical Network Theory,** by D. G. Tucker. Professor Tucker excuses himself for producing yet another book on network theory by pointing out that this is a small one (pp. 169) which aims to provide all the theory required by a student in the first two or three years of a university course or in a course for a professional qualification. An introduction to non-linear circuit theory is included. Price 17s 6d. **Linear Network Theory,** by K. F. Sander is rather more advanced, covering network analysis as taught in the last years of an honours degree course. Again small (pp. 164), it concentrates mainly on the algebra. Price £1 1s. Both from Pergamon Press Ltd., Headington Hill Hall, Oxford.

# Audible Rate-of-Climb Indicator

## SIMPLE ELECTRONIC DEVICE FOR GLIDER PILOTS

By J. M. FIRTH

IT has been recognized for some time that it is undesirable that a glider pilot should spend a great deal of his time concentrating on his instruments; he should be looking out for other aircraft. His most important instrument is a sensitive rate-of-climb meter, or variometer, usually electrical, working on a hot bead principle.*

A typical circuit is shown here, Fig. 1. The thermistors Th I and Th 2 are heated by the current in them. Air flowing into or out of a Thermos bottle, due to the pressure change with rise or fall, is directed by small jets over one thermistor or the other, hence giving an up or down reading on the meter.

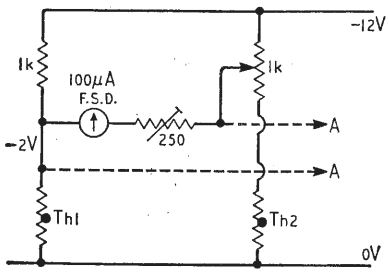


*Fig. 1. Basic "variometer" or rate-of-climb meter circuit.*

A recent improvement has been the addition of an audio circuit producing a varying tone with pitch propotional to the meter reading, above a certain threshold. The pilot can set the threshold to bring in the audio circuit at any desired rate of climb, thus relieving him of the need to glance at the meter frequently.

There must be many other fields in which this device might be of use, e.g., coupled to an electrical r.p.m. meter, and generally in any situation where an electric meter presents continuous information.

The circuit shown in Fig. 2, for a glider variometer, can be easily modified to accept different input levels. It can be constructed using cheap transistors and no special components.

The first stage is a long-tailed pair, with emitter resistors to raise the input impedance and stabilize the gain. It was designed to be driven fully by the voltage across the meter. Other input circuits are suggested later.

Tr3 and Tr4 are current sources driven by the first stage. They feed current to the bases of Tr5 and Tr6 which form an astable/bistable multivibrator. No output will be produced from this stage until the signal is large enough to turn on Tr3 and Tr4. Tr6 drives the output stage directly.

The threshold is set by $RV_1$, and $RV_2$ is a simple volume control which, used in series in this way, gives a saving in current when the volume is turned down. An ordinary cheap headphone can be used as the loudspeaker. This makes quite enough noise in a glider cockpit on a 12 V supply.

In this circuit the oscillation starts at 300-400 c/s and continues up to 8-10 kc/s at the top of the useful range. Tr1, Tr3, Tr5, and Tr6 can all be low-frequency, small-signal germanium types, with the proviso that Tr5 and Tr6 must be able to support a reverse base bias equal to the supply. If Tr6 is chosen to have a higher $\beta$ than Tr5, Tr6 will normally be bottomed in the quiescent

*See, for example, "The Electric Variometer," by P. G. Davey, Technical Papers of OSTIV (Organisation Scientifique Internationale du Vol à Voile), June 1961.

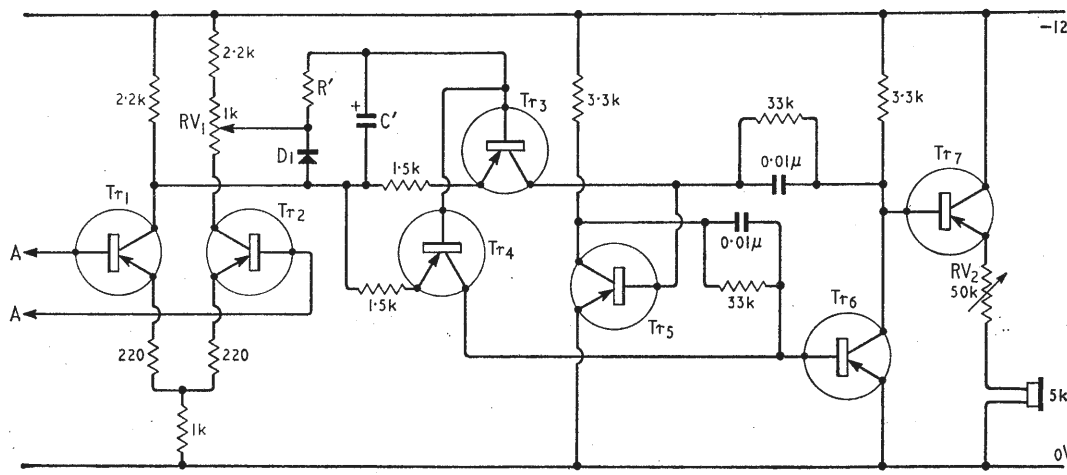


*Fig. 2. Transistor tone generator circuit.*

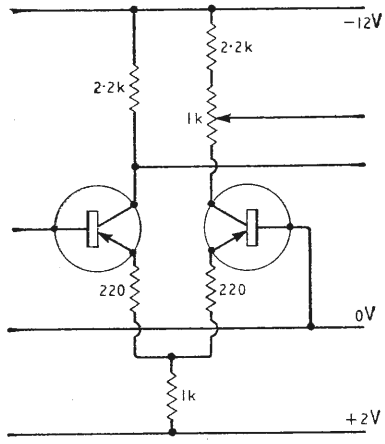


*Fig. 3. Modified circuit for inputs varying about, or just above the 0V line.*

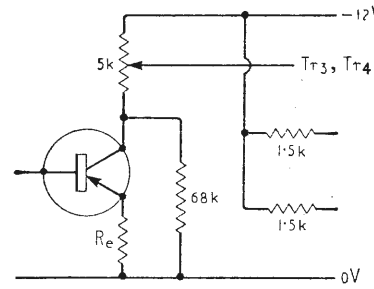


*Fig. 4. Alternative circuit for inputs about 1V with respect to earth.*

state, and Tr7 will draw no current. Tr3 and Tr4 must be silicon n-p-n types, but can have quite low $\beta$'s. Tr7 does not dissipate much power, as it is switched hard on and off, but it must have an adequate current gain at full working current. Again, it can be a low-frequency germanium type.

More gain can be obtained from the first stage at the expense of lowering the input impedance, by decreasing the emitter resistors, but care must be taken to leave Tr1 and Tr2 with sufficient working collector voltage.

Fig. 3 shows how the input circuit can be modified to accept an input which varies about, or just above, the 0V rail. Fig. 4 indicates how one might eliminate the +2V rail, but can only be used where the source provides an input of about one volt as the knee voltage of the transistor must first be overcome. The 68kΩ resistor povides a little forward bias for the second stage. With the above disadvantage goes those of poor initial linearity and large temperature drift. However, this circuit may be suitable for use with a car r.p.m. meter, where one side of the meter is probably grounded.

A word of caution here; many frequency indicating devices such as the r.p.m. meter, supply the meter with pulsed current, and the audio circuit may not cope with this, or may produce an objectionably modulated output. The addition of C′ and R′ shown in Fig. 2 will overcome this. With RC=0.1 sec, suggested values are R=10kΩ and C=10$\mu$F. D1 prevents the electrolytic capacitor from being reverse biased.

The circuit can be used with other supply voltages, but the 0.01$\mu$F capacitors may have to be changed to give acceptable audio frequencies.

I shall be interested to hear of other uses which *Wireless World* readers can find for this device.

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# BRITISH BROADCASTING 1927-1939

**The History of Broadcasting in the United Kingdom: Vol. II.—The Golden Age of Wireless.** By Asa Briggs. Pp. 663+xvi; 54 illustrations. Oxford University Press, Amen House, Warwick Square, London, E.C.4. Price 75s.

This volume of Professor Briggs's monumental history covers the period from 1927, when the British Broadcasting Company became the present Corporation, to the outbreak of war in 1939. During that epoch receiving licences rose from some two million to nine million. The B.B.C. was in process of consolidating itself into a national institution.

Though there is some emphasis on internal organization and policies, everything is covered—programme analyses and listener surveys, overseas broadcasting, the beginnings of television and preparations for war, with just enough of the technical background to help the story along as each development arises. Everything is fully documented and the history derives unique authority from the fact that the author had access to Lord Reith's diaries and private papers. Now we need no longer guess as to what really happened: Reith was Director-General for practically the whole period and played a dominant part in every important event. Naturally and properly, he overshadows the book.

Almost as soon as the possibilities of shortwaves for world-wide broadcasting became evident in the 1920s, accusations were levelled against the B.B.C. of dragging its feet in failing to set up a service of what was then called Empire Broadcasting. Criticism would have been largely disarmed had all the obstacles been fully known at the time. Money was one of the major troubles; the Dominions and colonies were not enthusiastic about contributing to the cost while the home government did not take kindly to the idea of the British taxpayer footing the bill. Reith objected in principle to the use of British listeners' money for the service. In 1930 he wrote in a private memorandum: "We are likely to be left with the baby to carry because everybody else is too selfish and we are too decent to let it drown." At that stage he was finding the Post Office unhelpful but later got its blessing and in 1932 a regular service was started from the multiple transmitter at Daventry. "The design of a broadcasting station to give effective world-wide coverage was a new concept."

The story of experimental 30-line television transmission (from 1929 to 1935) is largely one of protracted triangular negotiations between Baird interests, the B.B.C. and the Post Office, made still more involved by "the publicity seekers with whom Baird was to have so many complicated dealings" when television moved into the arena of high finance and speculation. When higher-definition television came on the scene the situation developed into a more straightforward contest between Baird's mechanical system and the "all-electronic" Marconi-E.M.I. Clearly, the B.B.C. and the Post Office as umpire were still making an effort to give Baird every chance. But the issue did not remain long in doubt; as Campbell-Swinton had forecast decades earlier, the "weightless cathode rays" were bound to win.

One could wish that someone with Briggs's powers of detachment, industry and ability to ferret out sources of information had arisen to write a history of the earliest days of radio communication in, say, the mid-1930s—when many of the pioneers were still alive, before records were destroyed and late enough to get the story in perspective.

H. F. S.

# The Case of the Micromin Ostrich

ONE of the precepts which I learned at my mother's knee —or perhaps it was some other low joint—runs as follows:—

"If you can keep your head when all around you are losing their's—perhaps it's because you just don't understand the situation?"

Now, be it far from me to suggest that this is the reason behind the British electronics industry's attitude towards microelectronics. Perhaps it's a superb example of stiff upperlip manship or—horrible thought—the hypnotized immobility of a rabbit when confronted by a weasel. Whatever the cause, it seems to be remaining incredibly calm about the economic implications behind the advent of the new technology.

These thoughts stem from a point I tried to make last month, namely that microelectronics is not just another step towards the ultimate in miniaturization, but a brand new process of manufacture which owes nothing to the conventional art of making and assembling components. Its adoption demands completely different plant, completely new categories of engineering and completely new thinking.

Our industry has evolved over the years on a sort of twin-tub basis comprising two complementary units, equipment manufacturers and component manufacturers. To change the simile abruptly, this *mariage de convenance* has been established for a very long time, and the partners, despite the inevitable domestic tiffs, have been tolerably happy, with never a thought of separation, much less divorce, entering their heads.

But recently the plot has thickened. Enter the villain, microelectronics, to make a triangle of the situation; a triangle with a difference, however, because the interloper is, so to speak, bi-sexual, and is dallying with both partners.

This character, microelectronics, is fast becoming irresistible. To descend to our own terminology he/she is offering a considerable increase in equipment reliability and the mass production of circuits (as distinct from discrete components) in a shorter space of time and from a smaller manufacturing area. And as a dowry, these circuits come in a very small size; a feature which the computer and avionics boys (among others) are prepared to give their right arms for. All this at a cost which promises to be highly competitive.

One of the potential crises in all this is that in the micromin world the manufacturer of discrete components vanishes in a puff of silicon dioxide as soon as integrated circuits are mentioned. Or, rather, he and the equipment designer suddenly fuse into one. The 64,000 dollar question here is, in which camp is this composite being to pitch his tent?

There is much to be said on either side; no doubt it will be said in due course and the sooner the better, for the ostrich attitude never got anybody anywhere.

In default of concerted action, three individual courses are possible. One is that the equipment manufacturers turn out their own microcircuits (this is in fact already being done on pilot scales). If this becomes general, then the components industry will lose a lot of business, thereby finding itself in the middle of a large creek with no paddle and a hole in the bottom of the canoe.

Secondly, the converse could materialize, with the components industry making microcircuits for offer to the equipment people (again, this is already being done). But any mass attack will surely be mounted over the dead bodies of the equipment circuit designers, who regard it as a Divine Right of Kings to exercise absolute control over each and every individual component which goes into their designs.

The third potential course (and alas! only too possible) is the good old British compromise in which everybody makes microcircuits, the components people have a stab at the equipment market and the devil takes the hindmost. This would be an admirable way of squandering time, money and effort and of killing the entire industry stone dead in one fell swoop.

The advent of microelectronics is, in a sense, phase two of the transistor breakthrough, so might not its introduction be as orderly as that of the transistor? It might, but the two events are not wholly comparable. The invention of the transistor did not threaten the stability of the two-partner set-up; moreover, the higher price of transistorized equipment put an effective brake on the speed of changeover. Micromin could gather momentum much faster by being cheaper.

True, micromin techniques can't be used in all equipment, and so the equipment manufacturer who offers a diversity of products—and particularly large capital goods—it likely to experience a gradual transition over the years, with some departments in which micromin may never encroach. This in turn would ease the situation somewhat for the components people.

But the big boys are better able to look after themselves anyway. It is the little boys we have to worry about, and particularly those who market a small range of products which happens to make ideal micromin material. Even supposing that their pockets are deep enough to dig into for the very expensive new plant, they cannot reorganize overnight; neither can they immediately switch to the "new thinking" engineering which micromin demands. What will they do when such competitors as the U.S.A. and Japan launch into the field on a vast scale, as they are likely to do any moment? One thing is sure; if they do nothing they will cease to be competitors.

Has there been an all-out effort by the various electronics associations to resolve such problems? And if not, why not? This is not an idle question because upon the answer may depend the matter of whether you and I make a down payment for an electric lawnmower this spring or whether we have to hock the old one.

On the face of it, quite apart from the overall problems, the outlook for engineers seems mixed. The chap who will probably be best off in micromin is the newcomer from University with a mind relatively uncluttered by conventional techniques. The older engineer who has lived by conventional techniques for years may find the change more than a bit of a jolt, while those who firmly maintain that there's nothing to touch the thermionic valve will be well advised to rub their rabbit's foot and pray that micromin won't touch their sphere of activity until after their retirement.

For, no doubt about it, a micromin outlook has to be developed. The overall field of knowledge has to be very wide; in the U.S.A. there is a school of thought which says that the man who dreams up a project should design it and take it right through production, only stopping short of actually posting it to the customer.

With integrated circuits layout and breadboarding as discrete operations are certainly abolished. And design approach is different, too. You can't take a conventional circuit and micromin it, because present limitations make it necessary to "design out" as far as possible items that can't be coped with (line inductors and large capacitors). And it is not enough to design. It has to be done with a much more careful eye on the economics of the thing.

I could go on, but the Editor insists that I mustn't be exclusively depressive. So let's end on a bright note. It looks as if there will be a lot more girls around the industry when microelectronics really get going; which is another very good reason why the industry should get down to some solid co-operative planning without further delay.

## Commercial Literature

**Signal Generator Comparison Chart.**—A comparative list of signal generators operating below 100 Mc/s has been compiled by Marconi Instruments from the published literature of various manufacturers. Sixteen generators are included on this chart, which is available on request. Many technical details are given along with price guidance, dimensions and weight.
**4WW 324 for further details**

**Broadcast Equipment.**—Two items of transistor equipment that should interest broadcast engineers—an equalizer and a video amplifier—are described in new leaflets available from the broadcast and recording division of EMI Electronics Ltd., of Hayes, Middx. The equalizer (Type 920, leaflet No. B/920/2) is a twin-channel unit and the response at both ends of the frequency range can be lifted or lowered, and a peak can be introduced towards the centre of the range. The video amplifier (Type 254, leaflet No. B/254/2) contains two independent amplifiers, each of which provide two isolated 75-ohm outputs. Sync pulses can be added to one or both outputs of each amplifier.
**4WW 325 for further details**

Literature describing **transistor heat sinks** made by the D.T.V. Group, and others for which they are representatives, is now available from the Group's headquarters, 126 Hamilton Road, West Norwood, London, S.E.27.
**4WW 326 for further details**

**Resistor Measurement.**—Two new application bulletins, one covering the measurement of standard resistors with a differential voltmeter (AB-1) and the other covering the measurement of megohm resistances with a differential voltmeter (AB-2), have been published by the John Fluke Manufacturing Company Incorporated. Both of these are available in the U.K. from Livingston Laboratories Ltd., of 31 Camden Road, London, N.W.1.
**4WW 327 for further details**

Issue three of the **precision resistor chart** published by Alma Components Ltd., is now available from the company's headquarters in Park Road, Diss, Norfolk. Alma's "J" range of loose wound resistors and their metal film resistors are included in this edition.
**4WW 328 for further details**

**Counter Details.**—Circuit details of the Type TF2401 along with the facilities this electronic counter can offer are included in a publication Marconi Instruments have produced for this eight-digit, all transistor counter. The company's address is St. Albans, Herts.
**4WW 329 for further details**

**Scattering Calculations.**—A leaflet describing how electromagnetic scattering by bodies of any shape can be determined accurately by digital computer programmes developed by TRG Incorporated is now available from the instrument division of Claude Lyons Ltd., of 76 Old Hall Street, Liverpool 3.
**4WW 330 for further details**

# APRIL MEETINGS

*Tickets are required for some meetings : readers are advised, therefore, to communicate with the secretary of the society concerned.*

**LONDON**

1st. I.E.E.—"Ranger 8 spacecraft, with special reference to moon-shot camera systems" by B. P. Miller at 5.30 at Savoy Place, W.C.2.

5th. I.E.E. & I.E.R.E.—Colloquium on "The design of real time computer systems" at 2.30 at Savoy Place, W.C.2.

6th. I.E.E.—"The future impact of integrated circuitry on the work of professional engineers" by Dr. J. T. Kendall at 5.30 at Savoy Place, W.C.2.

7th. I.E.E.—"The mode of use and the assessment of precision coaxial connectors" by I. A. Harris at 5.30 at Savoy Place, W.C.2.

7th. I.E.R.E.—Papers on "Inertial navigational systems for airborne & shipborne uses" at 6.0 at 9 Bedford Square, W.C.1.

8th. Radar & Electronics Assoc.—"The big screen—film has a future in radar & electronics" by C. Barwell at 7.0 at the Mullard Theatre, Mullard House, Torrington Place, W.C.1.

8th. Television Soc.—"Advanced television technical problems in Japan" by Dr. K. Suzuki at 7.0 at the I.T.A. 70, Brompton Rd., S.W.3.

9th. I.E.E. & I.E.R.E.—Discussion on "Electromyography" at 2.30 at Savoy Place, W.C.2.

12th. I.E.E. & I.E.R.E.—"Solid circuits in computers" by N. Miller at 5.30 at Savoy Place, W.C.2.

13th. I.E.E.—Colloquium on "Problems and developments in electron linear accelerators and associated radio-frequency valves" at 2.30 at Savoy Place, W.C.2.

14th. I.E.E.—"Acoustics and telephone transmission—examples of the problems of human judgement" by H. S. Leman at 5.30 at Savoy Place, W.C.2.

14th. I.E.R.E.—"B.R.E.M.A. colour television home viewing tests" by R. N. Jackson, K. E. Johnson & B. J. Rogers at 6.0 at London School of Hygiene & Tropical Medicine, Keppel Street, W.C.1.

21st. I.E.R.E.—"Effect on the ionosphere of nuclear explosions" by F. L. Hill, at 6.0 at the London School of Hygiene and Tropical Medicine, Keppel Street, W.C.1.

26th. I.E.E.—"Standards and converters" by P. Rainger and E. Rout at 5.30 at Savoy Place, W.C.2.

28th. I.E.R.E.—"Synchronously tuned methods of harmonic and intermodulation distortion analysis" by D. E. O'N. Waddington at 6.0 at 9 Bedford Square, W.C.1.

29th. I.E.E.—Kelvin lecture: "The particles of modern physics" by Prof. R. O. Frisch at 5.30 at Savoy Place, W.C.2.

29th. S.E.R.T.—"Some problems of computer maintenance" by L. Baldwin at 7.15 at London School of Hygiene & Tropical Medicine, Keppel Street, W.C.1.

29th. Television Soc.—Fleming memorial lecture on "The specification of an adequate television signal" by Dr. R. D. A. Maurice at 7.0 at the Royal Institution, Albemerle Street, W.1.

30th. I.E.E.—"Equipment and the results of tests with the NIMBUS meteorological satellite" by Dr. N. E. Rider at 5.30 at Savoy Place, W.C.2.

**BEDFORD**

26th. I.E.E.—"Frequency-modulated stereo broadcasting" by G. D. Browne at 7.0 at the Bridge Hotel.

**BIRMINGHAM**

1st. S.E.R.T.—"Colour television" by B. J. Rogers at 7.30 at the College of Advanced Technology, Gosta Green.

6th. I.E.E. & I.E.R.E.—One-day symposium on "Electronics in industry—the next five years" at the University.

21st. Television Soc.—"Post office towers" by R. E. G. Back and P. J. Edwards at 7.0 at the College of Advanced Technology, Gosta Green.

26th. I.E.E.—"Birmingham Post Office radio relay tower" by S. G. Young at 6.0 at the James Watt Memorial Institute.

**BRISTOL**

12th. I.E.E.—"An introduction to analogue and digital computers—their differences and their uses" by K. C. Parton at 6.0 at Electricity House.

13th. Television Soc.—"Lasers in applications allied to television" by M. Wall at 7.30 at the Royal Hotel, College Green.

24th. I.E.R.E. and Inst.P.& Phys. Soc.—"Microstructure and physical properties of thin film" by Dr. A. J. Forty at 7.0 at the University Engineering Laboratories.

26th. I.E.E.—"Static switching—principles of electronic logic" by F. S. Brown and S. L. Hurst at 6.0 at the College of Science and Technology, Ashley Down.

**CHELTENHAM**

30th. I.E.R.E.—"Integrated circuits" by G. C. Padwick at 7.0 at North Gloucestershire Technical College.

**COVENTRY**

13th. I.E.E. & I.E.R.E.—"Data transmission in industrial processes" by H. Cox and J. Adderley at 6.0 at the Lanchester College of Technology.

**EDINBURGH**

1st. I.E.E.—Faraday Lecture on "Colour television" by F. C. McLean at 7.0 at the Usher Hall.

**GLASGOW**

7th. I.E.E.—"Fuel cells" by Dr. I. Fells at 6.0 at the Institution of Engineers & Shipbuilders, 39 Elmbank Crescent.

12th. I.E.E.—"Speech compression" by Dr. J. Swaffield, at 6.0 at the University of Strathclyde.

**LEATHERHEAD**

7th. I.E.E.—"The measurement of noise" by C. M. Brownsey, at 7.30 at the C.E.R.L.

**LEEDS**

14th. I.E.R.E.—"405/625 line conversion systems" by C. R. Longman at 6.30 at the University.

**MALVERN**

1st. I.E.R.E.—"Small high-fidelity loudspeaker systems" by K. F. Russell at 7.0 at Abbey Hotel, Abbey Road.

**LIVERPOOL**

14th. I.E.R.E.—"Field effect transistors and their applications" by C. S. den Brinker at 7.30 at Walker Art Gallery.

**MIDDLESBROUGH**

7th. I.E.E.—"Computers in control of processes" by Dr. D. N. Truscott at 6.30 at Cleveland Scientific Institution.

**NEWCASTLE-ON-TYNE**

4th. I.E.R.E.—"Pulse modulation systems" by J. Balmer at 6.0 at the Institute of Mining & Mechanical Engineers, Westgate Road.

6th. I.E.E.—Faraday Lecture on "Colour television" by F. C. McLean at 2.30 and 7.15 at the City Hall.

8th. I.E.E.—"Loudspeakers" by K. F. Russell at 6.30 at Rutherford College of Technology.

**NOTTINGHAM**

5th. S.E.R.T.—"The 625-line television system and its reception problems" at 7.15 at the East Midlands Gas Board, Lower Parliament Street.

7th. S.E.R.T.—"U.H.F. aerials" at 7.15 at the Midlands Design Centre, Mansfield Rd.

**ST. ANDREWS**

9th. I.E.E.—Symposium on "Application of semiconductor devices to biological electronics" at 11.0 at the University of St. Andrews.

**STONE**

26th. I.E.E. & I.P.O.E.E.—"Trunking and traffic principles of a P.C.M. telephone exchange" by E. Walker and W. T. Duerdoth at 7.0 at Duncan Hall.

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# CLUB NEWS

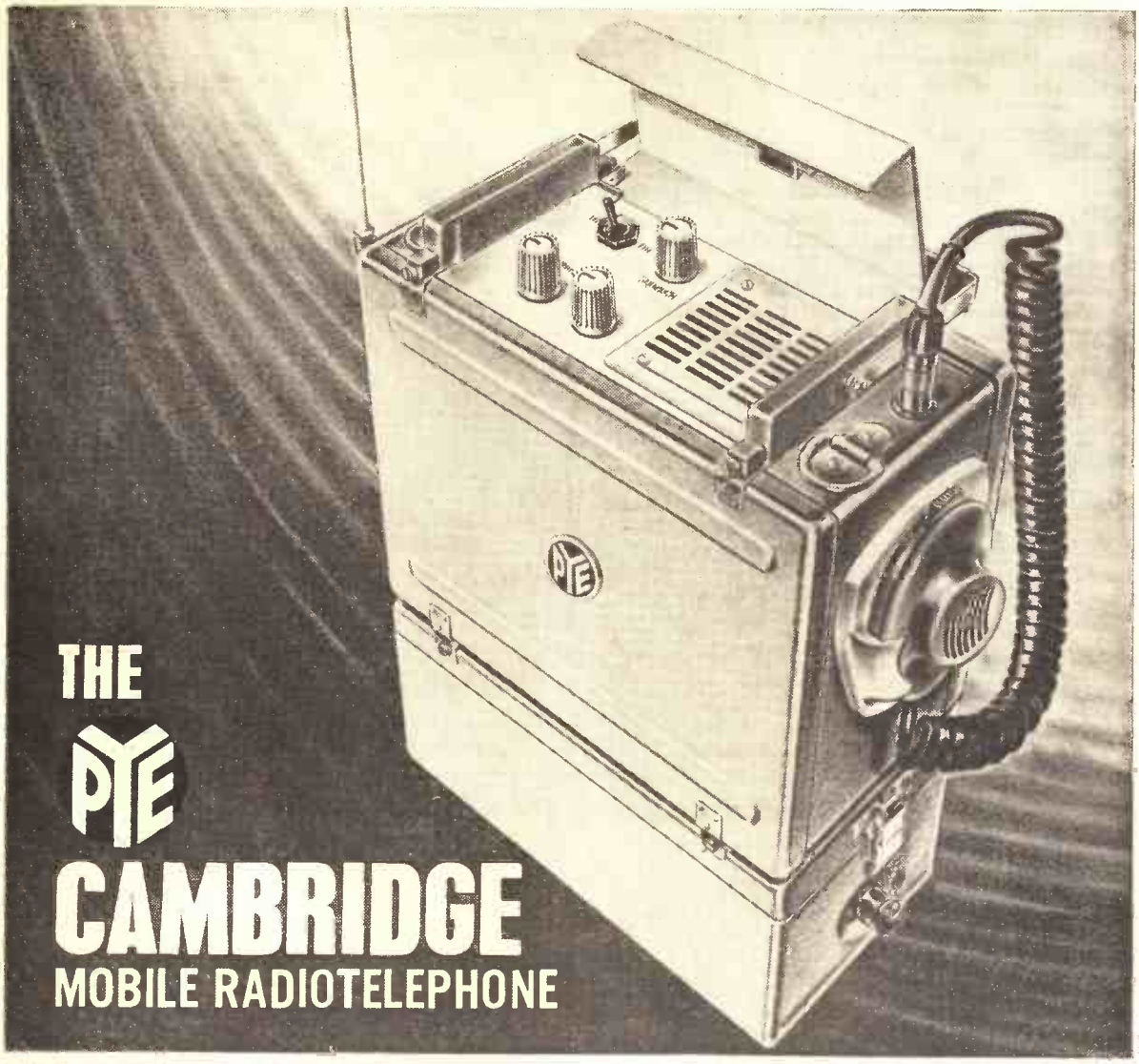
**BEXLEYHEATH.**—At the April 8th meeting of the North Kent Radio Society, Ian Lever will speak on "Television servicing" at 8.0 at the Congregational Church Hall.

**HECKMONDWIKE.**—Members of the Spen Valley Amateur Radio Society will visit the Royal Naval Reserve Communications Centre in Leeds on April 1st. A fortnight later C. R. Green, of Green & Davis, will talk about "commercial equipment" and on the 29th M. A. Browne will deal with "manned spaceflights." Meetings are held at 7.30 at the Grammar School, High Street.

**LEAMINGTON SPA.**—The fourth in a series of talks on radio theory will be given to members of the Mid-Warwickshire Amateur Radio Society on April 5th. It will cover valve performances. Fortnightly meetings are held at 7.45 at Harrington House, Newbold Terrace.

**NORTH MIDLANDS MOBILE RALLY.**—The University of Keele Radio Society will provide an "out-station" as part of the "talk-in" facilities for the Mobile Rally which will be held at Trentham Gardens on Sunday, April 11th. The Society's transmitters will be on 1960 kc/s and 145.4 Mc/s; call signs G3COY and G3SMD.

**WELLINGBOROUGH.** — "Transistorized TV" is the title of the talk to be given by K. Knibs at the April 1st meeting of the Wellingborough Radio Club which meets every Thursday at 7.45 at the Silver Street Club Room.

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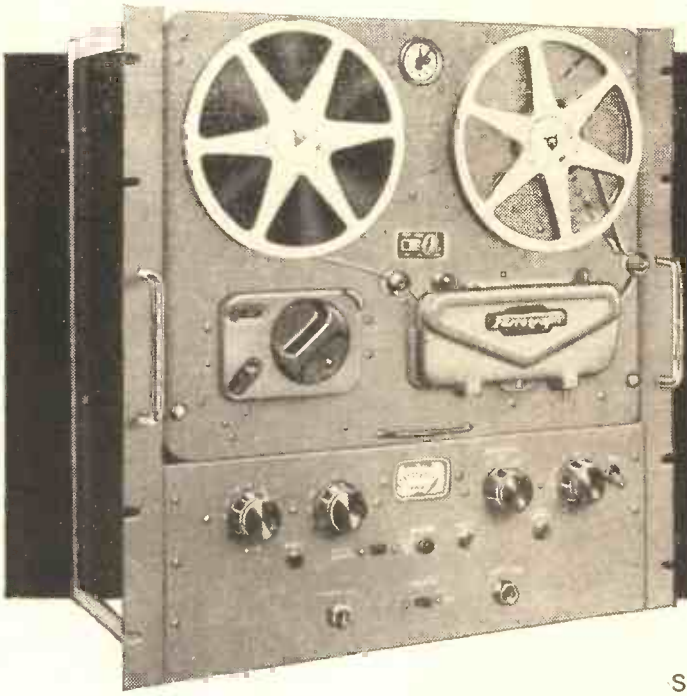

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Series "Y" instruments are housed in strong metal cases and, in some instances, can be rack-mounted. They are intended for those engaged in scientific research and industrial pursuits.

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## TYPE TG66A

**COVERS THE VERY WIDE FREQUENCY RANGE**

## 0·2c/s to 1·22 Mc/s

Frequency is selected by means of four in-line additive decade controls and a five-position multiplier switch. The last of the additive controls is continuously variable so that any frequency may be selected with a discrimination better than ±0.03% or 1/10th of the specified frequency accuracy, whichever is the greater.

The output source voltage of the oscillator is monitored by a meter with an expanded scale, and a continuous control is fitted so that the output may be set with a discrimination better than ± 0.05dB.

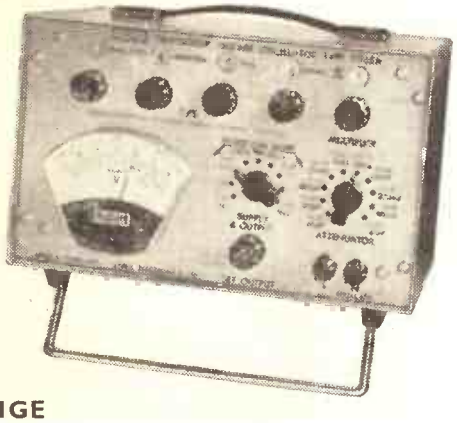
### SPECIFICATION

**ACCURACY**
±0.02 c/s below 6 c/s.
±0.3% from 6 c/s to 100 kc/s.
±1% from 100 kc/s to 300 kc/s.
±3% above 300 kc/s.
all measured at 25°C.

**STABILITY**
±6% mains voltage change produces less than ±0.005% frequency change up to 100 kc/s. Change of frequency with temperature is less than ±0.025% per °C above 100 c/s.

**DISTORTION**
Less than 0.15% from 15 c/s to 15 kc/s.
Less than 0.5% at 1.5 c/s. and 150 kc/s.

**OUTPUT**
Continuously variable from −94 dBm to +10 dBm into 600 ohms.
Source voltage variable from 30μV to 5V. Output impedance 600 ohms at all settings. Meter fitted with dBm and V scales.



**TEMPERATURE RANGE**
−10°C. to +45°C.

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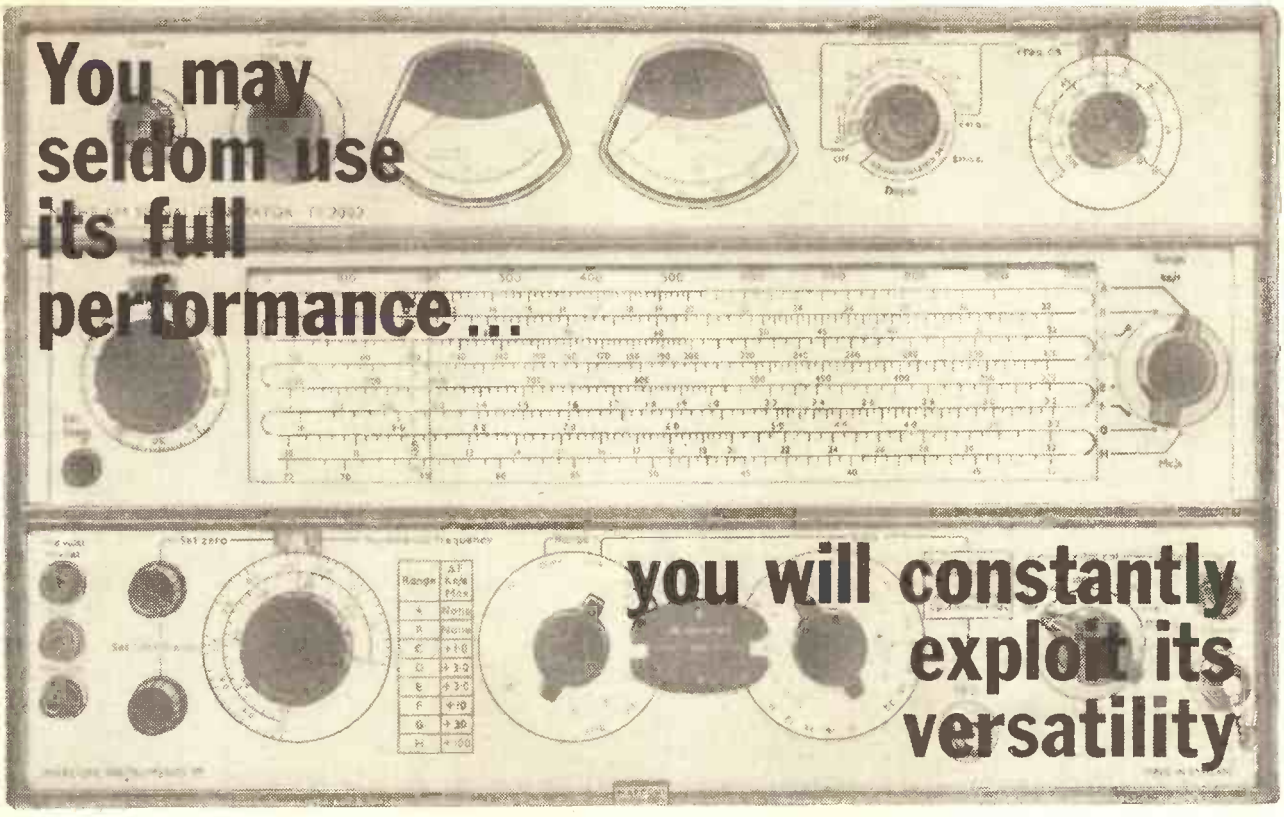


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# MF/HF AM SIGNAL GENERATOR

## Type TF 2002

Once you are convinced that frequency, carrier level and modulation depth need not be interdependent . . . when you can flip the a.m. on and off without re-setting anything . . . when your signal generator remains tuned for hours without a tweak, yet tests are made so rapidly that stability scarcely matters . . . then you tend to become *inventive*. External shift facilities tempt you to use the TF 2002 as a sweep generator. *Don't resist the temptation*. You devise a new way to measure deviation with an a.m. instrument, and a quicker way to measure bandwidth. *Go ahead*—the TF 2002 is intended for people like you. No other single commercially available equipment combines the wide carrier frequency range, output facilities, modulation characteristics and all-round performance and versatility of Marconi Instruments MF/HF AM Signal Generator Type TF 2002.

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* Carrier frequency 10 kc/s to 72 Mc/s in 8 ranges
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* AM up to 100% depth. Internal oscillator 20 c/s to 20 kc/s

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- All major circuits are plug-in epoxy glass-fibre printed boards.
- Accuracy and high-stability have been retained by the use of tantalum electrolytic capacitators and deposited metal-film resistors.
- Unit may be operated from A.C. Mains, external D.C., or internal rechargeable cells.

*For further particulars, please contact Engineering Products Division.*

## FUNCTIONS OF THE A220 (provisional)

- Measures signal level of transmission equipment, between 50 c/s and 250 kc/s; impedances of 75, 150, 600, 1,200 ohms. Terminating and bridging level measurements with balanced input.
- High-impedance voltmeter (unbalanced), 50 c/s to 650 kc/s, 1 Mohm input, sensitivity 10 mV, F.S.D.
- A balanced frequency-selective voltmeter to measure pilot carrier level and "Tone-on-channel" selection. Bandpass 100 c/s.
- Measures individual channel levels (end-to-end) between 200 c/s and 3.4 kc/s.
- Wien-bridge, sine-wave oscillator, frequency continuously variable over range 100 c/s to 630 kc/s. With associated amplifier outputs to +13 dbm in 75, 150, 600, 1,200 ohms (balanced).
- Wien-bridge, oscillator amplitude, modulated by internal oscillator at 820 c/s or by external tones between 200 c/s and 3.4 kc/s.
- High-sensitivity measurements (–80 dbm for transmission level and noise measurement).
- Meter indicates modulation percentage on carrier channels (8 kc/s to 250 kc/s).
- Weighted noise measurements (with optional external plug-in unit) to C.C.I.T. Specification or other network if required.
- Simulates broadband carrier channels with a.m. modulation.
- Wave analyser measures harmonic distortion and intermodulation products down to 0.1%.
- Amplitude modulation monitor, 0 to 80%.
- Measures the bandpass characteristics of filters.
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**Dimensions and Weight:**
*Height:* 8 inches 20.3 cm. *Width:* 14 inches 35.5 cm. *Depth:* 12.5 inches 31.75 cm. *Weight:* 20 lbs. 9 kg. (approx. including power supply).

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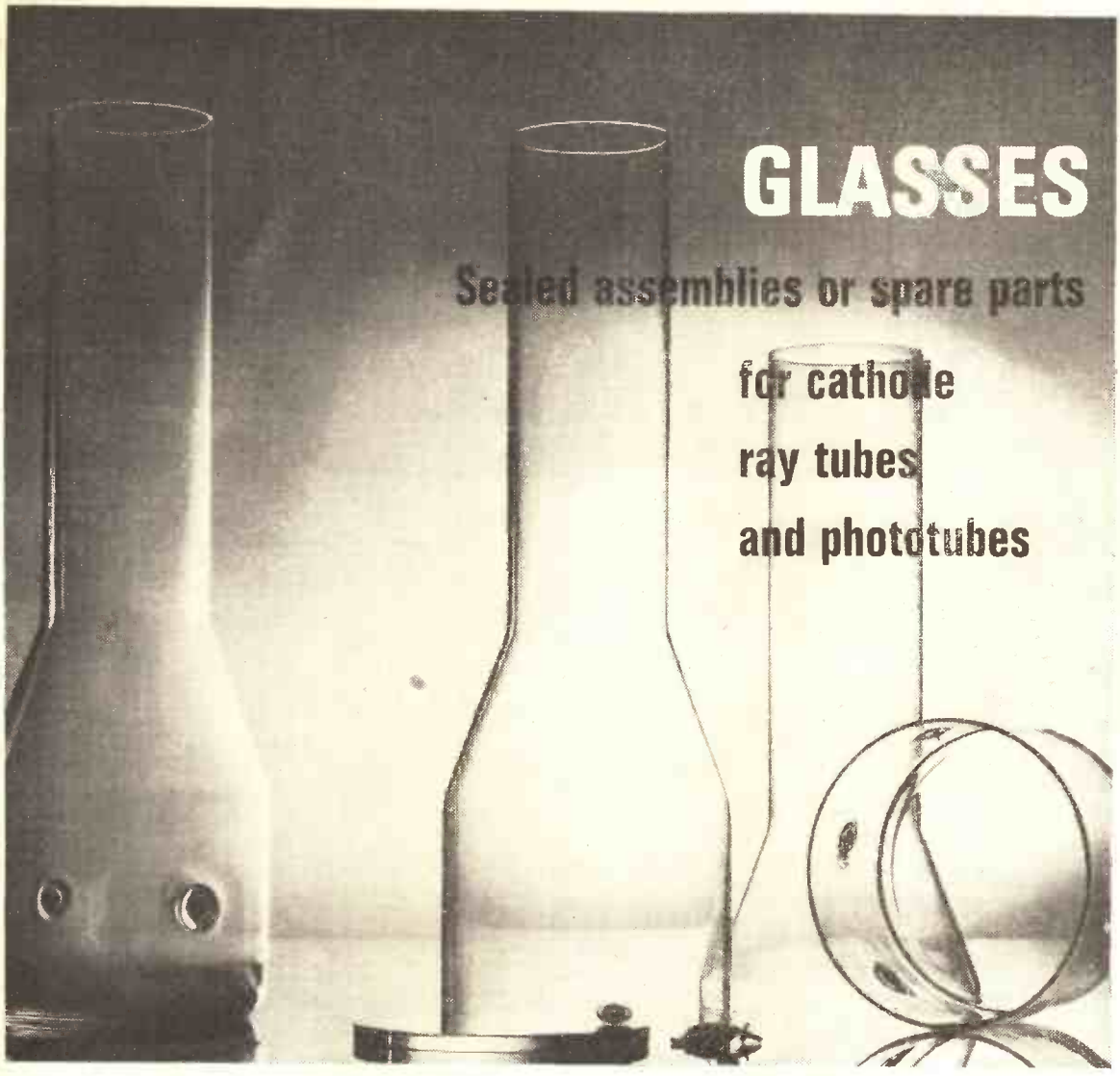


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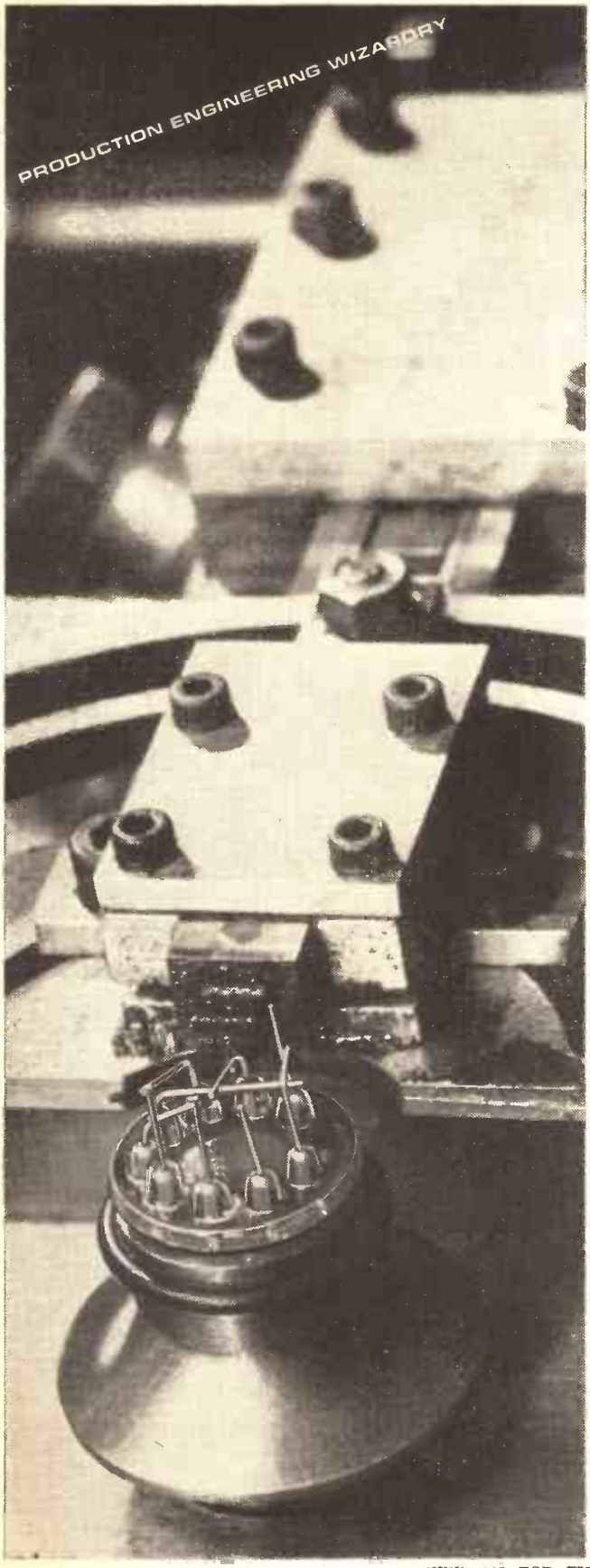



# BRIMAR

To make absolutely certain that stems mate accurately with valve electrodes prior to welding, stem wires are sent on a jigging, twisting run through the 34 stations of the Brimar in-line cropper and bender.

Here, wires are automatically selected, bent and cut in a variety of complex ways with unvarying precision, a tiny claw engaging with each wire as the arm thrusts forward to ensure a clean bend at the point of contact.

At the end of the run, the stem is eased from its seating and puffed gently by compressed air into a waiting tray – a Brimar valve part as near perfect as modern machinery (and human ingenuity) can make it!

*This ingenious in-line cropping and bending machine was designed exclusively by Thorn-AEI development and production engineers.*

**RADIO & ELECTRONICS COMPONENTS SHOW**

**OLYMPIA**

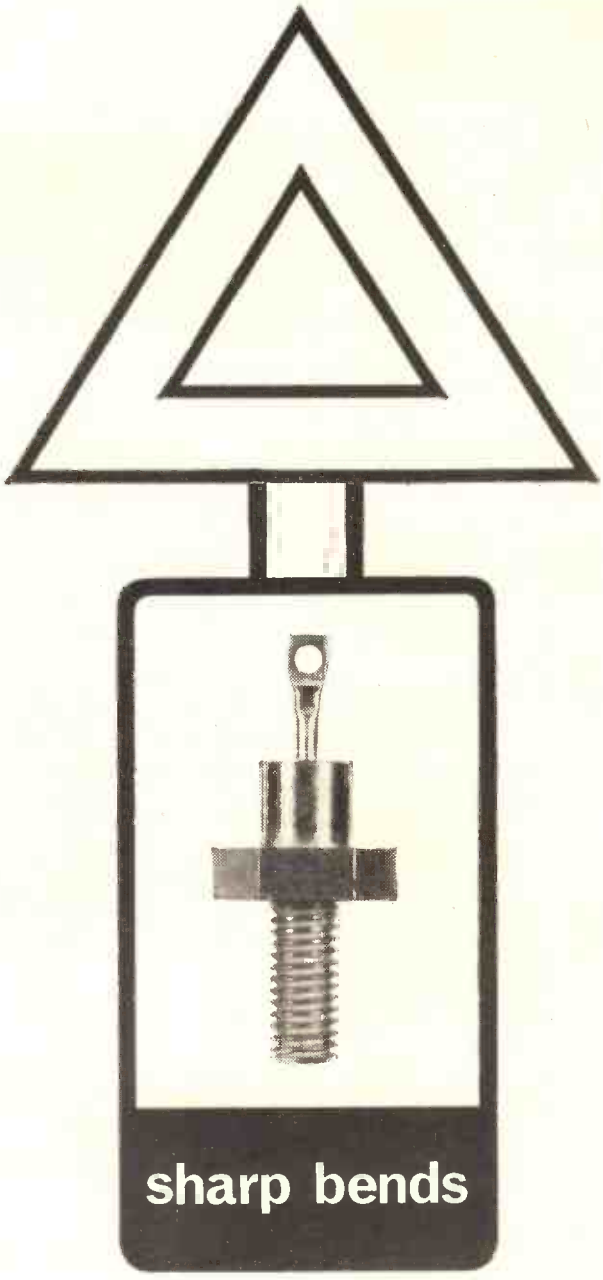
**STAND 325 GRAND HALL**

**THORN-AEI RADIO VALVES & TUBES LTD**

HEAD OFFICE:
155 Charing Cross Road, London WC2. GERrard 9797

EXPORT DIVISION:
Thorn House, Upper St. Martin's Lane, London WC2.

TPA 3




Over 300 of them: wicked square corners that can't be cut. There's one in the performance curve of every IR zener. Ask for details of zeners from 400mW to 50W, and 3.6V to 200V. The 1W and 10W range is fully type approved.

IOR **INTERNATIONAL RECTIFIER**

**Immediate off-the-shelf delivery from IR distributors—phone**

COLCHESTER 6173 · CRAWLEY 28700 · GLASGOW DOUGLAS 8671 · (LANCS) TODMORDEN 602 · LEEDS 35111
LEICESTER 68561 · (LONDON S.E.27.) GYPSY HILL 6166 · (MIDDLESEX) SKYPORT 1314 · PORTSMOUTH 20465

INTERNATIONAL RECTIFIER CO. (GREAT BRITAIN) LTD · HURST GREEN · OXTED · SURREY · TELEPHONE OXTED 3215 · TELEX RECTIFIER OXTED 8819

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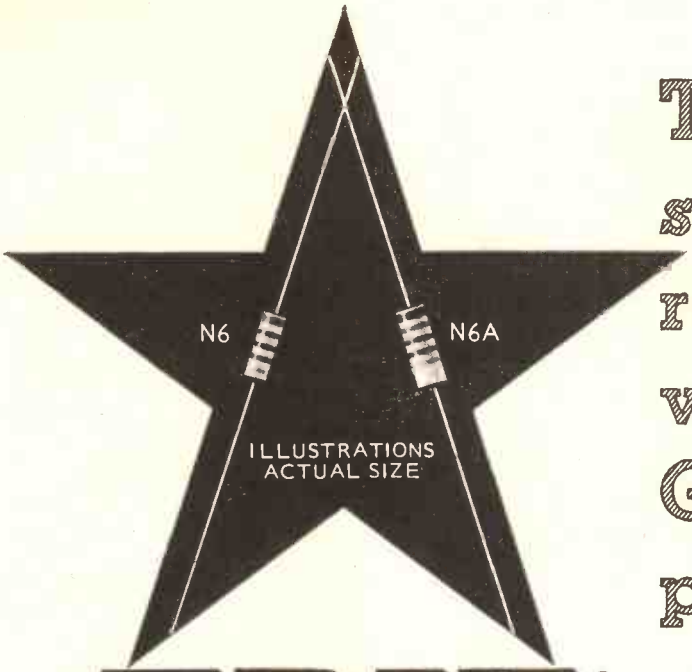



# The *sub-miniature* resistors with the GREAT performance...

## Type N6 and N6A

## INSULATED HIGH STABILITY RESISTORS

BRIEF SPECIFICATIONS

| STYLE | N6 | N6A |
|---|---|---|
| Length, maximum | 0.359in | 0.438in |
| Diameter, maximum | 0.131in | 0.162in |
| Resistance range ohms | 10 to 100KΩ | 10 to 1MΩ |
| Wattage rating | ⅛ Watt 70°C | ⅛ Watt 70°C |
| Voltage rating | 200V d.c. | 200V d.c. |

- ★ The world's smallest ceramic insulated resistors.
- ★ Special ceramic core to ensure perfect bonding of carbon film resulting in low inherent noise and excellent life characteristics.
- ★ Special "heavy carbon film" to ensure uniform high standard of stability and reliability throughout resistance range.
- ★ Ceramic encased to ensure maximum protection from mechanical shock and adverse climatic conditions.

*The N6 is Defence Approved to DEF 5112A.*

ERIE® ELECTRONIC COMPONENTS

®Registered Trade Mark

ERIE RESISTOR LIMITED GREAT YARMOUTH NORFOLK Telephone 4911 Telex 1720

4WW—035 FOR FURTHER DETAILS.

# STB2·STB2·STB2

# ANOTHER BRILLIANT DESIGN from BRENELL

The STB2 is a masterpiece in mechanical engineering and electronic circuitry. It is a versatile mono/stereo tape recorder and has been designed with high fidelity stereo installations particularly, in mind.

## SPECIFICATION (STB2/5/2)

It has all the standard Brenell features of 4 tape speeds, frequency correction at all speeds, three Papst outer rotor motors, pause control, monitoring and superimposing, 8½" dia. reels, fast rewind, etc., plus—adjustable attenuators on all input channels to ensure perfect matching with all auxiliary equipment · dual concentric recording level and playback level controls · cathode follower output four channel mixing on mono programme sources · twin recording and twin playback pre-amplifiers · comparison of original and recorded signal · adjustable bias level · recording facilities for 1/2 and 2/2 track · playback facilities for 1/2, 2/2, 1/4 and 2/4 track sound on sound facilities · two edgewise meters for recording level, tape output level and bias level · optional extra:- stereo power amplifiers and monitoring speakers.

ALTERNATIVE MODEL STB2/510/2 has special deck to accommodate 10½" N.A.B. reels.

*Please write for full details to the sole manufacturer:-*

**INTERNATIONAL AUDIO FAIR**
**STAND No. 12**
**DEMONSTRATION ROOM 337**

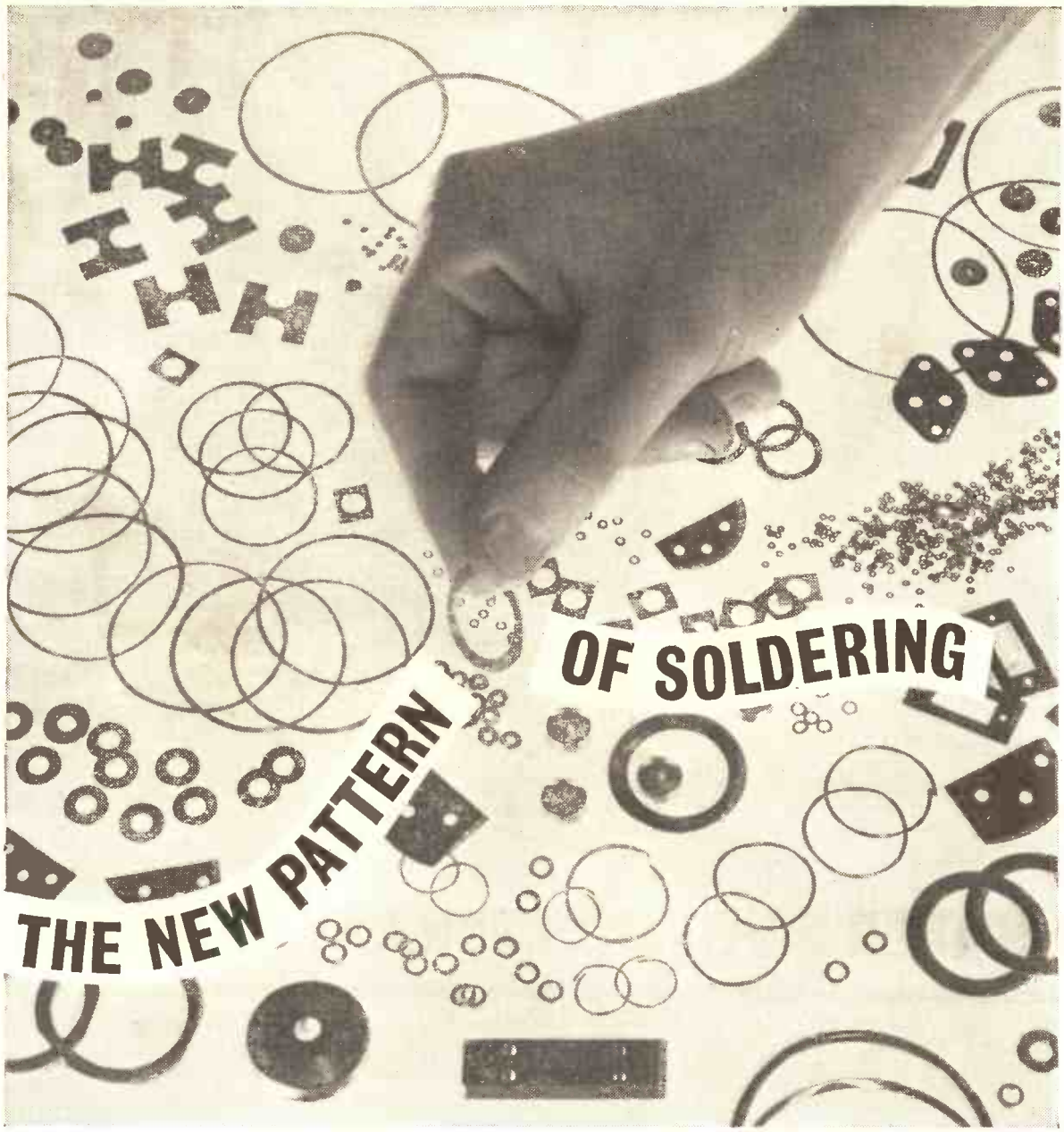
Brenell

4WW—037 FOR FURTHER DETAILS.

**BRENELL ENGINEERING CO. LTD.**

231/5 Liverpool Road, London, N.1.
Telephone: NORth 8271 (5 lines)

GD 998



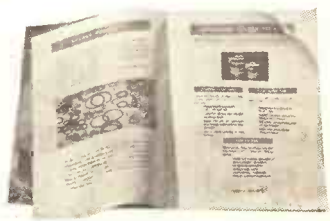

**Enthoven Preforms.** Solder preforms make for faster, more accurate and therefore *cheaper* soldering. Enthoven are leaders in the design and manufacture of solder preforms, and offer a wide range of alloys, both cored and solid, in the form of rings, washers, discs, shims, strips and ribbon.

Enthoven are always ready to discuss any industrial soldering problem, and, if necessary, to design special preforms in the light of your requirements and of their long experience of precision soldering techniques.

**ENTHOVEN SOLDERS LIMITED**

*Sales Office & Works:* Upper Ordnance Wharf, Rotherhithe Street, London, S.E.16. BER 2014
*Head Office:* Dominion Buildings, South Place, London, E.C.2. MONarch 0391

*This free booklet describes the complete range of Enthoven Solder Products . . . preforms among them. Ask for a copy.*



4WW—038 FOR FURTHER DETAILS.

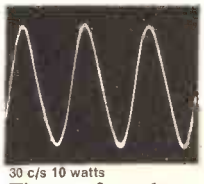
# TWO NEW CABINET MODELS

## OF OUTSTANDING PERFORMANCE from WHARFEDALE

Fitted with new type of 12″ bass units with **NEOPRENE SURROUND** giving remarkably clean bass. Both cabinets are of modern and attractive appearance, designed by Industrial Artist, Robert Gutmann, F.S.I.A. **Both models to be introduced and demonstrated at the 1965 Audio Festival and Fair, at the Russell Hotel, London.**

## W2-DOVEDALE

This is a modern version of the W2 at a rather higher price. Open baffle resonance of special 12″ unit is remarkably low at 15/18 c/s.

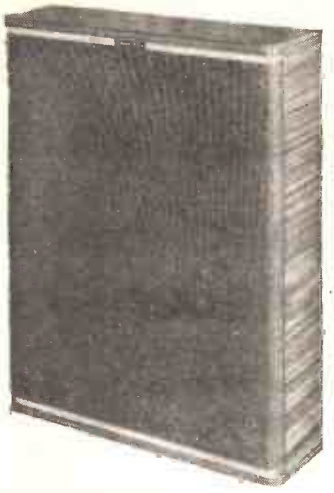


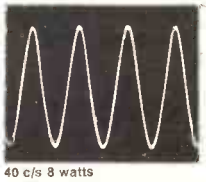
30 c/s 10 watts

The waveform shows a clean note at 30 c/s with 10 watts input.

Units:
WLS/12/Neoprene.
13,000 gauss.
Super 5, cloth surround.
14,000 gauss. Crossover frequency; 1,000 c/s.
Freq. range; 25-17,000 c/s. Impedance; 12/15 ohms.
Power handling capacity; 15 watts rms. 30 watts peak.
Size; 24″ x 14″ x 12″. Weight; 37 lb.
Finish; Zebrano veneer, wax polished.
Fitted treble control in back panel. PRICE **£31.10.0.**

## DALESMAN





40 c/s 8 watts

In spite of being only 6¼″ deep, this attractive design will handle 8 watts at 40 c/s without distortion, as shown in waveform.

Open baffle resonance of 12″ unit is 20/23/c/s.

Units: WNA/12/Neoprene. 11,000 gauss.
5″ silver, cloth surround. 12,000 gauss.
Crossover frequency; 1,000 c/s.
Frequency range; 30-15,000 c/s.
Impedance; 10/12 ohms.
Power handling capacity; 10 watts rms. 20 watts peak.
Size; 25″ x 20″ x 6¼″. Weight 31½ lb.
Finish; Zebrano veneer, wax polished.

PRICE **£25.10.0.**

**DELIVERY DATE FOR BOTH MODELS: APRIL 1965 onwards**

Wharfedale

**WHARFEDALE WIRELESS WORKS LTD.**
IDLE · BRADFORD · YORKSHIRE
Tel: Idle 1235/6 Grams: "Wharfdel" Bradford

**4WW—039 FOR FURTHER DETAILS.**

B

# CELESTION INTRODUCE THE 'DITTON 10' COMPACT LOUDSPEAKER SYSTEM

## (10 watts and only 12¾" x 6¾" x 8")

# any questions?

**What is the Ditton?**

The Ditton is a full range compact high fidelity loudspeaker system. It uses two new moving coil units to produce optimum results whenever space is at a premium.

**What does this mean in terms of actual performance?**

The Ditton has a frequency response extending from 35 - 15,000 c/s with exceptionally low distortion and yet the enclosure measures only **12¾" x 6¾" x 8"**

**Surely the bass notes are difficult to reproduce from such a small enclosure?**

Yes, this is because the efficient reproduction of low frequencies demands the displacement of large quantities of air. Hitherto, this has meant using a large diameter cone with a limited movement but the Ditton achieves the same results by making a small cone move further.

**I would expect large movements to mean greater distortion. How is this avoided?**

The bass unit in the Ditton has a very free mechanical suspension but uses the 'aircushion' effect of the relatively small volume of trapped air in the enclosure to act as a low distortion suspension.

**Now, about power handling capacity?**

In technical terms, the Ditton is rated at **10 watts** R.M.S. The efficiency of the unit is such that it requires an input of only 1 to 2 watts for comfortable listening levels. An amplifier capable of delivering at least 5 watts will be able to deal with any overloads due to peaks in the music signal.

**What about the middle and top frequencies?**

From 1,500 c/s to 15,000 c/s the Ditton employs an ultra linear pressure loaded device which is flat ± 2dB. This unit is used by broadcast authorities and other professional users.

**Does the Ditton have a small box sound?**

No. A small box usually means that extreme bass is missing and in its place is a 'one note bass' due to high and underdamped fundamental resonance of the system. The Ditton overcomes this by having an unusually low fundamental resonance and a very large magnet to give a high degree of magnetic damping.

*Please fill in the coupon to obtain a booklet giving comprehensive design details, response curves etc.*

Be in at the launching!
Hear the 'Ditton' for yourself at the
INTERNATIONAL AUDIO FAIR
Hotel Russell, London.
DEMONSTRATION ROOM 242 STAND No. 46

CELESTION LTD. Ferry Works, Thames Ditton, Surrey

*Please send me the booklet and colour brochure on the 'Ditton' compact*

Name _____

Address _____

_____

_____

A3

**Celestion** Studio Series

CELESTION LTD. Ferry Works, Thames Ditton, Surrey. Telephone: EMBerbrook 3402/6

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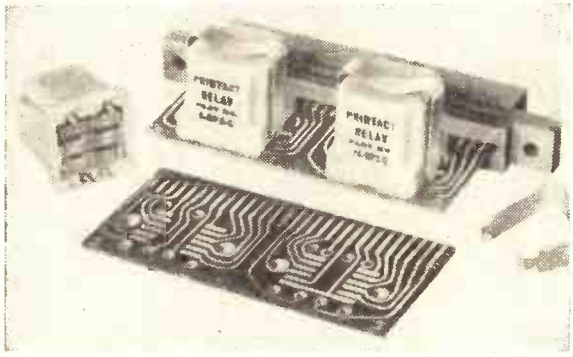
# THE MIGHTY MIDGET

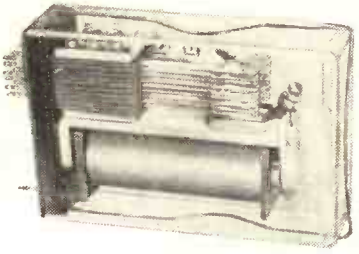
## Printed Circuit Relay

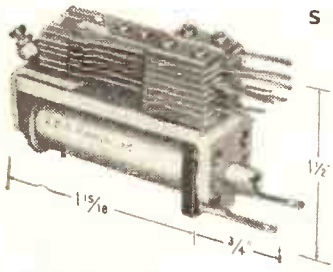


Supplied as standard or latching type, single or double winding. Size $\frac{7}{8}$in. cube, weight 0.8 oz.
Contact Rating 24 v. D.C. 3 pole double throw.
Voltage: 6, 12, 24, v. D.C. Power: 500 mW. Speed 10mS.
Temperature: 70 C max.

**3000 TYPE PLUG-IN**

Size 4in. x $2\frac{7}{8}$in. x $1\frac{1}{4}$in. Specification as 3000 type 6 change overs maximum, light duty.






**S 1500 MINIATURES**

A.C. or D.C. operating. Coil up to 10,000 ohms. Single or double winding. Contact material — Silver, Platinum, Spring Set — 6 change overs. Light duty maximum. Size: 2 11/16in. x $1\frac{1}{2}$in. x $\frac{3}{8}$in.

We are manufacturers of full ranges of 3,000 type, 600 type, and plug in relays, also 12 way mounting rack 19in. x $3\frac{1}{4}$in. Further details available on request to Mr. Clemens.

**FULLY APPROVED HOUSE**
**7 DAY PROTOTYPE SERVICE**

# A.D.S. RELAYS Ltd.

89-97, ST. JOHN STREET, LONDON, E.C.1.
Telephone: CLErkenwell 3393

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# MINIATURES from Airmed Ltd

Rugged high performance carbon microphones for communication use. They can be mounted on headset booms where small size and weight are obvious advantages. Both types can also be mounted in various ways to meet individual requirements.
These microphones are designed for close speaking where the special acoustic screens, high electrical output and tailored frequency response make an important advance in speech transmission.

| SPECIFICATION | A 301 | A 303 |
|---|---|---|
| Frequency response | 200-5000 c/s | 200-4000 c/s |
| Sensitivity | —50dB/V/dyne/cm² at 1000 c/s | |
| Load Resistance | 100 to 250 ohms | 100 to 250 ohms |
| Feed Current | Approx. 40 mA | 60 to 85 mA s/c current |
| Mounting | By two 8 BA screws which also form the contacts. | Special slip contact for mounting on headset boom. |
| Finish | High impact injection moulded case. Hermetically sealed except for small equalising leak. Fully tropicalised. | |

**LEAD SWITCH**

ARB Ref. WR650

A spring loaded single pole double throw snap-action positive contact switch, designed primarily as a microphone switch for airborne telecommunication headsets.

**RATINGS:** D.C. 28 v. D.C. max. at 100 mA.
A.C. 240 v. A.C. at 2 A.

Airmed LIMITED
EDINBURGH WAY
HARLOW · ESSEX
TEL: HARLOW 24331
One of the Clement Clarke Group

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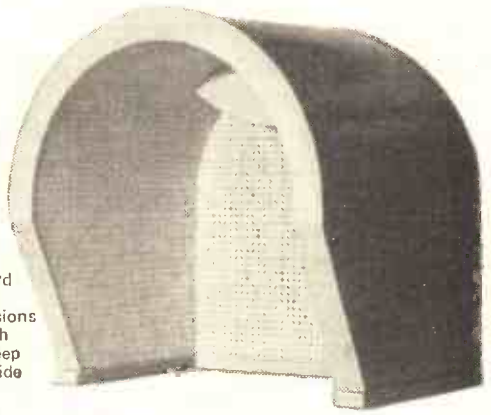
# WHITELEY

## for acoustic hoods

All noisy environments such as factories, workshops, department stores and hotels require the facility of an acoustic hood which permits telephone conversations to be held without the interference of annoying background noises. Whiteley acoustic hoods are strongly made from resin bonded ply and finished in a cellulose enamel which makes these suitable for indoor or outdoor use.



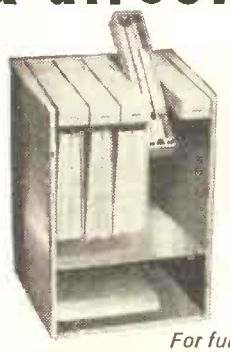
Standard Hood Dimensions
25″ high
20¼″ deep
24½″ wide

Fitted with loudspeakers

Fitted with doors for outdoor use

*Also available with internal light and/or a storage shelf below hood*

## & directory holders



These attractive, and extremely functional directory holders will hold five directories neatly and securely, in individual swivel holders permitting easy identification and reference. The lower shelf provides additional storage space. The units are of cast alloy and are finished in an attractive grey epoxy resin enamel and constructed to strict G.P.O. design specifications.

Directory Holder Dimensions
17¼″ high x 13½″ wide x 13⅝″ deep

*For further details please write or telephone.*

**WHITELEY ELECTRICAL RADIO CO. LTD**
**Mansfield · Notts. Telephone: Mansfield 1762-5**

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# It costs less to find the answers

*WITH THIS NEW LABORATORY RESEARCH TOOL*

## The LABCORDER

Instrumentation recording for research or laboratory use has usually meant costly, bulky equipment. *NOW,* the moderately priced EPSYLON MR800 'LABCORDER' provides all the facilities you will require in a compact, easily portable form—with simple operation and attractive savings in cost.

The 'LABCORDER' is suitable for many industrial data recording applications. Here are a few distinctive features

- *Two Wide Band FM Channels*
- *Speech Channel*
- *Time Marker Channel*
- *Four Tape Speeds allowing 8:1 expansion or compression of Data Time Scales*
- *Precise Tape Speed Control*
- *Quarter inch Magnetic Tape*

For digital recording, an alternative model, the MR800D is available. Features include four digital channels and high packing density.

*Please write or telephone for descriptive literature.*

## EPSYLON LABCORDER

**EPSYLON INDUSTRIES LIMITED**
Faggs Road, Feltham, Middlesex, England.
Telephone: FELtham 5091/5

STONE PLATT GROUP

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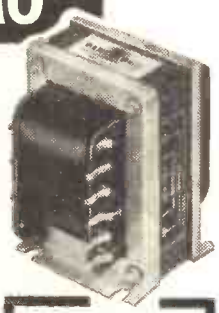
# NEW Partridge TRANSFORMERS



**for use with the**

## MULLARD 10 + 10 STEREO AMPLIFIER

**using ECL 86 Valves**

The range of Partridge Transformers for the High Fidelity enthusiast has recently been extended by two new types, for use with the Mullard 10 + 10 Stereo; Output Transformer TG 1073 (price 62/6) and Mains Transformer TG 1074 (price 70/-).

**ASK FOR TECHNICAL DATA SHEET No. 41**

● *FROM STOCK AND PARTRIDGE SUPPLIERS*

**PARTRIDGE TRANSFORMERS LTD.**

ROEBUCK ROAD, CHESSINGTON, SURREY. *Telephone: LOWer Hook 4353/4/5*

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MINIATURE IRON (Half Size)

# Vari-Stat

## THERMOSTATIC SOLDERING IRON

*FOR CONTROLLED TEMPERATURE*

**Miniature Model 50 watt**

| | |
|---|---|
| Weight | 1¾ oz. |
| Heating time | 20 secs. |
| "Push-in" Bit Sizes | 3/32", 1/16", 1/32" |
| Voltage | 250 to 12 volts |
| Price | **55/-** |

**Instrument Model 70 watt**

| | |
|---|---|
| Weight | 4½ oz. |
| Heating | 1½ min. |
| Bit Size | 11/64" dia. |
| Voltage | 250 to 24 volts |
| Price | Mk.I (Micro-switch) **79/6** |
| | Mk. II (Magnetic Contact Breaker) **72/-** |

Both Models give excellent bit and element life since the thermostat completely eliminates overheating and controls the reserve heating capacity, which makes possible continuous soldering without chilling of the bit.
The consistent temperature makes these irons ideal for printed circuit work.

**CARDROSS ENGINEERING CO., LTD.**

**Woodyard Road, Dumbarton**

*Phone: Dumbarton 2655*

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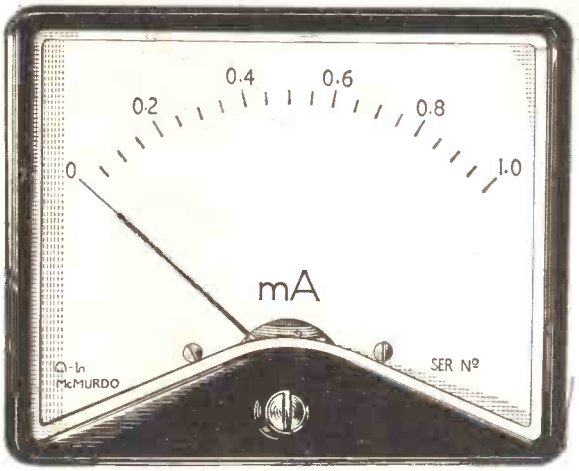
# McMURDO MAKE METERS




- MICROAM**METERS**
- MILLIAM**METERS**
- AM**METERS**
- VOLT**METERS**

**This is a range of moving coil instruments to B.S.89 for panel mounting. They are supplied in four different case sizes: 3", 2¼" and 1¾" rectangular and 2½" round. For full details of these meters, write to the address below for our illustrated brochure.**

# McMURDO

**McMurdo Instrument Company Limited**
**Rodney Road, Fratton Trading Estate, Portsmouth, Hants.**
**Tel: Portsmouth 35555 Telex 8612**

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# Wireless World

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To obtain further details of any of the coded items mentioned in the Editorial or Advertisement pages of this issue, please complete one or more of the attached cards entering the reference number(s). Your enquiries will be passed on to the manufacturers concerned and you can expect to hear from them direct in due course. Cards posted from abroad require a stamp.

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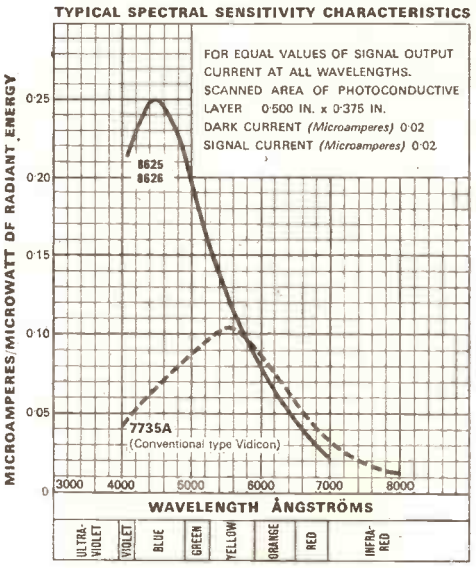
Con objeto de obtener mas detalles de caulquiera de los articu'os mencionados en las paginas editoria es o de annuncios de este numero sirvase rellenar una o mas de las unidas tarjetas citando el numero o numeros de re'erencia. Sus consultas seran transmitidas a los fabricantes interesados de quiene stendran noticias directamente a su debido tiempo. Las tarjetas enviadas desde el extranjero requireren franqueo.

**SIRVASE ESCRIBIR CON LETRAS MAYUSCULAS**


ENGLISH ELECTRIC

**ENGLISH ELECTRIC VALVE CO., LTD.,** can now supply from stock new high sensitivity vidicons which represent an important development in television camera tubes.

These new separate mesh tubes are characterised by their high sensitivity, short lag and high resolution. The spectral response peaks in the blue to provide correct panchromatic reproduction when used with tungsten lighting yet the sensitivity is equal to that attainable with "red sensitive" types such as the 7735A. Although primarily intended for broadcast television these tubes have many industrial applications especially where fluorescent lighting is employed. Two types are available, differing in heater ratings.

8625 with 6.3V/0.6A heater.
8626 with 6.3V/0.095A heater.

Please write for comprehensive data on these and other EEV vidicons.

**ENGLISH ELECTRIC VALVE CO LTD** CHELMSFORD ENGLAND

Telephone: Chelmsford 3491, Ex 262, Telex 99103 | AGENTS THROUGHOUT THE WORLD

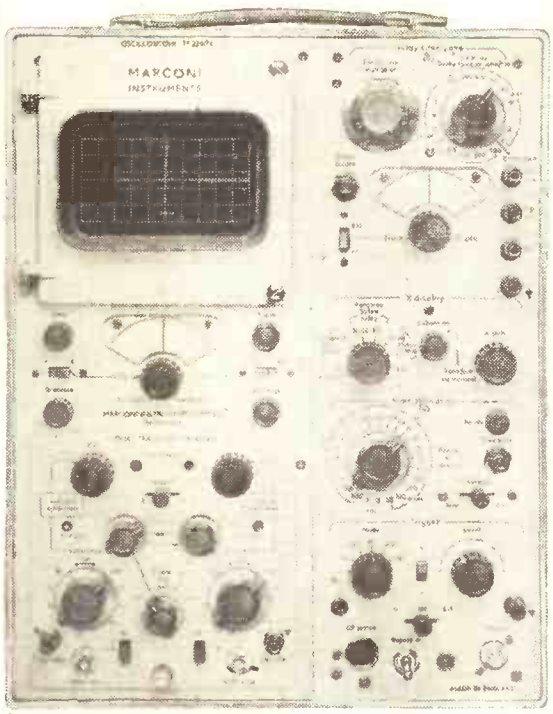
EEV

AP237A

4WW—004 FOR FURTHER DETAILS.

# MARCONI INSTRUMENTS LABORATORY MEASURING OSCILLOSCOPE

## Type TF 2200A




# MORE

## versatile

new delaying time base circuitry provides *eighteen* ranges in 1-2-5 sequence, 10 μsec to 5 sec.

# MORE

## adaptable

new rectangular bezel accepts a wide range of cameras, alternative graticules and viewing aids:
new BNC connectors for Y-input suit all new accessories.

# MORE

## accessories

new passive and active probes, new graticule projector, new polarising filter, new instrument trolly.

**BRIEF SPECIFICATION**

* D.C. to 40 Mc/s bandwidth at 50 mV/cm
* 12 nsec rise time for less than 1% overshoot
* 10 nsec/cm writing speed
* 3 mode sweep delay from less than 1 μsec to 5 sec for detailed waveform analysis or line strobe
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* Simplified triggering control
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* Slide-back or direct time and voltage measurement with built in voltage calibration

Are you kept fully informed about Marconi Instruments activities in the oscilloscope field? Continuous development of proven designs (including important valve and circuit improvements in the TF 2200A) is backed by specialised research aimed at the production of radical new instruments and better accessories. Some of the oscilloscope accessories represent significant advances in themselves: an attenuator probe incorporating a X10/X1 switching facility with a cable that is super-flexible and practically unbreakable: a graticule projector which eliminates parallax error, accepts all kinds of standard and specially drawn graticules or reference waveforms, and can be viewed by several observers simultaneously: and a new polarising filter which prevents surface reflection from the face of a tube or graticule.
If you use oscilloscopes please ask to be put on our mailing list for *regular* technical information—starting with full particulars of the TF 2200A.

A GOOD NAME FOR GOOD MEASURE

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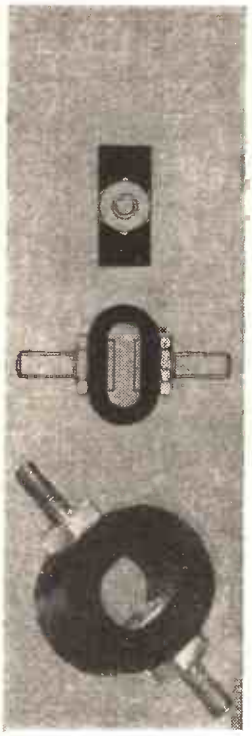

Take a Frustex instrument mounting . . . like the one featured on the left; or the bonded stud next to it. Perhaps the pedestal flange type in the centre and the ring stud mounting to its right command your interest? What do they all *mean?*
They, and the thousands of other components which SILENTBLOC design and manufacture, *mean* the end to most of those vibration troubles.
Combating vibration is SILENTBLOC'S business . . . but we're not dogmatic about it, low-frequencies constitute a special challenge. But, whatever your problem, give it to us — and you can be sure of one thing: if it can be solved we'll find the *correct* answer to it.

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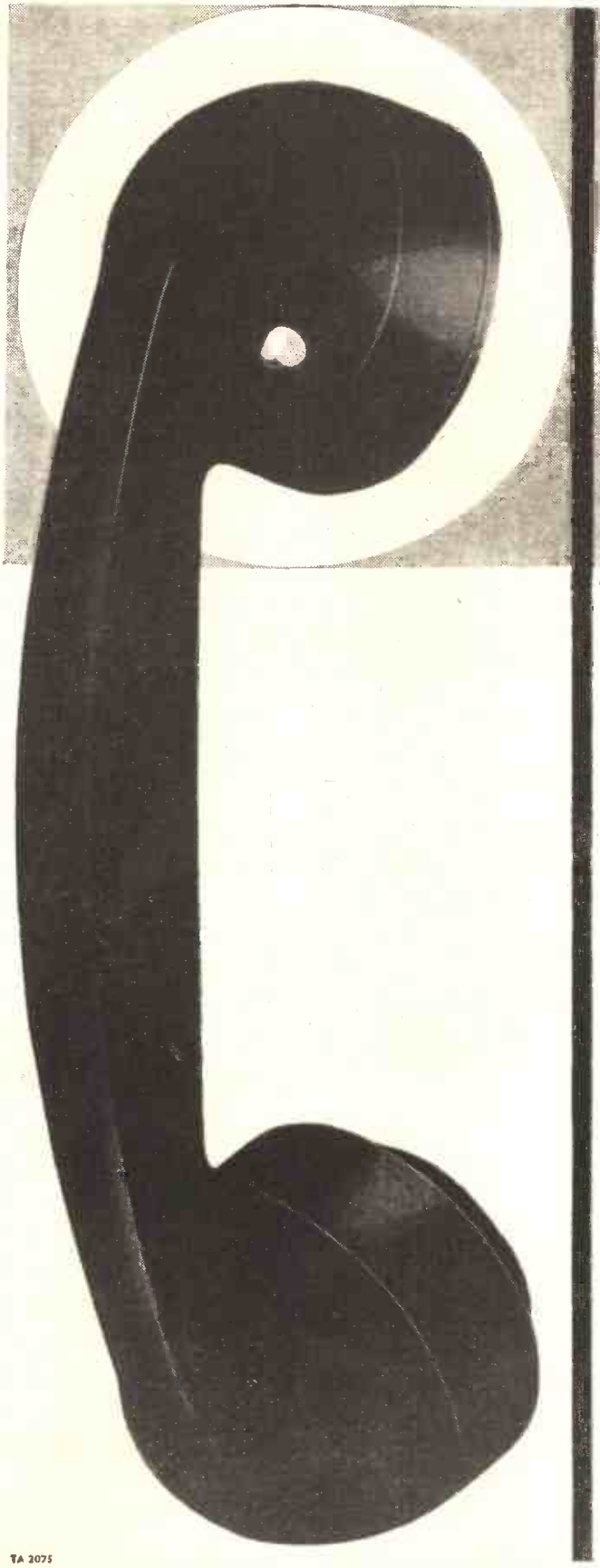
*Broadway S/503*



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**B.P.O. APPROVED**

# push-button handset

### TYPICAL USES

* Provides a convenient means of switching on and off to conserve power from local battery.
* Short-circuits transmitter to reduce side tone noise.
* Cuts out conversations when making asides.
* Switches radio transmitter when used for radio telephony.

### MICRO-SWITCH CONTROL

A fast-acting changeover speed of 5 milliseconds makes the provision of a make-before-break action unnecessary, since holding relays of automatic exchanges will not release in so short a time. The switch action is easily changed from locking to non-locking.

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High-efficiency electro-dynamic as standard.

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The Complete range of "Hatfield" instruments may be seen on Stand No. 469 at the R.E.C.S., Olympia, May 18th—21st, 1965

# Specialised instrumentation by...

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- **UNIVERSAL SIGNALLING TEST SET TYPE S.P.O. 7803**
  Designed to facilitate testing and alignment of transistorised out-of-band signalling equipment and to enable signalling and telegraph relays to be tested and adjusted. An amplifier is provided so that "end-to-end" measurements of signalling distortion may be made at levels higher than nominal.

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- **LOW FREQUENCY SELECTIVE LEVEL METER TYPE S.P.O. 7820**
  Frequency Range: 30 c/s - 30 Kc/s; Expanded Range 30 c/s - 4 Kc/s; Calibration Accuracy: ± 1% ± 5 c/s. Level Range: + 20 dBm to - 105 dBm. Through and terminated measurements may be made on 600 ohm and 140 ohm circuits, balanced and unbalanced. Harmonic discrimination: 65 dB; Accuracy: ± 0·1 dB within range + 5 dB to -10 dB on meter. ± 0·25 dB within range -10 dB to -15 dB on meter. Attenuator accuracy ± 0·2 dB.

- **LOW FREQUENCY OSCILLATOR TYPE S.P.O. 7806**
  Used in conjunction with the Low Frequency Selective Level Meter, automatic tracking is provided over the frequency range 30 c/s - 20 Kc/s. Sending levels are + 1 to - 82 dBm with an accuracy of ± 0·1 dB at 1 Kc/s and 0 dBm at 20°C. The "send level" meter accuracy is ± 0·2 dB at other readings and the 0 - 70 dB attenuator accuracy is ± 0·3 dB. Level/Frequency response is ± 0·2 dB and the error due to temperature changes in the range 0°C - 40°C is ± 0·3 dB. 600 ohm and 140 ohm balanced and unbalanced output impedances are provided. The network may be operated from internal batteries or an external 18 to 26·5 V.D.C. supply.

**These specialised instruments are manufactured by us by arrangement with the Transmission Division of G.E.C. (Telecommunications) Limited, Coventry who are responsible for the circuit design.**
**Enquiries for specialised instruments of any kind are welcome. Ask for a copy of our Catalogue or our Technical Representative will call.**

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*Phone: Plymouth 72773/4* *Grams: Sigjen Plymouth*

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SHAPES OF SOUND

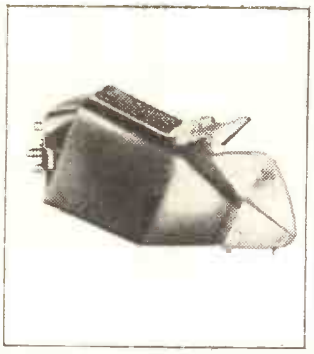
# The Goldring-Lenco GL58

The GL58 has long been popular amongst knowing audiophiles as the only transcription unit that provides true high fidelity quality at a really modest price. Now, in keeping with the modern trend towards shelf and table installations, the GL58 is also available plinth-mounted or with an elegant shallow cabinet with Perspex cover.

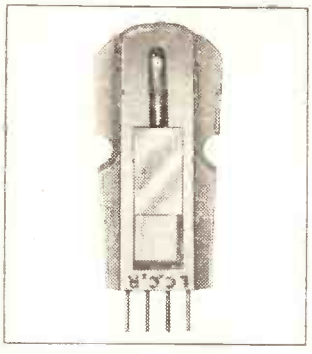
GL58 TRANSCRIPTION UNIT. The GL58 incorporates a sturdy, precision-engineered Swiss motor, a continuously variable speed-adjustment system with four adjustable click-in positions for standard speeds, an ingenious groove-selector-cum-lowering-device for the arm, and an integral transcription arm of proven performance which will accommodate any standard-fitting cartridge, on a removable 'platform'. All these features and a surprisingly low price make the GL58 an outstanding buy for hi-fi enthusiasts on a limited budget.

**GL 58 TRANSCRIPTION UNIT: £14.14.0** + £2.7.9 P.T.
**GL 58/P** unit on fabric-covered plinth: **£17.4.0** + £2.15.11 P.T.
**C 58 CABINET AND COVER FOR GL 58** Elegant sapele mahogany cabinet with removable, clear Perspex dust cover. Cut for spring or rigid mounting of unit. Size: 14″ x 17″ x 7″. **£8.19.6** + £1.12.0 P.T.

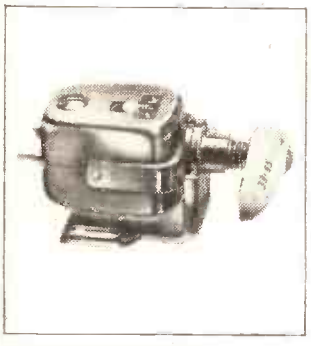
**Recommended cartidges for the GL 58 are: Pickering 380 A, Goldring CS 90 and Goldring 580.*



***PICKERING 380A**
Moving-magnet cartridge for exceptional mono or stereo reproduction. Features the exclusive V-guard push-in diamond stylus unit which prevents damage through accidental dropping of arm on record. The Pickering 380A ensures high channel separation and virtually eliminates needle talk, hiss or distortion. Hermetically sealed, it tracks at 2 grams, faultlessly reproduces the most exacting records. £12.12.0 + £2.0.11 P.T.



***GOLDRING CS90**
A stereo ceramic cartridge with excellent frequency response and cross-talk separation. Can be played at light tracking weights and gives an output of 50 mV. Fitted with replaceable 0.0005″ tip diamond stylus. £4.4.0 | 13.8 P.T.



***GOLDRING 580**
A high-performance variable reluctance cartridge of the turn-over type, for mono operation. Fitted with easily replaceable sapphire styli and enclosed in a mu-metal shell for hum shielding. The 580 tracks at low pressures and has adequate output for modern hi-fi amplifiers. £4.4.0 | 13.8 P.T.

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**41**
Demonstration Room **334**

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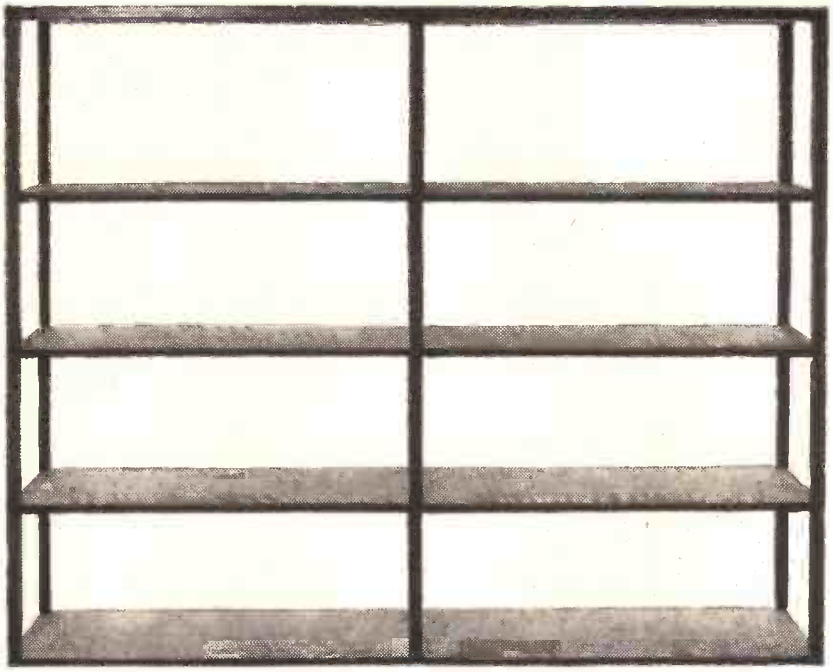

# We have extended our shelf space to take a new range of portable meters


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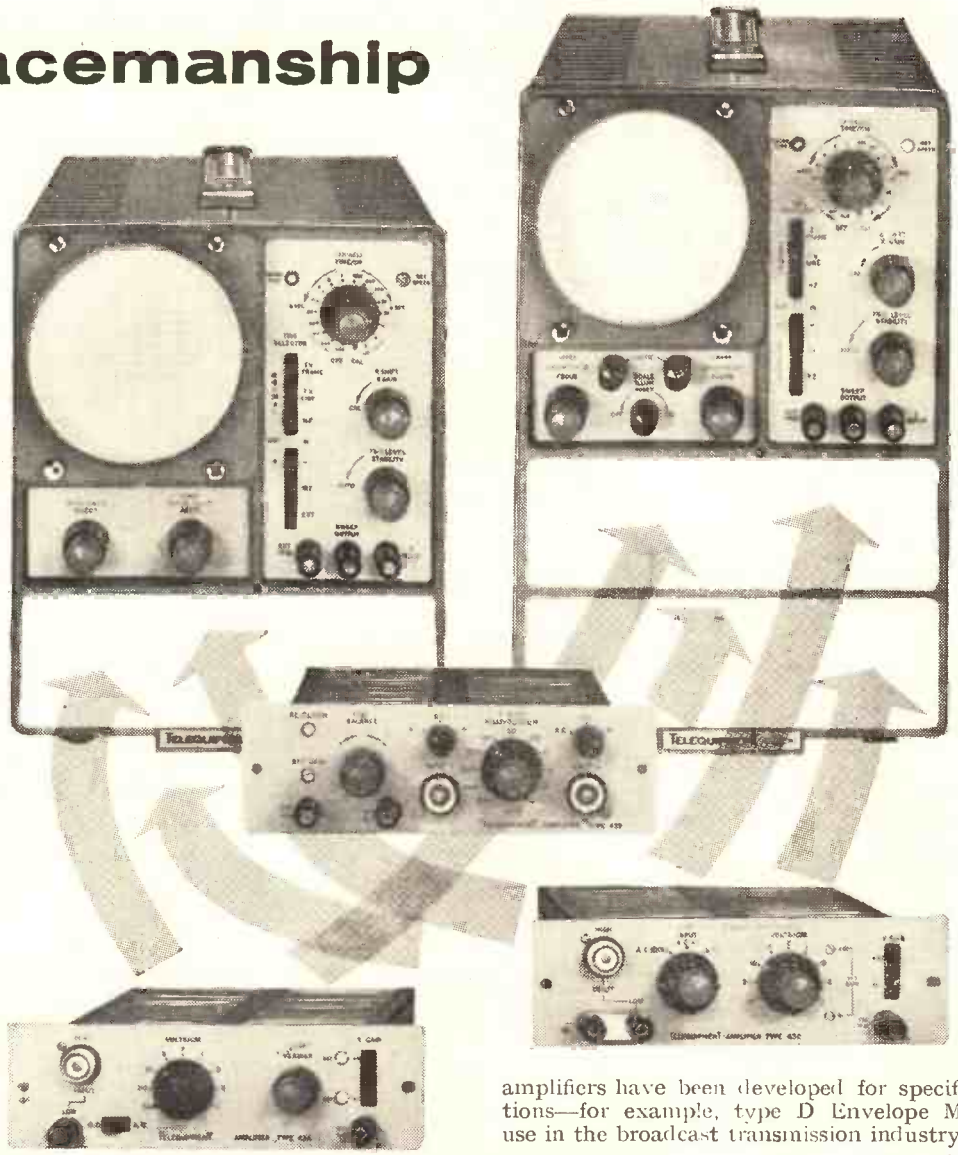

**Telequipment type S43 and D43 oscilloscopes can be used with any of three different plug-in-amplifiers, including the sensational G type wide band and differential.**

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| **G** | (Wide band differential) | DC-10 Mc/s at 20 mV/cm. Maximum sensitivity 2mV/cm |

(Bandwidths—3 dB approx.)

*Full details of this oscilloscope system will be sent on request.*

**S43** with type A amplifier **£92.**
**D43** with type A amplifiers **£125.**

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FIFTY-FIFTH YEAR
OF PUBLICATION

# Wireless World

ELECTRONICS, TELEVISION, RADIO, AUDIO

## APRIL 1965



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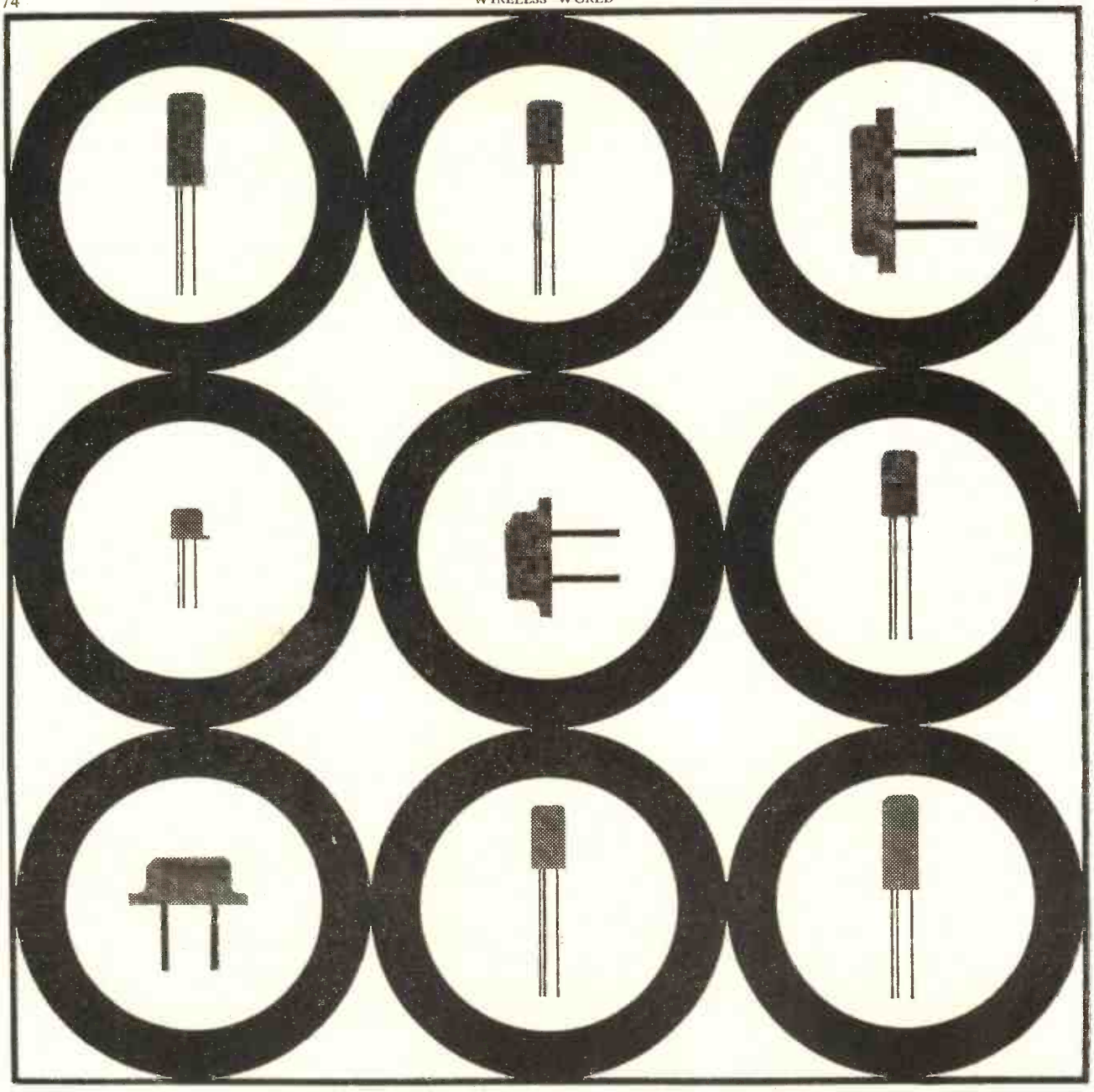

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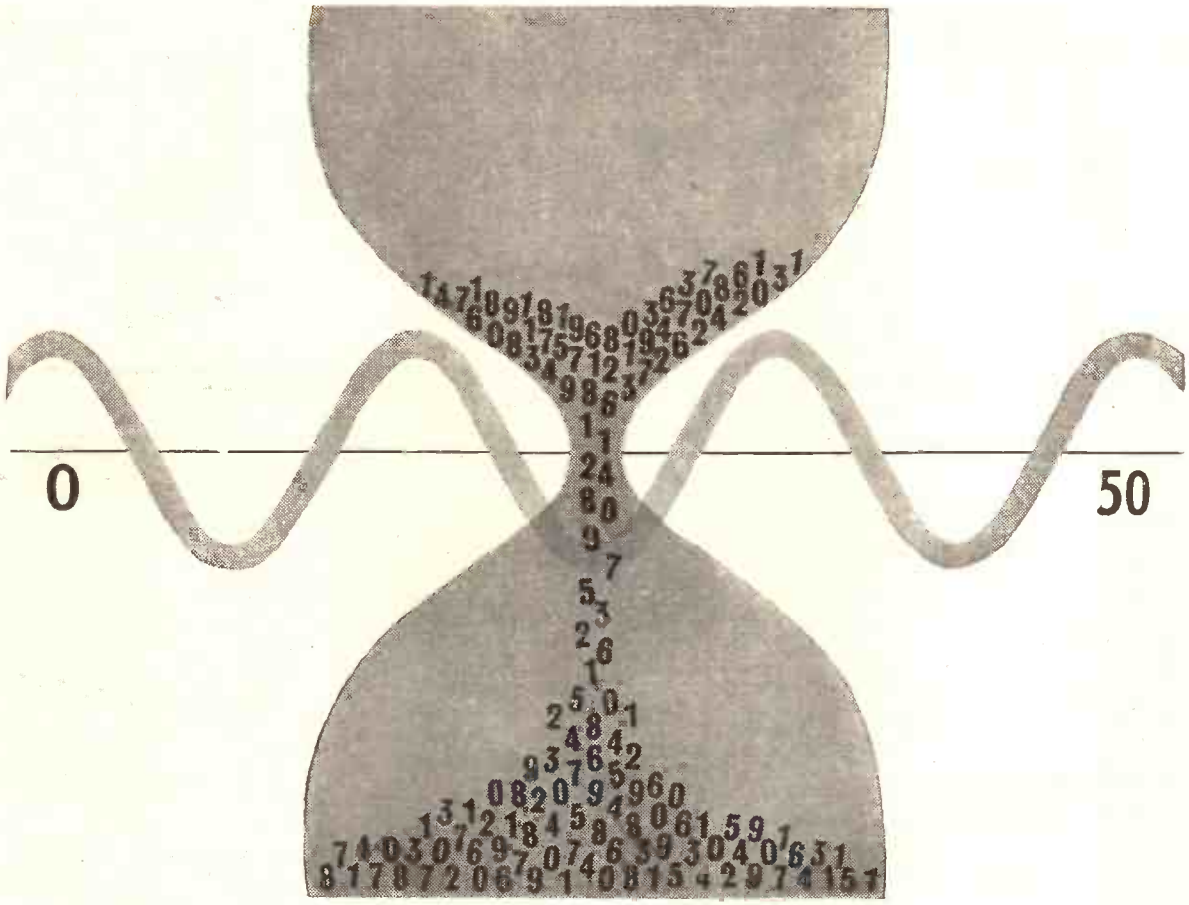


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The High Speed Counter Type 298 is part of the comprehensive range of high quality electronic instruments produced by Airmec for use in laboratories and workshops.


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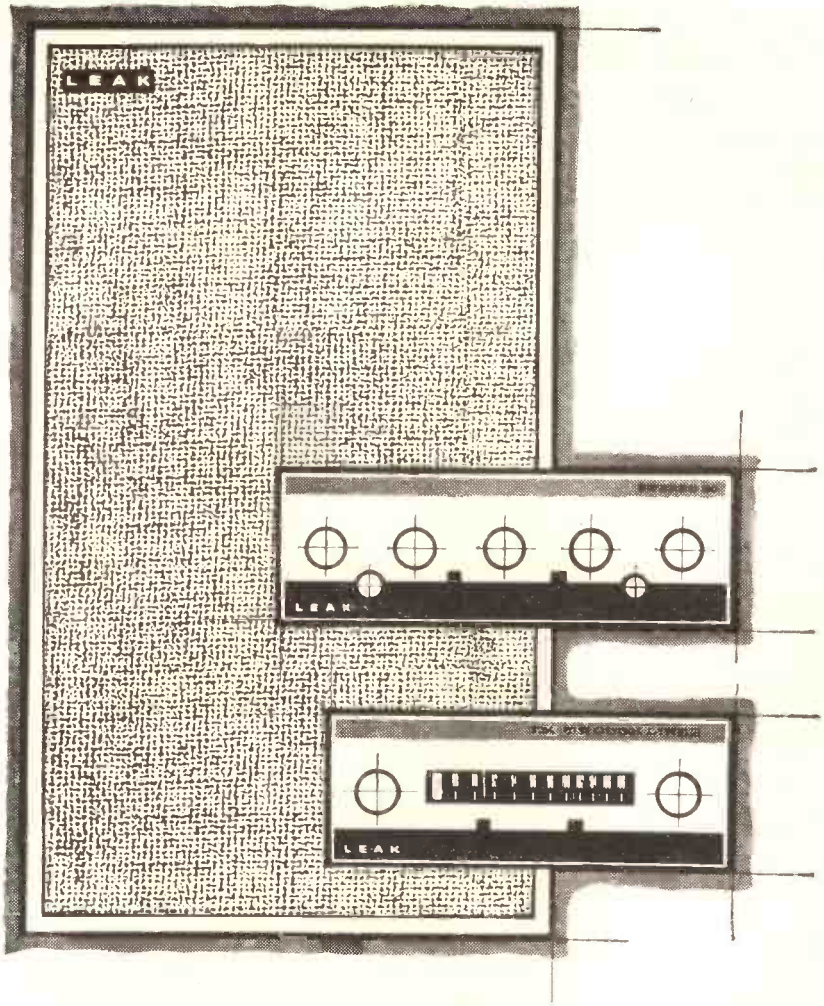


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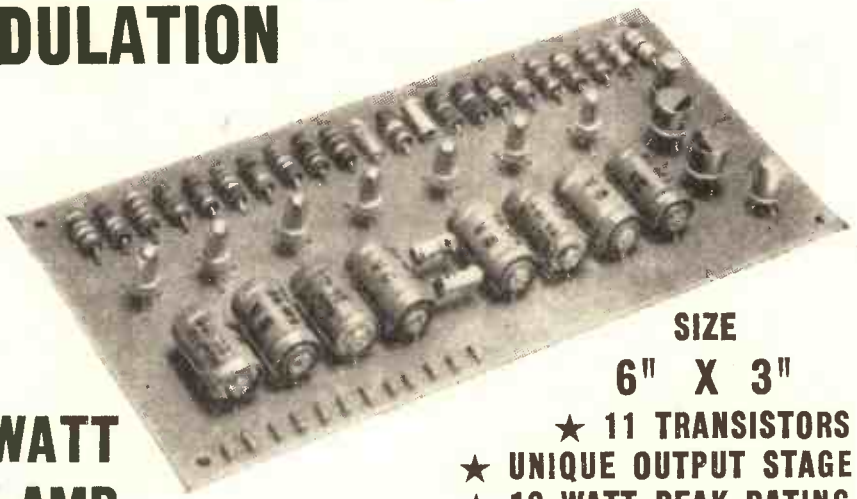

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**SIZE 6" X 3"**

★ 11 TRANSISTORS
★ UNIQUE OUTPUT STAGE
★ 10 WATT PEAK RATING
★ 15 OHMS OUTPUT

## *Hi-Fi quality for very low cost*

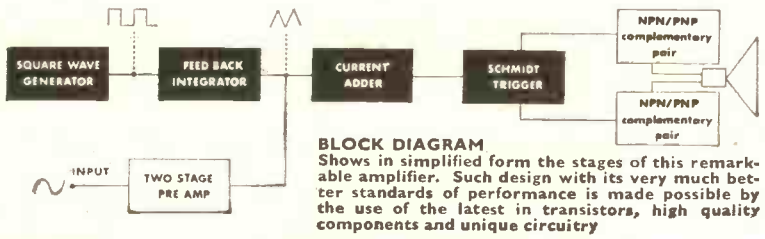
★ **INPUT SENSITIVITY 1 mV into 1 K ohms**

★ **TOTAL HARMONIC DISTORTION <0·1%**

★ **SUITABLE FOR ALL TYPES OF PICK-UPS**

★ **OPERATES FROM 12 to 15 V.D.C.**

By using pulse width modulation, the Sinclair X-10 integrated amplifier and pre-amp. offers the constructor entirely new concepts of amplifier design and performance. Everything, except the tone and volume controls, is contained on the printed circuit board which measures only 6" x 3" and, since no heat sink is necessary, the saving in space is enormous. This gives the constructor the opportunity to build a modern, sleek, hi-fi installation. In performance, the X-10 is a revelation in quality and power. There is no falling off of higher frequencies up to 20Kc/s, transient response is superb and current consumption for the power output obtained is appreciably less than in comparably rated conventional amplifiers. In fact the X-10 will operate perfectly well from 2 6-volt lantern batteries. The Sinclair X-10 Manual included with every X-10 Amplifier explains how it functions and gives tone control and stereo matching circuits, none of which costs more than a few shillings.




**BLOCK DIAGRAM**
Shows in simplified form the stages of this remarkable amplifier. Such design with its very much better standards of performance is made possible by the use of the latest in transistors, high quality components and unique circuitry

*All parts for building including 11 transistors, with X-10 Manual and instructions come to* **£5.19.6**

*Ready built and tested with X-10 Manual* **£6.19.6**

*X-10 Power Supply Unit (ready built) for A.C. Mains* **£2.14.0**

*FULL SERVICE FACILITIES ALWAYS AVAILABLE TO SINCLAIR CUSTOMERS*

sinclair

**SINCLAIR RADIONICS LTD.**
**COMBERTON, CAMBRIDGE**
*Telephone COMBERTON 682*

4WW—119 FOR FURTHER DETAILS

# Sinclair Designs

## 2 LONG RANGE POWERFUL RADIO SMALLER THAN A MATCH-BOX

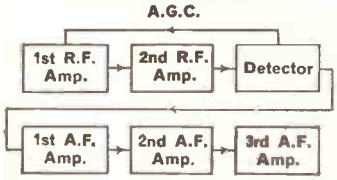
## SINCLAIR MICRO-6 6-STAGE RECEIVER


### THE SMALLEST IN THE WORLD

— SIZE $1\frac{4}{5}$" × $1\frac{3}{10}$" × $\frac{1}{2}$"

**No transistor set has ever yet compared with the Micro-6 for size, power performance and design and thousands upon thousands are now in use throughout the world. Everything except the lightweight earpiece is contained within the smart minute white, gold and black case. Unique features include bandspread over the higher frequency end of the medium waveband for easy reception of Luxembourg, powerful A.G.C. to counteract fading of distant stations, and vernier type tuning. Quality of reproduction is outstandingly good. Order your Micro-6 now and prove for yourself why it cannot be too highly recommended as an intriguing design to build and a most practical radio to use, and you can build it in an evening.**

ACTUAL SIZE




Six-stage circuit using 3 special Micro-alloy transistors (M.A.T.s) provides 2 stages of R.F. amplification, double diode detector and high gain 3-stage A.F. amplifier plus A.G.C. Tunes over the Medium Waveband. Two self-contained batteries give about 70 hours' working life.

### Build it in an evening

*All parts including M.A.T.s, lightweight earpiece and instructions come to*

**59/6**

**MALLORY MERCURY CELL**

| | |
|---|---|
| *Type ZM.312 (2 required) each* | 1/11 |
| *Pack of 6* | 10/6 |
| **"Transrista"** *Black nylon wrist strap* | 7/6 |

## 3 SINCLAIR TR 750 POWER AMPLIFIER

### SIZE 2" × 2"

Another outstanding Sinclair design. Incorporates its own volume control and on-off switch. Used with the Sinclair Micro-6 or makes a powerful high quality car portable or domestic radio. 750 milliwatt output into a standard 25-35 ohm speaker for 10 mV input. Frequency response from 30 to 20,000 c/s ±1dB. The TR 750 will also make an excellent mono record reproducer (paired for stereo), baby alarm, etc.

*All parts for building with instructions come to* **39/6** *Ready built and tested* **45/-**

TRACE THAT FAULT WITH A

## SINCLAIR MICRO-INJECTOR 4

This ingeniously designed device generates a test signal at any frequency from 1 Kc/s to 30 Mc/s which is injected via the probe into any part of audio or radio equipment to enable the user to trace faults rapidly and accurately. The case measures only 1.8" x 1.3" x ½" with self-contained battery. With full instructions.

Parts for building come to **27/6** Ready built and tested **32/6**

## SINCLAIR MICRO-AMPLIFIER 5

***Smaller than a 3d. piece!***

With a frequency response from 30 to 50,000 c/s ±1dB and power gain of 60dB (1,000,000 times) makes a broad band R.F. amplifier. A.F. quality amplifier or F.M. transmitter. Invaluable to keen experimenters. All parts with instructions come to **28/6**

***TOMORROW'S DESIGNS READY FOR YOU TO BUILD TO-DAY***

**TO SINCLAIR RADIONICS LTD., COMBERTON, CAMBRIDGE**

*Phone: COMBERTON 682*

*Please send items detailed below:* £ s. d.

.....

.....

.....

.....

*TOTAL* .....£———

*For which I enclose cash/cheque/money order.*

*NAME* .....

*ADDRESS* .....

.....

.....

BLOCK LETTERS WW.4

**USE THE COUPON TO-DAY**

**4WW—120 FOR FURTHER DETAILS.**

**MARCONI TF-390-G SIGNAL GENERATOR.** £7/10/-. Carr. £1. Four ranges: 16-32, 32-60, 50-100 and 75-150 Mc/s. A.C. mains operation. AS NEW in original transit cases with correct individual calibration and instruction books.

**MARCONI SIGNAL GENERATOR TF-517.** Three ranges. 18 to 58 Mc/s. in 2 individually calibrated ranges and 160 to 300 Mc/s. by **DIRECTLY** calibrated dial. A.C. mains operation. **AS NEW CONDITION.** in original transit cases with instruction book. **£7/10/-.** Carr. £1.

**PORTABLE RECEIVER TESTER MARCONI INSTRUMENTS TF-888/3**
This instrument combines the functions of a wide range signal generator and output meter. Continuous frequency coverage of 70 kc/s. to 70 mc/s. in 8 wavebands by means of a rotating coil turret. Output impedances 80 or 52 ohms or high level (500 mV) 40Ω Int. Mod. at 1000 c/s. Two crystal checks at 500 kc/s. and 5 mc/s. Panel meter monitors carrier and also functions as output meter full scale 10 mv., 100 mV. and 1 w. Input impedances 3, 33, 150 and 600Ω. Handsome grey case size 15½ x 7½ x 11½ high. Wt. 17½ lbs. Operates from A.C. mains 100 to 250 volts. As new, tested and guaranteed, **£39/10/-.** Carr. 10/-.

**MARCONI TF987/1 NOISE GENERATORS.** DETERMINE NOISE FACTOR of A.M. & F.M. receivers. A.C. mains operation. Stabilised. H.T. AS NEW. Tested, **£15,** carr. 7/6. SLIGHTLY USED (but tested), **£8/19/6,** carr. 7/6.

**RADIATION METERS**
Portable dose rate meter containing modern type rectangular 50 micro-amp meter CVX 494, electrometer valves, etc. BRAND NEW. In canvas carrying case. **£3/19/6.** Post 4/-.

**SIGNAL GENERATOR CT-53**
A precision instrument covering 8.9 to 15.5 Mc/s. and 20 to 300 Mc/s. in six ranges. Variable attentuator from 1μV to 100 millivolts. A.C. mains operation. Good condition, tested and complete with calibration charts. **£16/10/-.** Carr. 10/-.

**TS-175 HETERODYNE FREQUENCY METER**
A high frequency version of the well-known BC-221. Accuracy 0.05%. Frequency range 80 to 1,000 Mc/s. As new condition with original calibration book. Tested and guaranteed. **£75.**

**BC221** **FREQUENCY METER 126 kc/s. to 20 Mc/s.**
This crystal controlled heterodyne frequency meter is too well-known to need further description. Those we offer are complete with correct individual calibration book and are carefully tested and guaranteed. Used condition. Carr. 10/-. **£16**
***Laboratory Standard*** ***£25***

**GENERAL RADIO LR2 HETERODYNE FREQUENCY & CALIBRATOR EQUIPMENT. BRAND NEW.** **£75**

**LM-14 HETERODYNE FREQUENCY METER**
Naval version of the BC-221. 125 Kc/s to 20 Mc/s. Undoubtedly superior to the BC-221 in construction and performance. Requires 12 or 24 v. LT and between 200 and 475 v. HT (self-stabilised). A particularly useful feature is variable RF coupling and modulation is also available. With correct individual calibration books. Unused and guaranteed. **£25.** P. & P. 7/6. Separate power unit for A.C. (if required) **£4/10/-.** P. & P. 5/-.

**G.E.C. RECEIVER BRT402E**
14 valve superhet 150-385 Kc/s, 510 Kc/s to 30 Mc/s in six wavebands. Sensitivity, sig./noise ratio, freq. stability etc. of the highest order. Six step variable selectivity, Xtal filter (Xtal phasing control), RF, IF and AF gain, 500 Kc/s Xtal cal., Audio Filter, "S" meter, Ae trimmer, Variable BFO, A.C. mains operation. EVERYTHING. Reconditioned. **£60.** Carr. 30/-. S.A.E. for details.

**RECEIVER R.107T**
This receiver covers from 1.2 Mc/s to 17.5 Mc/s continuously in three wavebands. It is completely self-contained with built-in speaker and power unit for operation from A.C. Mains or 12 volt battery. Those we offer are guaranteed perfect. **£15.** Carriage 30/-.

**WIRELESS STATIONS B 43/R 220**
This is a complete mains operated (200-250 v. 50 c/s) transmitter and receiver in one metal case, size 21½ x 12½ x 18½in. and weight 90 lbs. They are for fixed frequency operation and are crystal controlled. Frequencies are between 60 and 100 Mc/s and the transmitter and receiver are not on the same frequency each using a separate crystal. Technical handbooks are supplied and it is not very difficult to alter the frequency of either or both sections. Transmitter output is 12 watts, the receiver has a built-in monitor speaker. There are 14 valves in the receiver and 8 valves in the sender. The whole station is supplied complete with all cables, connectors, feeder matching units, headphones, telephone hand set, a complete set of spare valves for receiver, transmitter and power unit. (In addition to those fitted.) Packed in a wooden case (total weight about 200 lbs.). Special note.—We cannot undertake to supply any particular frequency under any circumstances. BRAND NEW. **£25.** Carr. 50/-.

**HIGH STABILITY POWER UNIT**
Solartron Type SRS 156B. Designed to give ± 150 v. at 0-40mA. 6.3 v. 4 a. C.T., 6.3 v. 1 a. Operates from A.C. mains 100 to 250 v. 40 to 60 c/s. Size 9 x 6 x 6½in. high. Ripple and noise less than 350μV. Stability factor greater than 400 : 1. Source impedances less than 2Ω. BRAND NEW. **£5.** Post paid.

**CANADIAN CRYSTAL CALIBRATOR**
As used in Wireless Set No. 52. Gives marker pips at 1 Mc/s. 100 Kc/s and 10 Kc/s intervals. Harmonics are available up to 30 Mc/s. Incorporates a twin 1 Mc/s/100 Kc/s crystal and uses a multivibrator circuit for 10 Kc/s. Requires 12 v. L.T. and 150 v. H.T. Complete with valves, circuit of 52 set and operational notes. **BRAND NEW. 57/6,** plus 2/6 post.

**MAGNETIC COUNTERS** (Ex-G.P.O.). 4 figures to 9,999 Coils 500Ω for 24 v. operation. Tested (No reset). **5/-** each. P. & P. 1/6. SPECIAL OFFER. 10 for **30/-.** P. & P. 5/-.

**ABSORPTION WAVEMETERS**
**MARCONI TF-643B.** Covers from 20 to 300 Mc/s. in four plug-in coil ranges. Complete with individual calibration charts. Accuracy 1%. Indication is on a 50μA 2½in. panel meter. In original transit cases. Condition as new **£5/19/6.** Carr. 7/6.

**RELAYS G.C.E. MINIATURE SEALED**

| | |
|---|---|
| M–1099. 670Ω 2M H/D Wire Ends | 7/6 |
| M–1052. 5,000Ω 2/CO. Plat. Wire Ends | 10/– |
| M–1092 670Ω 4/CO. Plat. Wire Ends | 12/6 |

ALL BRAND NEW AND BOXED. Please add postage.

**MINIATURE RELAYS.** 240 v. A.C. coils. Contact assembly 2 "makes" and 1 C.O. 5 amps. Size 2 x 1½ x 1in. Unused and removed from brand new equipment. **8/6** post paid.

**STANDARD SIGNAL GENERATOR** **£16/10/-**
**MARCONI TF-144G/4** Carr. 30/–.
Complete and in apparently very good condition but sold as received from the Air Ministry, i.e., untested and less leads. Technical manual and circuit supplied. We assure potential customers that "untested" does NOT mean "beyond economical repair" but are willing to supply GUARANTEED WORKING instruments complete for **£25.**

**HEATHKIT & JASON AGENTS**

# CHARLES BRITAIN (Radio) LTD.

**11 UPPER SAINT MARTIN'S LANE**
**LONDON, W.C.2.** *TEMPLE Bar 0545*
Near Leicester Sq. Station. (Opposite Thorn House)
*Shop hours:* 9-6 p.m. (9-1 p.m. *Thursdays*). *Open all day Saturday.*

**SANGAMO WESTON VOLTMETERS**
**561.** Dual range 0-5 and 0-100 v. D.C. FSD 1 m/A. 3in. scale. Recent manufacture. Ideal for schools. Complete in super quality canvas carrying case, with test prods and leads. **BRAND NEW.** Boxed **32/6.** Post 2/6.

**MICROAMMETERS**
R.C.A. 0-500 microamps 2½in. circular flush panel mounting. Dials are engraved 0-15, 0-600 volts. As used in the American version of the No. 19 set. **15/-.**

**INDUSTRIAL METER.** Iron clad. 0 to 300 v. A.C. 50 cycles. Moving iron, 6in. scale Fl. mtg. BRAND NEW. **59/6.** P. 4/-.

**KILOWATT METER 0-16 KVA.** 3 phase 6in. scale. Boxed. New. **£5.** P. & P. 6/6.

**A.C. VOLTMETER.** 0-300 volts Moving Iron. Flush panel mounting. Barrel diameter. 2½in. **22/6.**

**AR-88 SPARES**

| | |
|---|---|
| R.C.A. Headphones | 12/6 |
| Escutcheons (Windows) | 8/6 |
| Knobs. Medium size. Set of 8 | 10/– |
| Block Condenser (3 x 4 mfd.) | 7/6 |

**PHASE MONITOR ME-63/U (AN/URM-67)**
Designed to measure directly the phase angle between two applied audio frequency signals of from 20 to 20,000 c.p.s. ±1°. Direct indication on a panel meter. Input can be sinusoidal or non-sinusoidal from 2 to 30 volts peak. Of recent manufacture (1957) by Control Electronics Inc. and ex-U.S.A. Air Force. In first class condition with handbook. A complex instrument with 19 valves. **£40.** Carr. 30/-.

**MOVING COIL PHONES.** Finest quality Canadian with chamois ear-muffs and leather-covered headband. With lead and jack plug. Noise excluding and supremely comfortable. **22/6.** Post 1/6. As above but complete with moving coil microphone. **25/-.** Post 2/6. DLR-5 Low impedance headphones with attached throat microphone. **12/6.** Post 1/6. All these items BRAND NEW.

**T.C.C. VISCONAL CONDENSERS.** 8 mfd. 800 v. D.C. wkg. at 71°C. CP 152 v. Size 3 x 1⅞ x 5in. high. BRAND NEW (boxed), **8/6** each. **DUBILIER NITROGOL.** 8 mfd. 350 v. D.C. wkg. at 71°C. Size 1⅞ x 1⅞ x 4⅜in. high. With fixing clips. BRAND NEW (boxed), 5/- each. **T.C.C.** or **DUBILIER.** 4 mfd. 600 v. wkg. CP 130T or similar. 1⅞ x 1⅞ x 4⅜in. high. BRAND NEW (boxed), 4/6 each. All post paid.

**ASSORTED CAPACITORS.** Mixed parcel of 100 all brand new, marked value quality types. Silver mica, ceramicon and feed through from 1 pF to 3,000 pF. **10/-.**

**STANDARD TRANSFORMERS**
Vacuum impregnated, interleaved, E.S. screen, universal mounting. Size 4 x 3½ x 2½in. ALL BRAND NEW. **18/6** each. Post 2/6.
**Type 1.** 250-0-250 v. 80 m/a. 6.3 v. 3 a. tapped at 4 v., 4 a. 6.3 v. 1 a. tapped at 4 v. and 5 v. 2 a.
**Type 2.** As above but 350-0-350 v. 80 m/a.
**Type 3.** 30 v. 2 a., tapped at 12, 15, 20 and 24 v. to give 3-4-5-6-8-9-10 v., etc.
**Type 5.** 0-6-9-15 v. 4 a. Ideal for chargers.

**ADVANCE CONSTANT VOLTAGE TRANSFORMERS.** Input 190-260 v. 50 c/s. A.C. mains. Output 230 v. 150 watts. **£7/10/-.** Carr. 5/-.

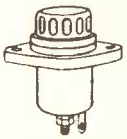
**OSCILLOSCOPE TRANSFORMER**
These are replacements for the Cossor 339A 'scope. BRAND NEW in original packing. Only a limited number. **79/6.** P. & P. 5/6.

# UNIQUE BARGAINS — MUST BE CLEARED

### SPOT OR FOG LAMP

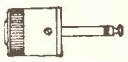
Made by Lucas, Flat or Pencil beam 36 watt. Suitable for car, boat, caravan, etc. Complete with 6 v. or 12 v. bulb, flex cables and fixing bolt. Remarkable bargain **12/6** plus 2/6 post and insurance.

**LUCAS 12 v. IGNITION COIL** Ex-W.D. Unused, guaranteed perfect order. Suit most cars **12/6** plus 1/6 post.



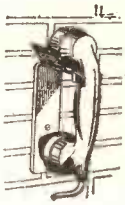
**INDICATOR LAMP** fitted perspex top. Takes standard screw in flash light bulb. Price **18/-** doz. Similar thing but flush, **12/-** doz.

### TELEPHONE JACKS & PLUGS



Jack Plugs, bakelite. Standard size—fit most tape recorders, **4/6** doz.

### SELF ENERGISED TELEPHONES



These require no batteries in fact they have only to be connected by a pair of wires. They can thus be fitted into existing bell circuits. Results are extremely good and maintenance costs are nothing. Handsets only complete as illustrated. **15/-** each, 2/6 post. Two post free.

### CATHODE RAY TUBES

| | | | |
|---|---|---|---|
| VCR 517 | 6in. | **9/6** carr. and ins. | 8/6 |
| (replaces VCR 97 | | new and unissued | |
| VCR 139A | 2½in. | **27/6** carr. and ins. | 4/6 |
| VCR 138 | 3½in. | **27/6** ,, ,, ,, | 5/6 |
| VCR 4/1 | 3in. | **32/6** ,, ,, ,, | 4/6 |
| VCR 112 | 5in. | **27/6** ,, ,, ,, | 5/6 |
| CV 996 | 6in. | **22/6** ,, ,, ,, | 5/6 |
| VCR 97 | 6in. | **42/6** ,, ,, ,, | 8/6 |
| CV 1140 | 12in. | **27/6** ,, ,, ,, | 12/6 |
| CV 1590 | 12in. | **27/6** ,, ,, ,, | 12/6 |

**10 way Cable,** ideal for interconnecting units and for remote switching circuits—each way has a flex copper core capable of carrying 5 amps and insulated to 500 v. The cable is P.V.C. covered overall. Price **1/6** per yard. 10 yards post free, otherwise add 3/6 post.

**5 way Cable.** Similar to 10 way, **9d.** yd., 20 yds. or more post free, otherwise add 2/6.

**Twin Rubber High Current Flex.** 110 strands in each core, 250 volt grade; carry a length of this in your car—if you are ever stuck with a flat battery you can join up to another car; regular price of this cable is **3/-** per yd. Our price **17/6** for 10 yds. post paid.

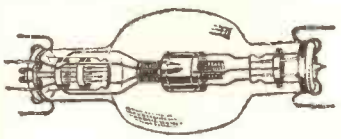
**Bakelite Wall Switches.** Normal household type for lighting, etc., **9/-** doz. one way or **10/-** 2 way—36 or over post free, otherwise add **2/6.**

**A.C. Meter, Wall or Panel Mounting.** Voltmeter 6in. dia. in metal box] for flush mounting—install one in your workshop and you will always know how the mains are. **35/-** each, 3/6 post and ins.

**Blower Motor.** If you are thinking of making a heater or cooler for your car or equipment, this could be the basis—intended for cooling aircraft equipment, runs O.K. off 12 volt, price **12/6** plus 2/6 post and ins.

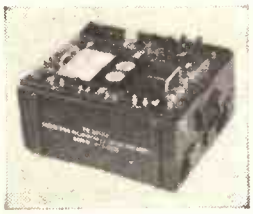
**Electrical Rev. Counter.** This is a dynamo with flex drive shaft. Simply take output to a voltmeter which you can calibrate in R.P.M.—beautiful instrument, must have cost a fortune, **19/6** each, post 2/6.

### TETRODE TYPE VT31 TRANSMITTING VALVE

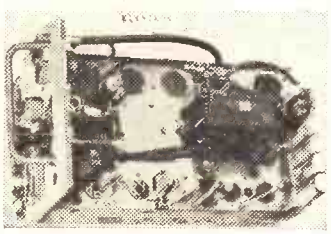


This is a high-powered air-cooled tetrode Specification of which is as follows: Heater volts 11.25, heater current 8 amp., maximum anode voltage 5 KV, anode dissipation 250 watts, size approximately 14½in. long and 6½in. across the bulb. Limited quantity only at **£1,** 4/6 P.T. each, still in original packing.

**TELEPHONE REPEATER No. 1 MARK 1.** This equipment is for amplifying telephone signals in both directions of traffic and also to remedy line distortion of speech. It is intended for use with two wire or four wire circuits, has four amplifiers and is in fact two quite independent repeaters mounted on the same panel and having a common power supply. The power supply may be operated from a 12-volt car battery or from standard A.C. Mains. The units are absolutely new in original packing complete with spares and instructional manual. Price **£7/10/-** each and 12/6 P. & P.

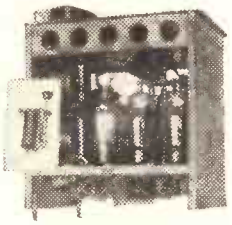


### KLYSTRON RECEIVER



Partly stripped but containing valuable Klystron with tuning mechanism and a host of spares including condensers (paper and mica) transformers relay bobbins, pot meters, resistors, delay line, coils, coil formers, knobs pye sockets, trimmers, valve holders, a very useful chassis and case size approx. 15 x9 x 7½in. and hundreds of other useful sundries. Price only **9/6,** plus 7/6 carriage and packing.

### BUILDING AN AMPLIFIER?



Here is a buy for you! Modulator Unit type 20. Contains parts ideal for building a large output amplifier and already set out in metal case. To name a few:—

Four high output valves Type KT44. Driver valve Type MH41. Iron cored choke for up to 200 milliamps. Dozens of wire wound and carbon resistors, paper and mica condensers. Terminals and tag panels, etc., etc. Three other items of interest to everybody and well worth the price asked for the unit are:—

**1. Transformer Reference 10K/143.** This can act as auto transformer to convert 230 to 110 or 230 to 460, and also a sa filament transformer 230 to 6.3 or 230 to 12.6 volts.

**2. Miniature Circuit Breaker.** For breaking 10 amps A.C. reset by pushing knob.

**3. Steel Case.** With heavy gauge chassis, already cut out and fitted valve holders, etc. Price for complete unit is **12/6,** carriage 7/6.

### UNITS FOR CONTROLLED AUTOMATIC ROTATION

Two units work together to form a Tower rotating device, with remote control.

**Item 1,** known as Tower 24A, is in fact the geared driving motor which rotates the mast. This is quite a heavy construction and would rotate a heavy scanner, reflector, Beam array, etc., etc.

**Item 2,** known as Indicator 1-221-A is the remote controller which enables the azimuth position of Tower 24A to be controlled from a remote point. Conversely, it enables the azimuth position of the tower to be known at any time. Both the Tower and the Indicator contain selsyn transmitter/receivers and it is these that provide the impulses which cause the aerial to rotate backwards or forwards. The equipment intended for 117 volt. A.C. mains but will operate from our mains if connected through step down transformer of 1 K.W. rating.

Prices 1-221-A **£25,** TR24A **£35.**

Special discount of £5 for cash with order or C.O.D. if both units purchased together.

## THE INSTRUMENT COMPANY

**43 SILVERDALE ROAD, EASTBOURNE**

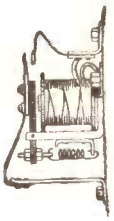
***mail order only from this address — goods may be seen by appointment in Oxfordshire***

### CHARGING SWITCHBOARDS

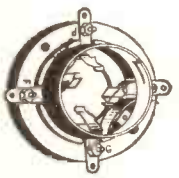
**Type A,** 550 w. 13 v.—contains three reverse current relays, one voltmeter rated 25 v., f.s.d., one main ammeter rate 40 amps f.s.d., one secondary ammeter rated 15 amps f.s.d., and two secondary meters rated 20 amps f.s.d., one 2 ohm variable resistor, one 11 ohm variable resistor and two 1.2 ohm variable resistors. Complete in metal case 2ft. 6in. x 2ft. 8in. approx. Price **£2/15/-,** carriage and ins. 15/-.

**Type B,** 1260 w. 50 v., 12 amps.—contains one 14 ohm variable resistor and four 1 ohm variable resistors, one main ammeter rated at 40 amps f.s.d., four secondary meters rated at 20 amps f.s.d., and one voltmeter rated at 50 volts, and two reverse current relays. Complete in metal case—size approximately 2ft. 6in. x 2ft. 8in. Price **£4/15/-,** carriage 15/-.

### CONTACTOR

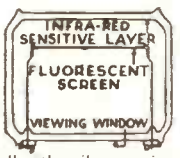


For breaking 25 amps. coil voltage is 24 v. D.C., but with a rewind or a small rectifier these will close off A.C. mains. Very heavy duty contacts. Enclosed in bakelite case. Price **2/6,** 24/- doz.



**JUMBO VALVE BASES** Ceramic 4 pin for transmitting valves. Price **3/6** each.

### SNIPER-SCOPE




Famous war-time "cats eye" used for seeing in the dark. This is an infra-red image converter cell with a silver caesium screen which lights up (like a cathode ray tube) when the electrons released by the infra-red strike it. It follows that as light from an ordinary lamp is rich in infra-red these cells will work; burglar alarms, counting circuits, smoke detectors and the hundred and one other devices as will the simpler type of photo cell. Here then is a golden opportunity for some interesting experiments, price **5/-** each, post 1/-. Data will be supplied with cells if requested.

**Spot or Fog Lamp.** Made by Lucas, Flat or Pencil beam. 36 watt. Suitable for car, boat, caravan, etc. Complete with 6 or 12 v. bulb, flex, cables and fixing bolt. Remarkable bargain. **12/6** plus 2/6 post and insurance.

### SLIDER RESISTORS

Heavy Duty Type. Size 7in. x 1½in. 11 ohms 4.5 amp, **22/-.** Size 9in. x 1½in. 1.2 ohms 15 amp., **15/-.** Size 13½in. x 1½in. 3 ohms 10 amp., **51/-.** 1 ohm 25 amp., **15/-.** 4 ohms 100 amp **10/-,** plus post.

## HEAVY DUTY L.T. TRANSFORMERS

**All primaries 220-240 volts. Terminal block connections.**

| No. | Sec. Taps | Price | Carr. |
|---|---|---|---|
| 1 | 25 30 35 v. 40 a. | £11 19 6 | 10/– |
| 2 | 25 30 35 v. 20 a. | £6 19 6 | 7/6 |
| 3 | 25 30 35 v. 10 a. | £4 15 0 | 5/– |
| 4 | 25 30 35 v. 2 a. | £1 17 6 | 3/6 |
| 5 | 10 17 18 v. 10 a. | £2 17 6 | 4/– |
| 6 | 24 volts 30 amps. | £7 15 0 | 7/6 |
| 7 | 20 volts 30 amps. | £6 15 0 | 7/6 |
| 8 | 50 volts, 15 amps. | £6 19 6 | 7/6 |
| 9 | 30, 40, 50 v., 5 a. | £4 15 0 | 5/– |
| 10 | 25, 36, 48 v., 8 a. | £4 19 6 | 5/– |
| 11 | 17, 18, 20 v., 20 a. | £4 19 6 | 5/– |
| 12 | 6, 12 v., 20 a. | £3 12 6 | 5/6 |
| 13 | 20 v., 20 a. | £4 15 0 | 7/6 |
| 14 | 30, 32, 34, 36 v., 5 a. | £2 17 6 | 4/– |
| 15 | 6, 12 v., 10 a. | £2 2 6 | 4/– |
| 16 | 12 v., 5 a. | £1 9 6 | 3/– |
| 17 | 24 v., 10 a. | £3 5 0 | 4/– |
| 18 | 24 v., 5 a. | £1 19 6 | 3/6 |
| 19 | 48, 56, 60 v., 1 a. | £1 9 6 | 3/6 |
| 20 | 12, 24, 30, 48 v., 2 a. | £2 5 0 | 3/6 |
| 21 | 6.3 v., 15 a. | £1 17 6 | 3/6 |
| 23 | 12, 24 v., 1 a. | 15 0 | 2/6 |
| 24 | 9, 15 v., 2 a. | 17 6 | 2/6 |
| 25 | 6, 9, 15 v., 4 a. | £1 5 0 | 3/6 |
| 26 | 12, 18 v., 10 a. | £2 12 7 | 4/– |
| 27 | 12, 18 v., 20 a. | £3 19 6 | 5/– |
| 28 | 10, 18, 20 v., 9 a. | £3 9 6 | 5/– |
| 29 | 15 v., ct., 5 a. | £1 5 0 | 3/6 |
| 30 | 10, 11, 12 v., 1½ a. | 10 6 | 2/– |

**Multi-tapped TRANSFORMERS**

Pri. T. 200-250 v. Sec. T. 3, 4, 5, 6, 8, 9, 10, 12, 15, 18, 20, 24, 30 v. 5 amps., **47/6**. P.P. 4/-. 4 amps. **39/6**, P.P. 3/6. 2 amps. **25/-**. P.P. 3/-.

### AUTO TRANSFORMERS

240 v.-110 v. Completely Shrouded fitted with 2 Two-Pin American Sockets or Terminal Blocks. Please state which type required. 1,000 watts. **£4/15/-**. carr. 5/-. 500 watts, **£3/10/-**, carr. 4/-. 300 watts, **47/6**, P.P. 3/6. 150 watts, **37/6**, P.P. 3/-. 60 watts, **29/6**, P.P. 2/6. **2,000 watts.** Completely enclosed in metal case. Size 10 x 8 x 6in. Fitted with 2 American Sockets or Terminal Blocks, **£9/15/-**. Carr. 7/6.

## Samson's Electronics Ltd.

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PAD 7851 AMB 5125

**We have London's largest selection of Low Tension Transformers, Variable Voltage Transformers, Smoothing Chokes, Capacitors, Sliding Resistors, Low Tension D.C. Supply Units. Send for lists.**

### SPECIAL OFFER OF BRAND NEW ERNEST TURNER 2½in. ROUND FLUSH PANEL D.C. INSTRUMENTS.

50-0-50 microamps **50/-**. 0-50 microamps **45/-**. 0-200 microamps **30/-**. 0-500 microamps **25/-**. 0-50 milliamps **19/6**. 0-10 v. **15/-**. 0-20 v. **15/-**. 0-200 **17/6**. 0-500 v. **22/6**. Ediswan 3in. square instruments flush D.C. 0-50 mA. **19/6**. 0-250 v. **22/6**. Rectified A.C. 0-8 amps. **19/6**. 2½in. round dual purpose 200 mA. and 75 mA. or 100 mA. 75 v. with res. box **22/6**. Please add 2/6 P.P. on all meters.

### RE-ENTRANT LOUD HAILERS

15 ohm, 20 watt, dia. 15 in. Complete with mounting bracket. Brand new **£8/19/6**. Carr. 10/-

### SPECIAL OFFER OF BRAND NEW CAPACITORS

4 mfd. 800v. wkg. at 180 deg. F. **3/9**, P.P. 2/-. 5 mfd. 400 v. a.c. wkg. 400 cycles **4/9**, P.P. 2/-. 5.25 mfd. 660 v. a.c. wkg. 50 cycles **6/6**, P.P. 2/-. All by famous makers.

### L.F. CHOKES BY FAMOUS MAKERS.

20 H. 30 mA. 200Ω, **17/6**. P.P. 5/-. 20H. 250 mA 250Ω, **15/-**, P.P. 4/6. 15H. 250 mA. 130Ω, Sealed "C" Core, **17/6**, P.P. 5/-. 10H. 250 mA. 124Ω, "C" Core, **12/6**, P.P. 3/-. 10H. 75 mA. 400Ω Sealed "C" Core, **7/6**, P.P. 2/6. 1H 240 mA. 35Ω, Sealed, **7/6**. P.P. 2/6.

### WODEN A.C. CHOKES

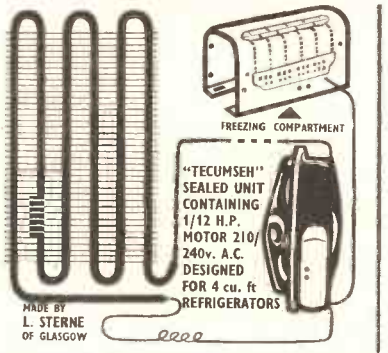
To pass 100 Amps at 220 v. Base size 6 x 5. Height 4in. Weight 18 lbs. Supplied Brand New in Maker's cartons, **45/-**. Carr. 7/6.

### IBM DOUBLE WOUND TRANSFORMERS

Pri. Tapped 220, 220, 240 v. Sec. Tapped, 110-100 v., 200V. A. **47/6**, Carr. 5/-. Tropically rated.

## REFRIGERATION SEALED UNITS

*BRAND NEW!*




These units are ideal as replacement units, refrigeration cupboards and cold stores, ice making, etc. Type P1219 sizes, unit 10 x 10 x 5ins. Freezer 12 x 6½ x 5ins. Condenser 19 x 2ins.

**Complete in Original Packing** P. & P. 10/-. **£8.10.0**

**THERMOSTATIC CONTROL** for above **15/-**. If Sold Separately, P. & P. 1/6

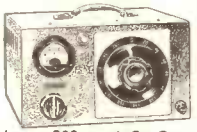
### STC INTER-COM. TELEPHONES.

Latest type. All components, Buzzer and Battery housed in beautifully made Hand Set. Size 9 x 2½ x 2½in. Effective communication up to 60 miles. Supplied brand new, **£9/12/-** per pair. P.P. 4/-. Further particulars sent on request.

## NO EXCUSES! NO DELAYS! FROM STOCK!

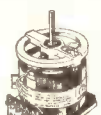
# VARIABLE VOLTAGE TRANSFORMERS

### PORTABLE

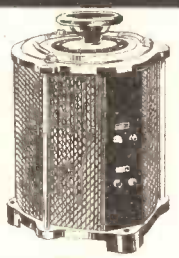


Input 230 v. A.C. Output variable 0-260 v. A.C. at 2.5 v. Fitted in beautifully finished steel case. Complete with voltmeter, pilot lamp, fuse, switch, carrying handle, **£9/17/6** P.&C.5/-.

### 1 AMP. OPEN TYPE.



(Type 1A) Compact well constructed unit designed for building into equipment. Panel or rack mounting, extending shaft. Complete with engraved voltage panel and control knob. Input 250 v. A.C. Output variable 0-260 v. Ideally suited for Manufacturers of variable voltage equipment. Price **£4/17/6** post paid.



**50 AMPS.**

**1 AMP.**

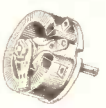
**INPUT 230 v. A.C. 50/60~**
**BRAND NEW. Carriage Paid. Buy direct from the importer, keenest prices in the country. All Types (and Spares) from ½ to 50 amp. available from stock.**

| | | | |
|---|---|---|---|
| 0-260 v. at ½ amp. | £3 | 3 | 0 |
| *0-260 v. at 1 amp. | £4 | 10 | 0 |
| *0-260 v. at 2.5 amps. | £5 | 17 | 6 |
| 2.5 amps., Portable | £9 | 17 | 6 |
| *0-260 v. at 4 amps. | £8 | 7 | 6 |
| *0-260 v. at 5 amps. | £9 | 0 | 0 |
| *0-260 v. at 8 amps. | £13 | 10 | 0 |
| *0-260 v. at 10 amps. | £17 | 0 | 0 |
| *0-260 v. at 12 amps. | £19 | 10 | 0 |
| *0-260 v. at 20 amps. | £32 | 10 | 0 |
| *0-260 v. at 37.5 amps. | £65 | 0 | 0 |
| *0-260 v. at 50 amps. | £85 | 0 | 0 |

***These instruments are fully shrouded.**

**INSULATED TERMINALS** available in black, red, white, yellow, blue and green. New, 15/- per doz. P. & P. 1/-.

### 100 WATT POWER RHEOSTATS (NEW)

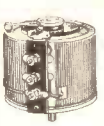


Ceramic construction winding embeddded in Vitreous Enamel heavy duty brush assembly designed for continuous duty.

**Available in the following four values.**

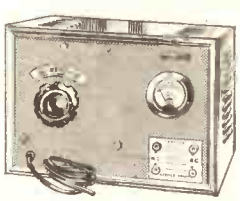
50 ohm. 1.4 a., 100 ohm. 1 a., 1,000 ohm., 280 mA., 1,500 ohm. 230 mA. Dia. 3½in. Shaft length ⅞in., dia. ¼in., **27/6**. P. & P. 1/6.

### NEW ½ AMP. FULL RANGE VARIABLE VOLTAGE TRANSFORMER



Input 230 v. A.C. Output continuously variable from 0 to 260 v. at ½ amp. Size: dia. 3in., depth 3½in. including shaft, single hole fixing. Easily built into equipment. Ideal for manufacturers or Lab. use. **£3/3/0.**

### 7 AMP. A.C./D.C. VARIABLE OUTPUT POWER UNIT

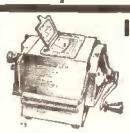


Input 230 v. A.C. Output continuously VARIABLE from 0 to 260 v. A.C. OR 0 to 230 v. D.C. at 7 a. Robustly constructed in metal case, complete with safety fuse, neon indicator and voltmeter. Size 17 x 12 x 7in. Weight 36lb. Price **£34/10/-**. Carriage 20/-.

### SLIDER RESISTANCES

1 ohm., 12 amp., **17/6**; 1.2 ohm, 14 amp. **27/6**; 75 ohm, 2 amp. **37/6**; 200 ohm, 1.25 amp. **37/6**; 36 ohm, 6.5 to 2.8 amp., tapered winding, geared drive (less knob), **37/6**. P. & P. 3/6.

### INSULATION TESTERS (NEW)



Test to I.E.E. Spec. Rugged metal construction, suitable for bench or field work, constant speed clutch. Size: L. 8in., W. 4in., H. 6in. Weight 6lb. 500 volt, 500 megohms. Price **£22**, carriage paid. 1,000 volts, 1,000 megohms, **£28**, carriage paid.

## SERVICE TRADING COMPANY →

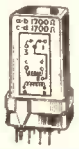
# SERVICE TRADING CO

Postage and Carriage shown below are inland only. For overseas please ask for quotation. We do not issue a catalogue or list.

## ULTRA VIOLET BULBS

Easy to use source of U.V. for dozens of practical and experimental uses.
12 volt 36 watt A.C./D.C. SBC **6/6.** P. & P. 1/-.
12 volt 60 watt A.C./D.C. SBC **8/6.** P. & P. 1/-.
Transformer to suit the above. Input 200-240 v. A.C., 12 volt 36 watts, **16/6**; P. & P. 2/6. Input 200-240 v. A.C. 12 volt 60 watt, **22/6.** P. & P. 3/6.
**Set of 4 Colours FLUORESCENT PAINT.** Red, yellow, green and cerise. In ½ oz. tins. Ideal for use with the above Ultra Violet Bulbs. **9/6,** plus 1/6 P. & P.

## SIEMENS SEALED HIGH SPEED RELAYS



H96A, 2.2 ohm + 2.2 ohm., new **12/6.**
H96B, 50 ohm + 50 ohm, new **12/6.**
H96C, 145 ohm + 145 ohm, new **12/6.**
H96D, 500 ohm + 500 ohm, new **12/6.**
H96F, 1,000 + 1,000 ohm, new **12/6.**
H96E, 1,700 ohm + 1,700 ohm, ex. equip., **16/6.** P. & P. 1/- on each Relay.

### CARPENTER'S POLARISED RELAY

Type 5A57, 65 ohm coil will operate on less than .5 of a volt. **22/6.** P. & P. 1/-.
Bases for Carpenter Relay. New, **3/6** each.

### P.O. RELAYS, Type 3,000

200 ohm, 6 c/o. 6,500 ohm, 1 c/o, 1 break.
500 ohm, 6 c/o. 16,000 ohm, 2 make, 2 break.
500 ohm, 4 Heavy Duty Make.
2,000 ohm, 4 make, 4 break.
All at **12/6** each, plus 1/- P. & P.

### G.E.C. SEALED RELAYS

M1069 5,000 ohm, 2 c/o. M1084 180 ohm, 4 c/o.
M1092 670 ohm, 4 c/o. M1095 670 ohm, 2 m. 2 b.
M1100 670 ohm, 2 c/o. Ex new equipment.
All at **12/6** each plus 1/- P. & P.

**7,000 OHM SEALED RELAY.** High Speed single c/o. Platinum contacts. Super-sensitive, ideal for Transistor circuitry. Will operate on 1 milliamp. **25/-.** P. & P. 1/-.

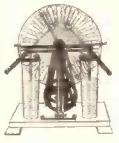
### SPECIAL REVERSING 24 VOLT D.C. MOTOR 2-AMPERE

Quadrant moves 90 degrees with limit switches. Ideal for opening doors, etc. Price **32/6** P. & P. 3/-.

**SOLENOID.** Overall length 3⅛in., stroke ⅛in. to ¼in. Maximum push 8 oz. 12-24 v. D.C. operation. D.C. resistance 35 ohm. Price **8/6.** P. & P. 1/6.
**SOLENOID** Heavy Duty 230 v. A.C. Approx. 3lb. pull. **15/-.** P. & P. 1/6.
**SOLENOID OPERATED MAGNETIC RELAY.** Type Sc/3944, 4 Pole c/o., 10 amp. Contacts, 24 volt D.C. operation, **12/6** each. P. & P. 1/6.

**SX 631 SILICON RECTIFIER.** 100 v. PIV. 750 mA in air or 2 amp. on 2×2 ali. heat sink, **3/6** each, P. & P. 6d., or 4 to make bridge **12/-,** P. & P. 1/-.

## WIMSHURST ELECTROSTATIC GENERATORS



Really well constructed machine. Ideal for School and Laboratory to demonstrate the various effects associated with static energy. Will work well in any atmospheric condition giving a spark over 3in. long in dry weather. 11in. dia. twin plates. 2 Leyden jars. Discharge electrodes. Heavily plated fittings, mounted on solid wooden base. Outstanding value at **£13/17/6.** Carriage U.K. (B.R.S.) 10/-.

**RESETTABLE HIGH SPEED COUNTER.** 3 figure, 1,500 ohm coil, 40-50 v. D.C. operation. Brand new, **50/-** each, plus 1/6 P. & P.
**EX P.O. MAGNETIC COUNTER (old type),** either 500 ohms for 24 volt operation or 3 ohms for 6 volt D.C. operation. 4 figures to 9,999. Price, either type, **8/6.** P. & P. 1/6.
**LATEST HIGH SPEED MAGNETIC COUNTERS.** 4 figure, 10 impulses per second. Type 100D, 4.1 ohm coil, 3-6 v. D.C. operation. Type 100A, 500 ohm coil, 18-24 v. D.C. operation. Type 100B, 2,300 ohm coil, 36-48 v. D.C. operation. Any type **15/-** each, plus 1/6 P. & P.

**DIALS FOR AUTOMATIC TELEPHONES,** used but good condition, **12/6** ea., plus 2/6 P. & P.

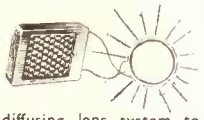
**CROMPTON PARKINSON BRAND NEW ¼ h.p. MOTORS.** 230/250 VOLT A.C. 1,400 R.P.M. Fitted with 2½ x ½in. SPINDLE. **Price £3/5/-.** Carriage 8/6.

### HIGH SPEED BLOWER UNIT

200/250 volt A.C. Powerful 2-speed motor, 11,000 and 13,000 R.P.M. **17/6,** plus P. & P. 2/6.
**AUTO TRANSFORMERS.** Step up, step down. 110-200-220-240 v. Fully shrouded. New. 300 watt type **£2/6/6** each. P. & P. 2/6. 500 watt type **£3/7/6** each. P. & P. 3/9. 1,000 watt type **£4/10/-** each. P. & P. 6/6.

## FIRST AGAIN!

### TYPE 34R SILICON SOLAR CELL



Four .5 volt units series connected in high impact polystyrene case, flying lead connections. Specially designed diffusing lens system to ensure maximum light pick-up. Output—up to 2 v. at 16—20 mA. in bright sunlight. Wider spectral response, and thirty times the efficiency of selenium cells. As used to power earth satellites! **37/6,** and 1/- P. & P.

**230 v. A.C. RELAY.** Type 1. 2 c/o, 2 amp. contacts, **9/6.** Type 2. 2×15 amp. break. 2×2 amp. make, 1×2 amp. break. **11/6.** Both types ex new equip. P. & P. 1/6 each.

## 230 VOLT A.C. GEARED MOTORS

**Type B16G 80 r.p.m. 26lb. inch £2/2/-. P. & P.2/-.**
**Type D16G 5 r.p.m. 1.7lb. inch £2/9/6. P. & P. 2/6.**
**Type D16G 13 r.p.m. 1.45lb. inch £2/12/6. P.&P. 2/6.**

**230 Volt AC** 50 c/s. 5-figure Veeder-Root Counter (not resettable) New. Boxed. **19/6,** plus 2/6 P. & P.

### MINIATURE UNISELECTOR SWITCH

3 banks of 11 positions, plus homing bank. 40 ohm coil. 24-36 v. operation. Ex equip. individually tested. **22/6,** plus 2/6 P. & P.
**20-way STRIP** containing standard Post Office telephone Jack, Sockets, overall size 11 x 3½ x ½in. New. Price **15/-** each. P. & P. 1/6.

## LIGHT SENSITIVE SWITCH

Kit and parts including ORP,12 Cadmium Sulphide Photocell, Relay, Transistor and Circuit. Now supplied with new Siemens High Speed Relay for 6 or 12 volt operation. **Price 25/-,** plus 2/6 P. & P.
**ORP.12 and Circuit 8/6,** post paid.

### SEMI-AUTOMATIC "BUG" SUPER SPEED MORSE KEY.

7 adjustments, precision tooled, speed adjustable, 10 w.p.m., to as high as desired. Weight 2½ lb. Price **£4/12/6,** post paid.

### KEYING LEVER

Especially designed for use with all types of electronic keyers. Fully adjustable micro-switch action, no contact bounce, precision made, finely polished parts. Screw down base. Price **£4/4/-,** post paid.
**TRANSISTORISED FULLY AUTOMATIC ELECTRONIC KEYER.** 230 v. A.C. or Battery operated. Incorporates built-in monitor Oscillator, Speaker, and Keying Lever. Adjustable speeds. Keying either auto., semi-auto. or hold. 4 diodes. 7 transistors. Price. **£16/10/-,** plus 4/6 P. & P.

**TRANSISTORISED MORSE OSCILLATOR** Fitted 2½in. Moving Coil Speaker. Uses type PP3 or equiv. 9 v. battery. Complete with latest design Morse Key, **22/6,** plus 1/6 P. & P.
**BOMBSIGHT COMPUTER, Type T.I.A.** Contains hundreds in precision gears plus infinitely variable resolving gears, worm drives, ½° repeater motor, 4 aneroid barometers, D.C. motors, gyro unit, rev. counters, etc. As new, **£3/12/6** plus 7/6 carriage (rail).

## TRANSISTORS

| 1st grade | | | | Brand new | |
|---|---|---|---|---|---|
| OC28 | 17/- | OC83* | 6/- | 2N458 | 20/- |
| OC29* | 18/- | OC139 | 12/- | 2S019 | 30/- |
| OC41 | 7/- | OC140 | 19/- | SB345 | 7/6 |
| OC44 | 6/6 | OC171 | 9/- | TK20B | 4/- |
| OC45 | 5/- | OC200 | 10/6 | AC107 | 14/6 |
| OC71 | 5/- | OC203 | 13/- | AF114 | 11/- |
| OC72* | 7/- | Get 104 | 6/- | AF115 | 10/- |
| OC73 | 6/- | Get 105 | 10/- | AF116 | 10/- |
| OC75 | 7/- | Get 573 | 12/6 | AF117 | 9/6 |
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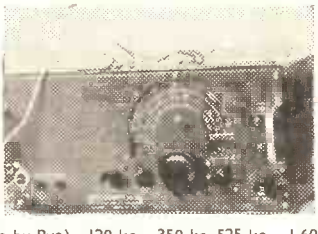

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**ULTRA MODERN POWER SUPPLY UNIT.** Supply voltage A.C.: 105, 110, 115, 200, 205, 210, 220, 225, 230, 240, 245, 250v. Available voltages D.C.:

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(b) 600 v. approximately 60mA.
(c) 260-350 v. (adjustable) approximately 25mA.
(d) 450 v. approximately 30mA.
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Stability 0.02%. **Price £18.**

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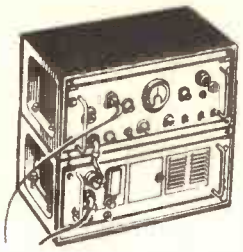

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**FACSIMILE KEYER UNIT KY 75 SRT,** 115/230 volts, £25 each.
**MODULATOR MD 168/UX** (for the above keyer), £12/10/-.
**SIGNAL GENERATOR 1-196A.** Freq. range 100-156 mc/s. Power requirements 115 v. A.C. or batteries. £3 each. Carr. 15/-.
**METERS.** 0–60 amps., centre zero 6in. scale, proj. m/c., 17/6 each, 5/- post. 0–150 amps., centre zero 6in. scale, proj. m/c. (requires external shunt), 17/6 each, 5/- post. 0–100 amps., 6in. scale, A.C./D.C., 30/- each, 6/6 post. 90–180 v., A.C./D.C., 4in. scale, £1 each, 5/- post.
**BC-221 or LM 13.** Freq. meter complete with original charts in good working order. Range 125 kc/s.–20 Mc/s., £16/10/-, carr. 15/-.
**SIGNAL GENERATORS**
TF.144G. 230 v. A.C. 85 kc/s.–25 mc/s. In excellent condition, £16/10/- each, 25/- carr.
TS.12AP. Standing Wave Indicator Equipment. Complete with Amplifier and waveguide plumbing equipment, £12/10/- each, 15/- carr.
TS.36AP Power Meter, with accessories, used for checking radar outputs, £5 each, 10/- carr.
**DE-ICER, Controller Mk. 3.** Contains 10 relays D.P. changeover heavy duty contacts, 1 relay 4P, C/O. (235 ohms coil). Stud switch 30-way relay operated, one five-way ditto, D.C. timing motor with Chronometric governor 20–30 volts 12 R.P.M., geared to two 30-way stud switches and two Ledex solenoids, 1 delay relay, etc., sealed in steel case, size 4×5×7in., £3 each, post 5/-.
**BC640 MODULATOR UNIT.** 2×811's, mod. transformer and fil., trans. complete mod. unit fits 19in. rack 50 watts, £5/10/-, carr. £1.
**GEARED MOTORS** (Reversible).
20-30 v. D.C. 72 r.p.m., 17/6, post 2/6.
28 v. 150 r.p.m., 25/-, post 2/6.
24 v. Open gears with governor, approx. 10 r.p.m., 25/-, post 2/6.
24 v. D.C., 1.4 r.p.m., reversible with two micro switches inside gear box, silent operation, £2 each, post 5/-.

**MARCONI V. LVE VOLTMETERS TF428-B/1.** Ranges: 0 to 1.5, 5, 15, 50 and 150 volts. Fitted with probe unit for RF measurements. 230 v. mains input. Brand new, £12/10/- each, carr. 10/-.

**TCS MODULATION TRANSFORMER** 20 w. Pri., 6,000 ohm C.T. Sec., 6,000 ohm. 25/- each, post 3/6. **MICROPHONE TRANSFORMER.** Pri., 75 ohm. Sec., 125,000 ohm. 10/- each, post 2/6.
**OUTPUT TRANSFORMER.** Pri., 7,500 ohm. Sec., 500 ohm. C.T., 2.5 w. 12/6 each, post 3/-.
**POWER SUPPLY** unit for SENDER No. 36, 110-240 v. A.C. input, contains Speech amplifier. Modulator and External power supplies, 3×FW4/500 rectifiers provide H.T. for F.R. unit Speech amplifier 6C5G, Modulator 2×6C5G and 2×807 output. Size 24×16×14 inches. Housed in a fine oak case with circuit. Weight 110 lbs. As new, £6/12/6, carr. 30/-.
**CONVERTERS.** Type 8 a., 24 v. D.C., 115 v. A.C. at 1.8 amps. 400 cycles, 3-phase. £5 each, carr. 7/6.
**CONDENSERS.** 1 mfd., 20 kv., £6/12/6 each, post 12/6 each. 0.25 mfd., 32,500 volts Wkg. £5 each, post 12/6 each. 150 mfd., 290 volts A.C. £5 each, post 12/6. 50 mfd., 330 volts A.C. 40/-, post 4/-. 10 mfd., 1,000 v. 12/6, post 2/6. 8 mfd., 1,500 volts, 17/6, post 2/-. 8 mfd., 1,200 volts, 12/6, post 3/-. 8 mfd., 600 volts, 8/6, post 2/6. 0.25 mfd., 2 kv. 4/-, post 1/6. Vacuum condenser 50 pf. 32 kv. 30/-, post 1/6. 6 pf. 20 kv. 22/6, post 1/6. All the above are new in cartons.
**POWER FACTOR CONDENSERS.** 160 mfd., 290 v. A.C. working. £5/10/- each, carr. 10/-.
4 mfd., 12,500 v. D.C. working, £7/10/- each, carr. 15/-.
**BLOWER MOTORS.** 24 v. D.C. (small U.S.A.), 12/6, post 2/-.
**TELEPRINTERS.** Type 7B, used, good condition. 24 v. D.C. £12/10/- each, carr. £1.
**OSCILLOSCOPES,** Cossor 1035 and 1049, used condition, £30 each. Hartley type 13A, £25 each. Solartron Type CT316, £20 each.
**INVERTERS.** Type AN3499, 28 v. D.C., 9.2 amps. input, 115 v. 400 c/s 3 phase, £5 each, post 5/-.
**TX DRIVER UNIT.** 100-156 Mc/s. Ideal for two meters, Valves 3C24, in excellent condition, fits 19in. rack, £5 each, carr. 20/-.

**CONTROL UNIT.** 230 v. A.C., output 24 v. 2 amps., 230 v. A.C. solenoid switch, 15 amps., plus relays and switches, etc., £2/10/-, carr. 12/6.
**RECEIVERS.** HRO. Used condition, less coils, £10 each, carr. £1. S.36, used condition, freq. 30-143 Mc/s. £25, carr. £2. S.27/U, used, freq. 143-210 Mc/s., £25, £2 carr. C.52, used, freq. 1.75-16 Mc/s., £5, carr. £1. H.63 (similar to 1392), 100-156 Mc/s., £5, carr. £1.

**MARINE RADAR EQUIPMENT.** Complete installation for 110/220 v., 3 cmm., made by B.T.H. Ltd. The equipment is mounted in a weatherproof steel van 6×6 6ft., with the scanner on top to rotate 360 deg. The units are available with service manuals and some spares. £500 each. F.O.B.

**UNISELECTORS.** 6 bank, 25 way, 20 ohm. coil, £2 each, post 2/6; 5 bank, 25 way, 20 ohm. coil, 35/- each, post 2/6. (Ex-new equipment.)
**BOMB SELECTOR UNIT,** complete with uniselector 3B., 25 watt, 22 ohms, magnetic counter 0-40, and 1 relay 500 ohm. 2 make, 50/- each, post 3/6.
**HEADPHONES.** DLR5, 10/- pair, 2/6 post. No. 10 headset and microphone, 15/-, post 2/6. M/C phones with chamois ear muffs and jack plug, 17/6 pair, post 2/6.

**POWER AND SMOOTHING UNITS.** 100-250 v., A.C. input 24 v., D.C. at 3 amps. or 12 v. twice at 3 amps., continuous rating, switched fused, etc. In metal case 19 × 7 × 7in. Smoothing two large chokes and 0-1 ma., meter scaled 0-50 volts. £7/10/- (pr.), 15/- carr.

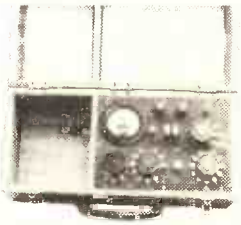
**APX6 TRANSPONDER.** Complete with UHF valves 2C42, 2C46 and 1B40, complete with special holders and condensers. 30 Valves, Blower Motor, Mechanical Counters, etc., 115 v. 400 c/s. (Suitable conversion for 1,200 Mc/s.). Price £10 each carriage 15/-.
**BATTERIES.** Portable in metal case with carrying strap. 6 volt, 40 amps., new, unused, 20/-, carr. 6/6. Car type, 6 volt 75 amps., £2, carr. 10/-.
**RESISTORS.** Variable. 3 ohm. 10 amps., 25/-, post 4/-.
**ROTARY TRANSFORMERS.** 24 v. input, 175 v. at 40 ma. output, 25/-, plus 2/- post. EICOR type, 12 v. input, 400 v. at 180 ma. output, 30/-, plus 4/- post. 12 v. input, 225 v. at 100 ma. output, 25/-, plus 3/- post. (All the above are D.C. only.)
**MICROPHONE Type T50.** Fits the palm of hand with on/off switch and lead (electro dynamic), 35/- each, plus 2/6.
**CIRCUIT BREAKER.** 150 amps. 600 v. A.C., £3 each, carr. 7/6.
**PLUGS.** Standard two-way jack plug PL55 with 6ft. lead and transformer, low to high impedance, 7/6 each, plus 1/6 post. PL68 plug and switch lead assembly, 5/- each, plus 1/6 post.
**DIPOLE AERIAL.** Complete set suitable for 60-100 Mc/s., 27/6, carr. 1/-.
**COMPRESSOR UNIT.** Aircraft cabin pressurisation unit, 28 v. D.C., with automatic switches, etc., £3/10/-, post 6/-.

**AR88 SPARES.** Set of 14 valves and headphones and 3 pilot lamps, new, original cartons, £3/10/- each, post 2/6. Set of 14 valves only, £2/10/-, post 2/-. Vibrator unit, 6 v., 15/-, post 4/-. Headset only, 12/6, post 2/-. Speaker unit, R.C.A., £3/10/-, plus 5/- post. Block condenser unit, 3×4 mfd. at 600 v., 25/- each, post 3/-. 0.01 mfd. 400 v. D.C., 4 for 12/6. Capacitor air trimmer, 2-20 pf., box of 3, 10/-.

**1154 TRANSMITTER UNIT** less power supplies (used), £4 each, plus 15/-.

**TRANSFORMERS.** 230 to 115 v., isolation 300 va., £3 each, plus 5/-. 230/115 auto 750 watts, £4, post 10/-. 230 v. pri., 1,850-0-1,850 at 500 ma., £5 each, plus 15/- carr. 230/115 auto 300 watts, £2, post 6/-. 230 v. pri., 24 v. at 2 amp., 22/6, post 5/-. 230/115 v. pri., 275-0-275 v. at 120 ma., 6.3 v. at 4 amp., 6.3 v. at 1 amp., 25/-, post 5/-.

**RADAR RECEIVER APG501.** Complete Unit with Blower Motor, 40 valves, Relays, Transformers, etc. Condition as new. Price £5 each, carriage 15/-.



**WHEATSTONE BRIDGE** in a beautiful oak case, centre zero galvanometer 2.5 mA., 4 stud switches, 0-10, 0-100 ohms, 0-inf., size 16×7½×6in., 45/- each, 5/- post.

**RADAR TRANSMITTER APG501.** Complete Unit in pressurised case with Magnetron CBPV6765 and Klystron 6378 and associated crystals and waveguides, Blower Motor and 12 valves. Power inputs 115 v. 400 c/s. Condition as new, price £10 each, carriage 15/-.

**FOR EXPORT ONLY**
**TRANS./REC. WIRELESS SET No. 31,** complete sets with aerials, headphones and mikes in working order. Freq. 30/40 Mc/s. 4 channel xtal-controlled, £8/10/- each. **WIRELESS SET No. 88.** 4 channel, xtal-controlled, complete with all valves and xtals and attachments, £10 each. **WIRELESS SET No. C52.** 12 v. D.C. 1.7-16 Mc/s. on three bands, 110 watts output. CW, MCW, etc. Can be used as Vehicle T/R, or base station (as new complete set £52).

*Complete installations can be quoted for. Please write further details. List available 6d. S.A.E, for all enquiries.*

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4-Speed Players. 2-tone Cabinets 17×15×3½in. High flux loudspeaker and 3 watt 2 valve 2 stage amplifier ready built. Quality output. Volume and Tone controls. All items fit together perfectly. Special instructions enable assembly in 30 minutes, only 5 wires to join. 12 months' written gnarantee.

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## Q MAX CHASSIS CUTTER

Complete: a die, a punch, an Allen screw and key.

| | | | | | |
|---|---|---|---|---|---|
| ½in. | 14/6 | 1 1/16in. | 18/– | 1¾in. | 22/6 |
| ⅝in. | 14/6 | 1⅛in. | 18/– | 2in. | 34/3 |
| ¾in. | 15/6 | 1¼in. | 18/6 | 2 3/16 in. | 37/9 |
| ⅞in. | 15/9 | 1⅜in. | 20/- | 2¼in. | 44/9 |
| 1in. | 18/– | 1½in. | 20/6 | 4in. sq. | 31/6 |

**CRYSTAL MIKE INSERTS.** 1 x 7/16in. 7/6
**ACOS MIKE INSERT** 1¾ x ¾in. 8/6
**ACOS STICK MIKE 39-1** 35/–
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**PROFESSIONAL MAGNETIC GUITAR MIKE with Vol. and Tone Controls** 59/6
**Moving Coil Mike 90/-. Floor Stand** 57/–
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**TRANSISTOR 4-CHANNEL MIXER with 4 separate input-output controls** 59/6

FULL WAVE BRIDGE SELENIUM RECTIFIERS
2, 6 or 12 v. outputs, 1½ amp., 8/9; 2 a. 11/3; 4 a. 17/6.
CHARGER' TRANSFORMERS. Tapped input 200/250 v. for charging at 2, 6 or 21 v., 1½ amps. 15/6; 2 amps., 17/6; 4 amps., 22/6. Circuit included. Amp. meter 5 amp., 10/6.

**MAINS POWER PACKS.** Ready built with Mains Transformers, Rectifiers and Condensers, etc., providing H.T. and L.T.
200 v. 20mA. D.C. ½ wave 6.3 v. 1 a. A.C. 25/6
220 v. 50mA. D.C. ½ wave 6.3 v. 2 a. A.C. 35/6
250 v. 80mA. D.C. Full wave 6.3 v. 4 a. A.C. 45/6

MOVING COIL MULTIMETER TK20A. 0-1,000 v. A.C./D.C. ohms. 0 to 100 K., etc., 0-150 mA. Pocket size 2in. scale, 49/6.
VALVE HOLDERS. EA50 6d. B12A, CRT. 1/3.
MOULDED Int. Oct. 6d. Mazda Oct. 6d.; B7G, B8A, B8G, B9A, 9d.; B7G with can 1/6. B9A with can 1/9. Ceramic types 1/-. Valve base plugs B7G, B9A, Int. Oct., 2/3.

## 1965 RADIOGRAM CHASSIS

**£9.15.6** Carr. 5/6.

Three Wavebands Five Valves: ECH81, Long, Med, Short. EF89, EBC81, EL84, EZ80.
12-month guarantee. A.C. 200-250 v. Ferrite Aerial, A.V.C P.U. and Tape Sockets Negative Feedback. 5 watts 3 ohm. Chassis 13½in. × 7in. high × 5in. deep. Glass dial size 13in. × 4in. horizontal wording. Two Pilot Lamps, Four Knobs. Aligned calibrated. Chassis isolated from mains.

NEW MODEL VHF-FM RADIOGRAM CHASSIS.
British made with Long, Med., VHF-FM Wavebands. 6 valves. Size 15in. × 7in. × 9in. Callers only £16/10/-.
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| 1/350 v. | 2/- | 100/25 v. | 2/- | 8/600 v. | 9/- |
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| 8/350 v. | 2/3 | 1,000/12 v. | 3/- | 32+32/350 v. | 5/6 |
| 16/450 v. | 3/- | 8+8/450 v. | 3/6 | 32+32/450 v. | 6/- |
| 32/450 v. | 3/9 | 8+16/450 v. | 3/9 | 50+50/350 v. | 7/- |
| 25/25 v. | 1/9 | 16+16/450 v. | 4/3 | 64+120/350 v. | 11/6 |
| 50/50 v. | 2/- | 32+32/350 v. | 4/6 | 100+200/275 v. | 12/6 |

PAPER CONDENSERS. 0.001 mfd., 7 kV., 6/6; 20 kV. 10/6; 0.1 mfd., 7 kV., 9/6; Tubular 500 v. 0.01 to 0.5. 9d.; 0.1 1/-; 0.25 1/6; 0.1/350 v. 9d.; 0.5/350 v. 1/9; 0.01 2.000 v. 2/6; 0.05/2,000 v. 3/6. CERAMIC. 500 v. 1 pF. to 0.1 mfd., 9d. Disc Ceramics 1/-. Pulse 100 pF., etc., 12 kV., 2/6.
SILVER MICA. Close tolerance (plus or minus 1 pF.), 2.2 to 47 pF., 1/-; ditto 1% 50 to 815 pF. 1/-; 1,000 to 5,000 pF., 1/9.
TWIN GANG. "0-0" 208 pF.+176 pF., 10/6; 365 pF., miniature 10/-; 500 pF. standard with trimmers. 9/-, midget. 7/6; midget with trimmers, 9/-; 500 pF. slow motion, standard 9/-; small 3-gang 500 pF. 17/6. Single "0" 365 pF. 7/6.
SHORT WAVE. Single 10 pF., 25 pF., 50 pF., 75 pF., 100 pF., 160 pF., 5/6 each Can be ganged together. Couplers 9d. each.
TUNING. Solid dielectric. 100 pF. 300 pF., 500 pF., 3/6 each.
TRIMMERS. Compression ceramic 30, 50, 70 pF., 9d.; 100 pF., 150 pF., 1/3; 250 pF., 1/6; 600 pF., 750 pF., 1/9.

## MAINS TRANSFORMERS

Post 2/- each.

250-0-250, 80 mA. 6.3 v. .35 a., or 4 v. 4 a. Rectifier 6.3 v. 1 a. or 5 v. or 4 v. 2 a., 22/6; Ditto 350-0-350, 29/6; 300-0-300 v. 120 mA., 6.3 v. CT 4 a., 0, 5, 6.3 v. 2 a. 33/6
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MIDGET 220 v. 45 mA., 6.3 v 2 a. 15/6
SMALL, 300-0-300 v., 70 mA., 6.3 v., 4 a 19/6
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HEATER TRANS. 6.3 v. 1½ a., 7/6; 6.3 v. 4 a. 10/6
Ditto tapped sec. 1.4 v., 2., 3, 4, 5, 6.3 v. 1½ amp. 8/6
GENERAL PURPOSE LOW VOLTAGE, Outputs, 3, 4, 5, 6, 8, 9, 10, 12, 15, 18, 24 and 30 v. at 2 a. 22/6
Ditto 1 amp, 12 taps up to 60 v. 29/6
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Manufacturers: Surplus

## GRAM AMPLIFIERS

Valves: UY85 Rectifier and UCL82 Triode/Pentode 3½ watts output. Size (inc. valves) 5 x 5½ x 2in. deep. New and Tested complete 3 ohm output tone and volume on/off controls. **ONLY 37/6** P. & P. 2/6. Ready for use 200-250 v. A.C. or can be used with 80 v. motor tap or 160 v. motor.

**BARGAIN XTAL PICK-UP ARM**
Complete with ACOS LP-78 Turnover Head ..... 20/-

**Transistor Mains Eliminators** ..... 29/6
PP1-6 v., PP9-9 v. Doubles 42/6. PP1 + PPP1, PP9 + PP9, PP11 (4½ + 4½).

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| BA2W 6in. Ferrite Aerial with car aerial coil, Osc. P50/1AC | 12/6. 5/4. | Spare Cores | 6d. |
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**Volume Controls**
Long spindles. Midget size 5 K. ohms to 2 meg. LOG or LIN. L/S. 3/-. D.P. 4/6.
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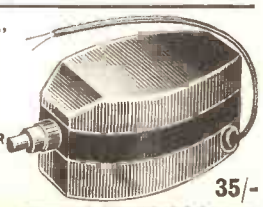
**80 Ohm CABLE Coax**
Semi-air spaced 6d. yd. 40 yd. 17/6. 80 yd. 25/-.
Low loss 5 dB. per 100ft. at 500 mc/s.
Ideal 625 lines 1/6 yd.

CAR AERIAL PLUGS 1/6. Sockets 1/3. COAXIAL PLUG 1/-. PANEL SOCKET 1/-. COAX. OUTLET BOXES. SURFACE OR FLUSH 4/-. BALANCED TWIN FEEDERS 6d. yd. 80 or 300 ohms. TWIN SCREENED FEEDER 1/- yd. 80 ohms. TELESCOPIC AERIALS. 12in. extends to 33in. 6/6 each.

THE "INSTANT" BULK TAPE ERASER AND RECORDING HEAD DEMAGNETIZER



Leaflet S.A.E.
200/250 v. A.C. **35/-**

**B.T.H. TAPE MOTORS 115 v. A.C. 28 w. 12/6 pair, for 200/250 v. (in series).**

## 12" GUITAR HEAVY DUTY 25w.

FOR BASS, LEAD AND RHYTHM GUITARS

**5GNS.**

**BAKERS**
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15 OHM VOICE COIL
20-10,000 cps
BASS RESONANCE 80 cps
GENUINE MUSICAL INSTRUMENT LOUDSPEAKER

**BAKERS PUBLIC ADDRESS MODELS**
12in. STANDARD HEAVY DUTY 20 w. **7gns.**
More powerful magnet 14,000 lines, special suspension. 40-14,500 c.p.s. Recommended wherever a high standard of reproduction is desired.
15in. AUDITORIUM MODEL 35 w. **18gns.**
Improved magnet alcomax with heavy plated assembly, 17,000 lines, 20-12,000 c.p.s. Special coil Former LOUDSPEAKERS. P.M. 3 OHMS FAMOUS MAKES. 2½in., 3in., 4in., 5in., 7in. × 4in., 15/6 each; 8in. 17/6; 6½in. 16/6; 10in. 30/-; 12in. 30/-; (15 ohms 35/-); 10in. × 6in. 22/6; 8in. × 5in. 21/-; 9in. × 6in. 21/-. E.M.I. Double Cone 13½ × 8in. 10 w. (Ceramic) 45/-. Horn Tweeter 104 dB 2 Kc/s. to 16 Kc/s. 29/6. Stentorian 10in. HF1012. 87/6; 8in. HF812 72/6. Crossover 3,000 c.p.s. 30/-. 35 ohm 5 x 2½in., 15/6; 5in. 17/6; 7 x 4in. 21/-

WAVE-CHANGE SWITCHES WITH LONG SPINDLES.
2 p. 2-way or 2 p. 6-way or 3 p. 4-way or 1 p. 12-way ea. 3/6
4 p. 2-way or 4 p. 3-way. 3/6; 8 p. 4-way, 2 wafer 6/6
Wavechange "MAKITS" Wafers available; 1 p. 12-way, 2 p. 6-way, 3 p. 4-way, 4 p. 3-way, 6 p. 2-way. Prices include click spindles, adjustable stops, spacers, etc. 1 wafer, 8/6; 2 wafer, 12/6; 3 wafer 16/-. Extra wafers up to 12, 3/6 each.
TOGGLE SWITCHES, s.p., 2/-; d.p., 3/6; d.p.d.t., 4/-.

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JACKS. Lead 6/- Standard open-circuit 2/6. closed-circuit 4/6. Grundig type 3-pin 1/3; Grundig Lead Type 3/6. PHONO PLUGS 1/-. Socket 1/-. Banana Plugs 1/-. Sockets 1/-.
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BULGIN NON-REV PLUGS and SOCKETS. P74 2-pin 4/3; P73 3-pin 4/6; P194 6-pin 6/6; P466 6-pin 12/6; P360 3-pin 4/-.
RESISTORS. Preferred values. 10 ohms to 10 meg. ¼ w. 10% 6d. ¼ w., ½ w., 1 w., 20% 4d; 1½ w. 8d.; 2 w. 1/-.
HIGH STABILITY. ½ w. 1% 2/-. Preferred values. 10 ohms to 10 meg. Ditto 5%, 10 ohms to 22 meg., 9d.

| | | |
|---|---|---|
| 5 watt, 10 watt, 15 watt | 0.5 to 8.2 ohms 3W. WIRE-WOUND RESISTORS 10 ohms 6,800 ohms | — 1/6 — 1/9 — 2/- |
| 10 K., 15 K., 20 K., 25 K., 10 w. | | — 3/- |

MAINS DROPPERS. Midget. With sliders. 0.3 a. 1 K., 6/- ea. 0.2 a. 1.2 K. 6/- ea. 0.15 a. 1.5 K. 6/- ea. 0.1 a. 2. K., 6/- ea.
LINE CORD 100 ohms ft. 3-way 1/- ft.

| WIRE-WOUND Pots. 3-WATT | WIRE-WOUND 4-WATT |
|---|---|
| Pre-set Min. T.V. Type. All values 10 ohms to 25 K., 3/- ea.; 30 K. 4/-. Carbon 30 K. to 2 meg., 3/-. | STANDARD SIZE POTS. LONG SPINDLE VALUES 50 OHMS to 50 K., 6/6; 100 K. 7/6. |

SPEAKER-FRET. Tygan various colours. 52in. wide from 10/- ft.; 26in. wide from 5/- ft. Samples, large, S.A.E. or 6d.
EXPANDED METAL. Gold 12×12in., 6/-.
ARDENTE TRANSISTOR TRANSFORMERS.
D3035, 7.3 CT : 1 Push Pull to 3 ohms for OC72, OC81 11/-
D3034, 1.75 : 1 CT. Push Pull Driver for OC72, OC81... 11/-
D3058, 11.5 : 1 Output to 3 ohms for OC72, OC81.... 11/-
D239, 4.5 : 1 Driver; D240, 8.5 : 1 Driver ..... ea. 11/6
ARDENTE TRANSISTOR POTS, 5 K,. with switch ..... 5/3

BLANK ALUMINIUM CHASSIS. 18 s.w.g. 4 sides, riveted corners, lattice fixing holes, 2in. sides. 7×4in. 5/6; 9×7in. 6/6; 11×3in. 6/6; 11×7in. 7/6; 13×9in. 9/6; 14×11in. 12/6; 15×14in., 15/-.
ALUMINIUM PANELS 18 s.w.g. 12×12in. 5/6; 14×9 4/6; 12×8in. 3/6; 10×7in. 2/9; 8×6in. 2/-; 6×4in. 1/6.

*RETURN OF POST DESPATCH* *(Export—Send remittance and extra postage, no C.O.D.)* *CALLERS WELCOME*

# RADIO COMPONENT SPECIALISTS

337 WHITEHORSE ROAD, WEST CROYDON Telephone THO 1665

12 Month Written Guarantee with every purchase Buses 133, 68. S.R. Stn Selhurst. Post 1/-. List 1/-, C.O.D. 2/-. extra

F

## MODEL PV-58 VACUUM TUBE VOLTMETERS

Latest design with special circuit for stable and accurate measurements. Resistors used are all within 1% tolerance. Special designed 4in. 200μA meter. 11 meg. inputs.

Ranges: —D.C.V. 0-1.5-5-15-50-150-500-1,500 V.
+D.C.V. 0-1.5-5-15-50-150-500-1,500 V.
A.C.V. 0-1.5-5-15-50-150-500-1,500 V.

R.M.S. 0-1.4-4-14-40-140-400-1,400-4,000 P.P.
Resistance: 2 ohm to 1,000 meg. ohm.
Decibels: —10db to +65db.
Operation: 220/240 volt A.C. Size 7 × 4½ × 4in. Supplied brand new and guaranteed complete with probe and instructions **£12/10/-**. P.P. 3/6.

## PRECISION COMBINATION VOLTMETER/AMMETER

Two separate instruments housed in polished wood case, 6in. scales with knife edge pointers. Ranges as follows: A.C. and D.C. Volts 0-160-300-600. A.C. and D.C. Current: 0-25-50-150-200 amps. Supplied complete with shunts, leads and leather carrying case. Brand new condition. **£9/19/6.** each. Carr. 7/6.

## LELAND MODEL 27 BEAT FREQUENCY OSCILLATORS

Frequency 0-20 Kc/s. on 2 ranges. Output 500Ω or 5kΩ. Operation 200/250 v. A.C. Supplied in perfect order **£12/10/-**. Carr. 10/-.

## MAINS ISOLATING TRANSFORMERS

230 V. to 230 V. 50 W. **16/6**. P.P. 3/-; 100 W. **29/6**. P.P. 3/6; 1,000 W. **£5**. Carr. 10/-.

## CLASS D WAVEMETER NO. 1. MK. II

Crystal controlled wavemeter covering 1.9-8 Mc/s. on 2 bands. 6 v. D.C. operation. Supplied brand new with handbook, headset and case. **59/6**. Carr. 5/-.

## R.107 COMMUNICATION RECEIVERS

1.2-17.5 Mc/s. Mains or 12 v. operation. Supplied in excellent condition, **£15**. Carr. 30/-.

## AR88D RECEIVERS

550 kc/s.-32 Mc/s. Available in excellent "as new" condition. **£65**. Carr. 30/-.

## NATIONAL H.R.O. RECEIVERS

A good selection available. S.A.E. for details.

## 9-TRANSISTOR 2 WAY RADIOS

Super quality. Range up to 5 miles. Complete with all accessories. **£25** per pair. Post extra. Also available, **3-TRANSISTOR MODEL.** Range up to 1 mile. Complete with all accessories. **£9/19/6** per pair. Post extra. (S.A.E. for full details.)

## RECORDING HEADS

| | |
|---|---|
| Reuter: ¼ track. Set of 2 | 19/6 |
| Miniflux: ¼ track. Set of 3 | 29/6 |
| Bradmatic: ¼ track. Set of 2 | 99/6 |

Post Extra.

## AMERICAN RECORDING TAPES

First grade quality American tapes. Brand new and guaranteed. Discounts for quantities.

| | | |
|---|---|---|
| 3in. | 200ft. L.P. mylar | 4/- |
| 3½in. | 600ft. T.P. mylar | 10/- |
| 5in. | 600ft. std. plastic | 8/6 |
| 5in. | 900ft. L.P. acetate | 10/- |
| 5in. | 1,200ft. D.P. mylar | 15/- |
| 5½in. | 1,200ft. L.P. acetate | 12/6 |
| 5½in. | 1,800ft. D.P. mylar | 22/6 |
| 7in. | 1,200ft. std. mylar | 12/6 |
| 7in. | 1,800ft. L.P. acetate | 15/- |
| 7in. | 1,800ft. L.P. mylar | 20/- |
| 7in. | 2,400ft. D.P. mylar | 25/- |

Postage 2/-. Over £3 post paid.

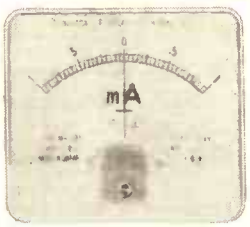
## MINE DETECTOR No. 4A

Will detect all types of metals. Fully portable. Compact with instructions 39/6 each. Carr. 10/-. Battery 8/6 extra.

# SEW PANEL METERS

MANUFACTURED BY SHINOHARA ELECTRICAL INSTRUMENTS LTD., JAPAN. FAMOUS ALL OVER THE WORLD FOR THE QUALITY, DEPENDABILITY AND ACCURACY OF THEIR INSTRUMENTS.
The comprehensive range below is available ex-stock. Other ranges to special order. Special quotations for quantities.

## CLEAR PLASTIC METERS



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

| | | | |
|---|---|---|---|
| 50μA | 32/6 | 750mA | 22/6 |
| 100μA | 29/6 | 1A D.C. | 22/6 |
| 200μA | 27/6 | 2A D.C. | 22/6 |
| 500μA | 25/- | 5A D.C. | 22/6 |
| 50-05-μA | 29/6 | 3V D.C. | 22/6 |
| 100-0-100μA | 27/6 | 10V D.C. | 22/6 |
| 500-0-500μA | 22/6 | 20V D.C. | 22/6 |
| 1-0-1mA | 22/6 | 50V D.C. | 22/6 |
| 1mA | 22/6 | 100V D.C. | 22/6 |
| 2mA | 22/6 | 150V D.C. | 22/6 |
| 5mA | 22/6 | 300V D.C. | 22/6 |
| 10mA | 22/6 | 500V D.C. | 22/6 |
| 50mA | 22/6 | 750 V D.C. | 22/6 |
| 100mA | 22/6 | 15V A.C. | 22/6 |
| 150mA | 22/6 | 50V A.C. | 22/6 |
| 200mA | 22/6 | 150V D.C. | 22/6 |
| 300mA | 22/6 | 300V A.C. | 22/6 |
| 500mA | 22/6 | 500V A.C. | 22/6 |
| | | 'S' Meter 1mA | 29/6 |

Type MR.52P. 2½in. square fronts.

| | | | |
|---|---|---|---|
| 50μA | 57/6 | 500μA | 37/6 |
| 100μA | 47/6 | 50-0-50μA | 57/6 |

Type MR.52P. 2½in. square fronts (Cont.)

| | | | |
|---|---|---|---|
| 100-0-100μA | 47/6 | 300V A.C. | 32/6 |
| 1mA | 32/6 | 'S' Meter 1mA | 39/6 |
| 5mA | 32/6 | *1A A.C. | 32/6 |
| 10mA | 32/6 | *5A A.C. | 32/6 |
| 100mA | 32/6 | *10A A.C. | 32/6 |
| 1A D.C. | 32/6 | *20A A.C. | 32/6 |
| 300V D.C. | 32/6 | *30A A.C. | 32/6 |

Type MR.85P. 4½in. 4½in. fronts.

| | | | |
|---|---|---|---|
| 50μA | 69/6 | 3 amp. D.C. | 45/- |
| 100μA | 59/6 | 15A D.C. | 45/- |
| 200μA | 55/- | 30A D.C. | 45/- |
| 500μA | 49/6 | *1A A.C. | 45/- |
| 50-0-50μA | 69/6 | *5A A.C. | 45/- |
| 100-0-100μA | 59/6 | *10A A.C. | 45/- |
| 500-0-500μA | 49/6 | *20A A.C. | 45/- |
| 1-0-1mA | 45/- | *30A A.C. | 45/- |
| 1mA | 45/- | 50V D.C. | 45/- |
| 10mA | 45/- | 150V A.C. | 45/- |
| 50mA | 45/- | 300V D.C. | 45/- |
| 100mA | 45/- | 15V A.C. | 45/- |
| 1 amp. D.C. | 45/- | 300V A.C. | 45/- |

Type MR.65P. 3½ × 3½in. fronts.

| | | | |
|---|---|---|---|
| 50μA | 59/6 | 50A D.C. | 42/6 |
| 100μA | 49/6 | *1A A.C. | 35/- |
| 500μA | 39/6 | *5A A.C. | 35/- |
| 50-0-50μA | 59/6 | *10A A.C. | 35/- |
| 100-0-100μA | 49/6 | *20A A.C. | 35/- |
| VU meter | 59/6 | *30A A.C. | 35/- |
| 1mA | 35/- | 10V D.C. | 35/- |
| 5mA | 36/- | 150V D.C. | 35/- |
| 10mA | 35/- | 300V D.C. | 35/- |
| 50mA | 35/- | 15V A.C. | 35/- |
| 100mA | 35/- | 50V A.C. | 35/- |
| 500mA | 35/- | 150V A.C. | 35/- |
| 1A D.C. | 35/- | 300V A.C. | 35/- |
| 5A D.C. | 35/- | 500V A.C. | 35/- |
| 15A D.C. | 35/- | | |
| 30A D.C. | 35/- | | |

## BAKELITE PANEL METERS

Type MR.65. 3½in. square fronts.

| | | | |
|---|---|---|---|
| 25μA | 65/- | 30A D.C. | 29/6 |
| 50μA | 42/6 | 50A D.C. | 29/6 |
| 100μA | 39/6 | *1A A.C. | 29/6 |
| 500μA | 35/- | *5A A.C. | 29/6 |
| 50-0-50μA | 42/6 | *10A A.C. | 29/6 |
| 100-0-100μA | 39/6 | *30A A.C. | 29/6 |
| 1-0-1mA | 29/6 | *50A A.C. | 29/6 |
| 50mv. | 39/6 | 10V D.C. | 29/6 |
| 100mv. | 39/6 | 50V D.C. | 29/6 |
| 1mA. | 29/6 | 150V D.C. | 29/6 |
| 5mA. | 29/6 | 300V D.C. | 29/6 |
| 10mA. | 29/6 | *30V A.C. | 29/6 |
| 50mA. | 29/6 | *50V A.C. | 29/6 |
| 100mA. | 29/6 | *150V A.C. | 29/6 |
| 500mA. | 29/6 | *300V A.C. | 29/6 |
| 1A D.C. | 29/6 | 300V A.C. | 35/- |
| 5A D.C. | 29/6 | VU Meter | 49/6 |
| 15A D.C. | 29/6 | | |

*Moving iron, all others moving coil.

S.A.E. FOR ILLUSTRATED LEAFLET

## MULTI-METERS

Brand New—Fully Guaranteed—Lowest ever prices.
**Supplied with leads, batteries, instructions**

**MODEL PT-34.** 1,000 O.P.V. 0/10/50/250/500/1,000 v. A.C. and D.C. 0/1/100/500 MA. D.C. 0/100 kΩ. **39/6**. P. & P. 1/6.

**MODEL 500.** 30,000 O.P.V. 0/.5/1/2.5/10/25/100/250/500/1,000 V. D.C.
0/2.5/10/25/100/250/500/1,000 V. A.C.
0/50μA/5/50/500mA. 12 amp. D.C.
0/60/K6 Meg/60 Mcg. Ω **£8/17/6**. Post paid.

**MODEL TE-12** 20,000 O.P.V. 0/.06/6/30/120/600/1,200/3,000/6,000 v. D.C. 0/6/30/120/600/1,200 v. A.C. 0/60μA/6/60/600 MA. 0/6K/600K/6 Meg./60 Meg. Ω. P.F.-.2 MFD. **£5/19/6.** P. & P. 2/6.

**MODEL NH201** 30,000 O.P.V. 0/.25/1/10/50/250/500/1,000 v. D.C. 0/10/50/250/500 v. A.C. 0/50μA/10/250 MA. 0/5/K500K/5 Meg. Ω **99/6**. P. & P. 2/6.

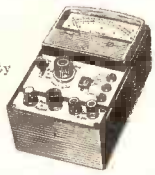
**MODEL NH-400** 10,000 O.P.V. 0/.3/3/30/120/300/600/1,200 v. D.C. 0/12/60/120/300/1,200 v. A.C. 0/120 μA/30/300 MA. D.C. 0/2K/200K/2 Meg. Ω. 100 PF.—2 MFD. **79/6.** P. & P. 2/6.

**MODEL AR-620** 20,000 O.P.V. 0/10/50/250/500/1,000 v. A.C. and D.C. 0/500μA/10/250mA. 0/10K/100K/1 Meg. Ω. 250 PF—.02 MFD. 0-500 Henrys **92/6**. P. & P. 2/6.

**MODEL ITI-2.** 20,000 O.P.V. 0/5/25/250/500/2,500 v. D.C. 0/10/50/500/1,000 V. A.C. 0/50μA/25/250 mA. D.C. 0/60K/6 Meg. Ω. .02-3 MFD. **82/6**. P. & P. 2/6.

**MODEL 250J.** 2,000 O.P.V. 0/10/50/500/2,500 V.D.C. 0/10/50/500/2,500 V.A.C. 0/2 Meg. Ω. 0/250 mA. —20 to +36 db. **49/6**. P.P. 2/6.

## MODEL ZQM TRANSISTOR CHECKER



It has the fullest capacity for checking on A, B and Ico. Equally adaptable for checking diodes, etc.
Spec.: A: 0.7-0.9967.
B: 5-200.
Ico: 0-50 microamps, 0-5 mA.
Resistance for diode 200Ω —1 MEG. Supplied complete with instructions, battery and leads. **£6/19/6**. P. & P. 2/6.

## PRECISION PORTABLE VOLTMETERS

Polished wood case. 8in. scale with knife edge pointer. A.C. and D.C. volts 0-160 volts, **59/6**. 0-160-32 **£5/19/6**. P.P. 3/6.

## RCA MODEL 195-A VALVE VOLTMETERS

11 meg. inputs. 4in. 200μA meter. Six D.C. ranges: 3-1,000 v. D.C. Five A.C. ranges: 10-1,000 v. A.C. Six OHM ranges: 1 K-1,000 megohms. 110/230 v. A.C. operation. Supplied brand new with instructions and test prods. **£7/19/6**. P. & P. 3/6.

## CHASSIS PUNCH SET

Set of 5 popular size hole cutters, ¾in., ⅞in., 1in., 1⅛in. Supplied complete with punches, dies, T drive handle, tapered reamer, fitted leather case and instructions. **49/6**. P.P. 2/-

## AUTO TRANSFORMERS

Step up or step down. Tapped 0/115/200/230/250 v. 20W. **9/-**; 60W. **12/6**; 75W. **15/6**; 150W. **18 6**; 200W. **27/6**; 300W. **42/6**; 500W. **67/6**; 1,000W., **90/-**; 1,500W. **£6/19/6**; 3,000W. **£7/10/-**; 7,500 W. **£15**.
(*Only tapped 0/110/230V.) Post extra.

## PLUGS AND SOCKETS

Painton 15 pin in line printed circuit connectors **7/6** pr. Large quantities available. Ditto 32 pin **12/6** pr.
**PAINTON MINIATURE JONES.** 4 pin 3/6 pr.; 6 pin **4/-** pr.; 8 pin **4/6** pr.; 12 pin **5/6** pr.; 18 pin **7/6** pr.; 24 pin **10/6** pr.; 33 pin **12/6** pr. Post extra.

## TS-382 F/U AUDIO OSCILLATOR

High quality modern American instrument. Frequency coverage on 4 bands. 0-200 Kc/s. Output impedance 1,000Ω. Output monitoring meter. 7 range output attenuator from 12 microvolts to 12 volts. Operation 115 v. 50-1,000 CPS. Supplied as new. **£40**. Carr. 20/-.

## NATIONAL H.R.O. DIALS

Brand new **27/6**. P.P. 1/6.

## 11FT. COLLAPSIBLE WHIP AERIALS

Brand new 8/6. P.P. 2/-.

## EMI WMS CONSUL OSCILLOSCOPES

Available as new. Guaranteed perfect order. **£65**

## HEADSETS

| | |
|---|---|
| DLR5. Low imp. | 10/6 |
| W.S.88. Low imp. with rubber ear pads | 17/6 |
| Chamois padded moving coil | 22/6 |
| Ditto with microphone | 25/- |
| S.F.20 High Imp. | 11/6 |

All new. Post extra.

## SILICON RECTIFIERS

| | |
|---|---|
| 250 P.I.V. 750 MA | 3/- |
| 400 v. P.I.V. 3 amp. | 7/6 |
| 200 v. P.I.V. 6 amp. | 5/6 |
| 1,000 v. P.I.V. 650 mA | 7/6 |
| 800 v. P.I.V. 500 mA. | 5/6 |
| 400 v. P.I.V. 500 mA. | 3/6 |
| 200 v. P.I.V. 200 mA. | 3/- |
| 95 v. P.I.V. 3 amp. | 5/6 |
| 70 v. P.I.V. 1 amp. | 3/6 |
| 150 v. P.I.V. 165 mA. | 1/- |

Discounts for quantities. Post extra.

# G. W. SMITH & CO.

3-34, LISLE STREET, LONDON, W.C.2

SEE OPPOSITE PAGE

## MODEL TE.18 GRID DIP METER

**COMPLETE WITH ALL COILS FOR ALL FREQUENCY RANGES FROM 360 Kc/s to 220 Mc/s.**

★ Compact—True one handed operation. ★ Covers 360 kc/s. to 220 Mc/s. ★ Functions as a Grid Dip Oscillator. Absorption wave meter and Oscillating Detector. ★ Completely wired—not a kit. The TE-18 can determine the resonant frequencies of tuned circuits, detect stray resonances in transmitters, check neutralization, etc. Frequency range 360 kc/s. to 220 Mc/s. in 8 accurately calibrated ranges. Grid current meter has a 500μA movement. Uses a 6AF4A valve, powered by a built-in transformer-operated power supply with selenium rectifier. For 220/240 v. A.C. 50-60 c/s. Size 7½in. H. × 2¾in. W. × 2in. D. **£12/10/-** Carr. 5/-.

## AVO ELECTRONIC TEST METERS

Portable A.C. mains operation Valve Voltmeter. Eight D.C. volt ranges: 5 millivolt to 1,000 v. Twelve A.C. volt ranges: 100 millivolt to 2,500 v. Ten D.C. current ranges: .5μA to 1 amp. A.F. output: 5 milliwatts to 5 watts. Capacity: 100 pF.-50 mfd. Resistance: .2 ohm to 1,000 megohm. Guaranteed perfect working order. **£20.** Carr. 10/-.

## NOMBREX EQUIPMENT

Transistorised Audio Generator 10-100,000 c/s. Sine or square wave. **£16/15/-.**
Transistorised Signal Generator 150 kc/s.-350 Mc/s. **£9/10/-.**
Transistorised resistance capacity bridge 1Ω-100 MegΩ, 1 pf.-100μF. **£8/5/-.**
Transistorised Induction bridge 1μH-100H. **£18.**
Mains Operated Transistor power supply unit, output 1-15 v. up to 100 mA. **£6/10/-.**
All above post paid with battery.

## MAIN LONDON AGENTS FOR CODAR EQUIPMENT

| | | | |
|---|---|---|---|
| PR.30 Preselector | £4 | 19 | 6 |
| PR.30X Self powered | £7 | 4 | 0 |
| RQ.10 "Q" Multiplier | £6 | 15 | 0 |
| RQ.10X Self powered | £8 | 2 | 0 |
| A.T.5 Amateur TX | £16 | 10 | 0 |
| A.T.5. Mains P.S.U. | £8 | 0 | 0 |
| A.T.5. 12 v. Transistor P.S.U. | £11 | 5 | 0 |
| A.T.5. Remote control and Aerial Switching Unit | £2 | 7 | 6 |

Postage extra.

## ILLUMINATED "S" METERS

Cal. in "S" units. 1mA basic 6 v. lamp, 1 21/32in. sq. front **29/6.** P. & P. 1/-. Ditto, 2⅝in. sq. front, **39/6.** P. & P. 1/-.

## DOUBLE BEAM C.R.T.'s

| | | | |
|---|---|---|---|
| Cossor 89D | £2 | 19 | 6 |
| Dumont K105 1PI | £2 | 19 | 6 |

Brand New. Post 3/6.

## COLLARO/MAGNAVOX STUDIO TAPE TRANSCRIPTOR

Brand new, 3 speeds. 1⅞, 3¾, 7½ i.p.s. 3 motors, digital counter. Complete with instructions. 2 Track **£10/10/-**; 4 Track **£13/10/-.** Carr. paid.

## TS-76 20,000 O.P.V. PUSH BUTTON MULTI-TESTER

Large clear plastic scale, simple operation. D.C. volts up to 1,000 v. A.C. volts up to 1,000 v. Resistance up to 10 megohm. Current up to 250 mA. Decibels −20 to +36 db. Size 6in. × 4⅛in. × 2¼in. Complete with leads, batteries and instructions. **£5/5/-.** P. & P. 2/-.

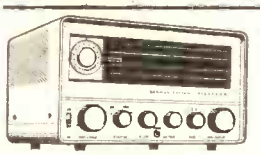
## BEST BUY!

**Send 1/- P.O. for full Catalogue and Lists. Open 9 a.m. to 6 p.m. every day Monday to Saturday. Trade supplied.**

## STAR SR.40 COMMUNICATION RECEIVER

4 Bands 550 kc/s.-30 Mc/s. 'S' Meter-BFO-ANL-Bandspread Tuning—Built-in speaker. 200/250 v. A.C. Brand New **18¼ GNS.,** carr. 10/-.

**PART EXCHANGE WELCOMED**

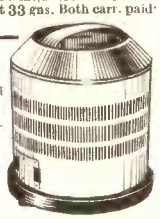


## LAFAYETTE HA-63 COMMUNICATION RECEIVER

7 valves + Rectifier 4 Bands. 550 kc/s.-31 Mc/s. 'S' Meter-BFO-ANL-Bandspread Tuning 200/250 v. A.C. Brand New. **24 Gns.** Carr. paid.

## LAFAYETTE HE-30 RECEIVERS

9 valves. 550 kc/s-30 Mc/s. Xemi kit form. **25 Gns.** Ready-built **33 gns.** Both carr. paid.

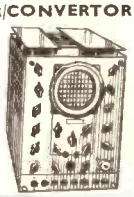


## VOLTAGE STABILIZER TRANSFORMERS

Will stabilize your mains voltage. Ideal for TV Receivers and Industrial equipment.
Input 80-120 v. and 160-240 v. Constant output 110 v. or 240 v. 250 watts. Brand new guaranteed **£10/10/-.** Carr. 7/6.

## LAFAYETTE 'PRECON' AMATEUR PRESELECTOR/CONVERTOR

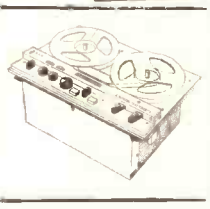
Convertor—20-15-10 metres. Preselector—80-40-20-15-10 metres. Crystal controlled—2 RF stages. 200-250 v. A.C. operation. Brand New **19 GNS.** Carr. 7/6.



## ERSKINE TYPE 13 DOUBLE BEAM OSCILLOSCOPES

Timebase 2 c/s.-750 kc/s. Separate Y1 and Y2 amplifiers. Up to 5.5 Mc/s. calib. at 100 kc/s. and 1 Mc/s. 110/230 v. A.C. Guaranteed perfect **£27/10/-.** carr. 20/-.

## PROFESSIONAL 4-TRACK STEREO RECORD AND PLAYBACK TAPE DECK



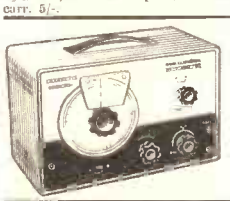
Complete with 4 valve/4 transistor pre-amplifier. Will record and play back ¼ track stereo and ¼ track mono at 7½ or 3¾ I.P.S. Twin meter level indicators, digital counter. Mic/gram/tuner inputs. Audio output 500 MW Bias and Erase 80 kc. Response 40-18,000 C.P.S. at 7½; 40-12,000 C.P.S. at 3¾ I.P.S. Motor 4 pole H.D. induction. Tape size up to 5in. 220/240 v. A.C. Size 15in. × 10½in. × 6½in. Line up: 4 × 28B173, 2 × 12AT7, 1 × 12AU7, 1 × 12BH7. S.A.E. FOR FULL DETAILS. **PRICE 42 GNS.** CARR. 15/-.

## LAFAYETTE TE-46 RESISTANCE CAPACITY ANALYSER

2 PF-2,000 MFD. 2 ohms-200 megohms. Also, checks impedance, turns ratio, insulation 200/250 v. A.C. Brand New **£15,** carr. 7/6.

## LAFAYETTE TE-20A R.F. SIGNAL GENERATOR

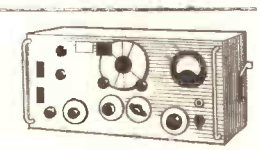
120 kc/s.-390 Mc/s. on 6 ranges. Variable R.F. and A.F. outputs. Large clear scale. Size 7½in. × 10½in. × 4½in. 220/250 v. A.C. operation. Brand New **£12/19/6.** carr. 5/-.



## TE22 SINE SQUARE WAVE AUDIO GENERATORS

Sine: 20 cps to 200 kc/s. on 4 bands. Square: 20 cps to 30 kc/s. Output impedance 5,000 ohms. 200/240 v. A.C. operation. Supplied Brand New and Guaranteed with instruction manual and leads. **£15.** Carr. 7/6.

## MARCONI TF 144G/4 STANDARD SIGNAL GENERATOR



85 kc/s.-25 Mc/s. ± 1%. Output variable from 1 μV to 1 volt. Internal sine wave modulation 400 c/s. up to 75% depth. Operation 200/250 volt A.C. Offered in really excellent condition, like new, fully tested and guaranteed. **£25.** carr. 30/-.

## G.E.C. BRT.402 RECEIVERS

A high grade 14 valve communication receiver covering 150-385 kc/s. and 510 kc/s to 30 Mc/s. in six bands. Special features include 2 RF stages, 'S' meter, Variable selectivity, B.F.O., ANL, AGC, 500 kc crystal calibrator, slide rule vernier dial with logging scale. Operation for 95-130 v. and 195-250 v. A.C. Output for phones, speaker or line. Offered in excellent condition, fully tested and guaranteed. **£60,** carr. 30/-.

## LAFAYETTE HI-FI STEREO HEADPHONES

★ **Air cushioned headband**
★ **Soft rubber ear pads**
★ **Frequency response,** 25 to 15,000 cycles. ★ **High sensitivity.** Impedance 8 ohms per phone. Supplied complete with all cables, wires, overload junction box and 3-connection plug. **82/6.** P. & P. 2/6.

## MODEL DA-1 TRANSISTORISED FULLY AUTOMATIC ELECTRONIC KEYER

230V. A.C. or Battery operated. Incorporates built-in monitor oscillator, speaker and keying lever. Fully adjustable speeds giving either auto., semi auto., or hold. 7 transistors, 4 diodes, **£16/10/-.** P. & P. 4/6.

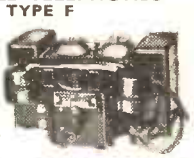
## SEMI-AUTOMATIC "BUG"

Super speed key, 7 speed adjustments. 10WPM to as high as desired. Weight scale for reproducible settings. Precision tooled, anti-rust nickel plated brass and stainless steel operating parts. Size 6⅝in. × 3in. 2¼in. Brand New. **£4/10/-.** P. & P. 2/6.

## COSSOR 1035 DOUBLE BEAM OSCILLOSCOPES

3in. C.R.T. Calibrated Y1 Amplifier from 50 mV. to 50 v., bandwidth 10 Mc/s. Calibrated Y2 Amplifier from 5 v. to 500 v., bandwidth up to 100 kc/s. Directly calibrated X shift providing time measurement from 15μsec. to 150 milliseconds. Supplied in guaranteed perfect working order. **£35.** Carr. 20/-. Also available COSSOR 1049 Double Beam Oscilloscope. **£40** each. Carr. 20/-.

## ARMY FIELD TELEPHONES TYPE F



Generator Bell Ringing—2 line connection with wood carrying case. Fitted batteries. Supplied fully tested. **£4/19/6** pair, carr. 7/6.

## VARIABLE VOLTAGE TRANSFORMERS

Brand New Guaranteed—
Fully Shrouded. Input 230 v. 50/60 c/s. Output 0-260 v.

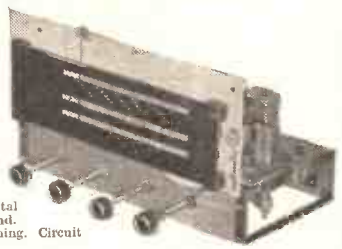
| | | | |
|---|---|---|---|
| 1 amp. | £4/10/- | 20 amp. | £32/10/- |
| 2.5 amp. | £5/17/6 | | |
| 5 amp. | £9/10/- | 2.5 amp. portable, metal case with meter-fuses, etc. | £9/17/6. |
| 8 amp. | £4/10/- | | |
| 10 amp. | £16/10/- | | |
| 12 amp. | £18/15/- | | |

## ALL MARTIN AUDIOKITS IN STOCK

ALSO SEE NEXT PAGE

## 7 VALVE AM/FM RADIOGRAM CHASSIS

*Valve line-up* ECC85, ECH81, EF89, EABC80, EL84, EM81, EZ80.



**Three Waveband and Switched Gram positions.** Med. 200-550 m. Long 1,000-2,000 m. VHF/FM 88-95 Mc/s. Phillips permeability tuning insert on FM and combined AM/FM IF transformers. Latest circuitry including AVC and Neg. Feedback. Three watt output. Sensitivity and reproduction of a very high standard. Chassis size 13½ × 6½in. Height 7½in. Edge illuminated glass dial 11½ × 3½in. Vertical pointer. Horizontal station names. Gold on brown background. A.C. 200/250 v. operation. Magic-eye tuning. Circuit diagram now available.

***Aligned and tested ready for use*** **£13 . 10 . 0** *Carr. & Ins. 7/6*

Complete with 4 Knots—walnut or ivory to choice. Indoor FM aerial 3/6 extra. 3 ohm P.M. Speaker only required. Recommended Quality Speakers 10in. Rola 27/6. 12in. R.A. 30/-. 12in. R.A. with Tweeter, 42/6. E.M.I. 13½ × 8in., 37/6. Carr. 2/6.

### CO-AX 80 ohm CABLE

High grade low loss Cellular Air Speed Polythene—¼in. diam. Stranded Cond.

**Now only 6d. yard**

**BARGAIN PRICES—SPECIAL LENGTHS**
20 yds. 9/-. P. & P. 1/6. Coax. Plugs 1/-. 40 yds. 17/6. P. & P. 2/-. Sockets 1/-. 60 yds. 25/-. P. & P. 3/-. Couplers 1/3.

### NEW BOXED VALVES ALL GUARANTEED

| | | | | | |
|---|---|---|---|---|---|
| IT4 | 3/6 | EF86 | 8/6 | PCL83 | 10/6 |
| 1R5, 1S5 | 6/- | EL33 | 12/6 | PCL84 | 10/- |
| 3S4, 3V4 | 7/- | EL34 | 12/6 | PCL85 | 11/6 |
| ECC81 | 7/- | EL84 | 7/- | PL36 | 10/6 |
| ECC82 | 7/- | EY51 | 9/- | PL81 | 9/6 |
| ECC83 | | EY86 | 9/- | PL83 | 8/- |
| ECL80 | 9/- | EZ81 | 7/- | PY33 | 10/6 |
| ECL82 | 10/- | GZ32 | 9/6 | PY82 | 7/- |
| ECL86 | 10/6 | PCC84 | 8/- | U25 | 10/6 |
| EF80 | 7/6 | PCF80 | 8/- | UL84 | 9/- |

**TRIMMERS.** Ceramic (Compression Type)—30 pF., 50 pF., 70 pF. 9d.; 100 pF., 150 pF., 1/3; 250 pF., 1/6; 600 pF. 1/9.

**PHILIPS Bee Hive Type** (conc. air spaced)—2-8 pF. 1/-; 30 pF 1/-.

**METAL RECTIFIERS-STC.** Types—RM1 4/9; RM2 6/6; RM3 7/6; RM4 16/-; RM5 21/-; RM4B 17/6; Mullard BY100 10/6.

**JACK PLUGS**—2½in. Igranic type 2/6; Screened ditto, 3/3; 1½in. Screened 2/3; Transistor type Min. and Sub.-min. 1/3.

**JACK SOCKETS**—Moulded Igranic type, open 3/6; ditto, closed 4/-. Pax. type open 2/6; ditto, closed 3/-. Transistor type, closed, Min. and Sub.-min. 1/6.

**PHONO PLUGS** 9d. Phono Sockets (open), 9d. Ditto (closed), 1/-. Twin Phono Sockets (open). 1/3.

**GRUNDIG CONTINENTAL.** 3 p. or 5 p. plug, 3/6. Sockets, 1/6.

**WAVECHANGE SWITCHES.** 1 p. 12-way, 2 p. 2-way, 2 p. 6-way, 3 p. 4-way, 4 p. 2-way, 4 p. 3-way, long spindle, 3/6 each.

**STYLUS REPLACEMENTS.** Diamond Styli for L.P. or Stereo, for all pop. types, BSR, Collaro, Garrard, etc., 11/3 ea. Gtd. 12 mths. SAPPHIRE ditto, 5/3 ea. Comp. range in stock.

## TRANSISTOR COMPONENTS

Midget I.F.'s—465 Kc/s. ⅜in. diam. ..... 5/6
Osc. Coil M/W. ⅜in. dia. ..... 5/3
Osc. Coil M. & L.W. ..... 5/9
Midget Driver Trans. 3.5 : 1 6/9
Midget Output Trans. Push Pull—3 ohms ..... 6/9

**Elec. Condensers**—Midget Type 1 mfd., 50 mfd. ea. 1/9, 100 mfd. 2/-. 12 v. wkg.

**Condensers** 150 v. working: .01 mfd., .02 mfd., .03 mfd., .04 mfd. 9d.; .05 mfd., .1 mfd. 1/-; .25 mfd. 1/3; .5 mfd. 1/6, etc.

**Midget Tuning Condensers.** J.B. "OO" 208 pf. and 176 pf. 8/6; ditto with trimmers 9/6. JB 220 pf. and 105 pf. conc. slow motion 10/6. 363 pf. single 7/6. Sub. Min. ¾in. Dilemin 100 pf., 300 pf., 500 pf. 7/- each.

**FERRITE AERIALS.** M. & L.W. car aerial coil 9/3.

**Midget Vol. Control** with edge control knob. 4 K/ohms, with switch, 4/9. Ditto less switch 3/9.

**Speakers: P.M.:** 2in. Plessey 75 ohms 15/6. 2½in. Continental 8 ohms 13/6. 7 x 4in. Plessey 35 ohms 23/6. 2½in. Continental 8 ohms 13/6.

**SOLDERING IRONS.** Mains 200/220 v. or 230/250 v. Solon 25 watt Inst., 22/6. Spare Elements, 4/6. Bits, 1/-. 65 watt, 27/6, etc.

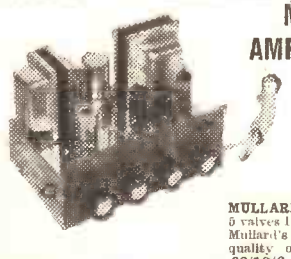
**ALUMIN. CHASSIS.** 18g. Plain Undrilled, folded 4 sides, 2in. deep, 6in. × 4in., 4/6; 8in. × 6in., 5/9; 10in. × 7in., 6/9; 12in. × 6in., 7/6; 12in. × 8in., 8/-, etc.

**ALUMIN. SHEET.** 18g. 6in. × 6in., 1/-; 6in. × 9in., 1/6; 6in. × 12in., 2/-; 12in. × 12in., 4/6, etc.

## 6 VALVE AM-FM TUNER UNIT

Med. and VHF 190 m.-550 m., 85 Mc/s.-103 Mc/s., 6 valves and metal rectifier. Self-contained power unit, A.C. 200/250 v. operation. Magic-eye indicator, 3 push-button controls, on/off, Med., VHF. Diode and high outputs ockets with gain control. Illuminated 2-col. perspex dial 11½ x 4in. Chassis size 11⅝ x 4 x 5¾in. A recommended Fidelity Unit for use with Mullard "3-3" or "5-10" Amplifiers. Available only at present as built-up units, aligned and tested ready for use. **Bargain Price £12/10/-.** Carr. 5/-. **We hope to produce this popular unit in kit form very shortly.**

## MULLARD "3-3" HI-FI AMPLIFIER, 3 VALVES 3 WATT



**3 ohm and 15 ohm Output.**
Hi-Fi quality at reasonable cost. Bass Boost and Treble controls, quality sectional output transformer, 40 c/s-25 kc/s. ±1 dB. 100 mV. for 3W., less than 1% distortion. Bronze escutcheon panel. Power take-off available.
**Complete Kit only £6/19/6.** Carr. 5/-. **Wired and tested 8 gns.**

**MULLARD "5-10" AMPLIFIER**
5 valves 10W. 3 and 15 ohms output. Mullard's famous circuit with heavy duty ultra-linear quality output transformer. Basic amplifier kit price **£9/19/6.** Carr. & Ins. 7/6. Ready Built 11½ Gns.

**CONTROL PANEL KIT**
Bass, Treble and Volume control with 4-position selector switch for radio, tape and p.u. and 11in. x 4in. escutcheon panel.
**Amplifier Kit and Control Panel Kit £11/19/6. Ditto ready wired £14/19/6.**

**2-VALVE PRE-AMP. UNIT**
Based on Mullard's famous 2-valve (2 x EF86) circuit with full equalisation, with volume, bass, treble, and 5-position selector switch. Size 9in. × 6in. × 2½in.
**Complete Kit £5/19/6.** Carr. 3/6. **Ready built £7/19/6.**

## ANOTHER TAPE RECORDER BARGAIN

***Manufacturers end of production Surplus Offer***

A 24 gn. Tape Recorder offered at the bargain price of only 15 gns. plus 10/- carr. Supplied in 3 Units already wired and tested. A modern Circuit for quality recording from Mike, Gram or Radio, using latest B.S.R. Twin Track Monar-deck Type TD2. Valve line-up—EF86, ECL82, EM84, EZ80 and Selenium Diode. Send for detailed list—3d. stamp.

**Complete Kit** comprising items below.

**BARGAIN PRICE 15 Gns.** +10/- Carr.

| | | | | | |
|---|---|---|---|---|---|
| 2-tone Cabinet and 8in. × 5in. Speaker. Size 14in. × 10in. × 7½in. | £3 | 10 | 0+ | 5/- | Carr. |
| Wired Amplifier complete with 4 Valves, front Panel, Knobs, etc. | £5 | 12 | 6+ | 3/6 | Carr. |
| B.S.R. Monardeck Type TD2 | £7 | 7 | 0+ | 4/6 | Carr. |
| Accessories: Mike, Tape, empty Reel, screened Lead and Plugs, Instructions, etc. | £1 | 0 | 0+ | 2/- | Carr. |

**We manufacture all types Radio Mains, Transf. chokes, Quality O/P. Trans., etc. Enquiries invited for specials, prototypes for small producton runs. Quotation by return.**

## RECORDING TAPE

**Famous American Columbia (CBS) Premier quality tape at NEW REDUCED PRICES.** A genuine recommended Quality Tape—TRY IT Brand new, boxed and fully guaranteed. Fitted with leader and stop foils.

| | Standard | | Double Play | |
|---|---|---|---|---|
| 5in. | 600ft. | 13/- | 1,200ft. | 31/6 |
| 5½in. | 900ft. | 16/- | 1,800ft. | 37/6 |
| 7in. | 1,200ft. | 21/- | 2,400ft. | 47/6 |
| | Long Play | | Post & Pack per | |
| 5in. | 900ft. | 17/6 | reel, 1/- plus 6d. | |
| 5½in. | 1,200ft. | 19/6 | ea. for additional | |
| 7in. | 1,800ft. | 28/6 | reels. | |

**SPECIAL OFFER.** 3in. Message tape 150ft. 3/9; 3in. L.P. 225ft. 4/9; 3in. D.P. 300ft. 6/6; P. & P. per reel 6d.
**TAPE REELS.** Mnfrs.' surplus 7in. 2/3; 5½in. 2/-; 5in. 2/-; 3in. 1/3; Plastic spool containers, 5in. 1/9; 5½in. 2/-; 7in. 2/3.

**SPEAKERS P.M.** 3 ohms. 2½in. EMI, 15/6. 3in. Goodmans 16/6. 5in. Rola 15/6. 6in. Elac 16/6. 7 × 4in. Goodmans 15/6. 8in. Rola 19/6. 10in. Elac 25/-. 10 × 6in. Goodmans 22/6. 2½in. E.M.I. Tweeter, 22/6. 13½in. × 8in. E.M.I. (Ceramic Magnet), 37/6.

**ENAMELLED COPPER WIRE**—½lb. reels 14g-20g 2/6; 22g-28g, 3/-; 30g-34g, 3/9; 30g-38g, 4/3; 39g-40g, 4/6, etc.

**TINNED COPPER WIRE** 16-22g., 2/6 ½lb. **VALVE HOLDERS**—Int. Oct. 6d. Nylon or Ceramic, B7G, B9A unskirted, 9d. B7G B9A skirted 1/- each; B7G with Can 1/6; B9A with Can, 1/9, etc.

**KNOBS**—Modern Continental types:—Brown or Ivory with Gold Ring. 1in. dia. 9d. ea. 1¾in. 1/- ea. Brown or Ivory with Gold Centre, 1in. dia. 10d. each; 1¾in. 1/3 each. LARGE SELECTION AVAILABLE.

**TYGAN FRET** (Contem. pat.) 12 × 12in. 2/-; 12 × 18in. 3/-; 12 × 24in. 4/-, etc.
**BONDACOUST Speaker Cabinet Acoustic** Wadding, approx. 1in. thick. 18in. wide, any length cut 2/3 ft. 6/- yd. **EXPANDED ANODIZED METAL.** Attractive gilt finish, ¼ × ¼in. diamond mesh 4/6 sq. ft. Multipies of 6in. cut. Max. size 4ft. × 3ft. 47/6 plus carr.

**JASON F.M. TUNER UNITS**
Designer-approved kits available.
**FMT1.** 5 gns. 4 valves 20/-.
**FMT2.** £7. 5 valves 35/-.
**JTV Mercury, 10 gns.** 3 valves 22/6.
**JTV2.** £13/19/6. 4 valves 28/6.
**NEW JASON F.M. HANDBOOK 2/6.**
48 hr. Alignment Services, 7/6 plus 2/6.

**CONDENSERS—Silver Mica.** All values, 2 pf. to 1,000 pf., 6d. each. Ditto ceramics 9d. Tub. 450 v. T.C.C., etc. .001 mfd., .01 and .1/350 v. 9d. .02-1/500 v., 1/-. .25 Hunts 1/6. .5 T.C.C. 1/9 etc., etc.
**CLOSE TOL S/MICAS,** 10% 5 pf.-500 pf. 8d. 600-5,000 pf. 1/-. 1% 2 pf.-100 pf. 9d. 100 pf.-500 pf. 11d. 575 pf.-5,000 pf. 1/6.

**RESISTORS—Modern ratings full range 10 ohms to 10 megohms,** 20% ½ w. 3d. ea., ditto 1 w. 6d. ea., 2 w. 9d. ea., 10% ½-1 w. 4d. ea., 5% Hi-stab, ½-1 w. 6d. ea. (below 100 ohms and over 1 meg. 9d. ea.). 1% Hi-stab., ½ w. 1/6 ea. (below 100 ohms 2/- ea.).
**WIREWOUND,** 25 ohms to 10K. 5 w. 1/3. 10 w. 1/6. 15 w. 2/-.

**PRE-SET T/V POTS.** W/W 25 ohms-50K, 3/-. 50 K. 2 Meg. (Carbon), 3/-.

**Electrolytics All Types New Stock**

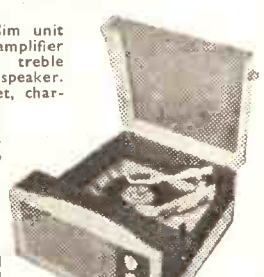
| TUBULAR | | CAN TYPES | |
|---|---|---|---|
| 25/25v. 50/12v. | 1/9 | 8+8/450 v. | 4/6 |
| 50/50v. 100/25v. | 2/- | 32+32/275v. | 4/6 |
| 8/450v. 4/350v. | 2/3 | 50+50/350v. | 6/6 |
| 16/60/450 v. | 5/6 | 60+250/275v. | 17/6 |
| 32/32/450 v. | 6/6 | 100+300/275v | 12/6 |

Transistor Midge types—all values 1 mfd. to 50 mfd. 1/9 ea. 100 mfd. 2/-, 12 v.

**VOLUME CONTROLS**—5K—2 Meg. ohms, 3in. SPINDLES, MORGANITE MIDGET TYPE. 1½in. dia. Guar. 1 year. LOG or LIN. ratios, less Sw. 3/-. D.P. Sw. 4/6. Twin Stereo less Sw. 6/6. Some values with DP Sw. 8/6.

## DE-LUXE RECORD PLAYER KIT

Incorporating 4 Sp. Garrard Auto-Slim unit and Mullard latest 3 watt printed circuit amplifier (ECL86 and EZ80), vol., bass and treble controls, with 8 x 5in. 10,000 line speaker. Contemporary styled two-tone cabinet, charcoal grey and off-white with matching blue relief. Size 17½in. x 16in. x 8in. A stylish unit capable of quality reproduction. Circuit and const. details 2/6 (free with kit).



**COMPLETE KIT** Carr. and ins. 10/-. **£13.19.6**

Illuminated Perspec control panel escutcheon 7/6 extra. Ready wired 30/- extra. 4 contemporary mounting legs (6 or 13in.), 12/6 per set.

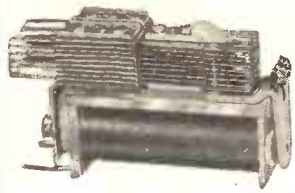
**Only a few items are listed from our comprehensive stock. Write now for full bargain lists, 3d.**

*Terms: C.W.O. or C.O.D. post and packing ½lb. 9d., 1lb. 1/3, 3lb. 2/3, 5lb. 2/9, 10lb. 3/9, etc.*

**T S RADIO COMPONENT SPECIALISTS** *Established 1946*

**70 BRIGSTOCK RD., THORNTON HEATH, SURREY**
*Tel.: THO 2188: Hours 9 a.m.—6 p.m. 1 p.m. Wednesday.*

# Wilkinsons FOR RELAYS



## P.O. TYPE 3000 AND 600

**BUILT TO YOUR REQUIREMENTS — QUICK DELIVERY**
**COMPETITIVE PRICES—VARIOUS CONTACTS**
**DUST COVERS—QUOTATIONS BY RETURN**

### MINIATURE SEALED RELAYS

**OVER 120 TYPES IN STOCK. SEND FOR LIST.**

| SIEMENS 1 C.O. | | | |
|---|---|---|---|
| 2.2Ω+2.2Ω | | H96A | 18/6 |
| 50Ω+50Ω | | H96B | 19/6 |
| 145Ω+145Ω | | H96C | 19/6 |
| 1,700Ω+1,700Ω | | H96E | 22/6 |
| **G.E.C.** | | | |
| 2,500Ω | 4CO | M1008 | 19/6 |
| 2,500Ω | 1CO | M1022 | 15/– |
| 5,000Ω | 2CO | M1052 | 17/6 |
| 670Ω | 2m2bHD | M1095 | 17/6 |
| 2,500Ω | 2C2K | M1417 | 19/6 |
| 5,000Ω | 2CO | M1452 | 17/6 |
| 2Ω | 2mHD | M1454 | 15/– |
| 2,500Ω | 2mHD | M1458 | 15/– |
| 2,500Ω | 1m1bHD | M1462 | 15/– |
| 40Ω | 2CO2K | M1482 | 19/6 |
| 180Ω | 1CO | M1486 | 15/– |
| 180Ω | 2m2bHD | M1487 | 17/6 |
| 180Ω | 2C2K | M1490 | 19/6 |
| 670Ω | 2C2K | M1493 | 19/6 |
| 670Ω | 4K | M1567 | 19/6 |

| S.T.C. | | | |
|---|---|---|---|
| 45Ω | 1mHD | 4186EB | 19/6 |
| 170Ω | 1mHD | 4186EC | 19/6 |
| 700Ω | 2COMD | 4190HD | 19/6 |
| 2,500Ω | 2CO | 4184GE | 19/6 |
| 2,500Ω | 1mHD | 4190EE | 19/6 |
| **ERICSSON** | | | |
| 7,000Ω | 1CO | N22242A10 | 25/– |
| 260Ω | 1CO | N22372AC1 | 15/– |
| 5,000Ω | 1CO | N22372AE1 | 15/– |
| 7,500Ω | 2CO | N22365AZ1 | 17/6 |
| 1.1Ω | 4CO | N22364AA1 | 19/6 |
| 1.1Ω | 2CO2K | N22366AA1 | 19/6 |
| 1,500Ω | 2CO2K | N22366AE1 | 19/6 |
| 2.4Ω | 2M | N22371AA1 | 15/– |
| 180Ω | 2M | N22371AC1 | 15/– |
| 2,000Ω | 2M | N22371AE1 | 15/– |
| 2.4Ω | 1m1b | N22370AA1 | 15/– |
| 52Ω | 1m1b | N22370AB1 | 15/– |
| 1,500Ω | 2m2b | N22369AE1 | 17/6 |
| 7,500Ω | 2m2b | N22369AZ1 | 17/6 |

**S.T.C. POLARIZED RELAY 4192B.** Coil 4×550Ω with jack, **50/-.**
**MINIATURE UNISELECTORS. Plug-in type. Occupies no more space than a P.O. 3000 Relay. Siemens No. 2200A, 3 level, 12 outlets, 50 volts, 1 bridging and 2 non-bridging wipers. Supplied complete with jack. EACH 90/-**
**STROWGER RELAYS.** 1500Ω 4 make Platinum. **35**/– each.
**LONDEX RELAYS** Type LF 24 v. D.C. or 440 v. A.C. 2 Break **35**/– each.
**RELAYS** 24 volt D.C. 4 Make, 4 Break 10 amp. 5C/3944 Dust cover. **12/6** each.

**KEY SWITCHES** (3 position).
P.O. 212 2C/2C Locking **6/6.**
P.O. 264 2K/2K Locking **9/–.**
4C/4C Non locking **13/6.**
P.O. 295 4C/6C NL/L **17/6.**
Other types available. Knobs **6d.** Plates **1/-.**

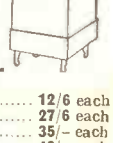
**LEDEX SOLENOID DRIVEN WAFER SWITCHES.** Size 5S. From **90/-**, 11 way and off 3 to 24 Pole, also 4 Pole 12 Way and 54 Pole on/off. Commutating switch section and control wafers available.

**POTENTIOMETERS, WIREWOUND AND CARBON** including Sub-miniature, sealed and precision types. latest addition 7.5 WATT PAINTON SEALED in preferred values 100Ω to 50KΩ **9/-** each, list now ready. 10 WATT BERCO 20KΩ with taps at 5, 10 and 15KΩ, ideal for test equipment etc. Complete with 3in. skirted knob and dial **15/-.** Post 3/-.

**GEARED CAPACITOR MOTORS.** 220/240 v., 50 cy., 30 watts, 300 r.p.m., also spindle for 1,425 r.p.m. Very powerful, **75**/–, post 5/-.
**MAINS MOTORS.** Capacitor 230 v. A.C. 1/40th h.p., 1,400 r.p.m. **55/–**, post 4/6.
**SYNCHRONOUS MOTOR.** 200/250 v. A.C. 50 cycles with gear train driving 5 dials 1/10th hr.-10,000 hrs., **22/6,** post 3/-.
**SYNCHRONOUS MOTOR.** 200/250 volts A.C. 60 r.p.m. Synclock, **25**/–, post 2/-.
**SATCHWELL THERMOSTATS** adjustable between 70°-190° Fahrenheit. 0-440 v. A.C., 20 amp., 11in. stem. Fitted cover **19/6,** post 2/6.
**ROOM THERMOSTAT.** Adjustable between 45 and 75 deg. Fahr., 250 v. 10 amp. A.C. Ideal for greenhouses, etc., **35/-**, post 2/6d.
**JACK PLUGS.** Screw-on cover, 2 contacts, **2/6,** post 6d.

P.O. 201 on headphone cord 10H/117 **3/-** ea. Post 1/-.
**SPEAKERS** Elac 5in. Round 3Ω **11/6**; Plessey 3in. with grille, **12/6,** post 2/-.
**AUTO TRANSFORMERS by S.T.C.** Totally enclosed C core type, 110-250 volts, 8 tappings, 50 cycles, size 6½×5¾×5½, 500 watts. New latest type **£4.**
**VOLTAGE REGULATORS.** Input 230 v. A.C., 21 amp. Output 57.5 v. to 230 in 16 steps with current limiting reactor, **£20** each, carriage 15/-.
**MAINS TRANSFORMERS.** Input 200/250 volts. Output 300-0-300 volts. 250 mA., 6.3 volts, 9 amps., **25/-.** Post 3/9.
**FANS INDUSTRIAL TYPE.** 230/240 volt A.C. Capacitor, Motor 16in. blades, adjustable louvres, filter. Ideal for paint shop, **£20,** carr. 25/-.
**XPELAIR EXTRACTION FANS.** 7½in. blades, Baffle outlet **190/-.** Carr. 6/-.
**BLOWER MOTORS.** 200/250 volt Capacitor Type 2,800 r.p.m. Cylindrical casing 7in.×7in.×7in. with open flange each end **£12/10/-.**

**ONE HOLE FIXING SWITCHES**
**12/- per dozen 75/- per 100**
SINGLE-POLE Double Throw, 3 amp. 250 A.C.
Can be used as ON/OFF or CHANGE-OVER SWITCH.



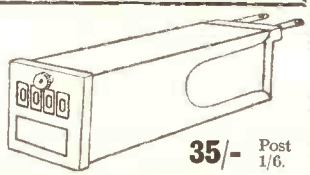
**SELENIUM METAL RECTIFIERS. FULL WAVE BRIDGE**

| | | | |
|---|---|---|---|
| 12 Volts 1 Amp. | 7/6 each | 24 Volts 1 Amp. | 12/6 each |
| 12 Volts 2 Amps | 12/6 each | 24 Volts 3 Amps | 27/6 each |
| 12 Volts 4 Amps | 17/6 each | 24 Volts 5 Amps | 35/– each |
| 12 Volts 6 Amps | 20/– each | 24 Volts 8 Amps | 40/– each |

**VEEDER-ROOT MAGNETIC COUNTERS WITH ZERO RESET 800 COUNTS PER MINUTE. 6 FIGURES. GENERAL PURPOSE TYPE. VARIOUS A.C. VOLTAGES AVAILABLE FROM 110V to 250V. 65/– post 2/6.**

### SMALL MAGNETIC COUNTERS

3½in.×1in. 10 counts per second, with 4 figures. The following D.C. voltages are available, 6 v., 12 v., 24 v., 50 v., or 100 v.



**35/-** Post 1/6.

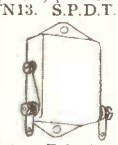
### Microammeters, Milliammeters, Voltmeters

**2½in. Moving Coil Flush Round.** 100 Microamp, **40/-**; 10-0-10 Milliamp, **35/-**; 50 Milliamp. **35/-**; 100 Milliamp **25/-**. Proj. Round 50 Microamps. Special scale **45/-**. All D.C.; 100 Microamps, A.C. **85/–.**
**3½in. MC Flush Round.** 100-0-100 Microamp, **70/-**; 500 Microamp **70/-**. 10 amp. **45/-**. 500 Milliamp **54/-.**
**2in. Moving Coil Flush Round.** 0/1 Milliamp; 0/5 Milliamp.; 0/10 Milliamp.; 0/20 volts; 0/30 volts; 0/40 volts; 0/5 amp., all at **27/6** each.
**MICROAMMETERS.** 2in. 0/500 D.C. Flush Round, **25/-.**
**M.C. RECTIFIER A.C. METERS.** 3½in. FR 10 Milliamps, **70/-**; 50 volts, **72/-**; 100 volts **70/-**; 200 volts **75/-**; 1,000Ω per volt.
**MOVING IRON AC AMMETERS.** 0/10 2½in., **44/-**; 0/20 3½in. **56/-**, both flush round 0/60 6in. Projection Round, **90/-.** Postage on small meters, 2/-.
**FREQUENCY METERS.** 45-55 cycles per second, 230 volt, 6in. dia. Flush round. Brand new in maker's box. **£10/10/-,** post 5/-.
**VOLTMETERS** with alarm contacts 55/65 volts Moving Coil 9in., **150**/– each.
**PORTABLE VOLTMETERS** 150 volts D.C. MC 6½in. square by 3½in., **70**/– each, post 3/6.
**PORTABLE AMMETER.** 0-3 amp. A.C./D.C. 3in. scale, **35/-,** post 2/6.
**AMMETER,** reading 50-0-50 amp., 2in. Flush Square, **17/6** each, post 2/-.
**VOLTMETER.** A.C. 0/300 2½in. Flush Round, **25/-,** post 2/-.

**WEE MEGGER INSULATION TESTERS. 500 VOLT SERIES 3. BRAND NEW in leather carrying case £18/10/-.**
**MEGGERS. SERIES 2 ALI CASE, 500 VOLTS 100 MEGOHMS, WITH LEATHER CASE, LEADS, KEY, ETC. BRAND NEW £37/10/-.**
**Few others available in good condition, £25.**

**AVO TEST BRIDGES.** 200/240 volt A.C. Measure capacities from 5 pf. to 50 mfd. and resistances from 5 ohms to 50 megohms. Valve voltmeter range 0.1 to 15 volts and condenser leakage test. Full working instructions supplied with instrument. **£9/10/-.** Post 5/-.
**MODEL 7 AVOMETER POWER FACTOR AND WATTAGE UNIT £7, NEW**
**A few AVOMETERS Model 7 also available.**

**MINIATURE SILVER ZINC ACCUMULATOR.** 1.5 volt, 1.5 ampere. Size 2in. × 1.13in. × 0.63in. Weight 1¼ oz. Ideal for model work **12/6** ea. **120/-** doz. post 9d.
**STROBOSCOPE FORK.** 125 cycles. P.O. No. 5 **30/-** ea., post 2/-.
**MIRROR GALVANOMETERS BB 3000.** N.E.P. Focal length 20 cm. **£18.**
**MICRO SWITCH.** Burgess MK4BR, robust die cast casing, **8/6** ea., post 9d.
**SUBMINIATURE MICRO SWITCHES HONEYWELL.** 11SM1-TN13. S.P.D.T. Size .781in.×.250in.×.356in. **6/6** each. Full details on request.



**MINIATURE BUZZERS.** 12 v. with adjustable tone. **7/6.**
**BUZZERS.** 230 v. Ironclad Gents P367AC **50/-.** Post 3/6.
**HIGH NOTE BUZZERS.** 24 v. AC/DC, with tone adjuster 2⅜in. dia. Bakelite case, **10/6.** Post 1/6.
**CHOKES** 9 Henries 100 m/A. Parmeko **7/6** each, post 3/-.
**RESISTORS WIREWOUND AND HIGH STABILITY CARBON** inc. Erie 109, 108 and 100, ex stock in quantity. Write or phone your requirements.
**LANCASTER PORTABLE ELECTRIC BRONZE WELDING AND SOLDERING OUTFITS.** 230/240 volts with 4 Position Rotary Switch and 3 terminal setting gives 12 variations of heat. Complete with metal carrying case containing filler rods, fluxes etc. **£25.**
**SIGNAL GENERATOR TYPE 52A.** Input 230 volt 50 cycles, complete with leads, dummy antenna. Brand new in transit case. 6 to 52 Mc/s. inclusive in 4 bands with calibration charts. Coarse and fine attenuators. Int. and ext. mod. Output 0.5 volt to 100 mv., impedance 70 and 100Ω, **£10,** carriage 20/-.
**PRECISION SILVER MICA CAPACITORS,** 0.1 mfd. ½%, **6/-** ea.; 1% **5/-** ea.
**"VISCONOL-CATHODRAY" CONDENSERS.** .001 mfd. 10 kV. **5/-**; .002 mf 15kV., **9/-**; .02 mf 10kV, **10/-**; .025mf 2.5kV, **5/-**; .05mf 5 kV, **9/-**; 0.1mf 4kV, **9/-**; 6kV, **17/6**; 0.5mf 2.5kV, **17/6**; 1mfd 2kV., **17/6.**

**L. WILKINSON (CROYDON) LTD.**
LONGLEY HOUSE LONGLEY RD. CROYDON SURREY
Phone: THO 0236 Grams: WILCO CROYDON

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## TWO-WAY RADIO

**A compact V.H.F. Trans./Rec., that can be held in the hand. Size approx. 12in. × 3in. × 2in. Range up to three miles under favourable conditions. Utilises 3 miniature valves and self-contained standard batteries. Easy to operate, economical to run. Ideal for authorised fixed or mobile operation. British manufacture. Limited number left. Price 12 gns. per pair, post free.**

## WANTED

WE WISH TO PURCHASE FOR SPOT CASH, RADIO COMMUNICATION EQUIPMENT: TRANSMITTERS, COMMUNICATION RECEIVERS, TRANSCEIVERS (Government surplus, Commercial and Foreign). WE ARE SURE THAT MANY ENTHUSIASTS HAVE UNWANTED EQUIPMENT TAKING UP SPACE AND COLLECTING DUST. SO LOOK AROUND AND TURN YOUR REDUNDANT EQUIPMENT INTO CASH, OFFERS MADE FOR ANY SUITABLE EQUIPMENT. SEND FULL DETAILS STATING TYPE, MAKE AND CONDITION, WITH S.A.E. FOR QUOTATION TO BUYING DEPT.

**Morse Keys.** Morse Key Assembly. Key with base, cover and terminals. Complete with lead. **6/11**, p/p 2/-. 2 Morse keys for **12/6**, post free.

**M.A.T. Transistors.** M.A.T. 100, 7/9; M.A.T. 120, 7/9; M.A.T. 121, 8/6. Ferrite slab aerials suitable for Transistor sets, 3/-, p/p 6d.

**Operators Unit.** Huge purchase enables us to offer at give-away price this unit containing standard jack socket 250 mfd., electrolytic condenser, 4-way telephone socket, midget selenium rectifier, etc. Price **3/6**, p/p 9d.

**Matched Mullard Transistors.** One OC81D driver. Two OC81 output stage matched pair. Price **9/11** the set, p/p 1/-.

**American Signal Generator V.H.F. Model.** A well made instrument with a built-in crystal and master osc. Exceptionally fine slow motion tuning with easily read scale. Stepped output and adjustable amplitude. Ideal for 2 metres and V.H.F. calibration. Price **49/6**, p/p 5/-.

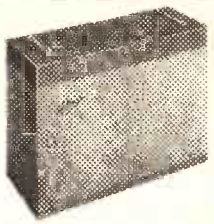
**Handy Power Pack.** Housed in compact metal case. 200/250 v. mains input. Output 250v. D.C. 60 m.a. fully smoothed. 6.3v. at 2 amps. Can be used for powering almost any preamp or radio tuner. Price **39/6**, p/p **2/6**.

**Portable Mains Soldering Iron.** 30 watt version. Features removable handle that covers tip and barrel. Complete with lead and plug. Only **10/6**, p/p 1/6.

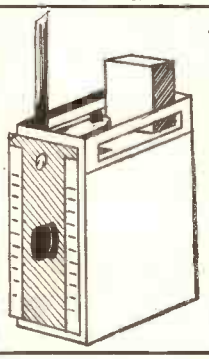
**6 ohm Wire Wound Miniature Potentiometers** with Standard Spindle, with many uses, **1/6** each, p/p 6d. 2 for **3/-**, post free.

**Crystal Set Kit.** A wonderful educational kit for all children. Provides hours of amusement while following the easy step by step instructions. It is powered entirely by wireless waves, eliminating the expense of batteries. No soldering required. Receives all main stations, **19/6**, p/p 2/6.

## HEAVY DUTY SPEAKER CABINETS



Attractive two-tone finished speaker cabinets, size 28in. × 20in. × 10½in. Will take two 12in. loudspeakers. Excellent acoustic properties. Ideal for home use, group or P.A. work. Price **10 gns.** each, p/p 10/-. B.R.S.



## VEHICLE RADIOTELEPHONE

Originally used by the armed forces for field communication. This compact little unit can be powered by a car battery and two 60V or 90V H.T. batteries. Communication is possible up to a distance of 3 miles in favourable terrain, and on testing the receiver we were able to receive many continental and maritime stations. Battery drain is less than ¾ of an amp. Output stage de-commissioned to conform with regulations. Full wiring instructions provided. Price **5 gns.** each, carriage free. 2 for **£10**, carriage free.

## THE Goldenair "THIRTY" HI-FI AMPLIFIER

A high quality 30-watt amplifier developed for use in large halls and clubs, etc. Ideal for bass, lead or rhythm guitars, schools, dance halls, theatres and public address. Suitable for any type of mike or pick-up. Valve line-up: two EF86; one ECC83; one GZ34; two EL34. Four separate inputs are provided with two volume controls. Bass and Treble controls are incorporated. Amplifier operates on standard 50 c/s. mains. 3 ohm and 15 ohm speakers may be used.
Perforated cover with carrying handles can be provided if required, price 21/-.

go Goldenair

Customers are invited to see and hear this amplifier at our shop premises in Lambert's Arcade. Send S.A.E. for illustrated leaflet.

Carriage 15/- to be sent with order.

16 GNS

**TWICE THE QUALITY — HALF THE PRICE**

## SPECIAL LINES

**19 set Instruction Handbook** 3/6 each, p/p 6d.

**1155 Instruction Handbook** 3/6 each, p/p 6d.

**H.R.O. Instruction Handbook** 3/6 each, p/p 6d.

**Frequency Meter, BC 221 Instruction Handbook** 3/6 each, p/p 6d.

**46 Walkie Talkie Set Circuit and Notes,** 3/6 each, p/p 6d.

**38 Set A.F.V. Instruction Handbook** 3/6 each, p/p 6d.

**R.F. Unit 24 Circuit Diagram and Details.** Price 1/6, p/p 3d.

**R.F. Unit 25 Circuit Diagram and Details.** Price 1/6, p/p 3d.

**R.F. Unit 26 Circuit Diagram and Details.** Price 1/6, p/p 3d.

**Receiver R1355 Circuit Diagram and Details.** Price 1/6, p/p 3d.

**Receiver R1224A Circuit Diagram and Details.** Price 1/6, p/p 3d.

**R.1116/A Circuit Diagram and Details.** Price 1/9, p/p 3d.

**Wave Meter Class D Handbook, Mk. I, II and III.** Price 3/6, p/p 6d.

**Multi Voltage Mains Transformer.** Primary 200/250 50 c/s. Secondary tapped as follows: 3V, 4V, 5V, 6V, 8V, 9V, 10V, 12V, 15V, 18V, 20V, 24V and 30V. All at 2 amps. Price **35/-** p/p 3/6.

**Battery Charge Adjuster.** Charge Rate Adjuster. Government manufacture. Easily fitted to charging circuit. **3/6** each, 2 for **6/6**, p/p 1/- each.

**Resistor Colour Code Indicator.** Saves time and money. Gives the value of a resistor at a glance. Price **1/6**, p/p 3d.

**Tank Aerials.** Fully interlocking copper sections one foot in length. Will make ideal dipoles, car or scooter aerials. Price 6 sections complete with canvas carrying case, **3/6**, p/p 1/6. Additional sections 6d. each. Please include sufficient postage.

**19 set Trans/Rec. Mains Power Pack.** Operate your 19 set receiver straight off the mains. Ready built power unit, complete with modification and fitting instructions. Price **49/6**, p/p 3/6. Please state Model, Mk. 2 or Mk. 3.

**High Quality Paxolin Sheets.** Strong high quality Paxolin sheets. Size 10½ × 8½ × 1/10in. Three for **5/-**, p/p 1/-. Six for **10/-**, post free. Twelve for **18/6**, post free.

**Constructors' Parcel No. 2.** All brand new items, not government surplus. 6 phono plugs, 2 continental plugs, 3 and 5 pin; 12 small croc. clips; 12 large croc. clips; 24 assorted new resistors; 3 pointer knobs; 3 coax plugs; 6 sheets of paxolin, approx. 10in. × 8in.; 2 sturdy panel mounting fuse holders; 6 multicored solder packs; 1 30-watt lightweight soldering iron. Price **29/11**, p/p 3/6.

**High Impedance Personal Listening Earpiece.** Suitable for all types of crystal sets and transistor sets. Complete with lead and plug. Price **4/11**. p/p 6d.

**Mains Metal Rectifiers.** Half wave, approx. rating 250 volts, at 75 mA., price **2/6** each, p/p 9d. **2 for 4/6**, post free.

**8 mfd Block Condensers,** metal encased made to high specifications. Rating 350 volts. Ideal for cross over networks. **5/11** each, post free. 1 mfd block condensers 750 volts, working, **3/11** each, post free.

**POSTAGE RATES APPLY U.K. ONLY. S.A.E. WITH ALL ENQUIRIES**
**NEW WALK ROUND STORE OPEN IN LAMBERT'S ARCADE, LOWER BRIGGATE, LEEDS 1. NEXT TO HALFORDS CYCLE SHOP. OPEN ALL DAY SATURDAY.**
**ALL MAIL ORDERS TO OUR BRIGGATE HOUSE ADDRESS**

**TERMS:**
**CASH WITH ORDER**
**5/- EXTRA ON C.O.D. ORDERS**
**No C.O.D. under 30/-**

SONA

**SEND 1/- FOR LISTS.**
**TRADE SUPPLIED**
**ORDERS FROM ABROAD WELCOMED**

**SONA ELECTRONIC CO., LTD. (Dept. W.W.10), BRIGGATE HSE., 13 ALBION PL., LEEDS**

# ervice in Great Britain

# CONSTRUCTORS BARGAINS

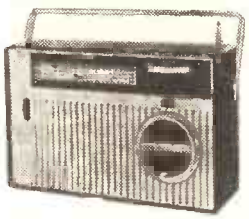
## LASKY'S RADIO

THE WIDEST RANGE AVAILABLE TODAY FOR HOME CONSTRUCTION OR READY BUILT TO HIGHEST STANDARDS

**We consider our Construction Parcels to be the finest value available on the home construction market. If on receipt you feel not competent to build the set, you may return it as received within 7 days, when the sum paid will be refunded less postage.**

## TRANSISTOR PORTABLES

### THE SKYROVER AND SKYROVER DE LUXE



**GENERAL SPECIFICATION**
7 transistor plus 2 diode superhet; 6 waveband portable receiver.
The SKYROVER and SKYROVER DE LUXE cover the full Medium Waveband and Short Waveband 31-49M. and also 4 separate switched band-spread ranges, 13M., 16M., 19M., and 25M., with Band Spread Tuning for accurate Station Selection. The coil pack and tuning heart is completely factory assembled, wired and tested. The remaining assembly can be completed in under three hours from our easy to follow, stage by stage instructions. Superhet, 470 Kc/s. All Mullard Transistors and Diode. Uses 4 U2 batteries. 5in. Ceramic Magnet P.M. Speaker. Easy to read Dial Scale. 500 MW Output. Telescopic Aerial and Ferrite Rod Aerial.

**NEW! SKYROVER MK. III** (Illustrated). Now supplied with redesigned plastic cabinet, finished in black and grey with chrome trim, edgewise controls. Controls: Waveband Selector, Volume Control with on/off switch, Tuning Control. In plastic cabinet, size 10 × 6¼ × 3¾in. with metal trim and carrying handle.

Can now be built for **£8.19.6** Post 5/- extra. H.P. Terms: £1 deposit and 11 monthly payments of 16/6 Total H.P.P. £10/1/6

**The SKYROVER De Luxe** Tone Circuit is incorporated, with separate Tone Control in addition to Volume Control. Tuning Control and Waveband Selector. In a wood cabinet, size 11¼ × 6¼ × 3in. covered with a washable material, with plastic trim and carrying handle. Also car aerial socket fitted.

Can now be built for **£10.19.6** Post 5/- extra. H.P. Terms: 25/- deposit and 11 monthly payments of 20/-. Total H.P.P. £12/5/-

Data for each receiver: 2/6 extra. Refunded if you purchase the parcel. Four U2 batteries 3/4 extra. All components available separately.

**★ LONG WAVE AND COVERAGE IS NOW AVAILABLE FOR THE SKYROVER & SKYROVER DE LUXE** A simple additional circuit provides coverage of the 1100/1950 M. band (including 1500 M. Light programme). This is in addition to all existing Medium and Short wavebands. All necessary components with construction data. Only **10/-** extra. Post Free.

**This conversion is suitable for Skyrover and Skyrover De Luxe receivers already constructed.**

### REALISTIC SEVEN

Fully tunable over long and medium wavebands. Uses 7 Mullard Transistors, plus Diode OA70.

**STAR features:**
★ 7 Transistor Superhet. ★ 350 Milliwatt output 4in. high flux speaker. ★ All components mounted on a single printed circuit board, size 5¼in. × 5¼in., in one complete assembly. ★ Plastic cabinet, with carrying handle, size 7in. × 10in. × 3¼in. in blue grey. ★ Easy to read dial. ★ External socket for car aerial. ★ I.F. frequency 470 Kc/s. ★ Ferrite rod internal aerial. ★ Operates from PP9 or similar battery. ★ Full comprehensive data supplied with each receiver. ★ All coils and I.F.s, etc., fully wound ready for immediate assembly. An outstanding Receiver.

Can be built for **£5 . 19 . 6** Post 4/6.

**REALISTIC SEVEN De Luxe** By popular request a De Luxe version of the well-known Realistic Seven now available. With the same electrical specification as standard model—PLUS A SUPERIOR WOOD CABINET IN CONTEMPORARY STYLING covered in attractive washable material, with super-chrome trim and carrying handle. Also a full vision circular dial, externally mounted to further enhance the pleasant styling. **ONLY £1 EXTRA.**
Both models: Battery 3/9 extra. (All components available separately). Data and instruction separately 2/6, refunded if you purchase parcel.

### SINCLAIR SUPER MINIATURES

**THE MICRO-6** Self-contained pocket radio, size only 1⅞in. × 1⅝in. × ⅝in. Truly amazing performance. All parts complete with earphone and detailed construction data. Mercury cell 1/11 extra (2 required). **59/6** CAN BE BUILT FOR

**THE SLIMLINE** The new 2-transistor pocket radio size only 2⅛in. × 1⅛in. × 1⅛in. Micro alloy transistorised and printed circuit. All components available separately. Easy to assemble. **49/6** CAN BE BUILT FOR

**THE NEW X10** 10 watt power amplifier fitted with integrated pre-amplifier. Requires only 1 mV. for an output of 10 watts undistorted. Size only 6 × 3 × ⅞in. Weight 5 oz. Circuit uses 7 M.A.T.s and 4 RF power transistors. **£5.19.6** KIT PRICE

AVAILABLE READY BUILT, TESTED AND GUARANTEED, £6/19/6 POST FREE.
3 pots. for vol., Bass and Treble, 7/6 the 3 extra. Mains power pack, if required, 54/-.

**MINIATURE EARPIECES** for Transistor Radios, Transparent ear inserts with 3ft. cord, sub-min. jack and socket. Fully guaranteed. Post free.

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| CE.5. | Crystal high imp. | 5 0 |
| MR.4. | Magnetic low imp. | 6 6 |

## CONSTRUCTORS BARGAINS

### THE NEW "KUBA" IMPORTED AM/FM STEREO RADIOGRAM CHASSIS

Long, medium and short waveband coverage, plus V.H.F./F.M. Piano key wavechange. Separate flywheel tuning on A.M. and F.M. Bass, treble and balance controls. Magic-eye tuning indicator. Ferrite rod aerial. The very latest printed circuitry. Provision for multiflex. 5 valves: line-up: ECC85, EC 801, ECC83, ELL80, EAF801. Full vision tuning scale size 21 × 6in. Overall dimensions 21 × 6¼ × 8in. Made to the very highest standards. 3Ω output. 5 watts per channel.

LASKY'S PRICE **29½ GNS.** Carriage and insurance 12/6 extra.

### BUILD A HIGH QUALITY TAPE RECORDER

**Using the famous Collaro "STUDIO" deck and MARTIN pre-assembled amplifiers, 2- or 4-track models.**

**COLLARO STUDIO TAPE DECK.**
Latest model 3 speed, 3 motors. Takes 7in. reels. Fitted with half-track heads. New and Unused. LASKY'S PRICE £10/10/-. Carr. & Pack. 7/6.

**COLLARO STUDIO TAPE DECK.** As above but fitted with the latest quarter-track heads. LASKY'S PRICE £13/19/6. Carr. & Pack. 7/6.

**MARTIN TAPE RECORDER AMPS.** Designed for use with Collaro Studio Tape Deck. In sub-assemblies for immediate installation. 6-valve circuit. Comprehensive instructions make final assembly as simple as possible. Everything supplied including valves, etc. Monitoring facilities. 3 ohm output, speed equalising, etc. For 200-250 v. A.C. mains.
PRICES: ¼ track Model **£11/11/-**, ½-track Model **£12/12/-**. Post 2/6.
Portable carrying case designed to take the Collaro Studio Tape Deck and the Martin Tape Amplifier. Fitted with 9 × 5in. speaker. Price complete with speaker £5/5/-. Post 5/-.

**HI-FI TAPE RECORDER HEADS** High Imp. Record/Play. Low imp. erase.
Upper or lower track. LASKY'S PRICE 29/6. Post free per pair. State track required.

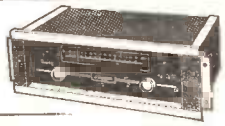
| | | |
|---|---|---|
| MARRIOTT "X" Type ¼-track heads | LASKY'S PRICE | 4 GNS. pair. |
| ¼-track heads Record/Play and Erase | LASKY'S PRICE | 59/6 pair. |
| MICHIGAN ¼-track heads | LASKY'S PRICE | 5 GNS. pair. |
| BOGEN ¼-track heads | LASKY'S PRICE | 7 GNS. pair. |

**TRANSISTORS** ALL BRAND NEW AND GUARANTEED
GET 81, GET 85, GET 86 2/6; 837A, 874P 3/6; OC45, OC71, OC81D 4/6; OC44, OC70, O76, OC81 (match pair 10/6) 5/6; AF117, OC75, OC200 6/6; OC42, OC43, OC73, OC82D 7/6; OC201, OC204 15/-; OC205, OC206 19/6; OC28 24/6.

**TRANSFILTERS** By BRUSH CRYSTAL CO. Available from stock.

| | | | |
|---|---|---|---|
| TO—O1B 465 kc/s. ± 2 kc/s. | TO—O2D 470 kc/s. ± 1 kc/s. | **6/6 EACH** | |
| TO—O1D 470 kc/s. ± 2 kc/s. | TF—O1B 465 kc/s. ± 2 kc/s. | **Post 6d.** | |
| TO—O2B 465 kc/s. ± 1 kc/s. | TF—O1D 470 kc/s. ± 2 kc/s. | | |

**JASON EQUIPMENT**



High quality home construction units for the discerning Hi-Fi enthusiast. We stock the complete range of component parts.

**FROM PRE-AMP TO 20 WATT HI-FI STEREO ASSEMBLY** BY BUILDING WITH MARTIN AUDIOKITS—AVAILABLE FROM STOCK.
Using specially developed circuits, the very latest transistors and printed circuits—these kits are all fully checked and tested before leaving the factory.

| | | |
|---|---|---|
| KIT 1. | 5-stage Matching Input Selector Unit | LASKY'S PRICE £2/7/6 |
| KIT 2. | Pre-amplifier with volume control | LASKY'S PRICE £1/17/6 |
| KIT 3. | 3-Channel Mixer, with plug-in adaptors for individually matching each circuit. Adaptors 8/6 each | LASKY'S PRICE £3/19/6 |
| KIT 4. | Pre-amplifier with tone/volume control stages | LASKY'S PRICE £3/2/6 |
| KIT 5. | 10 and 3 watt Main Amplifier | LASKY'S PRICE £5/12/6 |
| KIT 6. | Power supply Converter Unit | LASKY'S PRICE £2/12/6 |
| KIT 7. | 15 ohm version of Kit 5 | LASKY'S PRICE £6/12/6 |
| KIT 8. | Power supply for Kit 7 | LASKY'S PRICE £2/15/- |

**TAPE DECK MOTORS** Motors for the Collaro Studio Deck—new and unused. 200-250 v. A.C. Take-up and rewind. Listed at £2/5/- each.
LASKY'S PRICE **14/11 each** Post 2/6.
State motor required when ordering.

High quality tape deck capstan motor made by E.M.I. Holland. Bi-directional. Size 4in. dia. × 2in. high, 1in. × ⅜in. spindle. LASKY'S PRICE **19/11** Post 3/6

SEND FOR OUR LATEST BARGAIN BULLETIN. 20 foolscap pages. Hundreds of Bargains for the "ham" and service man. PRICE 6d. POST FREE.

## LASKY'S FOR SPEEDY MAIL ORDER SERVICE

P.T.O. FOR MORE NEWS

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## TEST EQUIPMENT

★ Marconi Universal Impedance Bridge Type 373d. Perfect condition ..... £30. P.P. 15/-
★ Marconi Circuit Magnification Meter Type 329G. As new. Late model ..... £65. P.P. 30/-
★ Marconi Signal Generator Type 144G. Perfect. £18. P.P. 25/-
★ Muirhead Valve Maintained Tuning Fork Type D-630-C incorporates stabilised power unit. Frequency 1,000 c.s. These instruments are new and comply to laboratory standards ..... £25.
Furzhill B.F.O. 0-10 kc/s. Perfect condition. As new. Complete with transit case, etc. £12. P.P. 20/-

## OSCILLOSCOPES

Cossor Double Beam Type 1035, perfect condition. £27/10/-. P.P. 20/-.
Cossor Double Beam Type 1052, portable, condition new, £30. P.P. 20/-.
Hartley/Erscine Double Beam Type 13a, perfect condition. £25. P.P. 20/-.
**B.P.L. ELECTRONIC FREQUENCY METER TYPE FM406-B. Mk. 2.** Range 100 c.s.-10 kc/s. direct reading on 5in. scale meter, facilitates for output to precision recorder if required, as new, £35. P.P. 17/6.

**G.E.C. V.H.F. PANORAMIC RECEIVER TYPE B.R.T.652.** Range 70-200 Mc/s. A laboratory instrument in as new condition. £125.

★ GR. type 583A Power Output Meters, range 5m W. to 5 w., input impedance 2.5-20k ohms, meter calibration 0-50mW and 0-17 DB, multiplier .1, 1, 10, 100 size 10×6×3in. in perfect condition £12/10/-. P.P. 7/6.
Measurement Corporation Square Wave Generator type 71 Frequency range 5 c.p.s. to 100 Kc/s. for 250 v. A.C. operation, size 15×8×7in., in as new condition ..... £35. P.P. 17/6

## PREC. DIRECT READING CAPACITY METER

Range 0-250 pf in three switched ranges, capacitators can be measured on this exceedingly accurate meter directly to terminals or by probe, easy to set up, easy to use, indication to 4inch meter, size 12×8×8in. ..... £35. P.P. 15/-.

## COMMUNICATIONS RECEIVERS

★ AR88D, as new ..... £45. P.P. 25/-
★ Hallicrafters 827 FM/AM 27.8 to 143 Mc/s. from £25. P.P. 25/-
★ S.T.C. B46 1.5 to 15 Mc/s. perfect order ... £12. P.P. 17/6
★ Hammerlund Super Pro SP400SX, 1.25 to 40 Mc/s. with power unit, in excellent condition ..... £45. P.P. 17/6
★ Marconi CR 100/2 60 Kc/s. to 30 Mc/s. perfect condition ..... £25 P.P. 19/6.

All receivers and test equipment offered are in excellent operating condition unless otherwise stated.

## RELAYS TYPE 3000

8 C.O. double wound coil 10+55 ohms, special latching type, a reverse polarity current to either coil releases armature, operating voltage, 6 or 12 v. d.c., brand new stock by famous manufacturer ..... 17/6 ea.
6 C.O. 500 ohms, new stock ..... 10/- ea.
8 C.O. 300 ohms, new stock ..... 10/- ea.
6 C.O. 350 ohms, new stock ..... 10/- ea.

## RELAYS TYPE 600

4 C.O. 1,000 ohms, new stock ..... 7/- ea.
4 C.O. 500 ohms, new stock ..... 7/- ea.
4 C.O. 500 ohms slugged type ..... 7/6 ea.

## RELAYS, MINIATURE

S.T.C. 4184GD, 24 v. 700 ohms, 2 C.O.
S.T.C. 418gb, 6 v. 45 ohms, 2 C.O.
S.T.C. 4184GE 48 v. 2,700 ohms 2 C.O.
S.T.C. 4186EA, 1 v. 2 ohms, 2 C.O.
All above relays 8/6 each, plus P.P. on all relays 1/-.

## SIGNAL GENERATORS VHF/UHF

G.R. type 804 Signal Generators. Frequency range 6-330 Mc/s directly calibrated in 5 switched bands, mod. up to 75% at 400 c.p.s., output from 1uv. to 20mv., easy read output and mod. per cent meters, for 250 v. A.C. operation size 19×12×8in. this fine laboratory instrument at a price you can afford, in perfect condition, £25 packing and carriage paid.

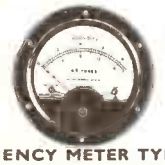
## POWER UNIT TYPE 234A

A source of power to operate your 1392 R/X or any equipment that requires a fully smoothed output of 250 v.d.c. + 6.3 v. at 6 amps., for bench or 19in. rack mounting, fully fused tapped input 200 to 250 v. a.c., brand new cased units at only 55/-. P.P. 12/6.

## DOUGLAS COIL WINDER

Hand operated type in perfect condition, complete with counter wire, guides, etc. ..... £35. P.P. 20/-

## SPECIAL OFFER



of new boxed Weston dual range Micro Amp Meters 50 and 100 size 3½in., flush mounting, sealed type

**59/6**

P.P. 3/6.

## FREQUENCY METER TYPE CT49

Small radio absorption meter frequency range 450 c/s to 22 Kc/s in four directly calibrated ranges ideal for frequency check of terminal units, F.S.K. etc. power supplies dry batteries 1.5v and 22v. Price as new £8.10.0. P.P. 12/6.

**HEADSETS AND MIKES**

DLR5 sound powered ..... 10/6 P.P. 1/6
No. 4A Hand Mikes ..... 7/6. P.P. 1/6

★ **RADAR RANGE CALIBRATOR TYPE 4807** (10s/16906) ★ Complete with all accessories as new.
Wave guide 3 cm. in 6ft. lengths, U.S.A. manufacture, new wrapped, £2/10/- per length.

## VIBRATION ABSORBERS

for motors, fans, blowers up to 1 h.p. and equipment, as illustrated 2in. O.D. ⅜in. screwed, each end. Will make ideal whip aerial bases. New in maker's cartons, 12/6 per carton of four. P.P. 2/6.

## UNIVERSAL WAVEMETER R502

Absorption type wavemeter by S.T.C. frequency range 100 kc/s to 48 Mc/s with nine plug-in coils. Powered by 1½ volt dry cell and triode valve, complete with all calibration charts 250 micro amp meter, super slow motion dial, etc., the wavemeter coils calibration charts are contained in a neat wooden transit case, 14×13×8in., excellent condition, £4/19/6, carr. 7/6.

## TEN TURN COLVERN HELIPOTS

30K ohms, brand new stocks ..... 19/6. P.P. 1/3.

## MARCONI SIGNAL GENERATOR TYPE 726/C1

Frequency range 200 to 400 Mc/s directly calibrated. A modern laboratory instrument, in as new condition £55. P.P. 25/-

## MINIATURE RELAY BANKS

Six miniature relays 9-12 v., 1 make per relay, contained in neat aluminium case 6×4×1½in., with six half inch spaced crystal holders, designed to switch any desired crystal by remote control. Relays and crystal holders can be easily removed for other uses if required, terrific value, only 15/6. P.P. 1/6.

## SOLARTRON OSCILLOSCOPES

Type C.D. 1014 Double Beam portable, late model price £55.

## L.T. TRANSFORMER

5 v. C.T. three times, at 5 amps., 230 v. primary. These U.S.A. transformers are excellent for charging purposes. New boxed, 22/6, Carr. 3/6

Western Electric Sound Level Meter type RA331 to measure from .5db to 120db for 250 v. A.C. operation. £25. P.P. 15/-
Genera Radio Portable Sound Level Meter. Battery operated. Range 40-120dB as new condition. £25. P.P. 12/6
Furzhill Micro Watt output meters, type 140 input impedance 150 ohms, range 1 to 20,000 micro watts. £5/10/- P.P. 5/6
Marconi Conductance Meter, type TF72lb battery operated.
Hewlett Packard Audio Oscillator type 205/Ag perfect condition ..... £30. P.P. 30/-

*We have in stock a fair range of teleprinting equipment, including Audio and I.F. F.S.K. units. Your enquiries are invited.*

**P. F. RALFE**
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**MOUNTVIEW 6939**

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# LASKY'S RADIO

## Super Spring Bargain for Motorists

# CAR RADIO SCOOP!

## BY FAMOUS BRITISH MANUFACTURER—

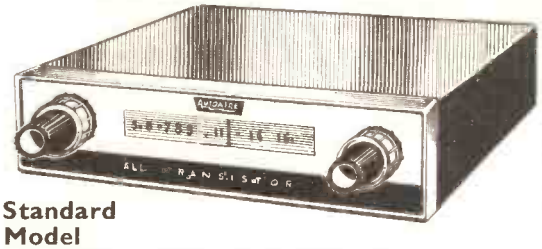
## READY TO FIT

### Standard Model

A high quality all transistor car radio covering the full Medium waveband. For use on all 12 v. D.C. systems—positive or negative earth. Very attractively styled in silver and black to harmonise with all interior styles. Standard dimension steel case 7 x 7 x 2in. complete with metal fixing brackets. Illuminated dial, "easy hold" control knobs. Tunable over full medium waveband—200/550 metres. Leads are fitted for battery, aerial and loudspeaker connections, a fuse is incorporated in the battery lead.

Technical details:
12 v. D.C., positive or negative earth; tuned R.F. stage superhet; fully transistorised using 7 semi conductors; power transistor with 3 ohm output sufficient for the largest car; permeability tuning for positive selection and stability.

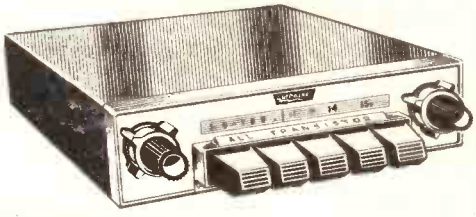
Instruction book and service manual including circuit diagram supplied. New and unused in makers original cartons. Fully guaranteed. **Today's value almost double.**



**Standard Model**

**LASKY'S PRICE £6.19.6** Post 5/6

Excluding speaker and aerial — see list below.



### De Luxe Model

Incorporating push-pull output providing 6 watts output together with fully variable tone control and five push button station preselectors. Ready to fit. Size—finish, etc., as standard model. Brand new and unused in makers original cartons. Fully guaranteed.

**De Luxe Model**

**LASKY'S PRICE £8.19.6** Post 5/6

Excluding speaker and aerial — see list below.

## A SELECTION OF SUITABLE AERIALS & SPEAKERS

**LOUDSPEAKERS.**
5in. round 10/6. 7 x 4in. elliptical 11/6.8 x 5in. elliptical 12/6. Post 1/6.

**SPEAKER ESCUTCHEONS.**
Chrome plated with matching grille, complete with fixing bolts. New and boxed. 5" round 12/6. 7" × 4" elliptical 15/6.

**AERIALS.** All heavily chrome plated, complete with connecting lead and plug. **Fully retractable.** Type A28 open 41in., closed 9in. 50/-. Type A24 open 61in., closed 16in. 55/-. Type A20 open 41in., closed 9in. (with locking device) 52/6. **Wing Mounting.** Type A13 opens to 48in. 25/-. Type A40 opens to 62in. 46/-. Post 2/-.

**FOR ADDRESSES SEE PRECEDING PAGE**

**4WW—147 FOR FURTHER DETAILS.**

# WIRECOMP ELECTRONICS

# BARGAINS FOR THE RADIO ENTHUSIAST

## THE SKYROVER & SKYROVER De Luxe

**GENERAL SPECIFICATION FOR BOTH MODELS**

7-transistor and 2-diode superhet—6 waveband portable receiver, covering the full Medium Waveband (180-576 M.) and Short Waveband (32-94 M.) and 4 separate switched Band Spread Ranges on 13M, 16M, 19M and 25M Bands—with Manual Band Spread Tuning for accurate Station selection. L.F. frequency 470 Kc/s. Output 500 M.W. 6in. Ceramic Magnet P.M. Speaker. Telescopic and internal Ferrite Rod Aerial. All Mullard Transistors and Diodes. The coil pack and tuning heart is completely factory assembled, wired and tested. The remaining assembly can be completed in under three hours from our detailed and easy to follow instructions. Operates on four 1.5 v. torch batteries (U2 or equivalent).

**THE SKYROVER DE LUXE.** Tone Control Circuit is incorporated with separate Control. In sturdy wood cabinet, size 11¼ × 6½ × 3in., covered in washable material with plastic trim and carrying handle. Also Car Aerial socket.

**MAY NOW BE BUILT FOR** All parts sold separately. **£10.19.6** H.P. Terms: 25/- dep. and 11 mths. at 20/-. Total H.P.P. £12/5/0.

A simple additional circuit provides coverage of the 1,100/1950 M. band (including 1,500 M. Light programme). All components with construction data. **Only 10/- extra** Post Free
This conversion is suitable for both models that have already been constructed

Circuit diagram and data for each set 2/6 extra, free if all parts bought. Four U2 batteries 3/4 extra. Add 5/- P. & P. on each parcel.

**NOW—THE SKYROVER Mk. III**
With new redesigned cabinet in black plastic with chrome trim and new edgewise controls. Controls: Waveband Selector, Volume on/off switch. Tuning Control with easy to read Dial Scale. Cabinet size 10 × 6½ × 3¼in., with carrying handle.
**MAY NOW BE BUILT FOR** All parts sold separately. **£8.19.6**
H.P. Terms: 20/- dep. & 11 mths. at 16/6. Total H.P.P. £10/1/6.

## WIRECOMP'S BARGAIN STORE

48 TOTTENHAM COURT ROAD LONDON, W.1. *Thousands of bargains — Stocks constantly changing — rock bottom prices.*

## THE 'REALISTIC 7'

The famous 7-transistor home construction receiver—still available. Full medium and long waveband coverage 4in. speaker, etc.
**MAY BE BUILT FOR** **£5.19.6**
Post 4/6.
Battery 3/9
De luxe version with wood cabinet full vision dial only £1 extra. All parts available separately. Data and instructions 2/6, refunded if your purchase parcel.

## CAR RADIO SCOOP!!

**By FAMOUS BRITISH MANUFACTURER—READY TO FIT**

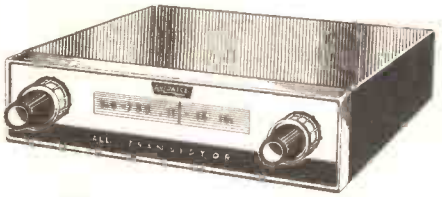
**Standard Model (illustrated).**
A high quality all transistor car radio covering the full Medium waveband. For use on all 12 v. D.C. systems—positive or negative earth. Very attractively styled in silver and black to harmonise with all interior styles. Standard dimension steel case 7 × 7 × 2in. complete with metal fixing brackets. Illuminated dial, "easy hold" control knobs. Tunable over full medium waveband—200/550 metres. Leads are fitted for battery, aerial and loudspeaker connections, a fuse is incorporated in the battery lead.

**Technical Details:**
12 v. D.C. positive or negative earth; tuned R.F. stage superhet; fully transistorised using 7 semi conductors; power transistor with 3 ohm output sufficient for the largest car; permeability tuning for positive selection and stability.
Instruction book and service manual including circuit diagram supplied. New and unused in maker's original cartons. Fully guaranteed. Today's value almost double.

**WIRECOMP'S PRICE £6.19.6** Post 5/6.
Excluding speaker and aerial.

**De Luxe Model**
Incorporating push-pull output providing 6 watts output together with fully variable tone control and five push button station preselectors. Ready to fit. Size—finish, etc., as standard model. Brand new and unused in maker's original cartons. Fully guaranteed.

**WIRECOMP'S PRICE £8.19.6** Post 5/6.
Excluding speaker and aerial.



**SPEAKERS:** 5in. round **10/6.** 7in. × 4in. elliptical **11/6.** 8in. × 5in. elliptical **12/6.** Post 1/6.

**SPEAKER ESCUTCHEONS:** Chrome plated with matching grill—complete with fixing bolts. 5" round **12/6.** 7" × 4" elliptical **15/6.** Post 1/6 extra.

**AERIALS:** Heavily chrome plated, complete with lead and plug.

**Fully Retractable**
Type A28 open 41in., closed 9in. **50/-.** Type A24 open 61in., closed 16in., **55/-.** Type A20 open 41in., closed 9in. (with locking device) **52/6.**

**Wing Mounting**
Type A13 opens to 48in. **25/-.** Type A40 opens to 62in. **46/-.** Post 2/-.

## READY BUILT TRANSISTOR RADIO OFFER

### THE "STELLA"

By famous maker—7 transistor portable radio. High sensitivity, circuit covering Long, Med., and Short wavebands. Fitted with tone switch and sockets for personal earphone and external aerial. Built-in chrome telescopic aerial. Powered by four 1.5 v. torch batts. Attractive plastic cabinet in beige and red, size 4 × 7 × 1¼in. Excellent tone 3in. p.m. speaker. Complete with leather shoulder strap and external aerial. Full maker's guarantee. List price 17 gns.

**WIRECOMP'S PRICE £9.19.6** Post 5/-.

## LEAK POWER AMPLIFIERS

For 200-250 v. A.C. mains. Fitted with integrated volume, bass and treble controls, with 100V line source output. New and boxed.

**TL25 Plus** ..... **Wirecomp's Price 15 gns.**
**TL50 Plus** ..... **Wirecomp's Price 19 gns.**
Carriage and Packing 7/6 extra on each.

### PAMPHONIC 100W RACK MOUNTING POWER AMPLIFIERS

For 200-250 v. A.C. mains. All controls fitted. 100V line source output. Uses KT88 valves in output stages. Perfect condition. **Very limited stock.**
**WIRECOMP'S PRICE 35 gns.** Carr. 15/- extra.

## PAMPHONIC 3001 INTEGRATED STEREO AMPLIFIER

New, and fully guaranteed. Spec.: 7 watts. per channel; freq. response 40 c/s to 20 kc/s.; sep. inputs for crystal and magnetic pick-ups, radio and tape; 15 ohms out. sockets for tape recording; volume, bass, treble and balance controls provided. For A.C. mains, 100/250 v. In free standing housing size 13 × 10 × 4½in. Maker's list price £38/10/-.
**WIRECOMP'S PRICE 23 Gns.** Post 10/6.

## PAMPHONIC 1002B PUSH BUTTON CONTROL UNIT/PRE AMP

A correction network is provided for every important recording characteristic with separate inputs for radio, tape and mic. Max. output is 1 volt. Unpowered. Volume, bass, treble and filter controls. 1—EF86 and 2—ECC81 valves fitted. Size 10 × 4 × 5in. New and boxed. Maker's list price £25/4/-.
**WIRECOMP'S PRICE £6.19.6** C. & P. 2/6.

## PAMPHONIC 1002A CONTROL UNIT

Inputs for pick-up, radio, tape and microphone. Controls for volume, bass, treble, filter and selector. Fitted with 2 EBC 40 valves.
**WIRECOMP'S PRICE £4.19.6** Post 2/6.

## PAMPHONIC 2001A PRE AMP

Sensitivity from 3 to 120 mV. for ½ v. out. Fitted with 2—ECC40 valves. Inputs for radio, tape, pick-up and microphone with pre-set level controls. Controls for bass, treble, filter and selector fitted. Unpowered. Size 10 × 4 × 4in.
**WIRECOMP'S PRICE £5.19.6** Post 3/6.

## PAMPHONIC 732A SWITCHED RADIO TUNER

Instant preselection of 3 medium wave stations and 1 long wave station (easily adjustable to your local frequencies). Self powered 3 valves. For 200/250 v. A.C. Fitted with tone and volume controls for use in conjunction with a power amplifier. In metal case, size 16 × 7 × 3½in.
**WIRECOMP'S PRICE £5.19.6** Post 7/6.

## PAMPHONIC SI SPEAKER UNIT

Cabinet type forward facing system. Fitted with 10 × 6in. eliptical double cone speaker. Wood cabinet size 15 × 12 × 11in., finished in medium walnut. New, and guaranteed. List Price 10 Gns.
**WIRECOMP'S PRICE £4.19.6**
Post 7/6.

## INTERNATIONAL TAPE

**Finest Quality American brand—fully guaranteed**

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|---|---|---|
| 3in. | Message tape, 150ft. | 8/6 |
| 3in. | Message tape, 225ft. | 4/11 |
| 3in. | Message tape, 300ft. | 7/6 |
| 3½in. | Triple play, 600ft. Mylar base | 15/- |
| 4in. | Triple play, 900ft. Mylar base | 17/6 |
| 5in. | Double play, 1,200ft. Mylar base | 15/- |
| 5in. | Long play, 900ft. Acetate base | 10/- |
| 5in. | Standard play, 600ft. P.V.C. base | 8/6 |
| 5in. | Triple play, 1,800ft. Mylar base | 35/- |
| 5½in. | Double play, 1,800ft. Mylar base | 22/6 |
| 5½in. | Long play, 1,200ft. Acetate base | 12/6 |
| 5½in. | Standard play, 850ft. P.V.C. base | 11/6 |
| 5½in. | Triple play, 2,400ft. Mylar base | 45/- |
| 7in. | Standard play, 1,200ft. Mylar base | 12/6 |
| 7in. | Long play, 1,800ft. Mylar base | 19/6 |
| 7in. | Double play, 2,400ft. Mylar base | 25/- |
| 7in. | Long play, 1,800ft. Acetate base | 15/- |
| 7in. | Triple play, 3,600ft. Mylar base | 58/6 |

Post 1/- extra per reel; 4 reels and over Post Free.

## "VIKING" GUITAR/P.A. AMPLIFIERS

"Transistor 50"—50 watts., fully transistorised with tremolo ..... 45 Gns.
"Sound 30"—30 watt valve model, 8 inputs.. 35 Gns.
Matching Speaker System for the "Viking" amplifiers ..... 33 Gns.
For details and illustration see March "W.W." including special package deal offer for the amplifiers and speaker system.

**323 EDGWARE ROAD, LONDON, W.2.** AMBassador 7115 — All branches open all day Saturday. Early closing Thursday.

**378 HARROW ROAD, LONDON, W.9.** CUNningham 9530 — Mail Orders to the above address for prompt service.

**To book panel advertisements in this section, apply to Wireless World, (Dept. P), Dorset House, Stamford St., London, S.E.1 or telephone WATerloo 3333, Ext. 210**

## 30,000 Ω per v. MULTIMETERS

★ ★ ★

A.C. volts: 0-2.5-10-25-100-250-500-1,000.
D.C. Volts: 0-.5-1-2.5-10-25-100-250-500-1,000.
D.C. Current: 0-50μA.-5-50-500mA.-12 amp.
Resistance: 0-60K-6M-60M.
What more can you ask for than all these ranges plus a specially damped "off" position for transit protection. Brand new, fully guaranteed, complete with leads, batteries and instruction booklet. Inc. P.P. **£7-19-6**

DON'T FORGET THAT ELECTROSURE BRAND RECORDING TAPE AS RECENTLY REPORTED ON IS AVAILABLE ONLY DIRECT FROM US.

**DUAL IMPEDANCE DYNAMIC MIC.**
A beautiful unit. Professional pattern with satin chrome finish. Swivel mount for standard ⅝in. 26 TPI stands. Troe Cardioid pattern with built in blast filter for close voice use Low 2 600Ω. High 2 50K.
**£5-17-6** inc. P.P.

**0-300v PANEL METERS**
Superior quality black Bakelite flush mounting with silver scale. Rectifier movement for A.C. use. Fits in 2⅜in. dia. hole. Inc. P.P. **30/-**

**CHASSIS PUNCH SETS**
High quality tool steel kit in zip leather case. Punches ⅛in., ¼in., ⅜in., ½in., 1⅛in. dia. holes in up to 16 swg. steel. Amazing value.
**47/6** Inc. P.P.

**ELECTROSURE LTD.**
**FORE STREET, EXETER.** *Telephone: 56687*

**Brand New GERMAN P.V.C. RECORDING TAPES**
Manufactured by world famous firm and offered at less than half price.
All tapes are 100% tested, have fitted leaders, are boxed and fully guaranteed.
(Not to be confused with used or sub-standard tapes.)
These tapes are comparable with any other on the British market.

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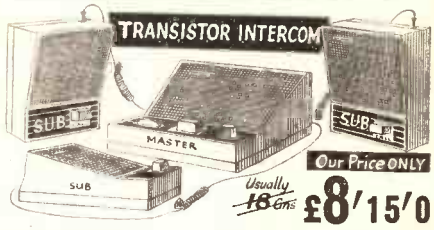
| **S.P.** | 5in. | 600ft. | 6/- |
| | 5¾in. | 900ft. | 7/6 |
| | 7in. | 1,200ft. | 10/- |
| **L.P.** | 5in. | 900ft. | 9/- |
| | 5¾in. | 1,200ft. | 11/- |
| | 7in. | 1,800ft. | 14/- |
| **D.P.** | 5in. | 1,200ft. | 13/- |
| | 5¾in. | 1,800ft. | 18/- |
| | 7in. | 2,400ft. | 23/6 |

*Postage and packing 1/- per spool 4 or more post free.*

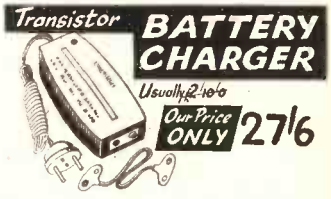
STARMAN TAPES LTD.
28, LINKSCROFT AVENUE,
ASHFORD, MIDDX.




Solve your communication problems with this 4-STATION INTERCOM (One MASTER and Three SUB8) housed in attractive plastic cabinets for desk or wall mounting. Four-way press button calling (buzzing) and talking from SUB units to MASTER and MASTER to SUB units. Buzzing system operates to call attention even when switched off, thus saves battery. Operates on single 9 volts PP3 battery which lasts months. Volume control. 2½ in. dynamic speaker. Ideal for Office, Warehouse, Works and Home. Complete with 3 pcs. of cord (each 66 ft.), 45 staples, 1 role of tape and a battery. Ready to operate. P. & P. 4/6.


Two-way TRANSISTOR INTERCOM, Master and Sub two units in Ivory plastic cabinets with chrom. stands. Both units operate on a single battery. Also useful as a BABY ALARM. Indispensable in home, office, shop and warehouse. Size: 4 x 2½ x 1¾ in. Complete with 60 ft. wire and battery. Ready to operate. P. & P. 2/6.

*By using this combined CHARGER & A.C. ELIMINATOR you can use your TRANSISTOR RADIO or INTERCOM on domestic A.C. mains. **Most effectively charges Dry Batteries 006P or PP3 used in TRANSISTOR RADIOS and INTERCOMS. Unbeatable value, save your pounds on batteries. Complete with Plug, Lead, and snap cord. P & P. 1/6.




*All our goods are fully guaranteed.*

**WEST LONDON DIRECT SUPPLIES (Dept. WW/11)**
6 CHIGNELL PLACE, WEST EALING, LONDON, W.13

## NEW DINSDALE AMPLIFIER

**PRINTED CIRCUITS**
(Approved by Mr. Dinsdale)
UNDRILLED **30/-** set of 4.

**W.W. XTAL. F.M.**
UNDRILLED **10/6** set of 2.

**NEVIN ELECTRIC LTD.**
Arkwright Road, Colnbrook, Bucks.

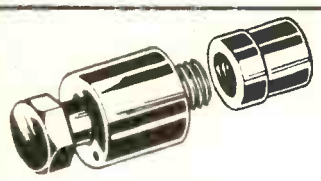
## PRINTED CIRCUITS

***A NEW SERVICE FOR THE HOME CONSTRUCTOR***

**INDIVIDUAL BOARDS**

*Made to your specification:*
**All in charge 10/- plus 1/- per sq. inch**
*Enquiries for quantities welcomed*

**EDEN ELECTRONICS**
**140 Eyhurst Avenue, Elm Park, Hornchurch Essex.** *Phone: 47912*



*The PUNCH you need!*

**HOLE PUNCHES**

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|---|---|---|---|
| **Instant Type** | | | |
| ⅜in. diameter | ... ... ... ... | 6/10 | ea. |
| **Screw-up Type** | | | |
| 15/32in. diameter | Toggle switch ... | 8/6 | ea. |
| ½in. | ,, ... ... ... ... | 8/6 | ea. |
| ⅝in. | ,, B7G ... ... | 9/- | ea. |
| ¾in. | ,, B8A, B9A ... ... | 9/6 | ea. |
| 13/16in. | ,, ... ... ... ... | 10/2 | ea. |
| ⅞in. | ,, ... ... ... ... | 10/8 | ea. |
| 1in. | ,, ... ... ... ... | 11/8 | ea. |
| 1⅛in. | ,, Int. Octal ... ... | 13/4 | ea. |
| 1¼in. | ,, ... ... ... ... | 16/2 | ea. |
| 1⅜in. | ,, ... ... ... ... | 18/10 | ea. |
| 1½in. | ,, B9G ... ... ... | 21/8 | ea. |
| 1¾in. | ,, ... ... ... ... | 24/4 | ea. |
| 2 3/32in. | ,, Meter ... ... ... | 33/2 | ea. |

Complete Set £9/3/6.

*No extra charge for postage and packing in the U.K.*

**Oliver & Randall Ltd**
Dept. 17
9 KELSEY PARK ROAD
BECKENHAM, KENT
*Tel.: Beckenham 8262*

**WHEN REPLYING TO ADVERTISEMENTS PLEASE MENTION WIRELESS WORLD**

**ALL ITEMS**
*with the exception of*
**MULLARD TRANSISTORS AND DIODES**
Still available as details in the
**MARCH**
ISSUE OF
**WIRELESS WORLD**
**See page 142.**
*Send for complete list post free.*

**TRANSUNITS LIMITED**
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SURREY.
**Telephone: Walton-on-Thames 21361**

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**DISPLAYED:** £5 per single col. inch.
**LINE** advertisements (run-on): 5/6 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 1/-.
**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 15th APRIL for the MAY issue, Subject to space being available.**

## SITUATIONS VACANT

AN OVERSEAS CAREER WITH
INTERNATIONAL AERADIO, LIMITED
TO meet the requirements of constant growth and expansion we invite applications from technicians and engineers for an overseas career in North, West and East Africa, the Mediterranean area, the Caribbean, the Arabian Gulf and the Far East. If you have recently completed service in a trade such as Ground Wireless Fitter in the R.A.F. or Radio Electrical Artificer in the Royal Navy or have other experience in the maintenance of HF and VHF communications, RTT and navigational aids, we should be interested to hear from you. Successful candidates would normally spend six weeks at our Radio Training School, Southall, Middlesex, before proceeding overseas, but in some cases staff with suitable qualifications and experience may be offered immediate posting. Overseas staff receive a tax-free salary with married and child allowances if appropriate and accommodation, bachelor or married, is provided free; other benefits include generous U.K. leave and membership of an excellent pension and life assurance scheme.
WRITTEN applications, please, to Personnel Officer, 40, Park St., W.1. [115

RADIO & Television Testers.
FOR City Factory; good rates up to 7/6 per hour, five-day week.
APPLY to Personnel Manager:—
ALBA (RADIO & TELEVISION), Ltd., Tabernacle St., London, E.C.2. [105

MEDICAL RESEARCH COUNCIL.
ELECTRONICS TECHNICIAN.
ELECTRONICS Technician required, experience with medical or industrial electronics or nucleonic equipment an advantage, good prospects of promotion, salary according to age and experience, £721-£886+ qualification allowance and London Weighting.
APPLICATIONS to the Director, Neuropsychiatric Research Unit, Medical Research Council Laboratories, Woodmansterne Rd., Carshalton, Surrey. [1172

TELECOMMUNICATIONS ENGINEERS.
THE EAST AFRICAN POSTS AND TELECOMMUNICATIONS ADMINISTRATION has vacancies, arising from the retirement of officers on the permanent establishment, for men to serve on contract for a tour of 24 months in the first instance. The job will present a challenge and provide satisfaction and an opportunity of widening experience.
SALARIES, recently substantially increased, new range from approx. £1,940 to £2,200 a year inclusive of overseas addition.
A generous gratuity—25% of total emoluments—and a disturbance allowance of £200 for married men and £100 for bachelors are also payable. There are also children's educational allowances, free passages and liberal leave on full pay.
MEN are needed in three main fields and the subcategories as shown:—
ASSISTANT ENGINEERS, Grade I, for V.H.F. Specialist posts; Carrier & Telegraph duties; External general duties and Automatic Exchange maintenance.
ENGINEERING INSTRUCTORS, Grade I, on the transmission side: embracing H.F. and V.H.F. multi-channel carrier and telegraph equipment and involving lecturing and demonstrating on principles and equipment functions.
ENGINEERING FIELD TRAINING OFFICERS to train African staff in a wide range of duties—involving the officer in extensive travelling in East Africa.
CANDIDATES should be aged between 28 and 45 years and possess relevant City & Guilds Certificates, or equivalent qualifications, together with sound experience in their particular field. Those applying for Field Training posts must have had 10 years' experience in telecommunications engineering.
APPLY to Crown Agents, M. Dept., 4 Millbank, London, S.W.1. for application form and further particulars, stating age, name, brief details of qualifications and experience, and quoting reference M2T/52098/WF. [1154

UNIVERSITY OF ST. ANDREWS.
SENIOR TECHNICAL OFFICER: ELECTRONICS AND CHEMICAL INSTRUMENTATION.
APPLICATIONS are invited from persons holding a University degree with specialisation in electronics, or an equivalent technical qualification, for the post of Senior Technical Officer in the Department of Chemistry, St. Salvator's College, St. Andrews. The person appointed will be required to assist with the maintenance and development of instruments used in teaching and research, and to be familiar with the high stability power supplies, amplifiers and oscillators as used in I.R., U.V., N.M.R., E.S.R., and Mass Spectrometers. Salary scale £1,300-£75-£1,600 (efficiency bar) £75-£1975; initial placing according to qualifications and experience; further particulars may be obtained from—The Secretary, University of St. Andrews, College Gate, St. Andrews, Fife, to whom applications should be sent with the name of a referee by 17th April, 1965. [1168

# PROGRESS CHASERS & PROVISIONING CLERKS

The Decca Navigator Company wish to recruit the services of the above personnel for work in their Production Control Department. Applicants should be conversant with the workings of such an office and experienced in the Electrical/Electronics field.

These positions carry attractive salaries and excellent opportunities for advancement.

Please write, telephone or call to the:—

**Personnel Officer,**
**The Decca Navigator Co. Ltd.,**
**88 Bushey Road,**
**Raynes Park,**
**S.W.20**
Phone: WIM 8011

# BABCOCK & WILCOX LTD

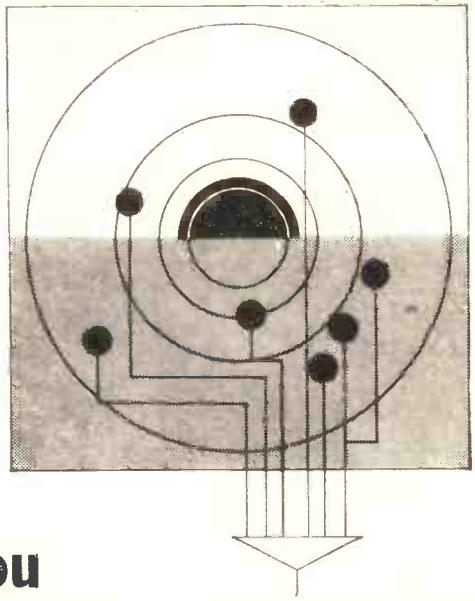
*invite applications from*

# ELECTRONIC ENGINEERS for COMPUTER MAINTENANCE

The successful applicant will be responsible for the maintenance of the equipment in a large analogue computer centre. Education to HNC standard or considerable experience is required, and a knowledge of analogue computers is desirable. Opportunities for programming are available. Salary will be commensurate with qualifications and experience.

*Detailed applications should be addressed to the*

**Assistant Secretary (Ref TBW/RJW)**
**Babcock & Wilcox Ltd.,**
**209 Euston Road, London, N.W.1.**



# Could you trouble shoot a computer?

Keeping a computer working smoothly is only part of a Customer Engineer's job at IBM. He works with his customers (within daily reach of his home) in their offices, helping them to use the equipment more effectively. He meets all levels of customer management in different branches of commerce and industry. He should have the ability to produce fresh ideas and have confidence in his own judgment. He must be able to combine his engineering skill with an understanding of his customers' needs and business systems. The job is a challenge, so is any work worth doing. And it's never dull.

We offer a thorough training. Starting salaries are normally in the region of £1,000 a year, with special consideration for men with special aptitude or specific experience. Increases are on individual merit. As a Customer Engineer you could be earning between £1,250 and £1,700 in three years. Promotion also is on merit and from within the company.

Is this the kind of career you're looking for? If you are between 21 and 29 and have a working knowledge of electronics (e.g. through a Radar/radio Fitters Course, Telecommunications experience or ONC/HNC Electrical or Electronic) we'd like to discuss your plans with you and show you how they could be realised in our rapidly growing organisation.

If you're not quite old enough to have reached the standards we've indicated, we'd still like to hear from you. If you've just left school with 'A' level Maths and English or are studying for ONC Electrical Engineering, we invite you to apply to us. There could be a place for you.

Please send a summary of your education, experience, interests and age to Mr. I. F. Bush, IBM United Kingdom Limited, 101 Wigmore Street, London, W.1., quoting reference CE/WW/155.

**You can grow with IBM**

## PYE OF CAMBRIDGE

We require trained men for production testing, fault finding and inspection of Modern equipment.

★ **SINGLE sideband equipment**
★ **VHF radiotelephone equipment**
★ **ELECTRONIC telephone exchanges**

We have limited vacancies for more senior and experienced technicians with drive, who can lead small teams. There are also vacancies for men with less experience who can be trained for such work.

*Apply:* **The Personnel Manager, Cambridge Works Limited, Haig Road, Cambridge.**

WORCESTERSHIRE EDUCATION COMMITTEE, BROMSGROVE COLLEGE OF FURTHER EDUCATION. APPLICATIONS are invited for the following post, the appointment to begin on 1st September, 1965.
SCIENCE DEPARTMENT.
LECTURER IN ELECTRONICS to develop courses in electronics in the college; the department has a well-equipped modern electronics laboratory, applicants should have a degree or equivalent qualification with electronics, together with industrial experience in this field.
SALARY scales: Lecturer—£1,670 p.a. to £1,895 p.a., starting point on scale according to qualifications and experience.
APPLICATION forms and further details obtainable from the Principal, College of Further Education, Stratford Rd., Bromsgrove, Worcs., and completed application forms should be returned to him within two weeks of the date of this advertisement. Please enclose stamped, addressed foolscap envelope. [1180

CITY and County of Bristol Education Committee.
Bristol Technical College.
Principal: E. Poole, B.Sc.(Eng.), M.I.Mech.E., M.I.Prod.E.
Applications are invited for the following new post. Appointment from 1st September, 1965.
Department of Navigation, Radio and Radar Lecturer in Marine and/or Aircraft Radio and Radar.
Applicants should preferably hold one or more of the following qualifications, and should have suitable experience in Marine or Aircraft Radio Communications or Electronic equipment in general.
(a) 1st Class P.M.G. Certificate with M.o.T. Radar Maintenance Certificate.
(b) Aircraft Radio Maintenance Engineers' Licences, categories A & B with Radar endorsement.
(c) A Higher National Certificate in Electronics and/or Electrical Engineering, or equivalent.
Salary on scale £1,670-£1,895 (at present under review).
Further particulars and application forms, returnable by 8th April, from Registrar, Bristol Technical College, Ashley Down, Bristol, 7.
Please quote ref. no. T65/14/1. [1165

SOUND reproduction and acoustics; junior engineer of H.N.C. standard required in small laboratory near Watford.—Ring Kings Langley 2955. [1123

## SALES ENGINEER

U.S.A. International manufacturers require a Sales Engineer to establish and maintain liaison with designers of radio and other equipment. He will be required to travel extensively and will be based in Philadelphia, Pennsylvania. There is an excellent pension scheme and generous home leave. A moving allowance will be made. Qualifications: Science Degree or other technical qualification. Experience of radio design or similar. Some selling experience would be beneficial.

Interviews will be held in London in the early part of April.

Please send details regarding qualifications, age, experience, and present salary to: Box No. 5012, c/o "WIRELESS WORLD."

## SITUATIONS WANTED

ELECTRICAL instrument mechanic seeks sub contract work, assembly/wiring, electro/mechanical equipment.—Box WW 85, Wireless World.

S.O.S. from Sweden! Engineer, 35, Hungarian in exile, entirely devoted to sound, seeks position within the British Hi-Fi, record or broadcasting industry due to the minimal audio activity in Sweden; has mechanical and electrical qualifications and more than ten years of private practice; special interest: tape recorders; for more information contact—B. Tary, Väringavägen 16, Djursholm 1, Sweden. [81

## BOOKS, INSTRUCTIONS, ETC.

TWENTY-SIX bound volumes "Wireless World" 1932 to 1953, 1954 to 1960 complete; unindexed, loose, as issued.—Offers to Box W.W.74, Wireless World.

WEBB'S log books for recording signals heard and worked. 112 pages. 9¾×8in, approved format, semi-stiff covers, excellent value 7/6 post free, or callers 6/5.—Webb's Radio, 14, Soho St., London, W.1. [106

MANUALS, circuits of all British ex-W.D. 1939-45 wireless equipment and instruments, from original R.E.M.E. instructions; s.a.e. for list, over 70 types.—W. H. Bailey, 167a, Moffat Rd., Thornton Heath, Surrey. [143

## ARTICLES FOR SALE

FERROGRAPH 5/AN (March 1964, £62, no offers (London).—Box WW 110, Wireless World.

LARGE quantity miscellaneous radio and electronic spares, offers.—Ham 9632. [1166

PHILIPS X-ray image intensifier with P.S.V.; excellent condition, tube very good; £300.—Box WW 76, Wireless World.

VIBRATOR G.E.C. Vem 5.2, complete with 2.1kW amplifiers, driver unit and audio osscillators; £350.—Romford 44473. [1157

TELEVISION sets, not working, for callers only, 17in £1/10, 21in £3/10, 14in mains portables £2/10.—'Phone Bournemouth 26849 [1178

LAFAYETTE International Tape; example: 7[illegible] 2,400ft. polyester, 22/6; p. & p. 2/-; wide rang[illegible] s.a.e. list.—Leda Tapes, 27, Baker St., W.1. [

PHILIPS relay bargains: e.g. 800+400Ω 6 gold c[illegible] 7/6, silver and platinum also in stock, s.a.e. [illegible] list.—J. Taylor, 26, Bewlay St., York. [

SPIRE, plain, self locking nuts, screws and rive[illegible] large quantities wanted for cash.—L. Kayser, 1[illegible] Highbury Quadrant, London, N.5. Canonbury 67[illegible] [

RADIO Luxembourg (London), Ltd., have for sale E.M.I. 5-channel mixer and a Philips EL 35[illegible] 7½in/sec recorder.—38, Hertford St., London, W.1. [1[illegible]

TRANSISTORS: AF.114/115/116/117, 4/- ea.; 2501[illegible] 10/- ea.; AF.127, 5/- ea.; silicon diodes, 200P.I[illegible] 4amp 2/6 each.—Pattrick & Kinnie, 81, Park La[illegible] Hornchurch, Essex. Romford 44473. [1[illegible]

700,000 semiconductors, radio manufacturer's surpl[illegible] AF/RF transistors, silicon rect., diodes, etc., off[illegible] accepted for part lots; lists and details to Box W.W[illegible] Wireless World.

QUAD complete stereo system, electrostatic speak[illegible] GL70P transcription, Empire 880P head, MIC[illegible] new and guaranteed; £240, value nearest £170.—[illegible] 2808. [

METERS 7KV electrostatic 3½in £3 ea.; 3.5 [illegible] 2½in rd. 30/- ea.; 500 Micro-Amp 2½in rd. 1[illegible] ea.; 115V 400 g.p.s. 2½in rd. 25/- ea.; 1-0-1 M[illegible] 4in rd. 25/- ea.; p.p. 2/6.—Pattrick & Kinnie, 81, P[illegible] Lane, Hornchurch, Essex. Romford 44473 [

UNISELECTORS (ex. equipment) 25 way, 4-ban[illegible] 22/6; 6-bank, 27/6; 8-bank, 32/6 ea.; p.p. 2[illegible] latest type (smoke grey) telephone handsets, 10/- e[illegible] p.p. 1/—Pattrick & Kinnie, 81, Park Lane, Ho[illegible] church, Essex. Romford 44473. [1[illegible]

## ARTICLES WANTED

WANTED, Air Ministry surplus aerial masts t[illegible] 50, 30ft high, reference No. 10B/1600.—Staray Ltd., King's Ride, Ascot, Berks. [1[illegible]

WANTED, C.R.T. regunning Glasswork mach[illegible] details and price required.—Midland TV Servic[illegible] High St., Harbury, Leamington Spa., Warwicks. [

WANTED, all types of communications receiv[illegible] and test equipment.—Details to R. T. & Electronics, Ltd., Ashville Old Hall, Ashville Rd., L[illegible] don, E.11. Ley. 4986. [

URGENTLY wanted, new valves, transisters, radi[illegible] cameras, binoculars, tape recorder and tap[illegible] watches, any quantity.—S. N. Willetts, 43, Spon La[illegible] West Bromwich, Staffs. Tel. Wes. 2392. [

## TAPE RECORDING ETC.

SAVE on cost of hi-fi. See Audio Supply notice (adv[illegible] No. 111). [

"SLEEP learning," the book essential for all [illegible] ahead people.—Send 6/6 to York House, H[illegible] dersfield. [

## MISCELLANEOUS

DINSDALE amplifier, set of printed circuits, drilled and fitted with solder tags, 35/-.—P. & M. Services, 126, Ramsay St., Rochdale, Lancs. [1156

METALWORK, all types cabinets, chassis, racks, etc., to your own specification, capacity available for small milling and capstan work up to 1in bar. PHILPOTT'S METAL WORKS, Ltd., Chapman St., Loughborough. [123

BENSON'S better bargains, send s.a.e. for free catalogue of Government and manufacturers' electronic surplus, to—Superadio (W.), Ltd., 116, Whitechapel, Liverpool, 1. [100

THE trade Mark No. 772762 consisting of the device of spokes radiating from a black centre and registered in respect of photographic and cinematographic films prepared for exhibition; and wireless, telephonic, television, telegraphic, sound recording and sound reproducing instruments and parts thereof included in Class 9, was assigned on 29th July, 1964, by Associated-Rediffusion Limited of Television House, Kingsway, London, W.C.2, to—Rediffusion Television Limited of Television House, Kingsway, London W.C.2. Without the goodwill of the business in which it was then in use. [1185

"ABACS of Nomograms." By A. Giet. Translated from the French by H. D. Phippen and J. W. Head. Most engineers have made use of nomgrams at some time in their careers, and are fully alive to the fact that they are a very convenient tool when the same formula has to be solved repeatedly for several sets of variables. It is fair to say, however, that only a small proportion of even those who habitually employ nomograms know how to construct them for their own use. Most of the comparatively small literature on the subject is written for mathematicians and is extremely difficult for the practical engineer to comprehend. This book is essentially practical, and not only demonstrates the many and varied applications of the abac of nomogram, but shows how even those without highly specialized mathematical knowledge may construct their own charts. 35/- net from all booksellers. By post 36/- from Iliffe Books Ltd., Dorset House, Stamford St., London, S.E.1.



"RADIO Designer's Handbook." Editor, F. Langford-Smith, B.Sc., B.E., Senior Member I.R.E. (U.S.A.), A.M.I.E. (Aust.), a comprehensive reference book, the work of 10 authors and 23 collaborating engineers, containing a vast amount of data in a readily accessible form; the book is intended especially for those interested in the design and application of radio receivers or audio amplifiers. Television, radio transmission and industrial electronics have been excluded in order to limit the work to a reasonable size. 65/- net from all booksellers. By post 67/9 from Iliffe Books Ltd., Dorset House, Stamford St., London, S.E.1.

"WIRELESS Servicing Manual." W. T. Cocking, M.I.E.E. This is the tenth edition of a book which since 1936 has been known to radio servicemen everywhere as a reliable, thorough and comprehensive guide to solving most of the problems that arise in the repair, maintenance and adjustment of the modern radio receiver. In the present edition a major addition is a chapter devoted to transistors and transistor sets. The author of "Wireless Servicing Manual" is well known to a wide circle of readers as former editor of "Electronic Technology" and now of "Industrial Electronics." His crisp lucid style makes this handbook of utmost value to the service man and amateur alike. 25/- net. 26/- by post from Iliffe Books Ltd., Dorset House, Stamford St., London, S.E.1.

"BASIC Mathematics for Radio and Electronics." By F. M. Colebrook, B.Sc., D.I.C.A.C.G.I. Revised and enlarged by J. M. Head, M.A. (Cantab.), presents in readable form a complete course in basic mathematics from engineering students of all kinds and leads on to the more advanced branches of mathematics of increased importance to radio engineers. In this edition the chapter covering the application of mathematics to radio has been revised and enlarged, while new subjects covered include Stability, Linar Differential Equations, Elementary Statistics, Short Cuts to Numerical Calculations and an Introduction to Matrices. Will be invaluable to those without previous knowledge of the subject. 17/6 net from all booksellers. By post 18/6 from Iliffe Books, Ltd., Dorset House, Stamford St., London, S.E.1.

# INDEX TO ADVERTISERS

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